CATEGORY 1

REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:9905060221 DOC.DATE: ~~98/12/31~~ NOTARIZED: NO DOCKET #
FACIL:50-315 Donald C. Cook Nuclear Power Plant, Unit 1, Indiana M 05000315
50-316 Donald C. Cook Nuclear Power Plant, Unit 2, Indiana M 05000316
AUTH.NAME AUTHOR AFFILIATION
BAKKEN,A.C. Indiana Michigan Power Co. (formerly Indiana & Michigan Ele
RECIP.NAME RECIPIENT AFFILIATION

See Environmental Reports

SUBJECT: "Annual Environ Operating Rept for Jan-Dec 1998 for DC Cook Nuclear Plant,Units 1 & 2." With 990430 ltr.

DISTRIBUTION CODE: C001D COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 200
TITLE: Licensing Submittal: Environmental Rept Amdt & Related Correspondence

NOTES:

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	STANG,J	1	1			
INTERNAL:	FILE CENTER 01	1	1	LA	1	1
	NUDOCS-ABSTRACT	1	1	OGC/HDS3	1	0
	RGN3 DRS/RSB	1	1			
EXTERNAL:	NOAC	1	1	NRC PDR	1	1

C A T E G O R Y 1 D O C U M E N T

NOTE TO ALL "RIDS" RECIPIENTS:
PLEASE HELP US TO REDUCE WASTE. TO HAVE YOUR NAME OR ORGANIZATION REMOVED FROM DISTRIBUTION LISTS OR REDUCE THE NUMBER OF COPIES RECEIVED BY YOU OR YOUR ORGANIZATION, CONTACT THE DOCUMENT CONTROL DESK (DCD) ON EXTENSION 415-2083

TOTAL NUMBER OF COPIES REQUIRED: LTTR 8 ENCL 7

Indiana Michigan
Power Company
Cook Nuclear Plant
One Cook Plant
Bridgman, MI 49106
616 465 5901

INDIANA
MICHIGAN
POWER

April 30, 1999

AEP:NRC:0806S

Docket Nos.: 50-315
50-316

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

Gentlemen:

Donald C. Cook Nuclear Plant Units 1 and 2
ANNUAL ENVIRONMENTAL OPERATING REPORT
JANUARY 1, 1998, TO DECEMBER 31, 1998

Attached is the Cook Nuclear Plant Annual Environmental Operating Report for the year 1998. This report was prepared in accordance with Technical Specification, Appendix B, Part 2, Section 5.4.1, and Technical Specification 6.9.1.6.

Sincerely,

A. C. Bakken III
Site Vice President

/mah

Attachment

c: J. E. Dyer
MDEQ DW & RP
NRC Resident Inspector
R. P. Powers
R. Whale MPSC
1998 Annual Environmental Operating Report
Retention Number 4.5

Donald C. Cook Nuclear Plant Units 1 & 2

Annual Environmental Operating Report

January 1 through December 31, 1998

Indiana Michigan Power Company
Bridgman, Michigan

Docket Nos. 50-315 & 50-316
License Nos. DPR-58 & DPR-74

TABLE OF CONTENTS

LIST OF APPENDICES

I. <u>INTRODUCTION</u>

Technical Specifications Appendix B, Part 2, Section 5.4.1, requires that an Annual Environmental Operating Report be produced and include summaries and analyses of the results of the environmental protection activities required by Section 4.2 of the Environmental Protection Plan for the report period. The Annual Environmental Operating Report shall include a comparison with preoperational studies, operational controls (as appropriate), and previous non-radiological environmental monitoring reports, and an assessment of the observed impacts of the plant operation on the environment. In addition to Technical Specification, Appendix B, Part 2, Section 5.4.1, Technical Specification 6.9.1.6 requires that an annual report, which details the results and findings of ongoing environmental radiological surveillance programs, be submitted to the Nuclear Regulatory Commission.

This report serves to fulfill these requirements and represents the Annual Environmental Operating Report for Units 1 and 2 of the Donald C. Cook Nuclear Plant for the operating period from January 1 through December 31, 1998.

There were no operational parameters to report for the year as both units were taken offline in September 1997 and have not been returned to service.

Parameter	Unit 1	Unit 2
Gross Electrical Generation (MWH)	0	0
Unit Service Factor (%)	0	0
Unit Capacity Factor – MDC* Net (%)	0	0

II. <u>CHANGES TO THE ENVIRONMENTAL TECHNICAL SPECIFICATIONS</u>

There were no changes to Environmental Technical Specifications in 1998.

III. <u>NON-RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT</u>

A. Non-Routine Reports

A summary of the 1998 non-routine events is located in Appendix I of this Report. No long-term, adverse environmental effects were noted.

B. Environmental Protection Plan

There were no instances of Environmental Protection Plan noncompliance in 1998.

C. Plant Design and Operation

During 1998, there were no changes in station design, operations, tests, or experiments, which involved a potentially significant unreviewed environmental issue. There were no environmental evaluations performed during the reporting period.

D. Environmental Monitoring – Herbicide Application

Herbicide applications are the activities monitored in accordance with Technical Specification Appendix B Section 4.2. There were no preoperational herbicide studies to which comparisons could be made. Herbicide applications are managed by plant procedure 12 THP 2160 HER.001.

A summary of the 1998 herbicide applications is contained in Appendix III of this report. Based on observations, there were no negative impacts or evidence of trends toward irreversible change to the environment as a result of the herbicide applications. Based on our review of application records and field observations, the applications conformed to EPA and State requirements for the approved use of herbicide.

E. Mollusc Biofouling Monitoring Program

Macrofouling monitoring and control activities during 1998 are discussed in Appendix IV of this report.

F. Special Reports

There were no special reports during 1998.

IV. RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

The Radiological Environmental Monitoring Program annual report is located in Appendix VI of this report.

The objectives of the operational radiological environmental monitoring program are:

1. Identify and measure radiation and radioactivity in the plant environs for the calculation of potential dose to the population.

2. Verify the effectiveness of in-plant measures used for controlling the release of radioactive material.

3. Provide reasonable assurance that the predicted doses, based on radiological effluent data, have not been substantially underestimated and are consistent with applicable standards.

4. Comply with regulatory requirements and Station Technical Specifications and provide records to document compliance.

A. Changes to the REMP

There were no identified changes to the REMP during 1998.

B. Radiological Impact of Donald C. Cook Nuclear Plant Operations

This report summarizes the collection and analysis of various environmental sample media in 1998 for the Radiological Monitoring Program for the Donald C. Cook Nuclear Plant.

The various analyses of most sample media suggest that there was no discernible impact of the nuclear plant on the environment. The analysis of air particulate filters, charcoal cartridges, direct radiation by thermoluminescent dosimeters, fish, water, mild and sediments from Lake Michigan, drinking water, and food products, either did not detect any radioactivity or measured only naturally occurring radionuclides at normal background levels.

The only radionuclide that appears attributable to the Donald C. Cook Nuclear Plant operation is tritium, which was measured at low levels in onsite wells. However, the associated groundwater does not provide a direct dose pathway to man.

C. Land Use Census

The Land Use Census is performed to ensure that significant changes in the immediate vicinity of the Donald C. Cook Nuclear Plant are identified. Any identified changes are evaluated to determine whether a modification must be made to the REMP or other related programs. A further discussion of the land use can be found in Appendix VI of this report.

D. Solid, Liquid, and Gaseous Radioactive Waste Treatment Systems

There were no changes in the solid, liquid, or gaseous radioactive waste treatment systems during 1998.

V. CONCLUSION

Based upon the results of the radiological environmental monitoring program and the radioactive effluent release reports for the 1998 reporting year, it can be concluded that there were no adverse affects to the environment or to the general public due to the operation of the Donald C. Cook Nuclear Plant.

APPENDIX I

NON-ROUTINE REPORTS

1998

<u>1998 Non-Routine Events</u>

<u>February 9, 1998</u> - A spill occurred after a sight glass on a rented plant-heating boiler ruptured. Boiler condensate leaked into the trailer that houses the boiler control room and then spilled into a temporary spill containment under the trailer. Despite the placement of the spill containment, approximately five gallons of the condensate spilled onto an asphalt drive and flowed into a nearby storm drain which discharges into Lake Michigan. The five gallons of boiler condensate contained approximately 5 – 18 ppb hydrazine and less than one ppm ethanolamine.

The heating boiler operator discovered this condition by the presence of steam leaking through the doors of the trailer. The boiler was immediately shutdown and the site glass was isolated to stop the leak.

The site glass was replaced and a Plexiglas shield was installed around the glass to protect operators.

<u>March 27, 1998</u> – A spill occurred after a condensate drain valve located in the outside panel of the rented plant-heating boiler failed. The failed valve leaked approximately five gallons of condensate onto the metal skirting surrounding the containment berm and flowed into a nearby storm drain Outfall 001s which contained a secondary containment to prevent direct drainage discharge into Lake Michigan. The contents of the Outfall were analyzed for hydrazine and ethanolamine with results of 22 ppb and 3.38 ppm respectively. Despite the secondary containment, it was estimated that approximately 9.17E-7 pounds of hydrazine and 1.41E-4 pounds of ethanolamine were released to the lake during the event. The small discharge intermixed with the beach sand and will naturally breakdown in the environment.

The heating boiler was immediately shutdown and depressurized. The failed condensate valve was repaired. The storm drain catchbasin's contents were pumped out and properly disposed of.

The metal skirting was modified in such a way that further leakage would drain to the containment berm.

<u>June 17, 1998</u> – The Main Turbine Lube Oil cooling system is cooled by the service water system that eventually discharges into Lake Michigan via Oufalls 001 and 002. On this date at approximately 0100 hours, the service water cooling system was found to have a tube failure, which resulted in oil intrusion into the service water.

The heat exchanger was isolated immediately to prevent further oil leakage into the service water system and cleanup commenced.

A visual survey of the Unit 1 discharge showed very small oil sheens (< 2" in diameter) that surfaced and broke up within 20 feet of the discharge. The Unit 1 circulating water system was removed from service on 7/17/98 at 1359 hours to prevent additional oil from reaching the lake. Further observations later in the day indicated that the small oil sheens were no longer present in the Unit 1 discharge.

An inspection dive was conducted on 6/19/98 to verify that there was no accumulated oil in the Unit 1 discharge tunnel prior to starting the circulating water system. The circulating water system was restarted on 6/19/98 at 2300 hours.

Based on the amount of oil collected from the cooler and from absorbents placed in the circulating water system it was estimated that approximately 780 gallons of oil were released to Lake Michigan. The tube leaks were caused by corrosion and were repaired. A lube oil cooler inspection program has been established utilizing fiber optics and eddy current testing to monitor future corrosion and take actions to prevent tube failures.

June 23 and 26, 1998 – Spills occurred from a temporary ice-making system discharge line. The ice making system contained a weak sodium tetraborate solution that was being used to replenish the borated ice in the plant's ice condensers. The ice making system was mounted on a skid and had a spill containment system.

On 6/23 at 1900 hours, the discharge line developed a leak and oversprayed the containment, spilling approximately 50 gallons to the ground. It was calculated that approximately 0.7 pounds of boron and 0.8 pounds of sodium were discharged to the ground. When the leak was discovered, the system was shutdown and the leak was stopped. The leak was repaired prior to starting the system. Excessive vibration and wear against the discharge line caused the leak. The discharge line supports were redesigned to prevent further excessive wear on the line.

On 6/26 at 1410 hours, the discharge line was accidentally cut during the improvement work on the supports. Approximately 30 gallons of the weak sodium tetraborate solution leaked to the ground before the line was isolated. It was calculated that approximately 0.5 pounds of boron and 0.5 pounds of sodium were discharged to the ground. The line was replaced and the system was properly aligned to prevent further failures. The ground where the spills had occurred was excavated and properly disposed of.

APPENDIX II

ENVIRONMENTAL SCREENING REPORTS

1998

There were no environmental screenings performed in 1998 that resulted in an environmental evaluation.

APPENDIX III

HERBICIDE APPLICATION REPORT

1998

AMERICAN ELECTRIC POWER

Date April 1, 1999

Subject 1998 Herbicide Spray Report - Cook Nuclear Plant

From E. C. Mallen

To J. P. Carlson

The following herbicides were applied on Cook Nuclear Plant property during 1998:

- Round –Up Pro
- Oust
- Direx 80DF
- Weed-B-Gon
- Round - Up
- Riverdale Solution Water Soluble IVM
- Preen

On July 7, 1998, a mixture of Round-Up Pro, Oust, Riverdale Solution, and Direx 80DF was used for total plant control in the 345KV and 765 KV switch yards. The application was performed by Turf Management, an Indiana licensed herbicide applicator (CR-98-4229) on contract to the AEP Western Division. A total of 48 ounces of Oust, 384 ounces of Riverdale Solution, 24 quarts of Round-Up Pro and 96 pounds of Direx 80DF were used for the application and spread over 32 .47 acres. Trailite, a marker dye, was used at a rate of 10 oz./100 gal. mix. The following are the application rates used compared to the allowable application rates.

Product Name	Quantity Used	Quantity Used/Acre	Quantity Allowed/Acre
Round-Up Pro	24 qt.	0.74 qt.	5 qt. (1)
Riverdale Solution	384 oz.	12 oz.	45 oz.
Oust	48 oz.	1.5oz.	8 oz.
Direx 80DF	96 lb.	3 lb.	15 lb.
Trailite	180 oz.	10 oz./100 gal. mix	12 oz./100 gal. mix

(1) Based on application rate for Dandelion, Curly dock, woody brush and trees.

On August 17, and August 18, 1998, a mixture of Round-Up Pro, and Riverdale Solution was used for total plant control in the railroad right-of-way, around buildings, parking lots, the sewage and absorption ponds, and within the plant's protected area. The application was performed by DeAngelo Brothers, a Michigan licensed herbicide applicator who was subcontracted by Turf Management. A total of 45 quarts of Round-up Pro and 225 ounces of Riverdale Solution were used for the application and spread over 15 acres. A marker dye was not used for the application. The following are the application rates used compared to the allowable application rates.

Product Name	Quantity Used	Quantity Used/Acre	Quantity Allowed/Acre
Round-Up Pro	45 qt.	3 qt.	5 qt. (1)
Riverdale Solution	225 oz.	15 oz.	45 oz.

(1) Based on application rate for Dandelion, Curly dock, woody brush and trees.

On September 14, 1998, the mortality of these July 7th to August 18th herbicide applications was assessed near 100%. The results of the inspection were as follows:

- Large weeds on the south side of the Paint Storage Building
- Weeds noted growing on the east side of Warehouse 5 north of door to shooting range
- Weeds on the north end of the fire protection training area/laydown area between pieces of equipment that are farther away from the road
- Weeds noted at the southwest corner of the 345KV yard near entrance

Round-Up mixed with water in a backpack sprayer was used to spot spray weeds in the landscaped stone areas around the plant site, the fire protection water storage tanks, the sewage ponds, the Training Center AC units, and under the racks in the PM&IS steel yard. A total of 85 ounces of Round-Up was used for spot spraying in 1998. The applications were performed by a licensed applicator from the Maintenance ANR Buildings and Grounds crew. As these applications were not broadcast, but weeds were individually spot sprayed, product usage rates per acre are not reported for these applications.

One application of Preen was used for weed control in planting beds around the North Guardhouse entrance, east of the cafeteria, and the Training Building in 1998. Twelve pounds of Preen granules were spread over 2,703 square feet during the application on April 17, and April 20, 1998. This amounted to an application rate of 0.71 oz./10sq. ft. The allowed label rate was 1 oz./10sq. ft. per application. The herbicide was applied by a licensed applicator from the Maintenance ANR Buildings and Grounds crew. The herbicide was 100% effective and controlled weeds in the planting beds cutting back on weeding time.

Two applications of Weed-B-Gon were applied by spot spraying to the plant lawns for weed control in April-May and June-July. A total of 44 oz. was used in the first application and 33 oz. in the second application. The herbicide was applied by the licensed applicator from the Maintenance ANR Buildings & Grounds crew. As these applications were not broadcast, but weeds were individually spot sprayed, product usage rates per acre are not reported for these applications.

The plant lawns were inspected on Sept 22, 1998. The results of the inspection were as follows:

- Many dandelions in the protected area lawn. Plantain was noticed in the area north of the road to the cafeteria/main entrance. Moss was noted in the grass south of this road between it and the Service Building Extension.

- South of the road to the Radioactive Materials Building there was noted lots of dandelions and spurge. West of the Radioactive Materials Building there is some curly dock and thistle and another unidentified weed.

- Training Building: The back area outside of the Dosimetry/Access Control offices has plantain and dandelions. The areas north and east of the simulator are filled with dandelions. Finally, there are weeds along both sides of the tracks by the training parking lot.

In summary, based upon our review of the application records, manufacturer specifications, material safety data sheets (MSDSs) and observations of the treated areas, the herbicides were applied according to the manufacturer's labeled instructions and according to Federal and State requirements. With the exception of the applications performed by Turf Management who was not licensed in Michigan (see attached letter from Michigan Department of Agriculture), a Michigan certified applicator was used as required. Detailed maps and application records are filed in 12 PMP 2160 HER.001, Guidelines for the Application of Approved Herbicides. No signs of over spray or spillage were observed or noted. No adverse environmental effects occurred.

c: W. Tucker
B. Taylor
S:\enviro~1\ecm\98herbrpt.doc

STATE OF MICHIGAN

JOHN ENGLER, Governor

DEPARTMENT OF AGRICULTURE

P.O. BOX 30017 • LANSING, MICHIGAN 48909
611 W. OTTAWA • LANSING, MICHIGAN 48933
DAN WYANT, Director

March 24, 1999

Mr. Eric Mallen
AEP/Cook Nuclear
1 Cook Place
Bridgman, MI 49106

<u>Disposition Letter</u>
RE: UI 98-50-11

Dear Mr. Mallen:

The Michigan Department of Agriculture (MDA), Pesticide and Plant Pest Management Division, recently investigated concerns raised regarding Turf Management of Hartford City, IN. You were concerned that Turf Management, the contractor hired by AEP for pesticide applications to turf and the Cook Nuclear plant, was not licensed in the State of Michigan.

Since the MDA is authorized to enforce the Natural Resources and Environmental Protection Act, Act 451 of 1994, Part 83 Pesticide Control, and the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), all investigations are conducted to determine compliance with these Acts.

Our investigation revealed that Turf Management was not licensed at the time of your complaint. Appropriate regulatory action has been initiated.

The MDA appreciates your concern for the proper use of pesticides and the environment.
This letter will serve to conclude our investigation of this matter. If you have any questions about this investigation, or any other issues related to pesticide use, please contact me at the St. Joseph regional office at (616) 428-2575.

Sincerely,

Michael G. Hansen, Regional Supervisor
Pesticide and Plant Pest Management Division
4032 M-139, Building 116
St. Joseph, MI 49085

cc: Pollyanne Kapala, Pesticide Enforcement Manager
Richard Stenberg, Inspector

APPENDIX IV

MOLLUSC BIOFOULING MONITORING PROGRAM REPORT

1998

Cook Nuclear Plant
1998 Zebra Mussel Bio-fouling Monitoring
And Control Report

INTRODUCTION

Chlorine, molluscicides, mechanical cleaning, and changes in plant design continue as integral parts of the zebra mussel control strategy at the Cook Plant. Monitoring efforts continue to assess the threat of zebra mussel infestation and determine the effectiveness of plant control techniques. Cook Nuclear Plant personnel installed and successfully used the new chemical delivery system located in the intake tunnels in 1998 to treat zebra mussel infestation in all three intake tunnels and the circulating water system.

ERADICATION AND CONTROL MEASURES

The 1998 control strategy consisted of the use of continuous chlorination of the service water systems, mechanical cleaning, and a molluscicide treatment using the newly installed chemical delivery system for the circulating water system and intake tunnels. The installation of a new Pacesetter system for delivery of sodium hypochlorite to the circulating water and service water systems and the completion and use of the chemical injection pipeline system to the intake cribs constituted a large portion of the zebra mussel control efforts in 1998. Intermittent chlorination continues to be used in the condensers and circulating water system for slime control. The microfiltration system used for the Miscellaneous Sealing & Cooling Water (MSCW) system is still non-operational.

CHLORINATION TREATMENT RESULTS

A new vendor supplied "Pacesetter" chlorination system was installed and became operational in mid-July to improve the 12.5% sodium hypochlorite delivery system. The system continuously delivered the recommended chlorine concentration of 0.3-0.6 ppm Total Residual Chlorine (TRC) end-of-pipe residual in the Non-Essential Service Water (NESW) system. The Essential Service Water (ESW) system TRC concentrations were not achieved due to undersized chemical delivery pumps. Larger chemical delivery pumps were ordered and installed on 18 September and were placed into service on 7 October, however low TRC levels were still frequently measured after the larger pumps were installed. This may have been attributed to two items. First, the ESW sodium hypochlorite spargers may have been plugged and second, the Chemistry technicians' reluctance to exceed residual chlorine discharge limits due to the decreased lake water demand in the fall season. Though TRC levels in the ESW system were less than desirable for the year, the monitoring data indicate that a sufficiently hostile environment was created to prohibit prolonged or permanent settlement in the ESW system. Chlorination was removed from service on 14 November (ESW) and 16 November (NESW) for the service water systems. These dates were earlier than the desired 30 November date for chlorination system removal due to Chemistry personnel not wanting to order a bulk delivery of sodium hypochlorite late in the treatment season.

Intermittent chlorination of the circulating water systems was sporadic as these systems were out of service for most of the season. The Non-Essential service water (NESW) system was not cross-connected to the Miscellaneous Sealing & Cooling Water (MSCW) system to continuously treat the system as had been done in previous years as the micro-filtration system was scheduled to become operational in 1998.

MECHANICAL CLEANING

Mechanical cleaning of the Unit 1 intake forebay and Unit 1 ESW pump bays was performed by divers in April-July of 1998. The Unit 2 intake forebay was cleaned in June-August of 1998. The Unit 2 ESW pump bays were not cleaned in 1998 but are scheduled for cleaning in 1999. The Unit 1 & 2 main condenser inlet tunnels were also inspected and cleaned in 1998.

All three intake cribs were cleaned in the fall of 1998 to minimize the impact of the intakes on diving ducks and maintain a suction source for non-contact cooling water systems. The cleaning proved to be effective, as there were no occurrences of wild duck entrainment over the 1998-99 winter season.

MOLLUSCICIDE TREATMENT RESULTS

Betz Clam-Trol CT-2 was fed at a target rate of 4 ppm for 12 hrs. on August 28-29, 1998 for a treatment of the intake tunnels, circulating water system, and in service, service water systems. Six thousand pounds of CT-2 and 177,000 pounds of DTS, a 23-25% clay slurry, were used for the treatment. Bio-box mortality results showed 97-98% for the circulating water system, 82% for the MSCW system, 98-100% for the NESW system and 39% for the Unit 1 ESW and 100% for the Unit 2 ESW system. A diver inspection of the intake tunnels revealed that the kill was not entirely complete. There still remained a single layer of mussel coverage in the bottom corrugations of the pipes. This was deemed to be insignificant and would be removed in future treatments. Whole effluent toxicity testing was not required, as the products had been used successfully in previous years.

FOULING FROM THE INTAKE PIPELINES

The plants were down in 1998 and circulating water pump flows were low for most of the year. At most, one or two circulating water pumps were used during the year to support routine plant operations and chlorination. The pipelines were cleaned of loose shells after the molluscicide treatment in 1998. Traveling screen operation was reverted from a continuous operational mode to two ½ hr. intervals per day. This allowed the divers to catch up on traveling screen maintenance.

LAKE WATER SYSTEM FOULING

Fouling in the Miscellaneous Sealing & Cooling Water System

No major fouling was reported in the Miscellaneous Sealing & Cooling Water System in 1998, despite the system not being chlorinated. The system did receive the benefit of the August 28-29 Clam-trol treatment.

Fouling in the Service Water Systems

On November 4, 1998, three zebra mussels measuring 5/8"-3/4" in length were found in the crushed shell, sand, and silt debris cleaned out of the 1/32" mesh strainer for the Unit 1 W Motor Driven Aux. Feed Pump (MDAFP). Two were confirmed to be live by placing them in an aquarium and observing them to be filtering. The apparent cause (CR-98-6712) for the introduction of the live zebra mussels was attributed to the configuration of the 20" ESW header to 4" piping branch allowing debris to settle in the 4" horizontal piping suction. This 4" piping suction is only flushed every refueling outage making it a "dead" leg, which also is not exposed, to continuous chlorination. The possibility that zebra mussels were firmly attached and constricting the piping suction was discussed with the service water system engineer. He did not

believe this to be the case as the bulk of the debris was crushed zebra mussel shells and there were only three whole live individuals found. The 4" suction piping was able to exceed its design flow rate of 450 gpm, indicating that the flow was not constricted in the suction piping. This was further confirmed upon reviewing x-rays of the suction piping revealing that there was no growth on the walls of the pipe.

Fouling in the Service Water Systems – continued

An inspection of the Unit 1 CCW Heat Exchanger 1-HE-15E on 12/9/98 shed light on the investigation and raised the possibility that the 1/8" mesh ESW pump strainers were being bypassed. Large debris including pieces of driftwood, a 3" x 5/8" bolt, and a plastic cap, were found on the inlet side of the heat exchanger. Half shells found on the inlet and end bell sections of the heat exchanger were of the same size range as those found in the ESW to Aux. Feedwater piping leg. The presence of MIC and filamentous green algae were noted on the end bell section of the heat exchanger.

FIRE PROTECTION SYSTEM FOULING

On August 4, 1998, while conducting system flow testing of the fire suppression system for the Unit 1 Transformers, Plant Protection personnel found three deluge nozzles that did not flow water, or had restricted flow upon system actuation. During efforts to remove the blockage (A165886 & A138761), asiatic clam shells were found in the debris. These were believed to be the remnants of when the fire protection system was on lake water from the time of construction up until the time when the system was placed on chlorinated drinking water in the Spring of 1993. Two fire hydrants were flushed during the month of October through a plankton net to sample for biological contaminants. Microscopic worms, rotifers, and daphnia, were found in the samples. These occur naturally in the soil and were believed to be introduced through the hydrant drain holes. A dead zebra mussel veliger and a veliger fragment were also found in the samples. These are believed to be relics of when the system was on lake water and do not pose a problem to the fire protection system.

DESIGN CHANGES

Traveling Screens

DCP-149 for the replacement of the North and South Screenwash pumps was performed via component evaluation ENTM 99-011 as the replacement was basically like for like. These material upgrades will allow a greater number of hours of operation per year than was originally designed due to the onset of zebra mussels. Upgraded screenwash pump strainers were not installed in 1998 but have been purchased and are planned to be installed in the future.

Miscellaneous Sealing & Cooling Water Pump Strainer and Filter Upgrade

The two Ontario Hydro Industries 40 micron filters installed to run in parallel became operational in 1997. The new filters were not able to perform to the manufacturer's specifications due to an ineffective backwashing mechanism. This caused the filters to often be by-passed. A backwash retrofit kit provided by the vendor was not successfully installed in 1998 and the filters remained out of service for the year.

Chemical Injection Pipeline

The chemical injection pipeline installed under 12-DCP-108 was completed in 1998. The design consisted of two bundles of three 3-inch polyethylene pipes which run from the screenhouse through the center intake tunnel and branch at the center intake crib to the north and south intake cribs where they connect with diffuser rings at each crib. Chemicals were delivered to the intake cribs during the August 28-29 Clam-Trol treatment. A problem with the branch runs from the center to the north and south intake cribs being undermined by lake action remains to be resolved.

CONCLUSION

For the foreseeable future, chlorine and proprietary molluscicides will continue to be used for zebra mussel control. Mechanical cleaning can supplement chemical control methods in the circulating water system. Plant design changes including strainers, filters, screens, and chemical delivery systems, will work to resolve the plant's zebra mussel related problems. Continuous chlorination has proven to be effective in controlling zebra mussels in the service water and the miscellaneous sealing & cooling water systems, but must be operated and maintained during the veliger spawning season from early May to the end of November. A zebra mussel monitoring program utilizing side-stream and artificial substrate monitors, along with diver and heat exchanger inspections, will continue to be used to evaluate the effectiveness of chemical and physical control measures.

Prepared for

AMERICAN ELECTRIC POWER
Donald C. Cook Nuclear Plant
One Cook Place
Bridgman, Michigan

MOLLUSC BIOFOULING MONITORING DURING 1998

March 1999

LMSE-99/0361&673/005

Prepared by:

LAWLER, MATUSKY & SKELLY ENGINEERS LLP
Environmental Science & Engineering Consultants
10207 Lucas Road
Woodstock, Illinois 60098

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Biofouling Studies have been conducted at the Donald C. Cook Nuclear Plant since 1983. In 1991, monitoring of zebra mussels in the circulating water, essential service water (ESW), and nonessential service water (NESW) systems was added to the program. The objectives of this monitoring are to detect the presence and density of zebra mussel veligers in the circulating water system and postveliger settlement in the forebay and service water systems.

Veligers were present in the forebay from 7 May through 10 December 1998. Peak densities occurred on 6 August, 10 September, and 24 September, with the major peak occurring on the August date (99,250/m^3). The peak period of abundance occurred between 30 July and 6 August. Veliger densities in 1998 were less than those reported during previous studies, with the exception of 1995. It should be emphasized that the Station did not generate any power during 1998. As a result, unlike previous years, only one or two circulating water pumps were in operation. This resulted in a decrease in flow, which also decreases the number of organisms being entrained into the intake forebay and service water systems. Therefore, comparisons of 1998 data with previous studies should be viewed accordingly.

Settlement in the forebay occurred on all sampling dates except 4 and 18 June. Density data indicate that settlement was very low during May and June, the first half of July, November, and December. Peak settlement was observed between 23 July and 20 August, with the highest settlement densities of 61,280/m^2 occurring on 23 July. Few translocators were observed on the periodic slides taken from the intake forebay.

Cumulative settlement was monitored in the forebay using two six-inch PVC pipes. These were set on 23 April and retrieved in December. One sampler was exposed to Clam-Trol treatment and the other was placed in non-treated water during the Clam-Trol treatment period. The objective was to compare post-treatment settlement with that of the entire monitoring period. The treatment sampler was inspected before being reset in the forebay and was void of mussels at that time. Analysis following retrieval in December showed the density on the treated sampler was approximately 62% of the density on the sampler that was not exposed to Clam-Trol. Size ranges and mean sizes of zebra mussels observed on the two samplers were

similar suggesting that many translocators settled on the treated sampler during this three-month period. Similar results were observed in 1994 (LMS 1995). These findings emphasize the need for effective chlorination of the service water systems during September through December.

Service Water Systems

Settlement on the periodic artificial substrates placed in the service water system was observed between 7 May and 10 December. Settlement densities were low (0 to 960/m^2) in each of these systems during May, June, and the first two weeks of July. Highest settlement densities occurred from mid-July to mid-November. As was the case in the intake forebay, translocators were rarely encountered on the periodic substrates collected from the service water systems.

Inspection of both density and size data indicate that the chlorination was not totally effective at preventing attachment (settlement) of postveligers (those greater than 200-225 μm in size) in the ESW systems. However, chlorine treatment did appear to provide an environment that was sufficiently hostile to prevent prolonged settlement and growth. Size data collected from the cumulative artificial substrates indicate that long-term colonization is prevented. In addition, total residual chlorine (TRC) in these systems was typically less than the desired target of 0.3-0.6 ppm for effective zebra mussel control. As a result, larger sodium hypochlorite injection pumps were installed during September to increase the rate of chlorine delivery to the ESW systems. Densities were not as high following this installation as the pumps were installed after the season's peak spawning had occurred. Also, there was reluctance on the part of the Cook Plant staff to overdose the system and potentially violate the NPDES permit limits.

Periodic and cumulative mussel densities collected from the NESW system were relatively low throughout the year. Unlike the ESW systems, TRC levels in this system generally were in the desired range of 0.3-0.6 ppm TRC. However, the sampler at this location received minimal, inconsistent, and sometimes nonexistent flows during the entire sampling season. Therefore, data collected from this location should be used accordingly.

As previously mentioned, periodic settlement data indicates that chlorination was not totally effective at preventing settlement in these systems. With few exceptions, mean sizes of postveligers observed on the substrates were greater than settlement size throughout the sampling season. However, the cumulative substrate size data indicates that these smaller juveniles found the substrate sufficiently inhospitable and caused them to move on; thus preventing prolonged attachment.

Results of the forebay cumulative artificial substrate sampling emphasize the need for effective chlorination of the service water systems during the September through early December period. Improving the efficiency of chlorine delivery to each of the systems may further reduce settlement densities. A new "Pacesetter" chlorination system was installed and became operational in mid-July to improve the chlorine delivery system. This system was shut down on several occasions for various reasons (Clam-Trol treatments, diver inspections, installation of larger ESW chlorine pumps, etc.). If the chlorine delivery system functions as required, zebra mussel control should become more effective.

Miscellaneous Sealing and Cooling Water System

Settlement on the periodic artificial substrates placed in the MS&CW system was observed between 7 May and 19 November. Settlement densities were low (53-960/m^2) from 7 May through 23 July. Highest settlement densities occurred from 6 August to 17 September (1,227-12,693/m^2). As was the case in the intake forebay, translocators were rarely encountered on the periodic substrates collected from the MS&CW system.

Both the periodic densities and the mean size data of zebra mussels collected from the MS&CW system were generally less than those observed in the ESW systems. This system was chlorinated only incidentally via the circulating water system on an irregular basis. The major treatment of this system in 1998 was Clam-Trol, which was administered on 28-29 August.

Recommendations regarding chlorination include:

- **Chlorination must begin during the first half of May to prevent settlement of translocators that pass into the service water systems from Lake Michigan and/or untreated intake tunnels during the winter.**

- **Chlorine delivery systems must be properly designed and maintained to ensure consistent delivery of biocide at the desired dosage to all service water systems from May through November. The MS&CW system should be treated separately either by mechanical filtration or supplemental biocide treatment.**

Failure to implement these recommendations has the potential to foul the service water systems, particularly when all circulating pumps are operating.

Other recommendations are to continue initiating whole-water sampling at the end of April to ensure that the initial spawning period is observed and initiating the artificial substrate sampling in May to determine the first sign of settlement.

CHAPTER 1

INTRODUCTION

1.1 PAST HISTORY

American Electric Power Company (AEP) has been conducting zebra mussel monitoring studies at the Donald C. Cook Nuclear Plant since 1991. The purpose of these studies is to monitor the presence of zebra mussel veliger and postveliger settlement densities in the circulating water, essential service water (ESW), nonessential service water (NESW), and miscellaneous sealing and cooling water (MS&CW) systems to help determine the effectiveness of zebra mussel control programs.

The 1998 monitoring program conducted by Lawler, Matusky & Skelly Engineers LLP (LMS) was designed to detect the timing of spawning and settling of zebra mussels at the Cook Nuclear Plant and to collect and determine densities for: (1) whole-water samples for planktonic veligers; and (2) artificial substrates set within the circulating water, ESW, NESW, and MS&CW systems for periodic and cumulative postveliger settlement.

1.2 OBJECTIVES

Specific objectives for the 1998 Biofouling monitoring program were as follows:

- Whole-water sampling of the circulating water system was conducted weekly (June-October), bimonthly (May and November), and monthly (April and December) to determine the presence and density of larval zebra mussels.

- Artificial substrates were deployed in the intake forebay and service water systems to detect settlement of post-veligers. Samples were collected once in May, every two weeks from June through October, and once during November and once in December.

CHAPTER 2

METHODS

2.1 WHOLE-WATER SAMPLING

Whole-water sampling of the circulating water system was conducted from 23 April to 10 December 1998 (Table 2-1). Samples were collected from mid-depth in the intake forebay by pumping lake water through an in-line flowmeter into a plankton net. The sampling location was consistent with that of previous studies. Two replicates (2,000 liters each) were collected during each sampling event.

A Myers Model 2JF-51-8 well pump, rated to deliver 8 gpm, was connected to an in-line flowmeter assembly (Signet Model #P58640) and pumped water into a plankton net for approximately 55 minutes. To minimize organism abrasion, measured flow was directed into a No. 20 plankton net that was suspended in a partially filled 55-gal plastic barrel. The sampling net was inspected frequently to avoid net overflow. Sediment was washed down to ensure that overflow did not occur.

Samples were gently washed into the cod-end bucket of the plankton net using filtered, circulating water system water and then transferred into a one-liter plastic jar. If needed, filtered water was added to the jar to ensure that a full liter was analyzed. After the second replicate was collected, both samples were transported to the on-site laboratory and analyzed immediately.

Samples were initially mixed thoroughly for three minutes using a magnetic stir plate. Then, using a calibrated disposable Pasteur pipette, a 1-milliliter aliquot of mixed sample was placed into a Sedgewick-Rafter cell for counting, using an Olympus SZ-1145 binocular microscope (18-110X) equipped with cross-polarizing filters. Ten replicates were counted, and the average was extrapolated to determine the number of individuals per cubic meter. This process was repeated for the second replicate and the mean of the two values was calculated to yield a final

TABLE 2-1

SAMPLING SCHEDULE FOR ZEBRA MUSSEL MONITORING AT THE D.C. COOK NUCLEAR PLANT IN 1998

DATE		WHOLE-WATER	ARTIFICIAL SUBSTRATE	
			PERIODIC	CUMULATIVE
April	23	X		
May	7	X	X	X
	21	X		
June	4	X	X	
	11	X		
	18	X	X	X
	25	X		
July	2	X	X	
	9	X	X	
	16	X		
	23	X	X	X
	30	X		
August	6	X	X	
	13	X		
	20	X	X	X
	27	X		
September	3	X	X	
	10	X		
	17	X	X	X
	24	X		
October	1	X	X	
	8	X		
	15	X	X	X
	22	X		
	29	X		
November	19	X	X	X
	29	X		
December	10	X	X	X

density value. The density was calculated as follows:

$$\text{Density } (\#/m^3) = (\text{average } \#*DF) / 0.001L * 1L / 2{,}000L * 1{,}000L / m^3$$

Size measurements were recorded for up to 50 organisms from each sample. Veliger length was measured to the nearest 10 μm using an ocular micrometer that was calibrated to a stage micrometer.

2.2 ARTIFICIAL SUBSTRATES

To determine zebra mussel settlement in the circulating water, ESW, and NESW systems, artificial substrates were placed in the intake forebay upstream of the trash racks. Sidestream samplers were installed on the return side of both service water systems and on the miscellaneous sealing and cooling system. Monitors were equipped with modified test-tube racks designed to hold slides for periodic and cumulative sampling. (*Periodic settlement* is defined as short-term monitoring, either two- or three-week periods, depending on the month. *Cumulative settlement* is long-term monitoring that extends from initial deployment to the end of the sampling season.) Both periodic and cumulative sampling dates are presented in Table 2-1.

2.2.1 Periodic Settlement

Artificial substrates that were designed to measure periodic settlement were placed in the intake forebay (pre-chlorination) on 23 April and consisted of a cinder block with test-tube racks secured inside the openings. Periodic samplers were deployed by rope near the center of the intake forebay at approximately mid-depth.

Sidestream monitors were placed on the return side of the service water systems (ESW and NESW) and the miscellaneous sealing and cooling water system. Each monitor contained two modified test-tube racks that held all slides above the monitor base. This allowed silt and sediment to fall out before they could influence postveliger settlement. Monitors were covered

with a plant-approved fireproof fabric to limit light exposure. Plant personnel checked the monitors periodically to ensure that adequate flow was available, and flow was adjusted as necessary. On each sampling date ten slides from each location were retrieved and replaced with clean slides. These were labeled as periodic settlement. Slides were placed in labeled racks and transported in a cooler to the on-site laboratory where they were analyzed immediately.

2.2.2 Cumulative Settlement

A sufficient number of substrates were initially placed in each biobox sampler to allow ten slides to be removed once per month at the service water and miscellaneous sealing and cooling water locations. These slides were not replaced. Cumulative settlement was monitored in the forebay using two pieces of PVC pipe that were each six inches long and had an inside diameter of two inches. Each pipe was cut in half lengthwise; rejoined using hose clamps, and attached to a rope at intervals of about three feet. These substrates were also deployed near the center of the intake forebay at mid-depth. One sampler was exposed to Clam-Trol CT-2 and the other was not exposed to the toxicant during the 28-29 August Clam-Trol treatment. Cumulative monitoring was designed to provide information on accumulated infestation throughout the growing season.

2.2.3 Periodic and Cumulative Sample Analysis

Analysis was conducted with an Olympus SZ-1145 binocular microscope (18-110X) equipped with cross-polarizing filters. After one side of the slide was scraped clean, the slide was placed on the microscope stage so that the attached postveligers could be counted. When slides became heavily infested, a subsampling technique was followed:

- The slides were subsampled using a splitter that permitted either half or a quarter of the slide to be counted. Counts were then proportionally extrapolated to one square meter.

Settlement rates were computed by taking the average number of mussels from the ten slides and multiplying this value by 533.34 to obtain the density of zebra mussels per square meter. (One postveliger/microscope slide equals 533.34 veligers per square meter.)

Shell diameters were measured for up to 50 selected and random individuals for both unsubsampled and subsampled slides to obtain maximum, minimum, and mean sizes. Diameters were measured (μm) using an ocular micrometer calibrated to a stage micrometer.

CHAPTER 3

RESULTS AND DISCUSSION

The zebra mussel monitoring system performed up to expectations in 1998; however, several noteworthy events did occur. First, the Station did not generate power during the entire sampling season. As a result, only one or two circulating water pumps were in operation during 1998. During periods when the Station is fully operational, up to 7 circulating pumps may be in service. When the number of pumps in service are increased, intake flows also increase. This increase in flow results in an increase in the number of organisms being entrained into the intake forebay and service water systems. By way of comparison, the peak density of veligers in 1996 (when all pumps were operating), was approximately three times the peak density recorded in 1998 (292,750/m^3 : 99,250/m^3). Therefore, comparisons of data collected in 1998 (when only one or two pumps were in operation), to those of previous years (when more circulating pumps were in operation), should be viewed accordingly. In addition, flows to the biobox on the return side of the NESW system were minimal, erratic, or nonexistent in 1998. Data from this sampling location should also be viewed accordingly.

Concurrent with the extended Station outage that occurred throughout 1998, a new self-contained "Pacesetter" chlorination system was designed and went into service on 15 July. During the first ten days of operation, the service and circulating water systems were intermittently chlorinated (Appendix Tables 1 and 2). Chlorination went from intermittent too continuous on 25 July. Chlorination of these systems continued until 23 August when it was shut down in anticipation of a scheduled Clam-Trol CT-2 treatment. The Clam-Trol biocide treatment and detoxification, including the service water and miscellaneous and cooling water systems, was conducted on 28-29 August. Chlorination was again resumed on 31 August and continued through 18 September. The chlorination system was shut down at that time to install larger ESW chlorination pumps. The larger sodium hypochlorite injection pumps for the ESW system were installed in an attempt to attain 0.3-0.6 ppm total residual chlorine (TRC), which is the practical concentration for effective zebra mussel control. Chlorination was resumed on 7 October, was shut down for a few hours on 13 October, and was shut down again on 22

October for divers to enter the Unit 1 Discharge Tunnel. Chlorination resumed on 2 November and continued until the systems were taken out of service on 14 November (ESW) and 16 November (NESW) systems. The MS&CW system was incidentally chlorinated via the circulating water system for short periods of time (90 to 160 minutes) from 15-17 July, 20-21 July, 23 July, 22-23 August, 18-21 November, 23-28 November, and on 3 December (Appendix Table 1). It was also treated with Clam-Trol on August 28 - 29 and received benefits from the molluscicide treatment.

