

DAVIS - BESSE
NUCLEAR POWER STATION
UNIT NO. 1

ROOM 016

POOR ORIGINAL

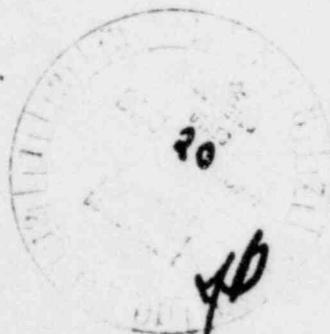
50-346

SUPPLEMENT
TO

Received in the Office 12-20-74

ENVIRONMENTAL REPORT
OPERATING LICENSE STAGE

RETURN TO REGULATORY DIVISION ROOM 016



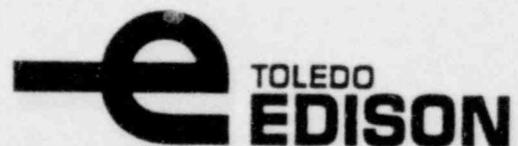
8002040625

12895

DAVIS - BESSE
NUCLEAR POWER STATION
UNIT NO. 1

SUPPLEMENT
TO
ENVIRONMENTAL REPORT
OPERATING LICENSE STAGE

POOR ORIGINAL





LOWELL E. ROE
Vice President
Facilities Development
(419) 259-5242

Docket No. 50-346

December 20, 1974

Mr. A. Giambusso, Deputy Director for Reactor Projects
Directorate of Licensing
Office of Regulation
United States Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Giambusso:

Under separate cover, we are transmitting Amendment No. 25 to the Application for Licenses for the Davis-Besse Nuclear Power Station Unit 1. This Amendment consists of the Supplement to the Applicant's Environmental Report-Operating License Stage. Three (3) original and twenty-five (25) conformed copies of the transmittal sheet are included together with two hundred (200) copies of the Supplement to the Environmental Report-Operating License Stage.

This Supplement to the Environmental Report addresses any differences between currently projected environmental effects of the Unit and the effects initially discussed in the Environmental Report-Operating License Stage; the results of studies which were not completed at the time of submission of the Environmental Report-Operating License Stage; and the monitoring programs which will be undertaken to determine the effects of unit operation on the environment.

We feel that with this Supplement, your staff will be able to continue their timely review of the Davis-Besse Nuclear Power Station Unit 1 Environmental Report-Operating License Stage. Should any further information or clarification be needed, do not hesitate to contact myself or any of my staff.

Yours very truly,

A handwritten signature in cursive script that reads 'Lowell E. Roe'.

INTRODUCTION

The Davis-Besse Nuclear Power Station Unit No. 1 Environmental Report-Operating License Stage was submitted December 20, 1972 in response to 10 CFR 50, Appendix D. The Environmental Report-Operating License Stage consisted of all information contained in the Applicants' Environmental Report-Construction Permit stage as amended by the Supplement to the Environmental Report and the Cost and Benefit Analysis Supplement to said Environmental Report. The purpose of this supplement to the Environmental Report-Operating License Stage is to provide information to:

1. Discuss any differences between currently projected environmental effects of the nuclear plant and the effects discussed in the Environmental Report submitted at the Construction Permit Stage.
2. Discuss the results of studies which were not completed at the time of preparation of the Environmental Report at the Construction Permit stage.
3. Describe in detail the monitoring programs which will be undertaken to determine the effects of the operating plant on the environment.

To achieve conformity with the Atomic Energy Commission's Regulatory Guide 4.2, issued in final form in March, 1973, a cross-reference to the Applicant's Environmental Report-Construction Permit Stage and the Commission's Final Environmental Statement-Construction Permit Stage has been developed as follows: The Table of Contents of Regulatory Guide 4.2 was utilized as the base for the cross-reference system. Where material requested by Regulatory Guide 4.2 has previously been addressed in either the Applicant's Environmental Report-Construction Permit Stage or the Commission's Final Environmental Statement-Construction Permit Stage it is referenced according to the appropriate section number in Regulatory Guide 4.2. Where supplemental information is supplied by the Environmental Report Supplement-Operating

Licenses Stage the appropriate reference to the added material is indicated. It is the purpose of this cross-reference system to achieve conformity with Regulatory Guide 4.2 while avoiding repetition of material already covered in the Applicant's Environmental Report-Construction Permit Stage and the Commission's Final Environmental Statement-Construction Permit Stage.

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES				ADDITIONAL INFORMATION SUPPLIED	
		DAVIS-BESSE UNIT NO. 1			AEC	Section	Page
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage	Cost * Benefit Analysis	Final Environmental Statement		
1.	<u>PURPOSE OF THE PROPOSED FACILITY</u>						
1.1	Need for Power		10.1	Bb 1.0	8.1	1.1	1.1-1
1.1.1	Load Characteristics		10.2	Bb 2.0			
1.1.2	Power Supply						
1.1.3	Capacity Requirements		10.3	Bb 3.0			
1.1.4	Statement on Area Need						
1.2	Other Objectives						
1.3	Consequences of Delay		10.4				
2.	<u>THE SITE</u>						
2.1	Site Location and Layout	II A	2.1 3.1	Bc 1.0 Bc 2.0	2.1		
2.2	Regional Demography, Land and Water use	Appendix A			2.2		

* See page xv for explanation of symbols used to reference Sections of the Cost and Benefit Analysis Report.

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES				ADDITIONAL INFORMATION SUPPLIED	
		DAVIS-BESSE UNIT NO. 1		AEC		Section	Page
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage	Cost Benefit Analysis	Final Environmental Statement		
2.3	Regional, Historic, Scenic, Cultural and Natural Land marks		3.		2.3		
2.4	Geology	Appendix A			2.4		
2.5	Hydrology		4.6.6		2.5		
2.6	Meteorology		3.3 Appendix 3A		2.6		
2.7	Ecology	Appendix C	3.4		2.7		
2.8	Background Radiological characteristics		3.5 Appendix 3B		2.8	2.8	2.8-1
2.9	Other Environmental features					2.9	2.9-1
3.	<u>THE PLANT</u>						
3.1	External Appearance		4.1 4.5		3.1		
3.2	Reactor and Steam Electric System				3.2	3.2	3.2-1

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES				ADDITIONAL INFORMATION SUPPLIED	
		DAVIS-BESSE UNIT NO. 1		AEC	Section	Page	
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage				Cost Benefit Analysis
3.3	Plant Water Use		4.6.1 4.6.2 4.6.3 4.6.6 Appendix 2G		3.3.2	3.3	3.3-1
3.4	Heat Dissipation System		4.6.1 4.6.4 4.6.5 4.6.6.3 Appendix 2G Appendix 4B		3.3.1 3.3.2 3.3.3	3.4	3.4-1
3.5	Radwaste Systems	Appendix B	4.4		3.4	3.5	3.5-1
3.6	Chemical and Biocide Wastes		4.6.6.2		3.5	3.6	3.6-1
3.7	Sanitary and Other Waste Systems		4.6.6.2		3.6	3.7	3.7-1

1A

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES				ADDITIONAL INFORMATION SUPPLIED	
		DAVIS-BESSE UNIT NO. 1			AEC	Section	Page
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage	Cost Benefit Analysis	Final Environmental Statement		
3.8	Radioactive Materials Inventory		5.4			3.8	3.8-1
3.9	Transmission Facilities		4.2 Appendix 4A		3.7		
4.	<u>ENVIRONMENTAL EFFECTS OF SITE PREPARATION, PLANT AND TRANSMISSION FACILITIES CONSTRUCTION</u>						
4.1	Site Preparation and Plant Construction		6.1 6.2 6.3		4.1 4.2 4.3 4.4		
4.2	Transmission Facilities Construction		Appendix 4A		4.1 4.4		
4.3	Resources Committed		13.0				
5.	<u>ENVIRONMENTAL EFFECTS OF PLANT OPERATION</u>						
5.1	Effects of Operation of heat dissipation system		7.3.1 7.3.3 7.4 Appendix 4B Appendix 7F		5.2.3 5.2.4 5.3 5.4 5.5	5.1	5.1-1

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES				ADDITIONAL INFORMATION SUPPLIED	
		DAVIS-BESSE UNIT NO. 1		AEC Final Environmental Statement	Section	Page	
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage				Cost Benefit Analysis
5.2	Radiological Impact on Biota Other Than Man		7.2		5.6		
5.2.1	Exposure Pathways				Fig 5.1	5.2	5.2-1
5.2.2	Radioactivity in environment					5.2	5.2-2
5.2.3	Dose Rate Estimates					5.2	5.2-4
5.3	Radiological Impact on Man		7.2		5.7		
5.3.1	Exposure Pathways				Fig 5.2	5.3	5.3-1
5.3.2	Liquid Effluents		Appendix 7B			5.3	5.3-2
5.3.3	Gaseous Effluents		Appendix 7A			5.3	5.3-3
5.3.4	Direct Radiation					5.3	5.3-5
5.3.4.1	Radiation from Facility					5.3	5.3-5
5.3.4.2	Transporation of Radio- active Materials				5.9	5.3	5.3-6

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES				ADDITIONAL INFORMATION SUPPLIED	
		DAVIS-BESSE UNIT NO. 1		AEC	Section	Page	
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage				Cost Benefit Analysis
5.3.5	Summary of Annual Radiation Doses					5.3	5.3-8
5.4	Effects of Chemical and Biocide Discharges		7.3.2		5.2.5 5.5.3	5.4	5.4-1
5.5	Effects of Sanitary and Other Waste Dis- charges		7.3.2		5.2.6		
5.6	Effects of Operation and Maintenance of Transmission System						
5.7	Other Effects				5.4	5.7	5.7-1
5.8	Resources Committed				8.4		
5.9	Decommissioning and Dismantling		2.5				
6.	<u>EFFLUENT AND ENVIRON- MENTAL MEASUREMENTS AND MONITORING PROGRAMS</u>						

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES				ADDITIONAL INFORMATION SUPPLIED	
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage	Cost Benefit Analysis	AEC Final Environmental Statement	Section	Page
6.1	Applicant's Pre-operational Environmental Programs						
6.1.1	Surface Waters						
6.1.1.1	Physical and Chemical Parameters						
6.1.1.2	Ecological Parameters						
6.1.2	Ground Water						
6.1.2.1	Physical and Chemical Parameters						
6.1.2.2	Models						
6.1.3	Air						
6.1.3.1	Meteorology						
6.1.3.2	Models						
6.1.4	Land						

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES				ADDITIONAL INFORMATION SUPPLIED	
		DAVIS-BESSE UNIT NO. 1		AEC	Section	Page	
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage				Cost Benefit Analysis
6.1.4.1	Geology and Soils						
6.1.4.2	Land Use and Demographic Surveys						
6.4.4.3	Ecological Parameters						
6.1.5	Radiological Surveys		3.5 Appendix 3B			6.1	6.1-1
6.2	Applicant's Proposed Operational Monitoring Programs						
6.2.1	Radiological Monitoring					6.2	6.2-1
6.2.1.1	Plant Effluent Monitoring System			6.1.2		6.2	6.2-1
6.2.1.2	Environmental Radiological Monitoring			6.2.3		6.2	6.2-8
6.2.2	Chemical Effluent Monitoring			6.1.1		6.2	6.2-11

x

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES				ADDITIONAL INFORMATION SUPPLIED	
		DAVIS-BESSE UNIT NO. 1		AEC	Section	Page	
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage				Cost Benefit Analysis
6.2.3	Thermal Effluent Monitoring					6.2	6.2-15
6.2.4	Meteorological Monitoring					6.2	6.2-15
6.2.5	Ecological Monitoring				6.2.1 6.2.2	6.2	6.2-18
6.2.6	Operational Noise Survey					6.2	6.2-20
6.3	Related Environmental Measurements and Monitoring Programs						
7.	<u>ENVIRONMENTAL EFFECTS OF ACCIDENTS</u>						
7.1	Plant Accidents Involving Radio- activity		8.1 through 8.9 Appendix 8A Appendix 8B		7.1 7.2	7.1	7.1-1

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES				ADDITIONAL INFORMATION SUPPLIED	
		DAVIS-BESSE UNIT NO. 1		AEC	Section	Page	
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage				Cost Benefit Analysis
7.2	Other Accidents						
8.	<u>ECONOMIC AND SOCIAL EFFECTS OF PLANT CONSTRUCTION AND OPERATION</u>						
8.1	Benefits			Ca Cb	8.3		
8.2	Costs			Db	8.2		
9.	<u>ALTERNATE ENERGY SOURCES AND SITES</u>						
9.1	Alternates not requiring the creation of new generating capacity				9.1		
9.2	Alternates requiring the creation of new generating capacity				9.3		

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES				ADDITIONAL INFORMATION SUPPLIED	
		DAVIS-BESSE UNIT NO. 1		AEC	Section	Page	
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage				Cost Benefit Analysis
9.2.1	Selection of Candidate Areas		11.2.2 11.2.5		1.2 9.2		
9.2.2	Selection of Candidate site-plant Alterna- tives		11.2.6		9.3		
9.3	Cost-Effectiveness comparison of candi- date site-plant Al- ternatives				9.3		
10.	<u>PLANT DESIGN</u> <u>ALTERNATIVES</u>						
10.1	Cooling System		11.7 14.5 14.7	Dc 1.2 Dc 3.1 Dc 3.4 Dc 4.3	10.1		
10.2	Intake System			Dc 1.1	10.2		
10.3	Discharge System			Dc 1.3	10.3		
10.4	Chemical Waste Treatment			Dc 1.4	10.4		

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES			ADDITIONAL INFORMATION SUPPLIED	
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage	Cost Benefit Analysis	AEC Final Environmental Statement	Section
10.5	Biocide Treatment				10.5	
10.6	Sanitary Waste System				10.6	
10.7	Liquid Radwaste System		11.5 14.6.2.2 14.6.2.3	Dc 1.5		
10.8	Gaseous Radwaste System		11.5 14.6.2.4	Dc 3.3		
10.9	Transmission Facilities		11.3 Appendix 4A		10.7	
10.10	Other Systems					
11.	<u>SUMMARY BENEFIT- COST ANALYSIS</u>		12.0 14.0		11.0	
12.	<u>ENVIRONMENTAL APPROVALS AND CONSULTATIONS</u>	III	2.2 2.3		1.3	12.1 12.1-1

SECTION	TITLE ENVIRONMENTAL REPORT (AEC GUIDE)	REFERENCES				ADDITIONAL INFORMATION SUPPLIED	
		Environmental Report Construction Stage	Environmental Report Supplement Construction Stage	Cost Benefit Analysis	AEC Final Environmental Statement	Section	Page
			Appendix 2A 2B 2C 2D 2E 2F 2I				

The Sections and Subsections of the Davis-Besse Nuclear Power Station Cost and Benefit Analysis Supplement to the Environment Report do not contain any numerical references in their titles. Therefore, these Sections and Subsection will be given the following reference symbols to facilitate their inclusion into the cross referencing index.

- A INTRODUCTION
- B BACKGROUND INFORMATION
 - Ba Summary
 - Bb Analysis of requirements for Additional Generating Capacity
 - Bc Site Description and Present Status of Construction
- C BENEFITS
 - Ca Direct
 - Cb Indirect
 - Cc. Tabulation of Benefits

- D EVALUATION OF PLANT DESIGNS
 - Da Alternatives
 - Db Generating Costs
 - Dc Environmental Effects
 - Dd The Alternative of Abandonment
- E TABULATION OF ENVIRONMENTAL AND GENERATING COSTS
FOR ALTERNATIVES

POOR ORIGINAL

1.0 PURPOSE OF THE PROPOSED FACILITY

Some of the estimated peak load and generating capability figures contained in Section 1.1 of this report have been revised to reflect the most recent peak load forecasts, generating unit ratings and availability. For these reasons some of the figures in this section are not the same as corresponding data in the Construction Permit Stage Report and in testimony presented at the Environmental Hearing. In addition, the scheduled commercial operation date of Davis-Besse Unit No. 1 has been delayed to June 1, 1976. This delay is such that the unit will not be available during the 1975 summer peak load season. The figures also reflect the effect of the scheduled commercial operation date of Mansfield Unit No. 2, which has been delayed to April 1, 1977. The Toledo Edison Company and The Cleveland Electric Illuminating Company will own 143 MW and 236 MW, respectively, as tenants in common with the other members of the CAPCO Group in the Mansfield Unit No. 2.

1.1 NEED FOR POWER

The projected system summer peak loads and generating capacities for TECo and CEI for the years 1975 and 1976, are presented in Tables 1.1-1 and 1.1-2, respectively. Since CAPCO operates as a pool a more meaningful picture of the reserves available for meeting the total CAPCO load are those based upon CAPCO data as presented in Table 1.1-3. Also shown in Table 1.1-3 are reserves without Davis-Besse Unit No. 1 during the summer peak load in 1976. The Federal Power Commission recommends a 20% reserve margin thus from having a less than adequate reserve margin in CAPCO of 16.6% with Davis-Besse Unit No. 1, the reserve margin drops to 9.4% without Davis-Besse Unit No. 1.

Davis-Besse Unit No. 1 generation will be shared between The Toledo Edison Company and The Cleveland Electric Illuminating Company in proportion to

their respective ownership shares of 52.5% and 47.5%. Since CAPCO operates on a one-system basis, sharing of the Davis-Besse Unit No. 1 generation during the initial few years of operation with the other CAPCO companies may become a necessity in order for each company to meet their load and reserve requirements. The sharing of the Davis-Besse Unit No. 1 generation among the CAPCO companies becomes more apparent if delays occur to other base load generating capacity on the CAPCO system.

At this time it is difficult to predict the ECAR (East Central Area Reliability Council) reserve situation (of which the CAPCO companies are members). This is due to a number of announcements of major delays of base load generating capacity.

Table 1.1-1
The Toledo Edison Company
Projected System Load
and
Generating Capacity

<u>Year</u>	<u>Projected Peak Summer Load (1) (MW)</u>	<u>Scheduled Seasonal Capacity (2) (MW)</u>	<u>Projected Net Power Purchases (3) (MW)</u>	<u>Available Capacity (MW)</u>	<u>Projected Reserves (MW)</u>	<u>Reserve Capacity (%)</u>
1975	1442	1549	137	1686	244	16.9
1976	1564	1731	112	1843	279	17.8

(1) As used in ECAR's reporting to the Federal Power Commission Pursuant to Docket R-362, Order 383-3, April, 1974.

(2) Estimate of CAPCO capacity schedule and tentative entitlement arrangements of capacity interchange between CAPCO companies at time of summer peak.

(3) Includes entitlement of OVEC.

Table 1.1-2
The Cleveland Electric Illuminating Company
Projected System Load
and
Generating Capacity

<u>Year</u>	<u>Projected Peak Summer Load (1) (MW)</u>	<u>Scheduled Seasonal Capacity (2) (MW)</u>	<u>Projected Net Power Purchases (MW)</u>	<u>Available Capacity (MW)</u>	<u>Projected Reserves (MW)</u>	<u>Reserve Capacity (%)</u>
1975	3460	3756	- -	3756	296	8.6
1976	3670	4032	- -	4032	362	9.9

(1) As used in ECAR's reporting to the Federal Power Commission Pursuant to Docket R-362, Order 383-3, April, 1974.

(2) Estimate of CAPCO capacity schedule and tentative entitlement arrangements of capacity interchange between CAPCO companies at time of summer peak.

1.1-4

DB-1

Table 1.1-3

CAPCO

Projected System Load
and
Generating Capacity

Year	Projected Peak Summer Load (1) (MW)	Scheduled Seasonal Capacity (2) (MW)	Projected Net Power Purchases (3) (MW)	Available Capacity (MW)	Projected Reserves (MW)	Reserve Capacity	
						With Davis-Besse (%)	Without Davis-Besse (%)
1975	11667	13323	378	13701	2034	-	17.4
1976	12434	14287	221	14508	2074	16.7	9.4

1.1-5

DB-1

(1) As used in ECAR's reporting to the Federal Power Commission Pursuant to Docket R-362, Order 383-3, April, 1974.

(2) CAPCO capacity schedule as of September 9, 1974.

(3) Includes entitlement of OVEC owners, and receipts for Buckeye Power to OE.

POOR ORIGINAL

2.8 BACKGROUND RADIOLOGICAL CHARACTERISTICS

Radiological characteristics of the site and surrounding area of the Davis-Besse Nuclear Power Station are being defined and documented through the operation of an extensive preoperational environmental radiological monitoring program designed by NUS Corporation⁽¹⁾ and initiated by Industrial Bio-Test Laboratories, Inc., in July, 1972. This program includes the collection (both onsite and offsite) and radiometric analyses of airborne particulates, airborne iodine, ambient gamma radiation, surface water, ground water, precipitation, soil, bottom sediments, fish, clams, food crops, vegetation, milk, meat, and wildlife. Figures 2.8-1 and 2.8-2 are maps showing the sampling locations used in the monitoring program.

Two years of data have been compiled and reported by Industrial Bio-Test in six separate reports covering the period July, 1972 through June, 1974 (2,3, 4,11,12,13). Summarized below are the results of this study in three separate environments: atmospheric, terrestrial, and aquatic.

2.8.1 THE ATMOSPHERIC ENVIRONMENT

2.8.1.1 Airborne Particulates and Radioiodine

Radioactive airborne particulates observed in the area are composed of a mixture of naturally occurring isotopes, such as ^7Be produced by cosmic ray interaction with the upper atmosphere, or the resuspension of terrestrial radioactive materials and artificially produced radio-nuclides (fallout) resulting from past and recently occurring nuclear weapons tests.

Gross beta and alpha measurements on airborne particulate samples serve as a good indicator of the current atmospheric levels and a sensitive monitor of temporal changes in airborne radioactivity. Since the cessation of atmospheric weapons testing, there has, with time, been a general decline in atmospheric activity. However, increases have occurred in this trend

during a recent period of atmospheric tests by the French and Chinese. In the period November, 1972 through June, 1974, gross beta activity on airborne particulates collected at or near the site averaged 0.088 pCi/m^3 with a range of 0.009 to 0.510 pCi/m^3 . Gross alpha activity measured on the same samples was found to be lower by an order of magnitude averaging 0.0038 pCi/m^3 , with a range of 0.0009 to 0.0131 pCi/m^3 . The monthly averages and ranges for gross alpha and beta are listed in Table 2.8-1. The general variation of the gross activity over the 20-month period is shown on Figure 2.8-3.

Specific radio-nuclides detected in airborne particulate samples were traces of ^{90}Sr , $^{144}\text{Ce-Pr}$, $^{95}\text{Zr-Nb}$, ^{106}Ru , and ^{137}Cs , all long-lived fallout products. The predominant radio-nuclide was naturally occurring ^7Be . The observed concentrations are listed in Table 2.8-2.

Radioiodine is the only gaseous radio-nuclide measured in the atmosphere, since it is the most important radio-nuclide in terms of its potential dose to man. From November, 1972, through June, 1974, no detectable levels of radioiodine (i.e. levels greater than 0.03 pCi/m^3) were obtained at any location in the study.

2.8.1.2 Precipitation

Radioactivity in precipitation samples collected onsite and at Put-In-Bay are listed in Table 2.8-3. Gross beta radioactivity deposition at the two sampling sites are plotted on Figure 2.8-4. The average monthly deposition in this area of Ohio for the 20 months ending July, 1974, was $9.17 \times 10^2 \text{ pCi/m}^2$. Tritium concentrations in precipitation ranged from 200 to 600 pCi/l during this period. These figures for deposition and tritium levels were compared to the measurements reported by the Environmental Protection Agency

(EPA) in their monthly publication Radiation Data and Reports and were found to be consistent with the range of values reported in this country ⁽⁵⁾ and in nearby Canadian stations. ⁽⁶⁾

2.8.1.3 Ambient Radiation Levels

Ambient external radiation levels are measured by thermoluminescent dosimeters (TLDs) on a monthly, quarterly, and annual basis. The estimated annual dose determined by the monthly and quarterly TLDs were found to be significantly different from what was measured using annual TLDs. At this time, it is impossible to determine which TLDs give the best estimate of the yearly dose at the Davis-Besse site. For this discussion, the average ambient levels will be based upon the monthly TLD measurements since there is a greater data base of monthly measurements. The estimated annual dose in the general area of the site was determined to be 59 ± 17 (2 S.D.) mR based upon 18 TLD's located within 40 mi of the site. At seven sampling points onsite or within 1.5 mi from the shield structure, the average annual dose was 55. The distribution at these locations is shown on Figure 2.8-5. The annual offsite dose measured at 11 locations was found to be 62 mR. The distribution at the offsite sampling points is shown on Figure 2.8-6. The seasonal variation of external radiation at three locations, using the monthly TLDs, is shown on Figure 2.8-7. No seasonal pattern is discernible from these data at any of the three locations.

Since there is a question about which TLD measurements give the best estimate of the yearly dose at the Davis-Besse site, the magnitude of the figures was compared to published data by Levin, ⁽⁷⁾ who conducted a comprehensive survey throughout the eastern half of the United States. They were also compared with some estimated values calculated by Oakley ⁽⁸⁾ in an attempt

to place these measurements in their proper perspective. Levin made four measurements in Ohio, reporting dose rates ranging between 9.9 and 10.8 mrad/hr, approximately equivalent to 87 to 95 mrad/yr.

Oakley's estimates for Ohio ranged from 72.8 to 111.9 mrem/yr. For Toledo, Ohio, the closest location to the site, he estimated 88.4 mrem/yr. Values obtained from the program generally fall below the range of published data. These are insufficient data to draw firm conclusions from the TLD measurements and caution should be exercised in their use.

2.8.2 THE TERRESTRIAL ENVIRONMENT

2.8.2.1 Soil

The results of the analyses performed on sixteen soil samples collected over a period of two years are listed in Table 2.8-4. Potassium-40 is the predominant radio-nuclide observed in the soil and accounts for approximately 70% of the gross activity. The soil samples collected on or near the beach, location T-1, were found to have significantly less ^{40}K than the soil collected on the farms. Apparently the higher levels on the farms are the result of the use of high potassium fertilizers which contain ^{40}K . Strontium-90 and ^{137}Cs concentrations, as measured in the soil, were low and variable, varying by a factor of 10 in an 18-month period.

2.8.2.2 Milk

The radioactivity measured in milk at the farms surrounding the Davis-Besse site and at two dairies processing milk from the surrounding region, including nearby states, are tabulated in Tables 2.8-5 and 2.8-6. The short-lived radio-nuclides such as ^{131}I , ^{89}Sr and ^{140}Ba were not detected in any samples during the 24-month period. Potassium-40 levels in the milk samples at the individual farms and at the dairies were very consistent throughout the year and are in agreement. Strontium-90 was found to be higher in the composite

dairy samples than at the individual farms by a factor of two. This trend is shown graphically on Figure 2.8-8.

The observed concentration reported in this program was compared to data gathered at nearby stations of the Pasteurized Milk Network operated by EPA. (9) The levels reported by the monitoring program were within the range reported by EPA in Table 2.8-7.

2.8.2.3 Agricultural Products

Considerable agricultural activity is conducted in the area of the Davis-Besse site, including truck farming, orchards, and dairy farms. Samples of grass and animal feed, as well as fruits and vegetables, were collected during the growing season and at harvest. Table 2.8-8 gives the average and range of the radio-nuclides detected in grass and animal feed samples. In addition to ^{137}Cs and ^{90}Sr , other fallout fission products, including $^{144}\text{Ce-Pr}$, $^{103/106}\text{Ru}$, and $^{95}\text{Zr-Nb}$, were identified as in composite airborne particle samples. Radioactivity levels in fruit and vegetable samples are tabulated in Table 2.8-9. Strontium-90 was the predominant fission product observed in the samples at an average concentration of 0.011 pCi/gm wet.

2.8.2.4 Wildlife

Eight indigenous species of wildlife were caught onsite and analyzed in the first 24 months of the program. The radioactivity measured in these samples are summarized in Table 2.8-10. Three samples of beef are listed with the wildlife sample for comparison.

2.8.2.5 Ground Water

Four wells were sampled in the monitoring program. The observed range of radiological results are given in Table 2.8-11. No significant difference in the radioactivity levels or kind of radioactivity was observed at the four wells.

2.8.3 THE AQUATIC ENVIRONMENT

2.8.3.1 Gross Radioactivity Levels in Lake and River Water

The gross radioactivity in untreated lake and river water is shown in Table 2.8-12. In the period from July, 1972 to June, 1974, gross beta averaged 4.32 pCi/l. Strontium-90 and tritium were the only specific radio-nuclides identified in the water as shown in Table 2.8-13. Strontium-90 averaged 0.79 pCi/l, while tritium was usually less than 300 pCi/l. Cesium-137 was undetectable in all samples.

2.8.3.2 Lake Erie

Treated Lake Erie water was found to average 50% less gross radioactivity than untreated water, presumably as a result of the removal of suspended material from the water by the treatment process. Strontium-90 concentration averaged 0.63 pCi/l, slightly less than the untreated water. Gross beta and alpha radioactivity data are shown in Table 2.8-14. Specific radio-nuclides in treated water are given in Table 2.8-15.

The observed levels in surface water were compared to measured values reported by the Office of Water Programs of the EPA for Lake Erie and rivers in the region. It was found that the values reported in the Davis-Besse monitoring program are consistent with the EPA values. ⁽¹⁰⁾

2.8.3.2.1 Lake Erie Sediment

Bottom sediments were collected in Lake Erie from three locations off the shore bordering the site. The results of the analyses on 23 samples are summarized in Table 2.8-16. Potassium-40 constitutes the predominant radio-nuclide in the sediment. Low levels of ¹³⁷Cs and ⁹⁰Sr were also present in the sediment.

2.8.3.2.2 Fish

Nine species of fish were collected and analyzed during the first two years of the monitoring program. The results of the analyses are presented in Table 2.8-17.

2.8.3.2.3 Clams

Clams were collected once during the period from one location bordering the site. The gross beta activity was 1.10 ± 0.09 pCi/g (wet). Analysis for gamma-emitting isotopes was not performed due to insufficient sample size. The low population of clams in the area may force discontinuance of this sample collection in the future.

DB-1

TABLE 2.8-1

RADIOACTIVITY IN AIR PARTICULATES (2,3,4,11,12,13)
 MONTHLY AVERAGE AND RANGE, * pCi/m³

Month	Number of Samples	Gross Alpha	Gross Beta
<u>1972</u>			
November	17	0.0032 (0.0018 - 0.0046)	0.039 (0.025 - 0.052)
December	40	0.0033 (0.0020 - 0.0059)	0.035 (0.030 - 0.061)
<u>1973</u>			
January	40	0.0038 (0.0013 - 0.0068)	0.033 (0.015 - 0.053)
February	40	0.0041 (0.0013 - 0.0076)	0.033 (0.021 - 0.053)
March	48	0.0032 (0.0009 - 0.0084)	0.023 (0.011 - 0.050)
April	36	0.0028 (0.0012 - 0.0043)	0.026 (0.015 - 0.040)
May	35	0.0030 (0.0016 - 0.0058)	0.029 (0.014 - 0.048)
June	45	0.0029 (0.0012 - 0.0048)	0.032 (0.009 - 0.042)
July	39	0.0038 (0.0022 - 0.0068)	0.048 (0.025 - 0.071)
August	39	0.0053 (0.0018 - 0.0088)	0.057 (0.037 - 0.087)
September	53	0.0045 (0.0015 - 0.0090)	0.053 (0.014 - 0.127)
October	46	0.0054 (0.0009 - 0.0131)	0.058 (0.022 - 0.130)
November	46	0.0042 (0.0010 - 0.0081)	0.051 (0.028 - 0.101)

DB-1

TABLE 2.8-1 (continued)

Month	Number of Samples	Gross Alpha	Gross Beta
December <u>1974</u>	55	0.0041 (0.0020 - 0.0065)	0.056 (0.027 - 0.087)
January	46	0.0049 (0.0022 - 0.0080)	0.084 (0.046 - 0.122)
February	47	0.0040 (0.0013 - 0.0079)	0.099 (0.051 - 0.142)
March	59	0.0037 (0.0018 - 0.0080)	0.149 (0.088 - 0.227)
April	46	0.0037 (0.0016 - 0.0059)	0.306 (0.073 - 0.487)
May	47	0.0030 (0.0014 - 0.0044)	0.302 (0.169 - 0.510)
June	60	0.0025 (0.0010 - 0.0042)	0.249 (0.141 - 0.380)

* Range in parentheses below average value.

DB-1

TABLE 2.8-2
 SPECIFIC RADIONUCLIDES DETECTED IN AIRBORNE PARTICULATE SAMPLES
 pCi/m³
 November, 1972 thru June, 1974

Study Period	Radionuclide	Value	Range
November and December 1972 (2)	⁹⁰ Sr	< 0.001	
	¹⁴⁴ Ce	< 0.01	
	⁹⁵ Zr - Nb	< 0.01	
	⁷ Be	0.06	(0.04 - 0.09)
January thru March 1973(3)	⁹⁰ Sr	0.0004*	(0.0004 - 0.0006)
	¹⁴⁴ Ce- ¹⁴⁴ Pr	0.0018*	(0.0020 - 0.0040)
	⁹⁵ Zr	0.0008*	(0.0008 - 0.0016)
	¹⁰⁶ Ru	0.0030*	(0.0020 - 0.0048)
	¹³⁷ Cs	0.0009	(0.0005 - 0.0013)
	⁷ Be	0.073	(0.055 - 0.091)
April thru June 1973(4)	⁹⁰ Sr	0.0006	
	¹⁴⁴ Ce- ¹⁴⁴ Pr	0.0017	
	⁷ Be	0.068	
	⁹⁵ Zr	0.0001	
	¹⁰⁶ Ru	0.0014	
	¹³⁷ Cs	0.0009	
July thru September 1973	⁹⁰ Sr	0.0009	
	¹⁴⁴ Ce- ¹⁴⁴ Pr	0.002	
	⁷ Be	0.090	
	⁹⁵ Zr	0.0009	
	¹⁰³ Ru	0.001	
	¹⁰⁶ Ru	0.0009	

TABLE 2.8-2 (continued)

Study Period	Radionuclide	Value	Range
October thru December 1973	^{137}Cs	0.001	
	^{141}Ce	0.0006	
	^{144}Ce - ^{144}Pr	0.0025	
	^7Be	0.0692	
	^{103}Ru	0.0013	
	^{106}Ru	0.0012	
	^{137}Cs	0.0003	
January thru March 1974	^{95}Zr	0.0025	
	^{95}Nb	0.0044	
	^{90}Sr	0.0002	
	^{89}Sr	0.005	
	^{90}Sr	0.0005	
	^{144}Ce	0.012	
	^{141}Ce	0.002	
	^7Be	0.102	
	^{103}Ru	0.003	
	^{106}Ru	0.006	
April thru June 1974	^{137}Cs	0.0010	
	^{95}Zr	0.009	
	^{95}Nb	0.017	
	^{89}Sr	0.007	
	^{90}Sr	0.0026	
	^{144}Ce	0.083	
	^{141}Ce	0.002	
^7Be	0.158		

TABLE 2.8-2 (continued)

Study Period	Radionuclide	Value	Range
	^{103}Ru	0.005	
	^{106}Ru	0.039	
	^{137}Cs	0.006	
	^{95}Zr	0.027	
	^{95}Nb	0.058	

*For averaging purposes, one-half of < values are used.

TABLE 2.8-3
 PRECIPITATION SAMPLES, ANALYSES FOR GROSS BETA AND TRITIUM
 DAVIS-BESSE NUCLEAR POWER STATION (2,3,4,11,12,13)

Location	Date Collected	Gross Beta*		Tritium* pCi/ml
		pCi/l	pCi/m ²	
T-1	10-02-72	4.47 ± 0.29	642 ± 41	0.3
(site boundary, NE of site)	10-30-72* Nov. Dec.	23.68 ± 1.75 N.L. N.L.	457 ± 34	0.3
T-23 (Put-In-Bay, 14.3 mi ENE of site)	10-02-72 10-30-72* 12-04-72 Dec.	4.21 ± 0.29 12.14 ± 1.22 9.93 ± 0.43 N.L.	511 ± 35 246 ± 25 1251 ± 56	0.42 ± 0.24 0.38 ± 0.24 0.33 ± 0.24
T-1 (site boundary, NE of station)	1-22-73 3-05-73* 4-09-73	6.35 ± 1.44 18.19 ± 1.56 8.99 ± 0.67	48 ± 11 382 ± 33 439 ± 34	0.52 ± 0.30 0.3 0.3
T-23 (Put-In-Bay, 14.3 mi ENE of site)	1-29-73 3-05-73* 4-02-73	6.59 ± 0.62 31.85 ± 3.61 6.22 ± 0.40	177 ± 17 230 ± 26 623 ± 41	0.53 ± 0.30 0.41 ± 0.30 0.3
T-1 (site boundary, NE of station)	4-30-73 5-04-73 7-02-73	- - -	- - -	- - -
T-23 (Put-In-Bay, 14.3 mi ENE)	5-07-73 6-04-73 7-02-73	163.88 ± 24.21 5.83 ± 0.74 9.27 ± 0.49	149 ± 22 429 ± 34 412 ± 34	0.35 ± 0.25 0.36 ± 0.23 0.51 ± 0.20
T-1 (site boundary 0.6 mi. NE of station, near inlet canal)	8-06-73 9-04-73 10-01-73	N.L.** N.L. 12.47 ± 0.89	- - 531 ± 38	- - < 0.3
T-23 (Put-In-Bay, 14.3 mi. ENE of station)	8-06-73 9-04-73 10-01-73	N.L. N.L. 9.70 ± 0.75	- - 424 ± 33	- - < 0.3
T-1 (site boundary 0.6 mi. NE of station, near inlet canal)	11-02-73 12-05-73 12-31-73	2.51 ± 0.23 N.L.** 4.41 ± 0.24	171 ± 16 - 441 ± 24	0.34 ± 0.27 - 0.26 ± 0.27
T-23 (Put-In-Bay, 14.3 mi. ENE of station)	11-02-73 12-05-73 12-31-73	4.98 ± 0.49 N.L.** 22.26 ± 0.73	150 ± 15 - 1075 ± 35	< 0.3 - < 0.3
T-1 (Site boundary 0.6 mi. NE of station, near inlet canal)	2-04-74 3-04-74 4-01-74 5-06-74 6-03-74 7-01-74	14.9 ± 0.4 19.7 ± 0.7 17.1 ± 0.5 87.4 ± 1.5 27.6 ± 0.6 48.7 ± 1.0	1032 ± 30 636 ± 23 906 ± 27 2732 ± 46 1730 ± 37 1941 ± 39	0.20 ± 0.18 0.20 ± 0.18 < 0.30 0.60 ± 0.19 0.36 ± 0.20 0.45 ± 0.20
T-23 (Put-In-Bay, 14.3 mi. ENE of station)	2-06-74 3-04-74 4-01-74 5-07-74 ^b 6-03-74 7-01-74	17.9 ± 0.6 30.7 ± 1.0 54.0 ± 0.9 2186 ± 46 351.4 ± 3.6 214.4 ± 3.6	798 ± 25 729 ± 24 2745 ± 45 1739 ± 36 2815 ± 46 2754 ± 46	< 0.20 < 0.30 0.47 ± 0.19 0.44 ± 0.20 0.35 ± 0.20 0.35 ± 0.20

* The error given is the probable counting error at the 95% confidence level. Less than < values are based on 3 sigma counting error for background sample.

** N.L. = liquid collected was of insufficient quantity for analyses.

^a No gamma-emitting isotopes were detected above background level.

^b Only 14 ml. of precipitation were collected.

TABLE 2.8-4

RADIOACTIVITY IN SOIL, AVERAGE AND RANGE, pCi/g (dry)^(2,3,4,12,13)
1972 to 1974

Analysis	Average	Range
Gross Beta	24	12 - 33
⁴⁰ K	19	9 - 24
¹³⁷ Cs	0.3*	ND - 0.8
⁹⁰ Sr	0.2*	ND - 0.7

*For averaging purposes, one-half of the minimum detectable concentrations are used.

ND - Nondetectable. Minimum detectable concentrations are:

¹³⁷Cs - 0.01 pCi/g (dry)

⁹⁰Sr - 0.1 pCi/g (dry)

TABLE 2.8-5

 RADIOACTIVITY IN MILK FROM NEARBY FARMS (2,3,4,11,12,13)
 pCi/l

Collection Date	Number of Samples	Gross Beta	^{89}Sr	^{90}Sr	^{131}I	^{140}Ba	^{137}Cs	^{40}K
7-31-72	3	1193	ND	2.53	ND	ND	ND	1320
9-05-72	2	1119	ND	2.66	ND	ND	3.48*	1272
10-02-72	3	1146	ND	2.72	ND	ND	6.74	1249
10-30-72	3	1172	ND	1.54	ND	ND	2.78*	1280
12-04-72	3	1090	ND	2.93	ND	ND	3.17*	1316
1-02-73	3	1182	ND	2.27	ND	ND	ND	1312
2-05-73	3	1216	ND	2.94	ND	ND	2.27*	1287
3-05-73	3	1140	ND	2.64	ND	ND	4.62*	1244
4-02-73	3	1166	ND	2.50	ND	ND	ND	1310
4-30-73	3	1185	ND	2.73	ND	ND	ND	1328
6-04-73	3	1297	ND	2.43	ND	ND	ND	1328
7-02-73	3	1288	ND	2.96	ND	ND	ND	1230
8-06-73	3	954	ND	2.86	ND	ND	2.72*	1267
9-04-73	3	1307	ND	2.78	ND	ND	ND	1249
10-01-73	5	1097	ND	2.25	ND	ND	ND	1216

2.8-15

DB-1

TABLE 2.8-5 (continued)

Collection Date	Number of Samples	Gross Beta	⁸⁹ Sr	⁹⁰ Sr	¹³¹ I	¹⁴⁰ Ba	¹³⁷ Cs	⁴⁰ K
11-05-73	3	941	ND	2.07	ND	ND	2.44*	1221
12-11-73	3	1114	ND	2.18	ND	ND	3.32	1208
1-07-74	3	1070	ND	2.08	ND	ND	3.29*	1215
2-04-74	3	965	ND	2.08	ND	ND	ND	1264
3-04-74	3	1129	ND	1.69	ND	ND	2.39*	1262
4-01-74	3	1133	ND	1.43	ND	ND	ND	1225
5-06-74	3	980	ND	1.97	ND	ND	ND	1214
6-03-74	3	1077	ND	2.24	ND	ND	3.59*	1237
Observed range at the three farms		838-1409	ND	0.87-3.97	ND	ND	3.22-8.83	1139-1349

* For averaging purposes, one-half of the minimum detectable concentrations are used.

ND = Nondetectable. Minimum detectable concentrations are:

⁸⁹Sr - 0.5 pCi/l, ¹³¹I - 3.3 pCi/l, ¹⁴⁰Ba - 3.7 pCi/l, ¹³⁷Cs - 3.5 pCi/l.

TABLE 2.8-6

RADIOACTIVITY IN MILK FROM TOLEDO AND SANDUSY DAIRIES^(2,3,4,11,12,13)
pCi/l

Collection Date	Number of Samples	Gross Beta	⁸⁹ Sr	⁹⁰ Sr	¹³¹ I	¹⁴⁰ Ba	¹³⁷ Cs	⁴⁰ K
7-31-72	2	1224	ND	4.69	ND	ND	ND	1224
9-05-72	2	1141	ND	4.42	ND	ND	3.59	1289
10-02-72	2	898	ND	4.82	ND	ND	4.73	1290
10-30-72	2	980	ND	3.66	ND	ND	4.09	1274
12-04-72	2	994	ND	4.97	ND	ND	5.57	1332
1-02-73	2	1192	ND	4.43	ND	ND	2.48*	1311
2-05-73	2	1150	ND	3.55	ND	ND	2.66*	1272
3-05-73	2	1120	ND	2.91	ND	ND	3.12*	1282
4-02-73	2	1265	ND	5.48	ND	ND	2.63*	1341
4-30-72	2	1259	ND	4.51	ND	ND	2.72*	1331
6-04-73	2	1237	ND	4.45	ND	ND	ND	1308
7-02-73	2	1181	ND	4.19	ND	ND	3.93	1278
8-06-73	2	1021	ND	4.54	ND	ND	5.14	1282
9-04-73	2	1190	ND	3.17	ND	ND	ND	1181
10-01-73	2	1067	ND	6.22	ND	ND	3.72	1229

2.8-17

DB-1

TABLE 2.8-6 (continued)

Collection Date	Number of Samples	Gross Beta	^{89}Sr	^{90}Sr	^{131}I	^{140}Ba	^{137}Cs	^{40}K
11-05-73	2	958	ND	6.22	ND	ND	2.63*	1254
12-11-73	2	1082	ND	7.14	ND	ND	ND	1301
1-07-74	2	1130	ND	5.08	ND	ND	3.14*	1252
2-04-74	2	1147	ND	3.08	ND	ND	2.77*	1284
3-04-74	2	1078	ND	3.07	ND	ND	ND	1288
4-01-74	2	1099	ND	3.41	ND	ND	ND	1330
5-06-74	2	1128	ND	4.00	ND	ND	ND	1300
6-03-74	2	1165	ND	4.21	ND	ND	4.82	1278
Observed range at the two dairies		832-1327	ND	1.69-9.81	ND	ND	3.20-9.38	1143-1357

* For averaging purposes, one-half of the minimum detectable concentrations are used.

ND=Nondetectable. Minimum detectable concentrations are:

^{89}Sr - 0.5 pCi/l, ^{131}I - 3.3 pCi/l, ^{140}Ba - 3.7 pCi/l, ^{137}Cs - 3.5 pCi/l.

TABLE 2.8-7

^{90}Sr AND ^{137}Cs IN MILK, pCi/l
 PASTEURIZED MILK NETWORK, ENVIRONMENTAL PROTECTION AGENCY⁽⁹⁾

Collection Period		Monroe, Mich.		Cleveland, Ohio		Windsor, Ont.	
		^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs
July	1972	3	0	6	0	NA	10
Aug.	1972	4	0	NA	0	NA	6
Sept.	1972	NA	NA	NA	19	3	0
Oct.	1972	0	NA	8	0	NA	0
Nov.	1972	0	0	NA	0	NA	4
Dec.	1972	0	0	NA	0	3	5
Jan.	1973	0	0	5	0	NA	5
Feb.	1973	8	0	NA	0	NA	15
Mar.	1973	9	0	NA	0	2	6
Apr.	1973	5	0	6	0	NA	3
May	1973	NS	NS	NA	0	NA	10
June	1973	14	0	NA	13	2	3

NA = No analysis

NS = No sample

0 = Value means that measured value is equal or less than the practical reporting value. The practical reporting values are:

^{90}Sr - 2 pCi/l

^{137}Cs - 10 pCi/l

TABLE 2.8-8
 RADIOACTIVITY IN GRASS AND ANIMAL FEED SAMPLES^(2,4,12)
 AVERAGE AND RANGE*
 pCi/g (wet)

Sample	Number of Samples	Collection Date	Gross Alpha	Gross Beta	⁹⁰ Sr	¹³⁷ Cs	¹⁴⁴ Ce - ¹⁴⁷ Pr	^{103/106} Mo	⁹⁵ Zr - ⁹⁵ Nb	⁴⁰ K
Grass	1	12-26-72	0.20 ($<0.09 - 0.19$)	14.71 (7.1 - 19.3)	0.20 (0.07 - 0.33)	0.10 (0.07 - 0.13)	0.15 0.14	0.44 (0.24 - 0.53)	0.15 (0.10 - 0.19)	7.49 (3.30 - 10.75)
Grass	2	5-11-73	0.20 (0.9 - 0.31)	5.67 (4.69 - 6.68)	0.04 (0.01 - 0.05)	<0.06	<0.06	0.06 (0.06 - 0.07)	0.001 ($<0.02 - 0.003$)	5.70 (5.67 - 5.72)
Hay	1	12-09-72	<0.15	29.41	0.35	<0.08	<0.37	<0.06	<0.13	16.9
Hay	2	5-31-73	<0.10	4.75 (4.24 - 5.26)	0.07 (0.06 - 0.08)	0.03 (0.02 - 0.03)	<0.04	0.07 (0.06 - 0.07)	0.01	4.38 (3.61 - 5.15)
Hay	2	10-02-73	<0.23	10.83 (4.59 - 17.06)	0.149 (0.075-0.222)	0.029 (0.004 - 0.053)	<0.15	0.06 (0.01 - 0.11)	0.13 (0.06 - 0.20)	10.00 (4.37 - 15.62)
Corn Feed	1	5-31-73	0.08	4.11	0.01	0.04	0.07	<0.01	0.01	3.05
Corn Feed	1	10-02-73	0.87	5.43	0.009	0.041	0.22	0.02	0.07	3.80
Ground Feed	1	5-31-73	0.91	5.37	0.01	0.06	0.53	0.01	0.04	4.70
Red Clover	1	5-31-73	<0.05	3.80	0.05	0.01	<0.03	0.05	<0.01	3.54
Smart Weed	1	10-02-73	<0.05	3.55	0.07	0.003	<0.04	0.03	0.06	3.70
Soy Bean	1	10-02-73	<0.06	3.50	0.04	0.009	<0.01	0.03	0.03	3.52
Corn	3	10-02-73	0.05 ($<0.04 - 0.08$)	3.51 (2.27 - 4.34)	0.021 (0.008-0.046)	0.009 (0.001 - 0.019)	<0.08	0.02 (0.01 - 0.04)	0.06 (0.01 - 0.14)	3.12 (2.24 - 3.73)
Silage	2	10-02-73	0.21 ($<0.07 - 0.38$)	7.91 (4.16 - 11.66)	0.11 (0.024-0.199)	0.026 (0.002 - 0.050)	<0.11	0.03	0.07 (0.05 - 0.28)	7.40 (4.12 - 10.68)

* Range in parentheses below average value.

TABLE 2.8-9
 RADIOACTIVITY IN FRUIT AND VEGETABLES (2,4,12,13)
 pCi/g (wet)

Sample	Collection Date	Gross Alpha	Gross Beta	^{90}Sr	^{137}Cs	^{40}K	Other Measurable Radionuclides
Tomatoes	9-11-72	<0.02	4.0 ± 0.2	0.005 ± 0.001	<0.01	4.3	-
Apples	9-11-72	<0.01	0.88 ± 0.04	<0.001	<0.01	0.9	-
Pears	9-11-72	<0.01	0.95 ± 0.04	0.002 ± 0.001	<0.01	0.8	-
Grape Juice	9-11-72	<0.009	0.83 ± 0.4	<0.007	0.002 ± 0.001	0.5	-
Cabbage	9-11-72	<0.01	1.56 ± 0.07	0.011 ± 0.001	<0.01	1.9	-
Yellow Beans	9-11-72	<0.03	4.4 ± 0.2	0.012 ± 0.002	<0.01	4.7	-
Plums	9-11-72	<0.01	1.40 ± 0.07	<0.001	<0.01	1.7	-
Rhubarb	5-31-73	<0.02	3.16 ± 0.17	0.014 ± 0.002	<0.01	2.3	Trace ^{90}Sr - ^{90}Zr 0.001 $^{103}/^{106}\text{Pu}$
Rhubarb	5-31-73	<0.02	4.88 ± 0.17	0.017 ± 0.003	0.01	4.2	0.007 $^{103}/^{106}\text{Pu}$
Rhubarb	5-31-73	<0.02	4.66 ± 0.15	0.020 ± 0.002	0.001	2.6	0.003 $^{103}/^{106}\text{Pu}$
Tomatoes	10-02-73	<0.01	2.11 ± 0.05	<0.001	0.01 ± 0.01	2.6	0.01 ± 0.01 ^{95}Zr
Apples	10-02-73	<0.01	0.76 ± 0.02	0.001 ± 0.001	0.01 ± 0.01	1.0	-
Squash	10-02-73	<0.02	1.93 ± 0.09	0.003 ± 0.001	0.01 ± 0.01	1.9	-
Grape Juice*	10-07-73	<13.1	288.20 ± 19.90	0.134 ± 0.063	3.51 ± 0.35	120.7	-
Cucumbers	10-04-73	<0.01	1.77 ± 0.04	0.001 ± 0.001	0.01 ± 0.01	3.4	0.01 ± 0.01 ^{95}Zr
Pears	10-04-73	<0.01	1.24 ± 0.03	0.004 ± 0.001	0.01 ± 0.01	1.2	-
Plums	10-04-73	<0.01	1.28 ± 0.04	0.002 ± 0.001	0.01 ± 0.01	1.2	-
Tomatoes	10-02-73	0.04 ± 0.03	2.34 ± 0.07	0.001 ± 0.001	<0.01	3.5	0.01 ± 0.01 ^{95}Zr
Apples	10-02-73	<0.01	0.77 ± 0.02	0.001 ± 0.001	0.01 ± 0.01	0.8	-
Pumpkins	10-02-73	<0.02	3.07 ± 0.08	0.003 ± 0.001	<0.01	4.2	-
Rhubarb	5-28-74	<0.03	3.6 ± 0.1	0.005 ± 0.001	<0.01	3.8	-
Rhubarb	5-28-74	<0.05	4.9 ± 0.2	0.009 ± 0.006	<0.02	5.9	-
Green Onions	5-28-74	<0.02	2.2 ± 0.1	0.006 ± 0.002	<0.01	2.4	-

*Results in pCi/l

TABLE 2.8-10

RANGE OF RADIOACTIVITY IN WILDLIFE AND DOMESTIC BEEF^(2,4,11,12,13)
1972 to 1974

Sample	Number of Samples	Gross Beta pCi/g wet tissue	⁹⁰ Sr pCi/g dry bone	¹³⁷ Cs pCi/g wet tissue	⁴⁰ K pCi/g wet tissue
Woodchuck	2	2.06 - 2.08	0.83 - 2.08	0.003 - 0.10	1.6 - 3.50
Muskrat	3	1.83 - 2.55	1.85 - 7.37	0.01	1.74 - 2.05
Green Winged Teal	1	2.54	2.86	0.07	2.69
Beef	3	1.69 - 1.84	NA	0.004 - 0.03	1.43 - 2.83
Mallard Duck	3	2.78	1.46	0.02	2.95
Wood Duck	2	2.68	1.60	0.07	2.62
Raccoon	1	2.52	0.43	0.16	2.56
Rabbit	3	2.81	0.67	0.01	2.47
Opposum	1	2.01	0.82	0.01	1.2

NA = Not analyzed

DB-1

TABLE 2.8-11

RADIOACTIVITY IN WELL WATER (2,3,4,11,12,13)
pCi/l
1972 to 1974

Analysis	Average*	Range*
Gross Alpha		
suspended solids	-	<0.04 - 0.21
dissolved solids	-	<0.36 - 5.33
total residue	-	<0.43 - 5.33
Gross beta		
suspended solids	-	<0.11 - 1.64
dissolved solids	-	<0.49 - 32.69
total residue	-	<0.71 - 32.69
Tritium	< 300	-
^{137}Cs	< 3.2	-
^{90}Sr	0.39	<0.26 - 0.96

*Radiological data based upon 28 samples.

TABLE 2.8-12

GROSS RADIOACTIVITY IN UNTREATED SURFACE WATER^(2,3,4,11,12,13)
 MONTHLY AND ANNUAL AVERAGE AND RANGE, pCi/l
 1972 to 1974

Sampling Period	Number of Samples	Gross Alpha			Gross Beta		
		Suspended Solids	Dissolved Solids	Total Residue	Suspended Solids	Dissolved Solids	Total Residue
July 1972	6	0.44	0.26	0.69	0.71	2.90	3.26
August	6	0.16	0.16	0.26	0.44	2.22	2.54
September	6	0.76	0.15	0.76	1.11	2.87	3.98
October	6	1.06	0.33	1.28	1.47	4.13	5.60
November	6	2.07	1.15	3.22	3.32	4.63	7.94
December	6	0.99	0.52	1.39	1.47	3.67	5.14
January 1973	4	0.47	0.41	0.88	0.86	3.37	4.22
February	4	0.32	0.63	0.93	0.74	3.16	3.93
March	4	2.59	0.53	2.39	2.49	3.05	5.38
April	4	0.32	0.80	1.12	1.16	3.53	4.69
May	4	0.59	0.63	1.14	0.89	2.84	3.72
June	4	0.24	0.25	0.45	0.44	3.27	3.70
July	4	0.43	0.65	1.02	1.19	2.91	4.10
August	4	0.62	0.57	1.14	1.23	2.70	3.93

2.8-21

DB-1

TABLE 2.8-12 (continued)

Sampling Period	Number of Samples	Gross Alpha			Gross Beta		
		Suspended Solids	Dissolved Solids	Total Residue	Suspended Solids	Dissolved Solids	Total Residue
September 1973	4	0.56	0.66	1.18	1.99	2.65	4.64
October	4	0.81	0.71	1.50	1.39	2.76	4.15
November	6	0.23	0.32	0.52	0.38	2.60	2.98
December	6	0.47	0.51	0.88	0.69	2.49	3.18
January 1974	4	0.35	0.61	0.96	0.43	3.15	3.57
February	4	0.24	0.49	0.72	0.39	2.91	3.29
March	6	1.15	1.16	2.29	1.70	3.35	5.05
April	6	0.97	1.16	2.12	1.54	4.69	6.23
May	6	0.88	0.63	1.26	1.02	3.59	4.61
June	6	0.65	1.01	1.01	1.09	2.42	3.51
Annual Average	120	0.72	0.60	1.21	1.17	3.16	4.32
Observed Range at 6 locations		0.10 - 5.73	0.18-2.79	0.37-7.57	0.07-8.93	0.95-6.90	.26-15.83

2.8-25

DB-1

TABLE 2.8-13

RADIOACTIVITY IN UNTREATED SURFACE WATER^(2,3,4,11,12,13)
 AVERAGE AND RANGE OF SPECIFIC RADIONUCLIDES, pCi/l
 1972 to 1974

Collection Period	Number of Samples	⁹⁰ Sr		¹³⁷ Cs		³ H	
		Average	Range	Average	Range	Average*	Range
July to September 1972	6	0.80	0.53-1.05	ND		<300	300-510
October to December 1972	6	0.72	ND	ND		<300	300-360
January to March 1973	4	0.82	0.57-1.27	ND		<300	300-330
April to June 1973	4	0.99	0.59-1.21	ND		<300	300-380
July to September 1973	4	1.01	0.77-1.19	ND		<300	<300-470
October to December 1973	4	0.92	0.65-1.20	ND		<300	<300-460
January to March 1974	4	0.61	0.38-0.98	ND		<300	<180-390
April to June 1974	6	0.47	0.27-0.73	ND		334	250-590

* For averaging purposes, one-half of the minimum detectable concentrations are used.

ND = Nondetectable. Minimum detectable concentration is 3.2 pCi/l.

DB-1

TABLE 2.8-14

GROSS RADIOACTIVITY IN TREATED LAKE ERIE WATER (2,3,4,11,12,13)
 AVERAGE AND RANGE, pCi/l
 1972 to 1974

Collection Period	Number of Samples	Gross Alpha		Gross Beta	
		Average*	Range	Average	Range
July 1972	5	0.26	<0.15-0.77	3.27	2.29-3.99
August	12	0.41	<0.16-1.41	3.24	2.02-4.56
September	12	0.27	<0.16-0.85	2.99	2.03-3.88
October	15	0.32	<0.21-0.95	3.71	2.03-5.14
November	12	0.27	<0.21-0.75	3.42	1.59-4.79
December	12	ND	-	2.88	1.06-3.78
January 1973	15	0.17	<0.14-0.34	2.80	1.50-3.50
February	12	0.41	<0.15-0.88	2.83	1.92-3.82
March	12	0.46	<0.21-1.08	2.83	1.61-3.76
April	15	0.44	<0.10-1.09	2.92	1.72-4.04
May	12	0.83	<0.31-1.72	2.67	1.49-3.97
June	12	ND	-	2.85	1.79-3.43
July	15	0.26	<0.21-0.63	2.84	1.81-3.95
August	12	0.28	<0.19-0.86	2.97	1.94-3.83
September	12	0.23	<0.24-0.78	2.86	1.98-4.05
October	15	0.23	<0.21- 0.69	2.33	1.51-2.96
November	12	0.19	<0.23- 0.41	2.04	1.39-3.02
December	15	0.22	<0.21-0.48	2.06	1.56-2.59
January 1974	12	0.24	<0.21-0.66	2.80	2.09-3.38
February	12	0.31	<0.22-0.64	2.73	1.99-3.60
March	12	0.23	<0.27-0.50	2.67	1.65-3.35
April	15	0.46	<0.28-1.30	2.70	1.52-3.76

DB-1

TABLE 2.8-14
(continued)

<u>Collection Period</u>	<u>Number of Samples</u>	<u>Gross Alpha</u>		<u>Gross Beta</u>	
		<u>Average*</u>	<u>Range</u>	<u>Average</u>	<u>Range</u>
May 1974	12	0.25	<0.28- 0.64	2.39	1.61-2.93
June	12	0.19	<0.25- 0.43	2.21	1.40-3.02

* For averaging purposes, one-half of the minimum detectable concentrations are used

ND = Nondetectable. Minimum detectable concentration is 3.2 pCi/l.

TABLE 2.8-15

RADIOACTIVITY IN TREATED LAKE ERIE WATER^(2,3,4,11,12,13)
 AVERAGE AND RANGE OF SPECIFIC RADIONUCLIDES, pCi/l
 1972 to 1974

Collection Period	Number of Samples	⁹⁰ Sr		¹³⁷ Cs		³ H	
		Average	Range	Average	Range	Average*	Range
July to September 1972	29	0.72	0.54-1.07	ND		370	<200-760
October to December 1972	39	0.68	0.60-0.83	ND		<300	<300-620
January to March 1973	39	0.67	0.57-0.73	ND		<300	<300-350
April to June 1973	39	0.76	0.47-1.10	ND		<300	<300-670
July to September 1973	39	0.66	<0.43-0.92	ND		403	<300-700
October to December 1973	42	0.84	0.78-0.88	ND		333	<200-540
January to March 1974	36	0.36	<0.50-0.46	ND		206	<180-410
April to June 1974	39	0.37	<0.34-0.57	ND		331	220-640

* For averaging purposes, one-half of the minimum detectable concentrations are used.

ND = Nondetectable. Minimum detectable concentration is 3.2 pCi/l.

TABLE 2.8-16

RADIOACTIVITY IN BOTTOM SEDIMENTS, DAVIS-BESSE NUCLEAR POWER STATION
 AVERAGE AND RANGE, pCi/g(dry)
 1972 to 1974 (2,3,4,11,12,13)

Analysis	Average*	Range of 23 Samples
Gross Beta	14.4	9.1 - 20.6
Gross Alpha	1.75	ND - 9.10
⁹⁰ Sr	0.12	ND - 0.61
¹³⁷ Cs	0.047	ND - 0.07
⁴⁰ K	14.8	12.3 - 19.7

* For averaging purposes, one-half of the minimum detectable concentrations are used.

ND = Nondetectable. Minimum detectable concentrations are:

Gross Alpha - 1.0 pCi/g(dry)

⁹⁰Sr - 0.14 pCi/g(dry)

¹³⁷Cs - 0.02 pCi/g(dry)

TABLE 2.8-17

RADIOACTIVITY IN FISH, * DAVIS-BESSE NUCLEAR POWER STATION^(2,4,11,12,13)
 AVERAGE AND RANGE, ** p/Ci (wet)

1972 to 1974

Type of Fish	Number of Samples	Gross Beta	⁹⁰ Sr+	¹³⁷ Cs	⁴⁰ K
Carp (<u>Cyprinus carpio</u>)	6	2.29 (1.85 - 2.58)	0.94 (0.55 - 1.75)	0.01 (0.01 - 0.02)	1.90 (1.50 - 2.24)
White Bass (<u>Morone chrysops</u>)	5	2.83 (2.44 - 3.59)	1.10 (0.99 - 1.55)	0.06 (0.05 - 0.07)	2.46 (2.14 - 2.65)
Catfish (<u>Ictalurus punctatus</u>)	8	2.07 (1.65 - 2.56)	0.90 (0.25 - 1.41)	0.02 (0.01 - 0.03)	2.04 (1.52 - 2.44)
Drum (<u>Aplodinotus grunniens</u>)	3	2.71 (2.50 - 3.02)	1.57 (0.80 - 2.13)	0.06 (0.02 - 0.11)	2.46 (2.07 - 2.80)
Perch (<u>Perca flavescens</u>)	2	2.54 (2.22 - 2.86)	0.95 (0.85 - 1.05)	0.02 (0.01 - 0.03)	2.13 (1.85 - 2.41)
Walleye (<u>Stizostedion vitreum</u>)	3	2.54 (2.33 - 2.89)	0.52 (0.21 - 0.68)	0.08 (0.04 - 0.11)	2.59 (2.05 - 3.08)
Shad (<u>Dorosoma celedianums</u>)	1	2.88	0.59	0.01	1.67

2.8-31

DB-1

TABLE 2.8-17 (continued)

Type of Fish	Number of Samples	Gross Beta	^{90}Sr	^{137}Cs	^{40}K
Bullhead (<u>Ictalurus nebulosus</u>)	1	2.43	0.79	0.01	1.82
Crappie (<u>Pomoxis annularis</u>)	1	2.64	0.68	0.02	2.5

2.8-32

DB-1

* Fish collected from Toussaint River (T-3) near storm drain outfall and from Lake Erie in vicinity of site (T-1).

** Range in parentheses below average value.

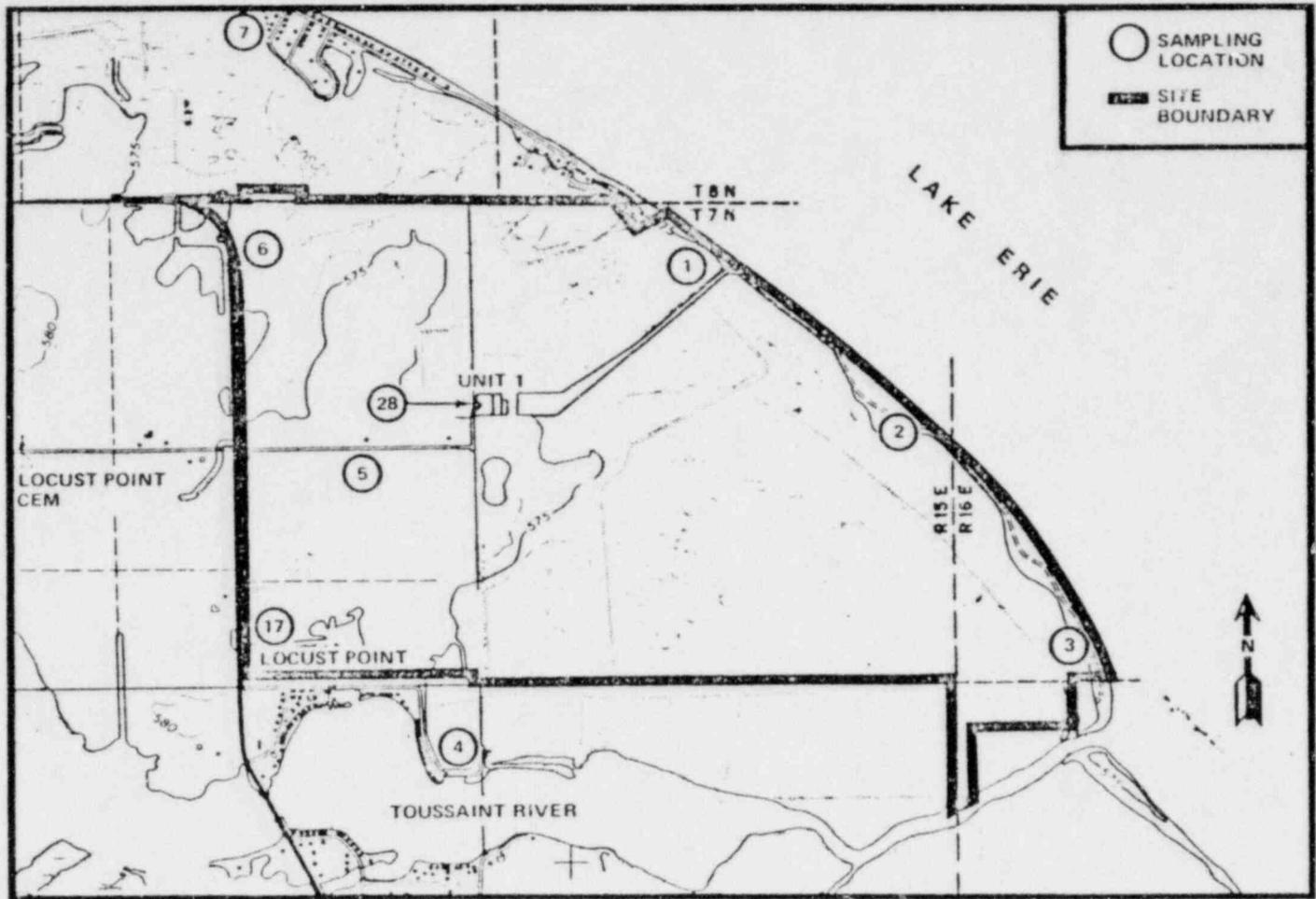
+ ^{90}Sr measured in bone only. Other analyses performed on flesh.

REFERENCES

1. L. K. Cohen, Environmental Radiological Monitoring Program for the Davis-Besse Nuclear Power Station, NUS-886, January 1972.
2. Preoperational Environmental Radiological Monitoring for the Davis-Besse Nuclear Power Station, Oak Harbor, Ohio, July through December 1972, IBT No. W1997, Industrial Bio-Test Laboratories, March 1973.
3. Preoperational Environmental Radiological Monitoring for the Davis-Besse Nuclear Power Station, Oak Harbor, Ohio, First Quarterly Report, January, February, March 1973, IBT No. 64301997, Industrial Bio-Test Laboratories, May 1973.
4. Preoperational Environmental Radiological Monitoring for the Davis-Besse Nuclear Power Station, Oak Harbor, Ohio, Second Quarterly Report, April, May, June 1973, IBT 64301997, Industrial Bio-Test Laboratories, August 1973.
5. New York State Department of Environmental Conservation, Annual Report of Environmental Radiation in New York State, 1972; Radioactivity in Air, Milk and Water for January-March, 1973, Environmental Radiation Bulletin 73-1; Radioactivity in Air, Milk, and Water for April-June 1973, Environmental Radiation Bulletin 73-2.
6. "Radioactivity in Airborne Particulates and Precipitation," Section III, Radiation Data and Reports, Vols. 13 and 14.
7. S. G. Levin, et al., "Summary of Natural Environmental Gamma Radiation Using a Calibrated Portable Scintillation Counter," Radiological Health Data and Reports (November 1968), pp 679-695.
8. D. T. Oakley, Natural Radiation Exposure in the United States, ORP/SID 72-1, Office of Radiation Programs, U.S. Environmental Protection Agency, June 1972.
9. "Pasteurized Milk Network," Radiation Data and Reports, Section I, Vols. 13 and 14.
10. "Water and Tritium Surveillance Systems," Radiation Data and Reports, Section II, Vols. 13 and 14.
11. Preoperational Environmental Radiological Monitoring for the Davis-Besse Nuclear Power Station, Oak Harbor, Ohio, Third Quarterly Report, July, August, September 1973, IBT No. 64301997, Industrial Bio-Test Laboratories, November 1973.
12. Preoperational Environmental Radiological Monitoring for the Davis-Besse Nuclear Power Station, Oak Harbor, Ohio, Fourth Quarterly Report, October, November, December 1973, IBT 64301997, Industrial Bio-Test Laboratories, February 1974.

REFERENCES (continued)

13. Preoperational Environmental Radiological Monitoring for the Davis-Besse Nuclear Power Station, Oak Harbor, Ohio, Semi-Annual Report, January-June 1974, IET 64301997, Industrial Bio-Test Laboratories, August 1974.

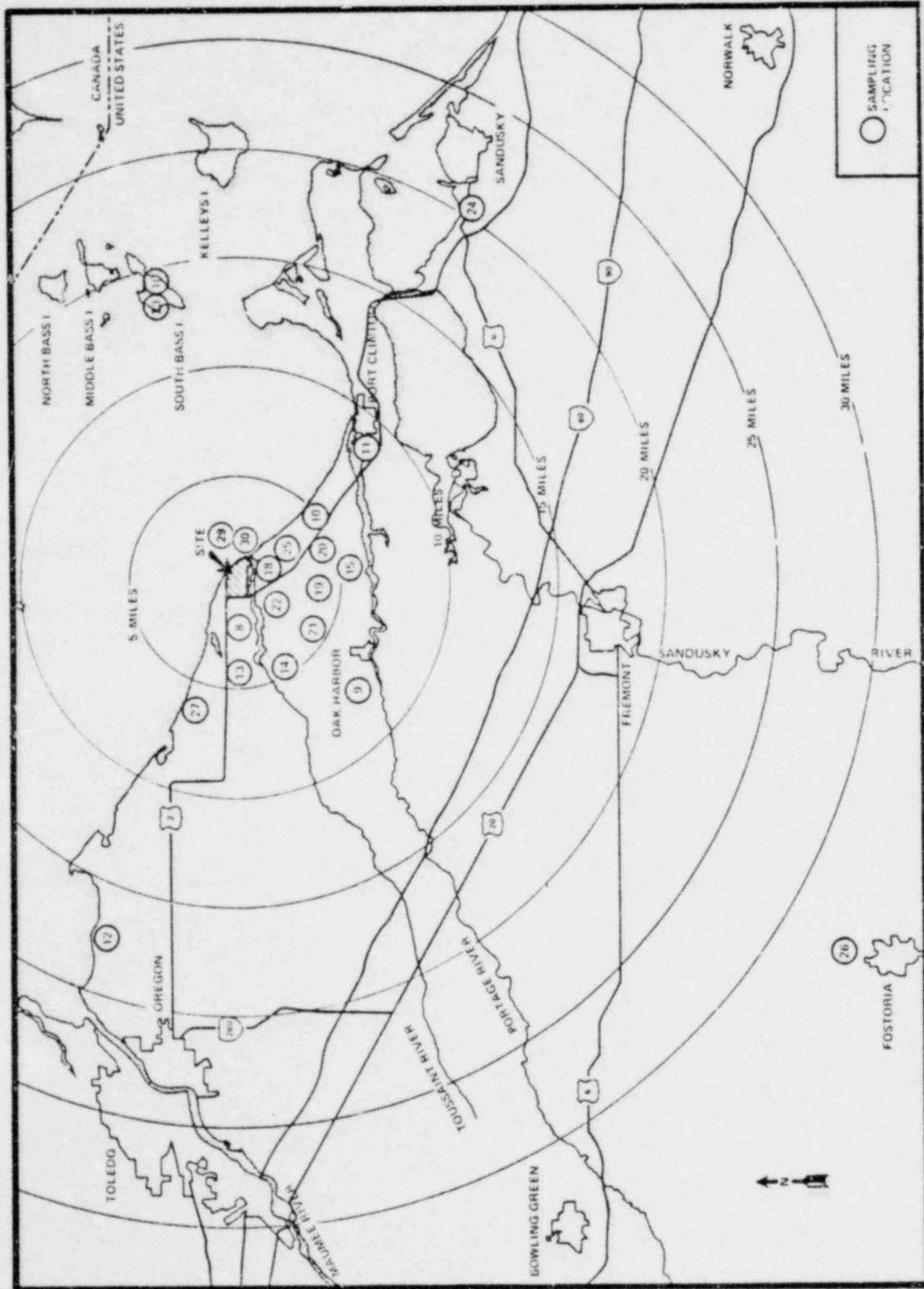


DB-1

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO.1

SAMPLING LOCATIONS ON THE SITE PERIPHERY

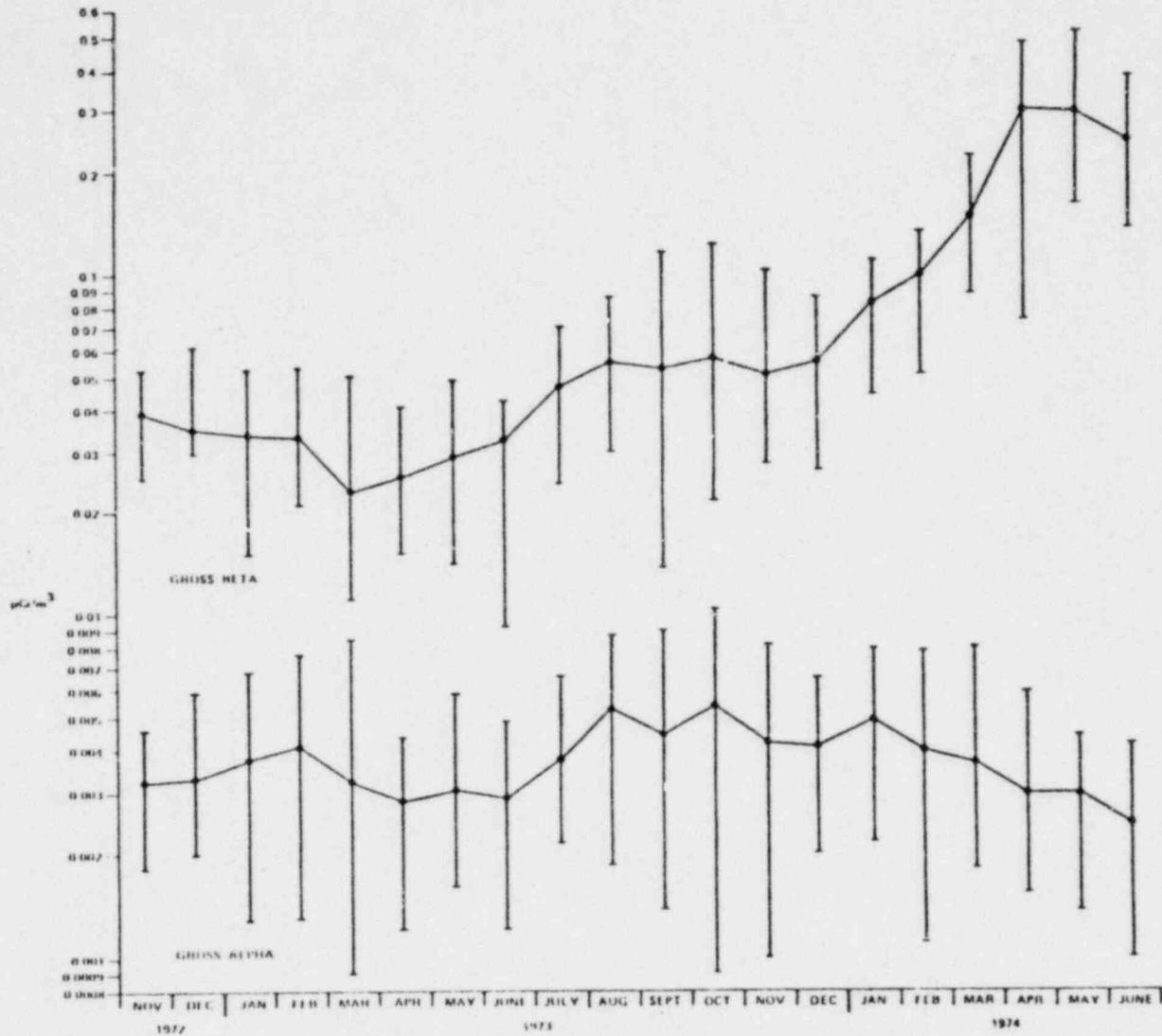
FIGURE 2.8-1



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

SAMPLING LOCATIONS (EXCEPTING THOSE ON THE SITE PERIPHERY)

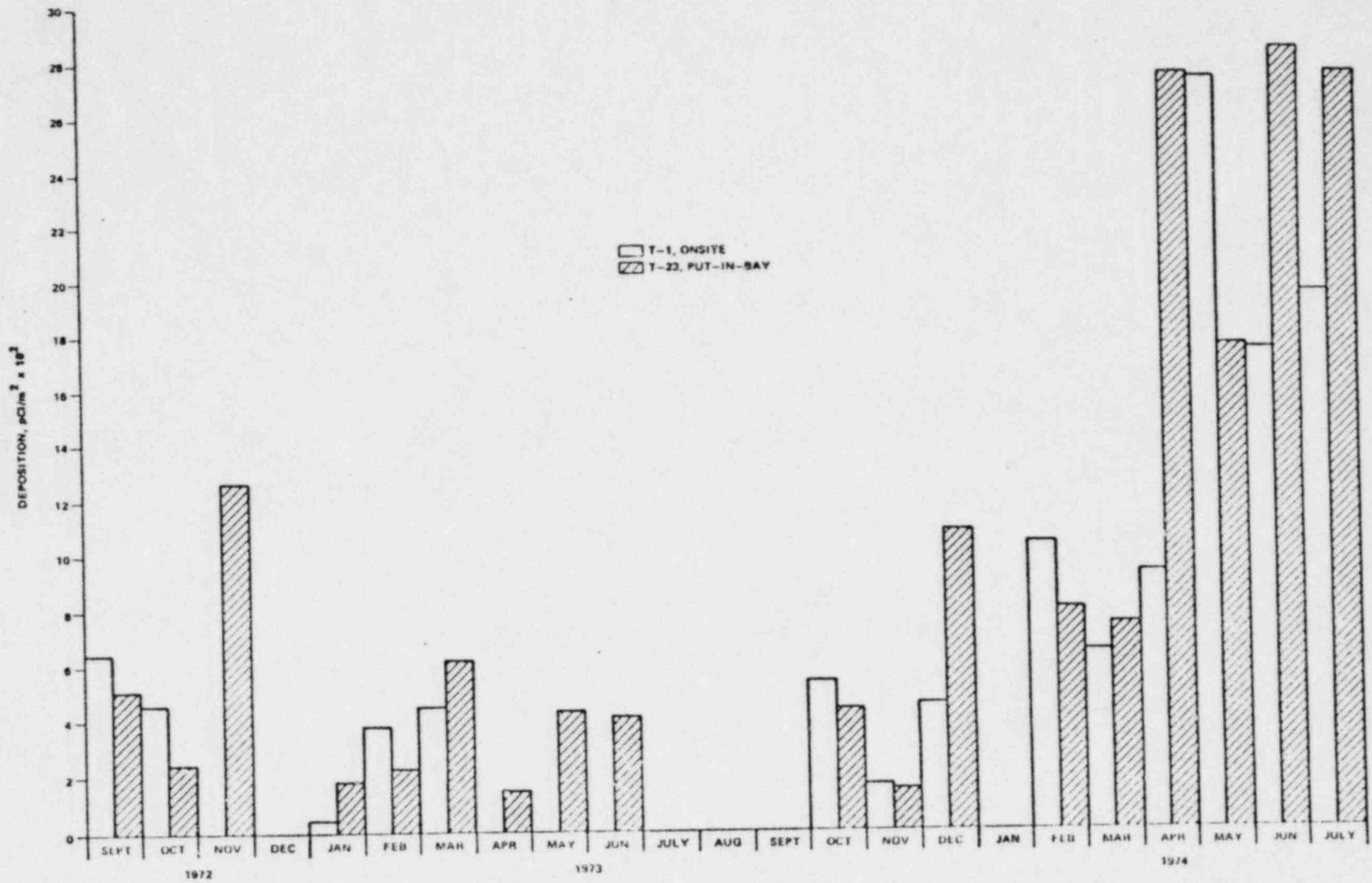
FIGURE 2.8-2



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO.1

GROSS RADIOACTIVITY IN AIRBORNE PARTICULATES

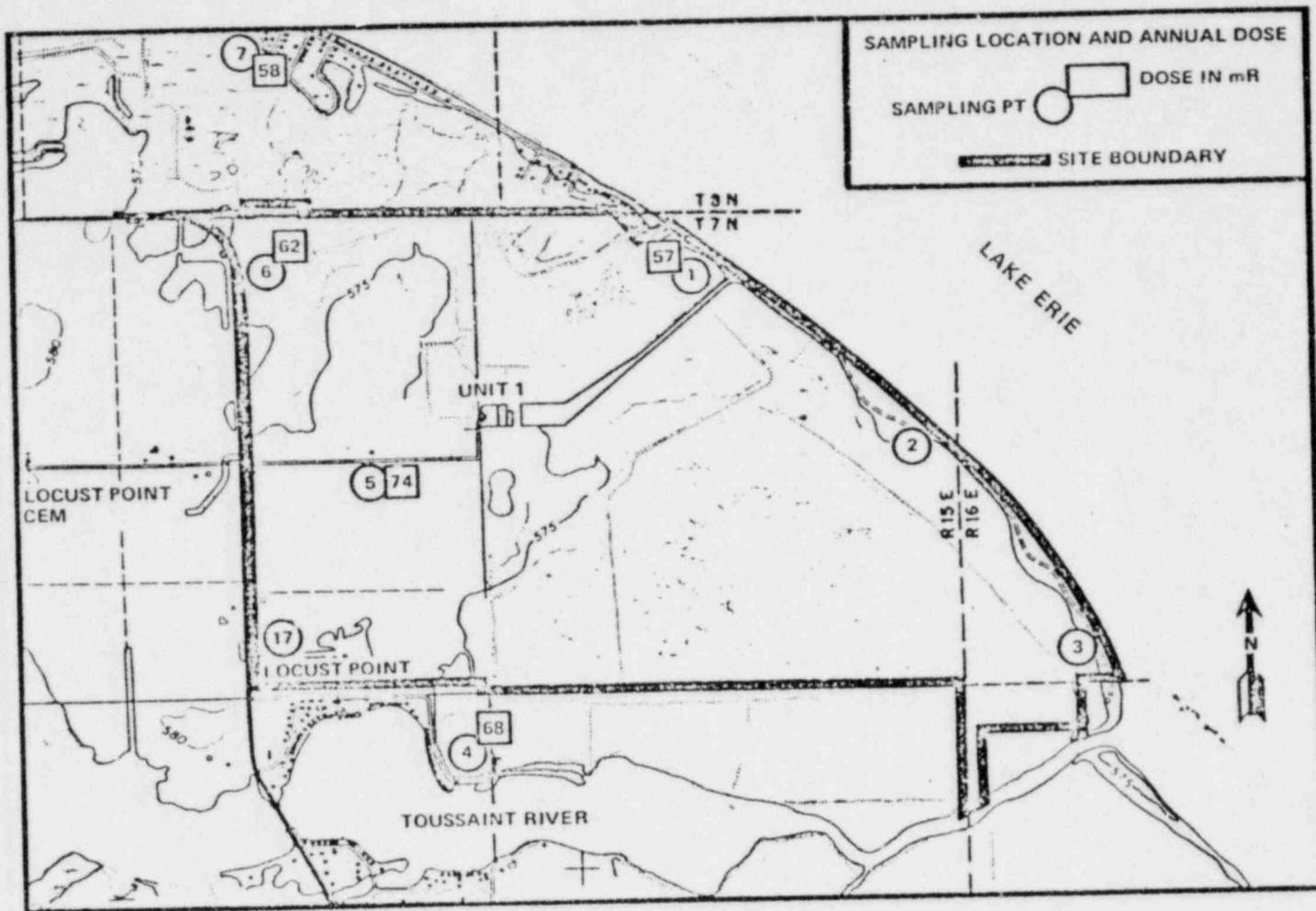
FIGURE 2.8-3



DB-1

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO.1
 GROSS BETA RADIOACTIVITY IN PRECIPITATION, pCi/m² X 10²