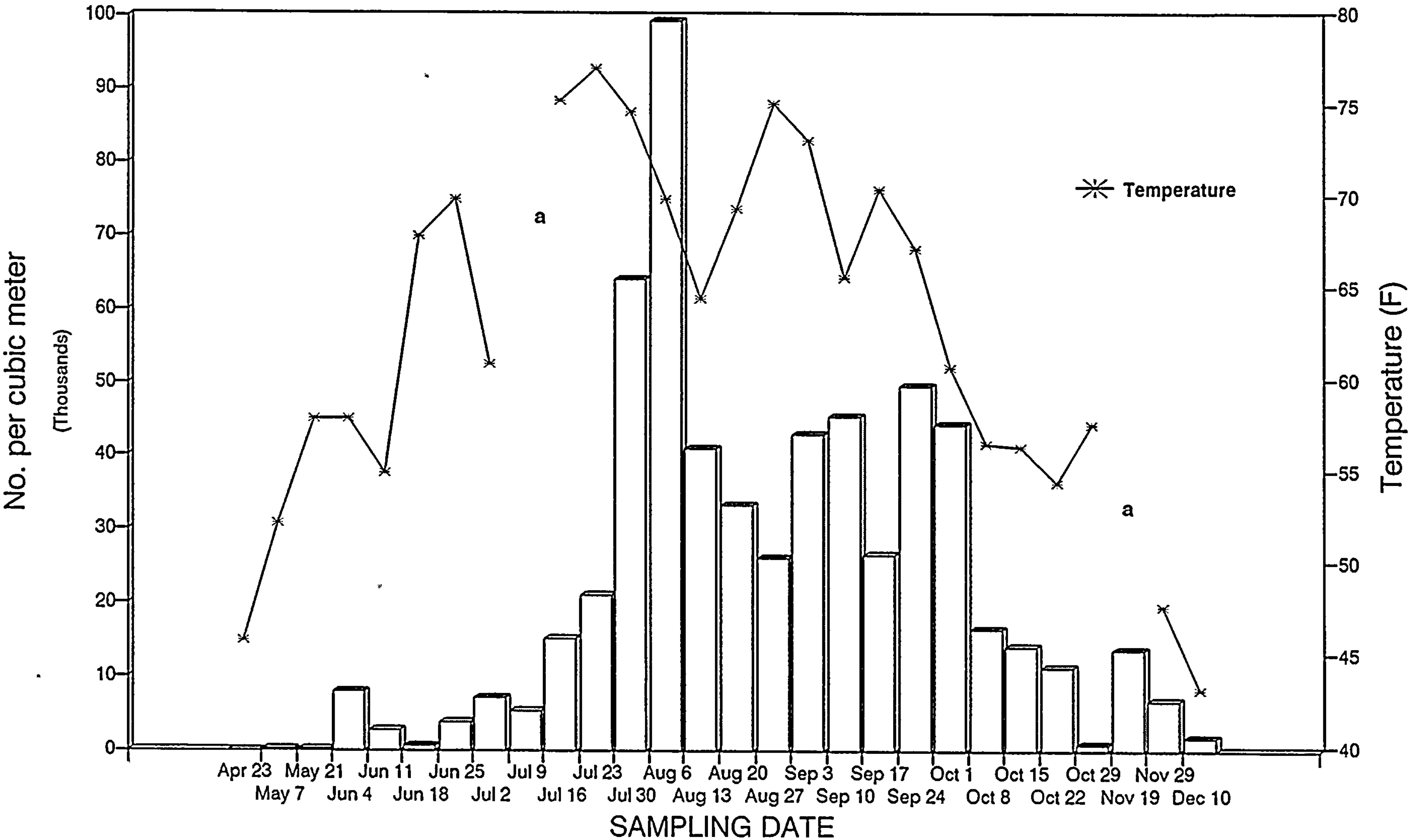
3.1 WHOLE-WATER SAMPLING

Sampling of planktonic veligers in the circulating water system was initiated on 23 April and completed on 10 December. Fifty-four samples were taken (two per sampling date) from the Station's intake forebay. Results of sampling are presented in Figure 3-1 and Table 3-1. Veligers first appeared in the 7 May sample and were present in all subsequent samples through 10 December. The major density peak was observed on 6 August (99,250/m^3), with the peak period of abundance occurring from 30 July through 20 August. Two secondary peaks of abundance were detected on 10 September (45,325/m^3) and 24 September (49,475/m^3). As was observed in previous years, veliger presence throughout most of the monitoring program (except for April and May) suggests that substantial densities of veligers are in the water column for six or more months of the year. Any amount of veligers present in the water column is of concern due to small valves and piping which is critical to the safety and operation of the plant.

Heaviest spawning activity occurred during the late-July to early-October period. During the ten weeks from 30 July through 1 October, mean veliger densities were approximately 47,190/m^3, which is about five times less than the peak five week period in 1997 (which occurred between mid-August and mid-September), and two times less than the seven week period in 1996 (which occurred between mid-September and the end of October). Mean whole-water densities in 1998 were greater than those of 1995, but somewhat less than those recorded in 1993 and 1994.

FIGURE 3-1

WHOLE-WATER SAMPLING PROGRAM NUMBER OF ZEBRA MUSSEL VELIGERS PER CUBIC METER AND WATER TEMPERATURE COLLECTED IN THE D.C. COOK NUCLEAR PLANT INTAKE FOREBAY IN 1998



[a] No temperature data available when no circulating pumps are running.

TABLE 3-1

WHOLE-WATER SAMPLING PROGRAM NUMBER OF ZEBRA MUSSEL VELIGERS PER CUBIC METER AND VELIGER SIZE (μm) COLLECTED IN THE D.C. COOK NUCLEAR PLANT FOREBAY IN 1998

DATE	DENSITY (No./m^3)	SIZE RANGE (μm)	MEAN SIZE (μm)
4/23/98	0	-	-
5/07/98	75	200 - 260	230
5/21/98	100	100	100
6/04/98	8,075	90 - 280	110
6/11/98	2,750	100 - 320	118
6/18/98	475	90 - 230	132
6/25/98	3,850	90 - 260	117
7/02/98	7,175	90 - 180	118
7/09/98	5,350	100 - 260	178
7/16/98	15,225	100 - 260	166
7/23/98	21,150	100 - 300	176
7/30/98	64,075	90 - 260	137
8/06/98	99,250	100 - 260	184
8/13/98	40,925	100 - 300	210
8/20/98	33,225	100 - 260	182
8/27/98	26,125	100 - 260	137
9/03/98	42,900	100 - 360	177
9/10/98	45,325	100 - 300	193
9/17/98	26,475	100 - 300	169
9/24/98	49,475	100 - 230	162
10/01/98	44,125	100 - 330	175
10/08/98	16,575	100 - 280	157
10/15/98	14,000	130 - 260	163
10/22/98	11,300	90 - 330	148
10/29/98	800	100 - 260	137
11/19/98	13,625	130 - 280	123
11/29/98	6,600	100 - 230	124
12/10/98	1,625	100 - 180	126

In 1993, 1995, and 1996, peak veliger densities were recorded during mid-September to the end of October. However, as was observed in 1994, 1997, and 1998, exceptions can occur. It is thought that the June 1994 peak was more the result of unusually hot weather that occurred during the first two weeks of June rather than environmental differences between the early fall periods amongst the years of record. In 1997, the peak period of abundance occurred about a month earlier than is typical for this region. Based on water temperature data, the peak period would have been expected to continue through the end of September. However, densities were reduced by an order of magnitude during the last two weeks of September. This may have been the result of lower flows into the forebay caused by a reduction in the number of circulating water pumps operating during this period rather than a decrease in the numbers of veligers present in the water column in the vicinity of the intake in Lake Michigan (LMS 1998). In 1998, the peak period of veliger abundance also occurred several weeks prior to the more typical time frame that has been reported to occur from mid-September through October. Due to the extended outage that occurred at the plant throughout the entire 1998 sampling season, data comparisons between 1998 and previous studies should be viewed with caution.

Size data for the 1998 sampling season shows that translocators were not active in the forebay in 1998. Spawning commenced between 7 May and 4 June and continued through December as indicated by the lower portion of the size range data. Beginning with 7 May, the upper end of the size range exceeded the size of settlement (200-225μm) on every sampling date, except 21 May, 2 July and 10 December. However, mean size approached this settlement size range only on 7 May, 13 August and 10 September. Typically, mean sizes approach the settlement range only during October (as in 1996).

In summary, zebra mussel veligers were present in the water column on all sampling dates from 7 May through 10 December. Spawning commenced between 7 May and 4 June and continued through the end of the sampling program. Peak veliger densities occurred during the ten-week period extending from the end of July to the first of October. This is approximately two months earlier than has been observed at the Cook Plant during 1993, 1995, and 1996.

3.2 ARTIFICIAL SUBSTRATE SAMPLING

3.2.1 Circulating Water System

Artificial substrate monitoring was conducted at the center forebay location (which is protected by a deflector wall) from 7 May to 10 December. Periodic settlement rates for the circulating water system (forebay) are shown in Figure 3-2. Table 3-2 provides density and size information for settled postveligers.

Settlement in the forebay occurred on all periodic sampling dates in 1998 except 4 and 18 June. Density information presented in Table 3-2 indicates that settlement was low from 7 May through 9 July (53-213/m^2) and from 19 October through 10 December (107-533/m^2). Few translocators were observed on the substrates during the 7 May through 9 July sampling dates. First evidence of settlement of 1998 spawned zebra mussels was observed on 9 July. Heaviest settlement occurred between 23 July and 20 August with the peak (31,093-61,280/m^2) occurring on 23 July. This is about two months earlier than the typical peak period reported for the lower Great Lakes and is the second time since 1992 that the peak period began prior to September. Similar results were observed in 1997, when the peak period of settlement occurred from 21 August to 18 September. As was the case in 1994, 1995, and 1997, very little settlement occurred during the late November to mid-December period. Based on size data, the majority of individuals settling during this period were postveligers whose average size ranged from 245 to 292 μm.

Cumulative settlement was monitored using two six-inch long pieces of PVC (ID 2 in.) that were suspended from a rope at mid-depth in the forebay. Both pipes were set on 23 April and retrieved on 10 December. One pipe was exposed to Clam-Trol CT-2 treatment while the other was placed in water that was not exposed to the chemical. The objective was to compare post Clam-Trol settlement on the treated substrate to the untreated substrate at the conclusion of the sampling period. Information gathered during previous years suggests that a substantial portion of the annual settlement occurs within a short time following the Clam-Trol treatment.

FIGURE 3-2

THE NUMBER OF ZEBRA MUSSELS SETTLING ON PERIODIC SUBSTRATE SAMPLERS FROM THE D.C. COOK NUCLEAR PLANT FOREBAY IN 1998

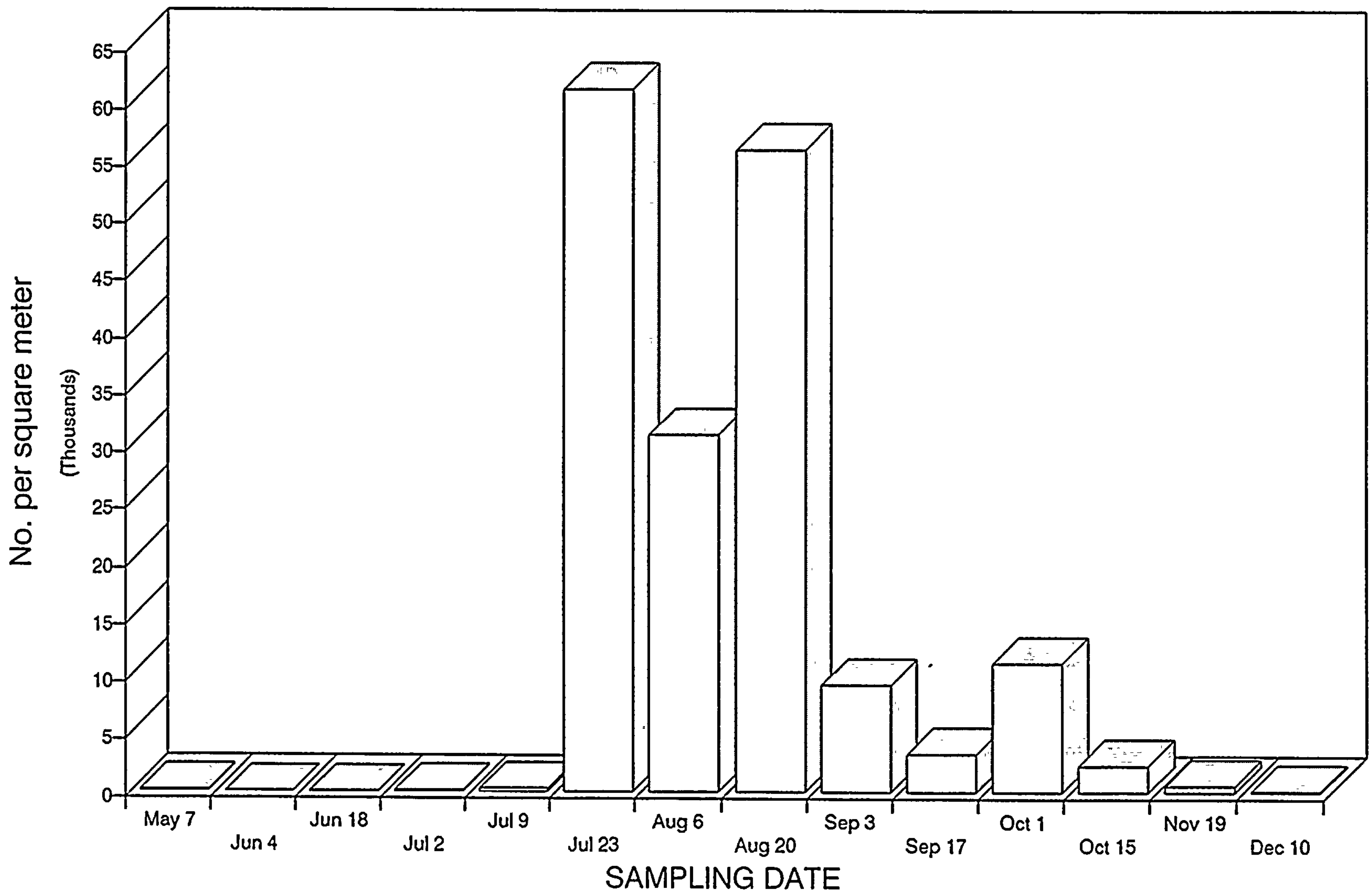


TABLE 3-2

DENSITY (No./m^2), AVERAGE SIZE (μm), AND SIZE RANGE (μm) OF SETTLED ZEBRA MUSSEL POSTVELIGERS COLLECTED ON PERIODIC ARTIFICIAL SUBSTRATES PLACED IN THE SERVICE WATER SYSTEMS (ESW R-1, ESW R-2, NESW) AND MISCELLANEOUS SEALING AND COOLING WATER SYSTEM IN THE D.C. COOK NUCLEAR PLANT IN 1998

	PERIODIC SAMPLES														
	FOREBAY			NESW[a]			MS&CW			ESW R-1			ESW R-2		
DATE	Density (No/.m^2)	Avg. Size (μm)	Range (μm)	Density (No./m^2)	Avg. Size (μm)	Range (μm)	Density (No./m^2)	Avg. Size (μm)	Range (μm)	Density (No./m^2)	Avg. Size (μm)	Range (μm)	Density (No./m^2)	Avg. Size (μm)	Range (μm)
5/07/98	107	645	630-660	0	-	-	107	265	230-300	107	710	660-760	107	210	190-230
6/04/98	0	-	-	0	-	-	640	215	180-260	320	337	130-630	0	-	-
6/18/98	0	-	-	0	-	-	53	330	330	53	130	130	0	-	-
7/02/98	53	560	560	0	-	-	213	145	130-160	160	167	160-180	160	250	130-460
7/09/98	213	263	160-430	107	115	100-130	960	130	100-230	160	157	120-180	213	125	100-160
7/23/98	61,280	278	200-400	533	309	230-400	747	240	100-430	3,200	243	200-300	4,320	247	180-330
8/06/98	31,093	266	200-330	0	-	-	7,573	191	100-360	3,787	196	100-300	5,173	186	100-300
8/20/98	56,053	198	100-300	1,066	203	100-300	12,693	198	100-300	6,613	205	100-260	5,280	217	160-300
9/03/98	9,280	241	100-400	800	183	130-230	2,293	195	130-330	2,080	199	100-360	1,150	189	100-260
9/17/98	3,253	256	100-430	747	199	100-330	1,227	202	130-300	8,587	240	160-330	6,080	232	100-360
10/01/98	11,200	282	200-560	1,813	253	100-380	907	204	100-360	1,813	231	100-400	1,920	259	100-400
10/15/98	2,293	281	200-630	907	351	160-630	427	234	100-300	960	302	130-530	2,133	275	180-660
11/19/98	533	292	200-430	480	267	130-360	373	203	180-260	267	252	200-330	320	330	230-430
12/10/98	107	245	230-260	0	-	-	0	-	-	176	230	130-300	213	430	160-760

[a] Minimal, inconsistent and sometimes nonexistant flow.

Density on the treated substrate was $90,675/m^2$. Individual sizes ranged from 300 to 8000 μm, and the mean size of 50 randomly selected individuals was 838 μm. Zebra mussel density data collected from the substrate that was not exposed to the treatment was $146,475/m^2$. The size of these individuals ranged from 100 to 11,000 μm and averaged 962 μm.

Review of these results indicate that resettlement occurred rapidly on the substrate exposed to Clam-Trol because the substrate was void of mussels when reset in the forebay. Therefore, settlement occurred rapidly on the "clean" surface to occupy available space. Similar results were noted in 1994 (LMS 1995). Divers in the forebay had also qualitatively observed this phenomenon in other years. Based on size data, it is reasonable to conclude that many of the mussels that settled between 29 August and 10 December were translocators. This indicates that a substantial number of zebra mussels of all sizes are available to colonize the "clean" surfaces of recently treated systems each fall. Although densities of veligers in the water column tend to decrease to low levels by the end of November, densities of translocators are sufficient to warrant continuing treatment until 1 December.

3.2.2 Service and Miscellaneous Sealing and Cooling Water Systems

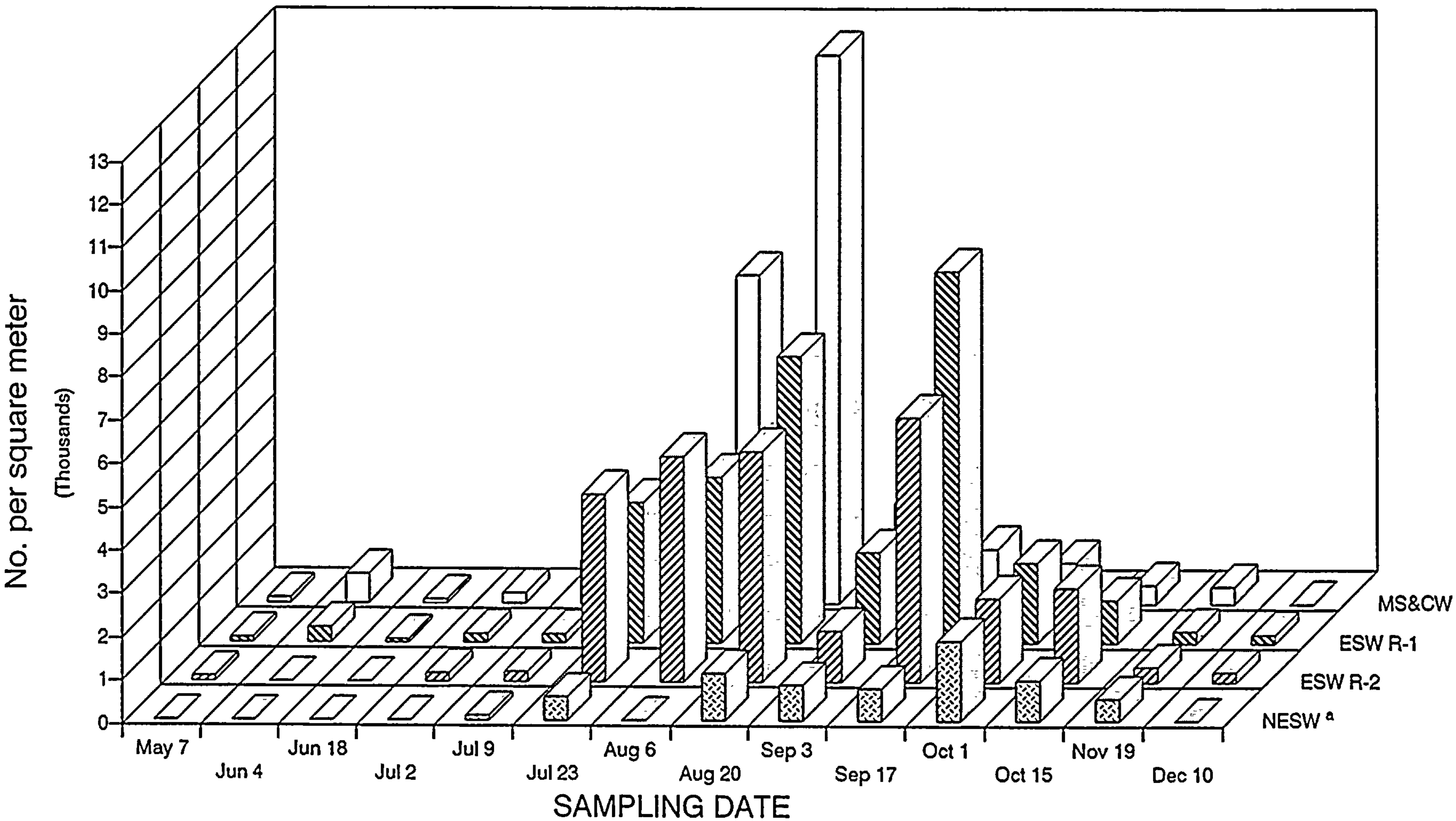
3.2.2.1 Service Water Systems

The return sides of the ESW and NESW systems were monitored during 1998. The ESW systems of both Units 1 and 2 were monitored throughout the sampling period, but only the Unit 1 NESW system was sampled. The ESW and NESW systems were programmatically scheduled for chlorination from mid-July to the end of November. Intermittent chlorination was initiated on 15 July and changed to continuous chlorination on 25 July. The delay in the start-up of chlorination in 1998 was due to the installation of the new "Pacesetter" chlorine injection system.

Periodic settlement densities for the service water systems are shown in Table 3-2 and Figure 3-3. Settlement densities were low in all four systems until 23 July. These low densities, coupled with the fact that the new "pacesetter" chlorination system was not yet operating,

FIGURE 3-3

ZEBRA MUSSEL POSTVELIGER DENSITIES PER SQUARE METER SETTLED ON PERIODIC ARTIFICIAL SUBSTRATES PLACED IN SERVICE WATER SYSTEMS (ESW R-1, ESW R-2, NESW) AND MISCELLANEOUS SEALING AND COOLING WATER SYSTEM IN THE D.C. COOK NUCLEAR PLANT IN 1998



[a] Minimal,inconsistent and sometimes nonexistant flow.

suggest that settlement rates during this period were very low. Similar results were noted in the intake forebay where large numbers of juvenile zebra mussels did not begin to settle until the 9-23 July period, when periodic settlement densities increased from 213 to 61,280/m^2. Periodic settlement of both essential service water systems also increased sharply during this same two-week period. This was somewhat surprising given the fact that intermittent chlorination began on 15 July. However, the total residual chlorine (TRC) measured at both the Unit 1 and Unit 2 ESW systems was below the targeted effective treatment range of 0.3-0.6 ppm (Appendix A). This condition persisted in the ESW system throughout the year. Larger sodium hypochlorite injection pumps for the ESW system were installed on 18 September to meet the target of 0.3-0.6 ppm TRC.

Peak periodic settlement densities at each sampling location occurred from 23 July to 15 October (Table 3-2 and Figure 3-3). During this time, settlement densities at ESW R-1 and ESW R-2 ranged from 960 to 8587/m^2 and 1920 to 6080/m^2, respectively. The average size of individuals collected at these locations was generally either above or near the threshold for settlement, suggesting that the chlorine treatment in these systems was effective at controlling prolonged settlement, particularly when the system was operating. Peak settlement in the NESW system also occurred during this same period of time, but at a much lower rate (0 to 1813/m^2). The lower densities of settled organisms in this system may be attributed to either more effective chlorine treatment (ppm TRC were consistently higher at this location) and/or the minimal or sometimes nonexistent flows to this monitor. Sampling densities were low at all service water sampling locations during the last two sampling dates.

Settlement densities in the NESW system remained low throughout the year. TRC levels in the NESW system were in the targeted range of 0.3-0.6 ppm TRC for the majority of the year. However, flow to the NESW biobox was also very erratic throughout the year, ranging from minimal to nonexistent. These inconsistent flows may have contributed to the low settlement densities observed at this location.

Mean sizes of postveligers at each of the service water sampling locations were generally at or above the threshold of settlement (200-225 μm) for the majority of the sampling period.

Figure 3-4 presents the comparison of periodic settlement densities with those of whole-water veligers for the sampling season. As expected, these data show that periods of increased settlement generally follow increases in whole-water densities by about one to two weeks. This is particularly evident during the mid-July to the end of August period.

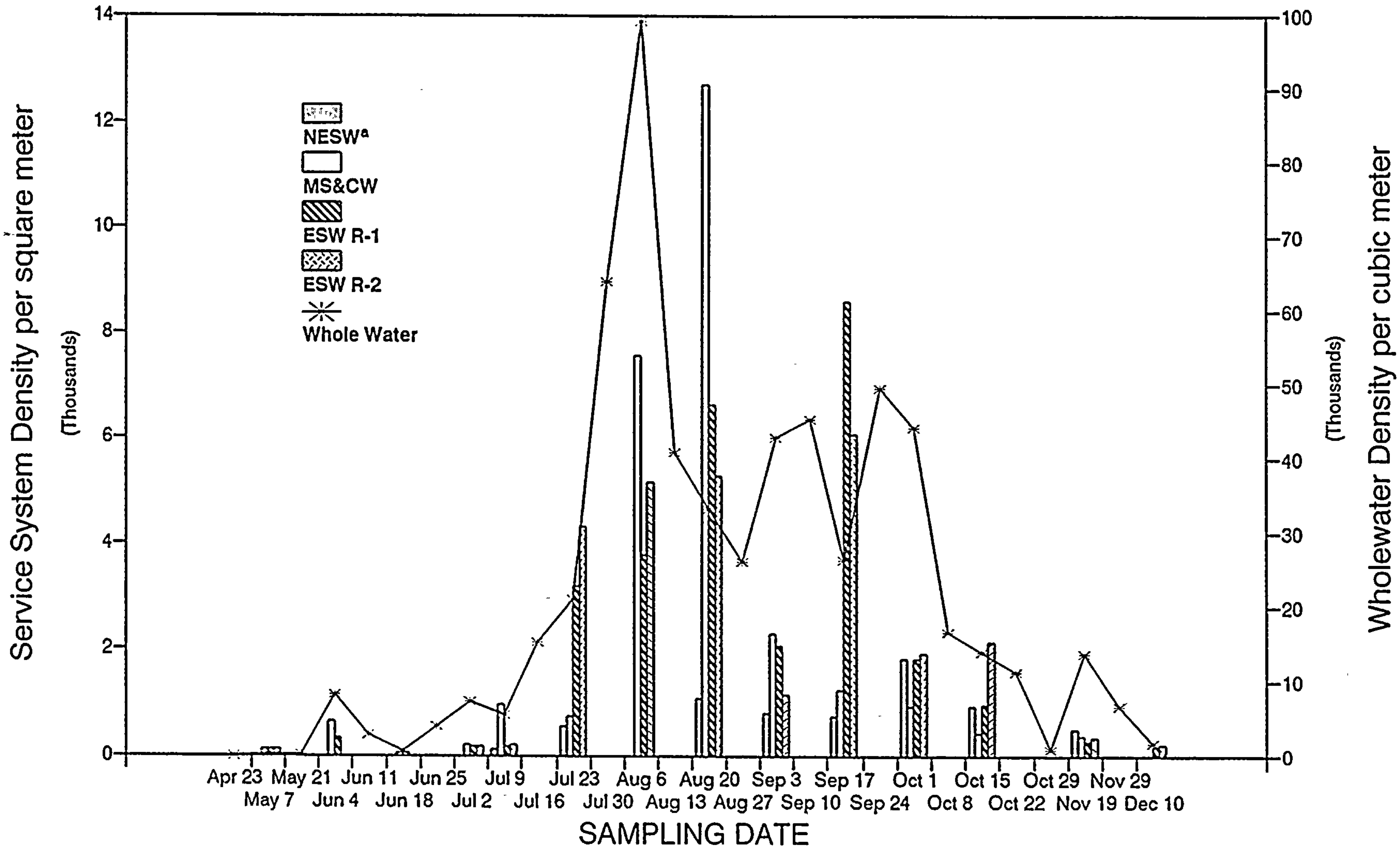
Chlorine was administered to the service water systems from 15 July to mid-November in 1998. The service water chlorination schedule and the total residual chlorine data were reported on a daily basis (Appendix Table 2). There were several occasions during the season when chlorine was not applied. For Unit 1 & 2 ESW systems, these include all sampling dates prior to 15 July, from 23 to 30 August, 19 September to 7 October, and 23 October to 1 November. The ESW and NESW chlorine injection systems were removed from service on 14 and 16 November, respectively.

The ESW systems are cross-tied downstream of the one chlorine injection point that serves both ESW systems. A separate chlorine injection location that serves the NESW system can also be cross connected to the MS&CW system. However, this was not connected in 1998. The 1998 data are consistent with the ESW cross ties and suggest that chlorine delivery may not have been adequate at the ESW injection point. The low residual chlorine values in the ESW system may have been due to either the injection pumps being too small or to sand build-up and plugging of the spargers located under the ESW pump bells. Larger pumps were installed on the ESW system on 18 September, yet TRC levels of less than 0.3-0.6 ppm were still frequently measured after the larger pumps were installed. There was a reluctance on the part of the Cook Plant staff to exceed NPDES Permit limits due to decreased lake water demand in the fall season, which helps to explain why the proposed levels were not achieved. Also, the Center Intake Gate Valve WMO-30 was closed during part of the year that created different flow characteristics in the intake forebay. This may have prevented the sodium hypochlorite from reaching the ESW pump suctions. Also, there was a reluctance to exceed NPDES chlorine discharge limits due to decreased circulating water demand in the fall of the season. Because settlement in the NESW system was similar to other years, postveliger settlement in this system may be related to the efficacy of chlorine during this portion of the

3-7A

FIGURE 3-4

WHOLE-WATER ZEBRA MUSSEL VELIGER DENSITY AND ZEBRA MUSSEL POSTVELIGER PERIODIC SETTLEMENT IN THE SERVICE WATER SYSTEMS IN THE D.C. COOK NUCLEAR PLANT IN 1998



[a]Minimal, inconsistent and sometimes nonexistant flow.

year (see discussion of temperature and pH effects on chlorine chemistry in 1996 annual report; LMS, 1997).

Inspection of the of the periodic sampling data indicates that settlement by translocators in the service water systems during May, June and July was minimal prior to the activation of the chlorination system. However, mean size data recorded for the ESW systems indicate that some settlement was occurring in these systems. The efficacy of the chlorine to prevent settlement of postveligers at settlement size is clearly demonstrated in the data presented for NESW. During periods of no chlorination, larger individuals settled on the substrates. It is these larger individuals that can cause operational problems. The mean sizes recorded for both ESW systems reflects settlement was not being prevented but seemed to provide a hostile enough environment to prohibit prolonged or permanent settlement.

Similar to 1996 and 1997, settlement of postveligers continued in all the systems through November and until mid-December in the ESW systems. Unlike 1996, densities in 1997 and 1998 were very low and declining through this period. This reflects the density of veligers in the intake water and the efficiency of the chlorine at cooler water temperatures and high pH. Figure 3-4 presents information showing whole-water veliger and periodic settlement densities for the sampling season. Whole-water densities began to decline during early October and generally continued to decline until the end of the program. This decline occurred during the period when peak densities are expected to occur. Water temperatures were conducive to spawning, particularly during the mid-September to early-October portion of the decline. This decline may have been at least partially attributable to only two circulating water pumps being in operation during the entire sampling season. This decrease in flow from Lake Michigan, resulting in fewer numbers of veligers being entrained into the plant, resulted in fewer veligers being present in the forebay. Whole-water densities recorded during the 1993 through 1995 programs for the November-December sampling periods were less than 1,000/m^3 for sampling conducted after 3 November. In 1998, whole-water densities recorded in November were similar to those of 1996 and 1997 and about five times greater than those of the 1993 through 1995 period, suggesting that spawning may have continued into the late fall period in 1998.

This was initially thought to be atypical in the vicinity of D.C. Cook Plant based on data from earlier years of monitoring. However, its occurrence during three consecutive years suggests that a change in either the *Dreissana* spp. populations or the Lake conditions may be underway and needs to be tracked.

Comparison of daily water temperatures recorded on the DMR's for the months of October, November, and December for 1993 through 1998 indicates that intake water temperatures in the first half of October 1998 were considerably cooler than each year except 1994. During the second half of the month, intake water temperatures were similar to previous years. November and December (first 15 days) mean intake water temperatures in 1998 were the warmest recorded during this period. As can be seen in the table below, December mean intake water temperatures recorded in 1998 were three to nine degrees warmer for this period than during 1993 through 1997.

Mean Intake Water Temperatures ºF

Year	Oct(1-15)	Oct(16-31)	Nov	Dec(1-15)
1993	59.8	56.7	49.0	44.6
1994	56.7	55.6	48.1	43.4
1995	60.1	55.1	45.8	38.8
1996	63.4	59.8	48.9	42.2
1997	63.4	54.1	46.3	39.1
1998	57.0	57.1	49.0	47.9

Mean intake water temperatures reflect lake conditions, which were less conducive to zebra mussel spawning during the first half of October in 1998 than they were in the 1995 through 1997 period. However, the data for the second half of October as well as November and the first half of December indicates that intake water temperatures in 1998 were warmer than normal and slightly more conducive to spawning compared to previous years. While some

spawning did occur during late fall, temperatures were not conducive for spawning near the end of the sampling period. These temperatures also suggest that chlorine was most likely not very effective during this same period [see discussion of the efficacy of chlorine at low water temperatures and high pH in 1996 annual report (LMS, 1997)].

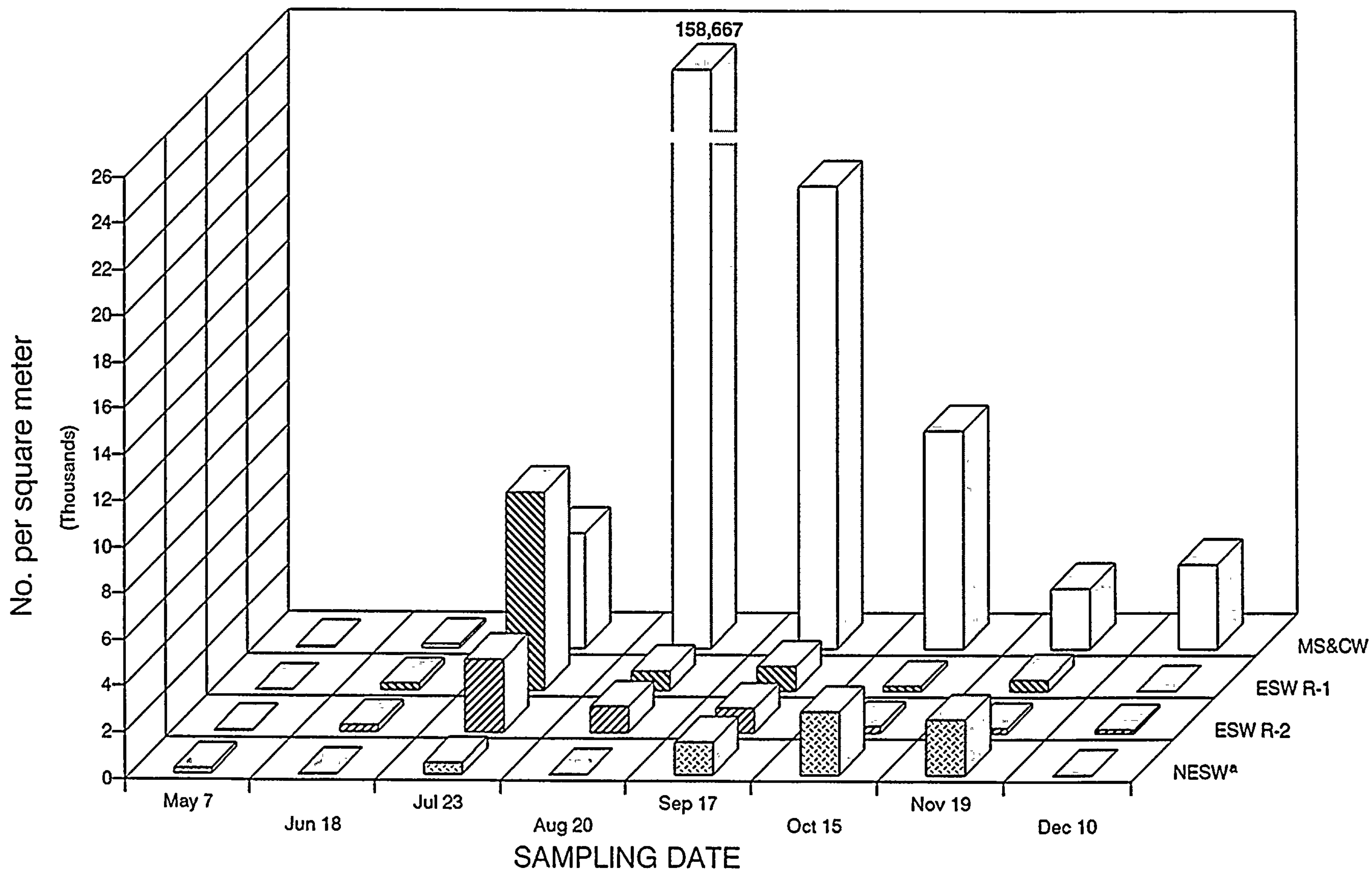
Cumulative data were collected from each of the service water systems for the purpose of determining the effectiveness of chlorination during the entire sampling season. These cumulative densities and associated size information are presented in Figure 3-5 and Table 3-3. Artificial substrates used for cumulative analyses were set on 23 April and sets of 10 slides were retrieved from each location at monthly intervals throughout the sampling season beginning on 7 May. Results were evaluated in conjunction with periodic data to better understand postveliger settlement in the systems. It should be remembered, however, that all of the data collected from the NESW system in 1998 is suspect because of the problems associated with maintaining consistent and adequate flow to this monitoring location.

Density data indicates that a few zebra mussels had settled on some of the artificial substrates as early as 7 May, which was prior to the initiation of chlorination. Size data on this date indicates that most of these individuals were translocators. At each location except the NESW system, settlement densities did increase to the 3,000 - 9,000/m^2 range by 23 July, reflecting the effects of increased spawning activity. Mean sizes of individuals at service water sampling locations were above the threshold for settlement on this date. On 20 August, densities decreased at all service water sampling locations.

Peak cumulative densities occurred on 23 July for both ESW systems (Unit 1 and Unit 2). Densities remained relatively high in both systems until 17 September (800 to 8,533/m^2) when densities fell below 500/m^2 for the remainder of the year (Table 3-3). Mean sizes on each of the sampling dates, except for 18 June at ESW R-2, were all above the settling threshold. As the season progressed, the mean sizes of the postveligers also generally increased slightly.

FIGURE 3-5

ARTIFICIAL SUBSTRATE SETTLEMENT-CUMULATIVE SERVICE WATER AND MISCELLANEOUS COOLING WATER SYSTEMS POSTVELIGER DENSITY PER SQUARE METER, D.C. COOK 1998



[a]Minimal, inconsistent and sometimes nonexistant flow.

TABLE 3-3

DENSITY (No./m²), AVERAGE SIZE (µm), AND SIZE RANGE (µm) OF SETTLED ZEBRA MUSSEL POSTVELIGERS COLLECTED ON CUMULATIVE ARTIFICIAL SUBSTRATES PLACED IN THE SERVICE WATER SYSTEMS (ESW R-1, ESW R-2, NESW) AND MISCELLANEOUS SEALING AND COOLING WATER SYSTEM IN THE D.C. COOK NUCLEAR PLANT IN 1998

	CUMULATIVE SAMPLES											
	NESW[a]			MS&CW			ESW R-1			ESW R-2		
DATE	Density (No./m²)	Avg. Size (µm)	Range (µm)	Density (No./m²)	Avg. Size (µm)	Range (µm)	Density (No./m²)	Avg. Size (µm)	Range (µm)	Density (No./m²)	Avg. Size (µm)	Range (µm)
5/07/98	160	243	230-270	53	230	230	0	-	-	53	900	900
6/18/98	0	-	-	107	705	260-1,150	213	650	130-2,150	213	178	120-260
7/23/98	427	236	160-300	4,960	311	200-1,290	8,533	227	100-330	3,147	228	130-330
8/20/98	0	-	-	158,667	264	160-360	800	209	100-260	1,066	203	100-300
9/17/98	1,387	185	130-230	19,947	236	130-330	1,013	228	200-260	1,013	229	130-500
10/15/98	2,667	302	160-500	9,333	242	100-430	160	230	180-280	213	215	200-230
11/19/98	2,347	285	200-430	2,560	263	130-760	427	356	200-600	160	250	160-330
12/10/98	0	-	-	3,627	243	160-360	0	-	-	107	415	200-630

3.2.2.2 Miscellaneous Sealing and Cooling Water System

A sidestream biobox monitor was placed on the MS&CW system which draws water from the circulating water system. Periodic settlement densities for the MS&CW system are shown in Table 3-2 and Figure 3-3. Settlement on the slides from the MS&CW system remained low until 6 August (7,573/m^2), which suggests that the incidental chlorine treatment of this system during mid-July was effective. Peak settlement in the MS&CW system occurred from 6 August to 1 October, when densities ranged from 907 to 12,693/m^2. Some variability may be explained by the incidental chlorination and the Clam-Trol treatment of the MS&CW system. A large portion of the individuals collected during this period was below the threshold size for settlement. Settlement densities on periodic substrates during the last two sampling dates (19 November and 10 December) were low.

Mean sizes of postveligers at the MS&CW system sampling location were generally at or above the threshold of settlement (200-225 μm) for the majority of the sampling period. Figure 3-4 presents the comparison of periodic settlement densities with those of whole-water veligers for the sampling season. As expected, these data show that periods of increased settlement generally follow increases in whole-water densities by about one to two weeks. This is particularly evident during the mid-July to the end of August period.

The MS&CW system was incidentally chlorinated via the circulating water system on an irregular basis for 90-160 minutes per day during 15-17 July, 20-21 July, 23 July, 22-23 August, 18-21 November, 23-28 November, and 3 December.

Cumulative settlement monitoring was conducted at the MS&CW system sampling location. These cumulative densities and associated size information are presented in Figure 3-5 and Table 3-3. Artificial substrates used for cumulative analyses were set on 23 April and sets of 10 slides were retrieved from each location at monthly intervals throughout the sampling season beginning on 7 May. Results were evaluated in conjunction with periodic data to better understand postveliger settlement in the systems.

Density data indicates that a few zebra mussels had settled on some of the artificial substrates as early as 7 May, which was prior to the initiation of chlorination. Size data on this date indicates that most of these individuals were translocators. Settlement densities did increase through 23 July, reflecting the effects of increased spawning activity. Mean sizes of individuals were above the threshold for settlement on this date. On 20 August, densities exhibited a dramatic increase in the MS&CW system reaching its peak density for the season (158,667/m^2). The MS&CW system was not incidentally chlorinated from 23 July through 21 August, which accounts for the dramatic increase in settlement densities. The system did not receive any chlorine until August 22 and August 23, two and three days after the peak densities occurred. Settlement densities dropped substantially in the MS&CW system during the remainder of the year following the intermittent chlorine treatments on August 22-23 and the Clam-Trol treatment of August 28-29, suggesting that these treatments were most likely effective.

In summary, density and size data collected in 1998 at the service water systems and miscellaneous sealing and cooling water system sampling locations indicate that zebra mussel settlement was very low during May and June and that a portion of these individuals were translocators. Translocators were sporadically present throughout the season at each of the sampling locations. The minimum of the size ranges continued to be less than the settleable size range through December. This is consistent with the whole-water data which indicates that spawning continued at low rates through December. Similar results were observed in 1996, when spawning also continued beyond the end of the sampling program. The continued growth of settled postveligers during the late fall of 1998 indicates that chlorination was not very effective during this period. This observation was also made in 1996 and 1997.

3.2.3 Fire Protection System

Two fire hydrants (Nos. 11 and 27) were flushed during October to determine the presence of mollusks and other biological contaminants. Flush water was filtered though the plankton net described in Chapter 2 and eight 1-ml samples from each flush were analyzed under a binocular microscope. Samples were drawn from hydrant No. 27 on 16 and 22 October and

from hydrant No. 11 on 16 October. In addition, TRC and dissolved oxygen concentrations were determined for each sample.

Hydrant No. 27 samples contained several live nematodes and two live gastrotrichs, all of which were between 200 and 300 microns in size. These samples also contained numerous dead rotifers, nematodes, and daphnia. The sample from hydrant No. 11 contained one dead zebra mussel veliger and one dead zebra mussel fragment. These ranged in size from 200 to 260 microns.