FIGURE 2.8-4

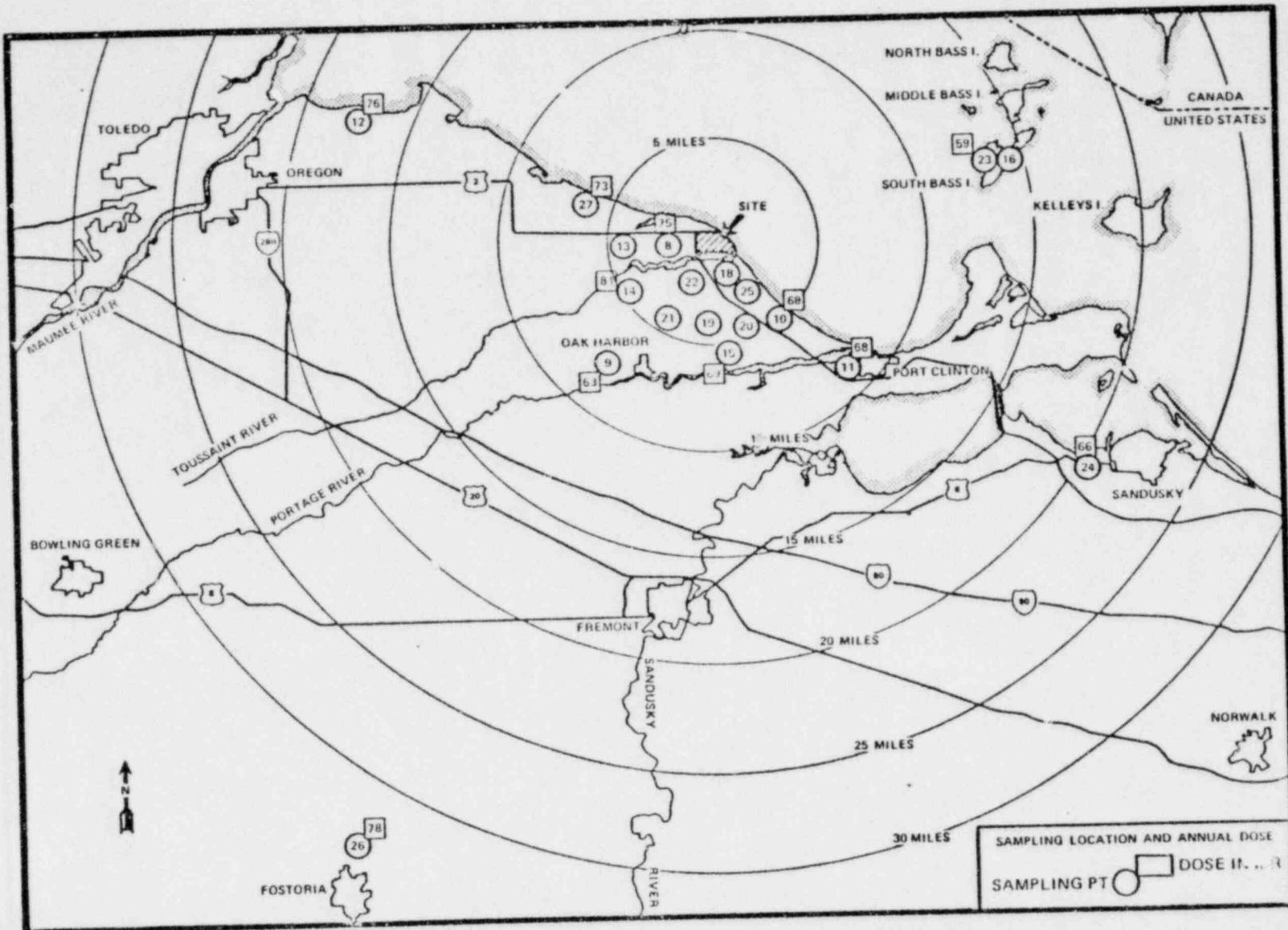


DB-1

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

ANNUAL DOSE FROM EXTERNAL BACKGROUND RADIATION AT SAMPLING LOCATIONS ON THE SITE PERIPHERY

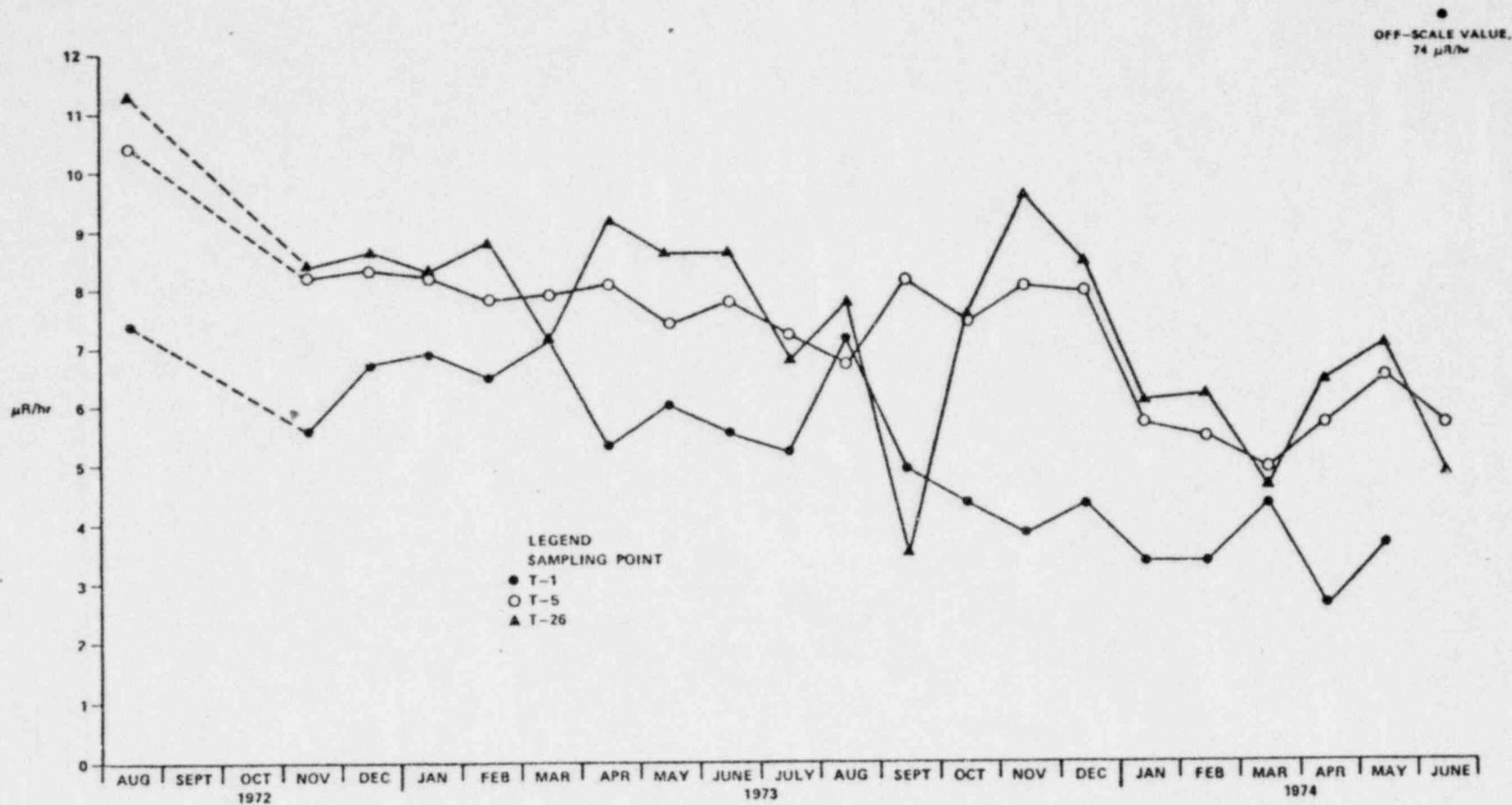
FIGURE 2.8-5



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO.1
 ANNUAL DCSE FROM EXTERNAL BACKGROUND RADIATION AT SAMPLING LOCATIONS
 (EXCEPTING THOSE ON THE SITE PERIPHERY)

FIGURE 2.8-6

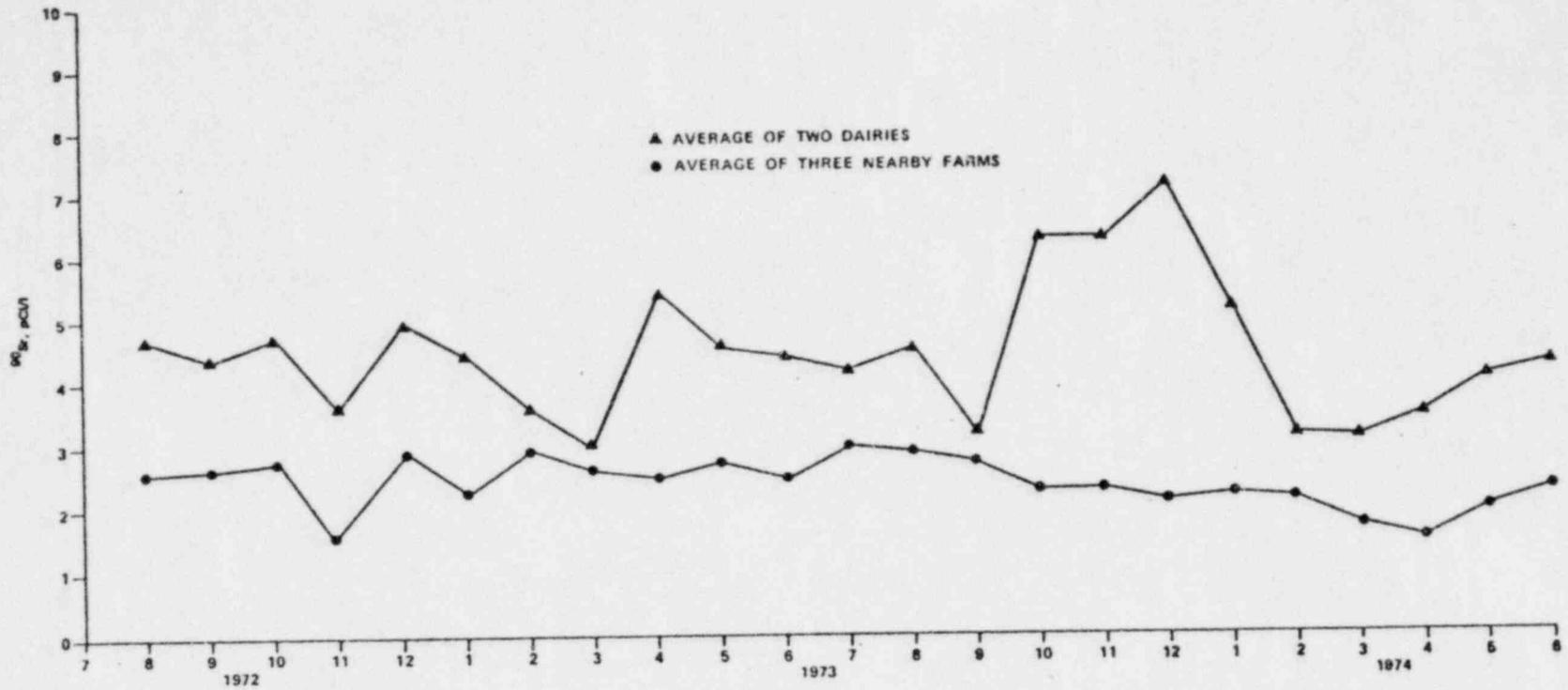
DB-1



DB-1

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO.1
EXTERNAL RADIATION DOSE RATES AT THREE SELECTED LOCATIONS

FIGURE 2.8-7



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO.1

⁹⁰Sr IN LOCAL MILK SUPPLIES

FIGURE 2.8-8

2.9 OTHER ENVIRONMENTAL FEATURES

2.9.1 PRESENT ENVIRONMENTAL SOUND LEVELS

To document the present environmental sound levels at the Davis-Besse site and its environs and to establish a noise baseline from which the noise impact of Unit No. 1 could be assessed, a background noise survey was conducted May 16-18, 1974, during the periods of daytime (0700-1900 hr), evening (1900-2200 hr), and nighttime (2200-0700 hr), using the methods described in Section 6.2.6. A site map showing the locations of five of the seven sampling points at which noise measurements were taken is shown in Figure 2.9-1. One location not shown (point 3) was on the lakefront northwest of Sand Beach, approximately 1.3 mi from the site. The other location (point 7) was in a rural area south-southwest of Locust Point, on the south side of the Toussaint River, approximately 1.8 mi from the site. The L_{50} sound levels (sound levels exceeded 50% of the time) at each sampling point and measurement period are shown in Table 2.9-1. The composite L_{50} sound levels during the survey at each sampling point were used to construct A-weighted sound-level contours on site maps. Figure 2.9-2 shows the daytime high, and Figure 2.9-3 shows the nighttime low. The meteorological data obtained during the survey from the onsite meteorological tower at the 10-m level and supplemented by data from nearby airports are contained in Table 2.9-2.

The composite L_{50} sound level for all sampling points during all measurement periods was 46 dBA. The principal noise sources were observed to be highway traffic along Route 2 and wave action along the shore of Lake Erie. The weekday daytime readings contain contributions from the construction activities of Unit No. 1. However, during the survey most of the heavy outside construction had been completed. The contribution of the construction

TABLE 2.9-1

L50 SOUND PRESSURE LEVEL MEASUREMENTS OBTAINED AT
THE DAVIS-BESCE SITE, MAY 17-18, 1974 (dBA)

<u>Location</u>	<u>Friday, May 17, 1974</u>			<u>Saturday, May 18, 1974</u>		
	<u>Daytime</u>	<u>Evening</u>	<u>Nighttime</u>	<u>Daytime</u>	<u>Evening</u>	<u>Nighttime</u>
1	48	50	49	54	56	54
2	47	37	34	42	43	34
3	50	56	52	63	64	61
4	46	44	37	46	41	35
5	50	42	37	44	42	36
6	58	49	45	52	54	40
7	42	44	33	40	43	35

TABLE 2.9-2

METEOROLOGICAL DATA FOR THE DAVIS-BESSE SITE
 DURING THE BACKGROUND NOISE SURVEY
 (Page 1 of 2)

<u>Time</u>	<u>Wind Direction</u>	<u>Wind Speed (mph)</u>	<u>Temperature (°F)</u>	<u>Dew Point (°F)</u>	<u>Barometric Pressure (in. Hg)</u>
Friday, May 17, 1974					
1100	180	10	69	68	29.89
1130	200	10	71	68	
1200	310	12	72	65	
1230	340	7	73	64	
1300	300	6	75	62	
1330	320	7	79	62	
1400	030	8	65	55	
1930	080	4	59	52	29.48
2000	070	3	59	52	
2030	070	3	59	52	
2100	080	2	59	52	
2200	080	3	59	52	
2230	060	3	59	52	
2300	050	3	59	52	
2330	090	3	59	52	29.45

2.9-3

DB-1

TABLE 2.9-2 (Page 2 of 2)

<u>Time</u>	<u>Wind Direction</u>	<u>Wind Speed (mph)</u>	<u>Temperature (°F)</u>	<u>Dew Point (°F)</u>	<u>Barometric Pressure (in. Hg)</u>
Saturday, May 18, 1974					
1000	060	7	58	41	
1030	040	7	58	41	
1100	030	9	59	41	29.43
1130	030	8	61	43	
1200	030	6	61	41	
2000	060	8	62	44	29.41
2030	050	6	62	44	
2100	030	9	61	44	
2130	040	6	59	47	
2200	030	6	59	48	
2230	040	5	59	48	
2300	030	6	59	48	29.44

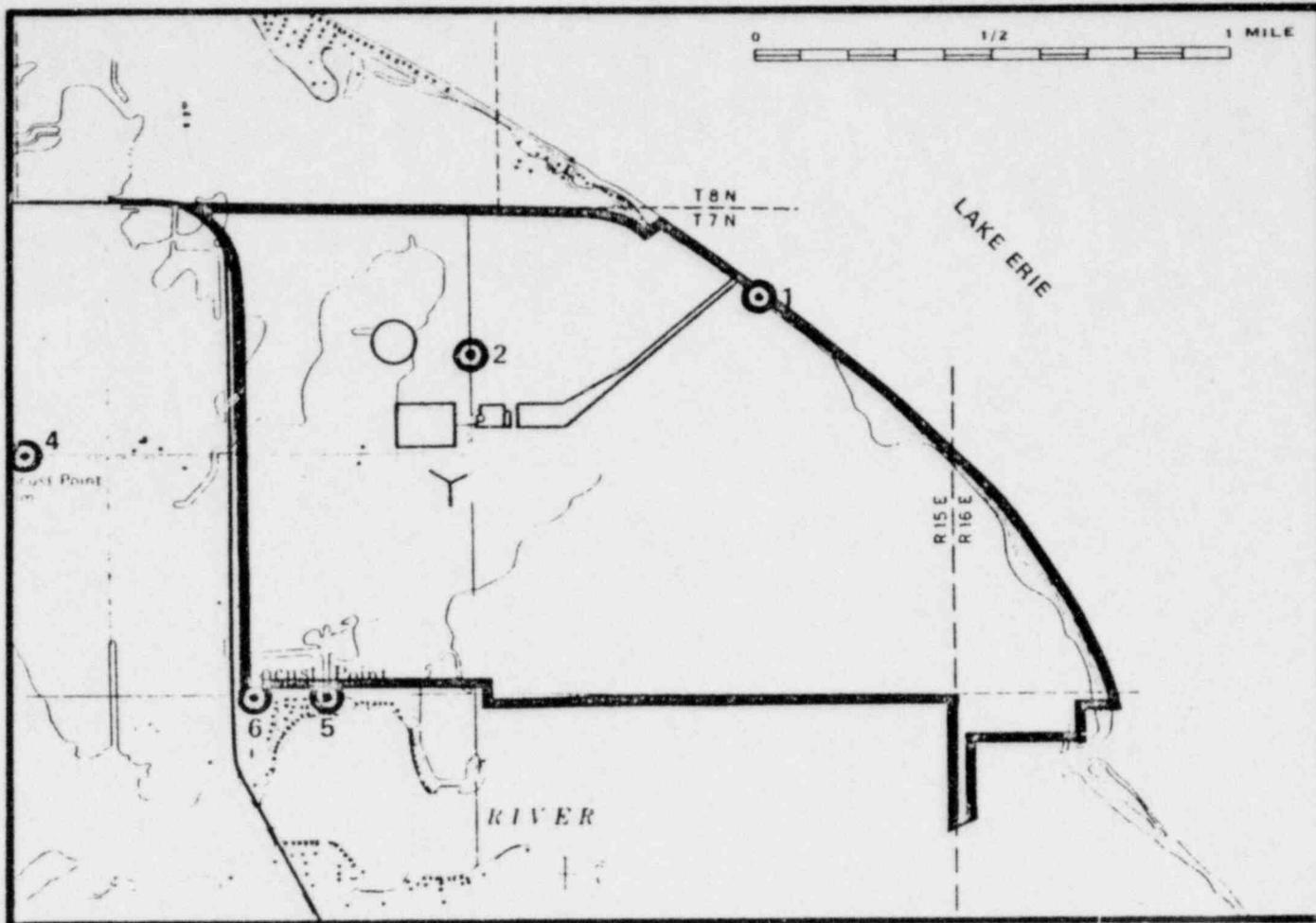
2.9-4

DB-1

activities to the weekday daytime sound levels (and sound levels during all other measurement periods) was minor compared with that of the principal noise sources. Other noise sources in the vicinity included wind, birds, rifle fire from Camp Perry, and distant lawnmowers. No intermittent, recurring, or particularly annoying sounds, such as high-pitched whines requiring octave band analysis, were present during the survey.

2.9.2 OTHER FEATURES

There are no other known environmental features of the Davis-Besse Nuclear Power Station Unit No. 1 and environs essential to an assessment of the environmental impact.

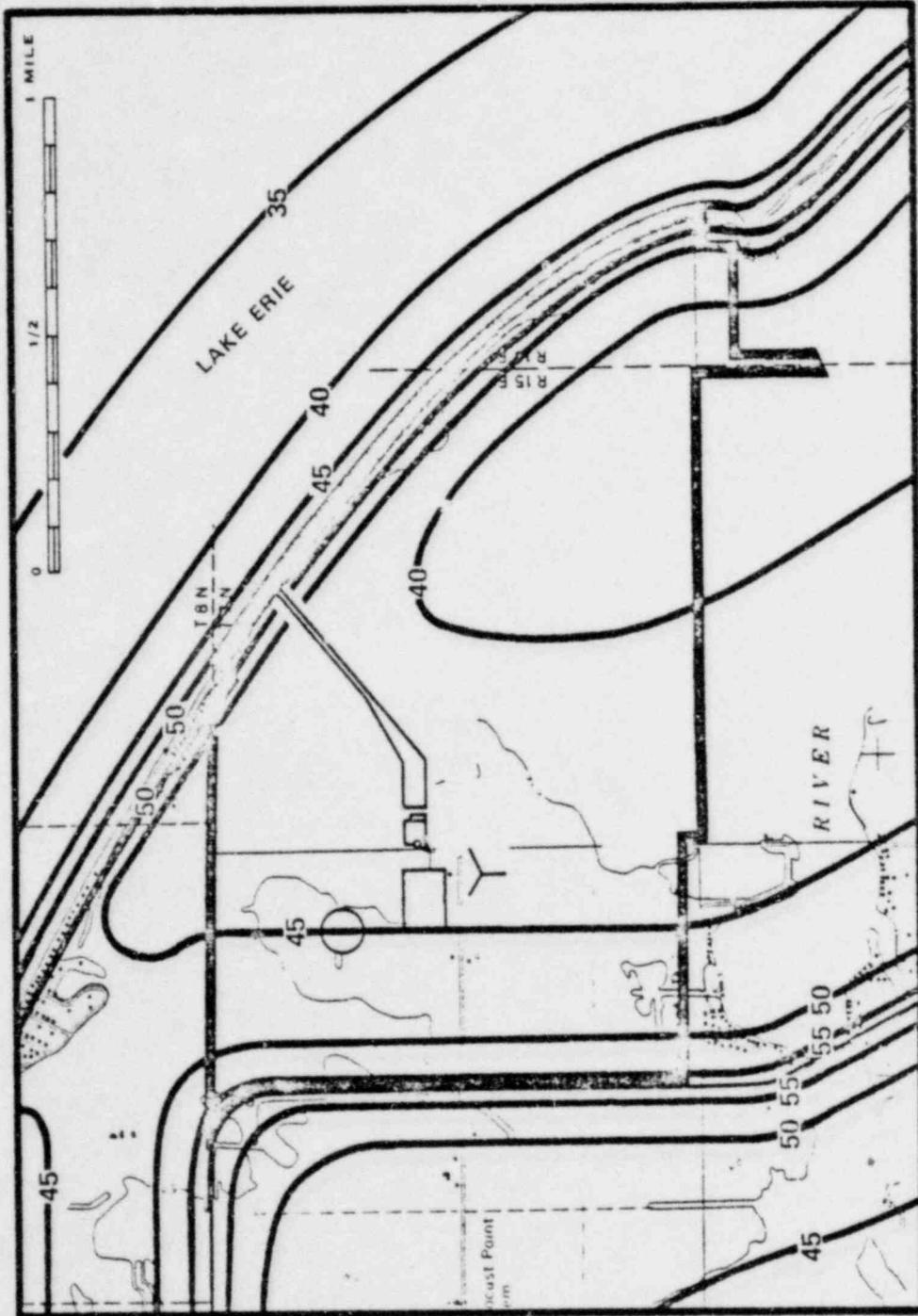


DB-1

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

NOISE LEVEL SAMPLING LOCATIONS

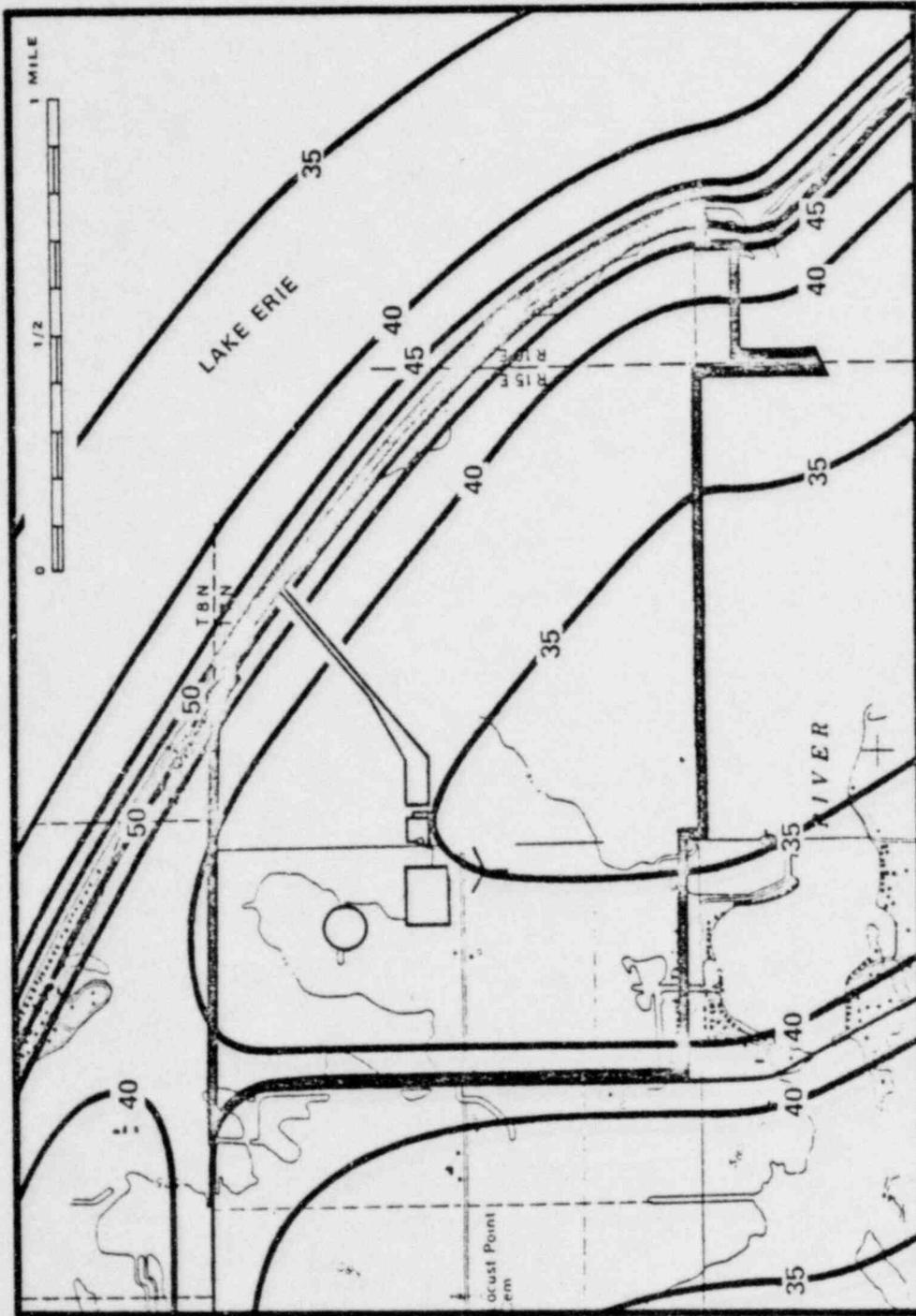
FIGURE 2.9-1



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

DAYTIME OPERATIONAL NOISE LEVEL CONTOURS (dBA)

FIGURE 2.9-2



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

NIGHTTIME OPERATIONAL NOISE LEVEL CONTOURS (dBA)

FIGURE 2.9-3

3.2 REACTOR AND STEAM ELECTRIC SYSTEM

The Davis-Besse Nuclear Power Station Unit No. 1 will have a pressurized water reactor nuclear steam supply system and a steam driven turbine-generator. A detailed description of the unit is incorporated in the Final Safety Analysis Report.

3.2.1 NUCLEAR STEAM SUPPLY SYSTEM

The nuclear steam supply system consists of the reactor vessel, two vertical once through steam generators, four shaft sealed reactor coolant pumps, an electrically heated pressurizer and interconnecting piping. The system is arranged as two heat transport loops, each with two reactor coolant pumps and one steam generator. The entire system is contained within a free-standing steel containment vessel surrounded by a reinforced concrete shield building.

The reactor coolant system is designed to contain and circulate the reactor coolant at flows and pressures necessary to transfer the heat generated in the reactor core to the feedwater in the secondary side of the steam generators. In addition to serving as a heat transport medium, the coolant also serves as a neutron moderator and a solvent for the soluble boron used as a chemical shim to control reactivity.

The nuclear steam supply system is designed and supplied by the Babcock and Wilcox Company. The system is designed to operate at 2,789 MWt with sufficient margin so that it can undergo any credible transients without experiencing any damage and without exceeding code limits.

Application has been made for an operating license to operate at a reactor power output of 2,772 MWt. Core performance analyses in this report are based on this power level. An additional 17 MWt will be contributed to the cycle by the reactor coolant pumps, resulting in a net electric output of

906 MWe. The reactor fuel is composed of sintered uranium dioxide pellets, stacked and sealed in Zircaloy-4 tubes.

Reactor power will be controlled by two independent reactivity control systems: (a) control rod assemblies, and (b) soluble boron. The control rod assemblies use a neutron absorbing alloy of silver, indium, and cadmium to control core reactivity. The control rods are used to ensure a safe shutdown (K_{eff} 0.99) in the hot condition, with the control rod containing the most reactivity stuck in the outposition. Additional shutdown capability comes from the soluble boron.

3.2.2 STEAM AND POWER CONVERSION SYSTEM

Steam produced in the steam generators enters a high pressure turbine, passes through two moisture-separator-reheaters, and then through two tandem double flow low pressure turbines. The rotational energy created in the turbine drives a generator to produce electricity. A General Electric TC4F-43 turbine will be used to drive the generator. The net electrical output, including 17 Mwt contributed by the reactor coolant pumps, will be 906 MWe. After passing through the turbine, the steam is condensed in the condenser by the circulating water in the closed condenser cooling water system. The heat transferred from the steam to the circulating water is rejected to the atmosphere in a single natural draft cooling tower. The subcooled condensate is pumped from the condenser through feedwater heaters prior to reentering the steam generators as feedwater. Various auxiliary systems are designed to provide makeup water to the reactor coolant and steam systems. Effluents from these systems will be processed to ensure their purity before being released to the environment.

3.3 UNIT WATER USE

3.3.1 WATER SOURCES AND USE

The use of water from Lake Erie for Davis-Besse Unit No. 1, and water discharges back into the Lake, are minimized by the use of a closed condenser cooling water system and the use of the unit's service water discharge as cooling tower makeup. A quantitative flow diagram of water use and discharge is shown in Figure 3.3-1.

All the water required for unit use is drawn from Lake Erie through a submerged intake crib and piped into an open intake canal. The water then flows through the intake canal to the intake structure located east of the unit and at the west end of the intake canal forebay. The details of the water intake system are provided in Section 3.4.

Raw lake water from the intake structure is provided for the following systems: the service water system, the dilution and cooling tower makeup system, the backwash pumps for the traveling water screens in the intake structure, the emergency backup fire pump, and the domestic and makeup water system.

The largest volume of water is used for makeup to the closed condenser cooling water system, which is isolated from the reactor coolant system and main steam system. Makeup water for this system normally comes from the discharge of the service water system. The details of the closed condenser cooling water system are provided in Section 3.4.

3.3.1.1 Service Water System

The service water system will provide water to the component cooling water heat exchangers, containment air coolers, and turbine building cooling water heat exchangers during normal operation. During an emergency, this system will supply water to the component cooling water heat exchangers, containment

air coolers, emergency core cooling system room cooler coils, and control room emergency condensing units.

The service water system provides water for the following:

a. Normal Operation

- (1) Component cooling water heat exchangers
- (2) Turbine building cooling water heat exchangers
- (3) Containment air coolers
- (4) Cooling tower makeup
- (5) Deaerator water jet exhausters
- (6) Condensate polishing demineralizers (as necessary)
- (7) Emergency core cooling system room cooling coils (as necessary)

b. Emergency Operation

- (1) Component cooling water heat exchangers
- (2) Containment air coolers
- (3) Emergency core cooling system room cooler coils
- (4) Control room emergency condensing units.
- (5) Auxiliary feedwater system (as necessary)

Three service water pumps are provided. They are located in the intake structure and use Lake Erie as a source of water. The service water is continuously chlorinated to prevent slime and algae growth in the system. Two service water pumps are normally used and the third pump provides standby. Motor-operated strainers at the pump outlets filter any material that may plug or foul tubes in the heat exchangers. A flow diagram of the service water system is provided in Figure 3.3-2. After passing through the heat exchangers, water from the service water system is discharged into the closed condenser cooling water system to supply the makeup requirements of

the system, as shown in Figure 3.3-1.

3.3.1.2 Dilution and Cooling Tower Makeup System

The dilution and cooling tower makeup system provides dilution water to mix with cooling tower blowdown and other unit effluents to reduce the unit's discharge temperature to within 20°F of lake temperature. Water from this system is also used, as required, for cooling tower makeup when the quantity of service water discharge is not sufficient or when service water system discharge is used for winter ice control in the intake canal forebay.

3.3.1.3 Domestic and Makeup Water System

The domestic and makeup water system is designed to provide high quality water, in sufficient quantity, for primary and secondary system makeup. In addition, this system supplies clarified, softened, filtered, and chlorinated water for the unit's potable water and sanitary systems.

Under normal operations, chlorinated Lake Erie water is delivered by one of two water treatment feed pumps to the two clarifiers. Chemical feeders are located near the clarifiers to provide lime for softening, and sodium aluminate for clarification. Clarified and softened water flows by gravity from the clarifiers through two anthracite and sand gravity filters to a clearwell. From the clearwell, the clarified, softened, and filtered water is pumped to the domestic water system or through two activated carbon filters to one of two demineralizer trains. The water delivered to the demineralizer trains flows through one of two primary cation units to a vacuum degasifier. From the vacuum degasifier, water is pumped through one of two primary anion demineralizers and to one secondary cation and anion demineralizer and terminates at the demineralized water storage tank.

One of three pumps is then used, as required, to transfer the demineralized water in the storage tank to various points throughout the unit, such as the

primary water storage tank, condenser hotwell, condensate storage tanks, and for miscellaneous flushing operations.

Prior to regeneration of the makeup demineralizers, the primary cation, secondary cation, and secondary anion demineralizers will be backwashed with clear water to loosen the resin and prepare them for regeneration. The backwash effluent will not contain any chemicals, but only fine suspended material. This effluent will go to the settling basin where the suspended material will settle. The clear effluent will discharge over a weir and be pumped to the collection box.

Regeneration of the makeup demineralizers is accomplished with sulfuric acid and sodium hydroxide. Regenerant wastes from the demineralizers are transferred to a neutralizing tank, where they are neutralized before discharge to the collection box. The treatment and discharge of this regenerant effluent is discussed in Section 3.6.

The clarifier blowdown and filter backwash are discharged into a sump, in the water treatment building, and pumped to the settling basin. The settling basin is equipped with an overflow weir to retain suspended solids and permit only clear water to flow into a sump adjacent to the settling basin. From the sump, the water will be pumped to the collection box where it will be discharged with the other unit effluents to Lake Erie. The settling basin is shown schematically in Figure 3.3-3.

A sewage treatment plant is provided to treat all effluent from the sanitary system. The treatment plant will provide primary and secondary treatment. The sewage treatment plant effluent is discussed in Section 3.7.

A storm drainage system is provided to drain runoff from paved and graded areas and buildings, as well as from miscellaneous equipment and floor drains in non-radioactive areas, into the existing ditch along the south boundary of

the site. Water from the miscellaneous equipment and floor drains will pass through oil interceptors prior to entering the storm drainage system. After entering this ditch the storm water travels a distance of about 7,000 feet before reaching the Toussaint River. No chemical, oily or radioactive wastes will be permitted to be discharged into this system.

3.3.2 WATER QUALITY

3.3.2.1 Influent Water

Table 3.3-1 summarizes the results of analyses of water samples taken from the construction water intake for the period April, 1971 through February, 1974. Dissolved oxygen measurements were made only on samples collected closer to shore, collected during the period November, 1968 to October, 1970. Chemical treatment of the water used in the service water system and the domestic and makeup water system was briefly described in Section 3.3.1.3. Further discussion of chemical additions and water treatment is provided in Section 3.6.

3.3.2.2 Water Effluents

All water effluents from the unit, except water in the storm drainage system, are discharged into Lake Erie through a buried pipe running along the southerly side of the intake canal to the beach area. From the beach area the discharge pipe heads easterly out into the lake for approximately 1,300 ft. to where it discharges into a 6 ft. depth of water below low water datum 568.6 (IGLD). The outlet of the discharge pipe into unrestricted lake water will be through a slot-type orifice to impart velocity to the discharge water which will promote rapid dilution and mixing with the lake water. The cross-sectional area of the orifice will provide a discharge velocity of 6.4 fps at an expected maximum discharge flow of 19,260 gpm, and a discharge velocity of 2.7 fps at an average discharge flow of 8,159 gpm. The discharge arrangement

TABLE 3.3-1

AVERAGE LAKE WATER QUALITY AT CONSTRUCTION INTAKE*

	Component Concentrations
Calcium (Ca)	42
Magnesium (Mg)	9
Sodium (Na)	15
Chloride (Cl)	22
Nitrate (NO ₃)	6
Sulfate (SO ₄)	41
Phosphate (PO ₄)	0.3
Silica (SiO ₂)***	1.0
Alkalinity as CaCO ₃	98
Suspended Solids	28
Dissolved Solids	234
Dissolved Oxygen***	10
BOD	2
pH	8.1
Ammonia Nitrogen	0.6
Chlorine Demand**	1.4

*Average of samples from April 20, 1971, through February 12, 1974, taken 2,700 ft from shore at approximately 7 ft water depth 3 ft from the lake bottom, except as noted.

**Samples from April 1971 through July 1971 only, at same location.

***Average of samples from November, 1968 to October, 1970 taken 50 to 100 ft. from shore.

General Note:

All values mg/l except pH.

is shown in Figure 3.3-4.

A common collection point for the various effluent streams from the unit is provided by the collection box, which discharges into the discharge pipe. The elevation of the collection box will provide the necessary head for discharge to the lake, under all lake water level conditions.

The various effluent streams from the unit to the collection box are listed below:

- a. Cooling tower blowdown
- b. Dilution water
- c. Service water (only during period of unit shutdown)
- d. Processed effluents from the radwaste system
- e. Sewage treatment plant effluent
- f. Neutralized regenerant waste from the makeup demineralizers
- g. Effluents from the settling basin receiving:
 - (1) Clarifier blowdown and filter backwash
 - (2) Condensate demineralizer backwash
 - (3) Makeup demineralizer backwash

The normal, maximum, and average monthly discharge flows from these systems are shown in Figure 3.3-1. The chemicals discharged from these systems are discussed in Section 3.6. Table 3.3-2 tabulates the quantity of the individual discharges, and shows the combined monthly average and maximum short-time peak flow.

The yard storm drainage system collects to a common point and is discharged into the drainage ditch, which runs for 7,000 ft. along the south site boundary before entering the Toussaint River. Building roof drains and floor drains in non-radioactive areas also discharge to this system; the floor drains only after passing through oil interceptors which eliminate any

TABLE 3.3-2

LIQUID EFFLUENTS DISCHARGED TO LAKE ERIE

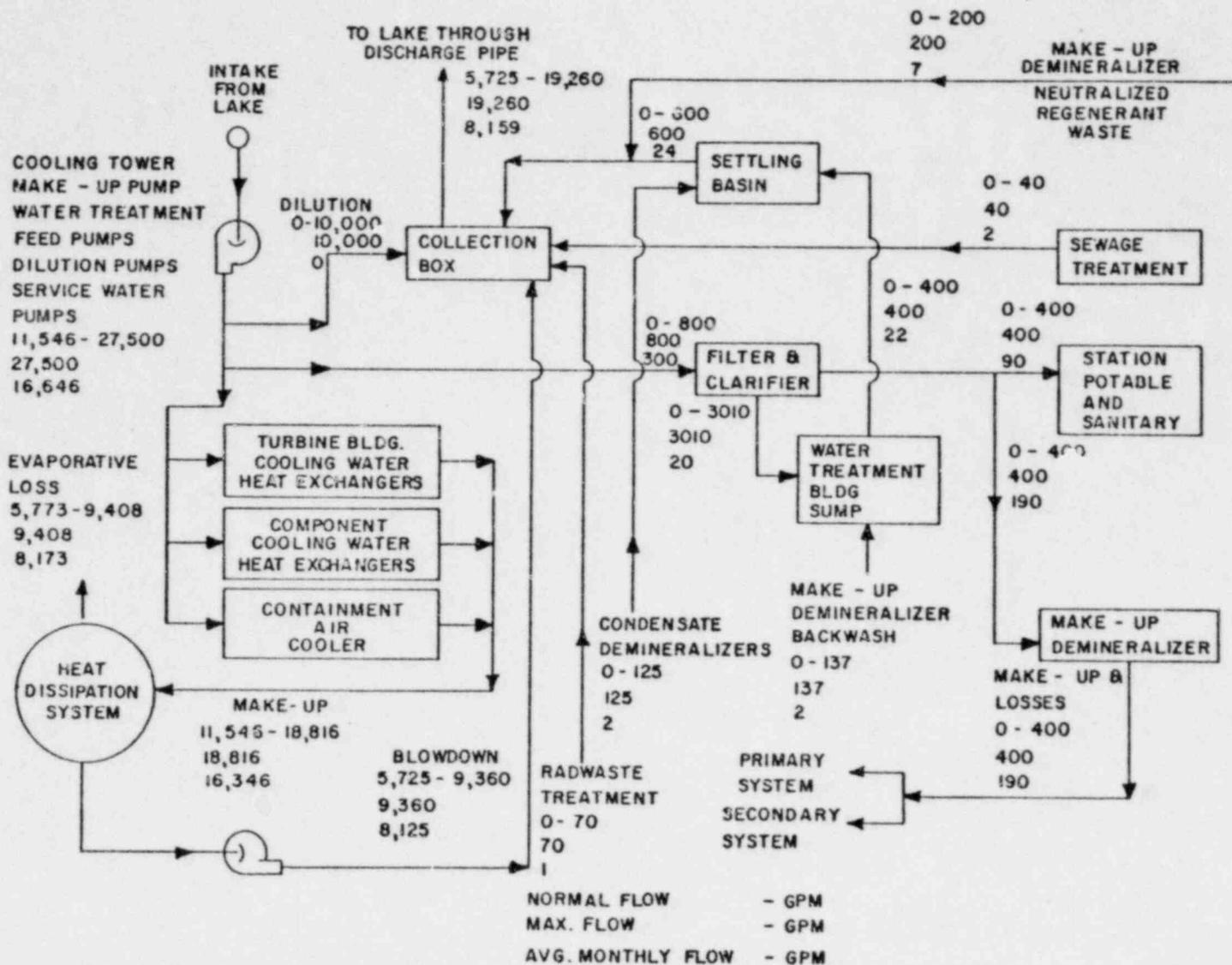
	Expected Max, Flow gpm	Average Flow gpm
Cooling Tower Blowdown	8,350*	8,125**
Dilution Water	10,000	0
Neutralized Regenerant Wastes	200	7
Pumped Effluents from Settling Basin, Clarifier Blowdown, Filter Backwash, Condenser Demineralizer Backwash	600	24
Processed Effluents from Radwaste System	70	1
Sewage Treatment Plant Effluents	<u>40</u>	<u>2</u>
Total Effluents	19,260	8,159

*Maximum cooling tower blowdown (9,360 gpm) does not occur at the same time with maximum unit discharge.

**Average cooling tower blowdown was computed using blowdown flows for February thru December. The flow for January was not used because of abnormally cold weather, during the period which onsite meteorological data was collected, resulting in an unrepresentative blowdown flow.

DB-1

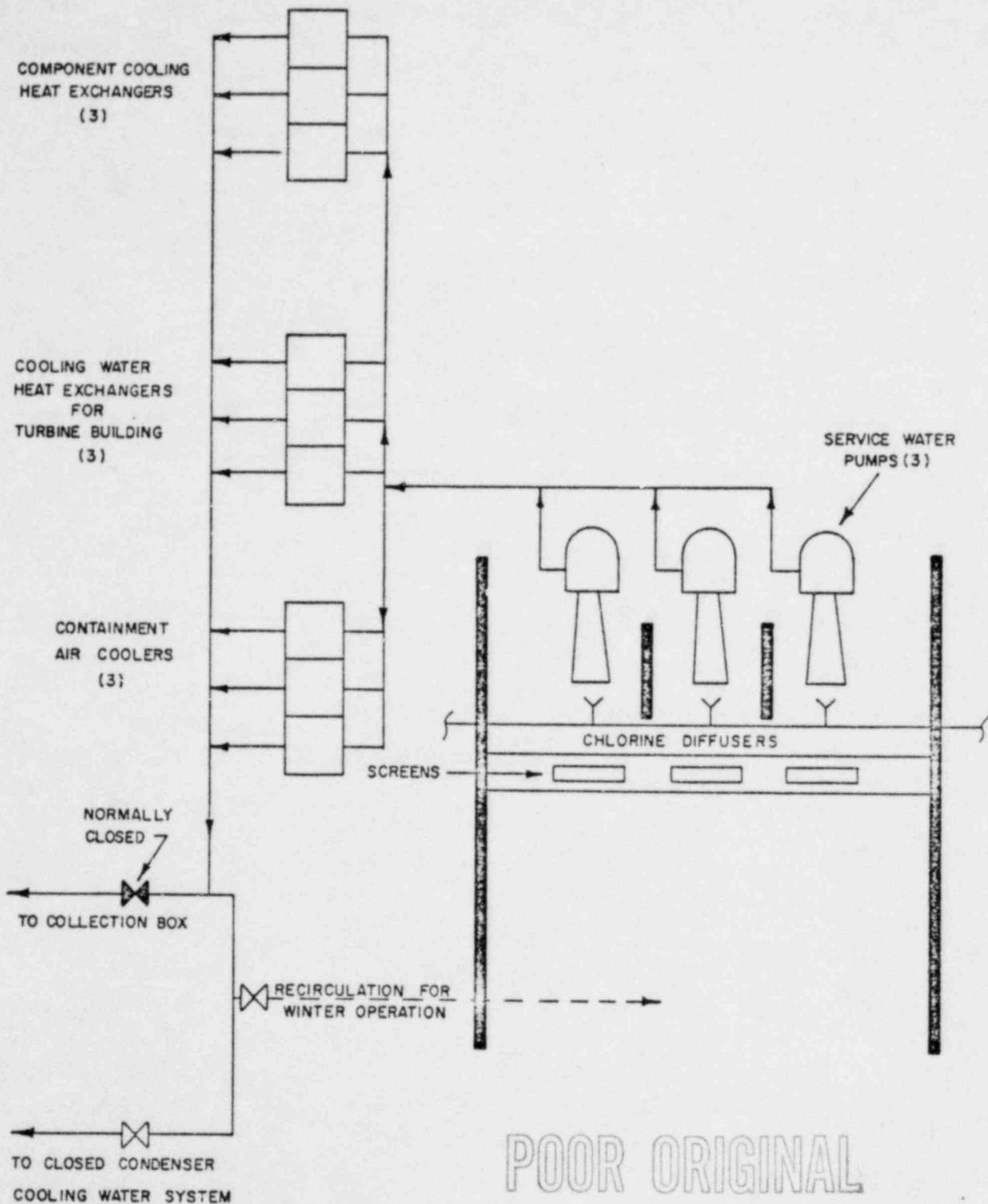
possibility of oil entering this system and being discharged. The diesel oil storage tank for the auxiliary boiler and emergency diesel generators are surrounded by a concrete wall to prevent fuel oil from entering the storm drainage system in the event of leakage.



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

UNIT WATER USE AND DISCHARGE DIAGRAM

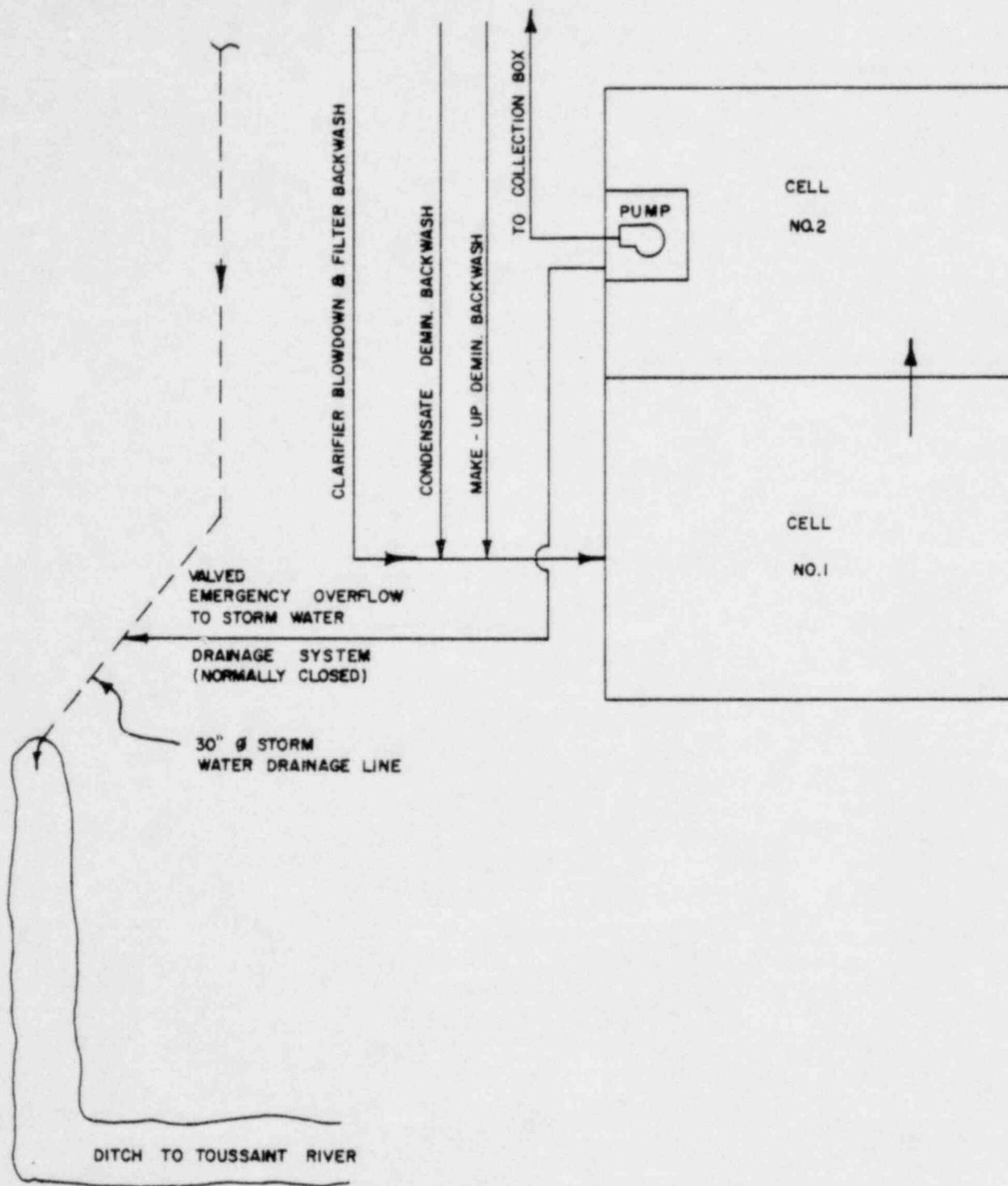
FIGURE 3.3-1



DAVIS - BESSE NUCLEAR POWER STATION UNIT NO. 1

SERVICE WATER SYSTEM

FIGURE 3.3-2

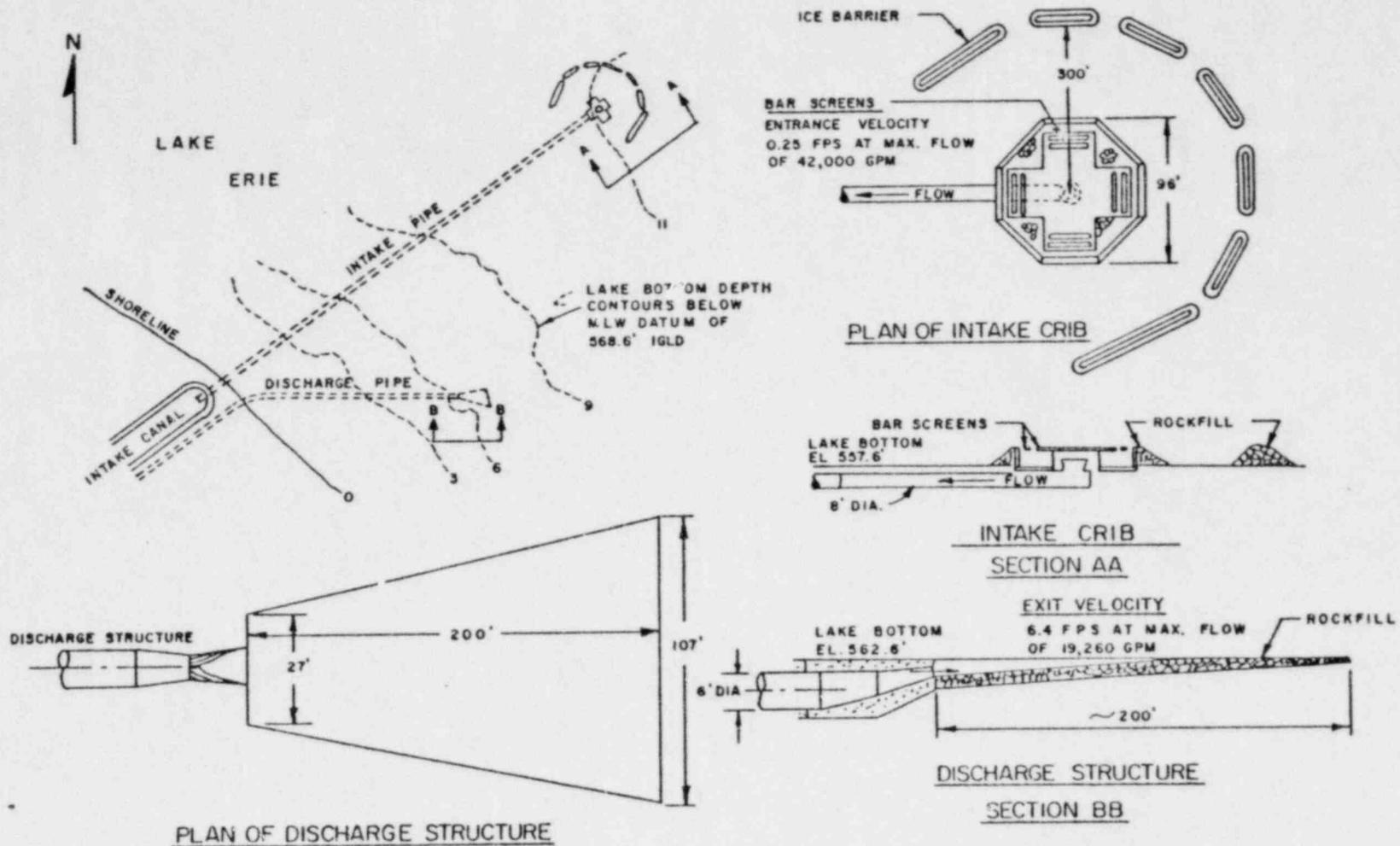


DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

SETTLING BASIN

FIGURE 3.3-3

POOR ORIGINAL



NOTE: NOT TO SCALE

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

SUBMERGED INTAKE AND DISCHARGE ARRANGEMENTS

FIGURE 3.3-4

3.4 HEAT DISSIPATION SYSTEM

For an installation of the type and size of the Davis-Besse Nuclear Power Station Unit No. 1, the heat discharged into Lake Erie will be very minimal due to the use of a closed condenser cooling water system to reject the heat in the condenser circulating water directly to the atmosphere.

3.4.1 Cooling Tower

A natural draft counterflow cooling tower will be used to dissipate 98% of the total heat from the Unit's condenser to the atmosphere. The cooling tower, which is approximately 493 ft. high and 415 ft. in diameter at the base, removes the heat from the condenser circulating water by evaporative cooling (see Figure 3.4-1.) The remaining 2% of the heat is discharged in the cooling tower blowdown to the collection box for discharge to Lake Erie. Condenser circulating water will be pumped through the cooling tower at a rate of 480,000 gpm, using four circulating water pumps each having a capacity of 120,000 gpm each. Water flow to the cooling tower from the condenser is carried by two 9 ft. diameter buried pipes and is then distributed to spray nozzles above the fill material through concrete ducts. From the cooling tower basin the cooled water will flow back to the circulating water pump house, on the east side of the turbine building, through an open channel and will be pumped back into the inlet of the condenser. Location of the cooling tower with respect to the other unit structures is shown in Figure 3.4-2. The only water losses from this system are from evaporation, drift, and blowdown. The temperature rise across the condenser and the temperature drop through the cooling tower will be 26^oF at full unit power, with a heat rejection to the atmosphere of 6.2×10^9 BTU/hour. Evaporation of water from the cooling tower is greatest during the higher wet bulb conditions and amounts to approximately 9,400 gpm during warm

weather, with a minimum of about 6,000 gpm during cold weather (a value of 5,773 gpm was calculated for January; this value was not used because of abnormally cold weather during the two Januarys in which onsite meteorological data were collected). The drift, or loss from entrained moisture droplets, is negligible, an expected 0.01% of the circulating water flow or 48 gpm.

A concentration factor of two is chosen for the cooling tower system which requires a blowdown approximately equal to the evaporative and drift loss with a resulting concentration of dissolved solids approximately twice that of the makeup water from the lake. This concentration factor was chosen to reduce the problems of scale formation on condenser tubes and to keep the dissolved solids in the blowdown water within acceptable levels. The amount of makeup water required at this concentration factor also permits the service water system discharge to serve as cooling tower makeup since these quantities are approximately equal and thereby reduces the amount of heat discharged to the lake.

The makeup water will be introduced into the system ahead of the circulating pumps with the blowdown taken from alternate pump discharges. Chlorination of the condenser circulating water will be done on a periodic basis to prevent algae growth within the system. The chlorine will be injected into those circulating pump suctions which do not have blowdown being taken from their discharge, so that blowdown water will contain minimal residual chlorine. The free residual chlorine will be maintained at a level not to exceed a daily maximum of 0.5 mg/l, at any time, and a daily average of 0.2 mg/l.

Sulfuric acid will be fed into the system to control the pH in the system to a nearly neutral level of 8.0. The sulfuric acid changes the calcium bicarbonate to calcium sulfate which reduces scaling tendencies in the heat exchange equipment. Other than this change, the only difference in the dissolved solids of the condenser circulating water and that of lake water is that the concentration is approximately double that of lake water.

3.4.2 SERVICE WATER SYSTEM

In addition to the major heat load from the turbine exhaust condenser, other cooling systems (i.e, turbine building cooling water, component cooling water, and containment air coolers) are supplied with cooling water by the service water system. A simplified flow diagram of the unit's cooling and makeup water flow is shown in Figure 3.3-1. Makeup water for the cooling tower is normally obtained from the service water system discharge as shown in Figure 3.3-2.

3.4.3 INTAKE CRIB

All water used in the unit is drawn from Lake Erie through a submerged intake crib about 3,000 feet offshore; the intake crib will be on a contour 11 feet below Lake Erie low water datum (568.6 IGLD) at a current water depth of about 14 feet (Figure 3.3-4). The intake consists of an octagonal crib made of timber with slots in the top for the entry of water. At the design maximum intake flow of 42,000 gpm, the maximum intake velocity will be 0.25 fps, the actual intake velocity will be about 0.12 fps at the nominal design flow rate of 20,850 gpm and about 0.10 fps at the expected average flow rate of 16,700 gpm. An air bubble screen is installed around the perimeter of the crib to discourage the entrance of fish.

Icing of the intake crib is not expected to occur; similar wooden cribs currently operating on Lake Erie have not been troubled by icing.

The intake crib has a semi-circular rockfill around it (Figure 3.3-4). The semi-circular rockfill, located about 300 feet away from the center of the intake crib is to prevent large chunks of ice from being driven into the crib by wind and wave action.

Water drawn into the crib enters an 8 ft. diameter intake pipe buried beneath the lake bottom. At the design maximum intake flow of 42,000 gpm the water velocity in the intake pipe will be about 1.9 fps. Water flows by gravity through this pipe into the intake canal which is separated from the lake by the beach and beachfront dike. The intake canal, which extends from the beachfront dike to the intake structure, as shown in the site plan, Figure 3.4-2, functions as a long reservoir where water is stored for unit use. At the design maximum flow of 42,000 gpm the water velocity in the intake canal is estimated to be about 0.11 fps.

3.4.4 INTAKE PUMPS AND SCREENS

All water used by the unit is provided by the following pumps located in the intake structure (see Figure 3.4-3).

- a. Three service water pumps (2 operating - 1 standby)
- b. Two cooling tower makeup pumps (when required)
- c. One dilution pump (when required)
- d. Two water treatment feed pumps (1 operating - 1 standby)
- e. One fire pump

Before the water reaches the pumps it passes through trash racks (4 in. x 26 in. openings) and then through traveling water screens with 1/4 inch square openings to prevent fish or small debris from entering the pump wells. The traveling water screens are periodically cleaned of entrained material by backwash sprays. The screen wash pumps, located in the intake structure,

draw water from the intake structure and discharge it along with any entrained material washed from the traveling water screens to the screenwash catch basin.

The water discharges from the screen wash catch basin by an overflow weir so that debris or fish, washed from the screens, can be monitored and kept out of the marsh.

3.4.5 DISCHARGE SYSTEM

All unit effluents (except storm water drainage, turbine building and non-radioactive auxiliary building drains, which go to the Toussaint River), will be mixed in the collection box prior to discharge to Lake Erie. Most of the unit discharge will be cooling tower blowdown and its associated dilution water as required. The collection box has a small volume (13,800 gallons) compared to the flow rates into it, and therefore has no holdup capacity but acts only as a collecting point for the various unit effluents. From the collection box a buried pipe, 6 ft. in diameter, runs parallel to the intake canal on its southerly side to the beachfront where it turns eastward and extends approximately 1,300 ft. out under the lake, where it terminates with a 1.5 foot high by 4.5 foot wide slot-type jet discharge (See Figure 3.3-4). The discharge is located at a current water depth of about 9 feet (6 feet below Lake Erie low water datum). The elevation of the collection box will provide the necessary head for discharge, through the discharge pipe to the lake, under all lake water level conditions. The slot-type discharge will have an exit water velocity of about 6.4 fps at the maximum discharge flow of 19,260 gpm. The nominal water velocity will be 2.7 fps at the expected nominal discharge flow of 8,159 gpm, thus promoting rapid entrainment and mixing with the lake water. The lake bottom will be riprapped with rock for

about 200 feet in front of the discharge to minimize scouring of the lake bottom and the resulting water turbidity.

3.4.6 THERMAL DISCHARGE TO LAKE ERIE

The only heat of any significance discharged into Lake Erie will be that contained in the cooling tower blowdown. Since the blowdown flow is relatively constant, the amount of heat discharge is dependent on the temperature difference between the lake water and the cooling tower blowdown. The temperature of the cooling tower blowdown, which is taken from the cold water side of the system, is entirely dependent on the wet bulb temperature of the air. Therefore, the amount of heat discharged to the lake from unit operation is a function of the difference between the atmosphere wet bulb temperature and lake temperature. The greater this temperature difference is, as in the spring with warm air and cold lake water, the greater the amount of heat discharged. During certain short periods, in the fall and winter, this temperature difference can be negative which will result in lake heat being discharged to the atmosphere through the cooling tower.

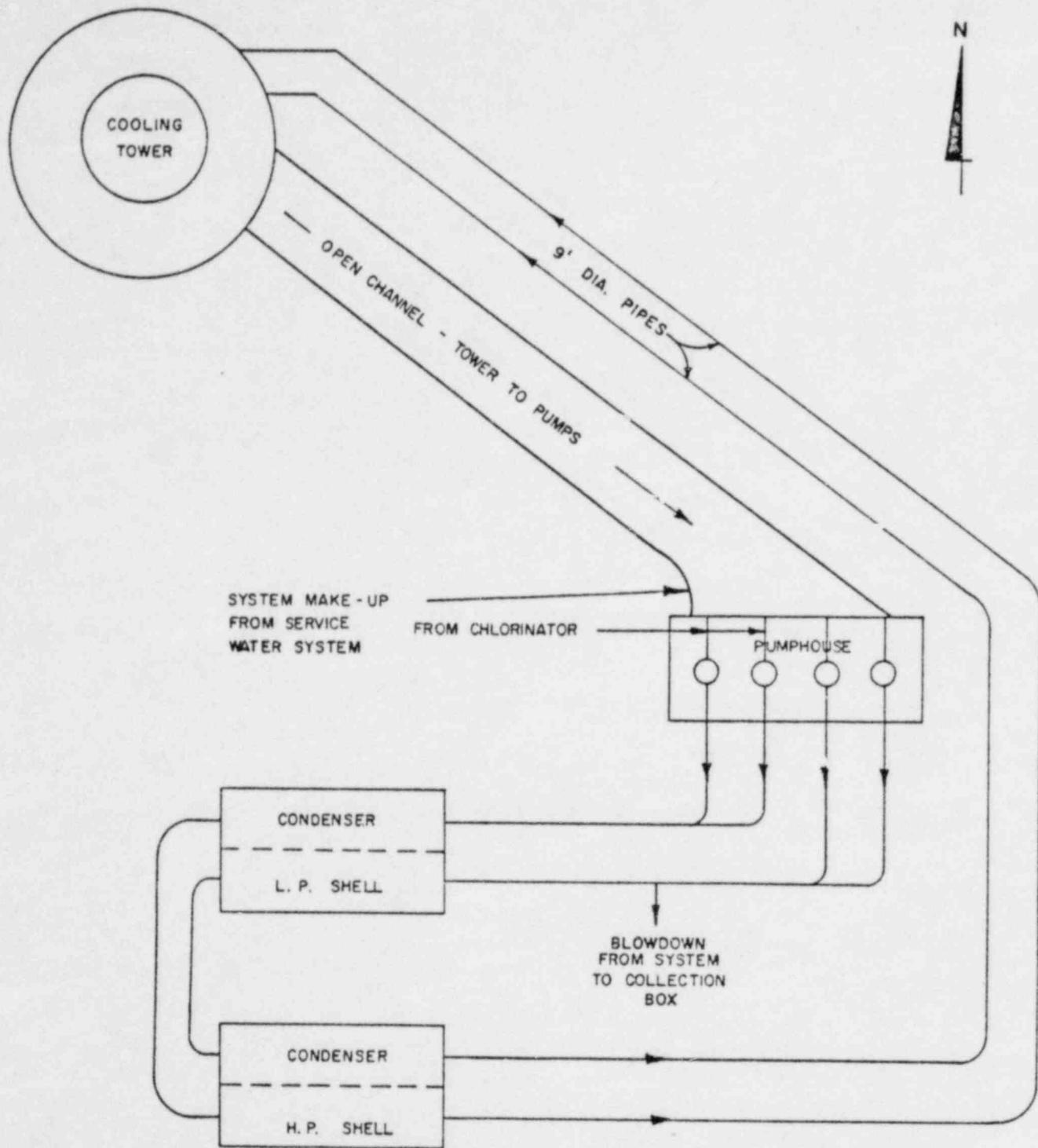
Since a good portion of the years operation will be during periods of changing lake temperatures, as in the spring when the lake is gaining temperature from the natural atmospheric heat exchange process, an analysis using average monthly temperature for the air and lake does not give a true indication of the extremes actually encountered. For this reason, the heat rejection information is given for both monthly average conditions and extreme monthly conditions. To determine the extreme conditions, daily wet bulb temperature data from the records for the onsite meteorological tower were used to determine the corresponding expected cooling tower water outlet temperatures and blowdown rates. The temperatures and rates are summarized on a monthly basis in Table 3.4-1. The maximum quantity of heat discharged from the unit

DB-1
 TABLE 3.4-1
 THERMAL CHARACTERISTICS OF DISCHARGE
 FROM DAVIS-BESSE UNIT NO. 1

Month	Cooling Tower Blowdown Temperature °F			Blowdown Rate, gpm
	Mean	Minimum	Maximum	
January	55.4	43.7	67.8	5,725
February	60.7	50.5	67.6	6,530
March	62.0	57.3	65.6	6,715
April	71.9	64.4	86.5	8,350
May	78.4	68.4	85.0	8,920
June	81.6	75.8	91.6	9,200
July	83.9	79.8	91.4	9,360
August	85.0	80.6	88.8	9,310
September	79.2	63.8	86.8	8,840
October	73.3	64.2	83.0	8,240
November	67.8	56.4	74.0	7,300
December	61.4	55.6	70.1	6,610

by blowdown will be 138×10^6 BTU/hr. and the average approximately 110×10^6 BTU/hr. Two 11,000 gpm cooling tower makeup pumps are provided for initial fill and makeup to the closed condenser cooling water system during winter months when all or a portion of the service water system discharge will be routed to the intake canal forebay ahead of the intake structure to keep the area in front of the intake structure free of ice. These pumps will also be used during periods when the required cooling tower makeup exceeds the discharge of the service water system.

A 10,000 gpm dilution pump is also provided. This pump will be the primary pump for dilution of the cooling tower blowdown to limit the temperature difference between the lake and the discharge to 20°F . The dilution pump will supply unchlorinated ambient lake water from the intake structure directly to the collection box to dilute the cooling tower blowdown and reduce the temperature of the unit's discharge. In the event that dilution greater than the capacity of the dilution pump is required or the dilution pump is out of service for maintenance, the cooling tower makeup pumps can also be used for dilution. The slot-type discharge at the terminus of the discharge pipe, in the lake, is designed to provide a relatively high velocity discharge to the effluent entering the lake and induce rapid jet entrainment mixing of the discharge with ambient lake water. The rapid dilution of the discharge with lake water to provide temperature reduction will also result in a like dilution of all substances such as dissolved solids and trace radio-nuclides contained in the unit discharge.

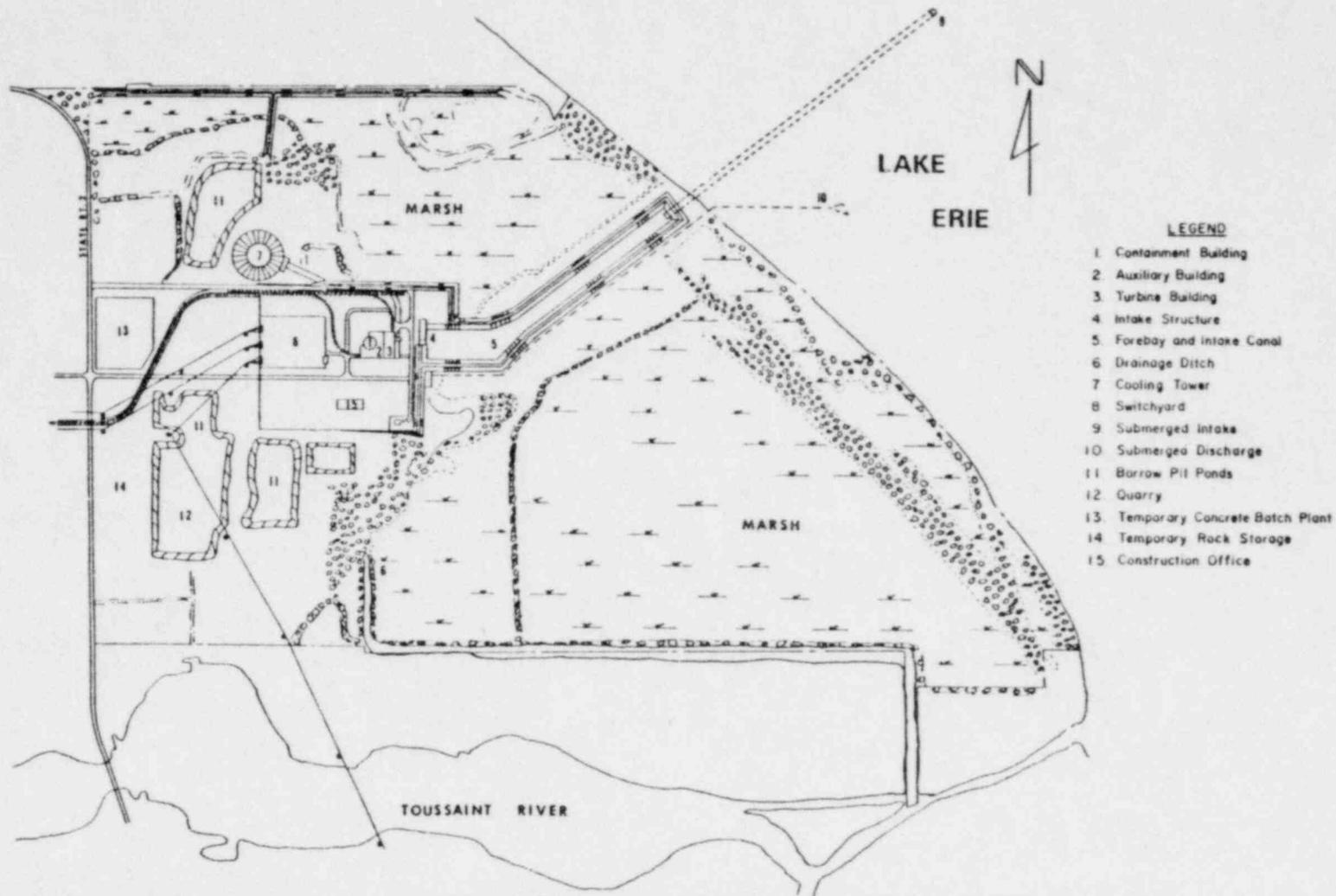


DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

CLOSED CONDENSER COOLING WATER SYSTEM

FIGURE 3.4-1

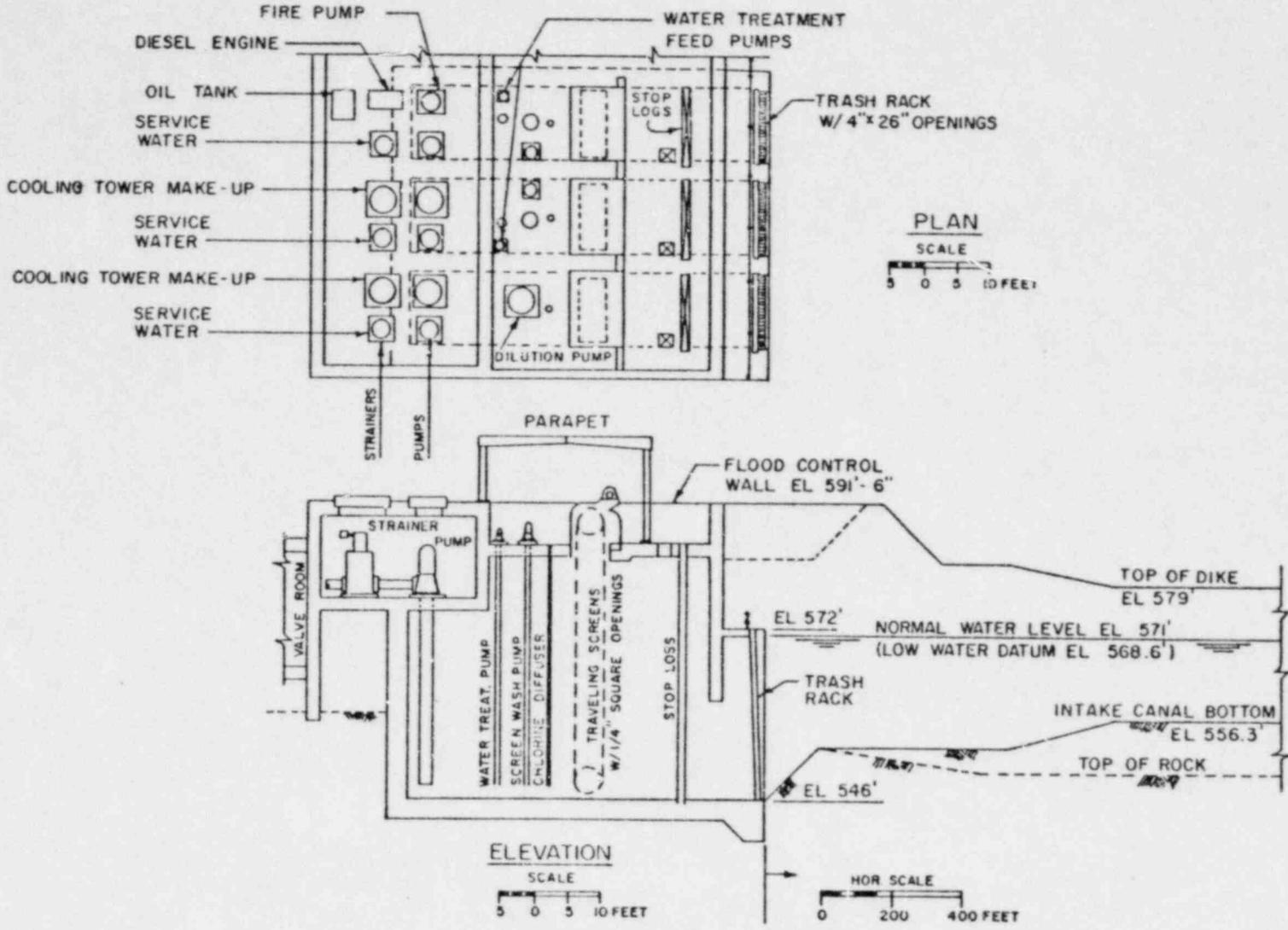
POOR ORIGINAL



- LEGEND**
- 1. Containment Building
 - 2. Auxiliary Building
 - 3. Turbine Building
 - 4. Intake Structure
 - 5. Forebay and intake Canal
 - 6. Drainage Ditch
 - 7. Cooling Tower
 - 8. Switchyard
 - 9. Submerged Intake
 - 10. Submerged Discharge
 - 11. Borrow Pit Ponds
 - 12. Quarry
 - 13. Temporary Concrete Batch Plant
 - 14. Temporary Rock Storage
 - 15. Construction Office

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

SITE PLAN
FIGURE 3.4-2



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO.1
 INTAKE STRUCTURE ARRANGEMENT

FIGURE 3.4-3

3.5 RADWASTE SYSTEMS

Radioactive fission products and products of neutron activation will be produced in the operation of the unit. Small quantities of these substances will enter some of the unit's systems and will find their way into (1) one of the cleanup devices, such as a filter or a demineralizer; (2) one of the liquid effluent streams; or (3) one of the gaseous effluent streams. With the exception of certain continuous gaseous effluents, such as the steam jet air ejector and ventilation air from the auxiliary and turbine buildings, these wastes are managed on a batch basis. In all cases, radwastes are processed and monitored, and releases to the environment or shipments offsite are audited and are made under controlled conditions. A more detailed description of these systems is presented in Chapter 11 of the Davis-Besse Nuclear Power Station Unit No. 1 Final Safety Analysis Report. In all cases the systems and procedures are designed to ensure that exposure to radioactive material in unit effluents is in accordance with the requirements set forth in 10 CFR Part 20 and with the "as low as practicable" criterion set forth in 10 CFR Part 50.

The principal assumptions and conditions employed in the calculation of radioactive effluent quantities and concentrations are shown in Table 3.5-1.

3.5.1 LIQUID RADIOACTIVE WASTES

The liquid radioactive wastes are processed in one or both of two systems: (1) the clean liquid radioactive waste system (CLRWS) and/or (2) the miscellaneous liquid radioactive waste system (MLRWS).

The purpose of the CLRWS is to collect, store, process, monitor, recycle, or discharge potentially radioactive reactor-grade waterborne wastes produced during normal unit operation. The flow paths in the CLRWS are shown in Figures 3.5-1 and 3.5-2. The CLRWS processes hydrogenated liquid waste

TABLE 3.5-1

CALCULATIONAL ASSUMPTIONS FOR THE RADWASTE
SYSTEMS ANALYSES
(Page 1 of 8)

1. Reactor power level: 2,772 MWt
2. Weight of uranium:
 - a. First fuel loading, 84.0 metric tons
 - b. Equilibrium cycle, no contract yet for subsequent fuel loadings
3. Isotopic loading in fresh fuel:
 - a. First fuel loading, 1.98-2.96%
 - b. Equilibrium cycle, no contract yet for subsequent fuel loadings
4. Assumed fraction of failed fuel: 0.1%
5. Escape rate coefficients for escape of fission products from fuel elements into primary coolant:

<u>Fission Product</u>	<u>Escape Rate Coefficient (sec⁻¹)</u>
Xe, Kr	6.5×10^{-8}
I, Br, Rb, Cs	1.3×10^{-8}
Mo, Nb	2.0×10^{-9}
Te, Se, Sb, Sn	1.0×10^{-9}
Sr, Ba	1.0×10^{-11}
Y, La, Ce	1.6×10^{-12}

6. Plant capacity factor: 80%
7. Number of steam generators: two
8. Type of steam generator: once-through

TABLE 3.5-1 (Page 2 of 8)

9. Mass of primary coolant:
 - a. Total, 508,807 lb
 - b. In reactor, 253,000 lb (maximum)
10. Primary coolant flow rate: 1.379×10^8 lb/hr
11. Mass of coolant in each steam generator:
 - a. Steam, 5,100 lb
 - b. Liquid, 49,000 lb
12. Total mass of secondary coolant: 2.93×10^6 lb
13. Steam generator operating conditions:
 - a. Temperature
 - (1) Inlet, 608°F
 - (2) Outlet, 556°F
 - b. Pressure
 - (1) Inlet, 2,149 psig
 - (2) Outlet, 2,144 psig
 - c. Flow rate, 6.895×10^7 lb/hr
14. Condensate demineralizer description:
 - a. Number, four, with three on line during operation and one on standby
 - b. Type, mixed powdered resin and/or Solka Flocc
 - c. Size, 68-in.-diameter shell and 17 ft 5 in. in overall height
 - d. Flow capacity, 2,605,500 lb/hr
15. Containment vessel free volume, 2,834,000 ft³
16. Assumed leak rate of primary coolant to the containment vessel atmosphere 10 lb/hr

TABLE 3.5-1 (Page 3 of 8)

17. There is no internal air cleanup in the containment vessel for cleanup prior to normal purges
18. Containment purge description:
 - a. Frequency of purges, four per year
 - b. Filtration, HEPA and two charcoal filters in series
 - c. Decontamination factor for iodine, 100
19. Primary coolant letdown description:
 - a. Letdown flow rate, 45 gpm
 - b. Return flow to primary system
 - (1) Flow rate, 43.35 gpm
 - (2) Treatment by mixed-bed demineralizer (Li-BO₃ form)
 - (3) Decontamination factors (see item 31)
 - c. Li and Cs control: separate cation demineralizer to be used as required
 - d. Shim bleed flow (average)
 - (1) Flow rate, 1.65 gpm
 - (2) Treatment by degasifier, filter, mixed-bed demineralizer (H⁺-OH⁻ form), evaporator, mixed-bed polishing demineralizer, filter
 - e. Unit design is for base-load operation
 - f. Assumed fraction of shim bleed that is recycled, 80%
20. Only the shim bleed portion of the letdown flow is stripped of dissolved gases.

TABLE 3.5-1 (Page 4 of 8)

21. Gases from shim bleed stripping:
- a. Average shim bleed flow, 1.65 gpm
 - b. Noble gases removed by a degasifier; the stripping fraction is 1.
 - c. Treatment of gases
 - (1) Collected in waste gas surge tank (1,026 ft³)
 - (2) Compressed and held in three decay tanks (1,013 ft³, 150 psi) for 30 days | 1
 - (3) Released to the atmosphere through HEPA filter and charcoal adsorber from unit vent at a uniform rate over 30 days
22. Gases from decay tanks are filtered through charcoal (and a HEPA filter) prior to release. Decontamination factor for iodine: 10
23. Gases from degasification of coolant during shutdown:
- a. Primary coolant volumes degassed, 4 vol/yr
 - b. Fraction of noble gas stripped, 1
 - c. Decay time (of gases), 30 days | 1
24. Other methods of degassing primary coolant:
- a. Infrequent venting of makeup tank, pressurizer, and quench tank
 - b. These gases are collected and held for 30-day decay | 1
25. Assumed leak rate of primary coolant into the secondary coolant:
4.6 lb/hr
26. Steam generator blowdown: none
27. Turbine building ventilation air:
- a. Assumed leak rate of secondary steam to the building, 1,700 lb/hr
 - b. Ventilation air flow rate, 285,000 cfm

TABLE 3.5-1 (Page 5 of 8)

- c. Release point, turbine building roof vents
 - d. Filtration, none
28. Steam jet air ejector:
- a. Flow rate, 50 cfm
 - b. Filtration, HEPA and charcoal filters
 - c. Release point, unit vent
29. Gland seal steam:
- a. Source, main steam supply
 - b. Treatment of leakage, none
30. Auxiliary building ventilation:
- a. Assumed leak rate of primary coolant to the auxiliary building,
13.3 lb/hr
 - b. Release point, unit vent
 - c. Ventilation flow rates and treatments

Fuel-handling area	20,000 cfm*	HEPA
Radwaste area**	50,000 cfm	HEPA
31. Volumes and activity concentrations of untreated liquid wastes, tank capacities, and decontamination factors of treatment steps in the liquid waste treatment systems:
- a. Volumes and activity concentrations of untreated wastes

*Periodic as access is required.

**Includes laboratory hoods.

TABLE 3.5-1 (Page 6 of 8)

<u>Source</u>	<u>Untreated Volume (gal/day)</u>	<u>Activity* (μCi/cc)</u>
High-level		
Shim bleed	2,376	1.2
Equipment leaks	240	
Dirty wastes (floor drains)		
Shield building	32	1.2
Auxiliary building	200	0.12
Laboratory wastes	400	0.024
Sample drains	15	1.2
Miscellaneous sources	700	0.012
Detergent wastes	450	10^{-4}
Steam generator blowdown	None	-
Turbine building drains	3,200	4.7×10^{-7}
Condensate demineralizer		
backwash	1,336	0.02
Demineralizer sluice	34.2	1.2
Resin regeneration	130	0.3

b. Tank capacities

(1) Clean liquid radioactive waste system

	<u>No.</u>	<u>Capacity (gal)</u>
Reactor coolant drain tank	1	655
Clean waste receiver tanks	2	103,000

*Does not include Kr and Xe, which are removed from liquid wastes by the degasifier.

TABLE 3.5-1 (Page 7 of 8)

	<u>No.</u>	<u>Capacity (gal)</u>
Clean waste monitor tanks	2	23,200
Concentrate storage tank	1	780
Spent resin storage tank	1	580
Sodium hydroxide mix tank	1	330

(2) Miscellaneous liquid radioactive waste system

	<u>No.</u>	<u>Capacity (gal)</u>
Miscellaneous waste drain tank	1	13,400
Detergent waste drain tank	1	7,300
Miscellaneous waste monitor tank	1	8,700
Evaporator storage tank	1	780
Antifoam tank	1	50

c. Treatment steps and decontamination factors. See Figures 3.5-3 and 3.5-5.

32. Dilution flow: Batches of liquid waste will be injected into a dilution flow consisting of (1) the normal cooling tower blowdown flow of 8,125 gpm and (2) an extra dilution flow of about 10,000 gpm. The cooling tower blowdown flow is expected to range from a minimum of about 6,000 gpm to a maximum of 9,360 gpm. Assuming a mixing factor of 0.8, this results in an annual average effective dilution flow of 14,500 gpm.