TRC values were low in all samples ranging from 0.04 to 0.06 mg/l while dissolved oxygen concentrations were in the range of 6.5 to 7.0 mg/l. This combination permits these small organisms to remain viable in the system. These small organisms do not present a serious threat to the systems due to their low numbers and small sizes.

CHAPTER 4

SUMMARY AND RECOMMENDATIONS

4.1 SUMMARY

The 1998 zebra mussel sampling program was initiated on 23 April and continued to 10 December. The major spawning peak occurred during the first week of August, with the peak spawning period occurring between 30 July and 20 August. Two secondary spawning peaks occurred during 10 and 24 September. The magnitude of the peak was about one-fifth that of 1997, one-half that of 1996, but greater than the 1995 peak, which was atypically low.

Peak postveliger settlement in the forebay occurred on periodic substrates during 23 July to 20 August, which generally coincided with peak whole-water densities. A secondary peak in settlement was observed on 1 October. The spawning and settlement peaks observed in 1998 occurred approximately two months earlier than typical fall spawning and settlement peaks for the lower Great Lakes. Cumulative settlement observations that included reinfestation following Clam-Trol treatment indicated that rapid settlement occurred after the treatment. Cumulative samples were collected at the end of the season. Mean density observed on the treated substrates was 90,675/m^2 with sizes of shells ranging from 300 to 8,000 μm. Mean density on the untreated substrates was 146,475/m^2 with size ranging from 100 to 11,000 μm.

Periods of heaviest periodic settlement occurred during the mid-July to mid-October period in all plant systems monitored. This corresponded to peak periods of spawning as measured in the whole-water samples. Based on size data of zebra mussels collected in 1998, chlorination treatments were only partially effective at preventing settlement. However, they appear to have prevented prolonged settlement or colonization in the system.

Cumulative settlement in the service water and Miscellaneous Sealing and Cooling Water systems occurred from May through the remainder of the sampling season. With the exception of NESW, peak densities were observed between 23 July and 17 September. Peak densities in the NESW system occurred between 17 September and 19 November. Size data show that a few translocators

settled on the slides before chlorination was initiated for the season and that recently settled postveligers dominated the collections during most of the year. With the exception on the NESW system, cumulative densities in the remaining systems generally declined as the season progressed. Density and size data indicate that the chlorine treatments prevented prolonged settlement of zebra mussels in these systems.

4.2 RECOMMENDATIONS

Based on observations made during the course of this program, LMS is making several recommendations:

- Whole-water sampling should continue to be initiated in April to determine the presence of veligers in the water column.

- Studies of cumulative postveliger settlement should continue to be conducted from May through December. Inspection of the substrates should include attempting to move the postveligers with a probe to determine whether they are still mobile or have begun to lay down byssal threats for permanent attachment.

- The chlorination system should be maintained to ensure appropriate intermittent or continuous delivery of chlorine to control postveliger settlement (1 May-30 November).

- Based on settlement data from the early part of the program (May-June), chlorine should be delivered to the service water systems beginning 1 May. This should reduce/eliminate the translocators from establishing residency in the critical service water systems.

- Daily chlorination and temperature data should continue to be made available to allow meaningful interpretation of results.

REFERENCES

Lawler, Matusky, & Skelly Engineers LLP. 1995. Mollusc biofouling monitoring during 1994, Donald C. Cook Nuclear Plant: Final Report. 33 pp.

Lawler, Matusky, & Skelly Engineers LLP. 1997. Mollusc biofouling monitoring during 1996, Donald C. Cook Nuclear Plant: Final Report. 33 pp.

Great Lakes Environmental Center. 1996. A zebra mussel (*Dreissena*) monitoring survey for the Donald C. Cook Nuclear Plant. Final Report. 37 pp.

APPENDIX A

TABLE 1

1998 CIRCULATING WATER CHLORINATION DATA
(End of Pipe Average TRC)

DATE	Unit One		Unit Two	
	# Minutes of Chlorination	Average TRC (ppb)	# Minutes of Chlorination	Average TRC (ppb)
07/15/98	145	70		
07/16/98	150	50		
07/17/98	160	3		
07/20/98	150	120		
07/21/98	150	145		
07/23/98	150	140		
08/22/98	155	3	155	23
08/23/98	155	150	155	140
11/18/98	150	45	150	67
11/19/98	150	<1	150	70
11/20/98	150	37	150	40
11/21/98	150	8	150	4
11/23/98	150	23	150	27
11/24/98	150	<1	150	<1
11/25/98	150	17	150	20
11/26/98	150	20	150	23
11/27/98	150	17	150	17
11/28/98	150	<1	150	<1
12/3/98	90	<1		

TABLE 2

JULY CHLORINATION - UNIT 1

Intermittent chlorination was initiated on 7/15/98.

Continuous chlorination was initiated on 7/25/98.

Date	End of Pipe Average TRC ESW ppm	NESW ppm
7/15/98	ND	ND
7/16/98	ND	ND
7/17/98	ND	ND
7/18/98	0.08	0.24
7/19/98	ND	ND
7/20/98	0.06	0.88
7/21/98	ND	ND
7/22/98	0.29	0.94
7/23/98	ND	ND
7/24/98	0.33	0.76
7/25/98	0.44	0.80
7/26/98	0.24	0.61
7/27/98	0.21	0.71
7/28/98	0.17	0.63
7/29/98	0.11	0.66
7/30/98	0.12	0.53
7/31/98	0.17	0.58

Comments: 1) ND - No Data

TABLE 2 (Continued)

JULY CHLORINATION - UNIT 2

Date	End of Pipe Average TRC ESW ppm	NESW ppm
	Intermittent chlorination was initiated on 7/15/98.	
	Continuous chlorination was initiated on 7/25/98.	
7/15/98	ND	ND
7/16/98	ND	ND
7/17/98	ND	ND
7/18/98	0.08	0.18
7/19/98	ND	ND
7/20/98	0.07	0.38
7/21/98	ND	ND
7/22/98	0.29	0.39
7/23/98	ND	ND
7/24/98	0.31	0.35
7/25/98	0.39	0.58
7/26/98	0.24	0.42
7/27/98	0.22	0.51
7/28/98	0.19	0.11
7/29/98	0.11	0.48
7/30/98	0.12	0.30
7/31/98	0.17	0.57

Comments: 1) ND - No Data

TABLE 2 (Continued)

AUGUST CHLORINATION - UNIT 1

Date	End of Pipe Average TRC ESW ppm	NESW ppm
8/1/98	0.22	0.62
8/2/98	0.17	0.58
8/3/98	0.25	0.62
8/4/98	0.19	0.51
8/5/98	0.27	0.58
8/6/98	0.32	0.58
8/7/98	0.29	0.60
8/8/98	0.30	0.53
8/9/98	0.23	0.59
8/10/98	0.15	0.54
8/11/98	0.25	0.64
8/12/98	0.23	0.40
8/13/98	0.42	0.71
8/14/98	0.36	0.57
8/15/98	0.34	0.64
8/16/98	0.32	0.55
8/17/98	0.30	0.45
8/18/98	0.37	0.86
8/19/98	0.30	0.65
8/20/98	ND	ND
8/21/98	ND	ND
8/22/98	ND	ND
8/23/98	-	-
8/24/98	-	-
8/25/98	-	-
8/26/98	-	-
8/27/98	-	-
8/28/98	-	-
8/29/98	-	-
8/30/98	-	-
8/31/98	ND	ND

Comments: 1) ND - No Data
2) - No chlorination

TABLE 2 (Continued)

AUGUST CHLORINATION - UNIT 2

Date	End of Pipe Average TRC ESW ppm	 NESW ppm
8/1/98	0.21	0.72
8/2/98	0.18	0.59
8/3/98	0.23	0.20
8/4/98	0.18	0.27
8/5/98	0.28	0.27
8/6/98	0.30	0.56
8/7/98	0.25	0.24
8/8/98	0.27	0.54
8/9/98	0.23	ND
8/10/98	0.15	0.17
8/11/98	0.24	0.58
8/12/98	0.21	0.44
8/13/98	0.41	0.69
8/14/98	0.33	0.54
8/15/98	0.34	0.15
8/16/98	0.31	0.26
8/17/98	0.32	0.52
8/18/98	0.36	0.47
8/19/98	0.30	0.60
8/20/98	ND	ND
8/21/98	ND	ND
8/22/98	ND	ND
8/23/98	-	-
8/24/98	-	-
8/25/98	-	-
8/26/98	-	-
8/27/98	-	-
8/28/98	-	-
8/29/98	-	-
8/30/98	-	-
8/31/98	ND	ND

Comments: 1) ND - No Data
2) - No chlorination

TABLE 2 (Continued)

SEPTEMBER CHLORINATION - UNIT 1

Date	End of Pipe Average TRC ESW ppm	NESW ppm
9/1/98	0.14	1.74
9/2/98	ND	ND
9/3/98	ND	ND
9/4/98	0.03	1.09
9/5/98	0.05	0.15
9/6/98	0.02	0.15
9/7/98	0.02	0.18
9/8/98	0.06	0.23
9/9/98	0.26	0.19
9/10/98	0.19	0.21
9/11/98	0.03	0.11
9/12/98	0.24	ND
9/13/98	ND	ND
9/14/98	0.25	0.57
9/15/98	0.09	0.55
9/16/98	0.09	0.45
9/17/98	0.02	0.51
9/18/98	ND	0.79
9/19/98	-	-
9/20/98	-	-
9/21/98	-	-
9/22/98	-	-
9/23/98	-	-
9/24/98	-	-
9/25/98	-	-
9/26/98	-	-
9/27/98	-	-
9/28/98	-	-
9/29/98	-	-
9/30/98	-	-

Comments: 1) ND - No Data
2) - No chlorination

TABLE 2 (Continued)

SEPTEMBER CHLORINATION - UNIT 2

Date	End of Pipe Average TRC ESW ppm	NESW ppm
9/1/98	0.08	1.08
9/2/98	ND	ND
9/3/98	ND	ND
9/4/98	0.03	0.33
9/5/98	0.05	0.43
9/6/98	0.02	0.51
9/7/98	0.02	0.55
9/8/98	0.07	0.41
9/9/98	0.20	ND
9/10/98	0.13	ND
9/11/98	0.03	0.30
9/12/98	0.24	ND
9/13/98	ND	ND
9/14/98	0.25	ND
9/15/98	0.09	0.67
9/16/98	0.09	0.81
9/17/98	0.02	0.54
9/18/98	ND	0.85
9/19/98	-	-
9/20/98	-	-
9/21/98	-	-
9/22/98	-	-
9/23/98	-	-
9/24/98	-	-
9/25/98	-	-
9/26/98	-	-
9/27/98	-	-
9/28/98	-	-
9/29/98	-	-
9/30/98	-	-

Comments: 1) ND - No Data
2) - No chlorination

TABLE 2 (Continued)

OCTOBER CHLORINATION - UNIT 1

Date	End of Pipe Average TRC ESW ppm	NESW ppm
10/1/98	-	-
10/2/98	-	-
10/3/98	-	-
10/4/98	-	-
10/5/98	-	-
10/6/98	-	-
10/7/98	0.28	1.72
10/8/98	ND	ND
10/9/98	0.31	ND
10/10/98	0.16	ND
10/11/98	0.25	0.17
10/12/98	0.17	0.18
10/13/98	0.19	ND
10/14/98	0.25	0.06
10/15/98	0.29	0.16
10/16/98	0.20	0.41
10/17/98	0.22	ND
10/18/98	0.31	ND
10/19/98	0.39	0.36
10/20/98	0.11	0.31
10/21/98	0.53	0.34
10/22/98	0.22	0.11
10/23/98	-	-
10/24/98	-	-
10/25/98	-	-
10/26/98	-	-
10/27/98	-	-
10/28/98	-	-
10/29/98	-	-
10/30/98	-	-
10/31/98	-	-

Comments: 1) - No chlorination
2) ND - No Data

TALBE 2 (Continued)

OCTOBER CHLORINATION - UNIT 2

Date	End of Pipe Average TRC ESW ppm	NESW ppm
10/1/98	-	-
10/2/98	-	-
10/3/98	-	-
10/4/98	-	-
10/5/98	-	-
10/6/98	-	-
10/7/98	0.29	0.57
10/8/98	ND	ND
10/9/98	0.54	0.26
10/10/98	0.16	0.25
10/11/98	0.17	0.23
10/12/98	0.17	0.26
10/13/98	0.21	0.12
10/14/98	0.28	0.16
10/15/98	0.39	ND
10/16/98	0.22	0.23
10/17/98	0.13	0.29
10/18/98	0.16	0.25
10/19/98	0.19	0.33
10/20/98	0.25	ND
10/21/98	0.21	ND
10/22/98	0.12	0.06
10/23/98	-	-
10/24/98	-	-
10/25/98	-	-
10/26/98	-	-
10/27/98	-	-
10/28/98	-	-
10/29/98	-	-
10/30/98	-	-
10/31/98	-	-

Comments: 1) - No chlorination
2) ND - No Data

TABLE 2 (Continued)

NOVEMBER CHLORINATION - UNIT 1

Date	End of Pipe Average TRC ESW ppm	NESW ppm
11/1/98	-	-
11/2/98	0.11	ND
11/3/98	0.30	0.28
11/4/98	0.10	0.15
11/5/98	0.08	0.12
11/6/98	ND	ND
11/7/98	0.17	0.20
11/8/98	0.21	0.22
11/9/98	0.59	0.47
11/10/98	0.48	0.56
11/11/98	0.42	0.49
11/12/98	0.32	0.46
11/13/98	0.43	0.36
11/14/98[a]	0.54	0.41
11/15/98	0.03	0.38
11/16/98[b]	0.06	0.30
11/17/98	0.02	0.18
11/18/98	0.04	0.15
11/19/98	0.06	0.13
11/20/98	0.03	0.08
11/21/98	0.02	0.02
11/22/98	ND	ND
11/23/98	0.02	0.02
11/24/98	-	-
11/25/98	-	-
11/26/98	-	-
11/27/98	-	-
11/28/98	-	-
11/29/98	-	-
11/30/98	-	-

Comments:
1) - No chlorination
2) ND - No Data
[a] Diluting, flushing and decommissioning commenced on ESW.
[b] Diluting, flushing and decommissioning commenced on NESW.

TABLE 2 (Continued)

NOVEMBER CHLORINATION - UNIT 2

Date	End of Pipe Average TRC ESW ppm	NESW ppm
11/1/98	-	-
11/2/98	0.11	ND
11/3/98	0.36	0.20
11/4/98	0.11	0.17
11/5/98	0.09	ND
11/6/98	ND	ND
11/7/98	0.09	0.16
11/8/98	0.09	0.17
11/9/98	0.55	0.98
11/10/98	0.41	0.45
11/11/98	0.38	0.47
11/12/98	0.14	0.36
11/13/98	0.40	0.12
11/14/98[a]	0.58	0.35
11/15/98	0.04	0.41
11/16/98[b]	0.04	0.34
11/17/98	0.02	0.19
11/18/98	0.04	0.09
11/19/98	0.07	0.13
11/20/98	0.03	0.07
11/21/98	0.02	0.03
11/22/98	ND	ND
11/23/98	0.02	0.05
11/24/98	-	-
11/25/98	-	-
11/26/98	-	-
11/27/98	-	-
11/28/98	-	-
11/29/98	-	-
11/30/98	-	-

Comments:

1) - No chlorination
2) ND - No Data

[a] Diluting, flushing and decommissioning commenced on ESW.
[b] Diluting, flushing and decommissioning commenced on NESW.

APPENDIX V

SPECIAL REPORTS:

1998

There were no special reports in 1998.

APPENDIX VI

ANNUAL REPORT:

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

1998

DONALD C. COOK NUCLEAR PLANT

UNITS 1 & 2

OPERATIONAL
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

1998 ANNUAL REPORT

JANUARY 1 to DECEMBER 31, 1998

Prepared by

Indiana Michigan Power Company
and
Teledyne Brown Engineering

April 15, 1999

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont)

APPENDICES

TABLE OF CONTENTS (Cont)

LIST OF FIGURES

LIST OF TRENDING GRAPHS

LIST OF TABLES

SUMMARY

INDIANA MICHIGAN POWER COMPANY

DONALD C. COOK POWER NUCLEAR PLANT

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

SUMMARY

This report summarizes the collection and analysis of various environmental sample media in 1998 for the Radiological Environmental Monitoring Program for the Donald C. Cook Nuclear Plant.

The various analyses of most sample media suggest that there was no discernible impact of the Donald C. Cook Nuclear Plant on the environment. The analysis of air particulate filters, charcoal cartridges, direct radiation by thermoluminescent dosimeters, fish, water, milk and sediments from Lake Michigan, drinking water, and food products, either did not detect any radioactivity or measured only naturally occurring radionuclides at normal background levels.

Tritium, measured at low levels in on-site wells, appears to be the only radionuclide attributable to the plant operations. However, the associated groundwater does not provide a direct dose pathway to humans.

I. INTRODUCTION

I. INTRODUCTION

The Donald C. Cook Nuclear Plant's Radiological Environmental Monitoring Program (REMP) is conducted in compliance with NRC Regulatory Guide 1.21 and 4.1, licensing commitments, and Technical Specifications. The REMP was developed in accordance with the NRC Radiological Assessment Branch Technical Position (BTP), Rev. 1, November 1979. A synopsis of the sampling program and maps can be found in Section II, Sampling and Analysis Program. This report represents the Annual Radiological Environmental Operating Report for Units 1 and 2 of the Donald C. Cook Nuclear Plant for the operating period from January 1, 1998 through December 31, 1998.

A. The Donald C. Cook Nuclear Plant of American Electric Power Company is located on the southeastern shore of Lake Michigan approximately one mile northwest of Bridgman, Michigan. The plant consists of two pressurized water reactors, Unit 1, 1030 MWE and Unit 2, 1100 MWE. Unit 1 achieved initial criticality on January 18, 1975 and Unit 2 achieved initial criticality on March 10, 1978.

B. Objectives

The objectives of the operational radiological environmental monitoring program are:

1. Identify and measure radiation and radioactivity in the plant environs for the calculation of potential dose to the population.
2. Verify the effectiveness of in-plant measures used for controlling the release of radioactive materials.
3. Provide reasonable assurance that the predicted doses, based on effluent data, have not been substantially underestimated and are consistent with applicable standards.
4. Comply with regulatory requirements and Station Technical Specifications and provide records to document compliance.

During 1998 no changes were made to the Offsite Dose Calculation Manual (ODCM)

II. SAMPLING AND ANALYSIS PROGRAM

II. SAMPLING AND ANALYSIS PROGRAM

Table 1 summarizes the sampling and analysis program for the Donald C. Cook Nuclear Plant for 1998. For each sample medium, the table lists the sample locations, including distance and direction from the center of the two units, and the station identification. The station identifications for the sampling locations are shown on Figures 1 and 2. Also for each sample medium the sample collection frequency, type of analysis, and frequency of analysis are listed.

TABL C

DONALD C. COOK NUCLEAR PLANT- 1998

RADIOLOGICAL SAMPLING STATIONS

DISTANCE AND DIRECTION FROM PLANT AXIS

Location	Station	Distance	Direction	Degrees	Collection Frequency	Analysis/Frequency
Environmental (TLD's)						
ONS-1	(T-01)	1945 ft.		18°	Quarterly	Direct Radiation/Quarterly
ONS-2	(T-02)	2338 ft.		48°		
ONS-3	(T-03)	2407 ft.		90°		
ONS-4	(T-04)	1852 ft.		118°		
ONS-5	(T-05)	1895 ft.		189°		
ONS-6	(T-06)	1917 ft.		210°		
	(T-07)	2103 ft.		36°		
	(T-08)	2208 ft.		82°		
	(T-09)	1368 ft.		149°		
	(T-10)	1390 ft.		127°		
	(T-11)	1969 ft.		11°		
	(T-12)	2292 ft.		63°		
New Buffalo	(NBF)	15.6 mi	SSW			
South Bend	(SBN)	26.2 mi	SE			
Dowagiac	(DOW)	24.3 mi	ENE			
Coloma	(COL)	18.9 mi	NNE			
Intersection of Red Arrow Hwy. & Marquette Woods Rd, Pole #B294-44	(OFT-1)	4.5 mi	NE			
Stevensville Substation	(OFT-2)	3.6 mi	NE			
Pole #B296-13	(OFT-3)	5.1 mi	NE			
Pole #B350-72	(OFT-4)	4.1 mi	E			
Intersection of Shawnee & Cleveland, Pole #B387-32	(OFT-5)	4.2 mi	ESE			
Snow Rd., East of Holden Rd., #B426-1	(OFT-6)	4.9 mi	SE			
Bridgman Substation	(OFT-7)	2.5 mi	S			
California Rd., Pole #B424-20	(OFT-8)	4.0 mi	S			
Ruggles Rd., Pole B369-214	(OFT-9)	4.4 mi	ESE			
Intersection of Red Arrow Hwy., & Hildebrant Rd.,Pole #B422-152	(OFT-10)	3.8 mi	S			
Intersection of Snow Rd. & Baldwin Rd.; Pole #B423-12	(OFT -11)	3.8 mi	S			

TABLE 1 (Cont.)

DONALD C. COOK NUCLEAR PLANT- 1998

RADIOLOGICAL SAMPLING STATIONS

DISTANCE AND DIRECTION FROM PLANT AXIS

Location	Station	Distance	Direction	Degrees	Collection Frequency	Analysis/Frequency
Air Charcoal/Particulates						
ONS-1	(A-1)	1945 ft.		18°	Weekly	Gross Beta/Weekly
ONS-2	(A-2)	2338 ft.		48°		I-131/Weekly
ONS-3	(A-3)	2407 ft.		90°		Gamma Isotopic/
ONS-4	(A-4)	1852 ft.		118°		Quarterly Composite
ONS-5	(A-5)	1895 ft.		189°		
ONS-6	(A-6)	1917 ft.		210°		
New Buffalo	(NBF)	15.6 mi	SSW			
South Bend	(SBN)	26.2 mi	SE			
Dowagiac	(DOW)	24.3 mi	ENE			
Coloma	(COL)	18.9 mi	NNE			
Groundwater						
Onsite	(W-1)	1969 ft.		11°	Quarterly	Gamma Isotopic/Quarterly
Onsite	(W-2)	2292 ft.		63°		Tritium/Quarterly
Onsite	(W-3)	3279 ft.		107°		
Onsite	(W-4)	418 ft.		301°		
Onsite	(W-5)	404 ft.		290°		
Onsite	(W-6)	424 ft.		273°		
Onsite	(W-7)	1895 ft.		189°		
Onsite	(W-8)	1279 ft.		53°		
Onsite	(W-9)	1447 ft.		22°		
Onsite	(W-10)	4216 ft.		129°		
Onsite	(W-11)	3206 ft.		153°		
Onsite	(W-12)	2631 ft.		162°		
Onsite	(W-13)	2152 ft.		182°		
Onsite	(W-14)	1780 ft.		164°		
Steam Generator Groundwater						
Steam Generator Storage Facility	(SG-1)	0.8 mi		95°	Quarterly	Gross Beta/Quarterly
Steam Generator Storage Facility	(SG-2)	0.7 mi		92°		Gross Alpha/Quarterly
Steam Generator Storage Facility	(SG-4)	0.7 mi		93°		Gamma Isotopic/Quarterly
Steam Generator Storage Facility	(SG-5)	0.7 mi		92°		

TABLE 1 (

DONALD C. COOK NUCLEAR PLANT- 1998

RADIOLOGICAL SAMPLING STATIONS

DISTANCE AND DIRECTION FROM PLANT AXIS

Location	Station	Distance	Direction	Degrees	Collection Frequency	Analysis/Frequency
Drinking Water						
St. Joseph Public Intake	(STJ)	9.0 mi	NE		Daily	Gross Beta/14 Day Composite Gamma Isotopic/14 Day Composite I-131/14 Day Composite
Lake Township Public Intake Station	(LTW)	0.4 mi	S			Tritium/Quarterly Composite
Surface Water						
Condenser Circulating Water Intake	SWL-1	Intake			Daily	Gamma Isotopic/Monthly
Lake Michigan Shoreline	SWL-2	500 ft.	S			Composite
Lake Michigan Shoreline	SWL-3	500 ft.	N			Tritium/Quarterly Composite
Sediment						
Lake Michigan Shoreline	SL-2	500 ft.	S			
Lake Michigan Shoreline	SL-3	500 ft.	N		Semi-annually	Gamma Isotopic/Semi-Annually
Milk-Indicator (a)						
						I-131/Sample
Milk-Background (a)						
Broadleaf Vegetation (a)						
3 Indicator Samples 1 Control Sample	Within 8 miles of plant 15-25 miles distant		Highest D/Q Land Sector Less prevalent wind direction		Monthly when available	Gamma Isotopic/Monthly I-131/Monthly

(a) No milk samples were obtained in 1998 as 2 of 3 indicator farms dropped from program at the end of 1995 and no replacements have been found. Broadleaf vegetation samples were obtained in lieu of milk in 1998.

TABLE 1 (Cont.)

DONALD C. COOK NUCLEAR PLANT- 1998

RADIOLOGICAL SAMPLING STATIONS

DISTANCE AND DIRECTION FROM PLANT AXIS

Location	Station	Distance	Direction	Degrees	Collection Frequency	Analysis/Frequency
Fish						
Lake Michigan	ONS-N	0.3 mi	N		2/year	Gamma Isotopic/
Lake Michigan	ONS-S	0.4 mi	S			2 per year
Lake Michigan	OFS-N	3.5mi	N			
Lake Michigan	OFS-S	5.0 mi	S			
Grapes/Broadleaf						
Nearest sample to Plant in highest D/Q land sector containing media.			Sector D		At time of harvest	Gamma Isotopic at time of harvest.
Grapes						
In a land sector containing grapes approximately 20 miles from the Plant in one of the less prevalent D/Q land sectors.			Sector K		At time of harvest	Gamma Isotopic at time of harvest.

* Composite samples of Drinking and Surface water shall be collected at least daily.

* Particulate sample filters should be analyzed for gross beta activity 24 or more hours following filter removal. This will allow for radon and thoron daughter decay. If gross beta activity in air or water is greater than 10 times the yearly mean of control samples for any medium, gamma isotopic analysis should be performed on the individual samples.

Please note the following definitions:

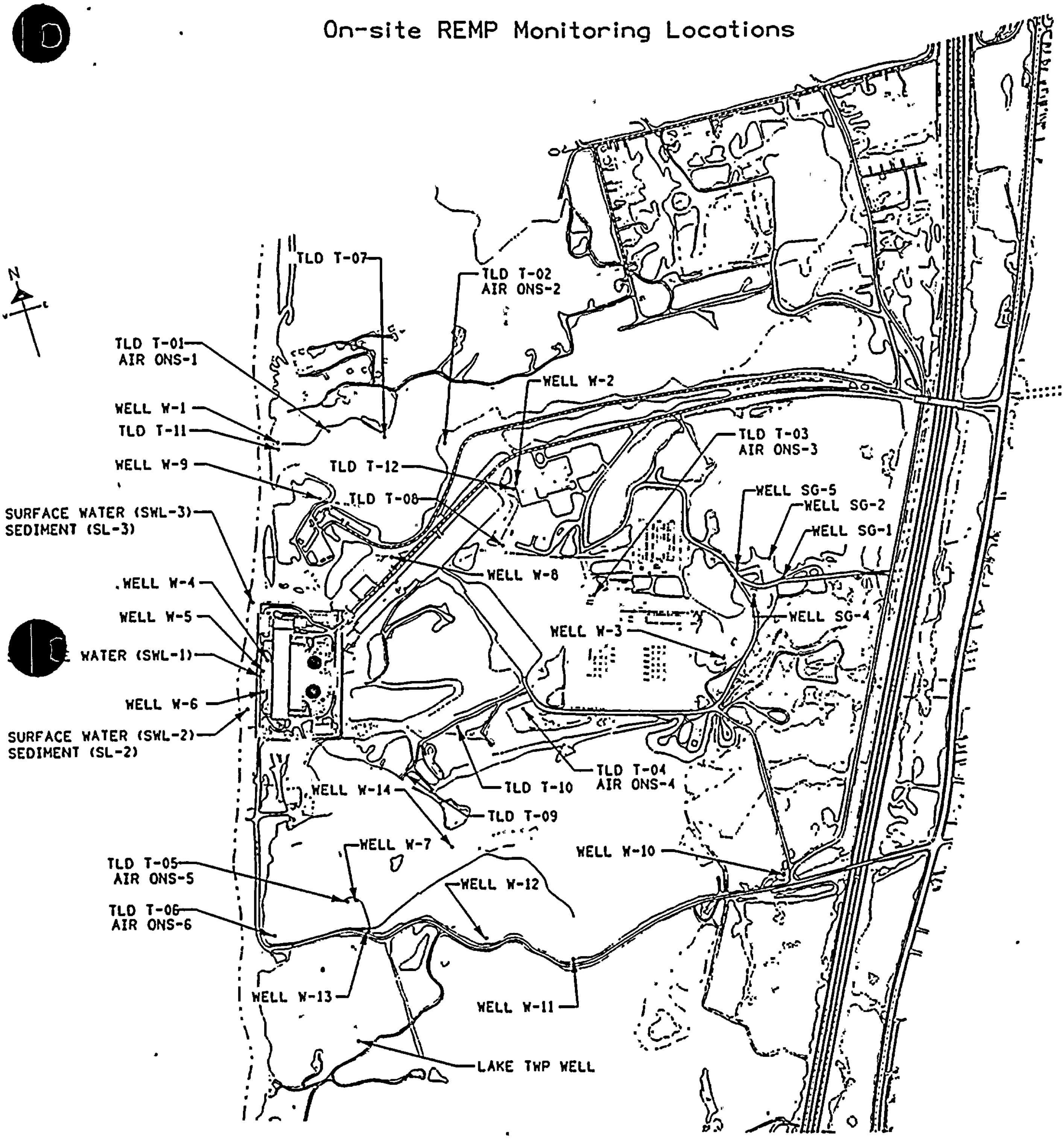
Weekly - at least once every seven (7) days

Monthly - at least once every (31) days

Quarterly - at least once every ninety-two (92) days

Semi-annually - at least once every one hundred eighty-four (184) days

On-site REMP Monitoring Locations



LEGEND

ONS-1 - ONS-6: Air Sampling Stations

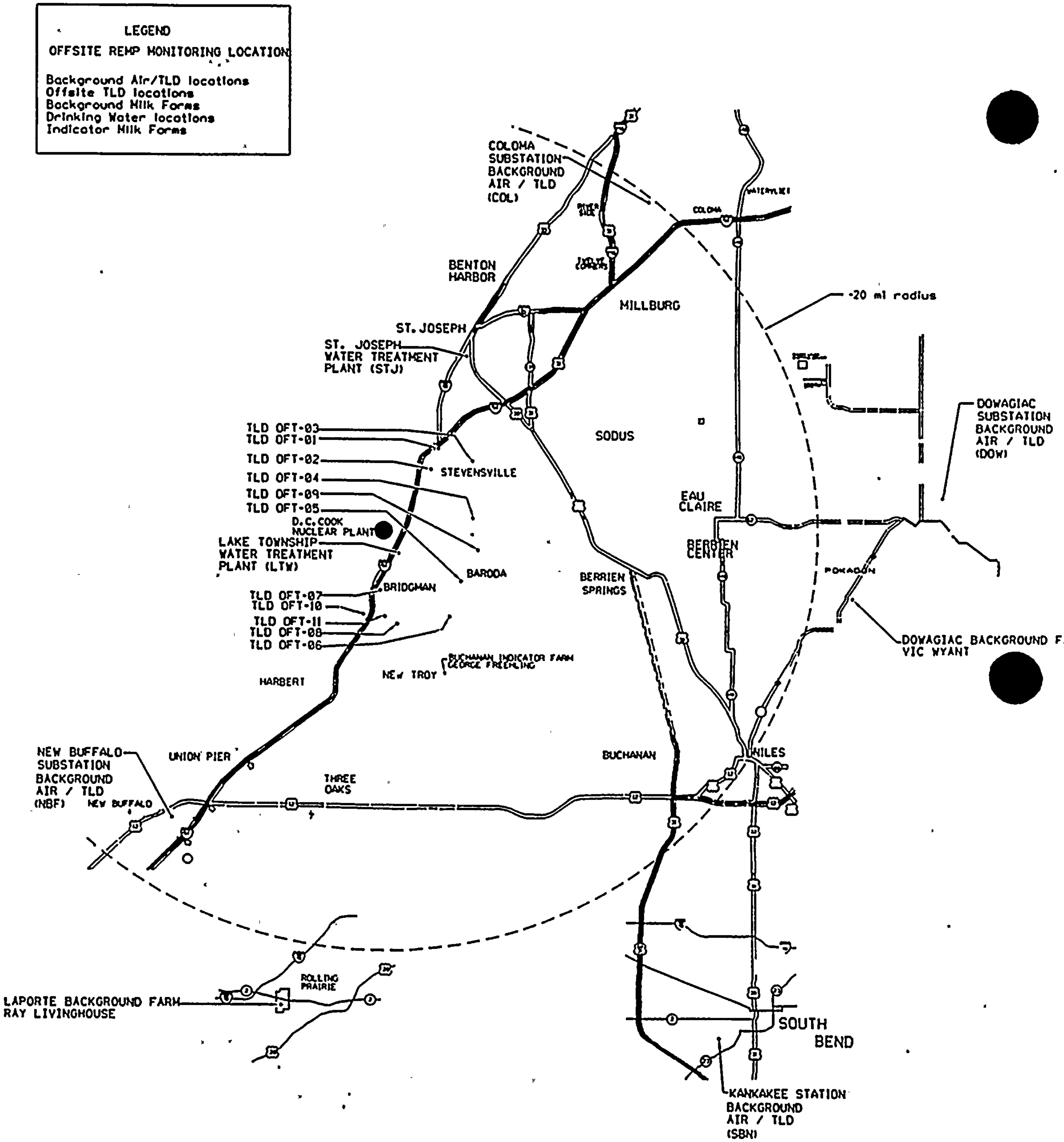
T-01 - T-12: TLD Sampling Stations

W-1 - W-14: REMP T/S Groundwater Wells

SG-1, SG-2, SG-4, SG-5: REMP Non T/S Groundwater Wells

SWL-1, 2, 3: Surface Water Sampling Stations

SL-2, 3: Sediment Sampling Stations

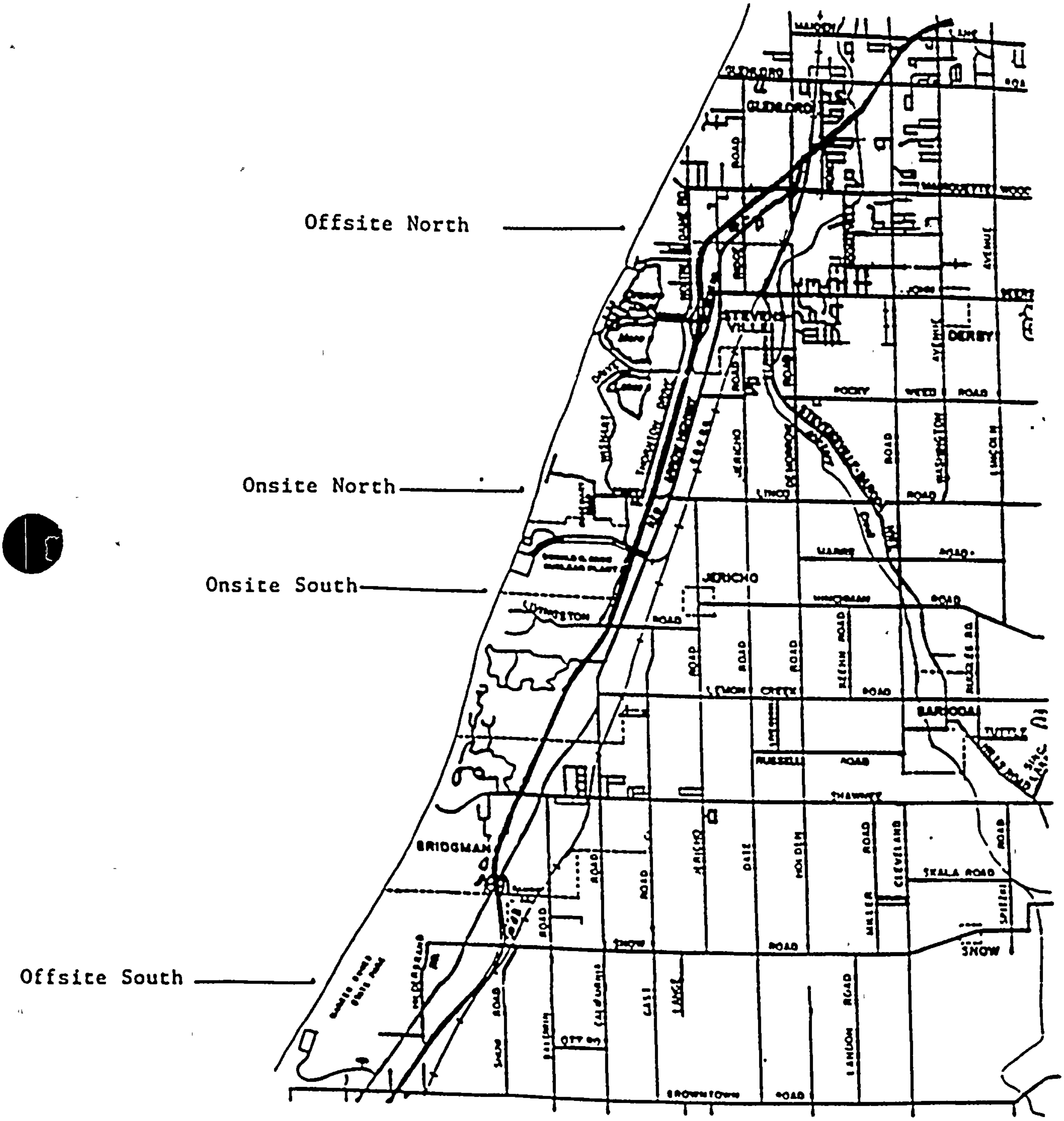


LEGEND
OFFSITE REMP MONITORING LOCATION
Background Air/TLD locations
Offsite TLD locations
Background Milk Farms
Drinking Water locations
Indicator Milk Farms
COLOMA SUBSTATION BACKGROUND AIR / TLD (COL)
COLOMA
BENTON HARBOR
MILLBURG
-20 mi radius
ST. JOSEPH
ST. JOSEPH WATER TREATMENT PLANT (STJ)
SODUS
DOWAGIAC SUBSTATION BACKGROUND AIR / TLD (DOW)
TLD OFT-03
TLD OFT-01
TLD OFT-02
STEVENSVILLE
TLD OFT-04
TLD OFT-09
TLD OFT-05
D.C.COOK NUCLEAR PLANT
EAU CLAIRE
BERRIEN CENTER
LAKE TOWNSHIP WATER TREATMENT PLANT (LTW)
BAROOA
BERRIEN SPRINGS
POKAGON
BRIDGMAN
TLD OFT-07
TLD OFT-10
TLD OFT-11
TLD OFT-08
TLD OFT-06
DOWAGIAC BACKGROUND FA
VIC WYANT
BUCHANAN INDICATOR FARM GEORGE FREEHLING
NEW TROY
HARBERT
NEW BUFFALO SUBSTATION BACKGROUND AIR / TLD (NBF)
NEW BUFFALO
UNION PIER
THREE OAKS
BUCHANAN
NILES
ROLLING PRAIRIE
LAPORTE BACKGROUND FARM
RAY LIVINGHOUSE
SOUTH BEND
KANKAKEE STATION BACKGROUND AIR / TLD (SBN)

FIGURE 3

SAMPLING LOCATIONS

FISH COLLECTED FOR RADIOLOGICAL ANALYSIS



III. SUMMARY AND DISCUSSION OF 1998 ANALYTICAL RESULTS

III. SUMMARY AND DISCUSSION OF 1998 ANALYTICAL RESULTS

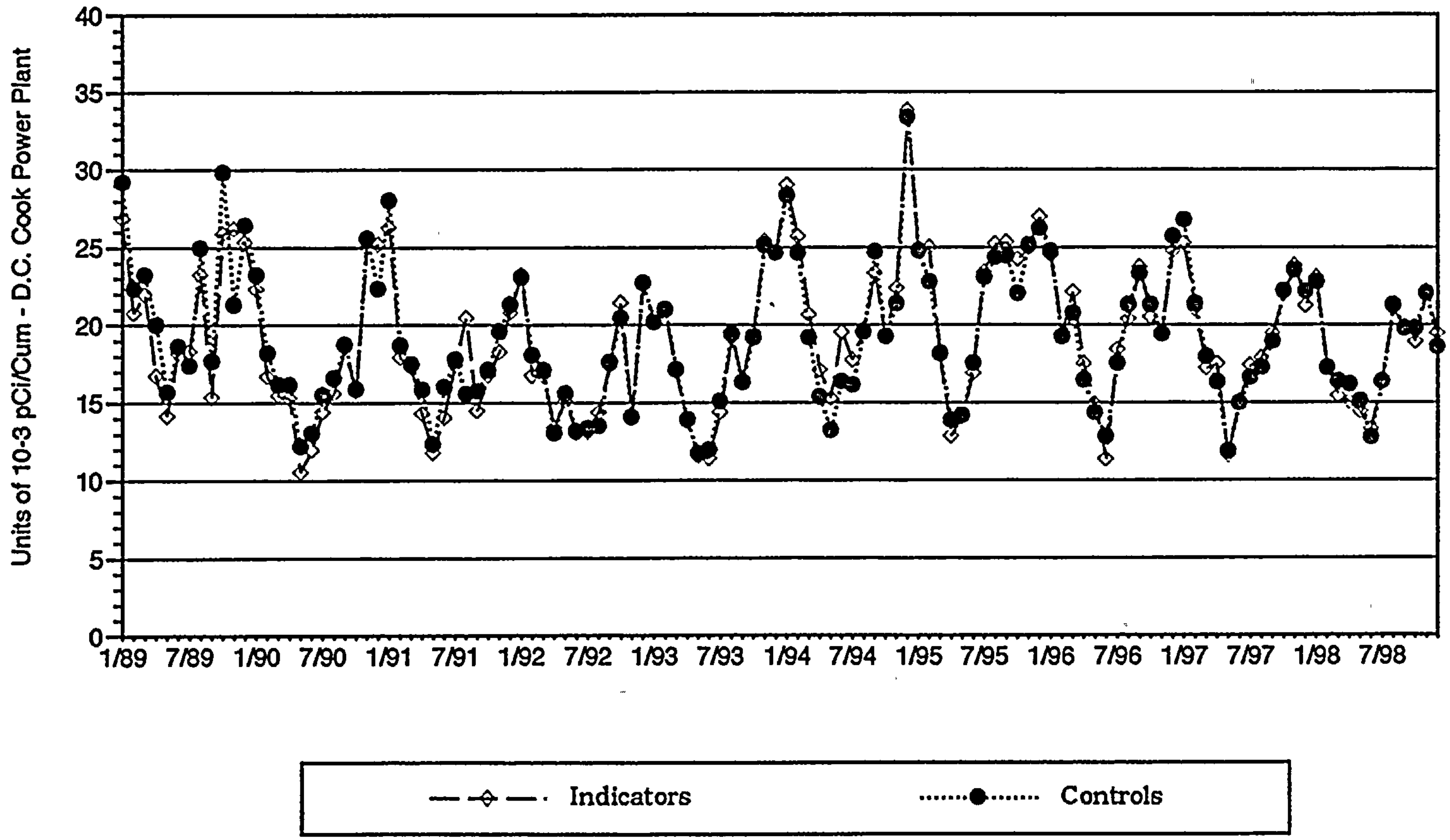
A discussion of the data from the radiological analyses of environmental media collected during the report period is provided in this section. Analyses of samples for 1998 were analyzed by Teledyne Brown Engineering, Inc. (TI) in Westwood, New Jersey. The procedures and specifications followed at Teledyne Brown Engineering are in accordance with the Teledyne Brown Engineering Quality Assurance Manual and are explained in the Teledyne Brown Engineering Analytical Procedures. A synopsis of analytical procedures used for the environmental samples is proved in Appendix C. In addition to internal quality control measures performed by Teledyne, the laboratory also participates in the Environmental Protection Agency's Interlaboratory Comparison Program. Participation in this program ensures that independent checks on the precision and accuracy of the measurements of radioactive material in environmental samples are performed. The results of the EPA Interlaboratory Comparison are provided in Appendix D.