TABLE 3.5-1 (Page 8 of 8)

33. Treatment of waste concentrates:

- a. Treatment, mixed with solidifying agent and catalyst, drummed, and shipped off the site for disposal
- b. Volumes and activities

	<u>Volume (ft³/yr)</u>	<u>Activity (Ci)</u>
Filter cartridges	214	5,978
Spent bead resins	600	9,960
Powdered resins	800	33
Evaporator bottoms	1,407	249

34. Dry wastes:

Volume, 992 ft³

Activity, 0.3 Ci

35. Deborating demineralizer regenerants

- a. Time between regenerations, 73 days
- b. Treatment of regenerants, processed by miscellaneous liquid radioactive waste system
- c. Volume, 130 gpd
- d. Fraction discharged, 1

36. Process diagrams:

- a. Liquid radwaste treatment, Figures 3.5-1 through 3.5-5
- b. Gaseous radwaste treatment, Figures 3.5-6 and 3.5-7
- c. Solid radwaste treatment, Figure 3.5-8.

from the reactor coolant drain tank as well as a portion of the letdown (shim bleed) from the reactor coolant system. This system also processes primary coolant collected from loop drains, seal pots, and valve leakoffs. The normal process cycle consists of degasification, filtration, demineralization, evaporation, demineralization, and filtration. The end products of the cycle are demineralized water and boric acid, which may be either reused or disposed of in accordance with applicable operating procedures.

In the degasifier, dissolved hydrogen and fission product gases are stripped from the liquid and sent to the gaseous radioactive waste system. From the degasifier, the waste is pumped (1) through one of the primary demineralizer filters, (2) through one of the primary demineralizers, and (3) into one of the clean waste receiver tanks. Periodic or continuous recirculation of the tank contents ensures adequate mixing. When sufficiently full, a tank is isolated and a representative sample of its contents taken and analyzed. Then, with its composition known, the waste is fed to one or both of the boric acid evaporators. There it is separated into its two reusable constituents: demineralized water and concentrated boric acid. The demineralized water (distillate) is pumped through one of the polishing demineralizers and clean waste monitor tank filters into one of two clean waste monitor tanks. Individual recirculation lines on these tanks ensure adequate mixing. When a sufficient quantity has been accumulated, the tank being filled is isolated and a sample taken. The processed waste is then sent to the primary water storage tank for eventual reuse or diluted and discharged to Lake Erie at a rate that does not lead to concentrations exceeding technical specifications. The boric acid from the evaporator bottoms is pumped through the concentrate demineralizer into the concentrate storage tank. After the contents of this tank have been thoroughly mixed

through recirculation, a sample is taken and analyzed. The acid is then pumped to one of the boric acid addition tanks, where it is stored for reuse, or to the miscellaneous liquid radioactive waste system, where it is further concentrated prior to packaging for shipment off the site. There is also a line that permits the direct addition of boric acid from the concentrates storage tank to the makeup tank should the need ever arise.

All waste tanks are automatically maintained above atmospheric pressure by a nitrogen blanketing system. When a tank is being filled, excess cover gas is displaced to the gaseous radioactive waste system or to the unit vent. When a tank is being emptied, any replacement gas needed is recycled back from the waste gas system or supplied from the nitrogen supply.

When the concentration of boron in the primary system is low, such as near the end of an equilibrium fuel cycle, the shim bleed from the reactor coolant letdown is directed through the deborating demineralizers and sent back to the primary system through the makeup tank. The normal operating mode process cycle is bypassed because of the larger volumes of coolant that have to be processed for boron control during the latter stages of the fuel cycle. The normal process cycle is limited by the boric acid evaporator maximum process rate of 15 gpm. In the deborating mode, the degasifier is usually bypassed to retard waste gas production. However, it can be utilized if there is a need to reduce total gas or fission gas activity in the reactor coolant.

If at some point in the normal process cycle sampling indicates that treatment has been inadequate, alternate flow paths can be used. These paths include recycle lines that permit the contents of the various system tanks

to be directed back through some portion of the cycle to undergo additional processing.

All waste being sent to the primary water storage tank or discharged to the environment must pass two monitors that measure and record radiation levels and control two downstream valves in each of the flow paths used. If either monitor indicates an excessive radiation level, all downstream valves are closed and discharge flow is terminated.

It is estimated that the CLRWS will process 1,224,480 gal/yr of liquid and discharge 258,000 gal/yr of processed liquid to Lake Erie. This volume corresponds to about 80% recycle.

The decontamination factors (DF's) assumed for each process step, and the cumulative DF's for classes of fission product and corrosion product radioactive isotopes are shown on Figure 3.5-3. The cumulative DF's (assuming one pass through a boric acid evaporator) are 1.0×10^5 for most isotopes, 2.0×10^4 for Cs and Rb, and 1.0×10^4 for Y.

The estimated concentrations of radioisotopes in effluents from the CLRWS are listed on Table 3.5-2. As noted above, the assumptions used in making these estimates are listed in Table 3.5-1.

The purpose of the MLRWS is to collect, store, process, monitor, recycle, or discharge potentially radioactive aerated or dirty liquid wastes that are generated during normal plant operation. The flow paths in the MLRWS are shown on Figure 3.5-4.

TABLE 3.5-2

CALCULATED ANNUAL RADIONUCLIDE RELEASES AND RELEASE
CONCENTRATIONS IN LIQUID WASTES

Nuclide	Annual Release, Ci	Concentration During Release, $\mu\text{Ci/cc}$			Annual Average Release Concentration, $\mu\text{Ci/cc}$
		From Clean Liquid Waste System	From Miscellaneous Liquid Waste System	From Secondary System Liquid Leakage	
^{51}Cr	6.03×10^{-5}	5.73×10^{-12}	1.12×10^{-11}	1.25×10^{-12}	2.21×10^{-12}
^{54}Mn	7.17×10^{-6}	6.53×10^{-13}	1.29×10^{-12}	1.42×10^{-13}	2.54×10^{-13}
^{55}Fe	2.47×10^{-4}	2.28×10^{-11}	4.47×10^{-11}	4.93×10^{-12}	8.72×10^{-12}
^{59}Fe	7.17×10^{-6}	6.53×10^{-13}	1.29×10^{-12}	1.42×10^{-13}	2.54×10^{-11}
^{58}Co	3.77×10^{-4}	3.43×10^{-11}	6.77×10^{-11}	7.50×10^{-12}	1.34×10^{-11}
^{60}Co	2.00×10^{-6}	1.84×10^{-13}	3.60×10^{-13}	4.00×10^{-14}	7.09×10^{-14}
^{95}Zr	4.43×10^{-4}	4.50×10^{-11}	8.90×10^{-11}	9.77×10^{-12}	1.74×10^{-11}
^{88}Rb	8.27×10^{-3}	5.53×10^{-9}	8.83×10^{-11}	9.93×10^{-11}	3.94×10^{-10}
^{89}Sr	2.81×10^{-6}	7.67×10^{-13}	1.51×10^{-13}	2.33×10^{-14}	9.92×10^{-14}
^{90}Sr	9.03×10^{-8}	7.46×10^{-14}	4.83×10^{-15}	7.50×10^{-15}	3.20×10^{-15}
^{91}Sr	1.67×10^{-5}	4.57×10^{-12}	9.03×10^{-13}	1.38×10^{-12}	5.92×10^{-13}
^{92}Sr	4.93×10^{-6}	1.37×10^{-12}	2.71×10^{-13}	4.00×10^{-13}	1.75×10^{-12}
^{90}Y	1.93×10^{-6}	5.27×10^{-13}	2.80×10^{-13}	3.40×10^{-15}	6.84×10^{-14}
^{91}Y	4.20×10^{-5}	1.15×10^{-11}	6.10×10^{-12}	7.43×10^{-14}	1.49×10^{-12}
^{99}Mo	2.19×10^{-2}	8.00×10^{-10}	4.73×10^{-9}	5.23×10^{-11}	7.76×10^{-10}
^{131}I	1.26×10^{-2}	5.57×10^{-9}	1.06×10^{-9}	1.48×10^{-10}	4.46×10^{-10}
^{132}I	8.10×10^{-2}	3.50×10^{-9}	6.87×10^{-10}	9.20×10^{-11}	2.87×10^{-10}
^{133}I	1.43×10^{-2}	6.17×10^{-9}	1.22×10^{-9}	1.68×10^{-10}	5.06×10^{-10}
^{134}I	1.65×10^{-3}	7.13×10^{-10}	1.41×10^{-10}	1.79×10^{-11}	5.85×10^{-11}
^{135}I	7.06×10^{-3}	3.03×10^{-9}	6.00×10^{-10}	8.23×10^{-11}	2.50×10^{-10}
^{134}Cs	2.83×10^{-4}	1.86×10^{-10}	2.95×10^{-12}	4.27×10^{-12}	1.00×10^{-11}
^{136}Cs	2.12×10^{-4}	1.40×10^{-10}	2.22×10^{-12}	3.22×10^{-12}	7.51×10^{-12}
^{137}Cs	8.43×10^{-4}	5.53×10^{-10}	8.83×10^{-12}	1.29×10^{-11}	2.98×10^{-11}
^{138}Cs	2.21×10^{-3}	1.47×10^{-9}	2.35×10^{-11}	2.89×10^{-11}	7.83×10^{-11}
^{137}Ba	9.17×10^{-5}	3.87×10^{-11}	7.60×10^{-12}	1.50×10^{-12}	3.25×10^{-12}
^{139}Ba	4.20×10^{-5}	1.18×10^{-11}	2.33×10^{-12}	3.33×10^{-12}	1.49×10^{-12}
^{140}Ba	3.50×10^{-6}	9.57×10^{-13}	1.89×10^{-13}	2.91×10^{-13}	1.24×10^{-13}
^{140}La	1.46×10^{-6}	3.97×10^{-13}	7.87×10^{-14}	1.21×10^{-13}	5.18×10^{-14}
^{144}Ce	3.21×10^{-7}	8.77×10^{-14}	1.73×10^{-14}	2.67×10^{-14}	1.14×10^{-14}
^3H	350	—	—	—	1.24×10^{-5}

Processing is accomplished on a batch basis and the normal cycle consists of a single pass through an evaporator, a demineralizer, and a filter. Dirty and aerated wastes from various sources are collected in tanks as follows:

<u>Waste Source</u>	<u>Collection Tank</u>
Laboratory and Sample Drains	Miscellaneous Waste Drain Tank
Demineralizer Sluice Water	
Deborating Demineralizer Regeneration	
Containment Vessel Sump	
Auxiliary Building Floor Drains	
Miscellaneous Sources	
Laundry	Detergent Waste Drain Tank
Hot Showers	
Condensate Demineralizer Backwash	Condensate Demineralizer Holdup Tanks
Secondary System Leakage	

When sufficient liquid has accumulated in any of the collection tanks, and after recirculation of the waste has ensured thorough mixing, a sample is taken and analyzed. If analysis shows there is no significant activity and the waste is not scheduled for reuse as primary water, the contents of the tank can be released from the unit without further treatment. Otherwise, the liquid is pumped to the waste evaporator where the ionic and solid impurities are concentrated in the bottoms and relatively pure distillate is produced. Some addition of chemicals to the evaporator feed may be necessary to neutralize boric acid, reduce foaming and carryover, or adjust pH. The evaporator bottoms, when concentrated to some upper limit of solubility or specific activity, are pumped to the evaporator storage tank. The bottoms are then recirculated to ensure adequate mixing, sampled, and

pumped to the drumming station, where they are prepared for shipment off the site. The distillate produced is pumped through the waste polishing demineralizer and waste monitor tank filter into the waste monitor tank. When a sufficient quantity has accumulated and been thoroughly mixed through recirculation, a sample is taken and analyzed. Normally the waste is diluted in a controlled manner and released from the unit, but it can be sent to the primary water storage tank for eventual reuse as reactor coolant. The gas inlets and vents on the miscellaneous waste drain tank, detergent waste drain tank, and evaporator storage tank are controlled to reduce the turnover of gases in the tank's vapor spaces. The miscellaneous waste monitor tank has a nitrogen feed arrangement that can be used either as a purge or a cover gas, maintaining a slight positive pressure. This latter capability is used when there is a possibility that the treated waste will be sent to the CLRWS for further processing.

If sampling indicates that additional treatment is required, the contents of the miscellaneous waste monitor tank can be recycled through part, or all, of the system and/or sent to the CLRWS.

All waste being sent to the primary water storage tank or discharged to the environment must pass two monitors that measure and record radiation levels and that control two downstream valves in either of the flow paths used. If either indicates an excessive radiation level, all downstream valves are closed and discharge flow is terminated.

It is estimated that the MLRWS will process 833,660 gal/yr of nondetergent wastes; this liquid will be discharged or recycled. The estimated volume of detergent waste is 155,000 gal/yr; this liquid will normally be

filtered and discharged without processing but will be processed through the MLRWS if it contains significant quantities of radioactivity. The volume of secondary leakage is estimated to be 934,000 gal/yr. The capability exists to also process this waste through the MLRWS if significant primary-to-secondary leakage is indicated.

The decontamination factors (DF's) assumed for each process step and the cumulative DF's for classes of fission-product and corrosion-product isotopes are given in Figure 3.5-5. The cumulative DF's are 1.0×10^5 for most isotopes and 1.0×10^4 for iodine, crud, and yttrium.

The estimated concentrations of radioisotopes in effluents from the MLRWS and in the (normally untreated) secondary system liquid leakage are listed in Table 3.5-2. The assumptions used in making these estimates are listed in Table 3.5-1, as already noted.

It is assumed that all tritium leaking into or produced in the reactor coolant will be released to the environment. This will amount to about 350 Ci/yr. The estimated total annual release to the environment of fission products and activated corrosion products in all liquid effluents is listed by isotope in Table 3.5-2.

Batches of liquid waste from both the CLRWS and MLRWS will be injected into a dilution flow of: (1) the normal cooling tower blowdown flow of 8,125 gpm and (2) an extra dilution flow of 10,000 gpm. Thus the dilution flow into which radwaste will be released amounts to an estimated 18,125 gpm. Assuming a mixing factor of 0.8, this results in an effective annual average dilution flow of 14,500 gpm. The total annual releases of radioactivity and the estimated average release concentrations of liquid released are given in Table 3.5-2.

3.5.2 GASEOUS RADIOACTIVE WASTES

Fission product noble gases (krypton and xenon) are very slightly soluble in water and will therefore occur almost exclusively in the gaseous phase.

Fission-product halogens (mainly iodines) are soluble and will partition between aqueous and gaseous phases. Steam leakage can result in other fission product isotopes, including both entrained particulates and particulate daughters of gaseous isotopes being released. The total particulate release is less than 0.002 Ci/yr.

The primary source of gaseous waste will be unaerated, hydrogenated gases from the degasifier in the CLRWS. Additional hydrogenated gases will come from the boric acid evaporators, the reactor coolant drain tank, and from infrequent venting of the makeup tank, pressurizers, and quench tank. These gases are processed in the gaseous radioactive waste system (GRWS). The flow paths in this system are shown in Figure 3.5-6; the cleanup process steps employed are shown schematically in Figure 3.5-7.

To preclude the leakage of air into the hydrogenated gases, a nitrogen blanketing system automatically maintains a minimum positive pressure in the surge tank. When sufficient gas has been collected, a pressure switch starts one of two compressors and connects its suction to the surge tank and its discharge to one of three waste gas decay tanks. The particular components that are to be involved in this operation are selected beforehand. The compressor runs until the pressure in the surge tank is sufficiently reduced and then stops. When a decay tank is full (contains gas at 150 psig or at some lower operator-designated pressure), it is valved off and another decay tank is valved in its place. A sample is then taken from the isolated tank and analyzed. If it shows a sufficiently low activity level, the stored gas can be released in a controlled manner through char-

coal and HEPA filters to the unit vent. If the analysis indicates significant activity, the gases are allowed to decay until future sampling shows that they are suitable for release to the environment. Using two of the decay tanks, gases can be held for at least 30 days with release spread out over the next 30 days. |1

Another major function of this system is to handle the nitrogen cover gas that is displaced from the clean waste receiver and clean waste monitor tanks as they are filled. Since this gas should contain little activity, an effort is made to keep it separate from the hydrogen and fission product gases. This is done by forming the remaining compressor and decay tank into a separate processing chain. The compressor takes suction directly from a header common to both the receiver and monitor tanks. A pressure switch located in this header controls the off-on operation of the compressor. Once compressed, the cover gas may be reused as needed or, after sampling, vented to the atmosphere. If the cover gas becomes significantly radioactive, there may be some danger of it contaminating the processed waste in the monitor tanks. To preclude this, the vents on the monitor tanks can be adjusted so that only flow out is allowed. In this arrangement, gas from the unit nitrogen system is used for makeup when the tanks are emptied.

Because of the large inventory of cover gas present, it is possible for more of it to be displaced ($>10,000 \text{ ft}^3 @ 14.7 \text{ psia}$) than one decay tank can hold. If this happens, excess gas is directed to one of the other decay tanks normally used for high-level gaseous waste. This is continued until (1) the filled tank is vented through the filters to the atmosphere if sampling indicates it is low in activity or (2) the displacement of gas stops. Since cover gas will probably not require decay before controlled

release, the decay tank picked to receive the overflow will generally be the one whose contents are due to be discharged first.

For flexibility, all compressors and all decay tanks in the system are interchangeable. How each is used is at the discretion of the operator. There are also lines and valves available to allow the transfer of gas within the system. Normally this is done by bleeding the gas from one of the decay tanks into the surge tank. From there a compressor can direct it to any of the decay tanks, including the one it came from. During this transfer the gas can be cleaned by passing it through the charcoal and absolute filters. Finally, if it is known that the cover gas or the contents of the surge tank are not significantly contaminated, the compressors can bypass the decay tanks and discharge directly to the unit vent. It is estimated that a total annual volume of 8,000 scf (STP) of unaerated, hydrogenated waste gases and cover gases will be released to the atmosphere. The estimated quantities of radioisotopes in these effluents are given in Table 3.5-3.

Gaseous wastes from various vents which should contain little or no radioactivity or which may contain oxygen are handled separately, as shown on Figure 3.5-6. This is to prevent unnecessary processing as well as preclude the formation of explosive mixtures. These low-level gases are simply collected, sometimes passed through a charcoal filter, and then released through the unit vent. Due to the random nature of the sources, it is not possible to make a realistic estimate of the volumes to be released. However, an estimate of the radioactivity in this effluent has been made and is given in Table 3.5-3.

TABLE 3.5-3

CALCULATED ANNUAL RADIONUCLIDE RELEASE IN GASEOUS EFFLUENTS
(Curies)

Isotope					Auxiliary Building		Containment Building Purge	Turbine** Building Ventilation	Decay* Products	Totals
	Un aerated Hydrogenated Wastes	Aerated Wastes	Cover Gases	Steam Jet Air Ejector	Except Refueling Area	Refueling Area				
H-3	-	-	-	-	-	280.	5.20	2.72	-	288.
Ar-41	-	-	-	1.69	2.45	-	0.0266	0.000530	-	4.17
Kr-83m	-	-	-	0.373	0.620	-	0.00680	0.000134	-	1.00
Kr-85m	-	-	-	2.09	3.38	-	0.0520	0.000747	-	5.52
Kr-85	209.	-	-	4.36	6.93	-	11.7	0.00156	-	231.9
Kr-87	-	-	-	1.09	1.84	-	0.0172	0.000394	-	2.95
Kr-88	-	-	-	3.58	5.90	-	0.0756	0.00129	-	9.56
Xe-131m	40.8	-	-	2.75	4.38	-	1.53	0.000994	5.79	55.2
Xe-133m	0.0389	-	-	3.76	6.0	-	0.456	0.00135	5.63	15.9
Xe-133	554.5	-	-	337.	539.	-	86.8	0.121	105.	1621.5
Xe-135m	-	-	-	0.822	1.57	-	0.00546	0.000295	2062.	2064.7
Xe-135	-	-	-	6.00	9.66	-	0.210	0.00216	195.	211.2
Xe-138	-	-	-	0.595	1.12	-	0.00460	0.000214	-	1.72
I-131	0.000615	0.0553	0.000865	0.000252	0.00767	-	0.184	0.00110	-	0.252
I-132	-	0.0357	0.000559	0.000157	0.00494	-	0.00588	0.000681	-	0.0494
I-133	-	0.0632	0.000987	0.000288	0.00875	-	0.0309	0.00125	-	0.108
I-134	-	0.00730	0.000114	0.0000305	0.00101	-	0.000792	0.000132	-	0.00966
I-135	-	0.0311	0.00049	0.000141	0.00431	-	0.00800	0.000611	-	0.0459

*These isotopes will be released into the auxiliary building ventilation streams.

**The turbine building ventilation is predicted to contain small amounts of particulate decay products as listed on Table 3.5-4.

3.5-20

DB-1

1

TABLE 3.5-3 (Page 2 of 2)

Isotope	Auxiliary Building										Totals
	Unacrated Hydrogenated Wastes	Aerated Wastes	Cover Gases	Steam Jet Air Ejector	Except Refueling Area	Refueling Area	Containment Building Purge	Turbine** Building Ventilation	Decay* Products		
I-131	0.00016	0.055	0.00087	0.00025	0.0077	-	0.0045	0.0011	-	0.0696	
I-132	-	0.036	0.00056	0.00016	0.0049	-	0.0002	0.00068	-	0.0425	
I-133	-	0.063	0.00099	0.00029	0.0087	-	0.0008	0.0012	-	0.0750	
I-134	-	0.0073	0.00011	0.00063	0.0010	-	0.00003	0.0001	-	0.0086	
I-135	-	0.0311	0.00049	0.00014	0.0043	-	0.00022	0.0006	-	0.0369	

Regardless of how the equipment is utilized, all gases being vented to the atmosphere must pass two radiation monitors. If either of these detects excessive radiation, two downstream valves are closed and discharge is stopped.

The containment vessel purge and ventilation system is indicated schematically in Figure 3.5-7. The containment vessel is expected to be purged four times per year, normally through a HEPA filter and two charcoal filters in series, the purge rate being 50,000 cfm. The annulus between the containment vessel and the shield building can be exhausted through the emergency ventilation system in accordance with indicated radioactivity concentrations. The containment vessel can also be purged through the emergency ventilation system.

The auxiliary building ventilation system, excluding refueling areas, operates continuously with a normal capacity of 47,160 cfm through a HEPA filter to the unit vent. The auxiliary building (refueling areas) ventilation system will operate when access to these areas is required. The system has a normal capacity of 20,000 cfm and exhausts through a HEPA filter to the unit vent. The auxiliary building ventilation system can be routed through the emergency ventilation system.

The turbine building ventilation system operates in accordance with need for cooling as determined by the outside temperature, but for estimating the release amounts the system was assumed to operate continuously at its overall capacity of about 285,000 cfm. The turbine building ventilation air is discharged directly to the atmosphere from the turbine building vents.

If there is a significant steam generator leak, the steam jet air ejector will exhaust through a HEPA (particulate) filter and a charcoal adsorber.

The unit vent through which all gaseous effluents (excepting the turbine building ventilation air and nonradioactive areas) are exhausted is a circular steel structure that protrudes above the shield building to an elevation of 834.5 ft. The exit velocity from the vent will be 2,100 ft/min and the flow rate will be 80,000 cfm. The turbine building ventilation is exhausted through six vents in the turbine building roof; the exit velocity is 1,700 ft/min.

The principal assumptions used in estimating releases are presented in Table 3.5-1. The estimated annual releases in building purge and ventilation effluents are listed by isotope in Tables 3.5-3 and 3.5-4.

3.5.3 SOLID RADIOACTIVE WASTES

Solid wastes will consist of high-activity spent demineralizer resins, evaporator concentrates and liquid filters, spent HEPA filters and charcoal adsorbers, and miscellaneous compressible low-activity wastes, such as clothing.

Periodically batches of high-level solid wastes in slurry form will be pumped to the drumming station in the auxiliary building, where the material will be mixed with a solidifying agent and catalyst, drummed, and stored for offsite burial. All dry solid miscellaneous wastes will be hydraulically compacted into drums and stored for offsite burial.

The radwaste solidification system, shown on Figure 3.5-8, is designed to process radwaste at a rate of up to six 50-ft³ casks in an 8-hr period. In general, the system contains a number of pumps that bring together the radwaste with the liquid solidification agent. These are then mixed and passed to a disposable liner where a catalyst is introduced. Both evaporator bottoms and powdered resin type slurries can be handled in this manner.

TABLE 3.5-4

CALCULATED ANNUAL PARTICULATE
RADIONUCLIDE RELEASE IN GASEOUS EFFLUENTS

(Activity in Curies in the Turbine Building Ventilation)

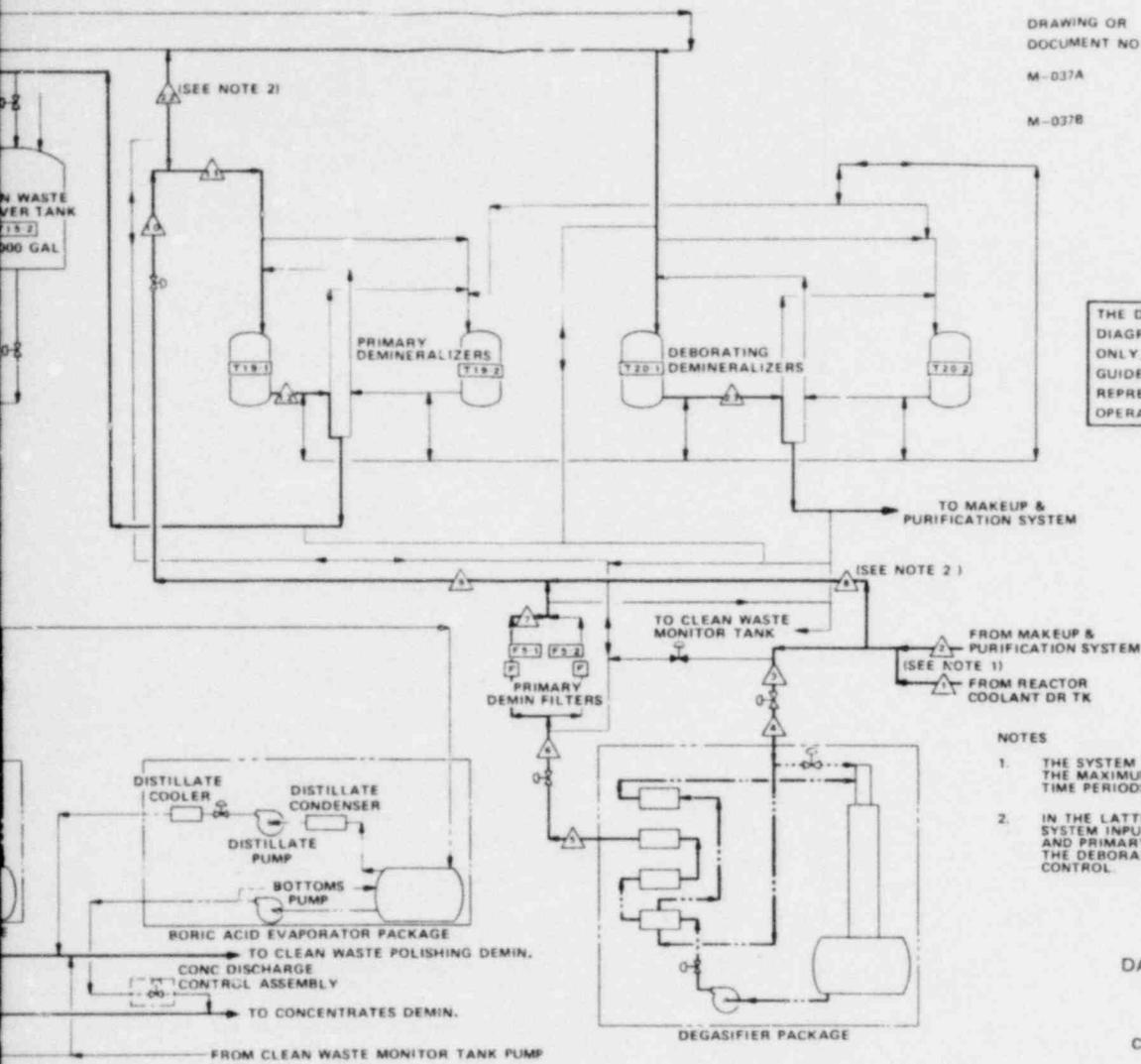
Isotope	Release	Isotope	Release
Cr-51	9.26×10^{-6}	Zr-95	7.24×10^{-5}
Mn-54	1.05×10^{-6}	Mo-99	3.89×10^{-4}
Fe-55	3.66×10^{-5}	Cs-134	3.18×10^{-5}
Fe-59	1.05×10^{-6}	Cs-136	2.38×10^{-5}
Co-58	5.53×10^{-5}	Cs-137	9.56×10^{-5}
Co-60	2.98×10^{-7}	Cs-138	2.14×10^{-4}
Rb-88	7.37×10^{-4}	Ba-137m	1.12×10^{-5}
Sr-89	1.73×10^{-6}	Ba-139	2.47×10^{-5}
Sr-90	5.58×10^{-8}	Ba-140	2.16×10^{-6}
Sr-91	1.02×10^{-5}	La-140	8.98×10^{-7}
Sr-92	2.98×10^{-6}	Ce-144	1.98×10^{-7}
Y-90	2.52×10^{-8}		
Y-91	5.53×10^{-7}		

Spent resin beads are pumped into the liners, where a filter and dewatering pump are used to draw off excess water. At this point, evaporator bottoms, mixed with solidification agent, are added and mixed by means of a disposable blade. The time required for the radwaste-solidification agent mixture to solidify is controlled by a catalyst and is normally a few minutes. The actual processing rate is about 10 gpm. Once packaged, the liners and shields can be removed to the loading area for offsite shipment.

The HEPA and charcoal filters will be boxed for shipment and offsite burial. Compressible low-level wastes will be compressed and shipped for offsite disposal. The volumes and amounts of radioactivity in solid wastes are indicated under items 33 and 34 of Table 3.5-1 and are discussed further in Section 3.8.

DRAWING OR DOCUMENT NO	REFERENCES TITLE
M-037A	P&ID - CLEAN LIQUID RADIOACTIVE WASTE SYSTEM - SHEET 1
M-037B	P&ID - CLEAN LIQUID RADIOACTIVE WASTE SYSTEM - SHEET 2

THE DATA SHOWN ON THIS FLOW DIAGRAM ARE FOR DESIGN PURPOSES ONLY, AND WHILE USEFUL AS GUIDES IN OPERATION, DO NOT REPRESENT EXACT OR GUARANTEED OPERATING CONDITIONS



NOTES

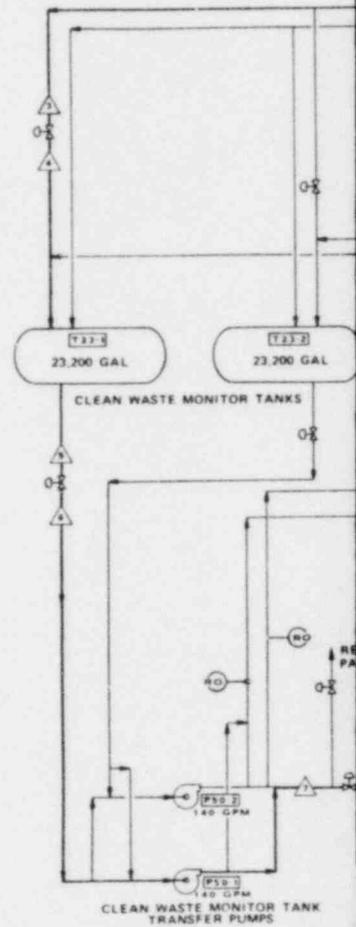
1. THE SYSTEM INPUT FLOW RATES (1 AND 2) ARE THE MAXIMUM EXPECTED VALUES FOR INTERMITTENT TIME PERIODS DURING NORMAL OPERATIONS.
2. IN THE LATTER PART OF THE EQUILIBRIUM FUEL CYCLE, SYSTEM INPUT IS BYPASSED AROUND THE DEGASIFIER AND PRIMARY DEMINERALIZER AND DIRECTED THROUGH THE DEBORATING DEMINERALIZERS FOR MAJOR BORON CONTROL.

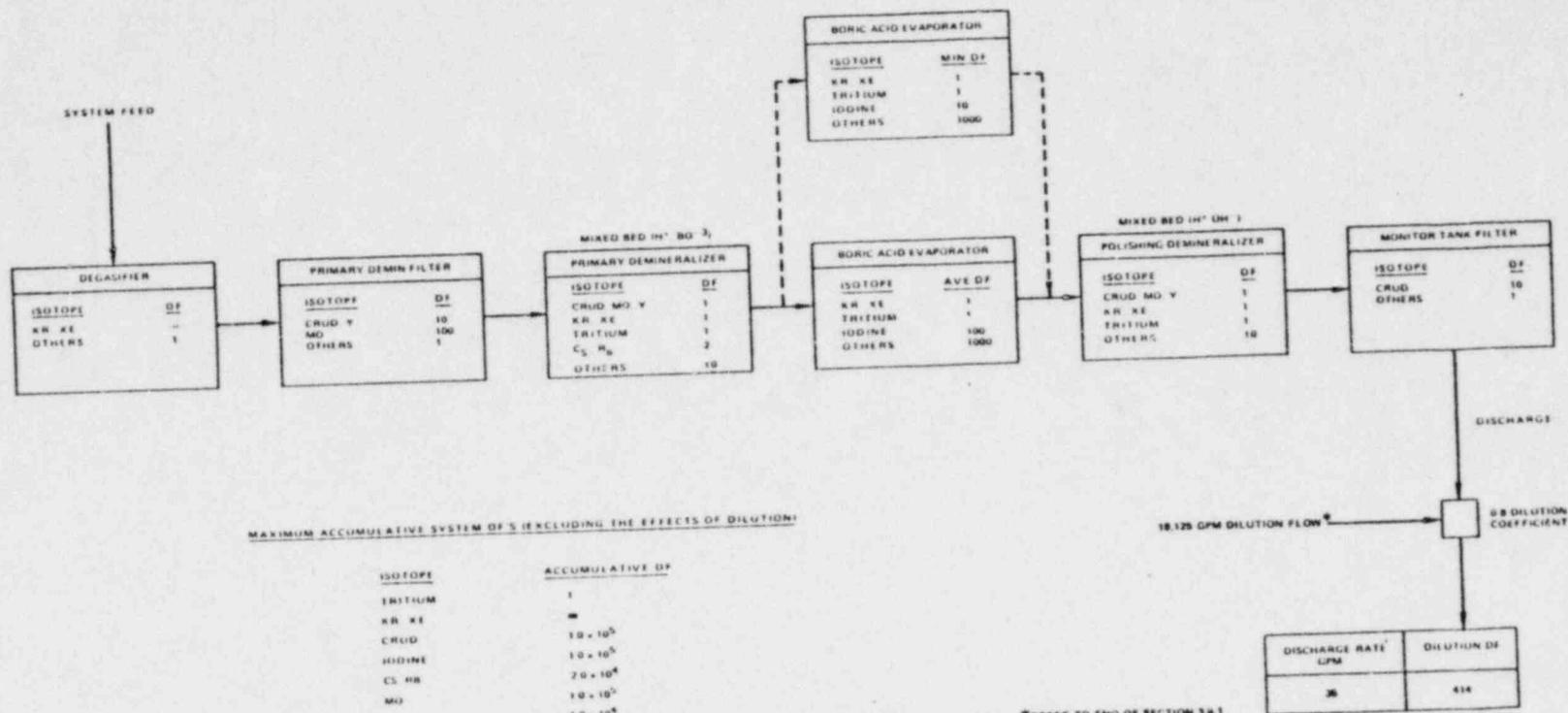
DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1

CLEAN LIQUID RADIOACTIVE WASTE SYSTEM
FLOW DIAGRAM - PART 1

FIGURE 3.5-1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30





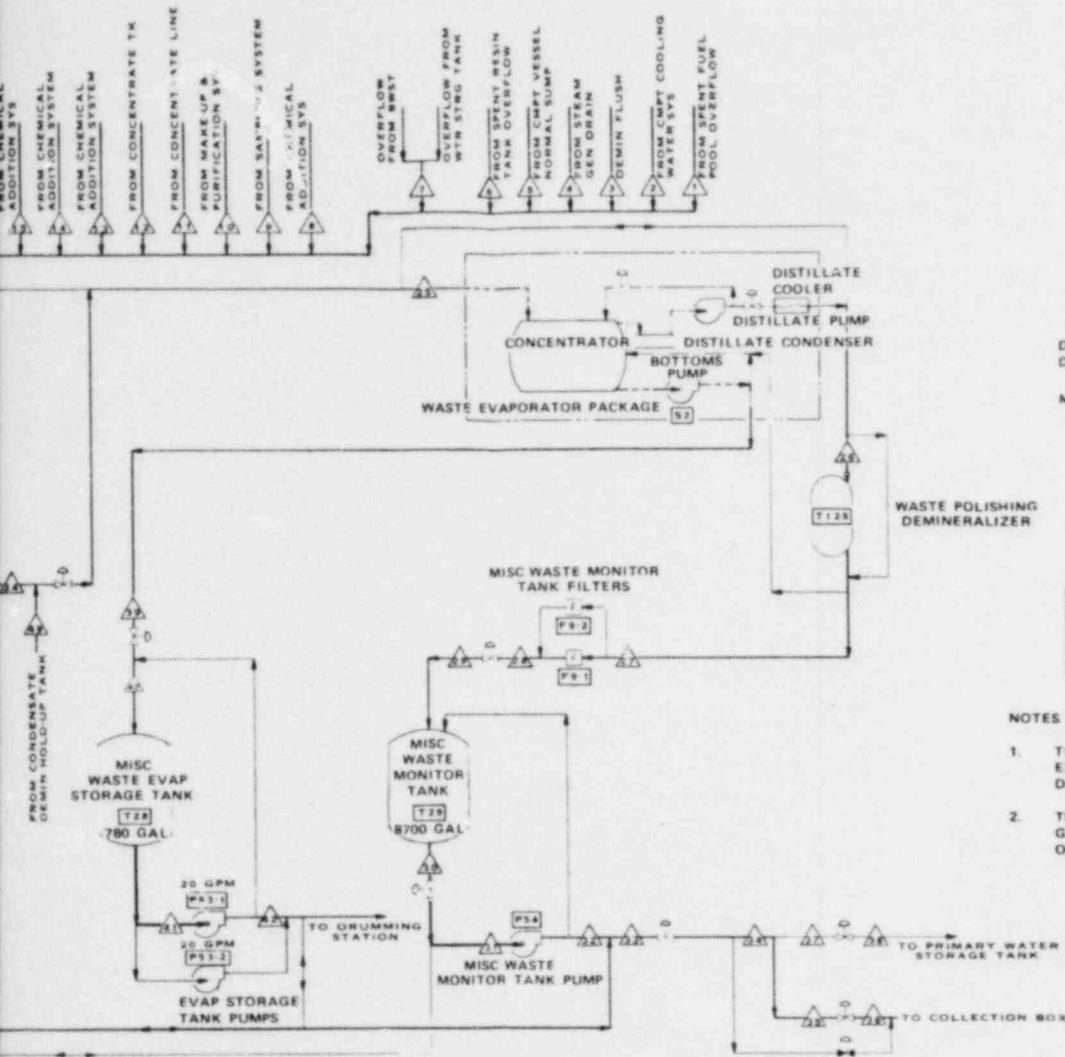
MAXIMUM ACCUMULATIVE SYSTEM DF'S (INCLUDING THE EFFECTS OF DILUTION)

ISOTOPE	ACCUMULATIVE DF
TRITIUM	1
KR XE	1
CRUD	10×10^5
IODINE	10×10^5
C ₁₄ H ₃	20×10^5
MO	10×10^5
Y	10×10^5
OTHERS	10×10^5

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1
 CLEAN LIQUID RADIOACTIVE WASTE SYSTEM
 DECONTAMINATION FACTORS

FIGURE 3.5-3

DB-1



REFERENCES

DRAWING OR DOCUMENT NO	TITLE
M-039	P&ID MISCELLANEOUS LIQUID RADIOACTIVE WASTE

THE DATA SHOWN ON THIS FLOW DIAGRAM ARE FOR DESIGN PURPOSES ONLY, AND WHILE USEFUL AS GUIDES IN OPERATION DO NOT REPRESENT EXACT OR GUARANTEED OPERATING CONDITIONS.

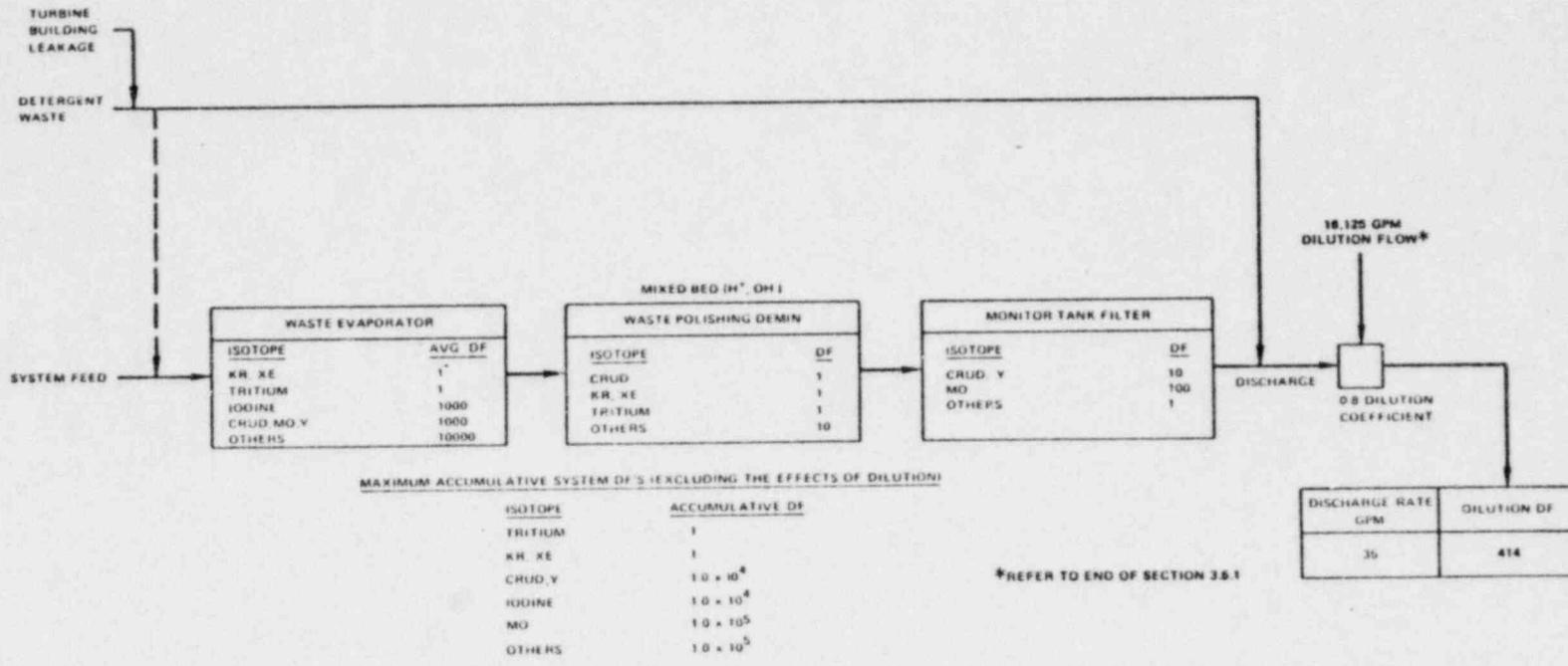
NOTES

1. THE SYSTEM INPUT FLOW RATES ARE THE MAXIMUM EXPECTED VALUES FOR INTERMITTENT TIME PERIODS DURING NORMAL OPERATION.
2. THE FLOW RATES FROM THOSE SOURCES WHICH ARE GRAVITY FLOW TO THE SYSTEM HEADER ARE BASED ON A FLUID VELOCITY OF 7 FT/SEC.