Radiological analyses of environmental media characteristically approach and frequently fall below the detection limits of state-of-the-art measurement methods. Teledyne Brown Engineering analytical methods meet or exceed the Lower Limit of Detection (LLD) requirements given in Table 2 of the USNRC Branch Technical Position of Radiological Monitoring, Revision 1, November 1979, and 12 PMP 6010OSD.001, "Off-Site Dose Calculation Manual".

The following is a discussion and summary of the results of the environmental measurements performed during the reporting period. Comparison is made where possible with radioactivity concentrations measured in the preoperational period of August 1971 to the initial criticality of Unit 1 on January 12, 1975. A brief summary of the preoperational program is found in Appendix G.

Trending Graph - 1

AVERAGE MONTHLY GROSS BETA IN AIR PARTICULATES



A. Airborne Particulates

Airborne particulate samples are collected with an oil less pump at approximately 56 LPM using a 47 mm particulate filter. Results of gross beta activities are presented in Table B-1. The measurement of the gross beta activity on the weekly air particulate filters is a good indication of the levels of natural and or manmade radioactivity in the environment. The average gross beta concentration of the six indicator locations was 0.018 pCi/m^3 with a range of individual values between 0.006 and 0.035 pCi/m^3. The average gross beta concentration of the four control locations was 0.018 pCi/m^3 with a range between 0.008 and 0.036 pCi/m^3. In Trending Graph 1 the monthly average gross beta concentrations for the indicator locations and for the control locations are plotted. The gross beta concentrations in air particulate filters in 1998 were lower than at the end of the preoperational period when the effects of recent atmospheric nuclear tests were being detected.

Air particulate filters were composited by location on a quarterly basis and were analyzed by gamma ray spectroscopy. Results are presented in Table B-2. Beryllium-7, which is produced continuously in the upper atmosphere by cosmic radiation, was measured in all forty samples. The average concentration for the control locations was 0.129 pCi/m^3 and the values ranged from 0.090 to 0.170 pCi/m^3. The average concentration for the indicator locations was 0.124 pCi/m^3 with a range of 0.017 to 0.186 pCi/m^3. These values are typical of beryllium-7 measured at various locations throughout the United States. Naturally occurring potassium-40 was measured in four of the twenty-four indicator quarterly composites with an average concentration of 0.005 pCi/m^3 and a range of 0.002 to 0.011 pCi/m^3. Potassium-40 was measured in four of the sixteen control quarterly composites with a concentration of 0.006 pCi/m^3 and a range of 0.002 to 0.013 pCi/m^3. No other gamma emitting radioactivity was detected.

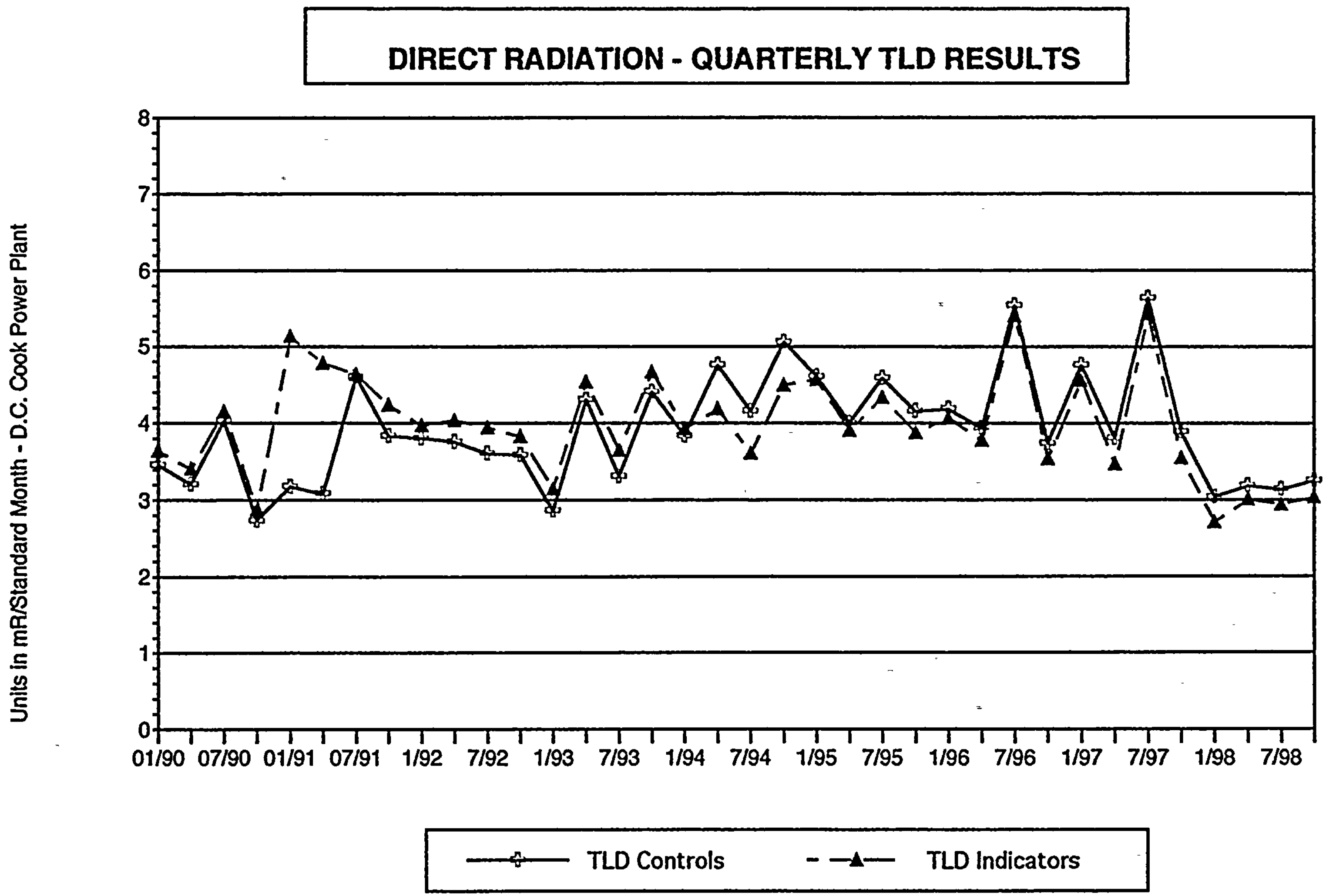
B. Airborne Iodine

Airborne iodine samples are collected with an oil less pump at approximately 56 LPM using a charcoal filter cartridge. Charcoal cartridges are installed downstream of the particulate filters and are used to collect airborne radioiodine. The results of the weekly analysis of the charcoal cartridges are presented in Table B-3. All results were below the lower level of detection of 0.07 pCi/m^3 with no positive activity detected.

C. Direct Radiation - Thermoluminescent Dosimeters

Thermoluminescent dosimeters (TLDs) measure external radiation exposure from several sources including naturally occurring radionuclides in the air and soil, radiation from cosmic origin, fallout from atomic weapons testing, potential radioactive airborne releases from the power station and direct radiation from the power station. The TLDs record exposure from all of these potential sources. The TLDs are deployed quarterly at 27 locations in the environs surrounding the D. C. Cook Nuclear Plant. The average value of the four areas of each dosimeter (calibrated individually after each field exposure period for response to a known exposure and for transit exposure) are presented in Table B-4. Those exposure rates are quite typical of observed rates at many other locations in the country. The average annual measurement for the control samples was 3.14 mR/standard month with a range of 2.5 to 3.9 mR/standard month. The annual accumulation of indicator samples had a measurement of 2.91 mR/standard month with a range of 0.5 to 4.1 mR/standard month. The 1998 annual average in the environs of the Donald C. Cook Nuclear Plant is at the low range of the exposure rates (1.0 to 2.0 mR/week) measured during the preoperational period. The results of the indicator and control TLDs are in good agreement and are plotted in Trending Graph 2.

Trending Graph - 2



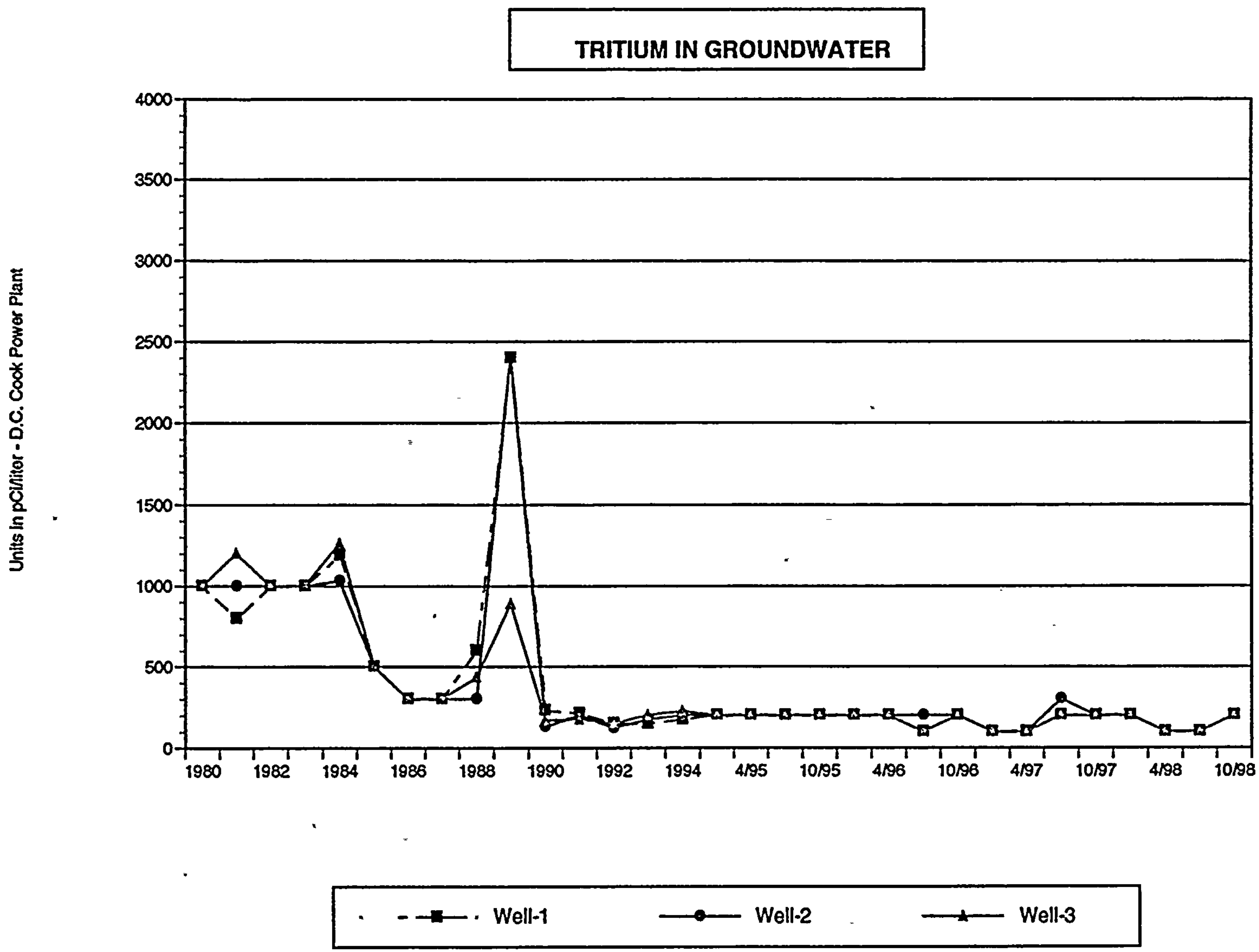
D. Surface Water

A 125 milliliter surface water sample is collected from the intake forebay and from two shoreline locations, all within 0.3 mile of the two reactors and were composited daily over a monthly period. The thirty-two samples were analyzed for iodine-131 by the radiochemical technique described on page 77. All results were less than the lower limit of detection of 1 pCi/l. The quarterly composite was analyzed for tritium by liquid scintillation method described on page 76. Results are presented in Table B-5. Tritium was detected in 6 of the 12 samples analyzed with an average concentration of 228 pCi/liter and a range of 170 to 350 pCi/liter. This is significantly lower than the 5 measurements in 1997 which had an average concentration of 1214 pCi/liter. During the preoperational period tritium was measured in surface water samples at concentrations of approximately 400 pCi/liter. Naturally occurring potassium-40 and cesium-137 were not measured during 1998. Naturally occurring gamma emitting isotopes were detected using gamma ray spectroscopy.

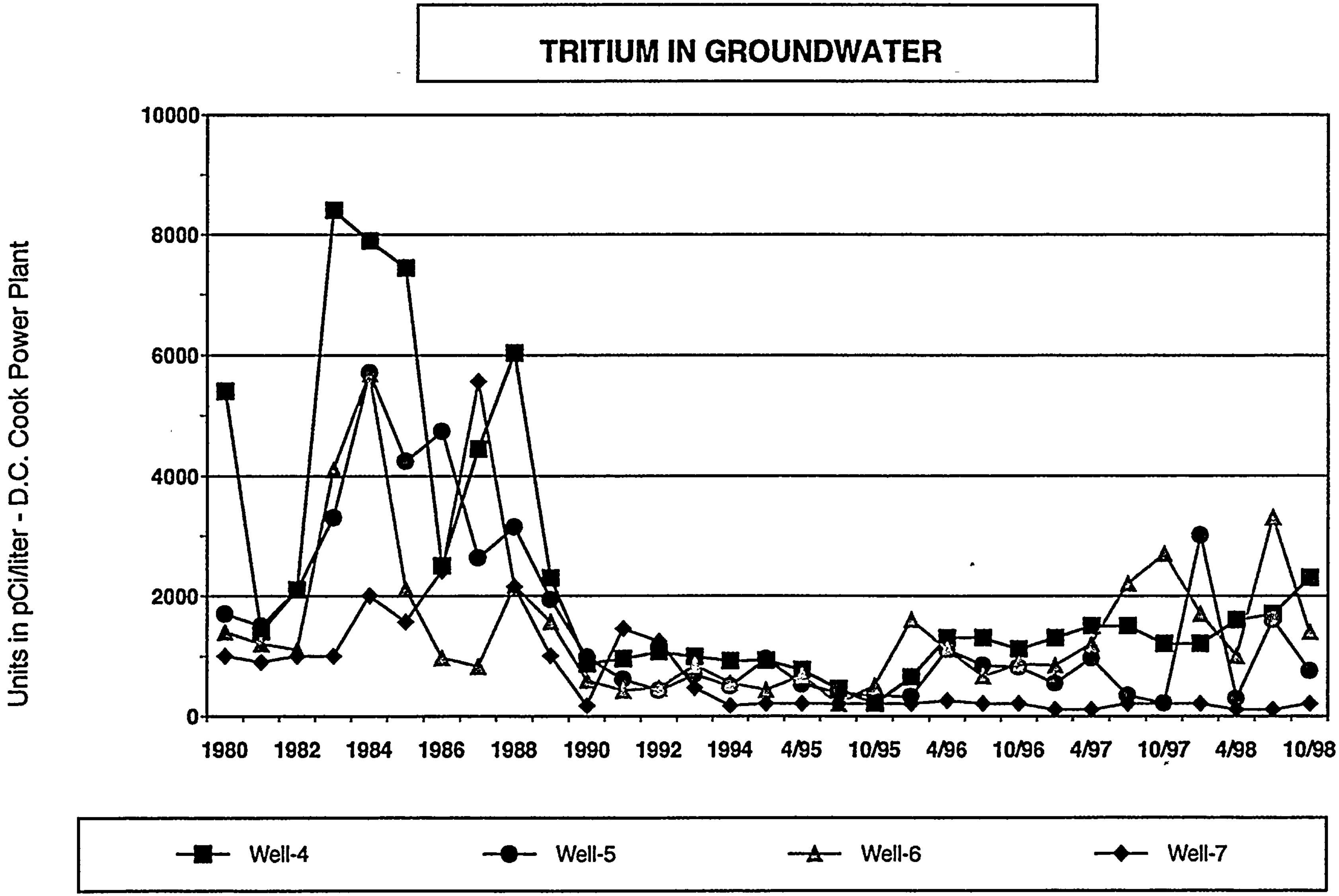
E. Groundwater

Water samples are collected quarterly from fourteen wells, all within 4300 feet of the reactors. First, a static water elevation is determined and three well bore volumes are purged from the well using a groundwater pump, or equivalent. A four liter sample is then obtained. The samples are analyzed for gamma emitters and tritium. The results are presented in Table B-6. Naturally occurring potassium-40 was measured in two samples with an average concentration of 46.4 pCi/liter and a range of 41.2 to 51.6 pCi/liter. There were no other gamma emitting isotopes measured. The groundwater wells W-4, W-5, W-6, W-8, and W-14 had measurable tritium activity throughout 1998. Tritium was measured in 14 of the 56 samples at the locations with an average concentration of 1561 pCi/liter and a range of 210 to 3300 pCi/liter. The annual

Trending Graph - 3

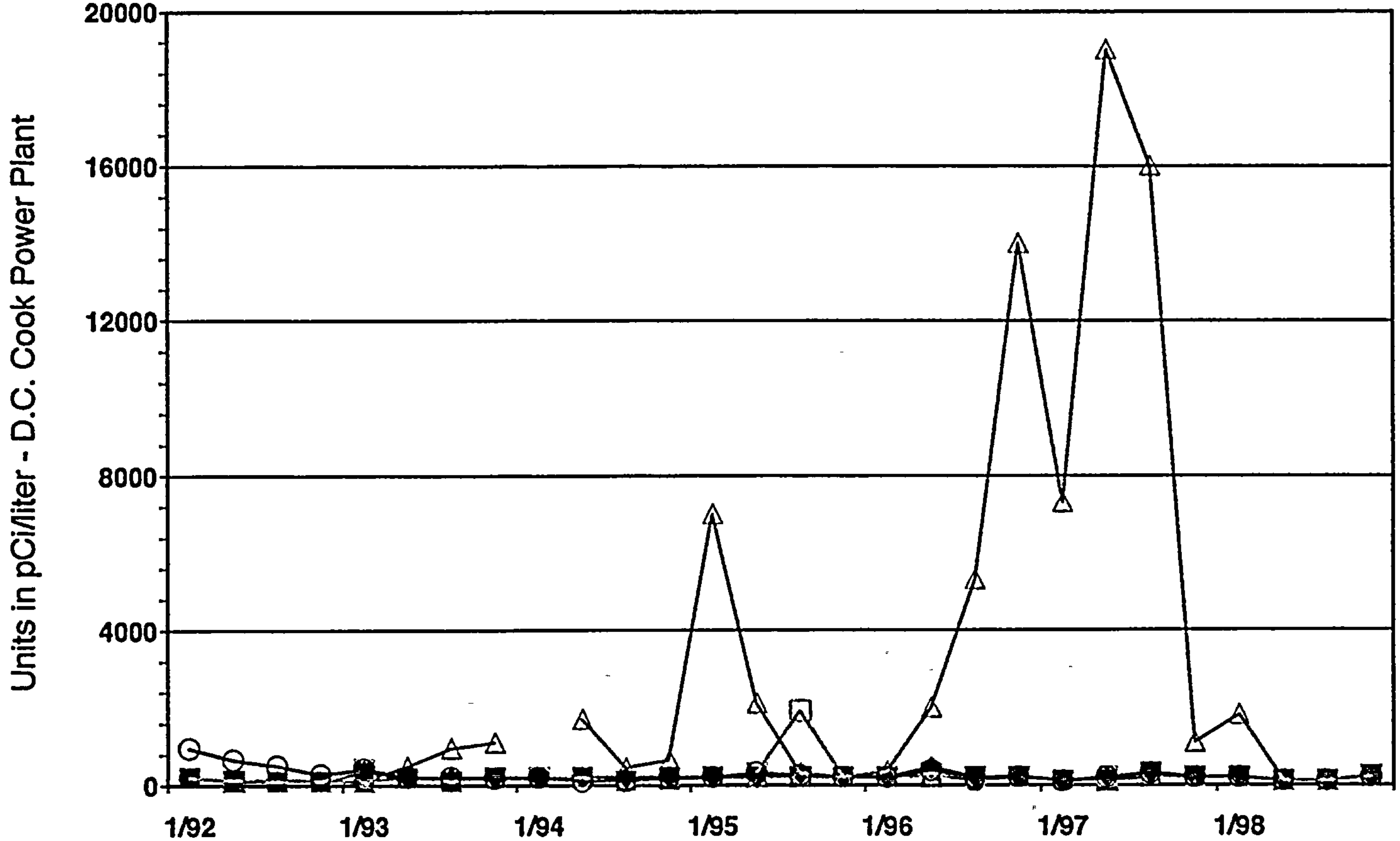


Trending Graph - 3 (Cont.)



Trending Grap[illegible] (Cont.)

TRITIUM IN GROUNDWATER



Well 14 added to the program in 1993.
No sample collected January 1994.

Well-8 Well-9 Well-10 Well-11 Well-12 Well-13 Well-14

concentrations of tritium in wells W-1 through W-7 are plotted in Trending Graph 3.

Tritium concentration in groundwater wells during the preoperational period typically averaged 400 pCi/liter.

F. Drinking Water

Daily samples are collected at the intake of the purification plants for St. Joseph and Lake Township. The 500 ml daily samples at each location are composited and analyzed for gross beta, iodine-131, and gamma emitters. On a quarterly basis the daily samples are composited and analyzed for tritium. The results of analyses of drinking water samples are shown in Table B-7.

Gross beta activity was measured in all twenty-six samples from the Lake Township intake with an average concentration of 2.77 pCi/liter and a range from 1.6 to 3.7 pCi/liter. Gross beta activity was measured in all twenty-six samples from the St. Joseph intake with an average concentration of 3.07 pCi/liter and a range from 1.5 to 8.9 pCi/liter. No gamma emitting isotopes or iodine-131 were detected. Tritium was not measured at the Lake Township location or the St. Joseph intake location. Tritium (or LLD values) in drinking water are plotted in Trending Graph 4.

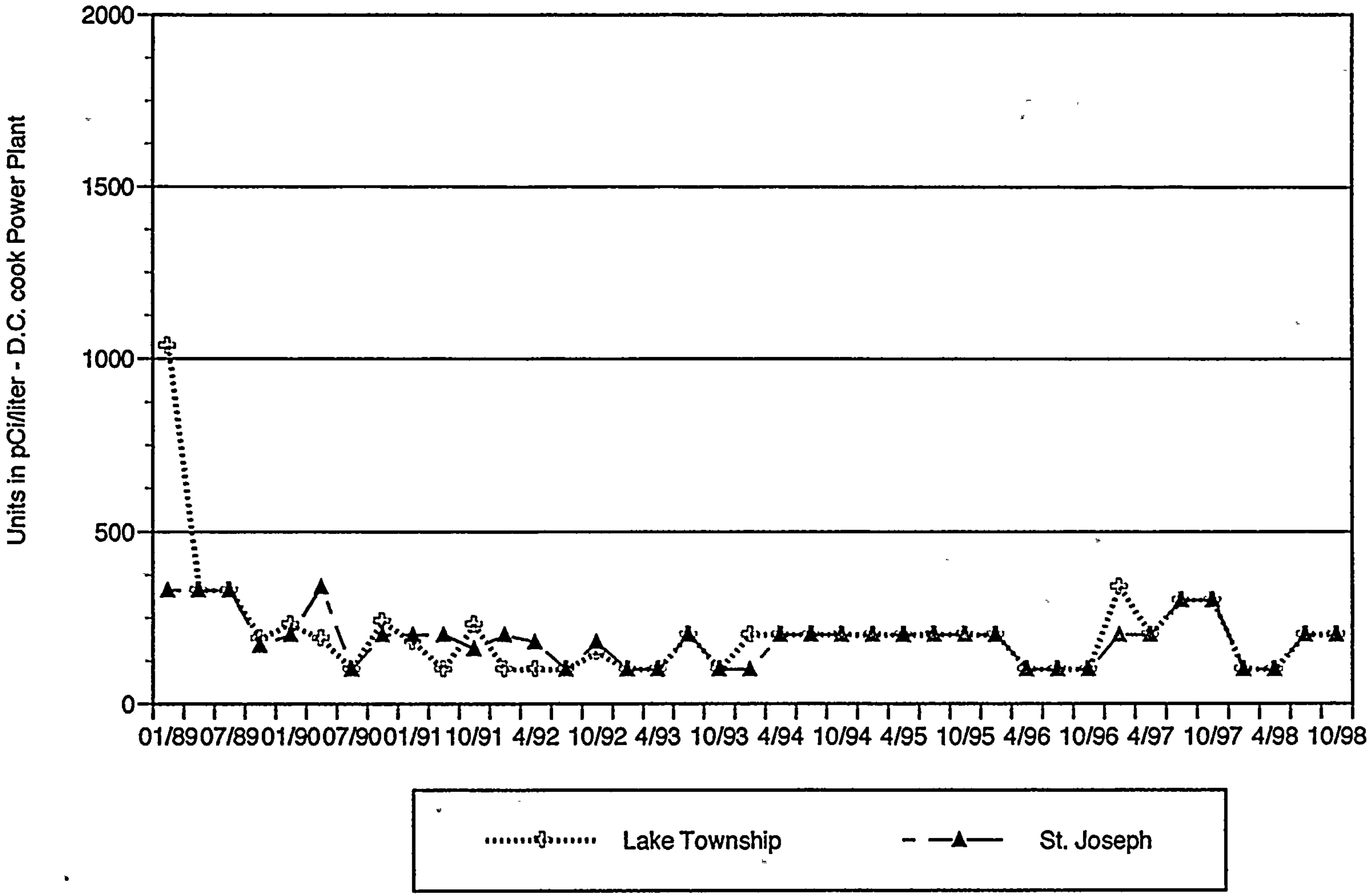
There were no drinking water analyses performed in the preoperational program.

G. Sediment

Sediment samples are collected semiannually along the shoreline of Lake Michigan at the same two locations as the surface water samples. Two liters of lake sediment are collected using a small dredge in an area covered part time by wave action. The sediment samples are analyzed by gamma ray spectroscopy, the results of which are shown in Table B-8. In April and October one sample was collected from location SL-2 and SL-3. Gamma ray spectroscopy

Trending Graph - 4

TRITIUM IN DRINKING WATER



detected naturally occurring potassium-40 in all four samples. The average potassium-40 concentration was 5088 pCi/kg (dry weight) with a range from 4850 to 5410 pCi/kg (dry weight). Thorium-228, also naturally occurring was measured in all four samples with an average concentration of 245 pCi/kg (dry weight) with a range from 87.2 to 500 pCi/kg (dry weight). Radium-226 was not measured during 1998. All other gamma emitters were below the lower limits of detection.

H. Milk

During 1998, the requirements of three indicator samples was not met. The sampling of food samples was increased to offset the milk.

I. Broadleaf Vegetation

Broadleaf vegetation was collected in lieu of milk during 1998. Twenty-five samples were collected and results are presented in Table B-10. Naturally occurring potassium-40 was measured in the six control samples with an average concentration of 4853 pCi/kg (wet weight) and a range of 3790 to 5700 pCi/kg (wet weight). Potassium-40 was measured in the nineteen indicator samples with an average concentration of 3621 pCi/kg (wet weight) and a range of 1290 to 7910 pCi/kg (wet weight). Cosmogenically produced beryllium-7 was measured in the six control samples with an average concentration of 1555 pCi/kg (wet weight) and a range of 749 to 3810 pCi/kg (wet weight). Beryllium-7 was measured in the nineteen indicator samples with an average of 1310 pCi/kg (wet weight) and a range of 512 to 3820 pCi/kg (wet weight). Cesium-137 was not detected during 1998. Radium-226 and thorium-228 were also not measured in 1998. This compares favorably with detections of these nuclides in 1997.

J. Fish

Using gill nets in approximately twenty feet of water in Lake Michigan, 4.5 pounds of fish are collected 2 times per year from each

of four locations. The samples were then analyzed by gamma ray spectroscopy. Results are presented in Table B-11. Naturally occurring potassium-40 was measured in the two control samples with an average concentration of 2660 pCi/kg (wet weight) and a range of 2590 to 2730 pCi/kg (wet weight). Potassium-40 was measured in three indicator samples with an average concentration of 3487 pCi/kg (wet weight) and a range of 3000 to 3930 pCi/kg (wet weight). Cesium-137 was measured in one control fish samples with a concentration of 25.2 pCi/kg (wet weight). Cesium-137, was measured in two of the three indicator samples with an average concentration of 54.0 pCi/kg (wet weight) and a range of 32.4 to 75.6 pCi/kg (wet weight).

K. Food Products

Food samples are collected annually at harvest, at two locations, as near the site boundary as possible, and approximately twenty miles from the plant. Each sample consists of 3 pounds of grapes and 3 pounds of broadleaves. There were four food samples collected during 1998 and results are presented in Table B-12. Naturally occurring potassium-40 was measured in the two control samples with an average concentration of 2535 pCi/kg (wet weight) and a range of 2470 to 2600 pCi/kg (wet weight). Potassium-40 was measured in the two indicator food samples with an average concentration of 2740 pCi/kg (wet weight) and a range of 2570 to 2910 pCi/kg (wet weight). Cosmogenically produced beryllium-7 was measured in one control sample with a concentration of 2300 pCi/kg (wet weight). Beryllium-7 was also measured in both indicator samples with an average concentration of 2220 pCi/kg (wet weight) and a range of 90.3 to 4350 pCi/kg (wet weight). All other gamma emitters were below the lower limits of detection.

IV. CONCLUSIONS

IV. CONCLUSIONS

The results of the 1998 Radiological Environmental Monitoring Program for the Donald C. Cook Nuclear Plant have been presented. The results were as expected for normal environmental samples. Naturally occurring radioactivity was observed in sample media in the expected activity ranges.

Occasional samples of a few media showed the presence of man-made isotopes. These have been discussed individually in the text. Observed activities were at very low concentrations and had no significant dose consequence. Specific examples of sample media with positive analysis results are discussed below.

Air particulate gross beta concentrations of all the indicator locations for 1998 appear to follow the gross beta concentrations at the control locations. The concentration levels are actually lower than during the preoperational period. Gamma isotopic analysis of the particulate samples identified the gamma emitting isotopes as natural products (beryllium-7 and potassium-40). No man-made activity was found in the particulate media during 1998. No iodine-131 was detected in charcoal filters in 1998.

Thermoluminescent dosimeters (TLDs) measure external gamma radiation from naturally occurring radionuclides in the air and soil, radiation from cosmic origin and fallout from atmospheric nuclear weapons testing, and radioactive airborne releases and direct radiation from the power plant. The average annual TLD results were at normal background exposure levels.

Surface water samples are collected daily from the intake forebay and two locations in Lake Michigan. The samples are analyzed quarterly for tritium, and monthly for gamma emitting isotopes. No gamma emitters were detected during 1998. Tritium was measured in six of the twelve samples collected. The tritium concentration was at a normal background level.

Groundwater samples were collected quarterly at fourteen wells, all within 4300 feet of the reactors. The three wells within 500 feet had measurable tritium which is attributed to the operation of the plant. The

highest concentration measured in 1998 was 3300 pCi/liter which compares well with the highest concentration measured during 1997 of 19000 pCi/liter. Potassium-40, a naturally occurring nuclide was detected in two of the fifty-six samples with an average concentration of 46.4 pCi/liter. No other gamma emitting isotopes were detected.

Samples are collected daily at the intakes of the drinking purification plants for St. Joseph and Lake Township. Samples composited daily over a two week period are analyzed for iodine-131, gross beta, and measured for gamma emitting isotopes. Samples are also analyzed quarterly for tritium. No iodine-131 or gamma emitting isotopes were detected. Gross beta was measured in all fifty-two samples at normal background concentrations. Tritium was not measured in the eight quarterly composite samples collected during 1998.

Sediment samples can be a sensitive indicator of discharges from nuclear power stations. Sediment samples are collected semiannually along the shoreline of Lake Michigan at two locations in close proximity of the reactors. The samples were analyzed by gamma ray spectroscopy and only naturally occurring gamma emitters were detected. There is no evidence of station discharges affecting Lake Michigan, either in the sediments or in the water, as previously discussed.

Milk samples were not analyzed during 1998 due to lack of participants in the program. Broadleaf sampling was performed in lieu of milk collection in 1998. Cesium-137 was not measured in broadleaf samples during 1998. Naturally occurring potassium-40 and beryllium-7 were observed during 1998. No other gamma emitting isotopes were measured in broadleaf samples in 1998.

Fish samples collected in Lake Michigan in the vicinity of the nuclear plant were analyzed by gamma ray spectroscopy. The only gamma emitting isotope measured was cesium-137 which was found in low concentrations in three samples.

Food products, consisting of grapes, and broadleaf vegetation were collected and analyzed by gamma ray spectroscopy. The only gamma

emitting isotopes measured during 1998 were potassium-40 and beryllium-7.

The results of the analyses have been presented. Based on the evidence of the Radiological Environmental Monitoring Program the Donald C. Cook Nuclear Plant is operating within regulatory limits. Tritium in four on-site wells appears to be the only radionuclide which can be directly correlated with the plant. However the associated groundwater does not provide a direct dose pathway to humans because these wells do not supply water to the local population.

V. REFERENCES

V. REFERENCES

1. Data Tables from 1985- 1988 CEP-AEPSC Annual Radiological Environmental Monitoring Program Reports.

2. Eberline Instrument Company. Indiana Michigan Power Company, "D. C. Cook Nuclear Plant Radiological Environmental Monitoring Program - 1974 Annual Report", May 1975.

3. American Electric Power, 12 PMP 6010 0SD.001, Offsite Dose Calculation Manual.

4. United States Nuclear Regulatory Commission, Regulatory Guide 4.8, "Environmental Technical Specifications for Nuclear Power Plants", December 1975.

5. United States Nuclear Regulatory Commission, Regulatory Guide 1.21 "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants, April 1974.

6. United States Nuclear Regulatory Commission, Regulatory Guide 1.4 "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants", April 1975.

7. USNRC Branch Technical Position, "Acceptable Radiological Environmental Monitoring Program", Rev. 1, November 1979.

APPENDIX A
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT DOCKET NO. 50-315/50-316

BERRIEN COUNTY JANUARY 1 to DECEMBER 31, 1998

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		ALL INDICATOR LOCATIONS MEAN (a/b) RANGE	LOCATION WITH HIGHEST MEAN NAME DISTANCE AND DIRECTION	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
Air Iodine (pCi/m^3)	I-131	520	-(0/312) -			-(0/208) -	0
Airborne Particulates ($1E-03\ pCi/m^3$)	Gross Beta (Weekly)	520	18.1(311/312) (6.0-35)	ONS-4 Onsite 1852 ft.	20.1(52/52) (9.4-35)	18.1(208/208) (7.9-36)	0
	Gamma	40					
	Be-7	40	124(24/24) (16.6-186)	ONS-4 Onsite 1852 ft.	150(4/4) (118-184)	129(16/16) (90.4-170)	0
	K-40	40	5.29(4/24) (2.35-10.7)	DOW 24.3 mi ENE	12.9(1/4) -	5.56(4/16) (2.38-12.6)	0
Direct Radiation (mR/Standard Month)	Gamma Dose Quarterly	107	4.25(91/91) (2.7-6.8)	SBN 26.2 mi SE	5.28(4/4) (4.4-6.3)	4.51(16/16) (3.1-6.3)	0

(a/b) Ratio of samples with detectable activity to total number of samples analyzed.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT DOCKET NO. 50-315/50-316

BERRIEN COUNTY JANUARY 1 to DECEMBER 31, 1998

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		ALL INDICATOR LOCATIONS MEAN (a/b) RANGE	LOCATION WITH HIGHEST MEAN NAME DISTANCE AND DIRECTION	LOCATION WITH HIGHEST MEAN MEAN RANGE	CONTROL LOCATION MEAN RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
Surface Water (pCi/liter)	Gamma	34	(0/12) -	N/A		(0/22) -	0
	H-3	12	170(1/4) -	SWL-2 Intake	243(4/4) (170-350)	240(5/8) (170-350)	0
Groundwater (pCi/liter)	Gamma	56					
	K-40	56	46.4(2/56) (41.2-51.6)	Well 5 -	51.6(1/4) -	-(0/0) -	0
	Th-228	56	-(0/56) -	N/A		-(0/0) -	0
	H-3	56	1561(14/56) (210-3300)	Well 6	1850(4/4) (1000-3300)	-(0/0) -	0
Drinking Water (pCi/liter)	Gross Beta	52	2.92(52/52) (1.5-8.9)	St. Joseph 9.0 mi NE	3.07(26/26) (1.5-8.9)	-(0/0)	0
	I-131	52	-(0/52) -	N/A	N/A	-(0/0) -	0
	Gamma	52	-(0/52) -	N/A	N/A	-(0/0) -	0
	H-3	8	-(0/8) -	N/A	N/A	-(0/0) -	0

(a/b) Rati[illegible]amples with detectable activity to total number of samples an[illegible]d.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT DOCKET NO. 50-315/50-316

BERRIEN COUNTY JANUARY 1 to DECEMBER 31, 1998

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		ALL INDICATOR LOCATIONS MEAN (a/b) RANGE	LOCATION WITH HIGHEST MEAN NAME DISTANCE AND DIRECTION	LOCATION WITH HIGHEST MEAN MEAN RANGE	CONTROL LOCATION MEAN RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
Sediment (pCi/kg dry)	Gamma	4					
	K-40	4	5088(4/4) (4850-5410)	SL-2 0.2 mi N	5130(2/2) (4850-5410)	-(0/0) -	0
	Cs-137	4	-(0/4) -	N/A	N/A	-(0/0) -	0
	Ra-226	4	-(0/4) -	N/A	N/A -	-(0/0) -	0
	Th-228	4	245(4/4) (87.2-500)	SL-2 0.2 mi N	397(2/2) (294-500)	-(0/0) -	0
Broadleaf/ Vegetation (pCi/kg wet)	Gamma	25					
	Be-7	25	1310(19/19) (512-3820)	Sector J	1555(6/6) (749-3810)	1555(6/6) (749-3810)	0
	K-40	25	3621(19/19) (1290-7910)	Sector J	4853(6/6) (3790-5700)	4853(6/6) (3790-5700)	0
	Cs-137	25	-(0/19) -	N/A	N/A	-(0/6) -	0
	Th-228	25	-(0/19) -	N/A	N/A	-(0/6) -	0

(a/b) Ratio of samples with detectable activity to total number of samples analyzed.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT DOCKET NO. 50-315/50-316

BERRIEN COUNTY JANUARY 1 to DECEMBER 31, 1998

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		ALL INDICATOR LOCATIONS MEAN (a/b) RANGE	LOCATION WITH HIGHEST MEAN NAME DISTANCE AND DIRECTION	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
Fish (pCi/kg wet)	Gamma	5					
	K-40	5	3487(3/3) (3000-3930)	ONS-North 5.0 mi N	3466(3/3) (3000-3930)	2660(2/2) (2590-2730)	0
	Cs-137	5	54.0(2/3) (32.4-75.6)	ONS-South 5.0 mi S	75.6(1/2) -	25.2(1/2) -	0
Food/Vegetation (pCi/kg wet)	Gamma	4					
	Be-7	4	2220(2/2) (90.3-4350)	Sector J	2300(1/2) -	2300(1/2) -	0
	K-40	4	2740(2/2) (2570-2910)	Sector D	2740(2/2) (2570-2910)	2535(2/2) (2470-2600)	0
	Cs-137	4	-(0/2) -		N/A	-(0/2) -	0

(a/b) Rati[illegible]mples with detectable activity to total number of samples a[illegible]d.

APPENDIX B
DATA TABLES

TABLE B-1

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GROSS BETA EMITTERS IN WEEKLY AIRBORNE PARTICULATES

Results in Units of 10^{-3} pCi/m^3 ± 2 sigma

COLLECTION DATES	STATION CODES ONS-1	ONS-2	ONS-3	ONS-4	ONS-5	ONS-6	NBF	SBN	DOW	COL	Average ± 2 s.d.
JANUARY 98											
01/07/98	11 ± 2	11 ± 2	12 ± 2	12 ± 2	13 ± 2	11 ± 2	11 ± 2	12 ± 2	12 ± 2	10 ± 2	12 ± 2
01/14/98	22 ± 2	20 ± 2	24 ± 2	22 ± 2	22 ± 2	20 ± 2	21 ± 2	20 ± 2	22 ± 2	19 ± 2	21 ± 3
01/21/98	33 ± 3	29 ± 2	32 ± 2	30 ± 2	34 ± 2	30 ± 2	32 ± 2	31 ± 2	31 ± 2	33 ± 3	32 ± 3
01/28/98	27 ± 2	29 ± 2	28 ± 2	32 ± 2	32 ± 2	27 ± 2	32 ± 2	27 ± 2	26 ± 2	25 ± 2	29 ± 5
02/04/98	21 ± 2	23 ± 2	23 ± 2	21 ± 2	20 ± 2	20 ± 2	23 ± 2	23 ± 2	22 ± 2	22 ± 2	22 ± 3
FEBRUARY											
02/11/98	27 ± 2	29 ± 2	27 ± 2	26 ± 2	25 ± 2	25 ± 2	26 ± 2	27 ± 2	25 ± 2	25 ± 2	26 ± 3
02/18/98	18 ± 2	16 ± 2	17 ± 2	17 ± 2	18 ± 2	17 ± 2	20 ± 2	18 ± 2	17 ± 2	20 ± 2	18 ± 3
02/25/98	13 ± 2	14 ± 2	13 ± 2	15 ± 2	14 ± 2	14 ± 2	17 ± 2	14 ± 2	12 ± 2	11 ± 2	14 ± 3
03/04/98	9.9 ± 1.7	11 ± 2	12 ± 2	12 ± 2	12 ± 2	12 ± 2	13 ± 2	9.9 ± 1.8	10 ± 2	10 ± 2	11 ± 2
MARCH											
03/12/98	11 ± 2	12 ± 2	11 ± 2	11 ± 2	3.9 ± 0.8(a)	3.2 ± 0.8 (a)	11 ± 2	8.3 ± 1.4	10 ± 2	11 ± 1	11 ± 2
03/18/98	20 ± 2	23 ± 2	22 ± 2	26 ± 3	6.3 ± 1.5	6.0 ± 1.5	25 ± 2	21 ± 2	23 ± 3	23 ± 2	20 ± 15
03/25/98	15 ± 2	(b)	14 ± 2	17 ± 2	16 ± 2	13 ± 2	17 ± 2	14 ± 2	14 ± 2	14 ± 2	15 ± 3
04/01/98	16 ± 2	(b)	17 ± 2	19 ± 2	16 ± 2	17 ± 2	19 ± 2	18 ± 2	17 ± 2	16 ± 2	17 ± 2
Quarter Avg.	**19 ± 14**	**20 ± 15**	**19 ± 14**	**20 ± 14**	**19 ± 16**	**18 ± 14**	**21 ± 14**	**19 ± 14**	**19 ± 14**	**18 ± 14**	**19 ± 14**

(a) Pump off; no power. Results in Total pCi and not included in averages.
(b) Sample not collected due to power loss.

TABLE [illegible] (Cont.)

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GROSS BETA EMITTERS IN WEEKLY AIRBORNE PARTICULATES

Results in Units of 10^{-3} pCi/m^3 ± 2 sigma

COLLECTION DATES	STATION CODES: ONS-1	ONS-2	ONS-3	ONS-4	ONS-5	ONS-6	NBF	SBN	DOW	COL	Average ± 2 s.d.
APRIL											
04/08/98	9.3 ± 1.9	(a)	11 ± 2	12 ± 2	11 ± 2	9.6 ± 1.9	12 ± 2	9.8 ± 1.9	21 ± 2	11 ± 2	12 ± 7
04/15/98	17 ± 2	(a)	17 ± 2	19 ± 2	20 ± 2	18 ± 2	20 ± 2	21 ± 2	18 ± 2	19 ± 2	19 ± 3
04/22/98	13 ± 2	(a)	15 ± 2	15 ± 2	13 ± 2	14 ± 2	14 ± 2	14 ± 2	14 ± 2	14 ± 2	14 ± 1
04/29/98	17 ± 2	16 ± 2	16 ± 2	19 ± 2	18 ± 2	16 ± 2	19 ± 2	18 ± 2	17 ± 2	16 ± 2	17 ± 2
MAY											
05/06/98	12 ± 2	11 ± 2	12 ± 2	14 ± 2	12 ± 2	10 ± 2	14 ± 2	13 ± 2	11 ± 2	12 ± 2	12 ± 3
05/13/98	12 ± 2	13 ± 2	11 ± 2	15 ± 2	9.8 ± 1.6	12 ± 2	14 ± 2	13 ± 2	12 ± 2	14 ± 2	13 ± 3
05/20/98	20 ± 2	21 ± 2	16 ± 2	22 ± 2	20 ± 2	21 ± 2	24 ± 2	19 ± 2	19 ± 2	19 ± 2	20 ± 4
05/27/98	15 ± 2	13 ± 2	12 ± 2	15 ± 2	13 ± 2	13 ± 2	17 ± 2	15 ± 2	12 ± 2	14 ± 2	14 ± 3
06/03/98	14 ± 2	15 ± 2	14 ± 2	16 ± 2	14 ± 2	14 ± 2	16 ± 2	16 ± 2	13 ± 2	14 ± 2	15 ± 2
JUNE											
06/10/98	8.3 ± 1.5	9.8 ± 1.5	8.3 ± 1.5	9.4 ± 1.5	7.7 ± 1.5	8.2 ± 1.5	8.7 ± 1.5	8.7 ± 1.5	7.9 ± 1.5	8.7 ± 1.6	9 ± 1
06/17/98	13 ± 2	15 ± 2	16 ± 2	15 ± 2	15 ± 2	13 ± 2	16 ± 2	10 ± 2	12 ± 2	15 ± 2	14 ± 4
06/24/98	15 ± 2	15 ± 2	16 ± 2	16 ± 2	16 ± 2	13 ± 2	18 ± 2	15 ± 2	12 ± 2	14 ± 2	15 ± 3
07/01/98	15 ± 2	14 ± 2	14 ± 2	15 ± 2	13 ± 2	14 ± 2	17 ± 2	14 ± 2	14 ± 2	12 ± 2	14 ± 3
Quarter Avg.	**14 ± 6**	**14 ± 6**	**14 ± 5**	**16 ± 6**	**14 ± 7**	**14 ± 7**	**16 ± 8**	**14 ± 7**	**14 ± 7**	**14 ± 6**	**14 ± 7**

(a) Sample not collected due to power loss.

TABLE B-1 (Cont.)

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GROSS BETA EMITTERS IN WEEKLY AIRBORNE PARTICULATES

Results in Units of 10^{-3} pCi/m^3 ± 2 sigma

COLLECTION DATES	STATION CODES ONS-1	ONS-2	ONS-3	ONS-4	ONS-5	ONS-6	NBF	SBN	DOW	COL	Average ± 2 s.d.
JULY											
07/08/98	12 ± 2	13 ± 2	14 ± 2	14 ± 2	13 ± 3	16 ± 3	13 ± 2	12 ± 2	12 ± 2	13 ± 2	13 ± 2
07/15/98	16 ± 2	18 ± 2	17 ± 2	19 ± 2	< 3 (a)	17 ± 2	19 ± 2	15 ± 2	16 ± 2	17 ± 2	17 ± 3
07/22/98	17 ± 2	18 ± 2	17 ± 2	22 ± 2	19 ± 2	17 ± 2	21 ± 2	21 ± 2	19 ± 2	19 ± 2	19 ± 4
07/29/98	17 ± 2	16 ± 2	16 ± 2	19 ± 2	17 ± 2	16 ± 2	18 ± 2	17 ± 2	17 ± 2	16 ± 2	17 ± 2
AUGUST											
08/05/98	15 ± 2	17 ± 2	16 ± 2	17 ± 2	16 ± 2	16 ± 2	15 ± 2	14 ± 2	16 ± 2	16 ± 2	16 ± 2
08/12/98	19 ± 2	17 ± 2	20 ± 2	19 ± 2	21 ± 2	17 ± 2	23 ± 2	19 ± 2	19 ± 2	19 ± 2	19 ± 4
08/19/98	19 ± 2	16 ± 2	18 ± 2	19 ± 2	17 ± 2	17 ± 2	20 ± 2	19 ± 2	16 ± 2	18 ± 2	18 ± 3
08/26/98	24 ± 2	30 ± 3	24 ± 2	29 ± 2	24 ± 2	25 ± 2	29 ± 2	23 ± 2	25 ± 2	26 ± 2	26 ± 5
09/02/98	20 ± 2	21 ± 2	22 ± 2	23 ± 2	24 ± 2	19 ± 2	24 ± 2	20 ± 2	20 ± 2	19 ± 2	21 ± 4
SEPTEMBER											
09/09/98	22 ± 2	23 ± 2	22 ± 2	24 ± 2	18 ± 2	21 ± 2	25 ± 2	23 ± 2	20 ± 2	23 ± 2	22 ± 4
09/16/98	25 ± 2	24 ± 2	24 ± 2	25 ± 2	24 ± 2	24 ± 2	24 ± 2	23 ± 2	22 ± 2	22 ± 2	24 ± 2
09/23/98	19 ± 2	18 ± 2	17 ± 2	20 ± 2	11 ± 1 (b)	16 ± 2	17 ± 2	18 ± 2	16 ± 2	16 ± 2	17 ± 5
09/30/98	23 ± 2	22 ± 2	20 ± 2	24 ± 2	23 ± 2	20 ± 2	25 ± 2	23 ± 2	21 ± 2	20 ± 2	22 ± 4
Quarter Avg.	**19 ± 8**	**19 ± 9**	**19 ± 6**	**21 ± 8**	**19 ± 9**	**19 ± 6**	**21 ± 9**	**19 ± 7**	**18 ± 7**	**19 ± 7**	**19 ± 8**

(a) Breaker [illegible]d; low sample volume.
(b) Actual [illegible]ld not be determined.

TABLE C-1 (Cont.)

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GROSS BETA EMITTERS IN WEEKLY AIRBORNE PARTICULATES

Results in Units of 10^{-3} pCi/m^3 ± 2 sigma

COLLECTION DATES	STATION CODES ONS-1	ONS-2	ONS-3	ONS-4	ONS-5	ONS-6	NBF	SBN	DOW	COL	Average ± 2 s.d.
OCTOBER											
10/07/98	14 ± 2	13 ± 2	15 ± 2	16 ± 2	14 ± 2	14 ± 2	14 ± 2	15 ± 2	13 ± 2	14 ± 2	14 ± 2
10/14/98	14 ± 2	11 ± 1	15 ± 2	16 ± 2	13 ± 2	14 ± 2	14 ± 2	14 ± 2	13 ± 2	14 ± 2	14 ± 3
10/21/98	18 ± 2	21 ± 2	19 ± 2	21 ± 2	19 ± 2	21 ± 2	20 ± 2	36 ± 3 (a)	20 ± 2	20 ± 2	22 ± 10
10/28/98	24 ± 2	20 ± 2	21 ± 2	27 ± 2	20 ± 2	24 ± 2	23 ± 2	24 ± 2	19 ± 2	21 ± 2	22 ± 5
11/04/98	22 ± 2	19 ± 2	16 ± 2	23 ± 2	17 ± 2	18 ± 2	20 ± 2	23 ± 2	17 ± 2	17 ± 2	19 ± 5
NOVEMBER											
11/11/98	16 ± 2	13 ± 2	15 ± 2	19 ± 2	15 ± 2	12 ± 2	13 ± 2	19 ± 2	15 ± 2	14 ± 2	15 ± 5
11/18/98	26 ± 2	27 ± 2	24 ± 2	35 ± 2	25 ± 2	24 ± 2	28 ± 2	25 ± 2	27 ± 2	27 ± 2	27 ± 6
11/25/98	18 ± 2	18 ± 2	20 ± 2	23 ± 2	20 ± 2	18 ± 2	21 ± 2	20 ± 2	20 ± 2	19 ± 2	20 ± 3
12/02/98	28 ± 2	25 ± 2	27 ± 2	34 ± 2	24 ± 3	25 ± 3	27 ± 2	24 ± 2	26 ± 2	26 ± 2	27 ± 6
DECEMBER											
12/09/98	19 ± 2	16 ± 2	19 ± 2	23 ± 2	16 ± 2	17 ± 2	17 ± 2	16 ± 2	17 ± 2	21 ± 2	18 ± 5
12/16/98	19 ± 2	20 ± 2	18 ± 2	22 ± 2	19 ± 2	17 ± 2	18 ± 2	19 ± 2	20 ± 2	18 ± 2	19 ± 3
12/23/98	15 ± 2	14 ± 2	14 ± 2	18 ± 2	14 ± 2	15 ± 2	15 ± 2	14 ± 2	13 ± 2	14 ± 2	15 ± 3
12/30/98	24 ± 2	23 ± 2	25 ± 2	32 ± 2	24 ± 2	23 ± 2	23 ± 2	22 ± 2	24 ± 2	25 ± 2	25 ± 6
Quarter Avg.	**20 ± 9**	**18 ± 10**	**19 ± 8**	**24 ± 13**	**18 ± 8**	**19 ± 9**	**19 ± 10**	**21 ± 12**	**19 ± 10**	**19 ± 9**	**20 ± 10**
Annual Avg.	**18 ± 11**	**18 ± 11**	**18 ± 10**	**20 ± 12**	**18 ± 11**	**17 ± 10**	**19 ± 11**	**18 ± 11**	**17 ± 10**	**18 ± 10**	**18 ± 11**

(a) Low sample volume.

TABLE B-2

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GAMMA EMITTERS* IN QUARTERLY COMPOSITES OF AIRBORNE PARTICULATES

Results in Units of 10^{-3} pCi/m^3 ± 2 sigma

Stations	Nuclides	First Quarter 12/31/97-04/01/98	Second Quarter 04/01/98-07/01/98	Third Quarter 07/01/98-09/30/98	Fourth Quarter 09/30/98-12/30/98	Average ±2 s.d.
ONS-1	Be-7	113 ± 11	167 ± 17	151 ± 15	129 ± 13	140 ± 48
	K-40	< 6	3.89 ± 1.91	< 4	< 5	3.89 ± 1.91
	Cs-134	< 0.3	< 0.2	< 0.3	< 0.3	-
	Cs-137	< 0.3	< 0.2	< 0.3	< 0.3	-
ONS-2	Be-7	65.7 ± 6.6	166 ± 17	135 ± 13	100 ± 10	79 ± 10
	K-40	< 7	< 5	< 7	< 4	-
	Cs-134	< 0.3	< 0.3	< 0.3	< 0.3	-
	Cs-137	< 0.3	< 0.3	< 0.3	< 0.2	-
ONS-3	Be-7	127 ± 13	130 ± 13	148 ± 15	93.8 ± 9.4	125 ± 45
	K-40	< 5	< 7	< 10	< 6	-
	Cs-134	< 0.3	< 0.3	< 0.3	< 0.2	-
	Cs-137	< 0.2	< 0.2	< 0.3	< 0.2	-
ONS-4	Be-7	118 ± 12	164 ± 16	184 ± 18	133 ± 13	150 ± 60
	K-40	10.7 ± 3.4	2.35 ± 1.34	< 4	< 5	6.53 ± 11.8
	Cs-134	< 0.4	< 0.3	< 0.2	< 0.3	-
	Cs-137	< 0.3	< 0.3	< 0.2	< 0.3	-
ONS-5	Be-7	101 ± 10	133 ± 13	148 ± 15	103 ± 10	121 ± 46
	K-40	< 4	< 5	< 6	< 5	-
	Cs-134	< 0.3	< 0.2	< 0.3	< 0.2	-
	Cs-137	< 0.2	< 0.3	< 0.2	< 0.2	-

* Typical LLDs are found in Table B-12. All other gamma emitters were <LLD.

E B-2 (Cont.)

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GAMMA EMITTERS* IN QUARTERLY COMPOSITES OF AIRBORNE PARTICULATES

Results in Units of 10^{-3} pCi/m^3 ± 2 sigma

Stations	Nuclides	First Quarter 12/21/97-04/01/98	Second Quarter 04/01/98-07/01/98	Third Quarter 07/01/98-09/30/98	Fourth Quarter 09/30/98-12/30/98	Average ±2 s.d.
ONS-6	Be-7	90.8 ± 9.1	136 ± 14	186 ± 19	101 ± 10	128 ± 86
	K-40	< 4	4.20 ± 2.06	< 5	< 4	4.20 ± 2.06
	Cs-134	< 0.2	< 0.2	< 0.3	< 0.2	-
	Cs-137	< 0.2	< 0.3	< 0.3	< 0.3	-
NBF	Be-7	107 ± 11	152 ± 15	170 ± 17	102 ± 10	133 ± 67
	K-40	3.63 ± 1.76	< 6	< 5	< 10	3.63 ± 1.76
	Cs-134	< 0.3	< 0.3	< 0.3	< 0.4	-
	Cs-137	< 0.3	< 0.3	< 0.2	< 0.3	-
SBN	Be-7	121 ± 12	152 ± 15	152 ± 15	100 ± 10	131 ± 51
	K-40	3.64 ± 1.94	< 5	< 6	< 10	3.64 ± 1.94
	Cs-134	< 0.2	< 0.3	< 0.3	< 0.3	-
	Cs-137	< 0.3	< 0.3	< 0.3	< 0.3	-
DOW	Be-7	90.4 ± 9.0	131 ± 13	158 ± 16	110 ± 11	122 ± 58
	K-40	< 4	12.6 ± 2.9	< 4	< 4	12.6 ± 2.9
	Cs-134	< 0.2	< 0.3	< 0.2	< 0.2	-
	Cs-137	< 0.2	< 0.3	< 0.3	< 0.2	-
COL	Be-7	91.2 ± 9.1	166 ± 17	144 ± 14	110 ± 11	128 ± 67
	K-40	< 7	< 5	2.38 ± 1.20	< 6	2.38 ± 1.20
	Cs-134	< 0.2	< 0.3	< 0.2	< 0.2	-
	Cs-137	< 0.2	< 0.2	< 0.2	< 0.2	-

* Typical LLDs are found in Table B-12. All other gamma emitters were <LLD.

TABLE B-3

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF IODINE-131 IN WEEKLY AIR CARTRIDGE SAMPLES

Results in Units of 10^{-3} pCi/m^3 ± 2 sigma

COLLECTION DATES	STATION CODES									
	ONS-1	ONS-2	ONS-3	ONS-4	ONS-5	ONS-6	NBF	SBN	DOW	COL
JANUARY 98										
01/07/98	< 10	< 10	< 10	< 10	< 6	< 7	< 7	< 8	< 8	< 5
01/14/98	< 10	< 10	< 10	< 10	< 6	< 9	< 10	< 10	< 10	< 7
01/21/98	< 10	< 10	< 10	< 10	< 6	< 7	< 8	< 8	< 8	< 5
01/28/98	< 10	< 10	< 10	< 10	< 6	< 7	< 7	< 8	< 8	< 5
02/04/98	< 10	< 10	< 10	< 10	< 6	< 7	< 7	< 8	< 8	< 5
FEBRUARY										
02/11/98	< 10	< 10	< 10	< 10	< 6	< 8	< 8	< 8	< 8	< 5
02/18/98	< 9	< 8	< 9	< 9	< 7	< 9	< 9	< 9	< 9	< 7
02/25/98	< 10	< 10	< 10	< 10	< 6	< 7	< 7	< 8	< 8	< 5
03/04/98	< 10	< 10	< 10	< 10	< 7	< 10	< 10	< 10	< 10	< 7
MARCH										
03/12/98	< 10	< 10	< 10	< 10	< 3 (a)	< 4 (a)	< 6	< 7	< 6	< 4
03/18/98	< 20	< 20	< 20	< 20	< 7 (b)	< 8	< 9	< 10	< 10	< 6
03/25/98	< 10	(c)	< 10	< 10	< 10	< 7	< 10	< 20	< 20	< 10
04/01/98	< 7	(c)	< 7	< 7	< 7	< 5	< 10	< 10	< 10	< 10

(a) Power off; reset. Low sample volume.
(b) Power loss.
(c) Sample not collected due to power loss.

TABLE B-3 (Cont.)

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF IODINE-131 IN WEEKLY AIR CARTRIDGE SAMPLES

Results in Units of 10^{-3} pCi/m^3 ± 2 sigma

	STATION CODES									
COLLECTION DATES	ONS-1	ONS-2	ONS-3	ONS-4	ONS-5	ONS-6	NBF	SBN	DOW	COL
APRIL										
04/08/98	< 10	(a)	< 10	< 10	< 10	< 6	< 7	< 8	< 8	< 8
04/15/98	< 6	(a)	< 7	< 7	< 7	< 5	< 10	< 10	< 10	< 10
04/22/98	< 4	(a)	< 6	< 6	< 7	< 7	< 5	< 10	< 10	< 10
04/29/98	< 6	< 8	< 6	< 6	< 5	< 10	< 10	< 10	< 10	< 7
MAY										
05/06/98	< 10	< 20	< 10	< 10	< 6	< 7	< 6	< 7	< 7	< 5
05/13/98	< 6	< 6	< 6	< 6	< 5	< 10	< 10	< 10	< 10	< 8
05/20/98	< 8	< 8	< 8	< 8	< 7	< 9	< 9	< 9	< 9	< 7
05/27/98	< 10	< 10	< 10	< 10	< 7	< 8	< 8	< 8	< 8	< 6
06/03/98	< 9	< 9	< 9	< 9	< 7	< 10	< 10	< 10	< 10	< 9
JUNE										
06/10/98	< 7	< 7	< 7	< 7	< 5	< 10	< 10	< 10	< 10	< 8
06/17/98	< 9	< 8	< 9	< 8	< 7	< 9	< 9	< 9	< 9	< 7
06/24/98	< 10	< 10	< 10	< 10	< 7	< 9	< 8	< 9	< 9	< 6
07/01/98	< 10	< 10	< 10	< 10	< 9	< 10	< 10	< 10	< 10	< 8

(a) Sample not collected due to power loss.

TABLE B-3 (Cont.)

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF IODINE-131 IN WEEKLY AIR CARTRIDGE SAMPLES

Results in Units of 10^{-3} $pCi/m^3 \pm 2$ sigma

COLLECTION DATES	STATION CODES ONS-1	ONS-2	ONS-3	ONS-4	ONS-5	ONS-6	NBF	SBN	DOW	COL
JULY										
07/08/98	< 10	< 10	< 10	< 10	< 40 (a)	< 40 (a)	< 6	< 7	< 7	< 7
07/15/98	< 7	< 7	< 7	< 7	< 8 (b)	< 8	< 6	< 7	< 6	< 5
07/22/98	< 10	< 10	< 20	< 10	< 8	< 9	< 8	< 8	< 8	< 6
07/29/98	< 9	< 9	< 9	< 10	< 8	< 10	< 8	< 9	< 9	< 7
AUGUST										
08/05/98	< 9	< 9	< 9	< 9	< 6	< 10	< 10	< 10	< 10	< 9
08/12/98	< 8	< 8	< 8	< 8	< 7	< 8	< 7	< 7	< 8	< 6
08/19/98	< 6	< 6	< 7	< 6	< 5	< 10	< 10	< 10	< 10	< 7
08/26/98	< 7	< 7	< 7	< 7	< 5	< 10	< 10	< 10	< 10	< 8
09/02/98	< 10	< 10	< 10	< 10	< 7	< 9	< 8	< 8	< 9	< 6
SEPTEMBER										
09/09/98	< 10	< 10	< 10	< 10	< 7	< 9	< 8	< 8	< 9	< 6
09/16/98	< 7	< 7	< 7	< 7	< 5	< 10	< 10	< 10	< 10	< 8
09/23/98	< 10	< 10	< 10	< 10	< 5 (c)	< 10	< 10	< 10	< 10	< 10
09/30/98	< 10	< 10	< 10	< 10	< 7	< 7	< 8	< 8	< 8	< 6

(a) Low sample volume.
(b) Breaker tripped; low sample volume.
(c) Sampler malfunction; actual flow volume could not be determined.

TABLE B-3 (Cont.)

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF IODINE-131 IN WEEKLY AIR CARTRIDGE SAMPLES

Results in Units of 10^{-3} pCi/m^3 ± 2 sigma

	STATION CODES									
COLLECTION DATES	**ONS-1**	**ONS-2**	**ONS-3**	**ONS-4**	**ONS-5**	**ONS-6**	**NBF**	**SBN**	**DOW**	**COL**
OCTOBER										
10/07/98	< 8	< 8	< 8	< 9	< 5	< 7	< 8	< 8	< 8	< 6
10/14/98	< 10	< 10	< 10	< 10	< 7	< 8	< 8	< 8	< 8	< 6
10/21/98	< 8	< 9	< 8	< 9	< 6	< 7	< 8	< 10	< 8	< 6
10/28/98	< 9	< 8	< 8	< 9	< 6	< 7	< 7	< 7	< 8	< 5
11/04/98	< 7	< 6	< 6	< 8	< 5	< 10	< 10	< 10	< 10	< 7
NOVEMBER										
11/11/98	< 10	< 10	< 10	< 20	< 7	< 7	< 8	< 7	< 8	< 6
11/18/98	< 20	< 10	< 10	< 10	< 7	< 10	< 10	< 10	< 10	< 8
11/25/98	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
12/02/98	< 7	< 6	< 6	< 6	< 8	< 20	< 10	< 10	< 10	< 7
DECEMBER										
12/09/98	< 8	< 8	< 8	< 9	< 7	< 20	< 10	< 10	< 10	< 9
12/16/98	< 7	< 7	< 7	< 7	< 5	< 10	< 10	< 10	< 10	< 7
12/23/98	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 8
12/30/98	< 20	< 20	< 20	< 20	< 10	< 10	< 10	< 10	< 10	< 8

TABLE B-4

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

DIRECT RADIATION MEASUREMENTS - QUARTERLY TLD RESULTS

Results in Units of mR/standard month

STATION CODES	FIRST QUARTER 12/31/97-04/01/98	SECOND QUARTER 04/01/98-07/01/98	THIRD QUARTER 07/01/98-09/30/98	FOURTH QUARTER 09/30/98-12/30/98	AVERAGE ± 2 s.d.
T-01	2.6 ± 0.2	2.7 ± 0.4	2.8 ± 0.3	3.2 ± 0.4	2.8 ± 0.5
T-02	2.7 ± 0.4	2.9 ± 0.2	2.8 ± 0.4	3.1 ± 0.3	2.9 ± 0.3
T-03	2.2 ± 0.1	2.4 ± 0.2	2.3 ± 0.1	2.4 ± 0.1	2.3 ± 0.2
T-04	2.7 ± 0.3	3.1 ± 0.3	2.9 ± 0.4	3.3 ± 0.3	3.0 ± 0.5
T-05	2.6 ± 0.3	2.8 ± 0.2	2.7 ± 0.3	3.1 ± 0.2	2.8 ± 0.4
T-06	2.5 ± 0.4	2.5 ± 0.8	2.8 ± 0.2	2.8 ± 0.2	2.7 ± 0.4
T-07	2.4 ± 0.2	2.7 ± 0.1	2.6 ± 0.5	2.8 ± 0.2	2.6 ± 0.3
T-08	2.4 ± 0.3	2.8 ± 0.4	2.9 ± 0.4	3.1 ± 0.4	2.8 ± 0.6
T-09	2.6 ± 0.2	2.8 ± 0.2	2.8 ± 0.3	2.8 ± 0.2	2.8 ± 0.2
T-10	2.2 ± 0.2	2.4 ± 0.2	2.2 ± 0.3	2.6 ± 0.2	2.4 ± 0.4
T-11	2.9 ± 0.3	2.9 ± 0.2	2.9 ± 0.4	3.2 ± 0.3	3.0 ± 0.3
T-12	2.7 ± 0.4	3.0 ± 0.3	2.9 ± 0.2	2.9 ± 0.1	2.9 ± 0.3
OFT-1	2.4 ± 0.9	2.9 ± 0.9	2.6 ± 0.3	3.0 ± 0.5	2.7 ± 0.6
OFT-2	2.2 ± 0.6	2.9 ± 0.3	2.6 ± 0.3	2.9 ± 0.3	2.7 ± 0.7
OFT-3	2.7 ± 0.3	3.0 ± 0.3	2.9 ± 0.4	3.0 ± 0.4	2.9 ± 0.3
OFT-4	2.6 ± 0.2	3.1 ± 0.7	3.0 ± 0.5	3.4 ± 0.6	3.0 ± 0.7
OFT-5	2.8 ± 0.3	3.1 ± 0.2	3.0 ± 0.4	3.4 ± 0.4	3.1 ± 0.5
OFT-6	3.7 ± 0.4	3.9 ± 0.8	4.1 ± 0.6	4.1 ± 0.4	4.0 ± 0.4
OFT-7	2.7 ± 0.3	3.2 ± 0.3	2.8 ± 0.3	3.1 ± 0.4	3.0 ± 0.5
OFT-8	3.4 ± 0.5	3.6 ± 0.6	3.7 ± 0.5	3.9 ± 0.5	3.7 ± 0.4
OFT-9	3.1 ± 0.5	3.4 ± 0.3	3.5 ± 0.5	0.5 ± 0.2	2.6 ± 2.9
OFT-10	2.5 ± 0.3	3.0 ± 0.1	2.7 ± 0.3	3.2 ± 0.4	2.9 ± 0.6
OFT-11	3.4 ± 0.6	3.8 ± 0.4	3.8 ± 0.4	3.9 ± 0.6	3.8 ± 0.4
NBF	3.3 ± 0.3	3.3 ± 0.7	3.4 ± 0.2	3.5 ± 0.3	3.4 ± 0.2
SBN	3.7 ± 0.5	3.9 ± 0.3	3.8 ± 0.5	3.9 ± 0.5	3.8 ± 0.2
DOW	2.6 ± 0.3	2.8 ± 0.2	2.7 ± 0.3	3.0 ± 0.2	2.8 ± 0.3
COL	2.5 ± 0.2	2.7 ± 0.2	2.6 ± 0.3	2.6 ± 0.3	2.6 ± 0.2
Average ± 2 s.d.	**2.7 ± 0.8**	**3.0 ± 0.8**	**3.0 ± 0.9**	**3.1 ± 1.3**	**3.0 ± 1.0**

* [illegible]d month = 30.4 days.

TABLE B-5

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF IODINE, TRITIUM AND GAMMA EMITTERS* IN SURFACE WATER

Results in Units of pCi/liter ± 2 sigma

STATION	Collection Date	I-131	K-40	Tritium
SWL-1 (Condenser Circ.)	01/31/98	< 0.6	< 50	< 100
	02/28/98	< 0.6	< 60	
	03/31/98	< 0.6	< 100	
	04/30/98	< 0.6	< 90	170 ± 90
	05/31/98	< 0.5	< 40	
	06/30/98	< 1	< 50	
	07/31/98	< 1	< 50	< 200
	08/31/98	< 0.7	< 90	
	09/30/98	< 0.9	< 40	
	10/31/98	< 0.6	< 50	< 300
	11/30/98	< 0.5	< 50	
	12/31/98	< 0.8	< 100	
SWL-2 (South Comp)	01/19/98 (a)	< 1	< 70	170 ± 100
	02/28/98	(b)		
	03/31/98	< 0.5	< 40	
	04/30/98	< 0.6	< 100	220 ± 90
	05/31/98	< 0.5	< 100	
	06/30/98	< 0.7	< 70	
	07/31/98	< 1	< 100	230 ± 120
	08/31/98	< 0.7	< 60	
	09/30/98	< 1	< 40	
	10/31/98	< 0.7	< 50	350 ± 170
	11/30/98	< 0.5	< 90	
	12/31/98	< 1	< 70	

(a) Collection period shortened due to ice on shoreline.
(b) Sample not collected due to ice on shoreline.
* Typical LLDs are found in Table B-12. All other gamma emitters were below <LLD.

TABLE B-5 (Cont.)

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF IODINE, TRITIUM AND GAMMA EMITTERS* IN SURFACE WATER

Results in Units of pCi/liter ± 2 sigma

STATION	Collection Date	I-131	K-40	Tritium
SWL-3	01/19/98 (a)	< 0.8	< 90	< 200
(North Comp)	02/28/98	(b)		
	03/31/98	< 0.6	< 50	
	04/30/98	< 0.6	< 100	230 ± 90
	05/31/98	< 0.5	< 90	
	06/30/98	< 0.8	< 50	
	07/31/98	< 1	< 70	< 200
	08/31/98	< 0.6	< 50	
	09/30/98	< 0.8	< 80	
	10/31/98	< 0.8	< 50	< 300
	11/30/98	< 0.5	< 100	
	12/31/98	< 0.8	< 50	

(a) Collection period shortened due to ice on shoreline.
(b) Sample not collected due to ice on shoreline.
*…ical LLDs are found in Table B-12. All other gamma emitte… e below <LLD.

TABLE B-6

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF TRITIUM AND GAMMA EMITTERS* IN GROUNDWATER

Results in Units of pCi/liter ± 2 sigma

STATION	Collection Date	I-131	K-40	Tritium
Well W-1	01/22/98	< 0.2	< 70	< 200
	04/23/98	< 0.3	< 40	< 100
	07/24/98	< 0.2	< 60	< 100
	10/22/98	< 0.3	< 50	< 200
Well W-2	01/22/98	< 0.3	< 50	< 200
	04/23/98	< 0.4	< 80	< 100
	07/24/98	< 0.3	< 90	< 100
	10/22/98	< 0.3	< 50	< 200
Well W-3	01/22/98	< 0.3	< 50	< 200
	04/23/98	< 0.3	< 100	< 100
	07/24/98	< 0.3	< 100	< 100
	10/22/98	< 0.3	< 90	< 200
Well W-4	01/23/98	< 0.2	< 50	1200 ± 200
	04/24/98	< 0.3	< 40	1600 ± 100
	07/24/98	< 0.3	< 100	1700 ± 100
	10/23/98	< 0.2	< 70	2300 ± 200
Well W-5	01/23/98	< 0.5	51.6 ± 26.2	3000 ± 200
	04/24/98	< 0.3	< 60	290 ± 70
	07/24/98	< 0.2	< 70	1600 ± 100
	10/23/98	< 0.2	< 90	750 ± 150
Well W-6	01/23/98	< 0.2	< 50	1700 ± 200
	04/24/98	< 0.3	< 50	1000 ± 100
	07/24/98	< 0.4	< 70	3300 ± 100
	10/23/98	< 0.3	< 50	1400 ± 100

* Footnotes located at end of table.

TABLE B-6 (Cont.)

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF TRITIUM AND GAMMA EMITTERS* IN GROUNDWATER

Results in Units of pCi/liter ± 2 sigma

STATION	Collection Date	I-131	K-40	Tritium
Well W-7	01/22/98	< 0.3	< 60	< 200
	04/23/98	< 0.4	< 40	< 100
	07/24/98	< 0.2	< 50	< 100
	10/22/98	< 0.4	< 40	< 200
Well W-8	01/23/98	< 0.2	< 50	< 200
	04/23/98	< 0.3	< 70	< 100
	07/24/98	< 0.2	< 50	< 100
	10/22/98	< 0.2	< 90	210 ± 120
Well W-9	01/23/98	< 0.3	< 90	< 200
	04/23/98	< 0.4	< 20	< 100
	07/24/98	< 0.3	< 50	< 100
	10/22/98	< 0.3	< 60	< 200
Well W-10	01/22/98	< 0.3	< 60	< 200
	04/23/98	< 0.4	< 50	< 100
	07/24/98	< 0.3	< 90	< 100
	10/22/98	< 0.3	< 60	< 200
Well W-11	01/23/98	< 0.3	< 60	< 200
	04/23/98	< 0.5	< 90	< 100
	07/24/98	< 0.2	< 50	< 100
	10/22/98	< 0.3	< 90	< 200
Well W-12	01/23/98	< 0.3	< 50	< 200
	04/23/98	< 0.4	< 90	< 100
	07/24/98	< 0.2	< 60	< 100
	10/22/98	< 0.3	< 80	< 200

* Footnotes located at end of table.

BLE B-6 (Cont.)

INDIANA MICHIGAN POWE MPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF TRITIUM AND GAMMA EMITTERS* IN GROUNDWATER

Results in Units of pCi/liter ± 2 sigma

STATION	Collection Date	I-131	K-40	Tritium
Well W-13	01/23/98	< 0.2	< 90	< 200
	04/23/98	< 0.3	< 100	< 100
	07/24/98	< 0.2	< 100	< 100
	10/22/98	< 0.3	< 50	< 200
Well W-14	01/23/98	< 0.3	< 50	1800 ± 200
	04/23/98	< 0.5	41.2 ± 21.9	< 100
	07/24/98	< 0.4	< 90	< 100
	10/22/98	< 0.3	< 60	< 200
Average ± 2 s.d.			**46.4 ± 14.7**	**1561 ± 1781**

* Typical LLDs are found in Table B-12. All other gamma emitters were LLD.

TABLE B-7

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GROSS BETA, IODINE, TRITIUM AND GAMMA EMITTERS* IN DRINKING WATER

Results in Units of pCi/liter ± 2 sigma

COLLECTION DATE	Gross Beta	Gamma Spec	Iodine-131	Tritium
LTW				
01/14/98	2.4 ± 0.9	< LLD	< 0.3	< 100
01/28/98	3.3 ± 0.9	< LLD	< 0.3	
02/11/98	2.4 ± 0.9	< LLD	< 0.3	
02/25/98	3.7 ± 1.0	< LLD	< 0.3	
03/11/98	2.5 ± 0.8	< LLD	< 0.4	
03/25/98	3.4 ± 1.0	< LLD	< 0.3	
04/08/98	1.8 ± 0.9	< LLD	< 0.3	< 100
04/22/98	2.1 ± 0.9	< LLD	< 0.3	
05/06/98	3.2 ± 0.9	< LLD	< 0.4	
05/20/98	3.1 ± 0.9	< LLD	< 0.4	
06/03/98	3.3 ± 0.9	< LLD	< 0.4	
06/17/98	2.9 ± 0.9	< LLD	< 0.4	
07/01/98	2.4 ± 0.9	< LLD	< 0.4	< 200
07/15/98	2.7 ± 1.0	< LLD	< 0.4	
07/29/98	3.0 ± 0.9	< LLD	< 0.5	
08/12/98	1.6 ± 1.0	< LLD	< 0.3	
08/26/98	2.7 ± 0.8	< LLD	< 0.6	
09/09/98	2.6 ± 0.9	< LLD	< 0.4	
09/23/98	3.1 ± 0.9	< LLD	< 0.2	
10/07/98	2.9 ± 0.9	< LLD	< 0.4	< 200
10/21/98	2.6 ± 0.9	< LLD	< 0.3	
11/04/98	2.9 ± 0.9	< LLD	< 0.3	
11/18/98	3.5 ± 0.9	< LLD	< 0.4	
12/02/98	2.3 ± 0.8	< LLD	< 1	
12/16/98	2.3 ± 0.8	< LLD	< 0.3	
12/30/98	3.3 ± 0.9	< LLD	< 0.4	
Average ± 2 s.d.	2.8 ± 1.1			

* [illegible]al LLDs are found in table B-12.

TA[illegible]-7 (Cont.)

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GROSS BETA, IODINE, TRITIUM AND GAMMA EMITTERS* IN DRINKING WATER

Results in Units of pCi/liter ± 2 sigma

COLLECTION DATE	Gross Beta	Gamma Spec	Iodine-131	Tritium
STJ				
01/14/98	2.5 ± 0.9	< LLD	< 0.3	< 100
01/28/98	3.3 ± 0.9	< LLD	< 0.4	
02/11/98	1.9 ± 0.9	< LLD	< 0.3	
02/25/98	1.9 ± 0.9	< LLD	< 0.3	
03/11/98	3.0 ± 0.9	< LLD	< 0.4	
03/25/98	8.9 ± 1.3	< LLD	< 0.2	
04/08/98	2.5 ± 1.0	< LLD	< 0.4	< 100
04/22/98	3.0 ± 1.0	< LLD	< 0.2	
05/06/98	3.2 ± 0.9	< LLD	< 0.5	
05/20/98	2.6 ± 0.9	< LLD	< 0.4	
06/03/98	2.8 ± 0.9	< LLD	< 0.4	
06/17/98	3.1 ± 1.0	< LLD	< 0.3	
07/01/98	2.5 ± 1.0	< LLD	< 0.4	< 200
07/15/98	4.0 ± 1.1	< LLD	< 0.4	
07/29/98	3.9 ± 0.9	< LLD	< 0.5	
08/12/98	2.5 ± 1.1	< LLD	< 0.5	
08/26/98	3.4 ± 0.9	< LLD	< 0.6	
09/09/98	4.0 ± 1.0	< LLD	< 0.4	
09/23/98	3.0 ± 0.9	< LLD	< 0.2	
10/07/98	2.2 ± 1.0	< LLD	< 0.3	< 200
10/21/98	2.5 ± 0.9	< LLD	< 0.3	
11/04/98	3.3 ± 1.0	< LLD	< 0.3	
11/18/98	2.6 ± 0.9	< LLD	< 0.4	
12/02/98	2.5 ± 0.8	< LLD	< 0.9	
12/16/98	1.5 ± 0.7	< LLD	< 0.3	
12/30/98	3.3 ± 0.9	< LLD	< 0.3	
Average ± 2 s.d.	**3.1 ± 2.7**			

* Typical LLDs are found in table B-12.

TABLE B-8

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GAMMA EMITTERS* IN SEDIMENT

Results in Units of pCi/kg (dry) ± 2 sigma

Station	Collection Date	Be-7	K-40	Cs-137	Ra-226	Th-228
SL-2	04/16/98	< 200	4850 ± 480	< 30	< 500	500 ± 50
SL-3	04/17/98	< 200	4980 ± 500	< 20	< 300	87.2 ± 15.1
SL-2	10/15/98	< 200	5410 ± 540	< 30	< 500	294 ± 30
SL-3	10/15/98	< 100	5110 ± 510	< 20	< 300	99.1 ± 20.7
Average			5088 ± 480			245 ± 389

* [illegible]cal LLDs are found in table B-12. All other gamma emitters [illegible]LLD.

TABLE B-9

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF IODINE AND GAMMA EMITTERS* IN MILK

Results in Units of pCi/liter ± 2 sigma

COLLECTION DATES	ANALYSIS	STATION CODES

There were no milk analyses completed during 1998 due to lack of participants to meet the minimum requirements of the REMP program. In lieu of milk, broadleaf vegetation samples were collected.

TA -10

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GAMMA EMITTERS* IN BROADLEAF VEGETATION COLLECTED IN LIEU OF MILK

Results in Units of pCi/kg (wet) ± 2 sigma

COLLECTION DATE	Station	Description	Be-7	K-40	I-131	Cs-137
05/27/98	Sector-J	Broadleaf	749 ± 75	5090 ± 510	< 20	< 9
05/27/98	Sector-A	Broadleaf	513 ± 96	3230 ± 320	< 20	< 10
05/27/98	Sector-A	Broadleaf	591 ± 77	3780 ± 380	< 10	< 10
05/27/98	Sector-A	Broadleaf	512 ± 111	3560 ± 360	< 20	< 20
06/24/98	Sector-J	Broadleaf	1090 ± 110	5700 ± 570	< 20	< 10
06/24/98	Sector-A	Broadleaf	1090 ± 150	5400 ± 540	< 20	< 20
06/24/98	Sector-A	Broadleaf	758 ± 119	4430 ± 440	< 20	< 20
06/24/98	Sector-A	Broadleaf	799 ± 97	2540 ± 250	< 20	< 10
07/22/98	Sector-J	Broadleaf	1160 ± 120	4570 ± 460	< 10	< 10
07/22/98	Sector-A	Broadleaf	2150 ± 210	1570 ± 160	< 10	< 20
07/22/98	Sector-A	Broadleaf	1280 ± 130	2780 ± 280	< 10	< 10
07/22/98	Sector-A	Broadleaf	825 ± 152	4200 ± 420	< 10	< 20
07/29/98	Sector-A	Broadleaf	2090 ± 210	1370 ± 160	< 100 (a)	< 20
08/19/98	Sector-J	Broadleaf	1290 ± 130	5360 ± 540	< 20	< 20
08/19/98	Sector-A	Broadleaf	899 ± 221	3900 ± 390	< 20	< 30
08/19/98	Sector-A	Broadleaf	1170 ± 200	6330 ± 630	< 20	< 30
08/19/98	Sector-A	Broadleaf	597 ± 86	2160 ± 220	< 20	< 10
09/11/98	Sector-J	Broadleaf	3810 ± 380	4610 ± 460	< 20	< 20
09/16/98	Sector-A	Broadleaf	1450 ± 170	7910 ± 790	< 20	< 30
09/16/98	Sector-A	Broadleaf	2340 ± 260	4680 ± 470	< 20	< 30
09/16/98	Sector-A	Broadleaf	1140 ± 120	1710 ± 170	< 20	< 20

(a) LLD for I-131 inadvertently not met by laboratory due to delay of analysis.
* Typical LLDs are found in table B-12. All other gamma emitters were <LLD.

TABLE B-10 (Cont.)

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GAMMA EMITTERS* IN BROADLEAF VEGETATION COLLECTED IN LIEU OF MILK

Results in Units of pCi/kg (wet) ± 2 sigma

COLLECTION DATE	Station	Description	Be-7	K-40	I-131	Cs-137
10/14/98	Sector-J	Broadleaf	1230 ± 120	3790 ± 380	< 50	< 10
10/14/98	Sector-A	Broadleaf	1660 ± 170	4470 ± 450	< 40	< 20
10/14/98	Sector-A	Broadleaf	3820 ± 380	3490 ± 350	< 40	< 20
10/14/98	Sector-A	Broadleaf	1200 ± 150	1290 ± 170	< 50	< 20
Average ± 2 s.d.			**1369 ± 1768**	**3917 ± 3256**		

* pical LLDs are found in table B-12. All other gamma emitters e <LLD.

TABLE B-11

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GAMMA EMITTERS* IN FISH

Results in Units of pCi/kg (wet) ± 2 sigma

Collection Date	Station	Description	Be-7	K-40	Cs-137	Ra-226	Th-228
07/30/98	ONS-N		< 200	3930 ± 390	< 10	< 200	< 20
08/21/98	OFS-N		< 100	2590 ± 260	25.2 ± 10.9	< 200	< 20
08/21/98	ONS-N		< 90	3000 ± 300	32.4 ± 9.4	< 200	< 20
08/21/98	ONS-S		< 90	3530 ± 350	75.6 ± 8.7	< 200	< 20
08/21/98	OFS-S		< 100	2730 ± 270	< 10	< 200	< 20
Average ± 2 s.d.				**3156 ± 1125**	**44.4 ± 54.5**		

* Typical LLDs are found in table B-12. All other gamma emitters were <LLD.

TABLE B-12

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

CONCENTRATIONS OF GAMMA EMITTERS* IN FOOD/VEGETATION

Results in Units of pCi/kg (wet) ± 2 sigma

COLLECTION DATE	Station	Description	Be-7	K-40	I-131	Cs-137
09/17/98	Sector-J	Grapes	< 60	2600 ± 260	< 10	< 7
09/17/98	Sector-D	Grapes	90.3 ± 33.2	2910 ± 290	< 8	< 5
09/17/98	Sector-J	Leaves	2300 ± 230	2470 ± 260	< 40	< 30
09/17/98	Sector-D	Leaves	4350 ± 440	2570 ± 260	< 30	< 20
Average ± 2 s.d.			**2247 ± 4261**	**2638 ± 380**		

* [illegible]ical LLDs are found in table B-12. All other gamma emitters [illegible] <LLD.

T[illegible] B-13

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

GAMMA SPECTROMETRY LOWER LIMITS OF DETECTION AND REPORTING LEVELS

Isotope	TI LLD	ODCM LLD	Rept Level	TI LLD	ODCM LLD	Rept Level
	Vegetation - pCi/Kg-wet			Water - pCi/liter		
Cerium-144	60	N/A	N/A	30	N/A	N/A
Barium/La-140	10	N/A	N/A	50/10	60/15	200
Cesium-134	10	60	1000	7	15	30
Ru,Rh-106	80	N/A	N/A	50	N/A	N/A
Cesium-137	10	60	2000	6	18	50
Zr,Nb-95	10	N/A	N/A	10/15	30/15	400
Manganese-54	10	N/A	N/A	5	15	1000
Iron-59	15	N/A	N/A	15	30	400
Zinc-65	20	N/A	N/A	10	30	300
Cobalt-60	10	N/A	N/A	5	15	300
Cobalt-58	10	N/A	N/A	5	15	1000
Iodine-131	20	60	100	10	1	2
Iodine-131 (a)				1	1	
	Milk - pCi/liter			Air Filter - pCi/m3		
Cerium-144	30	N/A	N/A	0.007	N/A	N/A
Barium/La-140	50/10	60/15	300	0.005	N/A	N/A
Cesium-134	7	15	60	0.002	0.06	10
Ru,Rh-106	50	N/A	N/A	0.010	N/A	N/A
Cesium-137	6	18	70	0.002	0.06	20
Zr,Nb-95	20	N/A	N/A	0.002	N/A	N/A
Manganese-54	5	N/A	N/A	0.002	N/A	N/A
Iron-59	15	N/A	N/A	0.002	N/A	N/A
Zinc-65	10	N/A	N/A	0.002	N/A	N/A
Cobalt-60	5	N/A	N/A	0.002	N/A	N/A
Cobalt-58	5	N/A	N/A	0.002	N/A	N/A
Iodine-131	10	1	3	0.040	0.07	0.9
Iodine-131 (a)	1	1				

(a) Analysis by radiochemistry and based on the assumptions in Procedure PRO-032-11.
* Charcoal Trap

TABLE B-13 (Cont.)