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1

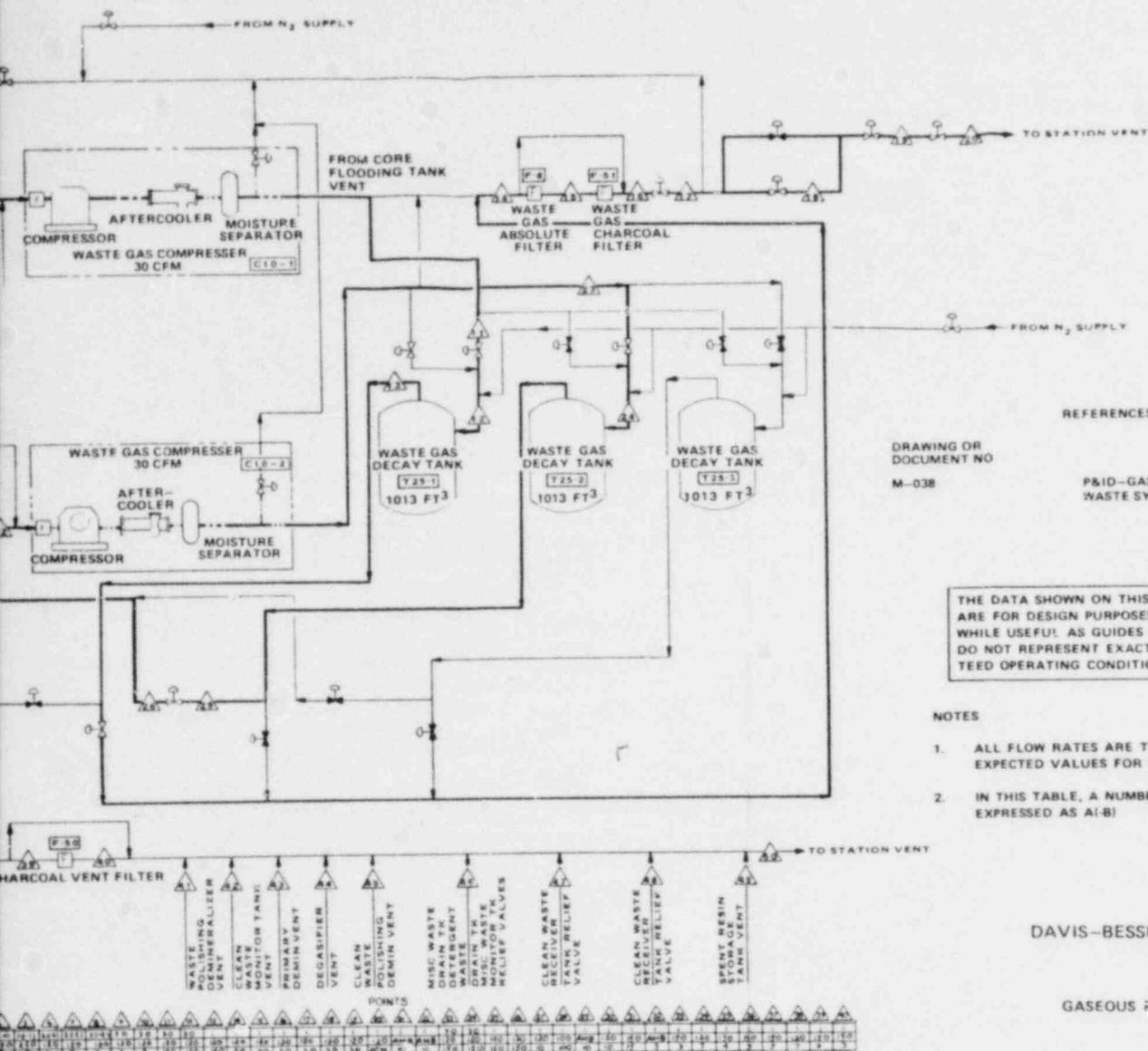
MISCELLANEOUS LIQUID RADIOACTIVE WASTE
SYSTEM FLOW DIAGRAM

FIGURE 35-4



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1
 MISCELLANEOUS LIQUID RADIOACTIVE WASTE SYSTEM
 DECONTAMINATION FACTORS

FIGURE 3.5-5



REFERENCES

DRAWING OR DOCUMENT NO
M-038

TITLE
P&ID-GASEOUS RADIOACTIVE WASTE SYSTEM

THE DATA SHOWN ON THIS FLOW DIAGRAM ARE FOR DESIGN PURPOSES ONLY, AND WHILE USEFUL AS GUIDES IN OPERATION, DO NOT REPRESENT EXACT OR GUARANTEED OPERATING CONDITIONS.

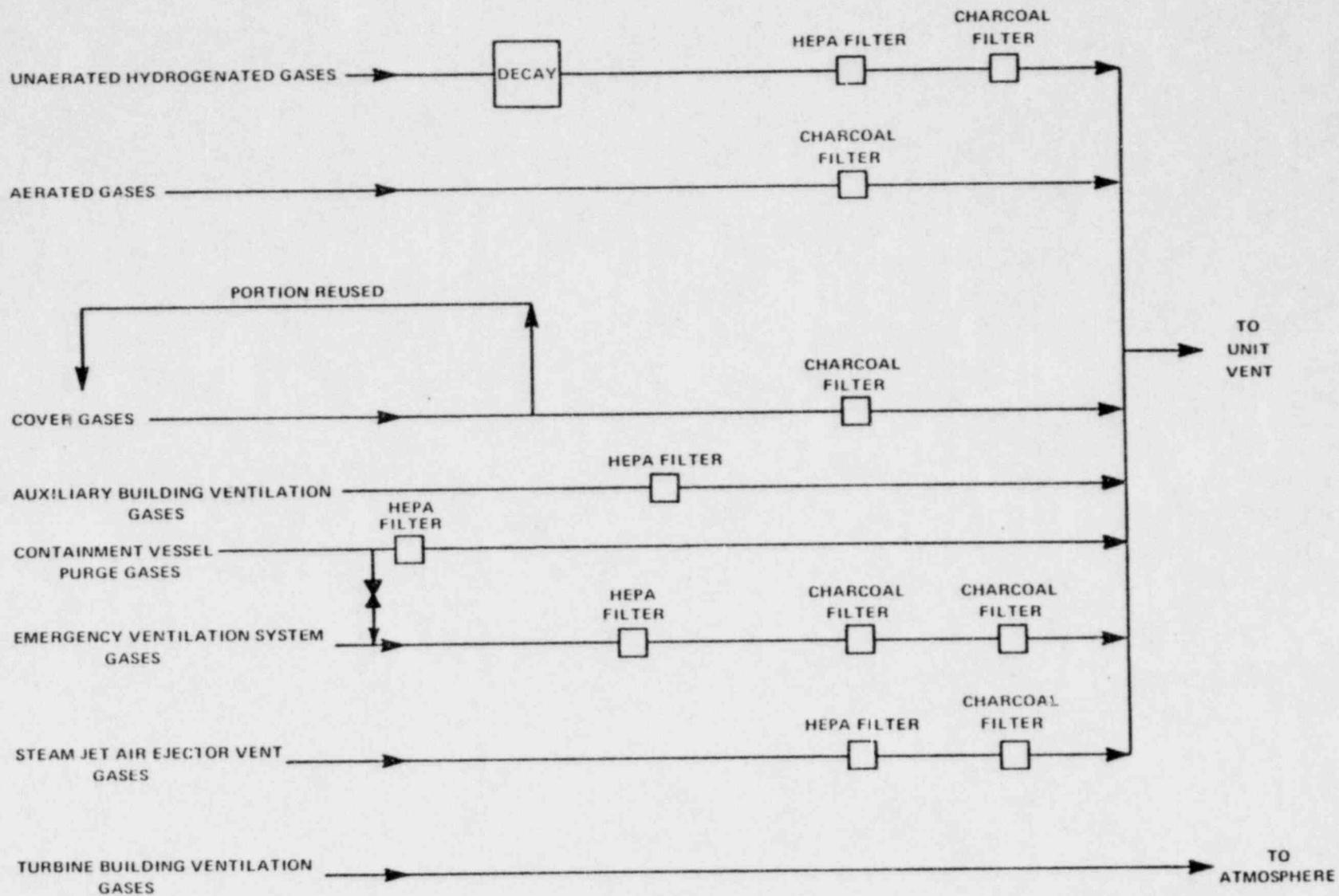
NOTES

1. ALL FLOW RATES ARE THE MAXIMUM EXPECTED VALUES FOR NORMAL OPERATION
2. IN THIS TABLE, A NUMBER $A \times 10^B$ IS EXPRESSED AS A(B)

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1

GASEOUS RADIOACTIVE WASTE SYSTEM
FLOW DIAGRAM

FIGURE 3.5-6

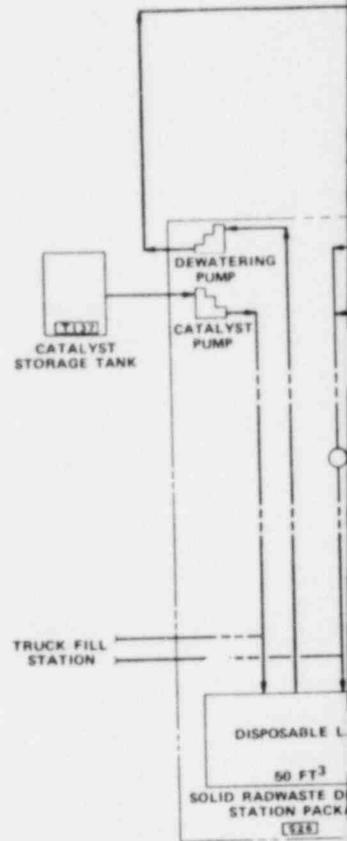


DB-1

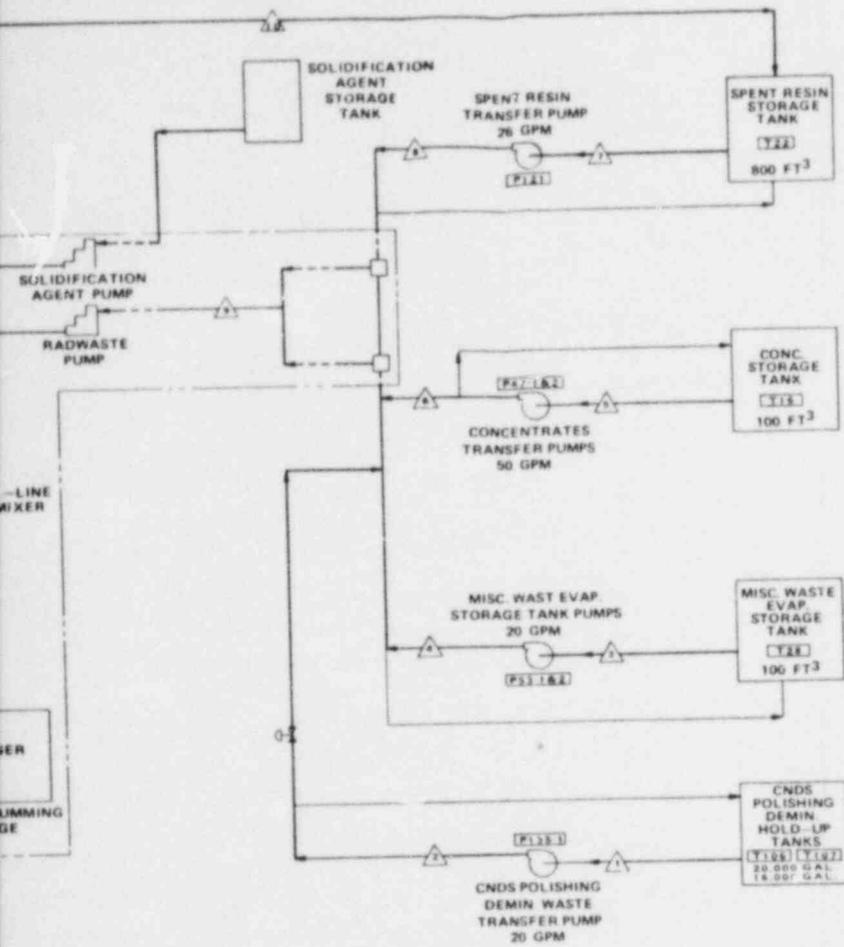
DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

GASEOUS RADIOACTIVE WASTE SYSTEM AND VENTILATION SYSTEMS

FIGURE 3.5-7



MODES	PARAMETERS					
	TCM	TCM	TCM	TCM	TCM	TCM
NORMAL	TCM	TCM	TCM	TCM	TCM	TCM
OPERATION	TCM	TCM	TCM	TCM	TCM	TCM



REFERENCE

DRAWING OR DOCUMENT NO. M-647

TITLE PAID RADWASTE DRUMMING STATION

THE DATA SHOWN ON THIS FLOW DIAGRAM ARE FOR DESIGN PURPOSES ONLY, AND WHILE USEFUL AS GUIDES IN OPERATION, DO NOT REPRESENT EXACT OR GUARANTEED OPERATING CONDITIONS.

NOTES

1. THE SYSTEM FLOW RATES ARE THE MAXIMUM EXPECTED VALUES FOR INTERMITTENT TIME PERIODS DURING NORMAL OPERATIONS.

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1

SOLID RADIOACTIVE WASTE SYSTEM

FIGURE 35-8

3.6 CHEMICAL AND BIOCIDES WASTE

3.6.1 GENERAL

The total water supply for equipment, personnel, and makeup requirements for the unit will be taken from Lake Erie. All effluents will be released to Lake Erie through a common discharge; only storm drainage and floor drains from non-radioactive areas will be discharged to the Toussaint River.

As the lake water passes through the unit, the addition of neutralizing chemicals will only slightly alter its mineral composition.

The pH will be reduced slightly, bringing it closer to neutral. The total weight of solids discharged will be slightly less than the weight of those removed from the lake.

Sampling and analysis of lake water at the station site has been conducted over a 34-month period. The data obtained were used for design of the unit water-treating equipment and for determination of effluent discharge quality. These water quality data are presented and discussed in Section 3.3.

3.6.2 SYSTEM DESCRIPTION

The unit discharges to the central collection box which receives all water discharges except storm water drainage, so there is only one discharge into Lake Erie. The pertinent water circuits are shown on Figure 3.6-1. In addition to the closed condenser cooling water system, which carries heat from the condensers to the cooling tower for discharge to the atmosphere, there are four pumping systems using lake water.

(1) Service water is pumped through the component cooling water heat exchangers, the turbine building cooling water heat exchangers, and containment air coolers from which heat must be removed.

(2) The cooling tower makeup system (two pumps) supplies makeup water to the

condenser cooling water system when the service water discharge is used for ice control in the intake canal forebay.

(3) The dilution water system (one pump and one cooling tower makeup pump, if required) supplies dilution water to the collection box when the temperature of the cooling tower blowdown approaches 20°F above lake temperature.

(4) Lake water supplied by the water treatment feed pumps is chlorinated, clarified, softened, filtered, and used for several purposes. It provides potable and sanitary system water and supplies the makeup water demineralizer which provides makeup to the primary coolant system and main steam cycle.

A settling basin is provided to contain the solids blown down from the clarifier and backwashed from the filters used in the domestic and makeup water system, and the solids from the secondary system condensate demineralizer backwash. The overflow from the settling basin is pumped into the collection box. There is a valued emergency overflow, normally closed to the drainage ditch which leads to the Toussaint River. | 1

Process wastes discharged into the radwaste monitor tanks are analyzed for radioactivity, then reused or discharged to the collection box.

3.6.3 CHEMICALS USED

The chemicals listed below will be used at the unit but not necessarily discharged from the unit. The resultant average chemical composition discharged from the unit is shown in Table 3.6-1.

(1) Sulfuric Acid

During operation, sulfuric acid will be used in the cooling tower and the water treatment system. In the cooling tower, acid is added to reduce the scaling tendencies of the water. The acid feed will reduce the alkalinity

TABLE 3.6-1

AVERAGE CHEMICAL DISCHARGE COMPOSITIONS UNIT 1

	Cooling Tower Blowdown	Dilution Flow	Neutralized Regenerant Wastes	Settling Basin Effluent	Sewage Treatment Plant	Discharge To Lake Erie
Flow (gpm)	8,125*	0	7	24	2	8,159
pH	8.0		7.0	9.6	9.6	8.0
Calcium (Ca)	84		481	15	15	84
Magnesium (Mg)	18		114	9	9	18
Sodium (Na)	30		1,784	15	15	31
Chloride (Cl)	44		300	22	22	44
Nitrate (NO ₃)	12		42	6	6	12
Sulfate (SO ₄)	174		4,890	41	41	178
Phosphate (PO ₄)	0.6		3	0.6	0.6	0.6
Silica (SiO ₂)	2		5	1	1	2.0
Total Alkalinity as CaCO ₃	100		89	29	29	100
Suspended Solids	45		5	5	15	45
Dissolved Solids	465		7,708	139	139	470
BOD	4		2	2	14	4
Dissolved Oxygen	7		9	9	0	7

All values in mg/l except pH

This table represents the average annual concentrations and flows. The total flow to Lake Erie includes 1 gpm of processed effluent from the nuclear area. This waste stream contains essentially zero dissolved solids and has a pH of 7.0.

*Average cooling tower blowdown was computed using blowdown flows for February thru December. The flow for January was not used because of abnormally cold weather, during the period which onsite meteorological data was collected, resulting in an unrepresentative blowdown flow.

of the closed condenser cooling water system to maintain an operating pH of approximately 8.0.

In the water-treating system, sulfuric acid is used in two places: for stabilization after the clarifiers, and in regeneration of the makeup demineralizers.

Following regeneration of the makeup demineralizer, the waste effluent containing sulfuric acid will be placed in the neutralization tank. In this tank the acid will be neutralized with caustic soda as required.

(2) Ammonium Hydroxide

During operation, ammonium hydroxide is used for feedwater treatment in the secondary system to raise pH and thus suppress iron corrosion. The concentration will be such to maintain a pH of 9.3 to 9.5. It is not expected that this system will ever be drained since it undergoes constant purification during operation.

Backwashing of the condensate demineralizer will release some water containing ammonium hydroxide to the settling basin (2,800 gal.). Due to dilution in the settling basin and collection box, there will be very little ammonium hydroxide at the point of discharge.

Ammonium hydroxide will also be used in the component cooling water system and auxiliary boiler as a pH control additive. The concentration control range will be similar to feedwater. There should be no discharge of water from these systems.

(3) Boric Acid

Boric acid will be used as the chemical shim in the reactor coolant system. No discharge of boric acid should take place because it is reclaimed through the boric acid evaporators and deborating demineralizers in the radwaste systems.

(4) Chlorine

Chlorine is added to the following systems: (1) the service water system continuously at a level to maintain 0.5 mg/l free residual chlorine; except when the system's discharges goes directly to the collection box. Under this condition chlorine will be added a maximum of two hours a day; (2) the recirculating cooling water system directly upstream of the circulating water pumps in four 30-min periods per day (to maintain 0.5 mg/l free residual chlorine at the condenser outlet); (3) the domestic and makeup water system prior to the clarifier; and (4) the effluent from the sewage treatment system, which is chlorinated continuously to maintain 0.5 mg/l free residual chlorine.

(5) Hydrazine

During operation, hydrazine is used as an oxygen scavenger in the secondary system. The concentration will be maintained at 0.02 mg/l. The only discharge of this water will occur while backwashing the condensate demineralizer. This level of hydrazine will be consumed on exposure to air.

Hydrazine is also used in the component cooling water system and auxiliary boiler at a level of 10-25 mg/l. During operation there is no discharge from these systems.

Hydrazine is also used in the building closed heating system at a level of 0.5 to 1.0 mg/l. No discharge should occur from this system.

Hydrazine will also be used in chemical wet layup of systems during maintenance outages. In wet layup, 200 mg/l hydrazine will be used as an oxygen scavenger to prevent corrosion. It is not anticipated that these systems will be drained but that this same water will be used on startup.

(6) Sodium Hydroxide

Sodium hydroxide is used for regeneration of the makeup demineralizers. Spent caustic is placed in the neutralizing tank where it reacts with spent acids. Additional caustic is added to the neutralizing tank as required.

Sodium hydroxide will be available for pH control of the containment spray water. This injection would only occur in the unlikely event of a loss-of-coolant accident. It is not anticipated that sodium hydroxide would reach the environment by this mechanism.

Sodium hydroxide can also be used for regeneration of the deborating demineralizers in the Clean Liquid Radioactive Waste System. Spent regenerant will be disposed of through the Miscellaneous Liquid Radioactive Waste System.

(7) Lithium Hydroxide

Lithium hydroxide will be used for pH control in the reactor coolant system. No discharge of lithium hydroxide will occur from this system due to the treatment given all primary system wastes.

(8) Calcium Hydroxide

Calcium hydroxide is used for softening of water. It is planned to carry a 2 to 5 mg/l excess of hydroxide in the water treatment system. This excess, however, will be partially neutralized by the sulfuric acid feed following the clarifier prior to use in the domestic water system. Some hydroxide will be discharged to the settling basin via clarifier blowdown. The effluent from the settling basin is pumped to the collection box where it is mixed with other waste streams prior to discharge to Lake Erie. Due to the small flow rate of the settling basin compared to the other waste stream, the slight excess of hydroxide will have no effect on Lake Erie.

(9) Sodium Aluminate

Sodium aluminate will be used in clarification of water in the water treatment system. This aluminum salt will result in precipitation of aluminum hydroxide and essentially no free sodium aluminate will be present in clarifier blowdown to the settling basin.

(10) Organic-Corrosion Inhibitor

An organic-based corrosion inhibitor will be used in the turbine building closed cooling water system. No routine discharges will occur. During maintenance outages, the entire system or parts of it could be drained for maintenance work. If the system is drained, for maintenance, tankage will be provided and the inhibitor returned to the system upon completion.

1

(11) Morpholine

Morpholine is used for pH control in the buildings' closed heating system at a level of 5 to 10 mg/l. No discharge will occur from this system.

1

3.6.4 CHEMICALS DISCHARGED

Unit systems that will be piped to the collection box and ultimately to Lake Erie are as follows:

1. Blowdown from closed condenser cooling water system
2. Service water discharge (during unit shutdown)
3. Neutralized regenerant waste from makeup demineralizers
4. Pumped effluent from the settling basin
5. Sewage treatment plant effluent
6. Processed liquid radwaste effluents
7. Dilution water from Lake Erie.

1

The composition of chemical waste based on maximum flows from all systems occurring at the same time is given in Table 3.6-2. The average annual composition for the combined effluents is shown in Table 3.6-1.

TABLE 3.6-2

MAXIMUM CHEMICAL DISCHARGE COMPOSITION UNIT 1

	Cooling Tower Blowdown	Dilution Flow	Neutralized Regenerant Wastes	Settling Basin Effluent	Sewage Treatment Plant	Discharge To Lake Erie
Flow (gpm)	8,350	10,000	200	600	40	19,260
pH	8.0	8.0	7.0	9.6	9.6	8.0
Calcium (Ca)	108	54	324	15	15	79
Magnesium (Mg)	18	9	61	9	9	13
Sodium (Na)	24	12	2,205	12	12	40
Chloride (Cl)	80	40	273	40	40	60
Nitrate (NO ₃)	14	7	25	7	7	10
Sulfate (SO ₄)	244	58	5,100	58	58	191
Phosphate (PO ₄)	2	1	6	1	1	1
Silica (SiO ₂)	2	1	31	1	1	2
Total Alkalinity as CaCO ₃	80	107	52	29	29	92
Suspended Solids	50	37	5	5	15	41
Dissolved Solids	572	289	8,077	172	172	488
BOD	2	1	1	1	14	1
Dissolved Oxygen	7	10	9	9	0	9

All values in mg/l except pH

This table represents the maximum concentrations corresponding to the worst ambient lake water chemical conditions at times of high dilution flow. The total flow to Lake Erie includes 70 gpm (maximum) of processed effluents from nuclear areas. This waste stream contains essentially zero dissolved solids and has a pH of 7.0.

Although calculations assume all these maximums occurring at the same time, it is highly unlikely to happen. If it did occur, it would be for only a short period of time.

3.6.4.1 Closed Condenser Cooling Water System

The largest source of discharge to the lake containing dissolved solids in higher concentrations than in lake water, is the cooling tower blowdown. The dissolved solids content of this water is slightly less than twice that contained in lake water and is almost solely due to the evaporation of water from the tower which leaves behind the dissolved solids. Based upon lake water containing 234 mg/l dissolved solids used as tower makeup, the dissolved solids content in the blowdown would be approximately 465 mg/l. To maintain this level of concentration, the amount of blowdown from the tower will be equal to the evaporative losses from the tower. These losses from the unit will vary from 6,000 gpm to 9,400 gpm. The blowdown piping will be designed to discharge a maximum of 11,000 gpm to the collection box. Due to the high alkalinity of the Lake Erie makeup water, some acid feed for neutralization is necessary to control scale formation on surfaces of the closed condenser cooling water system, and to maintain the pH of the discharged water within proposed water quality standards for Lake Erie. The acid feed will amount to 47 mg/l based on a maximum makeup flow of 18,816 gpm and will result in the discharge of water at a pH of approximately 8.0.

The closed condenser cooling water system will be periodically chlorinated to prevent slime and algae buildup in the condenser. Chlorination will be approximately four times per day at 30 min. each time. Free residual chlorine will be 0.5 mg/l at the outlet of the condenser. Chlorine will be added to two of the four circulating water pumps; blowdown will be taken from the pipe supplied by the other two pumps. Thus the water must pass through the cooling tower where some of this residual is lost so that minimal residual chlorine will be present in the blowdown water and will be principally chloramines.

The aeration effect on the closed condenser cooling water will result in the blowdown water being essentially saturated with dissolved oxygen at a value corresponding to the saturation temperature of the tower outlet water. This value is a low of 7 mg/l during hot weather periods and is correspondingly higher during the colder months. No chemical will be added to the water that would substantially reduce its oxygen content, and at the normal blowdown water temperature, the oxygen content will be essentially the same as that existing in ambient Lake Erie water at the same temperature.

No inhibitor will be used in the closed condenser cooling water system to help prevent corrosion and scaling in unit equipment. Scaling and corrosion will be controlled by proper maintenance of the Langeller stability index of the circulating water.

3.6.4.2 Service water from Turbine Room, Cooling Water Heat Exchangers, Component Cooling Water Heat Exchangers, and Containment Air Coolers

The chemical content of this service water will be unchanged as it passes through the heat exchangers except for small amounts of chlorine that will be added at the service water pumps to reduce slime and algae buildup on the heat exchange surfaces. This water is normally used for cooling tower makeup.

3.6.4.3 Neutralized Regenerant Waste from Makeup Demineralizers

Acid and caustic will be used to regenerate the makeup demineralizers. In order to avoid discharging these chemical wastes directly to the lake, they will be diverted to a neutralizing tank where excess acid or caustic will be neutralized. Following neutralization, the regenerant wastes are pumped to the collection box where they mix with other unit effluents prior

to discharge to the lake.

Due to the nature of the wastes and the fact that they have been neutralized, they contain high dissolved solids, approximately 7,700 mg/l. The amount of these wastes is quite low in relation to some of the other unit effluents and thus have a small effect on the resultant solids discharged to the lake.

3.6.4.4 Pumped Effluent from the Settling Basin

Effluent from the settling basin will come from three sources as follows:

1. Clarifier blowdown and filter backwash effluent
2. Condensate demineralizer backwash effluent
3. Makeup demineralizer backwash effluent.

These three system effluents are the only ones that contain suspended solids. The effluents from these systems are pumped through the two-cell settling basin. The design of this settling basin is expected to result in a suspended solids discharge equal to, if not better than, the lake water itself. The solids removed from the settling basin will be eventually disposed of in a landfill.

3.6.4.5 Effluent from Sewage Treatment Plant

Effluent from the sewage treatment plant will be piped to the collection box for mixing with other effluents prior to discharge to Lake Erie. The sewage treatment plant will process all effluents from the unit's sanitary water system. It will provide primary and secondary treatment which will meet all standards* of the Ohio Environmental Protection Agency.

Effluent water will be chlorinated so that the fecal coliform content will meet the criterion for waters used for recreational purposes.

3.6.4.6 Secondary System Blowdown

The secondary system contains ammonium hydroxide, hydrazine (0.02 mg/l), and dissolved solids at a concentration less than 0.02 mg/l. There will

be no blowdown from this system under normal operating conditions. If necessary, this system can be drained to the collection box.

3.6.4.7 Cooling Tower Drift

At the maximum anticipated drift, 0.01%, the cooling tower is expected to emit water droplets containing 270 lbs. of dissolved solids per day. As the water evaporates, its solids will deposit on the land. The estimated chemical composition of the drift and the solids deposited is shown in Table 3.6-3. For all constituents except sulfate and bicarbonate, concentrations were taken to be twice those in lake water. The sulfate level exceeds twice the lake concentration by an amount corresponding to the sulfuric acid added to reduce the alkalinity. This addition of sulfuric acid will reduce bicarbonate alkalinity to 100 mg/l in the blowdown.

3.6.4.8 Auxiliary Boiler Blowdown

A 175,000 pound per hour, 235 psig oil-fired auxiliary boiler is used during unit startup or shutdown. This auxiliary boiler does not operate during the normal operation of the unit. Demineralized water and deaerated condensate from the main condensate system will be used as boiler feedwater. Table 3.6-4 shows a typical analysis of the feedwater and blowdown for this boiler.

It is estimated that this boiler will be used approximately 735 hours per year. During this time, the boiler blowdown would be very infrequent (once a year) due to the "zero" solids treatment program. This blowdown containing 500 mg/l dissolved solids will be discharged into the auxiliary boiler blowdown tank. The condensate from this tank will be discharged to the storm sewer system.

DB-1

TABLE 3.6-3

DISSOLVED SOLIDS DISCHARGED IN COOLING TOWER

	Concentration in Drift (mg/l)	Percentage of Total	Deposits (lb/day)
Total Dissolved Solids	465	100.0	270.0
Calcium	84	18.1	48.9
Magnesium	18	3.9	10.4
Sodium	30	6.5	17.4
Chloride	44	9.5	25.4
Nitrate	12	2.6	6.9
Sulfate	174	37.4	101.2
Phosphate	1	0.2	0.6
Silica	2	0.4	1.2
Bicarbonate	100	21.4	58.0

TABLE 3.6-4

TYPICAL AUXILIARY BOILER FEEDWATER AND BLOWDOWN ANALYSES

	Auxiliary Boiler Feedwater		Boiler Blowdown Water
Fe, max	0.1	mg/l	100 mg/l
Cu, max	0.05	mg/l	50 mg/l
SiO ₂ , max	0.02	mg/l	20 mg/l
Dissolved O ₂	0.007	mg/l	0.007 mg/l
Total Dissolved Solids and Suspended Solids, max	10	mg/l	500 mg/l
pH at 77°F	9.3-9.5		9.3-9.5

3.6.4.9 Trash from Intake Screens

A screen wash catch basin is provided to collect the traveling screen's backwash water and trash. The makeup and service water system strainer backwash will normally be discharged to the forebay with provisions to discharge to the screen wash water basin only in emergencies. The screen wash catch basin drains to the marshes via an 18-in. diameter drain tile. The trash collected will be disposed of on a landfill as required.

3.6.5 BIOCIDES

Chlorination of the closed condenser cooling water system is done periodically to prevent algae growth within the system. Chlorine is injected into those circulating pump suction whose discharges are not providing blowdown water. In this way, blowdown water will contain minimal residual chlorine. No other biocide will be used.

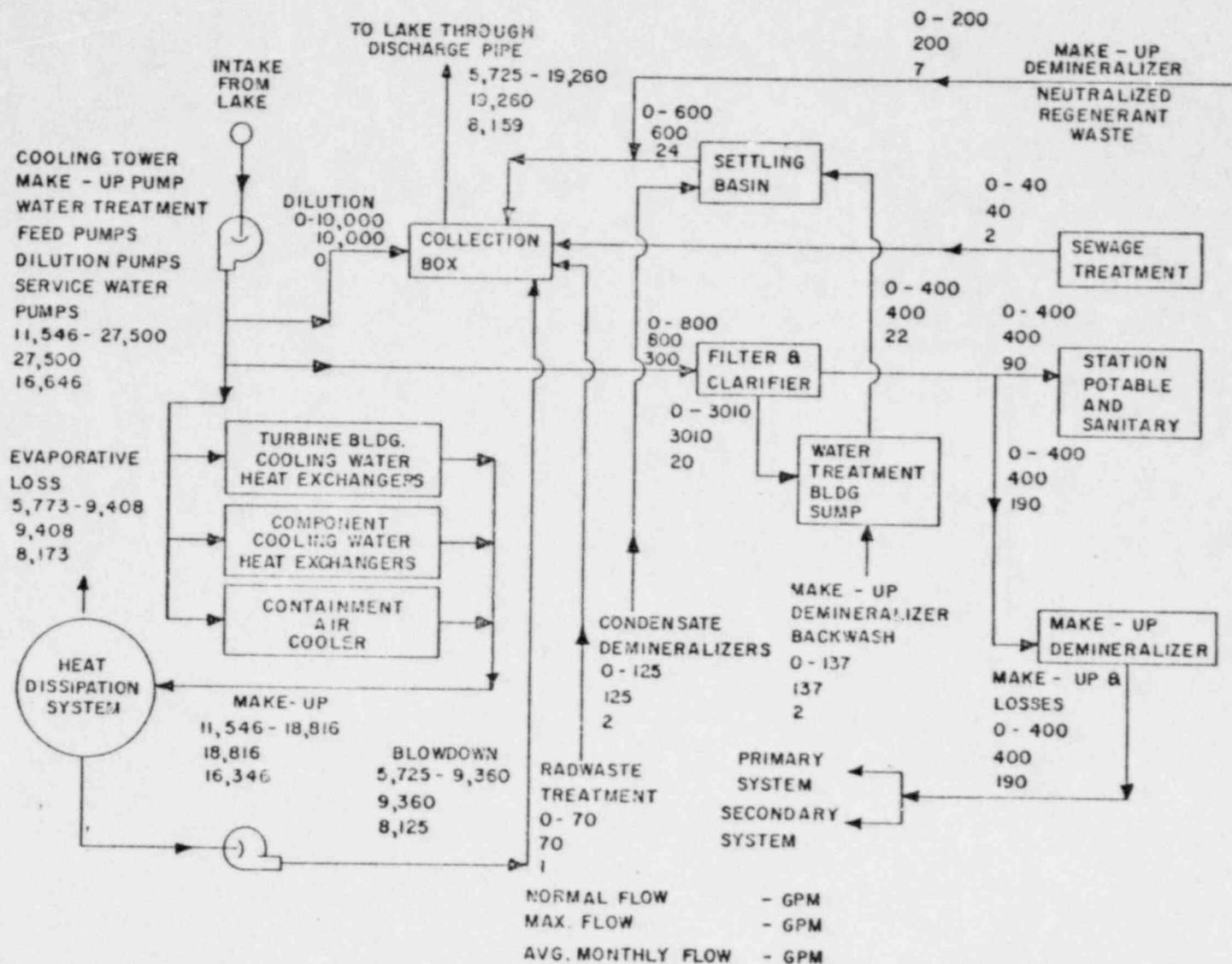
Chlorine to defoul the condenser and the cooling tower will be added to maintain 0.5 mg/l free residual chlorine at the end of the chlorination periods at the condenser outlet. The chlorine concentration, after chlorination is stopped, will decline by stripping chloramines from the water in passage through the cooling tower, reduction to chloride by reaction with chlorine-demand constituents in the makeup water, and reduction to chloride by reaction with water including the catalytic effect of light. It is expected that the total residual chlorine content of the blowdown water from the cooling tower and service water discharge will be reduced to below 0.5 mg/l by these factors.

The effluent from the sewage treatment plant will be chlorinated to maintain a residual of 0.5 mg/l chlorine for the control of fecal coliform. The high dilution provided in the collection box (2 gpm mixed with 8,159 gpm)

will reduce the chlorine concentration below detectable limits with a resultant zero effect on the receiving lake waters.

3.6.6 CORROSION PRODUCTS

In order to minimize any corrosive effects from the closed condenser cooling water system stainless steel tubes will be used in the construction of the condenser. The resulting water returned to Lake Erie through cooling tower blowdown should be essentially lake water at twice the solids level with an undetectable amount of corrosion products from the condenser.



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

UNIT WATER USE AND DISCHARGE DIAGRAM

FIGURE 3.6-1

3.7 SANITARY AND OTHER SYSTEMS

3.7.1 Sanitary Waste System

The sewage treatment plant for Unit No. 1 conforms to the Ohio Department of Health Bulletin 2451.10, 1964 (Revised) entitled "Water Supply, Sewage and Sewage Treatment for Public Buildings in Ohio" and the criteria of the Great Lakes-Upper Mississippi River Board of State Sanitary Engineers.

The sewage treatment plant is designed to serve a total of 360 employees and visitors. Design effluent flow rate is 40 gpm with intermittent operation (average effluent flow of 2 gpm). The treatment plant capacity is based on an average daily flow of 9,000 gpd. The effluent from the plant will be chlorinated continuously to maintain 0.5 mg/l residual free chlorine to assure that the fecal coliform content meets the criterion for water used for recreational purposes. Effluent BOD from the plant will meet the requirements for secondary sewage treatment. | 1

The sewage treatment plant is preceded by a 4,000 gallon surge tank. All sanitary wastes from the unit will go to the surge tank and be discharged to the sewage plant at a uniform rate. This will prevent the plant from receiving shock hydraulic loadings.

The sewage treatment plant effluent (40 gpm) is discharged to the collection box where it is diluted with the cooling tower blowdown (8,125 gpm average). As a result of this dilution the free chlorine content will be reduced to levels that have insignificant environmental impact.

3.7.2 NONRADIOACTIVE GASEOUS EFFLUENTS

The only significant emissions of gaseous effluents to the air will originate from the auxiliary boiler used during unit shutdown (refueling and maintenance) and startup (735 hrs/yr) and the emergency diesel generators, which are tested for one hour each month. The fuel burned in both the boiler

and diesel generators is No. 2 diesel fuel oil with a sulfur content of 0.3% by weight. Tables 3.7-1 and 3.7-2 present the emissions calculated for the auxiliary boiler and the emergency diesel generators. The emissions from the auxiliary boiler are well below applicable emission standards. Only one emission standard, that for SO₂, applies to the diesel generators, and that standard is easily met by these units.

During purging of the turbine-generator, anticipated once a year, hydrogen and carbon dioxide will be vented to the atmosphere through a separate vent pipe from the turbine building. No environmental or ecological impact will be associated with this release.

DB-1

TABLE 3.7-2

GASEOUS EMISSIONS FROM EMERGENCY DIESEL GENERATORS

Fuel - No. 2 Diesel Oil

Amount - 42,300 lb/yr,
or 5,800 gal/yr

Heat Content - 140,890 BTU/gal

Sulfur Content - 0.3%

Heat Input - 68×10^6 BTU/hr

Operating Hours - 12 hr/yr

<u>Pollutant</u>	<u>Emission Factor</u> lb/BHP/hr	<u>Emission</u>		<u>Std.</u> lb/hr	<u>% of Std.</u>
		lb/hr	lb/yr		
SO ₂	0.00495	20.2	242	68 (Ohio)	29.7
NO _x	0.0242	98.6	1,185	NA*	--
Hydrocarbons	0.00028	1.15	13.8	NA	--
CO	0.0085	34.7	417	NA	--

*NA - No applicable standard

3.8 RADIOACTIVE MATERIALS INVENTORY

The operation of Davis-Besse Unit No. 1 will entail the shipment of various radioactive materials to and from the site. New fuel will be shipped to the site initially, and annually thereafter. Solid radwaste will be shipped from the site in the form of spent resins, evaporator bottoms, spent filter cartridges, paper, clothing, etc. Spent fuel will be shipped annually to an as yet unidentified fuel processing center. The quantities of material shipped and the number of shipments per year are discussed below.

3.8.1 NEW FUEL

The initial fuel loading for each reactor will require 177 fuel assemblies. Each fuel assembly weighs 1,525 lbs and contains about 475 kg of uranium. Each assembly consists of 208 Zircaloy-4 clad fuel rods. The fuel for the first core will consist of UO_2 pellets, 0.368 in. in diameter and 0.700 in. long; the enrichment will vary from 1.98 wt% U-235 to 2.96 wt% U-235 for different core regions.

The initial fuel will be provided by the Babcock and Wilcox facility near Lynchburg, Virginia. Commitments for reload fuel have not been finalized. The new fuel will be shipped in reuseable fuel assembly containers, two elements to a container, with each transport vehicle carrying a maximum of six 2-element containers. Containers meet the type A packaging requirements of the Department of Transportation Regulations (49 CFR Part 173). The initial fuel loading will require 15 truck shipments and 5 shipments annually thereafter for each unit for refueling.

3.8.2 SPENT FUEL

The unit will generate about 52 irradiated fuel assemblies per year with a maximum average burnup of 31,300 MWd/MTH (megawatt days per metric ton of heavy metal). The design maximum assembly burnup is 43,000 MWd/MTH. Upon

completion of an operating cycle, selected fuel assemblies will be removed from the reactor vessel and then placed in the spent fuel pool where they will be allowed to decay for approximately four to six months. The first shipment is expected to be made in 1978. No specific licensed cask has been selected for shipping the irradiated fuel assemblies from Davis-Besse Unit No. 1; consequently, the number of shipments per year cannot be specified at this time. A cask designed for rail shipment of seven PWR assemblies is under consideration; use of this cask would result in 8-9 shipments from each unit per year.

The reprocessing facility has not been selected; however, Nuclear Fuel Services, Inc., in West Valley, New York, and Barnwell Nuclear Fuel Plant in Barnwell, South Carolina are possible processors. The route to be used and distance to these plants are not known.

3.8.3 SOLID RADIOACTIVE WASTES

Estimated quantities of solid radioactive material has been based upon an evaluation of the performance of the radioactive waste disposal system, anticipated reactor operations, and previous recent experience at other operating plants.

The quantity of high level wastes, such as spent resins and filters, and evaporator concentrates, is given in Table 3.8-1. These wastes will be de-watered as necessary and the residues solidified for disposal as solid wastes. Solidifying agents such as urea formaldehyde will be used as necessary for packaging. These wastes will be packaged in DOT Specification 17-H, 55-gal steel drums or 50 ft³ shielded casks with disposable liners.

Low activity wastes such as contaminated clothing, rags, paper, gloves, and shoe covers, will be compressed by means of a compactor and also packaged in 55-gal drums. The quantities anticipated are shown in Table 3.8-1. In

TABLE 3.8-1

SOLID RADIOACTIVE WASTES
(Annual Quantity)

Source	Waste Input to Solid Radwaste System	Solid Waste Volume Shipped Per Unit	Containers Per Year	Estimated* Activity Ci/Container
Spent Bead Resins	600 ft ^{3(a)}	600 ft ^{3(b)}	12 Shielded Casks with Disposable liners	830
Precoat Resins	600 ft ³	800 ft ^{3(c)}	16 Shielded Casks with Disposable Liners	2.1
Evap. Bottoms	1,115 ft ³	1,407 ft ^{3(d)}	87 Shielded Casks with Disposable Liners	2.9
Filter Cartridges	29 Cartridges	214 ft ³	29-55 gal Steel Drums	206
Miscellaneous Paper, Cloth, etc.	4,906 ft ³	992 ft ^{3(e)}	163 55-gal Steel Drums	0.002

* Note corrected for decay.