INDIANA MICHIGAN POWER COMPANY - DONALD C. COOK NUCLEAR PLANT

GAMMA SPECTROMETRY LOWER LIMITS OF DETECTION AND REPORTING LEVELS

Isotope	TI LLD	ODCM LLD	Rept Level	TI LLD	ODCM LLD	Rept Level
	FISH - pCi/Kg-wet (b)			Sediment/Soil - pCi/Kg-dry		
Cerium-144	200	N/A	N/A	150	N/A	N/A
Barium/La-140	200	N/A	N/A	5	N/A	N/A
Cesium-134	20	130	1000	30	150	N/A
Ru,Rh-106	200	N/A	N/A	200	N/A	N/A
Cesium-137	20	150	2000	30	180	N/A
Zr,Nb-95	40	N/A	N/A	40	N/A	N/A
Manganese-54	20	130	30000	9	N/A	N/A
Iron-59	40	260	10000	50	N/A	N/A
Zinc-65	40	260	20000	60	N/A	N/A
Cobalt-60	20	130	10000	20	N/A	N/A
Cobalt-58	20	130	30000	20	N/A	N/A
Iodine-131	100	N/A	N/A	30	N/A	N/A

Gross Beta/Tritium LLDs and Reporting Levels

	Gross Beta		
Air Particulates	0.01 pCi/m^3	0.01 pCi/m^3	N/A
Drinking Water	2 pCi/l	4.0 pCi/l	N/A
	Tritium - pCi/l		
Surface Water	200	2000	20,000
Ground Water	200	2000	20,000
Drinking Water	200	2000	20,000

(b) Based on the assumptions in procedure PRO-042-5.

APPENDIX C
ANALYTICAL PROCEDURES SYNOPSIS

ANALYTICAL PROCEDURES SYNOPSIS

Appendix C is a synopsis of the analytical procedures performed during 1998 on samples collected for the Donald C. Cook Nuclear Plant's Radiological Environmental Monitoring Program. All analyses have been mutually agreed upon by American Electric Power and Teledyne Brown Engineering and include those recommended by the USNRC Regulatory Guide 4.8,BTP, Rev. 1, November 1979.

GROSS BETA ANALYSIS OF SAMPLES

Airborne Particulates

After a delay of five or more days, allowing for the radon-222 and radon-220 (thoron) daughter products to decay, the filters are counted in a gas-flow proportional counter. An unused air particulate filter, supplied by the customer, is counted as the blank.

Calculations of the results, the two sigma error and the lower limit of detection (LLD):

$$\text{RESULT } (\text{pCi/m}^3) = ((S/T) - (B/t))/(2.22\ V\ E)$$

$$\text{TWO SIGMA ERROR } (\text{pCi/m}^3) = 2((S/T^2) + (B/t^2))^{1/2}/(2.22\ V\ E)$$

$$\text{LLD } (\text{pCi/m}^3) = 4.66\ (B/t/T)^{1/2}/(2.22\ V\ E)$$

where:

S = Gross counts of sample including blank
B = Counts of blank
E = Counting efficiency
T = Number of minutes sample was counted
t = Number of minutes blank was counted
V = Sample aliquot size (cubic meters)

DETERMINATION OF GROSS BETA ACTIVITY IN WATER SAMPLES

1.0 INTRODUCTION

The procedures described in this section are used to measure the overall radioactivity of water samples without identifying the radioactive species present. No chemical separation techniques are involved.

One liter of the sample is evaporated on a hot plate. A smaller volume may be used if the sample has a significant salt content. If requested by the customer, the sample is filtered through No. 54 filter paper before evaporation, removing particles greater than 30 microns in size.

After evaporating to a small volume in a beaker, the sample is rinsed into a 2-inch diameter stainless steel planchet which is stamped with a concentric ring pattern to distribute residue evenly. Final evaporation to dryness takes place under heat lamps.

Residue mass is determined by weighing the planchet before and after mounting the sample. The planchet is counted for beta activity on an automatic proportional counter. Results are calculated using empirical self-absorption curves which allow for the change in effective counting efficiency caused by the residue mass.

2.0 DETECTION CAPABILITY

Detection capability depends upon the sample volume actually represented on the planchet, the background and the efficiency of the counting instrument, and upon self-absorption of beta particles by the mounted sample. Because the radioactive species are not identified, no decay corrections are made and the reported activity refers to the counting time.

The minimum detectable level (MDL) for water samples is nominally 1.6 picocuries per liter for gross beta at the 4.66 sigma level (1.0 pCi/l at the 2.83 sigma level), assuming that 1 liter of sample is used and that $\frac{1}{2}$ gram of sample residue is mounted on the planchet. These figures are based upon a counting time of 50 minutes and upon representative values of counting efficiency and background of 0.2 and 1.2 cpm, respectively.

The MDL becomes significantly lower as the mount weight decreases because of reduced self-absorption. At a zero mount weight, the 4.66 sigma MDL for gross beta is 0.9 picocuries per liter. These values reflect a beta counting efficiency of 0.38.

ANALYSIS OF SAMPLES FOR TRITIUM

(Liquid Scintillation)

Water

Ten milliliters of water are mixed with 10 ml of a liquid scintillation "cocktail" and then the mixture is counted in an automatic liquid scintillator.

Calculation of the results, the two sigma error and the lower limit detection (LLD) in pCi/l:

RESULT = $(N-B)/(2.22\ V\ E)$

TWO SIGMA ERROR = $2((N + B)/\Delta t)^{1/2}/\ (2.22\ V\ E)$

LLD = $4.66\ (B/\Delta t)^{1/2}/(2.22\ V\ E\ )$

where:	N	=	the gross cpm of the sample
	B	=	the background of the detector in cpm
	2.22	=	conversion factor changing dpm to pCi
	V	=	volume of the sample in ml
	E	=	efficiency of the detector
	Δt	=	counting time for the sample

ANALYSIS OF SAMPLES FOR IODINE-131

Milk or Water

Two liters of sample are first equilibrated with stable iodide carrier. A batch treatment with anion exchange resin is used to remove iodine from the sample. The iodine is then stripped from the resin with sodium hypochlorite solution, reduced with hydroxylamine hydrochloride and extracted into toluene as free iodine. It is then back-extracted as iodide into sodium bisulfite solution and is precipitated as palladium iodide. The precipitate is weighed for chemical yield and is mounted on a nylon planchet for low level beta counting. The chemical yield is corrected by measuring the stable iodide content of the milk or the water with a specific ion electrode.

Calculations of results, two sigma error and the lower limit of detection (LLD) in pCi/l:

RESULT		=	$(N/\Delta t-B)/(2.22\ E\ V\ Y\ DF)$
TWO SIGMA ERROR		=	$2((N/\Delta t+B)/\Delta t)^{1/2}(2.22\ E\ V\ Y\ DF)$
LLD		=	$= 4.66(B/\Delta t)^{1/2}/(2.22\ E\ V\ Y\ DF)$
where:	N	=	total counts from sample (counts)
	Δt	=	counting time for sample (min)
	B	=	background rate of counter (cpm)
	2.22	=	dpm/pCi
	V	=	volume or weight of sample analyzed
	Y	=	chemical yield of the mount or sample counted
	DF	=	decay factor from the collection to the counting date
	E	=	efficiency of the counter for I-131, corrected for self absorption effects by the formula
	E	=	$E_s(\exp{-0.0085M})/(\exp{-0.0085M_s})$
	E_s	=	efficiency of the counter determined from an I-131 standard mount
	Ms	=	mass of PdI_2 on the standard mount, mg
	M	=	mass of PdI_2 on the sample mount, mg

GAMMA SPECTROMETRY OF SAMPLES

Milk and Water

A 1.0 liter Marinelli beaker is filled with a representative aliquot of the sample. The sample is then counted for approximately 1000 minutes with a shielded Ge(Li) detector coupled to a mini-computer-based data acquisition system which performs pulse height analysis.

Dried Solids other than Soils and Sediments

A large quantity of the sample is dried at a low temperature, less than 100°C. As much as possible (up to the total sample) is loaded into a tared 1-liter Marinelli and weighed. The sample is then counted for approximately 1000 minutes with a shielded Ge(Li) detector coupled to a mini-computer-based data acquisition system which performs pulse height analysis.

Fish

As much as possible (up to the total sample) of the edible portion of the sample is loaded into a tared Marinelli and weighed. The sample is then counted for approximately 1000 minutes with a shielded Ge(Li) detector coupled to a mini-computer-based data acquisition system which performs pulse height analysis.

Soils and Sediments

Soils and sediments are dried at a low temperature, less than 100°C. The soil or sediment is loaded fully into a tared, standard 300 cc container and weighed. The sample is then counted for approximately six hours with a shielded Ge(Li) detector coupled to a mini-computer-based data acquisition system which performs pulse height analysis.

Charcoal Cartridges (Air Iodine)

Charcoal cartridges are counted up to five at a time, with one positioned on the face of a Ge(Li) detector and up to four on the side of the Ge(Li) detector. Each Ge(li) detector is calibrated for both positions. The detection limit for I-131 of each charcoal cartridge can be determined

(assuming no positive I-131) uniquely from the volume of air which passed through it. In the event I-131 is observed in the initial counting of a set, each charcoal cartirdge is then counted separately, positioned on the face of the detector.

Airborne Particulates

The thirteen airborne particulate filters for a quarterly composite for each field station are aligned one in front of another and then counted for at least six hours with a shielded Ge(Li) detector coupled to a mini-computer-based data acquisition system which performs pulse height analysis.

A mini-computer software program defines peaks by certain changes in the slope of the spectrum. The program also compares the energy of each peak with a library of peaks for isotope identification and then performs the radioactivity calculation using the appropriate fractional gamma ray abundance, half life, detector efficiency, and net counts in the peak region. The calculation of results, two sigma error and the lower limit of detection (LLD) in pCi/volume of pCi/mass:

RESULT		=	$(S-B)/2.22\ t\ E\ V\ F\ DF)$
TWO SIGMA ERROR		=	$2(S+B)^{1/2}/(2.22\ t\ E\ V\ F\ DF)$
LLD		=	$4.66(B)^{1/2}/(2.22\ t\ E\ V\ F\ DF)$
where:	S	=	Area, in counts, of sample peak and background (region of spectrum of interest)
	B	=	Background area, in counts, under sample peak, determined by a linear interpolation of the representative backgrounds on either side of the peak
	t	=	length of time in minutes the sample was counted
	2.22	=	dpm/pCi
	E	=	detector efficiency for energy of interest and geometry of sample
	V	=	sample aliquot size (liters, cubic meters, kilograms, or grams)
	F	=	fractional gamma abundance (specific for each emitted gamma)
	DF	=	decay factor from the mid-collection date to the counting date

ENVIRONMENTAL DOSIMETRY

Teledyne Brown Engineering uses a $CaSO_4$:Dy thermoluminescent dosimeter (TLD) which the company manufactures. This material has a high light output, negligible thermally induced signal loss (fading), and negligible self dosing. The energy response curve (as well as all other features) satisfies NRC Reg. Guide 4.13. Transit doses are accounted for by use of separate TLDs.

Following the field exposure period the TLDs are placed in a Teledyne Isotopes Model 8300. One fourth of the rectangular TLD is heated at a time and the measured light emission (luminescence) is recorded. The TLD is then annealed and exposed to a known Cs-137 dose; each area is then read again. This provides a calibration of each area of each TLD after every field use. The transit controls are read in the same manner.

Calculations of results and the two sigma error in net milliRoentgen (mR):

RESULT $D = (D_1+D_2+D_3+D_4)/4$

TWO SIGMA ERROR = $2((D_1-D)^2+(D_2-D)^2+(D_3-D)^2+(D_4-D)^2)/3)^{1/2}$

WHERE:

D_1 = the net mR of area 1 of the TLD, and similarly for D_2, D_3, and D_4

D1 = $I_1 K/R_1 - A$

I_1 = the instrument reading of the field dose in area 1

K = the known exposure by the Cs-137 source

R_1 = the instrument reading due to the Cs-137 dose on area 1

A = average dose in mR, calculated in similar manner as above, of the transit control TLDs

D = the average net mR of all 4 areas of the TLD.

APPENDIX D

SUMMARY OF EPA INTERLABORATORY COMPARISONS

EPA Interlaboratory Comparison Program

Teledyne Brown Engineering participates in the US EPA Interlaboratory Comparison Program to the fullest extent possible. That is, we participate in the program for all radioactive isotopes prepared and at the maximum frequency of availability. Beginning with 1997, the US EPA discontinued providing milk and air particulate filter samples. For replacements, we have purchased comparable spiked samples from Analytics, Inc.

In this section, 1998 data summary tables are presented for isotopes in the various sample media applicable to the Donald C. Cook Nuclear Plant's Radiological Environmental Monitoring Program. The footnotes of the table discuss investigations of problems encountered in a few cases and the steps taken to prevent reoccurrence.

EPA INTERLABORATORY COMPARISON PROGRAM 1998
Environmental

Collection Date	Media	Nuclide	EPA Result(a)		Teledyne Brown Engineering Result(b)		Deviation(c)	
01/16/98	Water	Sr-89	8.0 ±	5.0	5.00 ±	1.73	-1.04	
		Sr-90	32.0 ±	5.0	31.67 ±	0.58	-0.12	
01/30/98	Water	Gr-Alpha	30.5 ±	7.6	33.00 ±	2.65	0.57	
		Gr-Beta	3.9 ±	5.0	5.60 ±	0.90	0.59	
02/06/98	Water	I-131	104.9 ±	10.5	110.00 ±	0.00	0.84	
02/13/98	Water	Ra-226	16.0 ±	2.4	14.67 ±	0.58	-0.96	
		Ra-228	33.3 ±	8.3	32.00 ±	2.00	-0.27	
03/13/98	Water	H-3	2155.0 ±	348.0	1833.33 ±	57.74	-1.60	
04/21/98	Water	Gr-Alpha	54.4 ±	13.6	50.00 ±	1.73	-0.56	
		Ra-226	15.0 ±	2.3	15.00 ±	0.00	0.00	
		Ra-228	9.3 ±	2.3	8.50 ±	0.20	-0.60	
		Gr-Beta	94.7 ±	10.0	102.00 ±	6.56	1.26	
		Sr-89	6.0 ±	5.0	4.67 ±	1.15	-0.46	
		Sr-90	18.0 ±	5.0	21.67 ±	1.15	1.27	
		Co-60	50.0 ±	5.0	52.33 ±	1.53	0.81	
		Cs-134	22.0 ±	5.0	21.00 ±	1.00	-0.35	
		Cs-137	10.0 ±	5.0	11.67 ±	0.58	0.58	
06/05/98	Water	Co-60	12.0 ±	5.0	13.00 ±	1.00	0.35	
		Zn-65	104.0 ±	10.0	111.67 ±	2.52	1.33	
		Cs-134	31.0 ±	5.0	32.33 ±	0.58	0.46	
		Cs-137	35.0 ±	5.0	37.67 ±	2.08	0.92	
		Ba-133	40.0 ±	5.0	35.00 ±	2.65	-1.73	
06/12/98	Water	Ra-226	4.9 ±	0.7	4.47 ±	0.85	-1.07	
		Ra-228	2.1 ±	0.5	1.93 ±	0.21	-0.58	
07/17/98	Water	Sr-89	21.0 ±	5.0	21.00 ±	1.00	0.00	
		Sr-90	7.0 ±	5.0	6.33 ±	0.58	-0.23	
07/24/98	Water	Gr-Alpha	7.2 ±	5.0	5.43 ±	0.64	-0.61	
		Gr-Beta	12.8 ±	5.0	14.67 ±	2.08	0.65	
08/07/98	Water	H-3	17996.0 ±	1800.0	16000.00 ±	0.00	-1.92	
09/11/98	Water	I-131	6.1 ±	2.0	5.93 ±	0.55	-0.14	
09/18/98	Water	Ra-226	1.7 ±	0.3	1.53 ±	0.46	-0.96	
		Ra-228	5.7 ±	1.4	6.70 ±	0.35	1.24	
10/20/98	Water	Gr-Beta	94.0 ±	10.0	74.67 ±	7.64	-3.35	(d)
		Sr-89	19.0 ±	5.0	18.33 ±	1.53	-0.23	
		Sr-90	8.0 ±	5.0	8.33 ±	1.15	0.12	
		Co-60	21.0 ±	5.0	22.33 ±	1.15	0.46	
		Cs-134	6.0 ±	5.0	6.67 ±	0.58	0.23	
		Cs-137	50.0 ±	5.0	56.33 ±	3.79	2.19	(e)

EPA INTERLABORATORY COMPARISON PROGRAM 1998
Environmental

Collection Date	Media	Nuclide	EPA Result(a)		Teledyne Brown Engineering Result(b)		Deviation(c)	
10/20/98		Gr-Alpha	30.1 ±	7.5	21.67 ±	2.31	-1.95	
		Ra-226	4.5 ±	0.7	4.67 ±	0.25	0.41	
		Ra-228	1.5 ±	0.4	1.9 ±	0.20	1.73	
11/11/98	Water	Co-60	38.0 ±	5.0	39.67 ±	2.52	0.58	
		Zn-65	131.0 ±	13.0	140.67 ±	10.97	1.29	
		Cs-134	105.0 ±	5.0	103.00 ±	2.00	-0.69	
		Cs-137	111.0 ±	6.0	115.33 ±	1.53	1.25	
		Ba-133	56.0 ±	6.0	46.33 ±	2.52	-2.79	(e)

Footnotes:

(a) EPA Results-Expected laboratory precision (1 sigma). Units are pCi/liter for water and milk except K is in mg/liter. Units are total pCi for air particulate filters.

(b) Teledyne Results - Average ± one sigma. Units are pCi/liter for water and milk except K is in mg/liter. Units are total pCi for air particulate filters.

(c) Normalized deviation from the known.

(d) The special EPA instructions concerning multiple evaporation with concentrated nitric acid (to purge chlorides derived from HCl preservative) were omitted by oversight. The chlorides cause greater self absorption and lead to lower results. Two additional aliquots using two evaporations with concentrated nitric acid were analyzed. The results, when corrected for decay of Sr-89, were 87 and 83 pCi/liter which compare favorably with the EPA result.

(e) An investigation is being conducted. If the results of this investigation reveal an analytical deficiency, then a separate report will be provided.

ANALYTICS CROSS CHECK COMPARISON PROGRAM 1998

Sample ID	Media	Nuclide	Teledyne Brown Engineering Result (a)	Analytics Result	Ratio (b)
E1346-396	Milk	I-131	87 ± 9	82 ± 4	1.06
TI #71657		Ce-141	66 ± 7	70 ± 4	0.94
03/12/98		Cr-51	220 ± 30	201 ± 10	1.09
		Cs-134	85 ± 9	84 ± 4	1.01
		Cs-137	180 ± 20	161 ± 8	1.12
		Mn-54	130 ± 10	133 ± 7	0.98
		Fe-59	110 ± 10	95 ± 5	1.16
		Zn-65	160 ± 20	142 ± 7	1.13
		CO-60	82 ± 8	85 ± 4	0.96
E1460-396	Milk	I-131	68 ± 7	67 ± 3	1.01
TI #78921		Ce-141	94 ± 9	99 ± 5	0.95
06/11/98		Cr-51	97 ± 31	132 ± 7	0.73
		Cs-134	101 ± 10	95 ± 5	1.06
		Cs-137	79 ± 8	70 ± 4	1.13
		Mn-54	112 ± 11	106 ± 5	1.06
		Fe-59	58 ± 9	45 ± 2	1.29
		Zn-65	143 ± 14	122 ± 6	1.17
		CO-60	157 ± 16	143 ± 7	1.10
E1630-396	Milk	I-131	65 ± 1	71 ± 4	0.92
TI #94881		Ce-141	647 ± 65	746 ± 37	0.87
12/14/98		Cr-51	900 ± 90	979 ± 49	0.92
		Cs-134	200 ± 20	220 ± 11	0.91
		Cs-137	177 ± 18	183 ± 9	0.97
		Mn-54	136 ± 14	142 ± 7	0.96
		Fe-59	156 ± 16	148 ± 7	1.05
		Zn-65	132 ± 14	140 ± 7	0.94
		CO-60	169 ± 17	178 ± 9	0.95
		Sr-89	20 ± 2	69 ± 3	0.29 (c)
		Sr-90	16 ± 1	41 ± 2	0.39 (c)
E1631-396	Filter	Ce-141	566 ± 57	524 ± 26	1.08
TI #94882		Cr-51	800 ± 80	687 ± 49	1.16
12/14/98		Cs-134	147 ± 15	154 ± 8	0.95
		Cs-137	158 ± 16	128 ± 6	1.23
		Mn-54	122 ± 12	100 ± 5	1.22
		Fe-59	134 ± 13	104 ± 5	1.29
		Zn-65	129 ± 13	98 ± 5	1.32
		CO-60	134 ± 13	125 ± 6	1.07
E1632-396	Water	H-3	5500 ± 200	5980 ± 299	0.92
TI #94883					
12/14/98					
E1633-396	Water	Am-241	8.3 ± 1.5	7.9 ± 0.4	1.05
TI #94884		Pu-239	9.8 ± 1.8	8.9 ± 0.4	1.10
12/14/98					

Footnotes:

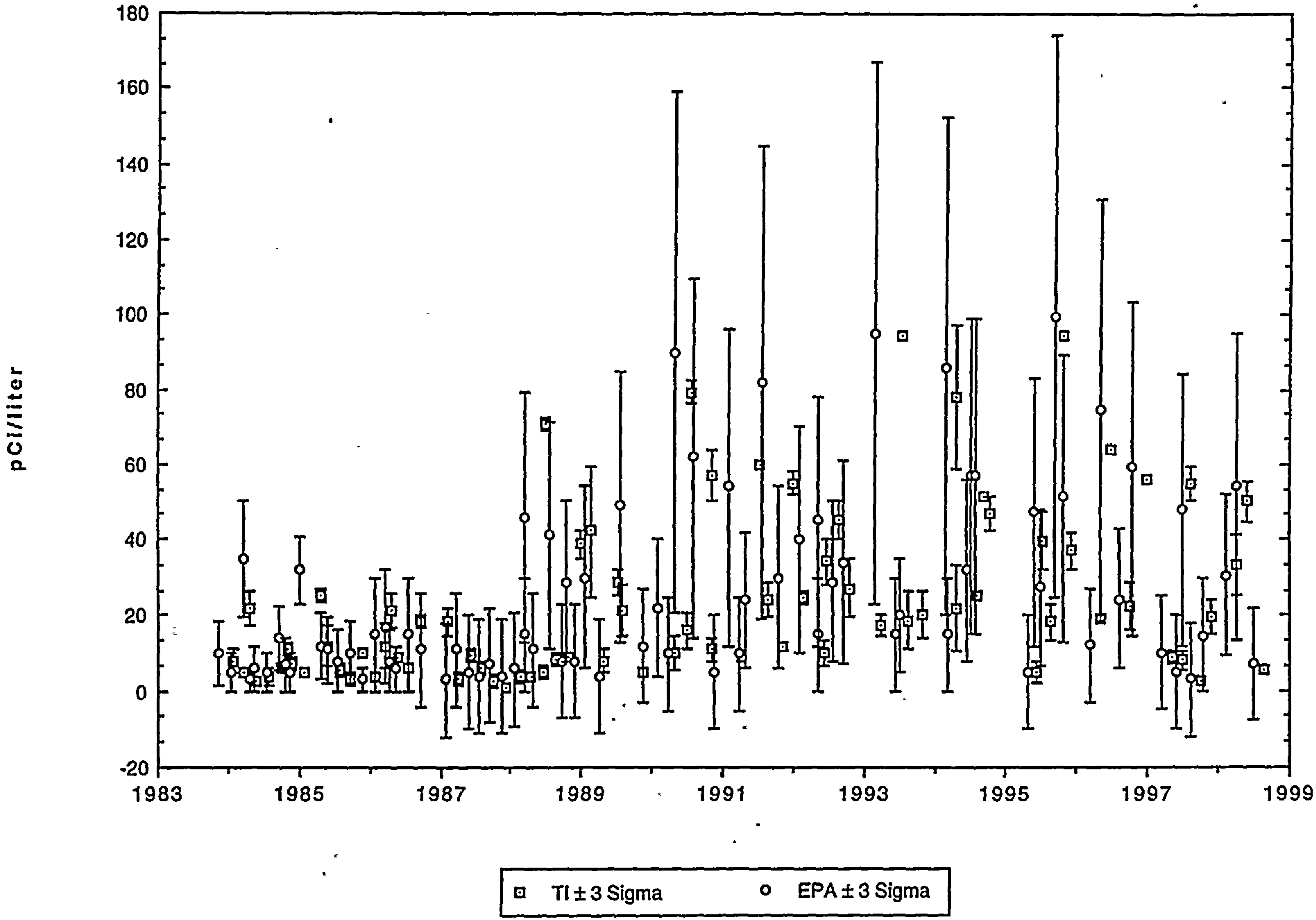
(a) Teledyne Results - counting error is two standard deviations. Units are pCi/liter for water and milk. For gamma results, if two standard deviations are less than 10%, then a 10% error is reported. Units are total pCi for air particulate filters.

(b) Ratio of Teledyne Brown Engineering to Analytics results. Acceptance criteria are based on USNRC acceptance criteria described in USNRC Procedure 84750 dated March 15, 1994.

(c) An investigation is being conducted. If the results of this investigation reveal an analytical deficiency, then a separate report will be provided.

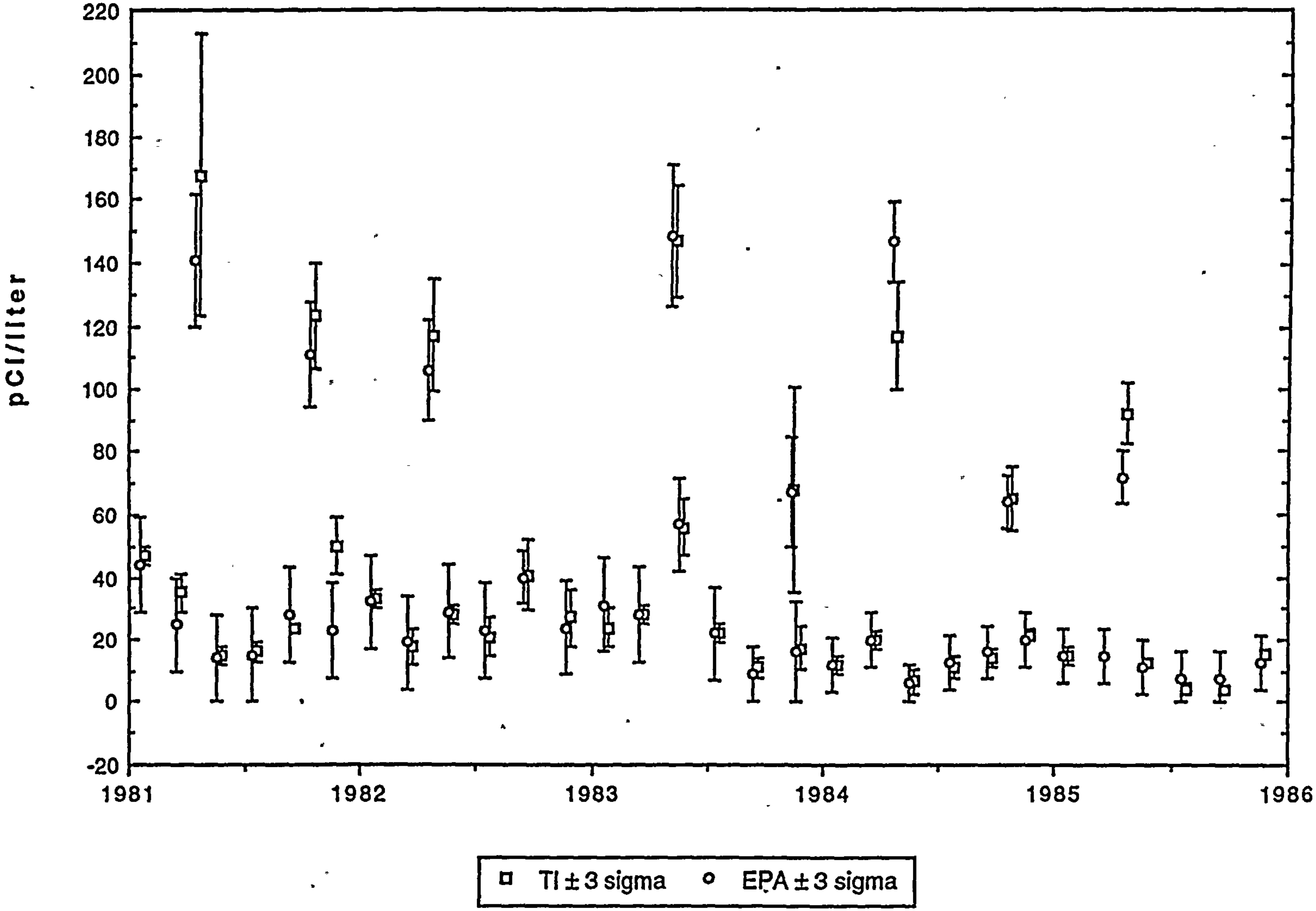
EPA CROSS CHECK PROGRAM

GROSS ALPHA IN WATER (pg. 1 of 1)



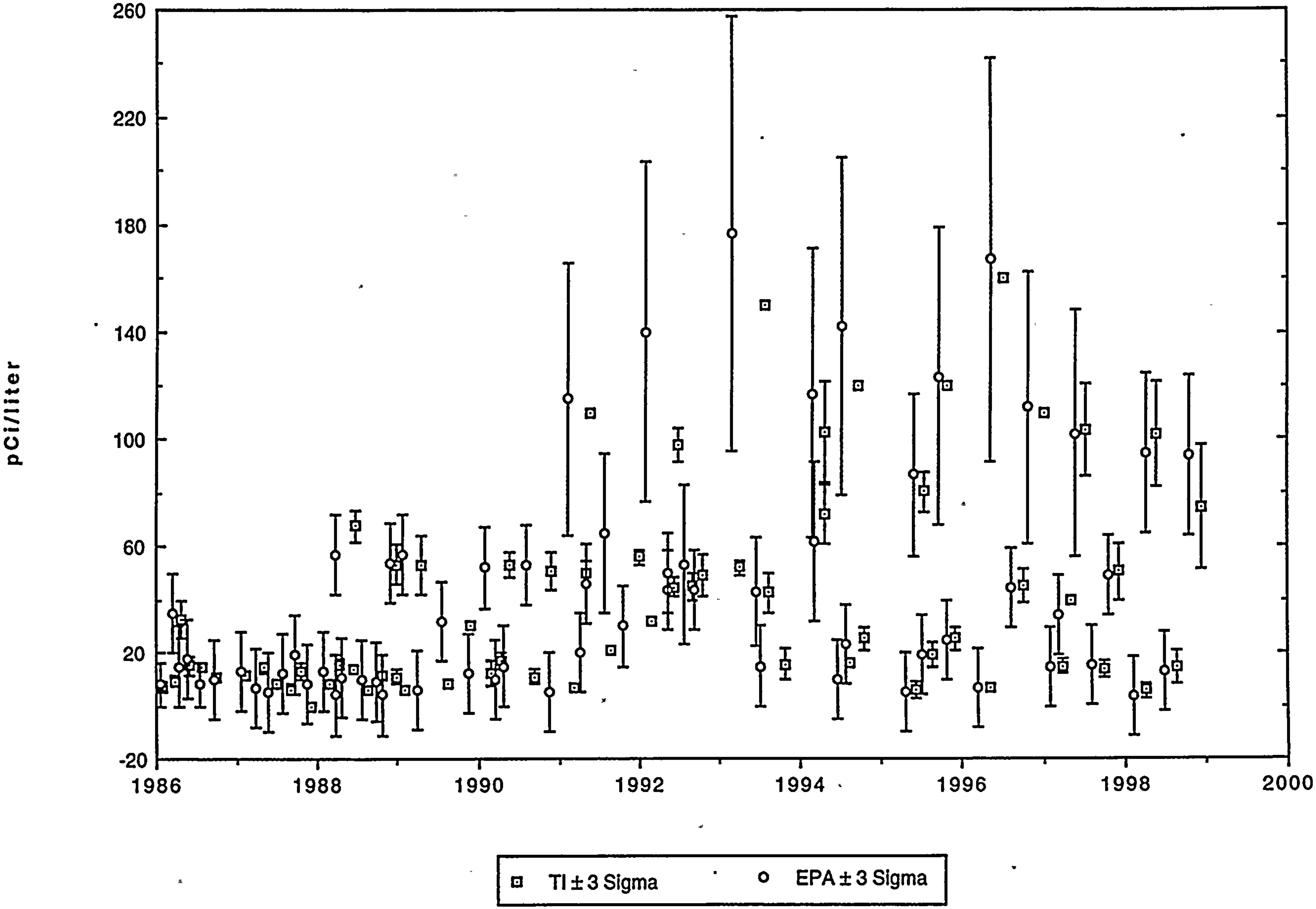
EPA CROSS CHECK PROGRAM

GROSS BETA IN WATER (pg. 1 of 2)



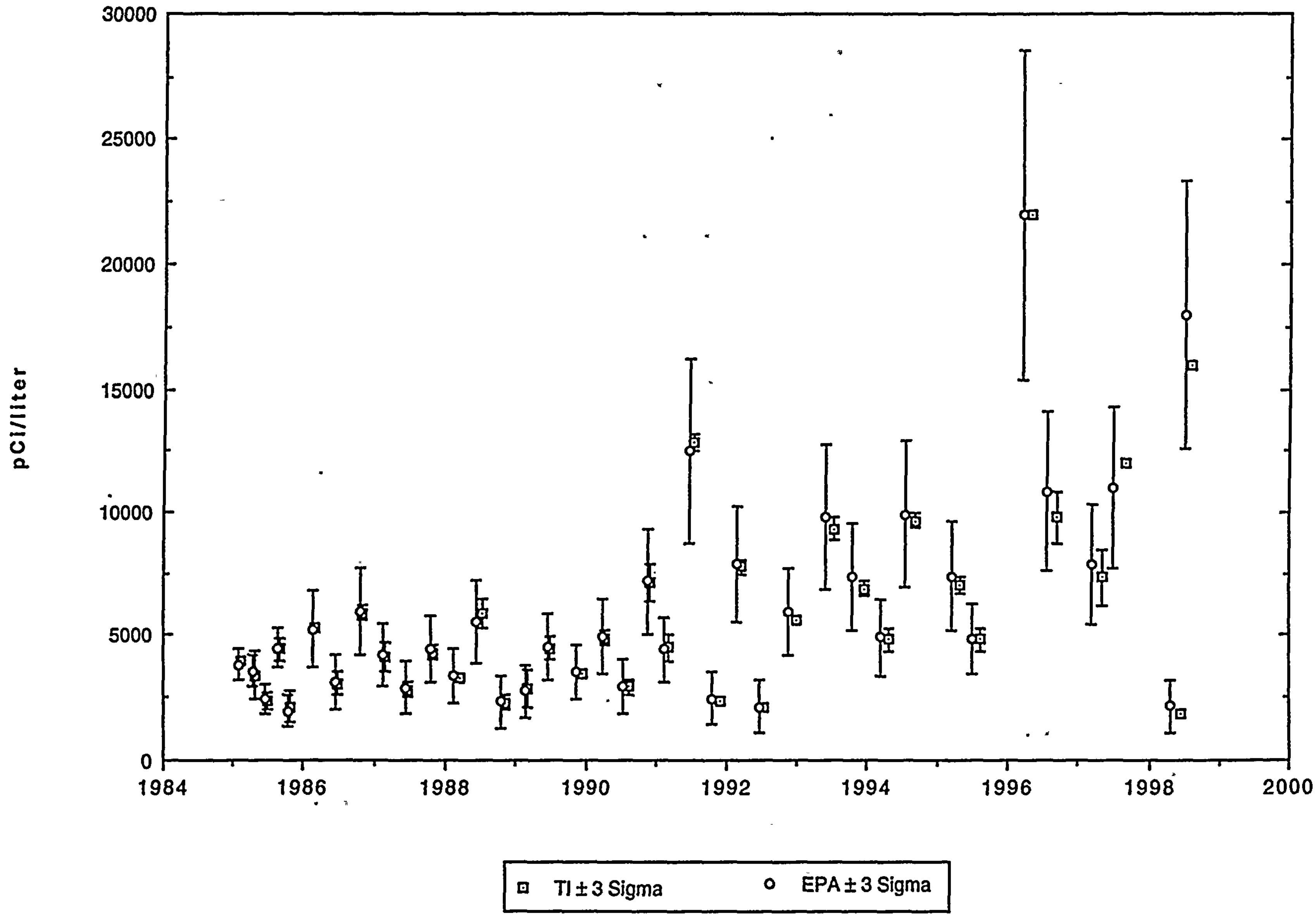
EPA CROSS CHECK PROGRAM

GROSS BETA IN WATER (pg. 2 of 2)



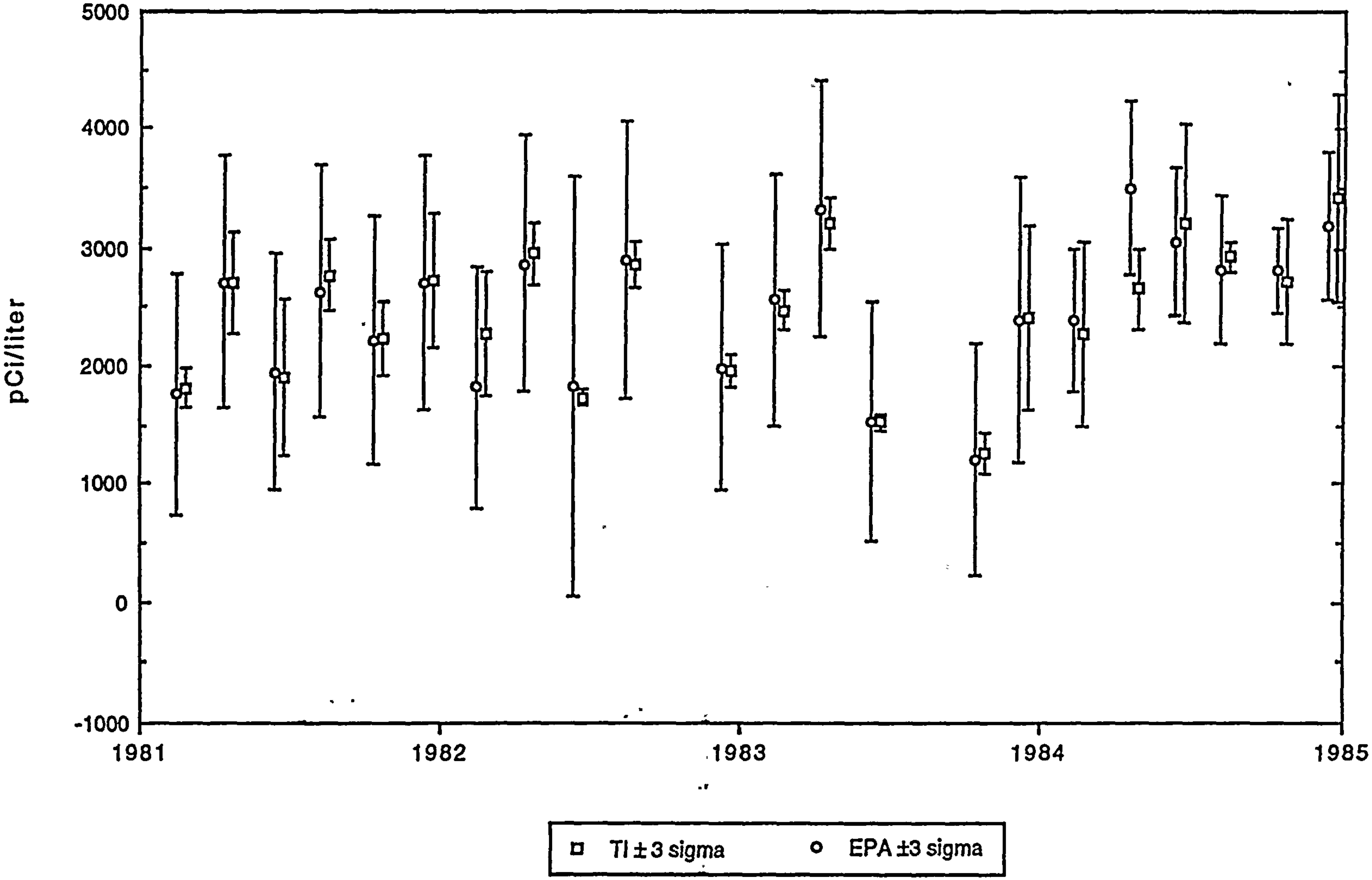
EPA CROSS CHECK PROGRAM

TRITIUM IN WATER (pg. 2 of 2)



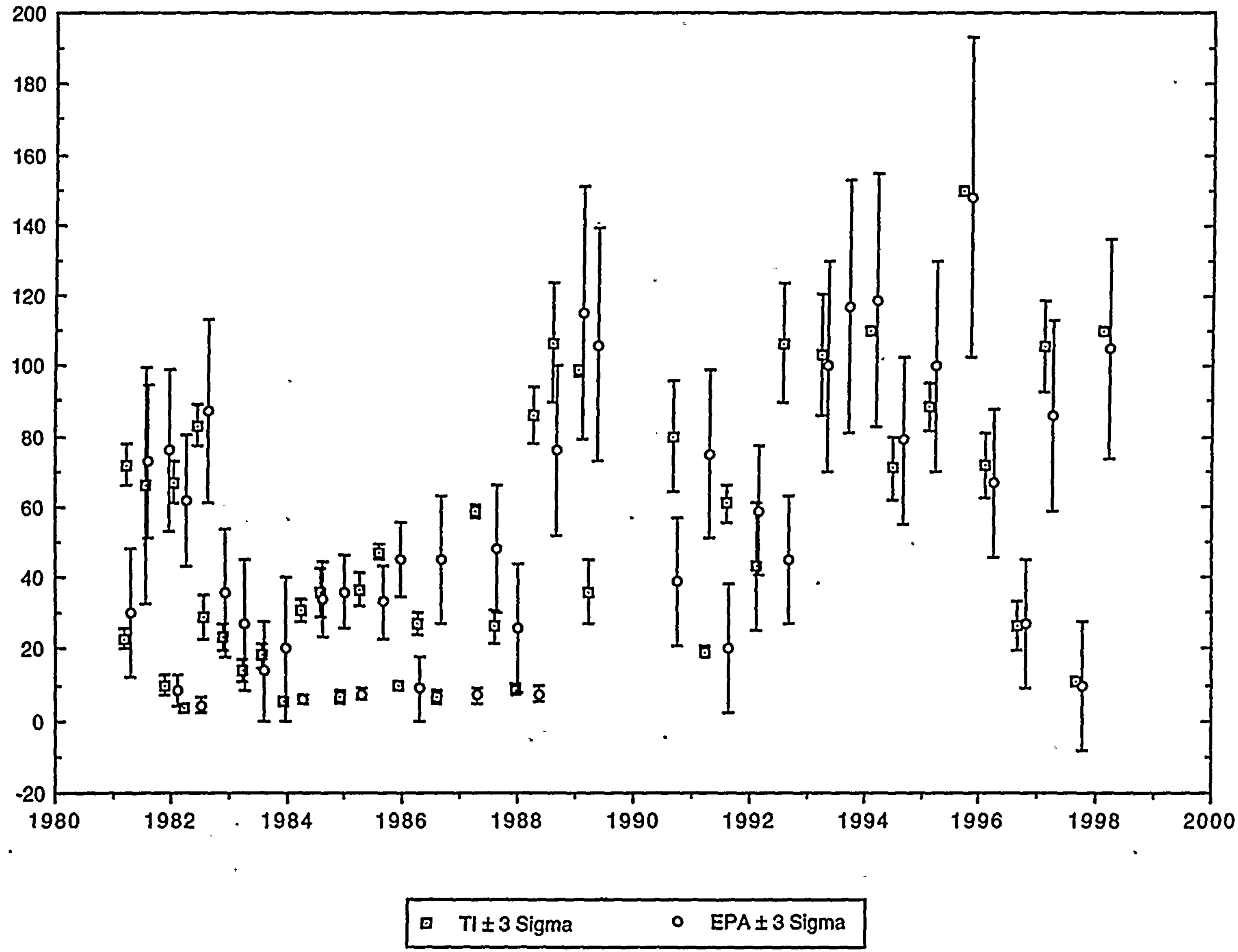
EPA CROSS CHECK PROGRAM

TRITIUM IN WATER (pg. 1 of 2)