- (a) Includes 35 percent void space.
 (b) Includes 60 ft³ of evaporator bottoms and 150 ft³ of solidification agent.
 (c) Based on 3:1 volume₃ ratio of waste to solidification agent.
 (d) Not including 60 ft³ of evaporator bottoms used to solidify resin.
 (e) Based upon a volume compaction ratio of 5:1 in the baler.

compiling this table, estimates of nuclide inventories were based on 0.1% failed fuel during an equilibrium fuel cycle. No credit was taken for decay. The transportation contractor and the location of the waste burial facility have not yet been determined, although it is anticipated that either Morehead, Kentucky, or Barnwell, South Carolina will be used, with all shipments being made via truck.

5.0 ENVIRONMENTAL EFFECTS OF STATION OPERATION

5.1 EFFECTS OF OPERATION OF HEAT DISSIPATION SYSTEM

Primary heat rejection at the Davis-Besse Nuclear Power Station will be accomplished by closed-cycle counterflow natural draft cooling towers. The Unit No. 1 cooling tower will dissipate 6.2×10^9 Btu/hr at a water flow rate of 480,000 gpm. Table 5.1-1 presents the design characteristics of the heat dissipation system. Section 3.4 presents a description of the cooling tower and auxiliary equipment. Section 3.3 discusses the average and maximum flow rates anticipated in operation.

The environmental effects of the operation of the Davis-Besse Nuclear Power Station natural draft tower heat dissipation system are discussed in Sections 5.1.1 and 5.1.2. Section 5.1.1 considers physical and biological effects on Lake Erie; Section 5.1.2 considers atmospheric effects and secondary effects on terrestrial ecology. Structural impacts are discussed in Section 5.1.3.

5.1.1 AQUATIC EFFECTS

5.1.1.1 Direct Physical Effects on Lake Erie

Lake Erie will experience a rise in temperature and dissolved-solids concentration in the vicinity of the Davis-Besse discharge structure. The regulatory framework for considering these impacts, the analyses performed, and predicted results are presented in the following sections. In addition, a prediction of the overall temperature rise for Lake Erie's western basin is presented in Section 5.1.1.1.4.

5.1.1.1.1 Water Quality Standards

The present Ohio Environmental Protection Agency water quality regulations pertinent to cooling tower operation are very general. The temperature in Lake Erie may not exceed 93°F, and dissolved solids concentrations

TABLE 5.1-1

DESIGN CHARACTERISTICS OF NATURAL DRAFT COOLING TOWER

Design Conditions:

Total Unit Generating Capacity, MWe	906
Total Heat Rejection Rate, Btu/hr	6.2×10^9
Total Circulating Water Flow Rate, gpm	480,000
Total Air Flow Rate, ft ³ /hr	2.35×10^9
Wet Bulb Temperature, °F	72
Dry Bulb Temperature, °F	86.5
Relative Humidity, percent	50
Hot Water Temperature, °F	116
Cold Water Temperature, °F	90
Range, °F	26
Approach, °F	18
Air Effluent Temperature, °F	104
Air Effluent Relative Humidity, percent	100
Cycles of Concentration of Water	2
Makeup Water Rate, gpm	20,232
Blowdown Water Rate, gpm	10,068
Evaporation Rate, gpm	10,116
Drift Loss, percent of Circulating Water Rate	0.01
Drift Loss, gpm	48

Approximate Tower Dimensions:

Number of Towers	1
Base Diameter of Tower, ft	415
Height of Tower, ft	493
Exit Diameter of Tower, ft	273

averaged over a period of 1 month may not exceed 500 mg/l, outside of an unspecified mixing zone.

5.1.1.1.2 Method of Analysis

The blowdown from cooling tower operation will be discharged to Lake Erie through a slot jet designed to induce rapid mixing with the lake water. To ensure minimal environmental impact, a dilution pump is available to add lake water to the discharge so that the effluent water temperature will not exceed the ambient lake temperature by more than 20°F. An alarm connected to the thermal discharge monitoring system will be sounded when the blowdown temperature exceeds the lake temperature by more than 18°F.

The operation of the dilution pump provides a temperature reduction to 48% of the original discharge temperature excess at the maximum blowdown rate. An analysis of the dispersion in Lake Erie of liquid effluent from the Davis-Besse Nuclear Power Station involves the specification of important lake parameters and station operating conditions. Lake parameters affecting jet performance are lake water level, lake temperature, and current velocity. Since no detailed current data for the vicinity of Davis-Besse Nuclear Power Station are presently available for an adequate near-field analysis, the analysis was made conservatively assuming discharge into still water. It is expected that any diversion of the plume by natural currents will not significantly increase the physical impact of the discharge of liquid effluent to Lake Erie.

Table 5.1-2 presents monthly normal and maximum discharge temperatures and rates for the Davis-Besse Nuclear Power Station Unit No. 1, based on heat dissipation system design characteristics and meteorological factors. Table 5.1-2 also shows the monthly average lake elevations and monthly

TABLE 5.1-2

DAVIS-BESSE UNIT NO. 1 EFFLUENT CHARACTERISTICS AND LAKE PARAMETERS

Month	Average Blowdown Temp., °F	Blowdown Rate, gpm	Maximum Expected Blowdown Temp., °F	Maximum Relative Heat Discharge Rate, Btu/sec	Corresponding Maximum Temp. After Dilution,* °F	Maximum Expected Discharge Rate Including Dilution Flow,** gpm	Average Lake Elevation, ft (IGLD)	Monthly Lake Temp., °F		Coefficient of Surface Heat Exchange, Btu/(ft ² day °F)†
								Mean	Minimum	
January	55.4	5,725	67.8	2.7×10^4	46.3	15,725	569.91	35.8	34	84
February	60.7	6,530	67.6	3.0×10^4	47.9	16,530	569.99	36.4	35	82
March	62.0	6,715	65.6	2.8×10^4	47.9	16,715	570.32	39.1	36	83
April	71.9	8,350	86.5	4.9×10^4	63.3	18,350	570.91	48.6	44	86
May	78.4	8,920	85.0	3.6×10^4	69.7	18,920	571.22	59.3	56	86
June	81.4	9,200	91.6	3.3×10^4	78.3	19,200	571.35	67.8	66	78
July	83.9	9,360	91.4	2.5×10^4	91.4	9,360	571.28	74.5	72	84
August	85.0	9,310	88.8	2.3×10^4	88.8	9,310	571.06	73.3	71	102
September	79.2	8,840	86.8	2.6×10^4	75.8	18,840	570.68	69.0	66	122
October	73.3	8,240	83.0	3.4×10^4	66.6	18,240	570.26	57.5	53	126
November	67.8	7,300	74.0	3.2×10^4	55.5	17,300	569.50	46.4	42	116
December	61.4	6,610	70.1	3.1×10^4	49.6	16,610	569.79	37.6	36	97

*Capacity of dilution pump is 10,000 gpm.

**Excluding miscellaneous effluents with an average (total) flow rate of 34 gpm.

†Reference 1.

average and minimum lake temperatures. Finally, the monthly average coefficients of surface heat exchange, derived from meteorological variables and summarizing the temperature response of water bodies to heat input, are listed in Table 5.1-2.

April was selected for the analysis of thermal plume configuration and dissolved-solids distribution because it is during this month that the maximum amount of heat is discharged to Lake Erie from the Davis-Besse Nuclear Power Station.

The station operating characteristics and lake conditions used in the analysis are as follows:

Lake temperature	44°F
Lake elevation	570.91 ft (IGLD)
Total discharge rate	19,260 gpm (includes miscellaneous effluents at maximum rates)
Discharge temperature	63.3°F
Discharge velocity	6.4 fps

Since the centerline of the slot jet is at an elevation of 560.15 ft International Great Lakes Datum (IGLD), the discharge will behave like a submerged jet, possessing momentum which will induce mixing with ambient water. Since the effluent will usually be warmer than the receiving water, there is a tendency for the effluent to rise as it propagates outward from the slot jet. As the effluent moves from the discharge point, it begins to dissipate its forward thrust (due to momentum transfer) and buoyant thrust (due to mixing with colder ambient water). When the effluent dissipates most of its momentum, it ceases to behave like a jet and continues to disperse as a passive layer of water in which mixing is dominated by turbulence in the receiving water body. It is

possible, in the case of a shallow discharge, for the effluent plume to arrive at the surface with a significant horizontal velocity and travel as a weak surface jet until its momentum is comparable with the natural turbulence of the receiving water. The plume then continues to disperse as a passive layer.

A computer model based generally on the work of Koh and Fan⁽²⁾ was developed to calculate the thermal dispersion from a submerged slot jet. Plume centerline characteristics and width are computed by numerical integration of the slot jet equations. From these data and the Gaussian cross-sectional distribution parameter variations of temperature with water depth are calculated. The code was modified to eliminate dilution by ambient water entrained from beneath the jet to better simulate shallow-water discharges. When the computations indicated the effluent had reached the surface, equations developed by Pritchard⁽³⁾ were used to calculate the diffusion of the plume. A "top-hatted" temperature distribution based on the Koh and Fan submerged-discharge model was used to begin the Pritchard diffusion model. The modified submerged-discharge model for the April conditions yielded a plume width of 60.1 ft with an average excess temperature of 6.6°F as a starting point for Pritchard's surface-diffusion model.

The average dissolved-solids concentration in Lake Erie in the vicinity of the Davis-Besse Nuclear Power Station is 234 mg/l (see Table 3.3-1). The cooling tower will concentrate the effluent to approximately twice this value, or about 465 mg/l. The distribution of dissolved solids was computed for the April data using the thermal dispersion code, substituting dissolved-solids concentrations for temperature values, and setting the coefficient of surface heat exchange to zero.

5.1.1.1.3 Induced Temperature and Dissolved-Solids Distributions

Induced temperature increases for the April data are presented in Figure 5.1-1 in the form of a surface isotherm map. The area of the 3°F rise is less than 1 acre. Similar information is shown for the dissolved-solids concentration in Figure 5.1-2.

5.1.1.1.4 Far-Field Analysis

An analysis was performed to determine the overall temperature rise expected as a result of the 1×10^8 Btu/hr annual average thermal discharge into Lake Erie's western basin from the Davis-Besse Nuclear Power Station Unit No. 1. The analysis balances increased heat exchange at the water surface and flow through the basin with heat input. Using the surface area of 9,910 mi², a flow rate of 202,000 cfs, and a coefficient of surface heat exchange of 95 Btu/(ft² day °F),⁽¹⁾ an overall temperature rise of 0.001°F is predicted. This rise will be undetected among natural variations in water temperature.

5.1.1.2 Biological Effects

5.1.1.2.1 Phytoplankton

The potential effects of the Davis-Besse Nuclear Power Station Unit No. 1 heat dissipation system on plankton include:

- a. Mechanical damage resulting from shear and pressure during entrainment of phytoplankton in the heat dissipation system.
- b. Thermal effects caused by entrainment of phytoplankton in the heat dissipation system and discharge plume.
- c. Effects of biocides used to control fouling of the heat dissipation system (see Section 5.4 for a discussion of the effect of biocides).

The phytoplankton community of the western basin of Lake Erie and of the area near the Davis-Besse site is described in Appendix C of the Environmental Report and Appendix 2 of the Final Safety Analysis Report for Davis-Besse Nuclear Power Station on Unit No. 1. Although the extent of mechanical damage to phytoplankton due to entrainment is difficult to estimate, cell breakage and disruption will undoubtedly result from shear, rapid pressure changes, and possibly abrasion. Losses due to such mechanical effects have previously been estimated at 15% by Ayers et al.⁽⁴⁾ and at 27% by Knight.⁽⁵⁾ Phytoplankton entrained in the heat dissipation system will be subjected to a temperature increase of 26°F across the condenser. The thermal tolerance limits for many algae range from 91°F to 113°F, according to Patrick.⁽⁶⁾ During the warm summer months, the maximum cooling water temperatures will fall within this range of maximum tolerance. Periodic chlorination of the cooling water system will also contribute to phytoplankton mortality.

In using a conservative approach in estimating the potential effects of station operation, it is assumed that all phytoplankton entrained within the Davis-Besse Nuclear Power Station Unit No. 1 heat dissipation system will be killed by a combination of mechanical, thermal, and biocidal effects. The Davis-Besse Unit No. 1 requires a maximum of approximately 34,000 gpm of lake water in full operation. This volume, which includes water for dilution of the effluent as discussed above, is equivalent to approximately 0.03% of the flow through the western basin of Lake Erie. The maximum fraction of phytoplankton that may be lost through entrainment in the condenser cooling water system is therefore approximately 0.03%. Conversely, assuming the volume of the entire lake and a homogeneous distribution of phytoplankton throughout

the water column within the lake, it may be calculated that less than 0.00003% per day of the phytoplankton of the lake will be lost through cooling water entrainment. Both results indicate that the effect on phytoplankton will be negligible. A portion of the phytoplankton biomass lost by entrainment may be replaced by slight increases in the reproduction of plankton near the discharge plume. Such increases in production may result from the addition of nutrients released from the killed plankton.

The second principal area of potential impact is the effect of increased temperatures on organisms entrained in the thermal plume. Some attention has been given to the effects of heated discharges on the composition of the phytoplankton community. Lauer⁽⁷⁾ indicated that his data from a study of 10 power stations did not indicate a shift in species composition or abundance due to thermal discharges. The area of Lake Erie within the thermal discharge plume which would be 3°F above ambient temperature under conditions of maximum heat discharge would include only 0.9 acre. The maximum residence time for phytoplankton entrained within this area would be less than 1 hr. The average induced current within the plume is approximately 0.2 fps. Such a short exposure time would not be sufficient to cause a shift in species composition since: (a) 8 or more hours are required for most algal reproduction, and (b) the temperature rise is too small to significantly affect later reproduction or other physiological responses. It therefore appears that the effect of the thermal plume on the phytoplankton community either in the lake as a whole or in the area immediately affected will be so slight as to be unmeasurable.

5.1.1.2.2 Zooplankton

Data describing the zooplankton of western Lake Erie and the area of the Davis-Besse site are presented in Appendix C of the Environmental Report and Appendix 2B of the Final Safety Analysis Report for Davis-Besse Nuclear Power Station Unit No. 1. In using a conservative approach in evaluating the potential impact of station operation, it is assumed that all zooplankton entrained within the Davis-Besse heat dissipation system will be killed by a combination of mechanical, thermal, and biocidal effects.

Based on the assumptions made for phytoplankton, it is estimated that entrainment of zooplankton will affect approximately 0.03% of the total zooplankton in the western basin of the lake. Zooplankton killed by entrainment will be essentially lost as a food source for most fish and larvae but will not be lost to the ecosystem of the lake. They will provide nutrients for plants and food for benthic organisms, the major source of fish food.

The second principal effect of the station heat dissipation system on zooplankton is that associated with entrainment of organisms within the thermal discharge plume. Mortality is not expected because of the short exposure time to increased temperatures. The area of Lake Erie within the thermal discharge plume which will be 3°F above ambient under conditions of maximum heat discharge will be approximately 0.9 acre. The maximum residence time for a zooplankton within this area will be about 1 hr. Due to the short exposure time, the slight rise in temperature will not induce a significant shift in species composition or abundance. Thus it appears the effect of the thermal plume on the zooplankton community will be very slight and probably undetectable.

5.1.1.2.3 Benthos

The benthos of the Locust Point area is dominated by oligochaete worms and midge larvae. In general, the benthic organisms found at Locust Point are characteristic of eutrophic conditions, although a number of taxa are also associated with mesotrophic or oligotrophic conditions. Under normal conditions of lake elevation, induced currents will be less than 0.1 fps within 10 ft of the intake. The entrainment of benthic organisms due to currents induced by the Davis-Besse Nuclear Power Station intake will be minimal. Turbulence caused by induced intake currents will increase as distance to the intake structure decreases. It is anticipated that an area of 0.2 acre will be initially scoured clear of benthic organisms and remain devoid of benthos during the operating life of the station. Benthos inhabiting the area associated with the discharge facility will experience currents and elevated temperatures. The area of influence experiencing induced currents in excess of 1.0 and 0.5 fps will be 0.014 and 0.086 acre, respectively. Benthic organisms inhabiting the area of induced discharge currents of 0.5 fps or greater may be swept clear and transferred to a nearby, more quiescent area. At the discharge, the lake bottom is rip-rapped with stones for 200 ft, beyond the influence of a current of 0.5 fps, preventing scouring of sediments. An isotherm of 15°F will extend only 23 ft from the discharge at the bottom. Benthos distribution will not be temperature restricted beyond this point. The discharge should have no discernible effect on the benthic ecology of the western basin or the lake as a whole.

A possible third result of the heat dissipation system on the benthic community is the potential for increased benthic production. Entrained plankters that die during passage through the cooling system may increase the food available to bottom-dwelling organisms. The organic remains of killed plankters will tend to settle to the bottom of the lake at the outer edges of the discharge plume, becoming a potential food source for bottom feeders. This may increase the benthic productivity slightly in the areas where the dead plankters settle. However, the net increase in benthic production is expected to be undetectably small at the outer periphery of the discharge plume and the general area of the lake proper.

5.1.1.2.4 Fish

Potential damage to fish resulting from operation of the heat dissipation system can be divided into three distinct problem areas:

- a. Impingement of fish in the water intake system
- b. Entrainment of fish eggs and larvae in the condenser system
- c. Thermal shock to fish in the discharge area.

5.1.1.2.4.1 Entrapment and Impingement

The rate of entrapment of fish is related to the velocity of water at the intake crib and to the volume of water used. The intake velocity will be less than 0.2 fps at the intake crib bar screen with Unit No. 1 in operation. The entrapment rate declined greatly when the intake velocity declined to 0.5 fps at the Indian Point Nuclear Generating Plant.⁽⁸⁾ Reduced intake velocities do not entirely eliminate the potential for entrapment. By counting fish on intake screens, Benda⁽⁹⁾ estimated that the entrapment rate was about 35,000 lb/yr at the Palisades Nuclear Generating Plant, where the intake velocity was 0.5-0.6 fps. However, the Palisades Plant was operating with a once-through cooling design. Since the Davis-Besse

Unit No. 1 closed system design requires a much smaller volume of water, the rate of entrapment should be a small fraction of that observed at Palisades. Assuming entrapment is directly proportional to volume of water taken in, approximately 3,000 lb/yr of fish will either impinge upon the bar screens of the intake crib or will be entrapped.

Fish passing through the bar screens of the intake crib will be carried through the intake pipe to the intake canal. The velocity in the canal is less than 0.1 fps. From the canal the fish are assumed to eventually enter the intake structure through the bars of the trash rack and to be impinged on the 1/4-in.-mesh traveling screens.

5.1.1.2.4.2 Entrainment

Fish eggs, larvae, and young capable of passing through 1/4-in. openings of the traveling screens will either be retained by the 1/16-in. strainers following the cooling tower makeup and service water pumps or continue on through the condenser and be subjected to lethal thermal, chemical, and mechanical stresses. Retention time will be about 20 hr, and complete mortality of fish eggs and larvae is expected. The impact can be estimated if the number of organisms lost can be estimated and projected to the total potential number of adults they would produce. Fish eggs and larvae would be expected during the spring and summer months. A realistic density estimate can be made from data obtained at other Great Lakes sites. The average densities found over a period of 3 months were 0.25 egg or larva per cubic meter in Lake Ontario⁽¹⁰⁾ and 0.17 egg or larva per cubic meter in the Central Basin of Lake Erie. These were predominantly alewives and smelt. Data of Wells⁽¹¹⁾ indicate that densities of larvae per 1,000 m³ along the eastern shore of Lake Michigan during 1972 were 11.7 on May 3 to 9, 1.4 on May 27 and 28,

9.8 on June 20 to 23 and 4.2 on June 28 to July 4, 386.2 on July 9 to 12, 1,939.7 on July 20 to 23, and 626.4 on August 25 to 30, averaging 425.6 over the 4-month period. They were predominantly alewives, with a fair number of yellow perch present. Using the higher value of 425.6/1000 m³ as an average density, and a pumping rate of 34,000 gpm (163,000 m³/day), it is estimated that approximately 9.1×10^6 ichthyoplankters would be entrained over a 120-day period. The number of potential adults this represents depends on the survival rates, which are poorly known. Kissel⁽¹²⁾ reported 0.0014% survival from eggs to emigrating juveniles for an anadromous alewife population in Connecticut. A 0.001% survival rate from egg to adult was estimated for Connecticut River American shad by Leggett.⁽¹³⁾ Survival rates would be different for the various species. Selection of 0.001% as a general rate between the egg and adult stages suggests that 91 potential adults would be lost from entrainment. Since the survival rate from egg to larva is often small, a separate calculation will be made for the entrained larvae. A survival rate of 0.01% would be more realistic from the larval to the adult stage, indicating a loss of 910 potential adults when the ichthyoplankton is dominated by larvae. Forage species such as alewives, gizzard shad, or smelt are likely to be dominant. The relatively small volume of water entrained is expected to result in a minimal impact on the fish populations.

5.1.1.2.4.3 Thermal Shock

The effects of a thermal discharge on the fish community can be classified as chemical or thermal. The heat of a thermal plume can have lethal or sublethal effects on fishes. Possible sources of mortality include heat shock and cold shock in young or adult stages. Heat shock can kill adult

fish if they are exposed to a lethal temperature for a specified time. Some laboratory-determined upper and lower lethal levels are given in Table 5.1-3. These lethal levels are strongly influenced by acclimation temperatures, and therefore would be highest in the summer.

At the Davis-Besse Nuclear Power Station, lethal levels for warm-water species would not be reached, even during the summer. Cold-water species, such as salmon, could possibly be exposed to lethal levels, but this is unlikely because of the high velocity of the discharge and the natural avoidance reaction of all fish to lethal temperatures. Fish often avoid heated discharges during the summer. Assuming fish will avoid a ΔT of 15°F during the summer, the area lost to fish production will extend only 23 ft beyond the discharge structure.

Fish will be attracted to the perimeter of the plume during most months of the year, possibly enhancing the sport fishery. Cold shock can occur if fish are suddenly exposed to winter ambient temperatures as a result of station shutdown or upwellings. Table 5.1-3 indicates that the temperature drop required to cause cold shock is generally 30°F or more during the winter. A temperature drop of as little as 9°F can induce cold shock in salmon. However, acclimation to this differential is not likely because of the plume structure.

Eggs and larvae are generally more sensitive to thermal shock than are adult fish. Mixing of the discharge could expose some planktonic eggs and larvae to slightly elevated temperatures, which could increase their rate of development. Sinking plumes can also enhance the developmental rate of winter-incubating demersal eggs, according to Edsall and

TABLE 5.1-3

MINIMUM AND MAXIMUM TOLERANCE TEMPERATURES FOR CERTAIN LAKE ERIE FISHES*

	Acclimated to		Lower Limit			Upper Limit		
	°C	°F	°C	°F	Hours	°C	°F	Hours
Gizzard shad	25.0	77.0	11.0	51.8	24	34.0	93.2	48
	35.0	95.0	20.0	68.0	24	37.0	98.6	48
Alewife	--	--	--	--	--	26.7-32.2	80-90.0	--
White perch	4.4	40.0	--	--	--	27.8	82.0	--
Goldfish	2.0	35.6	--	--	--	28.0	82.4	14
	17.0	62.6	0.0	32.0	14	34.0	93.2	14
White sucker	25.0	77.0	5.0	41.0	24	29.0	84.2	133
Salmon-general	5.0	41.0	0.0	32.0	--	22.0	77.0	--
	20.0	68.0	5.0	41.0	--	24.0	75.0	--
Yellow Perch	5.0	41.0	--	--	--	21.0	69.8	96
Winter	25.0	77.0	4.0	39.2	24	30.0	86.0	96
Summer	25.0	77.0	9.0	48.2	24	32.0	89.6	96

*From Christianson and Tichenor⁽¹⁴⁾
 NOTE: Values are LD₅₀ tolerance limits.

Yocom.⁽¹⁵⁾ However, species that exhibit this type of reproductive cycle (for example, lake trout, cisco, whitefish) no longer inhabit the area of the site.

5.1.1.2.5 Waterfowl

Operation of the heat dissipation system is expected to maintain a small area of open water in Lake Erie throughout the winter. Any open water is likely to attract waterfowl wintering in the area. Because only a few acres are likely to remain open, the impact on waterfowl can be considered neither positive nor negative.

5.1.2 ATMOSPHERIC EFFECTS

The proposed cooling tower arrangement for the Davis-Besse Nuclear Power Station Unit No. 1 is shown in Figure 5.1-3.

5.1.2.1 Operating Experience

Field investigations were made of two coal-fired electric power stations operating with a hyperbolic natural draft cooling tower, the 1800-MWe Keystone Station operated by Pennsylvania Electric Company and the 2609-MWe Paradise steam plant of the Tennessee Valley Authority. A summary of field observations by station personnel and others^(16,17) is presented below.

No significant fog induction by these natural draft cooling towers has been observed. For the greater percentage of time, the visible portion of the tower plume rose to an altitude of less than 700 ft and traveled downwind about 600 ft before evaporating. Only a small percentage of the observations recorded plumes on the order of 1 mi in length. Plume lengths of 1 to 10 mi occurred rarely, and when they did, it was in association with a high relative humidity aloft. However, plume paths

traced up to 10 mi by aerial humidity measurements, even when the visible plume was short. ⁽¹⁶⁾

Mist has been detected both under and downwind of the visible plume. ⁽¹⁷⁾ Nevertheless, no drizzle and no significant increase in humidity at ground level were observed underneath the plume path. The change in monthly total precipitation during the period since the stations were placed in operation was within the range of natural perturbation for the area. However, there were a few occasions when there was a possibility of thunderstorm and precipitation enhancement, according to the local Weather Bureau climatological data. ⁽¹⁶⁾ Cloud initiation is rare, but the merging of the plume with stratus clouds is relatively common. ⁽¹⁶⁾ No adverse effects of natural draft cooling tower operations have been reported.

5.1.2.2 Model Studies

Model studies were undertaken to investigate the behavior of the cooling tower plume as it might affect the local environment at the Davis-Besse site. The NUS Corporation computer program LVPM-3 (Lagrangian Vapor Plume Model, Version 3) was employed to examine the detailed plume behavior, and the NUS Corporation computer programs FOG and ICE were used to investigate the frequency of fogging and icing and the deposition of dissolved solids due to the operation of the evaporation cooling systems. These codes have been filed with the USAEC. ⁽³⁰⁾ The performance curves used in the study are shown in Figure 5.1-4.

5.1.2.2.1 General Plume Behavior

Upper air soundings supplemented by surface data taken at the Toledo Express Airport, Toledo, Ohio, approximately 40 mi west of the Davis-Besse

site, were used as basic states of meteorological conditions in investigating the general (average) behavior of the cooling tower plume at the Davis-Besse site. The reference state at the Davis-Besse site is, in general, similar to that at Toledo⁽¹⁸⁾ except that, during late spring and summer, the Davis-Besse site will be influenced by a land-lake circulation. The soundings used were averaged by month and hour of observation over the period January 1948 through November 1951, and supplemented by the average surface data observed at 7 a.m. and 7 p.m. EST at the Toledo Express Airport. Behavior of the cooling tower plume predicted by the model represents the mean for a given month.

Average February and August soundings were used as representative winter and summer conditions, respectively. For an average winter morning (7 a.m. EST) a weak ground-based inversion with surface temperature at -6.5°C (20°F) was observed for the first 400 m (1,300 ft); an almost isothermal layer extended for the next 800 m (2,600 ft). Surface wind was from the southwest at 4.3 m/sec (9.6 mph). The average summer morning (7 a.m. EST) sounding indicated a ground-based inversion while in the afternoon the lower atmosphere was in a near-neutral condition. Average sounding data used to represent summer and winter conditions are listed in Tables 5.1-4 through 5.1-7.

Figures 5.1-5 and 5.1-6 show some of the plume parameters as a function of height for winter and summer mornings, respectively. The height of maximum penetration is determined by taking the height at which the vertical velocity of the plume becomes zero. The equilibrium level of buoyancy (neutral buoyancy height) is the level where the plume and ambient temperatures are identical.

TABLE 5.1-4

AVERAGE MONTHLY SOUNDING FOR COOLING TOWER PLUME ANALYSIS
7 A.M. EST, FEBRUARY

Pressure (mb)	Height (m, MSL)	Temperature (°C)	Relative Humidity (%)	Wind Speed (m/sec)	Wind Direction (Deg.)
994 (surf.)	204	-6.5	74.0	4.3	183
950	595	-4.6	66.6	9.1	245
900	1,024	-4.9	50.1	10.8	261
850	1,481	-5.2	28.5	11.5	268
800	1,954	-6.2	34.9	12.9	275
750	2,463	-8.1	37.1	15.2	277

TABLE 5.1-5

AVERAGE MONTHLY SOUNDING FOR COOLING TOWER PLUME ANALYSIS
7 P.M. EST, FEBRUARY

Pressure (mb)	Height (m, MSL)	Temperature (°C)	Relative Humidity (%)	Wind Speed (m/sec)	Wind Direction (Deg.)
995 (surf.)	204	-2.0	65.7	4.6	290
950	592	-2.8	68.7	10.4	245
900	1,018	-4.4	52.0	12.2	259
850	1,475	-4.7	35.0	12.3	268
800	1,958	-6.0	30.0	13.2	272
750	2,474	-6.9	31.8	14.2	277

TABLE 5.1-6

AVERAGE MONTHLY SOUNDING FOR COOLING TOWER PLUME ANALYSIS
7 A.M. EST, AUGUST

Pressure (mb)	Height (m, MSL)	Temperature (°C)	Relative Humidity (%)	Wind Speed (m/sec)	Wind Direction (Deg.)
992 (surf.)	204	17.1	89.0	2.6	260
950	596	17.8	72.7	5.0	272
900	1,058	16.0	67.0	6.0	278
850	1,544	13.6	61.0	6.8	290
800	2,055	11.1	51.0	7.2	290
750	2,597	8.4	44.4	7.6	293

TABLE 5.1-7

AVERAGE MONTHLY SOUNDING FOR COOLING TOWER PLUME ANALYSIS
7 P.M. EST, AUGUST

Pressure (mb)	Height (m, MSL)	Temperature (°C)	Relative Humidity (%)	Wind Speed (m/sec)	Wind Direction (Deg.)
991 (surf.)	204	23.2	68.7	3.1	247
950	583	20.7	61.8	6.5	280
900	1,047	17.6	63.7	6.0	285
850	1,535	14.2	63.7	5.9	276
800	2,045	11.5	54.5	6.2	274
750	2,589	8.7	48.3	6.6	279

On summer mornings the effluent plume will penetrate the ground-based inversion and reach a maximum height of 700 m (2,530 ft) with a neutral buoyancy height at about 550 m (1,800 ft), while the plume becomes unsaturated at about 300 m (1,000 ft) in height. Maximum penetration on winter mornings is predicted at 570 m (1,870 ft) with the neutral buoyancy height of 515 m (1,690 ft). No major difference was found in the predicted plume rise and other parameters between winter mornings and afternoons, and a slightly higher rise of the plume was predicted for the average summer afternoon condition (approximately 740 m), in comparison with the plume for the average summer morning. The plume becomes unsaturated at about 280 m (920 ft) in height during the summer afternoons.

A longer visible plume is expected to appear during the cold winter months because of the smaller saturation deficit. This is shown in model predictions including more cloud water being formed in the wintertime (Figure 5.1-5) than in the summertime (Figure 5.1-6). The average plume length is estimated to be about 0.7 km (0.4 mi) on winter mornings and somewhat shorter on winter afternoons. The predicted visible plume lengths on summer mornings is about 0.3 km (0.2 mi). The length of the visible plume during summer afternoons is very short since the ambient air is neutral (adiabatic lapse rate) and the relative humidity is low.

Ground-level moisture increases over ambient air in the vicinity of the cooling tower are generally expected to be negligible for all seasons, as indicated in Figures 5.1-7 and 5.1-8. The influences of the plume on natural precipitation would be negligible at the Davis-Besse site. Maximum precipitation from drift was predicted to occur at a distance of 2.8 km (1.7 mi) west-southwest of the cooling tower at a total rate of 0.0003 in. annually.

5.1.2.2.2 Effect of Land-Lake Circulation on Plume Configurations

Land-lake circulation is a common phenomenon along the shoreline of the Great Lakes. Although no intensive field observational program has been conducted around the area of the Davis-Besse site, several field studies have been made on the western shore of Lake Michigan.⁽¹⁹⁻²²⁾ During the warm season (April through August) the lake breeze occurs on more than 35% of the days in the Chicago area. The structure of a typical land-lake circulation has been described by Lyons and Olsson.⁽²³⁾ This typical structure, as observed on the western shore of Lake Michigan, is expected to occur similarly in the area of the Davis-Besse site, although Lake Erie is somewhat shallower than Lake Michigan.

Based on a sounding taken in the early afternoon of June 25, 1965, by Olsson, a special run by the computer program LVPM-3 was made to investigate the behavior of cooling tower plumes at the Davis-Besse site under the land-lake circulation condition. The model prediction shows that they penetrate through the onshore flow layer (about 1,000 m thick) and then reverse directions and move offshore, oscillating with an amplitude of 150 m along a neutral buoyancy height of 1,500 m. The visible plume dissipates during the course of onshore travel.

In most lake breeze situations, it is quite likely that the visible plume will disperse and evaporate immediately. On some higher relative humidity occasions visible plumes may extend over the lake and reach the subsidence region. In this situation plumes will probably evaporate during their descent.

5.1.2.2.3 Parametric Study of Cooling Tower Plume Rise

The ability of the natural draft cooling tower plume to rise to considerable heights is a significant factor in reducing the potential for adverse

ground level environmental effects. To examine the plume rise that may be expected with the Davis-Besse Unit No. 1 cooling tower, a parametric analysis of the winter and summer seasons was performed. Two major parameters that influence the plume rise are the ambient temperature lapse rate and the ambient wind speed. Thus, the following analyses were performed:

- a. Examination of plume rise as a function of the vertical temperature gradient (assuming it is constant with height) as presented in Figure 5.1-9
- b. Examination of plume rise as a function of wind speed at the tower top as presented in Figure 5.1-10.

In the second analysis the wind profile was assumed to vary according to the empirical power law,

$$u_z = u_H (Z/H)^p$$

where

u_z = the wind speed at height Z

u_H = the known wind speed at height H

$p = 0.21$ obtained from average morning sounding at the Toledo Express Airport.

The average monthly soundings of Tables 5.1-4 and 5.1-6 were used as representative winter and summer morning reference states, respectively.

The initial momentum and buoyancy of the effluent from the cooling tower are expected to result in substantial plume rise during all seasons of the year. During the winter months the plume height can be expected to exceed 400 m (1,300 ft) and during the summer months to exceed 350 m (1,150 ft), under average wind speed. The effect of high wind, on the order of 15 to 20 m/sec at tower height, would limit the plume rise to less than 100 m (330 ft) as shown in Figure 5.1-10. However, high wind speed will help

the plume to mix with ambient air, which will result in more rapid dissipation.

5.1.2.2.4 Probable Fogging and Icing

The analytical models used to predict fogging and icing effects are the NUS computer codes FOG and ICE. The analyses include calculations of plume rise and dispersion based on surface meteorological observations taken at 3-hr intervals at the Toledo Express Airport at Toledo, Ohio, for the 3-yr period from January 1, 1965, through December 31, 1967. Upper air climatological summaries were obtained from the Toledo Express Airport radiosonde station for the period January 1948 through November 1951. These data include statistics on the wind and relative humidity through the first 1,000 m above the ground. The reduced ground-level visibility analysis was based on a visibility criterion of 1,000 m or less. A 1,000-m visibility has been defined as visible fog.⁽²⁴⁾ A liquid water content of 0.0147 g/m^3 of dry air is used in the FOG model as the criterion for a visibility of 1,000 m.⁽²⁵⁾

5.1.2.2.4.1 Ground Transportation

State Route 2 is the closest highway that could be affected by the fogging and icing due to the operation of the natural draft tower. The highway borders the western boundary of the site. Visibility reductions over Route 2 due to the operation of the cooling tower are predicted to occur with a maximum frequency of 2 hr/yr. Such occurrences would exist more as an extension of periods of natural fog than as isolated events. These 2 hr/yr are an insignificant increase to the climatological mean of 90 hr/yr occurring naturally over the area. Figure 5.1-11 shows the predicted increase of occurrences of visibility of less than or equal to 1,000 m over and around

the site. The predicted ground-level icing due to the operation of the natural draft cooling tower is negligible for Route 2 and all other offsite roadways.

5.1.2.2.4.2 Air Transportation

The nearest commercial airport is the Toledo Express Airport, located approximately 40 mi west of the site. There are other smaller airports located as close as 12 mi to the site. There are no predicted occurrences of fog, visible plumes, or icing at any of these airports due to the operation of the natural draft cooling tower.

5.1.2.2.4.3 Water Transportation

The predicted occurrences of fog due to the operation of the cooling system are insignificant over all bodies of water near the Davis-Besse site. The maximum predicted frequency is approximately 1 hr/yr over Lake Erie near the community of Sand Beach (see Figure 5.1-11). There are no predictions of icing over any neighboring waterways.

5.1.2.2.4.4 Vegetation

Fog is predicted infrequently offsite from the operation of the natural draft cooling tower (see Figure 5.1-11). Increases in ground-level atmospheric moisture content not leading to fog formation would be expected more frequently, but the cooling tower is predicted to increase the relative humidity less than 0.5% at the site boundary. The normal annual average relative humidity for the area is 72%. Based on these predictions, it is concluded that the atmospheric moisture increases are not expected to produce any adverse effects upon the vegetation in the site region. No predicted ground-level icing is predicted to occur offsite due to operation of the cooling system.

5.1.2.2.5 Discharge of Solids

The NUS analytical model used to predict the ground deposition of the dissolved solids in the drift released by the cooling towers is the FOG computer code. The results are presented in Section 5.4.3.1.

5.1.3 STRUCTURAL EFFECTS

5.1.3.1 Aesthetics

The natural draft tower will be a dominant visual element in the vicinity of the Davis-Besse site. Based on an assumption of a flat terrain, the tower would theoretically be visible to a 6-ft observer out to a distance of approximately 30 mi. However, because of the existence of intervening hills, buildings, trees, etc., combined with the normal limited atmospheric visibility, the actual observing distance will be much less than the theoretical limit. The frequency of visible plumes from the tower is presented in Figure 5.1-12. Visible plumes are predicted to extend as far as Port Clinton, located 10 mi southeast of the site, with a frequency of 1 hr/yr.

5.1.3.2 Wildlife

A tall and relatively isolated structure presents a hazard to nocturnal migratory birds. Kills at radio towers have reached 1,500 in a single night,⁽²⁶⁾ and kills of a hundred or more are not unusual.⁽²⁶⁻²⁸⁾ Even though the structures at the Davis-Besse site are too low to produce the large kills that occur on some radio and television towers, kills can still be anticipated. A four-season study of bird kills on the Davis-Besse site indicated that 211 birds impacted on the cooling tower. A smaller number, 122, were killed on other site structures (meteorological tower and shield building). With the exception of one gull, no large birds were reported to have impacted on the cooling tower. During migration many small birds tend to move around the western end of Lake Erie rather than cross open

water. This results in a concentration of smaller birds along the lakeshore. (29) Therefore the number of bird strikes on the Davis-Besse cooling tower will probably be higher than would be normally predicted for a 493-ft structure.

REFERENCES

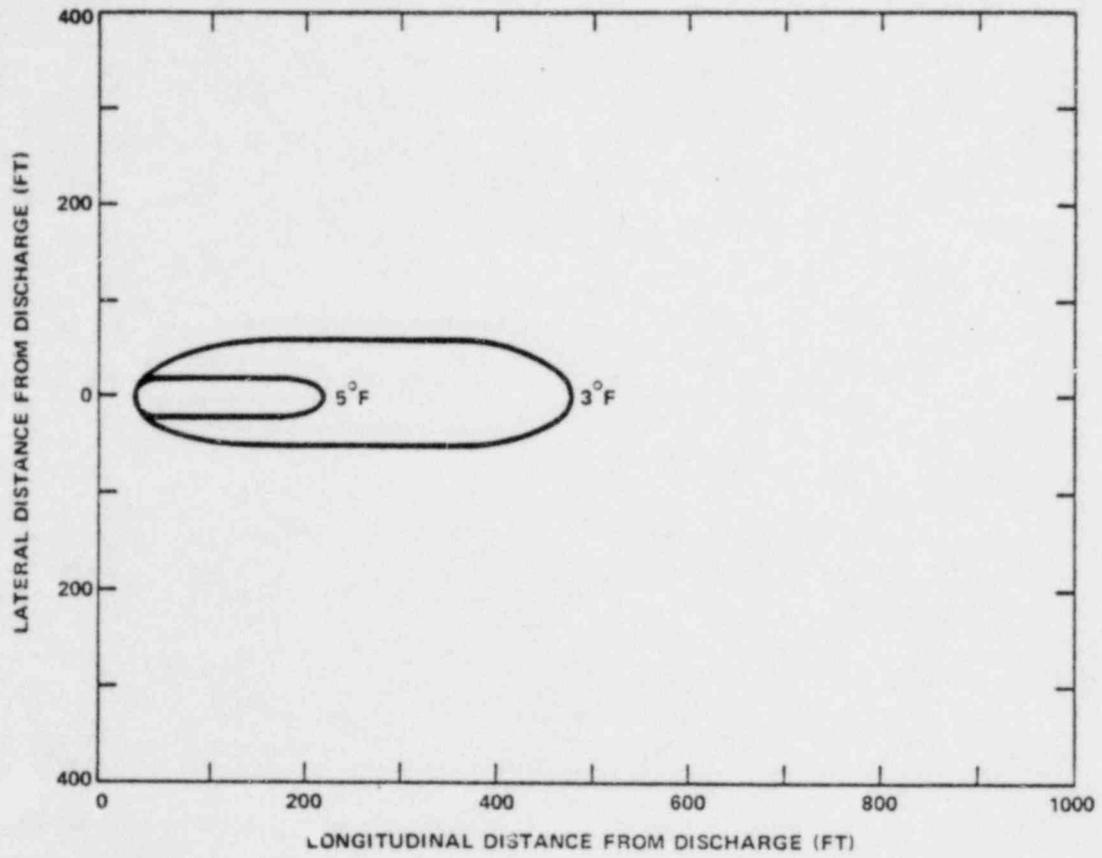
1. J.G. Asbury, Effects of Thermal Discharges on the Mass/Energy Balance of Lake Michigan, Center for Environmental Studies Argonne National Laboratory, Argonne, Illinois, 60439, July 1970.
2. R.C.Y. Koh and Loh-Nien Fan, Mathematical Models for the Prediction of Temperature Distributions Resulting from the Discharge of Heated Water into Large Bodies of Water, U.S. Government Printing Office, Washington, D.C., 20402, October 1970.
3. D.W. Pritchard, Design and Siting Criteria for Once-Through Cooling Systems, Chesapeake Bay Institute, The Johns Hopkins University, March 1971.
4. J.C. Ayers, R.F. Anderson, N.W. O'Hara, and C.C. Kidd, Benton Harbor Power Plant Limnological Studies, Part IV of Cook Plant Preoperational Studies, 1969, Special Report No. 44, Great Lakes Research Division, 1970.
5. R.L. Knight, Entrainment and Thermal Shock Effects on Phytoplankton Numbers and Diversity, ESE Publication No. 336, Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina, Chapel Hill, 1973.
6. R. Patrick, "Some Effects of Temperature on Freshwater Algae," In Biological Aspects of Thermal Pollution, P.A. Krenkel and F.A. Parker, eds., Vanderbilt University Press, 1969.
7. G.J. Lauer, "Statement on Temperature Standards for Lake Michigan," Environmental Analysis, Inc., New York, 1971.
8. Atomic Energy Commission, Final Environmental Statement Related to Operation of Indian Point Nuclear Generating Plant, Unit No. 2, Docket No. 50-247, 1974.
9. R.S. Benda, "Thermal Effects Studies at the Palisades Nuclear Plant," Unpublished Report, American Fisheries Society National Meeting, Hot Springs, Arkansas 1972.
10. New York State Electric and Gas, Cayuga Station Application to the New York State Board on Electric Generation Siting and the Environment, 1974.
11. L. Wells, Distribution of Fish Fry in Nearshore Waters of Southeastern and East-Central Lake Michigan, May-August 1972, Great Lakes Fishery Laboratory Admin. Report., Ann Arbor, Michigan, 1973.
12. G. Kissel, "Contributions to the Life History of the Alewife, (Alosa pseudoharengus) in Connecticut," Ph.D. Thesis, University of Connecticut, 1969.
13. W.C. Leggett, "Studies on the Reproductive Biology of the American Shad (Alosa sapidissima)," Ph.D. Thesis, McGill University, Montreal Quebec, 1969.