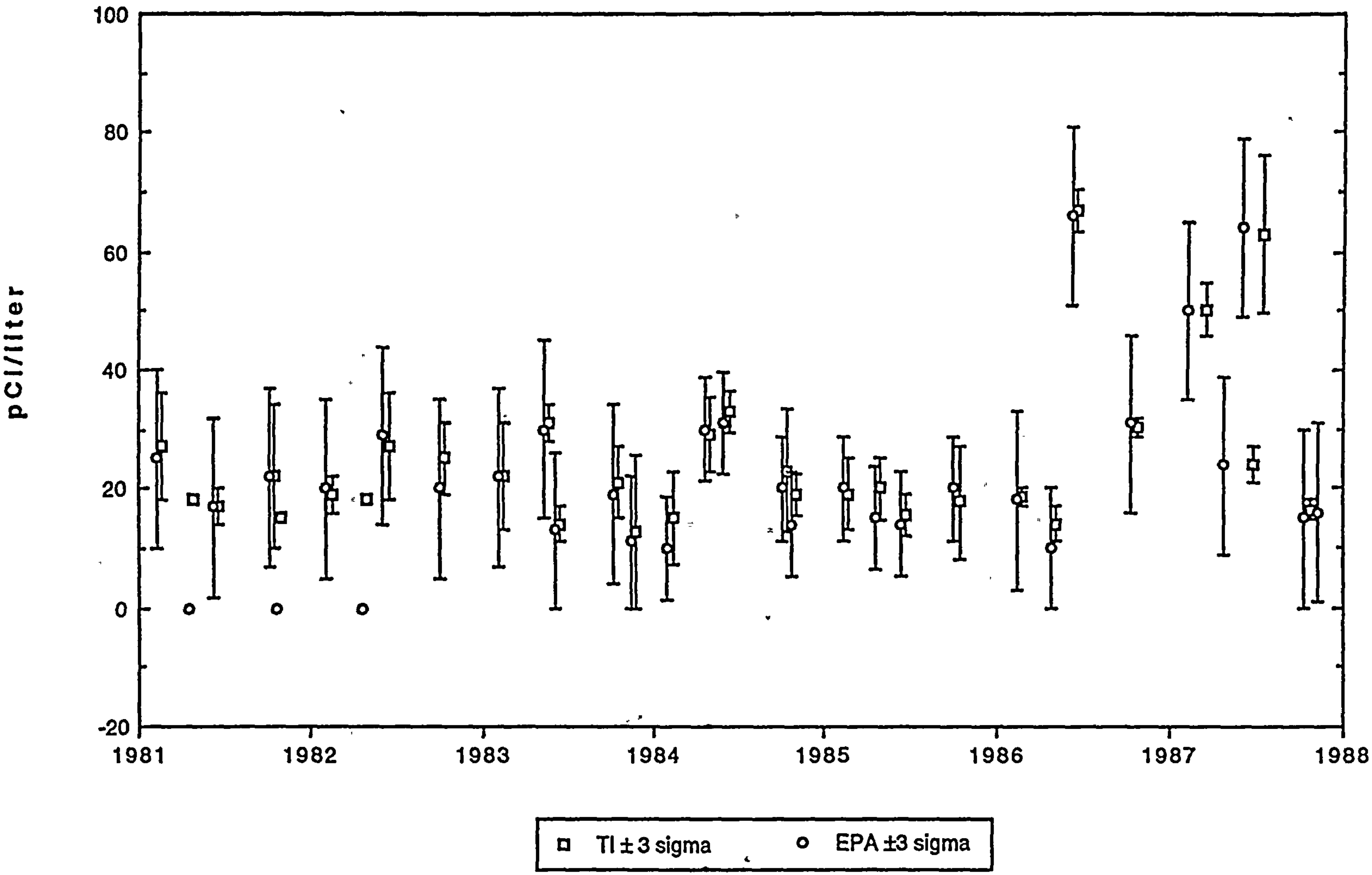
EPA CROSS CHECK PROGRAM

IODINE-131 IN WATER (pg. 1 of 1)



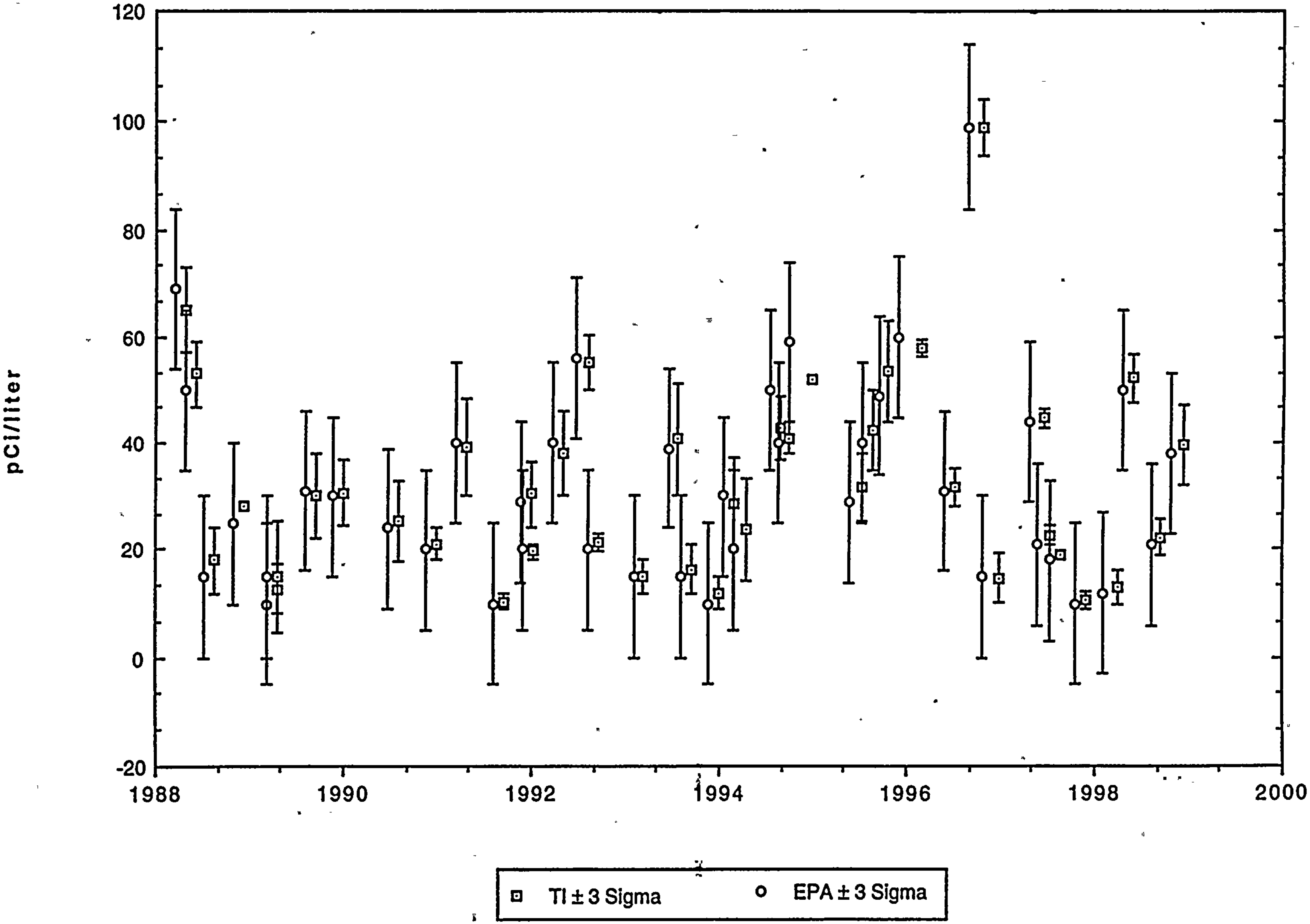
EPA CROSS CHECK PROGRAM

COBALT-60 IN WATER (pg 1 of 2)



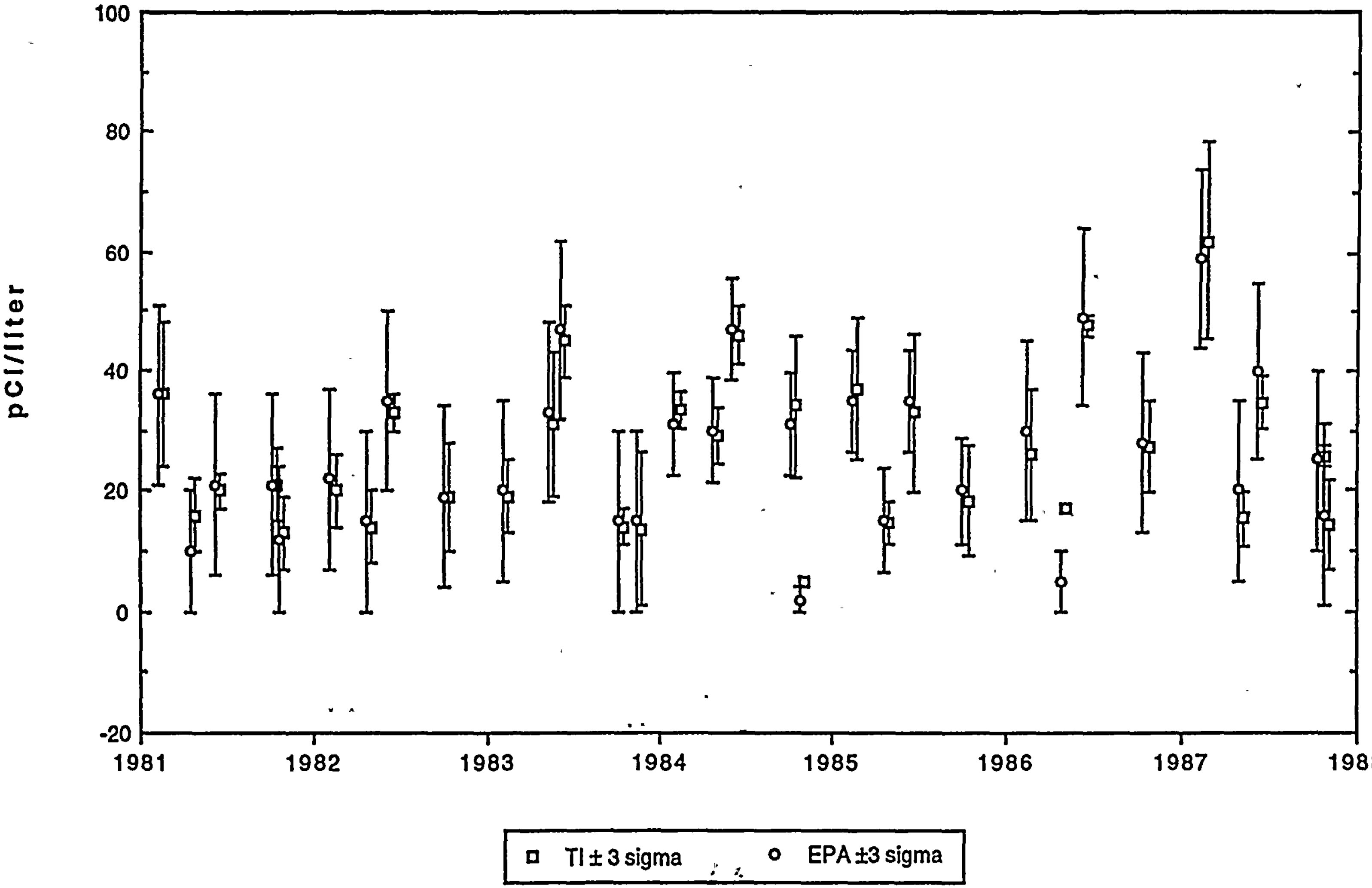
EPA CROSS CHECK PROGRAM

COBALT-60 IN WATER (pg. 2 of 2)



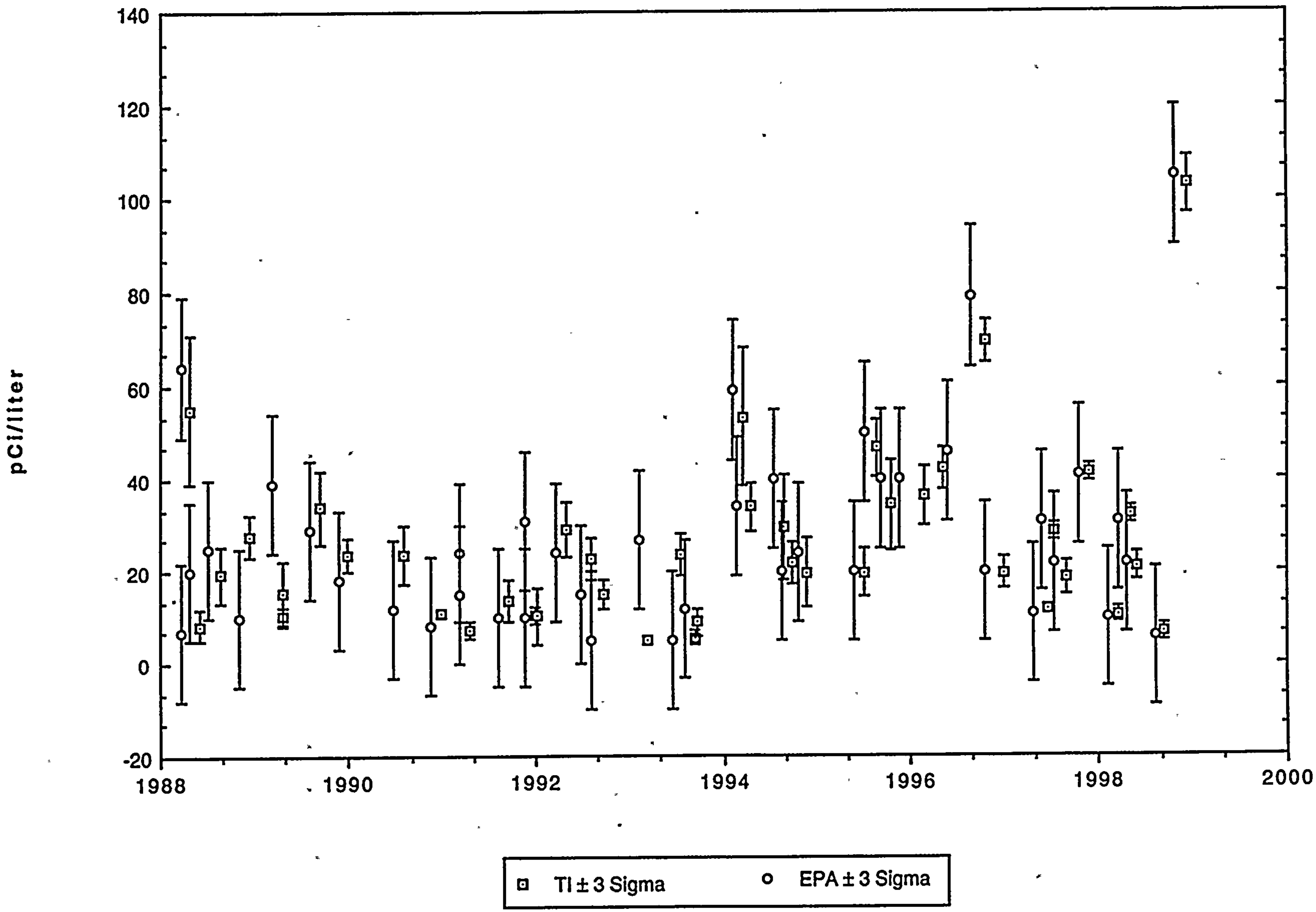
EPA CROSS CHECK PROGRAM

CESIUM-134 IN WATER (pg. 1 of 2)



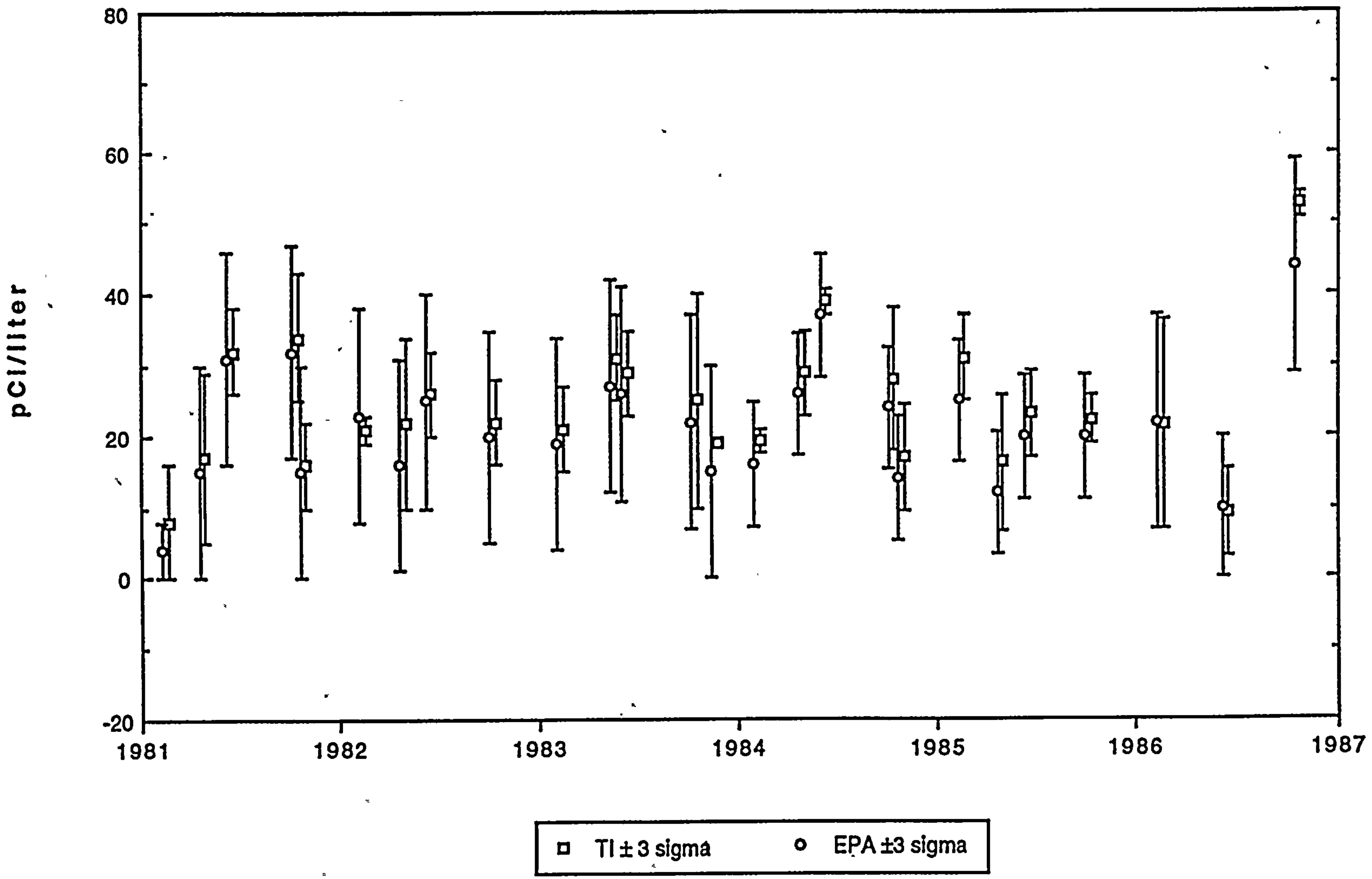
EPA CROSS CHECK PROGRAM

CESIUM-134 IN WATER (pg. 2 of 2)



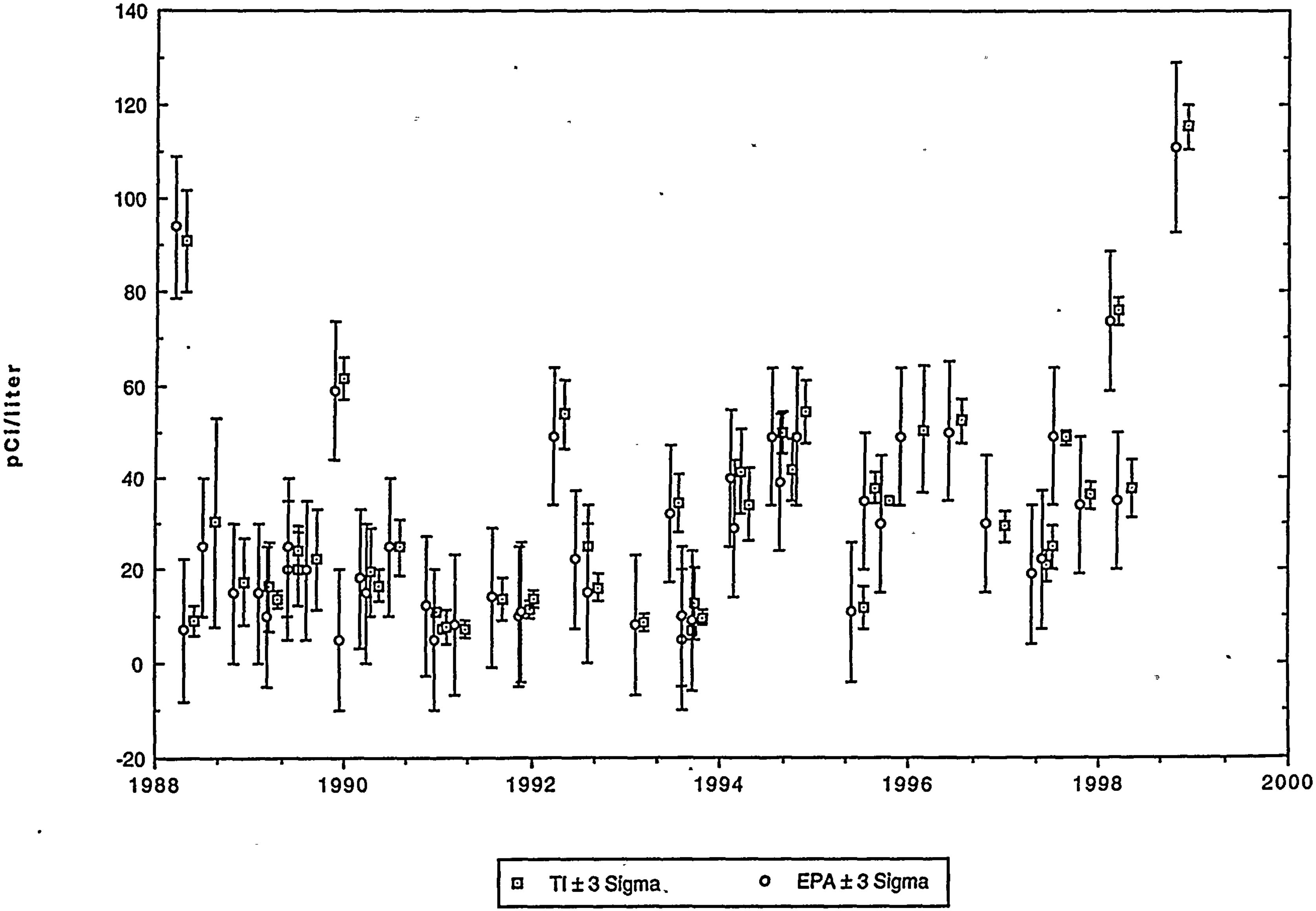
EPA CROSS CHECK PROGRAM

CESIUM-137 IN WATER (pg. 1 of 2)



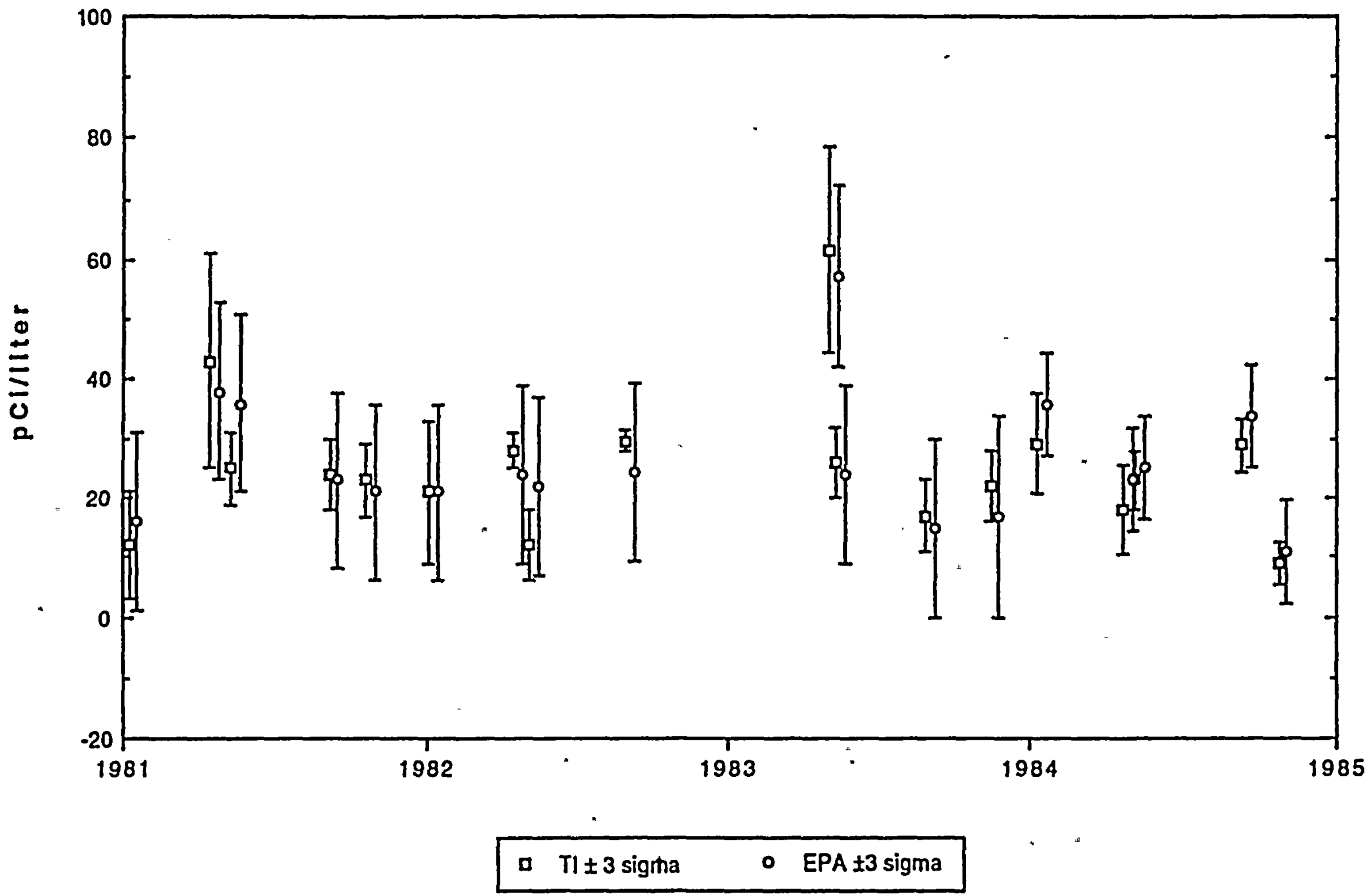
EPA CROSS CHECK PROGRAM

CESIUM-137 IN WATER (pg. 2 of 2)



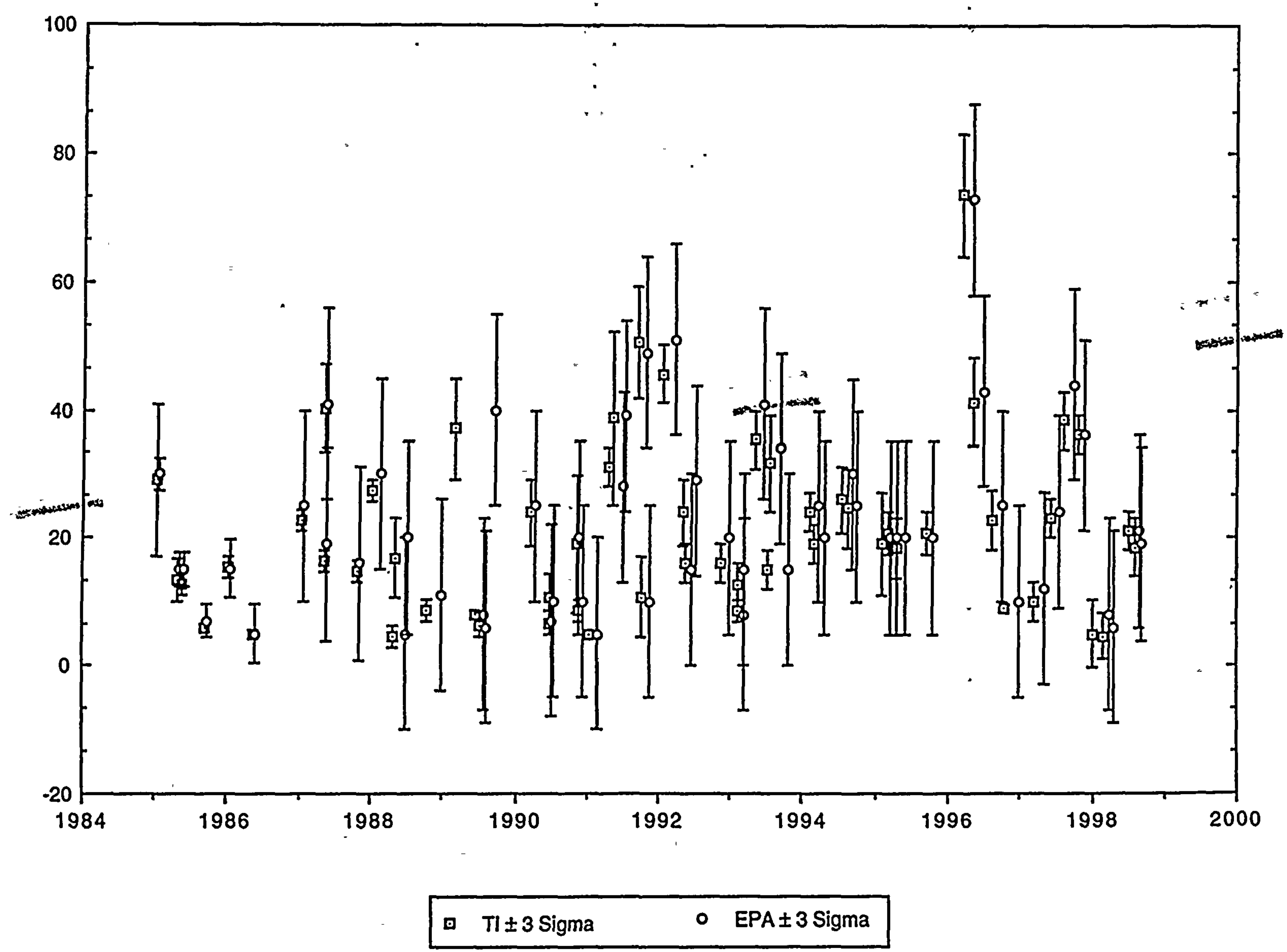
EPA CROSS CHECK PROGRAM

STRONTIUM-89 IN WATER (pg. 1 of 2)



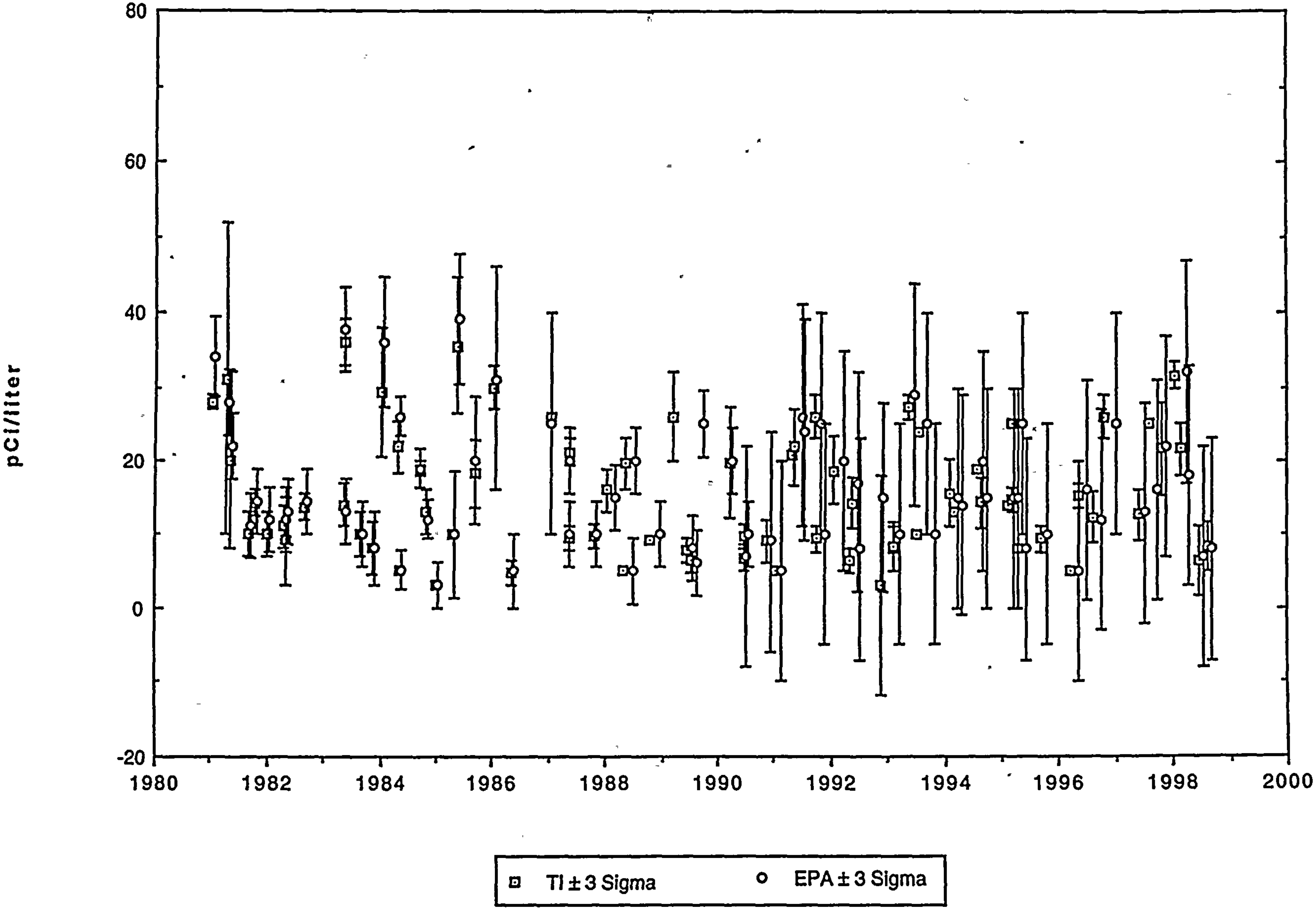
EPA CROSS CHECK PROGRAM

STRONTIUM-89 IN WATER (pg. 2 of 2)



EPA CROSS CHECK PROGRAM

STRONTIUM-90 IN WATER (pg. 1 of 1)



APPENDIX E
REMP SAMPLING AND ANALYTICAL EXCEPTIONS

PROGRAM EXCEPTIONS

AIR PARTICULATES

Throughout the year air particulate gross beta results did not meet the ODCM LLD of 0.01 pCi/m^3. This was consistent with historical data.

On 3/12/98, the electrical power was discovered to be off at locations ONS-5 & 6 thus rendering invalid sample results at these locations. This was due to a snow and ice storm that came through the area on 3/9/98. As a result, collection of all samples were delayed one day since on 3/11/98 the roads were still hazardous from the storm. Power was restored to these air stations sometime before 3/18/98 but sample results from that period were considered to be invalid, as sample time and volume were incorrect.

Electrical power was lost at location ONS-2 sometime between 3/18/98 and 3/25/98. This was eventually traced to a faulted 4 kV power cable (JO A0159889 for repair) which was repaired on 4/24/98. Because of this, air samples were not collected between 3/18/98 and 4/31/98 and cesium-134 and 137 LLDs (6E-2 pCi/ m^3) were not met for the 2nd quarter air particulate composite at ONS-2.

The electrical power was discovered to be off on 7/8/98 at locations ONS-5 & 6. The line fuse found was found open. Power was restored on 7/9/98.

The electrical power was discovered to be off at location ONS-5 on 7/15/98. An open line fuse was found.

The electrical power was discovered to be off at location ONS-2 on 10/14/98. Again an open line fuse was found. Power was restored the next day and the sample was obtained.

The air sample pump at location ONS-5 was found to be performing erratically on 9/23/98. The actual airflow could not be determined, therefore, sample results were considered to be invalid.

SURFACE WATER

Surface water samples were not obtained from beach locations SWL-2 & 3 between 1/19/98 and 3/2/98 due to ice formation and hazardous conditions. Other dates that samples were not collected at locations SWL-2 & 3: 1/1, 1/10, 1/11, 1/18, 3/8, 3/9, 3/10, 3/11, 3/12, 3/14, 3/15, 3/19, 4/16, 10/17, 11/11, 12/22, 12/29, and 12/31/99

THERMOLUMINESCENT DOSIMETERS (TLD's)

An inspection was conducted on 11/18/98 following a 70 mile-per-hour windstorm and the TLD at location OFT-09 was missing. A replacement TLD was obtained from vendor and deployed on 11/24/98.

GROUNDWATER

The groundwater well sample from location W-5 for 1/23/98 had a tritium result of 3000 pCi/l, which exceeded the ODCM LLD of 2000 pCi/l.

The groundwater well sample from location W-6 for 7/24/98 had a tritium result of 3300 pCi/l, which exceeded the ODCM LLD of 2000 pCi/l.

The groundwater well sample from location W-4 for 10/23/98 measured a tritium result of 2300 pCi/l, which exceeded the ODCM LLD of 2000 pCi/l.

The gross beta results exceeded the ODCM LLD of 4.0 pCi/l at location SG groundwater wells 1, 2, 4 and 5 on 1/23/98, 4/23/98 and 7/24/98. The groundwater well SG-4 gross beta result from 10/23/98 exceeded the ODCM LLD of 4.0 pCi/l. This was consistent with historical data.

DRINKING WATER

St Joseph water treatment facility gross beta result measured 8.9 pCi/l for the composite sample from 3/12/98 - 3/25/98. This composite result exceeded the ODCM LLD of 4.0 pCi/l. This is consistent with historical data.

BROADLEAF SAMPLES IN LIEU OF MILK SAMPLES

Broadleaves samples were not obtained during January, February, March, April, November and December due to season unavailability.

FISH COLLECTION

No fish were collected at OFS-N, ONS-S, OFS-S on 7/30/98. Several attempts were made to collect the samples as indicated in our program. The nets were pulled in early as wave heights were increasing and creating hazardous conditions. When the nets were deployed at approximately 0730, the waves were about one foot high. The weather report indicated that waves would increase but not until the evening. However by 0930, the waves had increased to approximately three to four feet high. This had been the third attempt to deploy the nets this season but hazardous conditions had thwarted these attempts. On 8/21/98 fish samples were collected from all locations (ONS-N, OFS-N, ONS-S, OFS-S).

APPENDIX F
1998 LAND USE CENSUS

APPENDIX F

SUMMARY OF THE 1998 LAND USE CENSUS

The Land Use Census is performed to ensure that significant changes in the areas in the immediate vicinity of the plant site are identified. Any identified changes are evaluated to determine whether modifications must be made to the REMP or other related programs. The following is a summary of the 1998 results.

Dairy Farm Survey

The milk farm survey is performed to update the list of milk farms located in the plant area, to identify the closest milk farm in each land sector, and to identify the nearest milk animal whose milk is used for human consumption. The milk farm survey for the Donald C. Cook Nuclear Plant was conducted on June 23, 1998.

There was one dairy farm deleted from the Michigan Department of Agriculture Operating Dairy Farms list for Berrier County between June 1, 1997 and June 1, 1998. This location (Roberts' farm south of Galien) was visited and no milk cattle remain.

Locations not listed by the Michigan Department of Agriculture where dairy cattle were found included Jerry Warmbein's farm in Three Oaks, and George and Bill Wesner's farm in Eau Claire.

Although there are three dairy farms within the eight-mile indicator range (Shuler, Glen-Troy and Jerry Warmbein), Shuler and Warmbein have indicated that they do not want to participate in the milk program.

The program will continue to obtain monthly broadleaf vegetation samples in the absence of three participating indicator range milk farms.

The Dorman family no longer has milking goats at their residence at 7496 Dorman Road in Stevensville. At this time, the closest milk producing animal (cow) is at the Shuler & Son Farm, 2791 Snow Road in Baroda.

Residential Survey

From June 1, 1997 through June 1, 1998, six residential building permits were issued for new construction in Lake Township sections 5,6,7, and 8. These sections border the D. C. Cook Nuclear Plant.

One of the construction permits was for lot #6 in the Wildwood development north of Bridgman, between I-94 and the lake. This permit, issued on 3/25/98, was a duplicate from 1997, as construction had not taken place during 1997. Construction began at this location this past April. When

completed, the new house will be the closest residence from the plant in sector H. New residences, at the other five locations, are all farther than the current closest residences in respective sectors. This was also verified by performance of a door-to-door survey.

Broadleaf Survey

In accordance with Offsite Dose Calculation Manual, broadleaf vegetation sampling is performed in lieu of a garden census. Broadleaf sampling is performed to monitor for plant impact on the environment. The samples are obtained at the site boundary. The broadleaf analytical results for 1998 were less than ODCM LLDs.

1998 LAND USE CENSUS – OPERATING MILK FARMS IN BERRIEN COUNTY

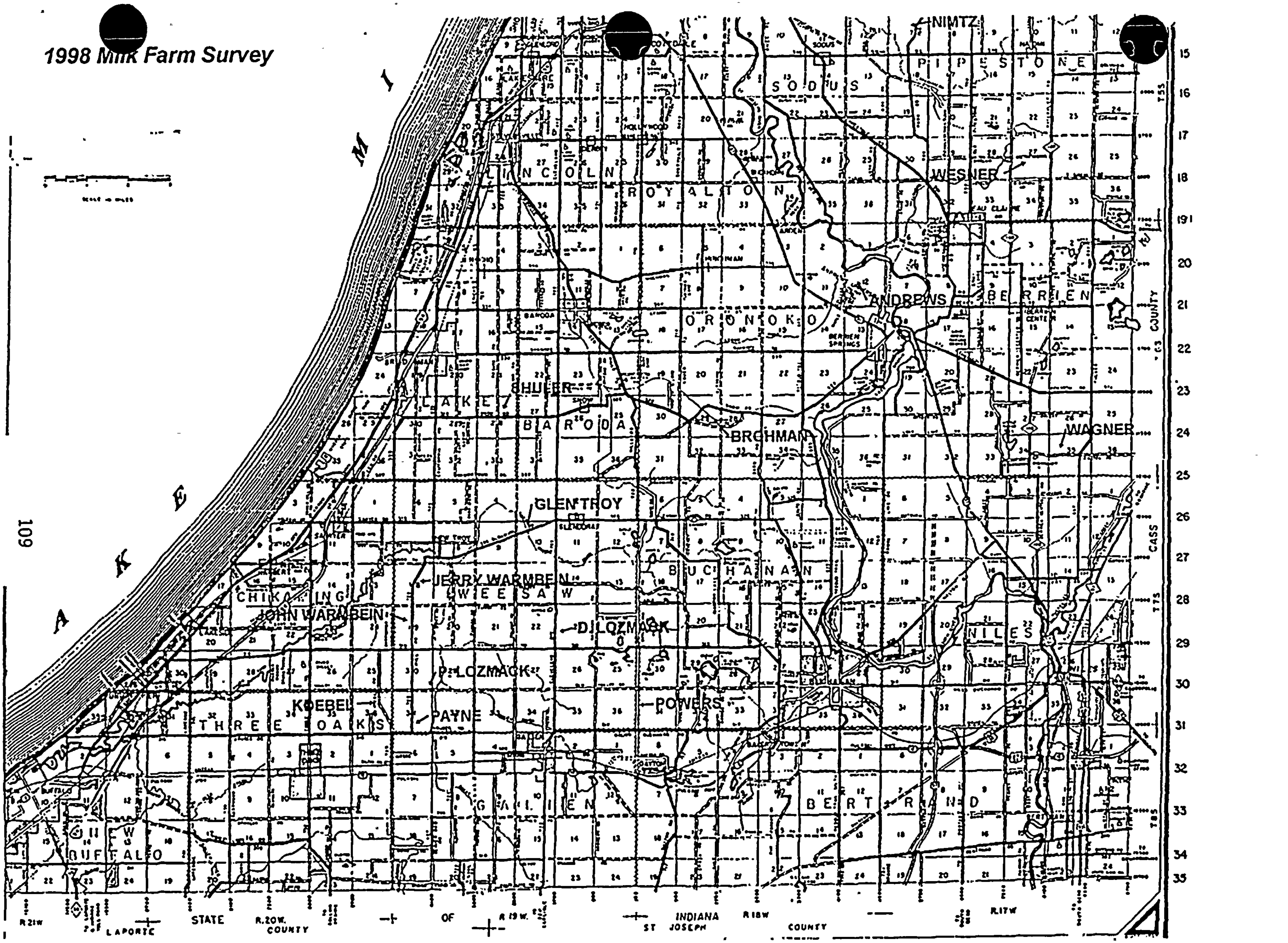
Name and Address	Township	Section	Sector/Distance
Andrews University Dairy Rd Berrien Springs 49104	12 - Oronoko	12	E / 10.5 miles
Brohman Farm 1637 Mt. Tabor Rd Berrien Springs 49103	12 - Oronoko	29	F / 8.5 miles
Glen Troy Farm 2221 Glendora Rd Buchanan 49107	15 - Weesaw	10	H / 7.0 miles
Jerry Koebel 16318 Avery Rd Three Oaks 49128	19 – Three Oaks	36	J / 10.6 miles
Dean Lozmack 14843 Cleveland Rd Galien 49218	15 - Weesaw	23	H / 9.2 miles
Paul Lozmack 4193 Elm Valley Three Oaks 49128	15 - Weesaw	30	J / 10.3 miles
William Nimtz 3445 Park Rd Eau Claire 49111	10 - Pipestone	07	D / 13.5 miles
Howard Payne RFD 2 Box 148 Three Oaks 49128	15 - Weesaw	31	J / 10.9 miles
Powers Farm 16402 Wells Rd Buchanan 49107	16 - Buchanan	31	H / 12.7 miles
*Shuler & Sons Farm 2791 Snow Rd Baroda 49101	11 - Lake	28	G & H / 4.1 miles
Carl Wagner Jr. 8523 Chapel Rd Niles 49120	13 - Berrien	26 & 35	F / 16.5 miles
John Warnbein RFD 2 Box 180 Three Oaks 49128	15 - Weesaw	19	J / 8.5 miles

All above farms are Michigan Department of Agriculture Grade A and MFG approved. The farms listed below are not MI Dept. of Agriculture approved.

Name and Address	Township	Section	Sector/Distance
Jerry Warnbein 14143 Mill Rd Three Oaks 49128	15 – Weesaw	18	J / 7.7 miles
George and Bill Wesner 7655 Sinclair Rd Eau Claire 49111	10 – Pipestone	27	E / 15.0 miles

** Indicates closet milk producing animal*

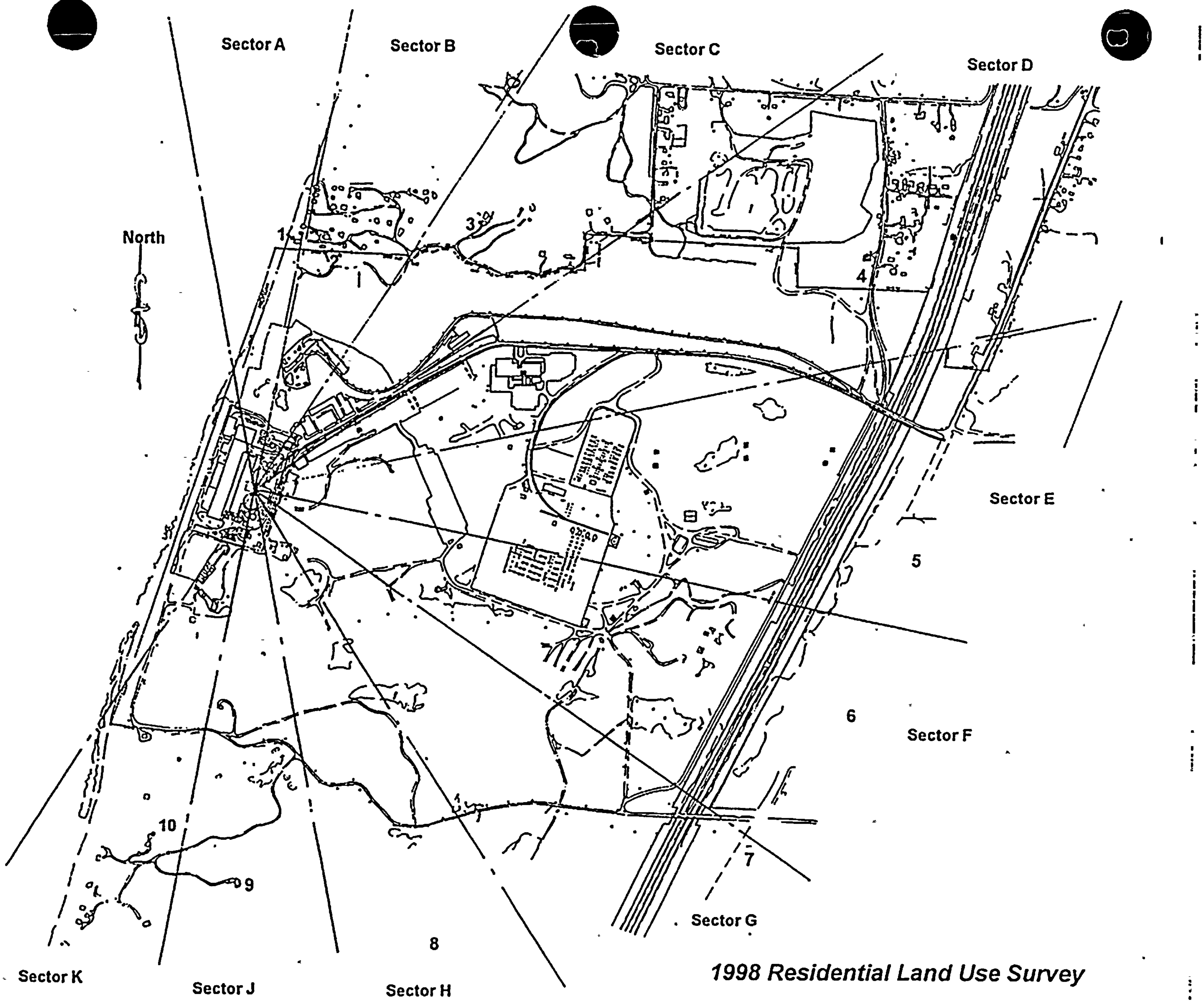
1998 Milk Farm Survey



LAND USE CENSUS

I. RESIDENTIAL LAND USE DATA

Sector	House Number	Lot Number	Distance (ft)
A	1	11-11-0006-0004-01-7 Iler Rd. Rosemary Beach Same as 1997	2161
B	2	11-11-0006-0004-09-2 Iler Rd. Rosemary Beach Same as 1997	2165
C	3	11-11-6800-0028-00-0 Lake Rd. Rosemary Beach Same as 1997	3093
D	4	11-11-0005-0036-01-8 7500 Thorton Rd. Same as 1997	5733
E	5	11-11-0005-0009-07-0 7927 Red Arrow Highway Same as 1997	5631
F	6	11-11-0008-0015-03-1 8197 Red Arrow Highway Same as 1997	5392
G	7	11-11-0008-0010-03-0 8345 Red Arrow Highway Same as 1997	5382
H	8	1998: 11-11-8600-0006-00-4 Lot #6 Wildwood 1997: 11-11-8600-0004-00-1 Lot #4 Wildwood	4650 4944
J	9	11-11-0007-0010-02-3 Livingston Hills Same as 1997	3366
K	10	11-11-0007-0010-03-1 Livingston Hills Same as 1997	3090



1998 Residential Land Use Survey

APPENDIX G
SUMMARY OF THE PRE-OPERATIONAL RADIOLOGICAL MONITORING PROGRAM

SUMMARY OF THE PREOPERATIONAL RADIOLOGICAL MONITORING PROGRAM

A preoperational radiological environmental monitoring program was performed for the Donald C. Cook Nuclear Plant from August 1971 until the initial criticality of Unit 1 on January 18, 1975. The analyses of samples collected in the vicinity of the Donald C. Cook Nuclear Plant were performed by Eberline Instrument Corporation. The summary of the preoperational program presented in this appendix is based on the seven semi-annual reports covering the period. The purpose of this summary is to provide a comparison of the radioactivity measured in the environs of the Donald C. Cook Nuclear Plant during the pre-start up of Unit 1 and the radioactivity measured in 1998.

As stated in the report for the period of July 1 to December 31, 1971, the purposes of a preoperational radiological monitoring program include:

(a) "To yield average values of radiation levels and concentrations of radioactive material in various media of the environment.

(b) To identify sample locations and/or types of samples that deviate from the averages.

(c) To document seasonal variations that could be erroneously interpreted when the power station is operating.

(d) To indicate the range of values that should be considered "background" for various types of samples.

(e) To "proof test" the environmental monitoring equipment and procedures prior to operation of the nuclear power station.

(h) To provide baseline information that will yield estimates of the dose to man, if any, which will result from plant operation."

The discussion that follows is for the various sample media collected and analyzed in both the preoperational period and during 1997. Analyses

performed during the preoperational but not required in 1997, are not discussed.

The gross beta activity in air particulate filters ranged from 0.01 to 0.17 pCi/m^3 from the middle of 1971 to the middle of 1973. In June of 1973 and in June of 1974 the People's Republic of China detonated atmospheric nuclear tests. As a result there were periods during which the gross beta results were elevated to as high as 0.45 pCi/m^3 with no statistically significant differences between indicator and background stations. By the end of the preoperational period the values were approximately 0.06 pCi/m^3.

The gamma ray analyses of composited air particulate filters showed "trace amounts" of fission products, Ce-144, Ru-106, Ru-103, Zr-95, and Nb-95, the results of fallout from previous atmospheric nuclear tests. Cosmogenically produced beryllium-7 was also detected.

The direct radiation background as measured by thermoluminescent dosimeters (TLD) ranged between 1.0 and 2.0 mrem/week during the three and one-half years period.

Milk samples during the preoperational period were analyzed for iodine-131 and by gamma ray spectroscopy (and for strontium-89 and strontium-90). All samples had naturally occurring potassium-40 with values ranging between 520 and 2310 pCi/liter. Cesium-137 was measured in many samples after the two atmospheric nuclear tests mentioned above. The cesium-137 activity ranged from 8 to 33 pCi/liter. Iodine-131 was measured in four milk samples collected July 9, 1974. The values ranged between 0.2 and 0.9 pCi/liter.

Lake water samples were collected and analyzed for tritium and by gamma ray spectroscopy. Tritium activities were below 1000 pCi/liter and typically averaged about 400 pCi/liter. No radionuclides were detected by gamma ray spectroscopy.

Gamma ray spectroscopy analyses of lake sediment detected natural abundances of potassium-40, uranium and thorium daughters, and traces of cesium-137 below 0.1 pCi/g which is attributed to fallout.

Gamma spectroscopy analyses of fish detected natural abundances of potassium-40 and traces of cesium-137, the latter attributed to fallout.

Drinking water analysis was not part of the preoperational program.

APPENDIX H
SUMMARY OF THE SPIKE AND BLANK SAMPLE PROGRAM

TELEDYNE BROWN ENGINEERING QUALITY CONTROL PROGRAM

The goal of the quality control program at Teledyne Brown Engineering is to produce analytical results which are accurate, precise and supported by adequate documentation. The program is based on the requirements of 10CFR50, Appendix B, Nuclear Regulatory Guide 4.15 and the program as described in Quality Assurance Manual IWL-0032-395 and Quality Control Manual IWL-0032-365.

All measuring equipment is calibrated for efficiency at least annually using standard reference material traceable to NIST. For alpha and beta counting, check sources are prepared and counted every day the counter is in use. Control charts are maintained with three sigma limits specified. Control of the alpha-beta counting equipment is described in procedure PRO-032-27, "Calibration and Control of Alpha/Beta Counters". Backgrounds are usually measured at least once per week.

The gamma spectrometers are calibrated annually with a NIST traceable standard reference material selected to cover the energy range of the nuclides to be monitored and to include all of the geometries measured. Backgrounds are determined every other week and check sources are counted weekly. The energy resolution and efficiency were plotted at two energy levels on charts and held within three sigma control limits. From January 1, 1996 December 31, 1996 the energy levels were 59.5 and 1332 KeV. This procedure is described in PRO-042-44, "Calibration and Control of Gamma Ray Spectrometers".

The efficiency of the liquid scintillation counters is determined at least annually by counting NIST traceable standards which have been diluted in a known amount of distilled water and various amounts of quenching agent. The procedure is described in PRO-052-35, "Determination of Tritium by Liquid Scintillation". The background of each counter is measured with each batch of samples. A control chart is maintained for the background and check source measurements as a stability check.

Preparation of carrier solutions and acceptability criteria are contained in procedure PRO-032-49 "Standardization of Radio-chemical Carrier

Solutions". Preparation of efficiency calibration standards and check sources is described in procedure PRO-032-27, "Calibration and Control of Alpha/Beta Counters".

Results are reviewed before being entered into the data system by the Quality Assurance or Laboratory Manager, or supervisors for reasonableness of the parameters (background, efficiency, decay, etc.). Any results which are suspect, being higher or lower than results in the past, are returned to the laboratory for recount. If a longer count, decay check, recount on another system or recalculation does not give acceptable results based on experience, a new aliquot is analyzed. The complete information about the sample is contained on the work sheet(s).

The Donald C. Cook Nuclear Plant's procedures for implementing the quality control program references Regulatory Guide 4.15 which outlines the use of blank, replicate and spike samples within four different parameters: gross beta, iodine, gamma isotopic, and tritium. The blank and replicate samples are prepared at Donald C. Cook Nuclear Plant and spiked samples are prepared by Teledyne Brown Engineering.

No deviations from written procedures occurred during 1998.

Results of Duplicate Analyses for 1998

Sample Type	Analysis	First Analysis	Second Analysis
Air Particulates Results in Units of 10^{-3} pCi/m^3	Gr-Beta	2.2 ± 0.2 E-02	2.5 ± 0.2 E-02
	"	3.2 ± 0.2 E-02	3.1 ± 0.2 E-02
	"	2.5 ± 0.2 E-02	2.4 ± 0.2 E-02
	"	1.7 ± 0.2 E-02	1.7 ± 0.2 E-02
	"	8.3 ± 1.4 E-03	9.6 ± 1.5 E-03
	"	1.4 ± 0,2 E-02	1.3 ± 0.2 E-02
	"	1.1 ± 0.2 E-02	1.0 ± 0.2 E-02
	"	1.3 ± 0.2 E-02	1.5 ± 0.2 E-02
	"	1.3 ± 0.2 E-02	1.3 ± 0.2 E-02
	"	1.2 ± 0.2 E-02	1.4 ± 0.2 E-02
	"	1.5 ± 0.2 E-02	1.5 ± 0.2 E-02
	"	1.3 ± 0.2 E-02	1.5 ± 0.2 E-02
	"	1.9 ± 0.2 E-02	1.9 ± 0.2 E-02
	"	1.7 ± 0.2 E-02	1.7 ± 0.2 E-02
	"	1.9 ± 0.2 E-02	1.7 ± 0.2 E-02
	"	2.5 ± 0.2 E-02	2.5 ± 0.2 E-02
	"	2.3 ± 0.2 E-02	2.1 ± 0.2 E-02
	"	1.9 ± 0.2 E-02	1.8 ± 0.2 E-02
	"	1.3 ± 0.2 E-02	1.4 ± 0.2 E-02
	"	1.9 ± 0.2 E-02	1.8 ± 0.2 E-02
	"	2.3 ± 0.2 E-02	2.5 ± 0.2 E-02
	"	2.5 ± 0.2 E-02	2.7 ± 0.2 E 02
	"	2.5 ± 0.3 E-02	2.7 ± 0.3 E-02
	"	1.8 ± 0.2 E-02	2.0 ± 0.2 E-02
	"	2.2 ± 0.2 E-02	1.9 ± 0.2 E-02
Air Particulates/ Charcoal Filters Results in Units of 10^{-3} pCi/m^3	Iodine-131	L. T. 1. E-02	L. T. 1. E-02
	"	L. T. 6. E-03	L. T. 2. E-02
	"	L. T. 8. E-03	L. T. 1. E-02
	"	L. T. 7. E-03	L. T. 1. E-02
	"	L. T. 7. E-03	L. T. 1. E-02
	"	L. T. 2. E-02	L. T. 1. E-02
	"	L. T. 8. E-03	Not Analyzed
	"	L. T. 4. E-03	L. T. 7. E-03
	"	L. T. 6. E-03	Not Analyzed
	"	L. T. 1. E-02	L. T. 1. E-02
	"	L. T. 8. E-03	L. T. 7. E-03

* Footnotes located at end of table.

Results of Duplicate Analyses for 1998 (Cont.)

Sample Type	Analysis	First Analysis	Second Analysis
Air Particulates/ Charcoal Filters Results in Units of 10^{-3} pCi/m^3	"	L. T. 9. E-03	L. T. 1. E-02
	"	L. T. 6. E-03	L. T. 9. E-03
	"	L. T. 9. E-03	L. T. 2. E-02
	"	L. T. 8. E-03	L. T. 1. E-02
	"	L. T. 1. E-02	L. T. 2. E-02
	"	L. T. 6. E-03	L. T. 6. E-03
	"	L. T. 1. E-02	L. T. 1. E-02
	"	L. T. 8. E-03	L. T. 7. E-03
	"	L. T. 8. E-03	L. T. 5. E-03
	"	L. T. 8. E-03	L. T. 1. E-02
	"	L. T. 7. E-03	L. T. 1. E-02
	"	L. T. 2. E-02	L. T. 2. E-02
	"	L. T. 1. E-02	L. T. 5. E-03
	"	L. T. 1. E-02	L. T. 1. E-02
Surface Water Results in Units of pCi/liters	Gamma	(a)	(a)
	Gamma	(a)	(a)
Ground Water Results in Units of pCi/liter	Gamma	(a)	(a)
	H-3	3.0 ± 0.2 E 03	3.5 ± 0.2 E 03
	Gamma	(a)	(a)
	H-3	3.3 ± 0.1 E 03	3.2 ± 0.1 E 03
Drinking Water Results in Units of pCi/liter	Gr-Beta	2.6 ± 0.9 E 00	2.2 ± 0.9 E 00
	I-131	L. T. 4. E-01	L. T. 5. E-01
	Gamma	(a)	(a)
	Gr-Beta	2.9 ± 0.9 E 00	2.4 ± 1.0 E 00
	I-131	L. T. 4. E-01	L. T. 5. E-01
	Gamma	(a)	(a)

(a) All gamma results were less than the detection limit (LLD).

Teledyne Brown Engineering In-House Spiked Sample Results - 1998

Water

Analysis	Spike Levels (pCi/L)	Acceptable Range (pCi/l)
Gross Beta	2.2 ± 0.7 E 01	1.5 - 2.9 E 01
Gamma (Cs-137)	2.0 ± 0.3 E 04	1.7 - 2.3 E 04
H-3 (LS)	1.7 ± 0.5 E 03	1.2 - 2.2 E 03

TI #	Analysis Date	Gross Beta Activity (pCi/l)
69696	02/11/98	2.1 ± 0.2 E 01
71056	03/04/98	2.1 ± 0.2 E 01
72103	03/18/98	1.6 ± 0.1 E 01
72771	04/01/98	2.1 ± 0.2 E 01
74945	04/29/98	1.7 ± 0.1 E 01
79134	06/10/98	2.6 ± 0.2 E 01
82652	07/22/98	2.1 ± 0.2 E 01
83464	08/05/98	2.1 ± 0.1 E 01
85587	08/26/98	2.2 ± 0.2 E 01
85918	09/02/98	2.2 ± 0.2 E 01
87302	09/09/98	2.3 ± 0.2 E 01

SPIKES - GAMMA (Cs-137)

TI #	Analysis Date	Activity (pCi/l)
69693	02/11/98	2.15 ± 0.22 E 04
71056	03/04/98	2.21 ± 0.22 E 04
72103	03/18/98	2.17 ± 0.22 E 04
72771	04/01/98	2.13 ± 0.21 E 04
74945	04/29/98	2.18 ± 0.22 E 04
79134	06/10/98	2.20 ± 0.22 E 04
82652	07/22/98	2.16 ± 0.22 E 04
83464	08/05/98	2.18 ± 0.22 E 04
85587	08/26/98	2.24 ± 0.22 E 04
85918	09/02/98	2.22 ± 0.22 E 04
87302	09/09/98	2.13 ± 0.21 E 04

SPIKES - TRITIUM - (H-3) 10ml

TI #	Analysis Date	Activity (pCi/l)
71061	03/04/98	1.5 ± 0.1 E 03
72108	03/18/98	1.4 ± 0.1 E 03
72776	04/01/98	1.5 ± 0.1 E 03
74956	04/29/98	1.4 ± 0.1 E 03
79140	06/10/98	1.5 ± 0.1 E 03
82648	07/22/98	1.4 ± 0.1 E 03
83460	08/05/98	1.4 ± 0.1 E 03
85583	08/26/98	1.2 ± 0.1 E 03
85914	09/02/98	1.6 ± 0.2 E 03
87298	09/09/98	1.7 ± 0.2 E 03
89375	10/07/98	1.7 ± 0.2 E 03
91364	10/28/98	1.5 ± 0.2 E 03

Teledyne Brown Engineering In-House Blanks Sample Results - 1998
Water

GROSS BETA BLANKS

TI #	Analysis Date	Gross Beta Activity (pCi/l)
69695	02/11/98	L. T. 8. E -01
71057	03/04/98	L. T. 8. E -01
72104	03/18/98	L. T. 8. E -01
72772	04/01/98	L. T. 8. E -01
74946	04/29/98	L. T. 8. E -01
79133	06/10/98	L. T. 8. E -01
82651	07/22/98	L. T. 1. E -00
83463	08/05/98	L. T. 7. E -01
85586	08/26/98	L. T. 8. E -01
85917	09/02/98	L. T. 7. E.-01
87301	09/09/98	L. T. 7. E -01

TRITIUM - (H-3) - BLANKS

TI #	Analysis Date	Activity (pCi/l)
69698	02/11/98	L. T. 3. E 02
71059	03/04/98	L. T. 1. E 02
72106	03/18/98	L. T. 1. E 02
72774	04/01/98	L. T. 1. E 02
74959	04/29/98	L. T. 1. E 02
79139	06/10/98	L. T. 1. E 02
82647	07/22/98	L. T. 1. E 02
83459	08/05/98	L. T. 1. E 02
85582	08/26/98	L. T. 2. E 02
85913	09/02/98	L. T. 3. E 02
87297	09/09/98	L. T. 3. E 02
89374	10/07/98	L. T. 2. E 02
91363	10/28/98	L. T. 2. E 02

APPENDIX I
TLD QUALITY CONTROL PROGRAM

TLD QUALITY CONTROL PROGRAM

Teledyne Brown Engineering performs an in-house quality assurance testing program for the environmental TLD laboratory. The QA manager or a qualified designate exposes groups of TLDs to three different doses using a known exposure rate from a cesium-137 source.

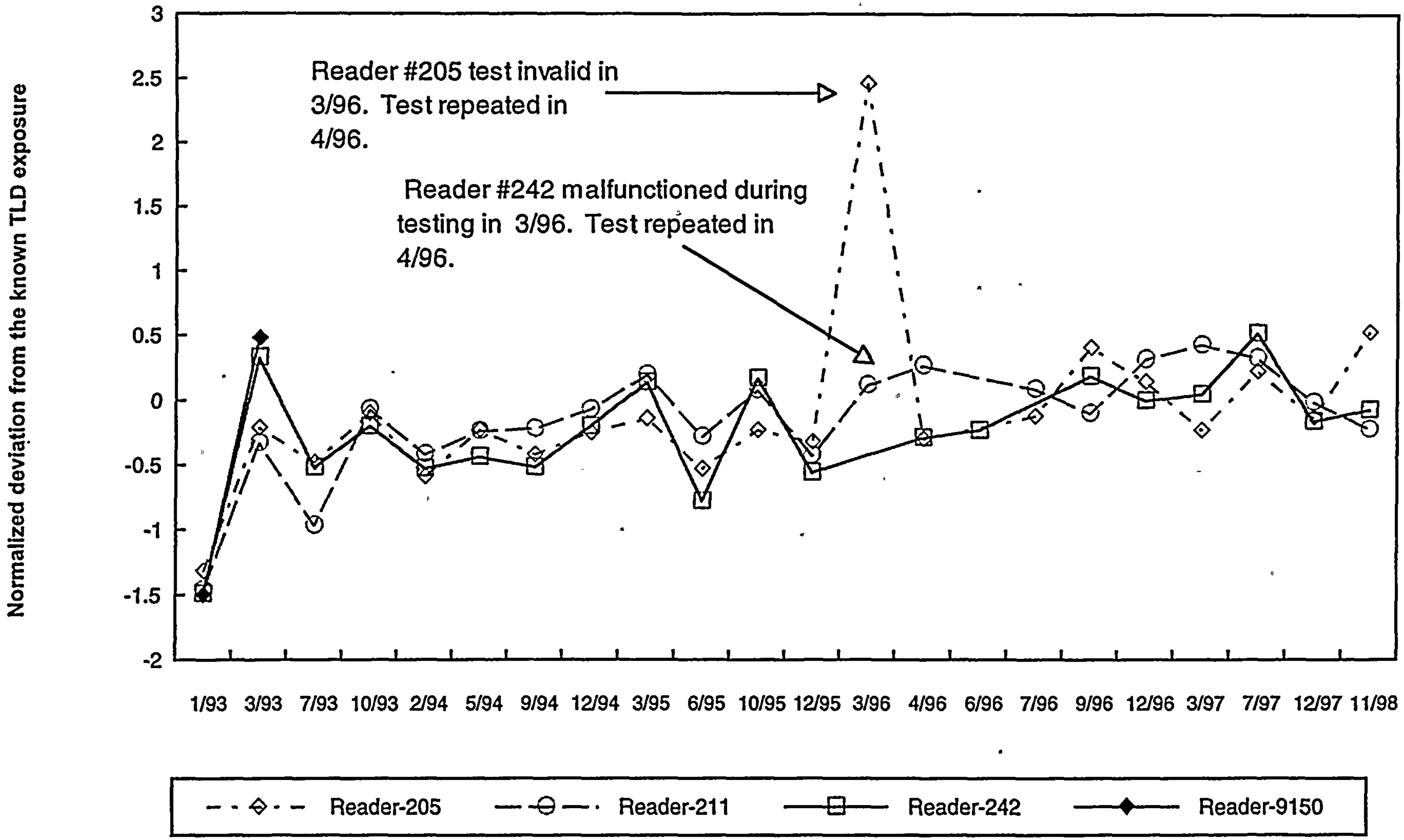
Thirty-three badges with no cases were prepared and color coded into three groups of eleven. Each group was assigned to a unique reader. Two dosimeters for each color group were used as controls for the model 8300 manual readers. The remaining dosimeters were exposed to three different test levels: 32.1 mR, 55.0 mR and 82.4 mR.

The results for the readers compare favorably with the requirements of Regulatory Guide 4.13, Section C. The standard deviation of the three measurements is less than 7.5% for readers 211 and 242. The variation from the known for all readers is less than 30%. Four dosimeters (0378, 6433, 6580 and 8669) used in the reader 205 quality control test caused the standard deviation of the three measurements at each exposure level to exceed 7.5%. An inspection of the dosimeters determined that they were significantly bent which may have contributed to the poor precision in the measurements. These dosimeters have been replaced. The calibration of the reader is not in question.

Attached also are graphs reflecting the normalized deviation from the known based on an expected laboratory precision for a single determination of 20% and for three determinations for all readers. All the TLD readers responded within the acceptance limits at each dose level, although the response for reader 205 was affected by the problem with the dosimeters used in the quality control test as discussed earlier.

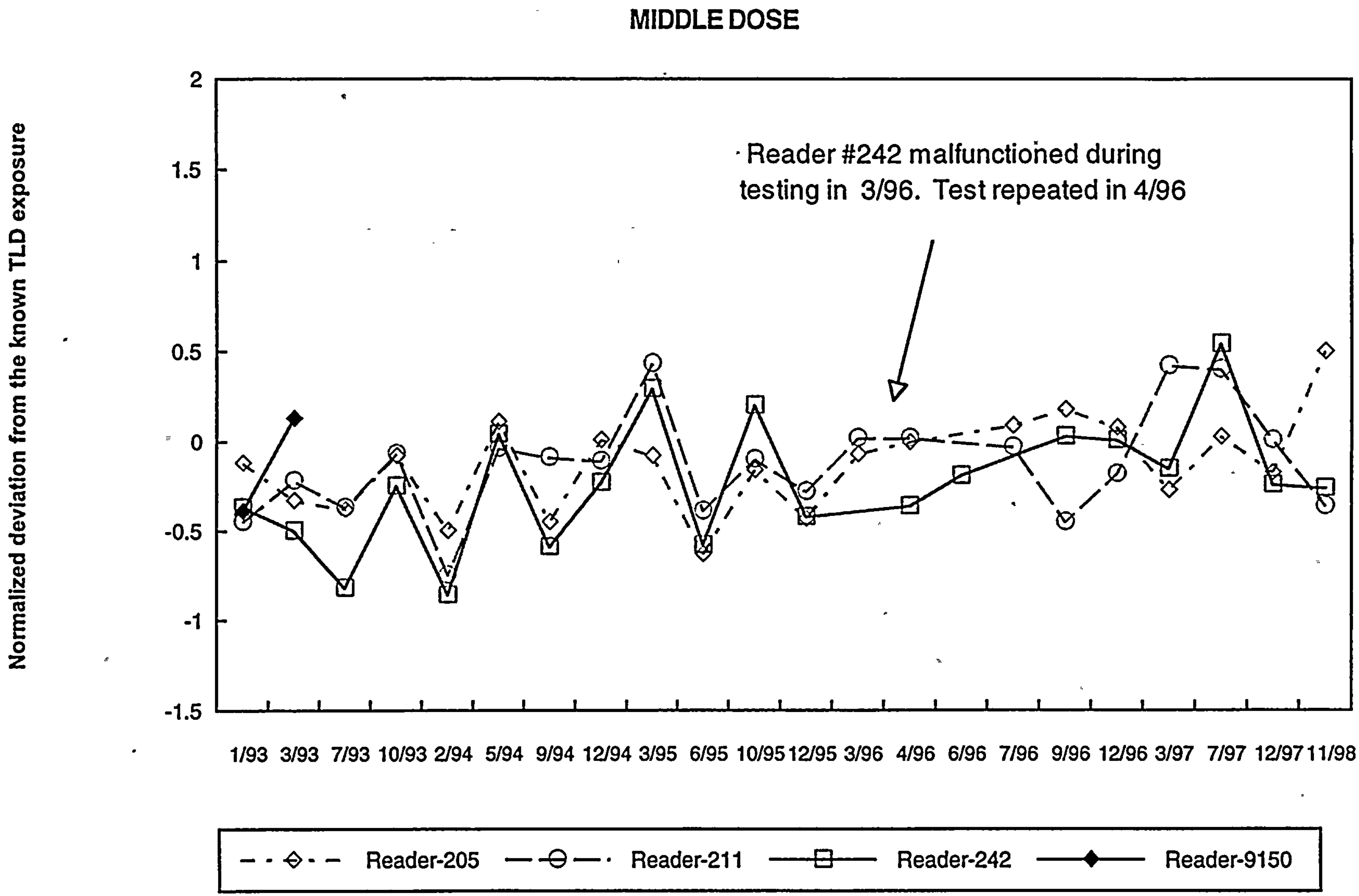
QUALITY CONTROL - TLDs

LOW DOSE



Reader-9150 was permanently removed from [illegible]ce during the first quarter 1993.

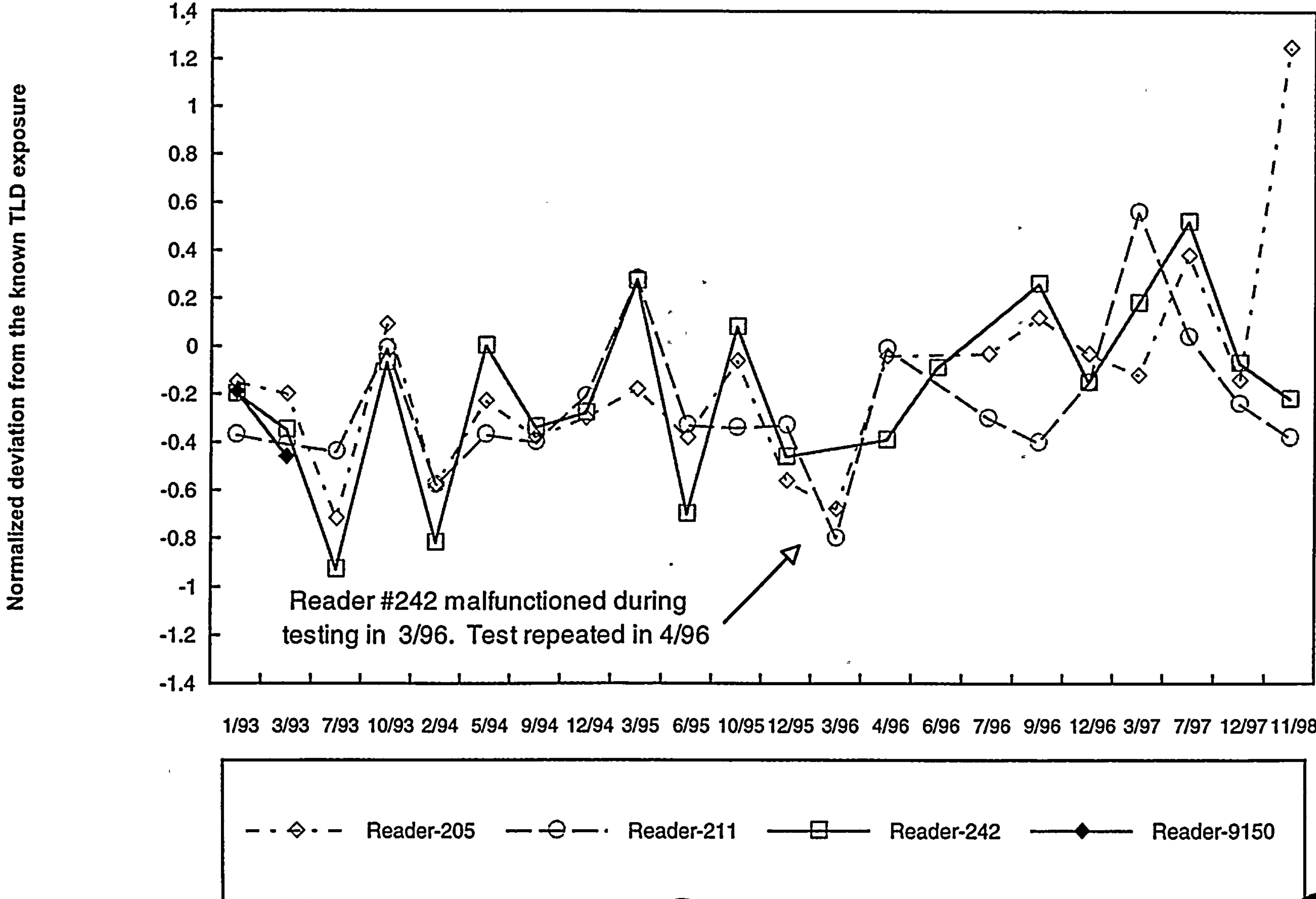
QUALITY CONTROL - TLDs



Reader-9150 was permanently removed from service during the first quarter 1993.

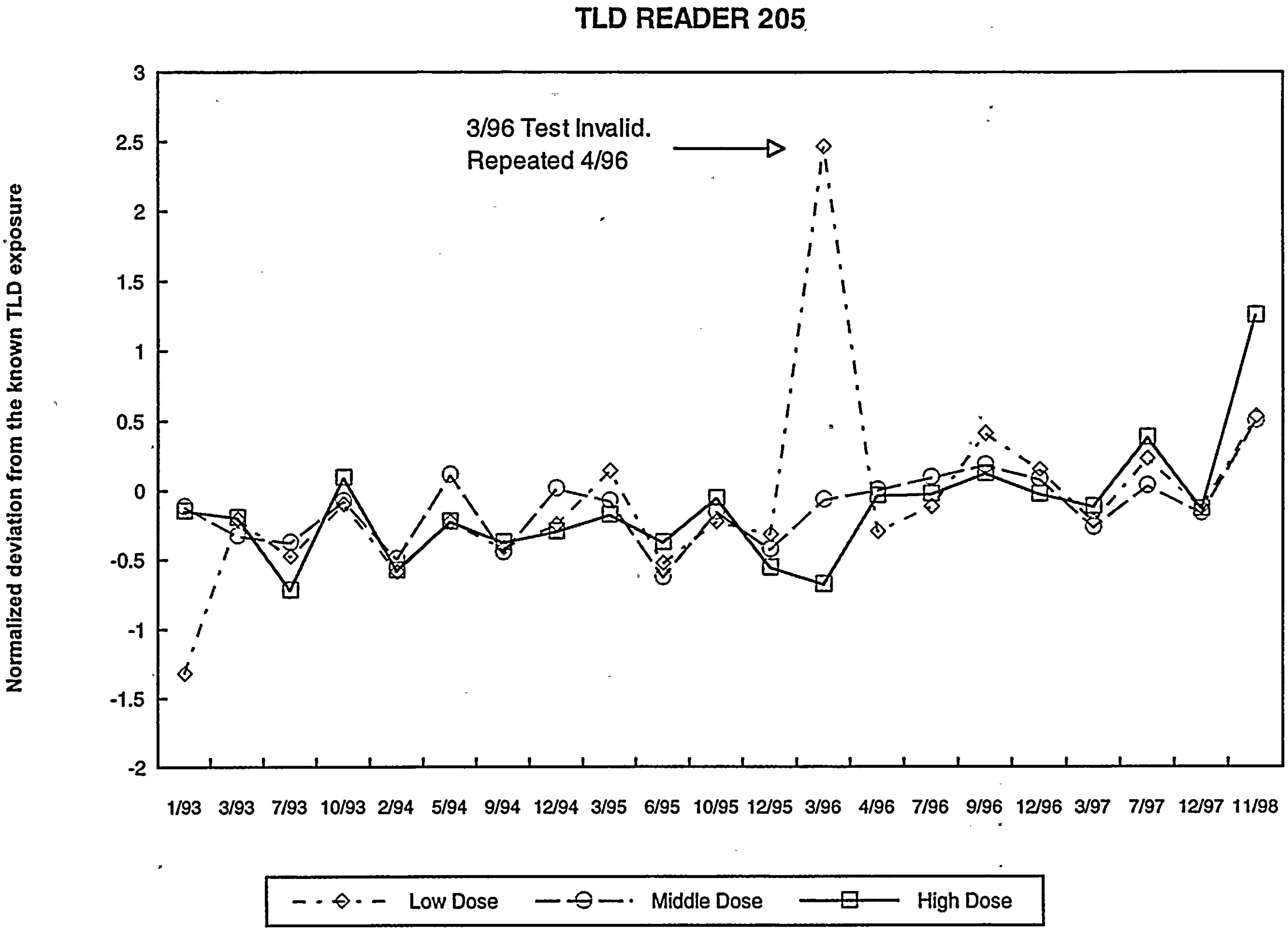
QUALITY CONTROL - TLDs

HIGH DOSE



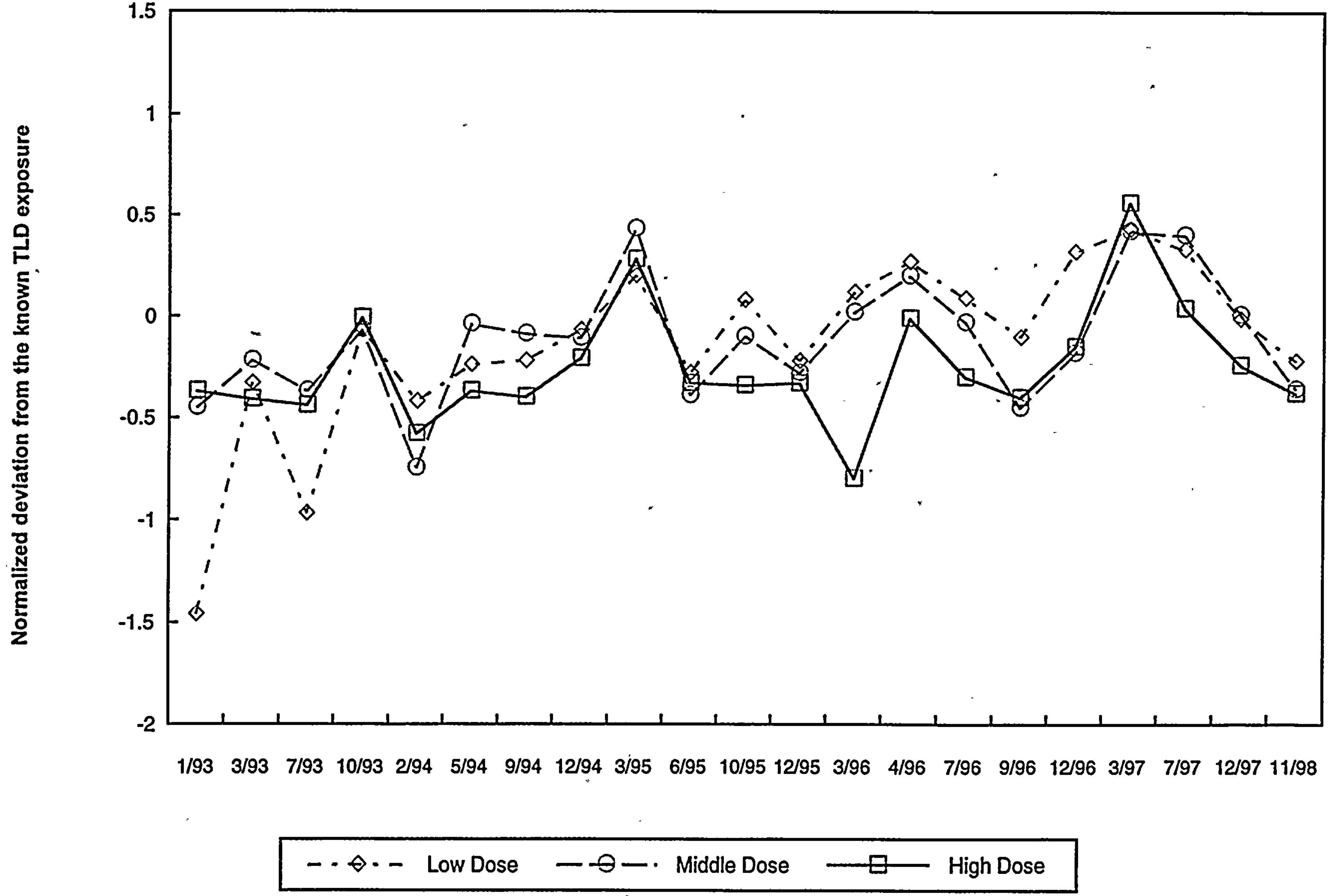
Reader-9150 permanently removed [illegible] service during the first quarter 1993.

QUALITY CONTROL - TLDs



QUALITY CONTROL - TLDs

TLD READER 211



QUALITY CONTROL - TLDs

TLD READER 242