REFERENCES

14. A.C. Christiansen and B.A. Tichenor, Industrial and Waste Guide on Thermal Pollution, Federal Water Pollution Control Administration, 1968.
15. T.A. Edsall and T.G. Yocom, Review of Recent Technical Information Concerning the Adverse Effects of Once-Through Cooling on Lake Michigan, Great Lakes Fisheries Laboratory, Ann Arbor, Michigan, 1972.
16. IIT Research Institute, Cooling Tower Study, IITRI Final Report No. CG187-3 to EPA Air Pollution Control Office, January 1971.
17. W.C. Colbaugh, J.P. Blackwell and J.M. Leavitt, Interim Report on Investigation of Cooling Tower Plume Behavior, 68th National Meeting of the American Institute of Chemical Engineers, February 28 - March 4, 1971.
18. NUS Corporation, Evaluation of Environmental Effects of a Natural Draft Cooling Tower at the Davis-Besse Nuclear Power Station, NUS-799, 1971.
19. L.E. Olsson, "Lake Effects on Air Pollution Dispersion," Doctoral Dissertation, University of Michigan, June 1969.
20. W.A. Lyons, Mesoscale Transport of Pollutants in the Chicago Area as Affected by Land and Lake Breezes, Proceedings of the Second International Clean Air Congress, H.M. Englund and W.T. Beery, International Union of Air Pollution Prevention Associations, Academic Press, New York, 1971, pp. 973-978.
21. D.F. Gatz and E.W. Klappenbach, City of Chicago Pollution Incidents: Case Studies, 62nd Annual meeting of the Air Pollution Control Association, New York, New York, June 1969.
22. W.J. Moroz, A Lake Breeze on the Eastern Shore of Lake Michigan: Observations and Model, J. Atm. Sci., 24, (July 1967) p 337.
23. W.A. Lyons and L.E. Olsson, Mesoscale Air Pollution Transport in the Chicago Lake Breeze, J. Air Pollution Control Association, 22, November 1972, pp 876-881.
24. R.E. Huschke, Glossary of Meteorology, American Meteorological Society, Boston, 1959, pp 227-228.
25. S. Petterssen, Weather Analysis and Forecasting, Vol. II, 2nd Edition, Weather and Weather Systems, McGraw-Hill, New York, 1959, pp 103-132.
26. R. Brewer and J.A. Ellis, "An Analysis of Migrating birds Killed at a Television Tower in East-Central Illinois, September 1955-May 1957," AUK 75, (1958), pp 400-414.

REFERENCES

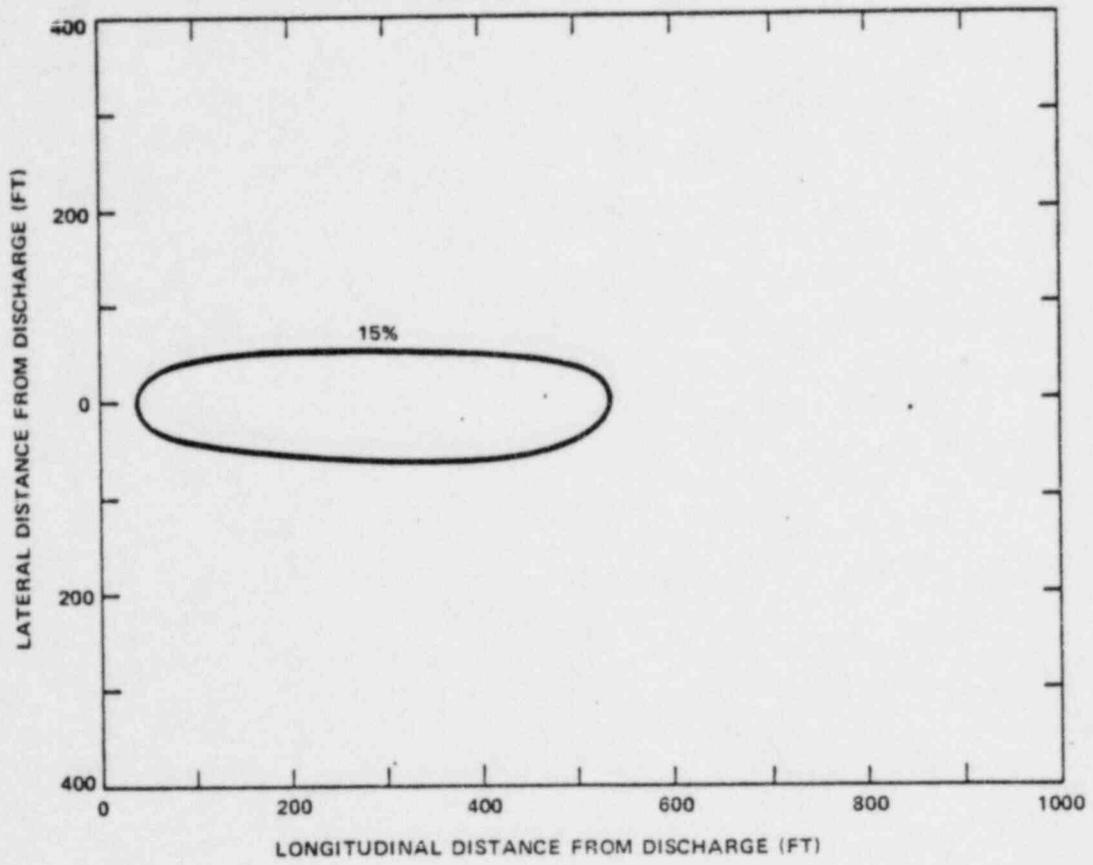
27. W.K. Taylor and B.H. Anderson, Nocturnal Migrants Killed at a Central Florida TV Tower; Autumns 1969-1971. Wilson Bulletin 85 (1), (1973).
28. C.A. Kemper, "A Tower for TV: 30,000 Dead Birds," Audubon 66, (1964), pp 86-90.
29. L. Campbell, "Birds of the Toledo Area," The Blade, Toledo, Ohio, 1968.
30. Davis-Besse Nuclear Power Station Units No. 2 and 3 Environmental Report, 1974.



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

3°F AND 5°F ISOTHERMS

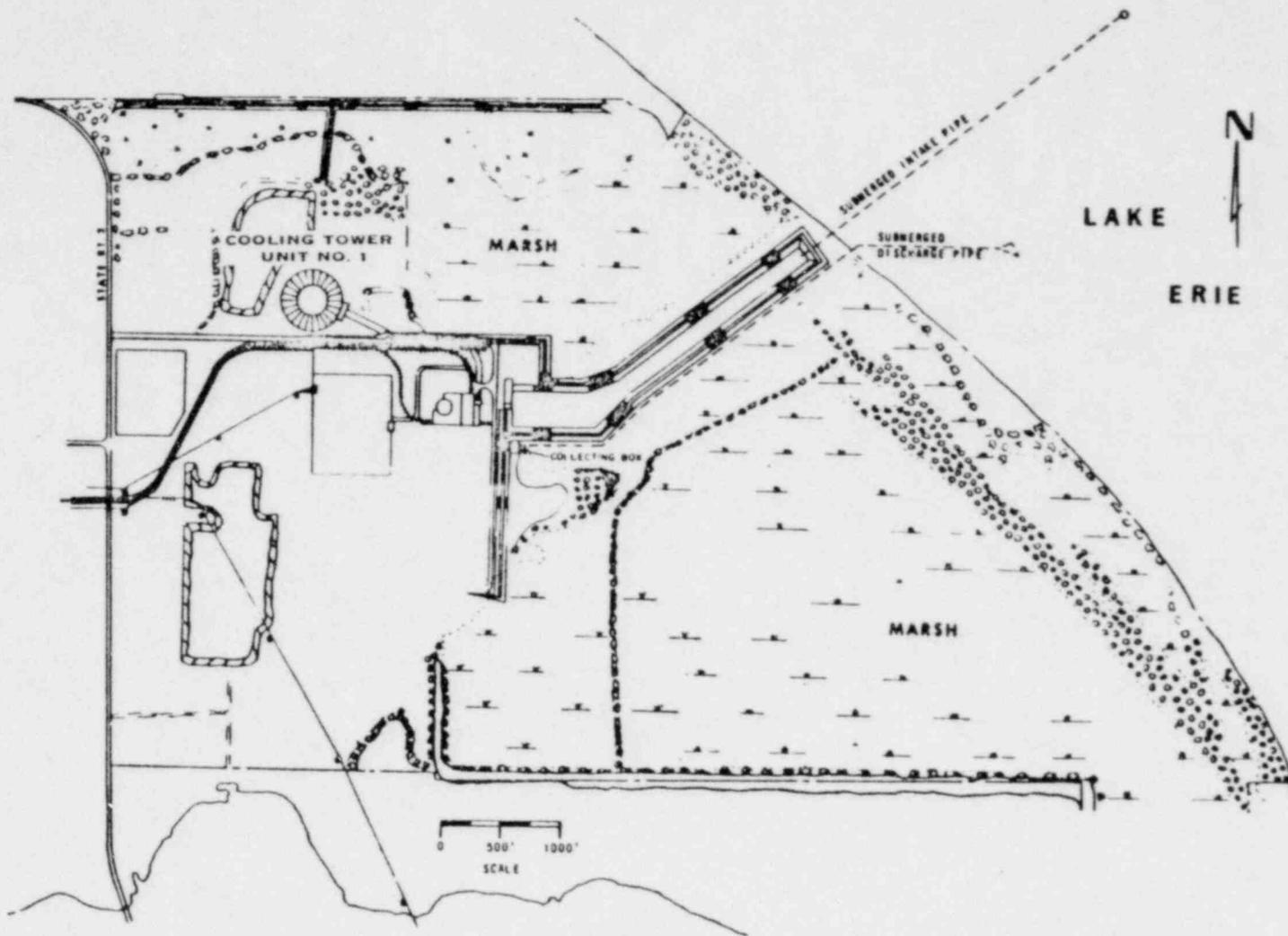
FIGURE 5.1-1



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

15% TDS ISOPLETHS

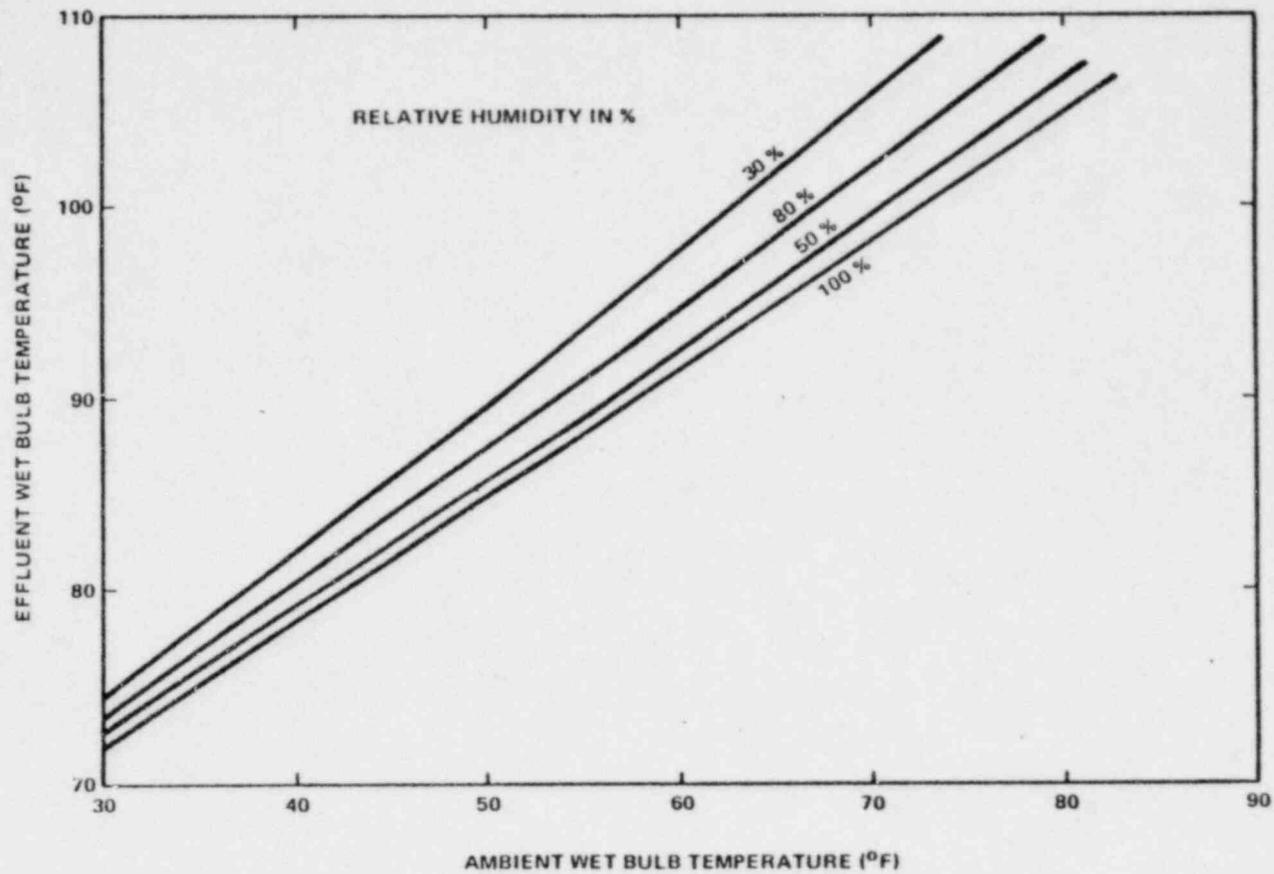
FIGURE 5.1-2



DB-1

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1
 PROPOSED NATURAL DRAFT COOLING TOWER SYSTEM LAYOUT

FIGURE 5.1-3

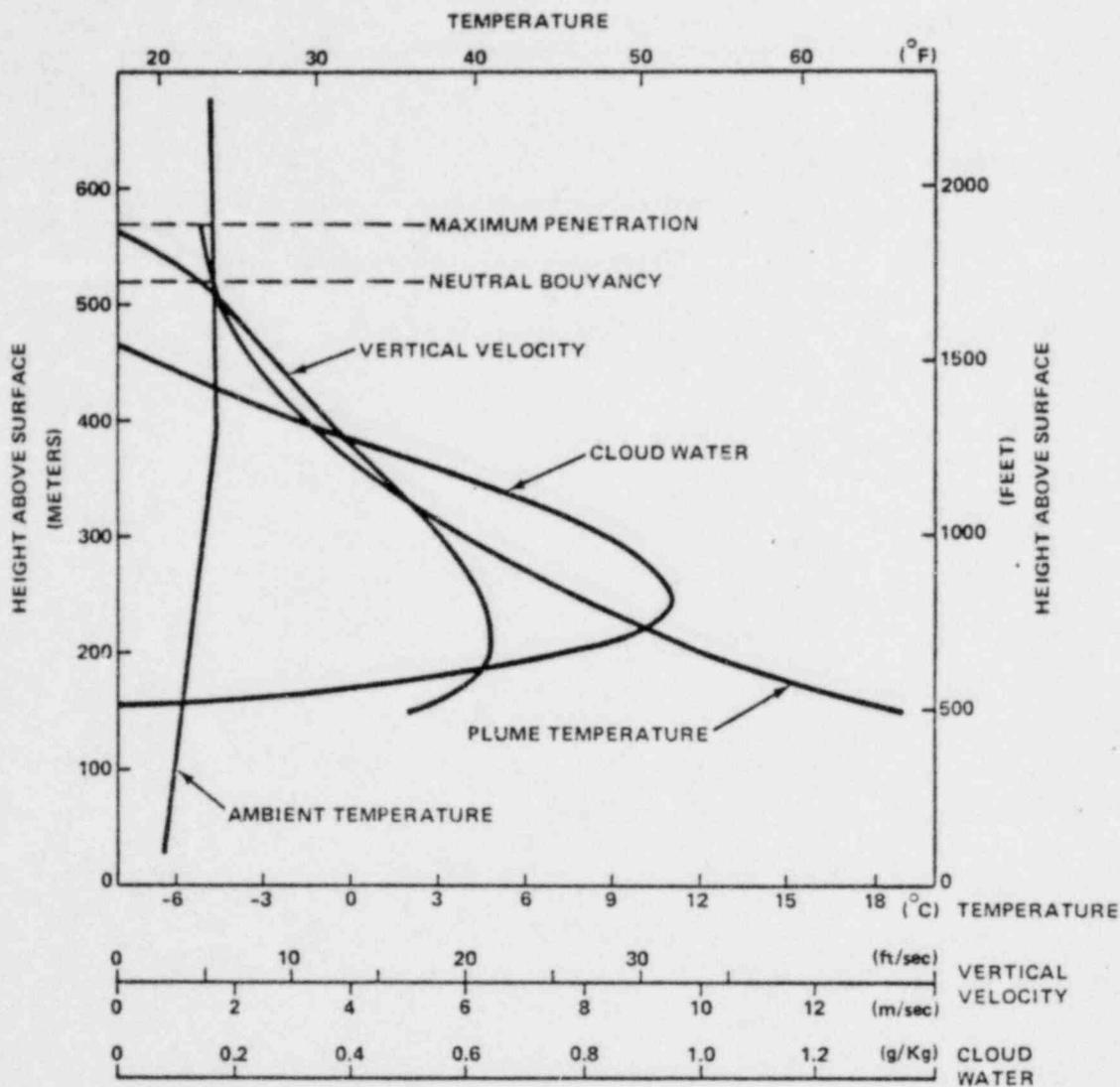


DB-1

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

PERFORMANCE CURVES FOR THE NATURAL DRAFT COOLING TOWER SYSTEM

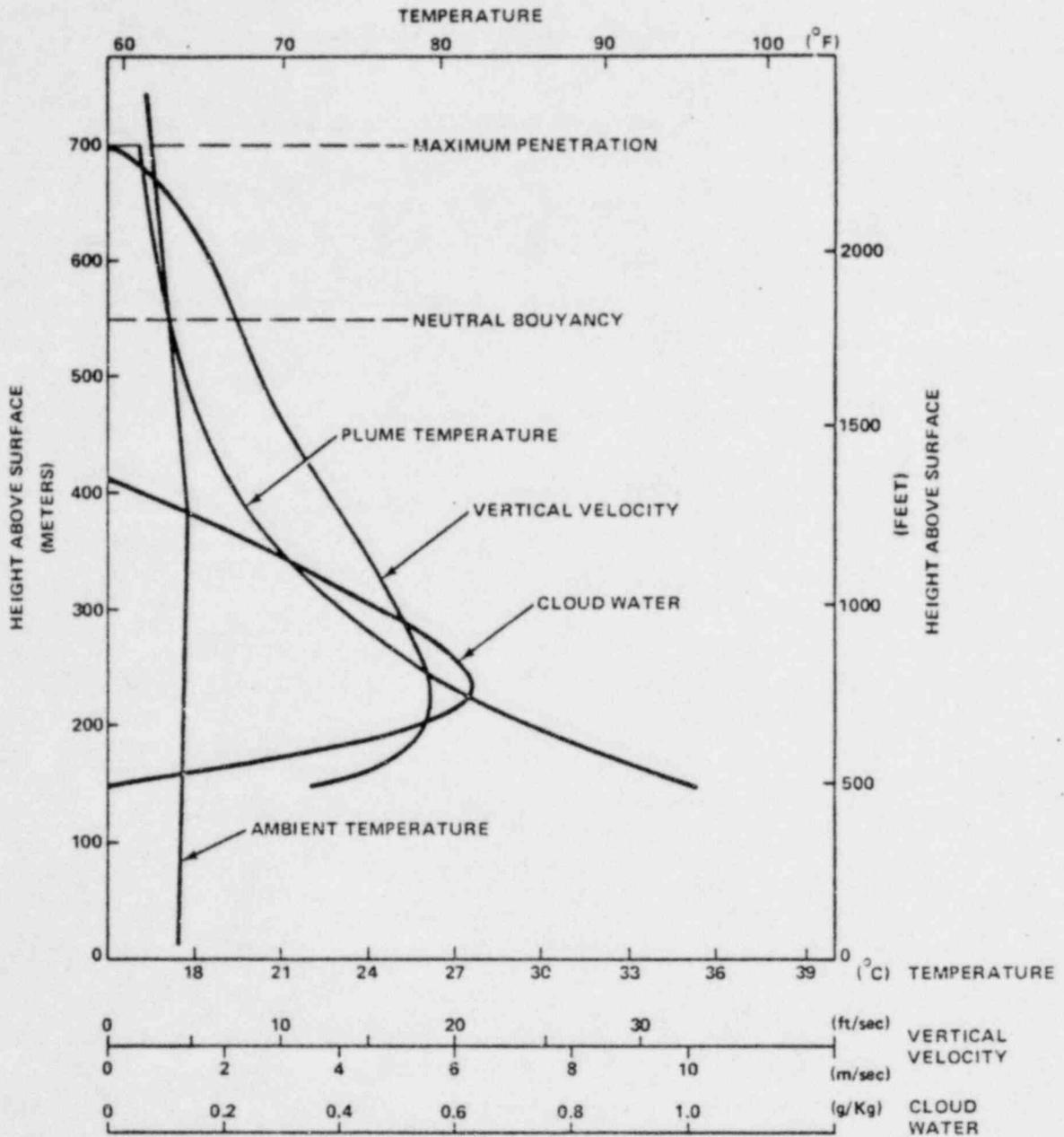
FIGURE 5.1-4



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

VARIATION OF COOLING TOWER PLUME PARAMETERS WITH HEIGHT FOR AN AVERAGE WINTER MORNING CONDITION

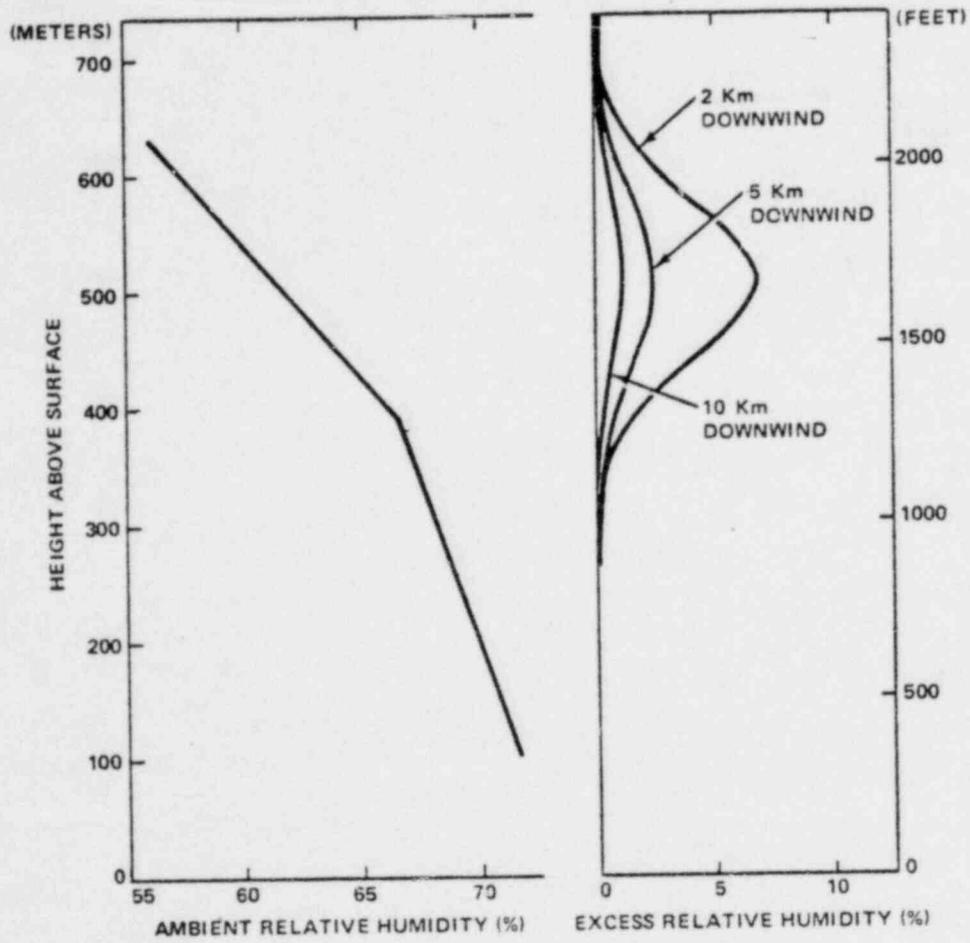
FIGURE 5.1-5



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

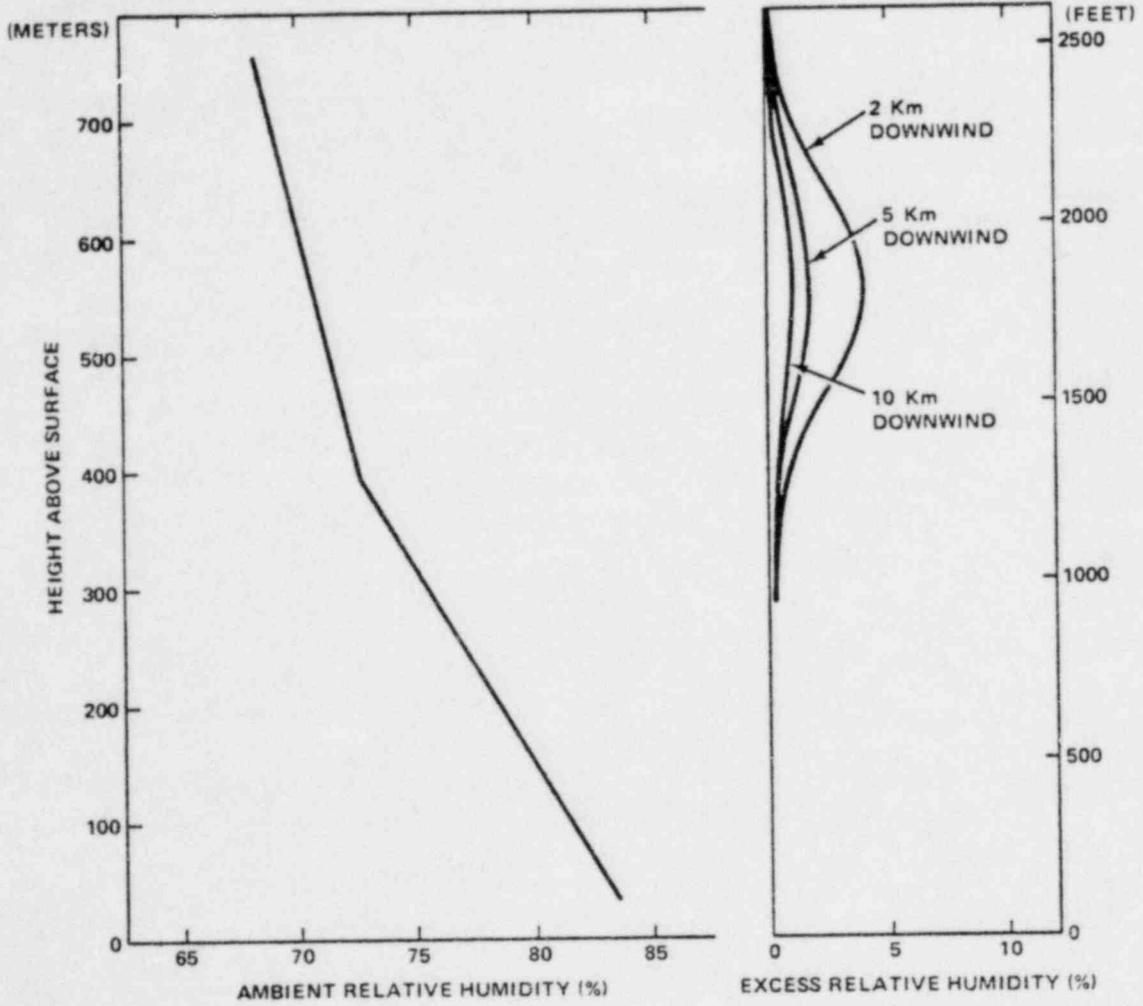
VARIATION OF COOLING TOWER PLUME PARAMETERS WITH HEIGHT FOR AN AVERAGE SUMMER MORNING CONDITION

FIGURE 5.1-6



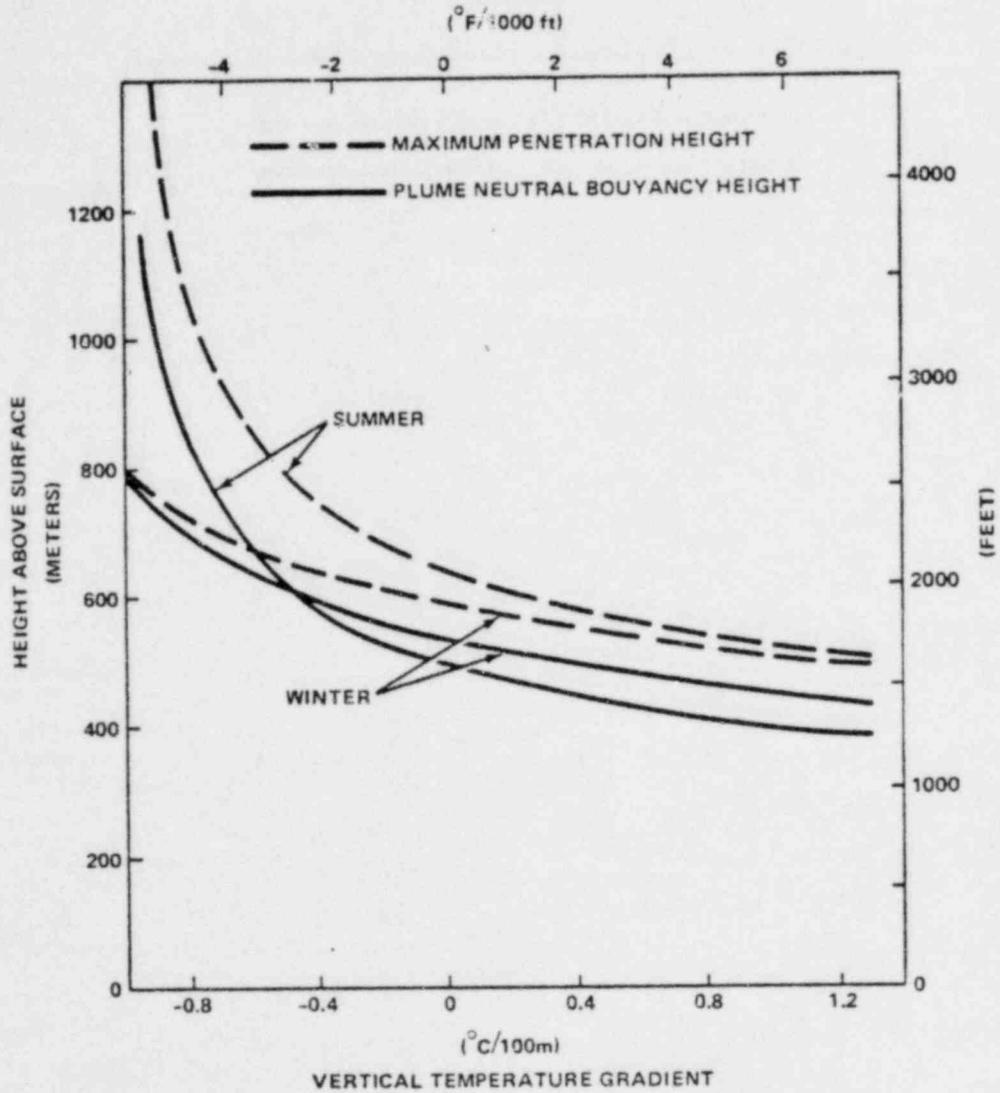
DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1
 AMBIENT RELATIVE HUMIDITY AND EXCESS RELATIVE HUMIDITY AT VARIOUS
 DOWNWIND DISTANCES FOR AN AVERAGE WINTER MORNING FROM
 OPERATION OF NATURAL DRAFT WET COOLING TOWER

FIGURE 5.1-7



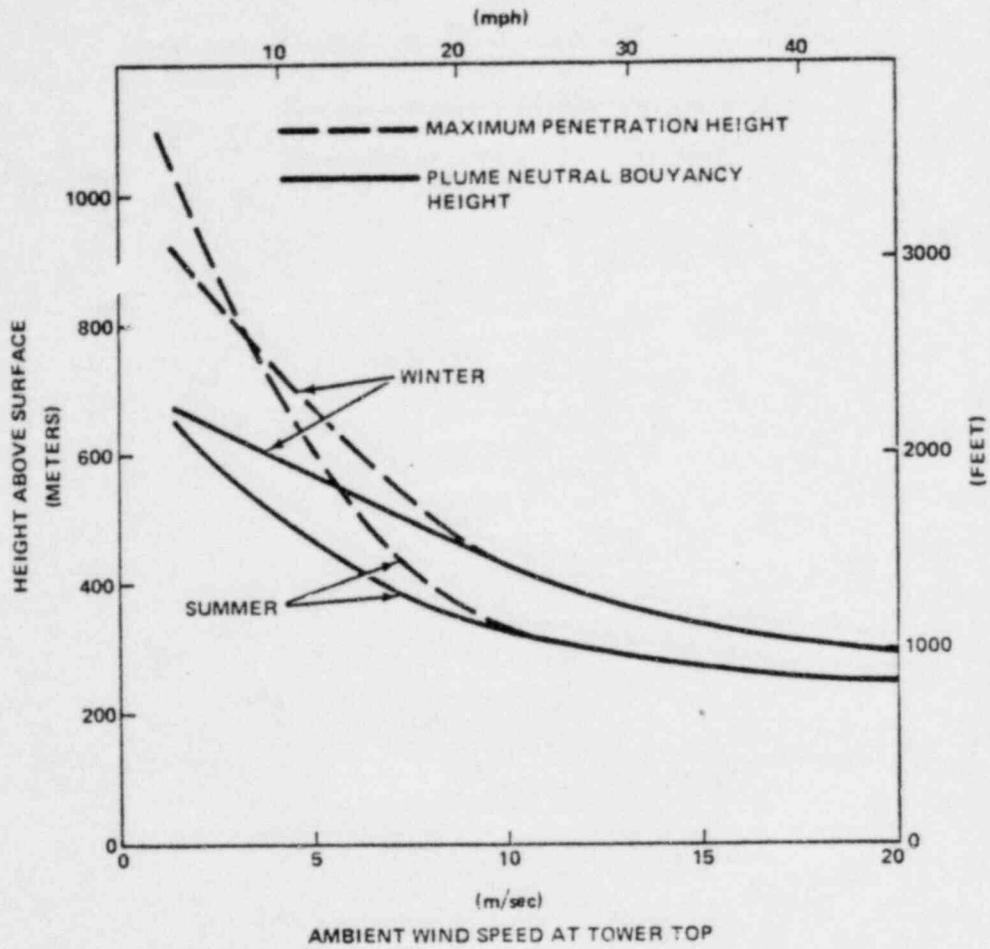
DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1
 AMBIENT RELATIVE HUMIDITY AND EXCESS RELATIVE HUMIDITY AT VARIOUS
 DOWNWIND DISTANCES FOR AN AVERAGE SUMMER MORNING FROM
 OPERATION OF NATURAL DRAFT WET COOLING TOWER

FIGURE 5.1-8



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1
VARIATION OF PLUME HEIGHT VS VERTICAL TEMPERATURE GRADIENT

FIGURE 5.1-9

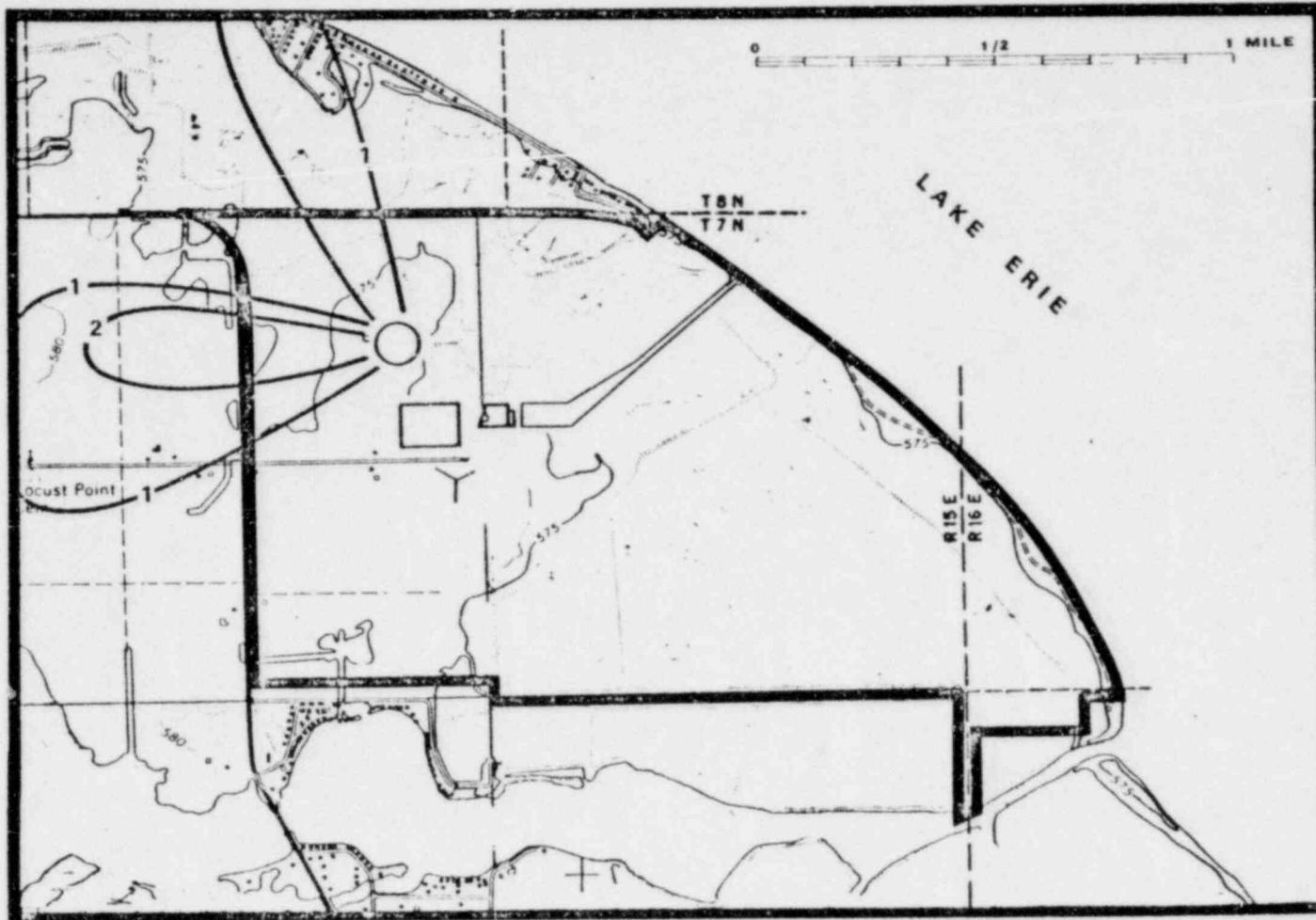


DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

VARIATION OF PLUME HEIGHT VS WIND SPEED

FIGURE 5.1-10

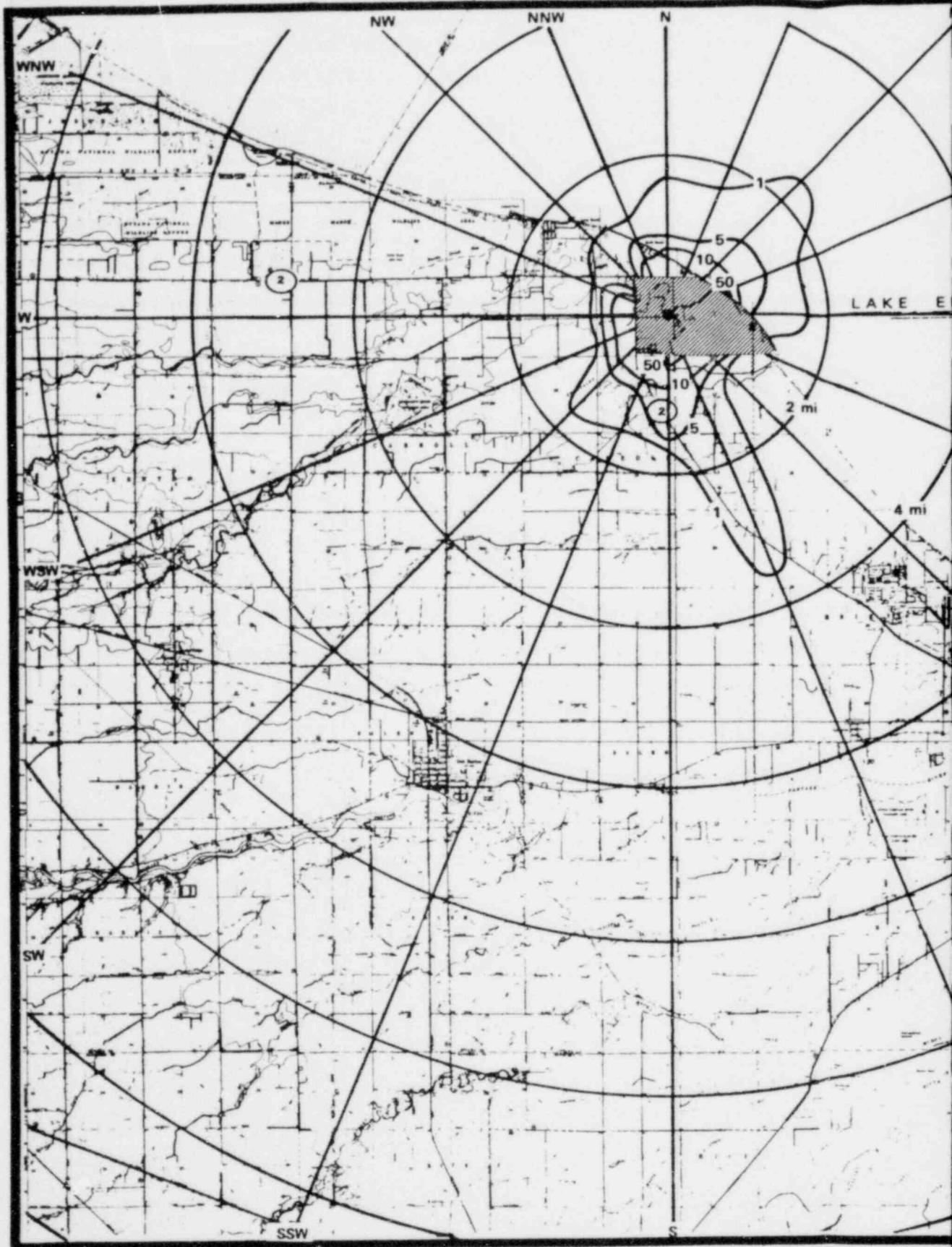
POOR ORIGINAL



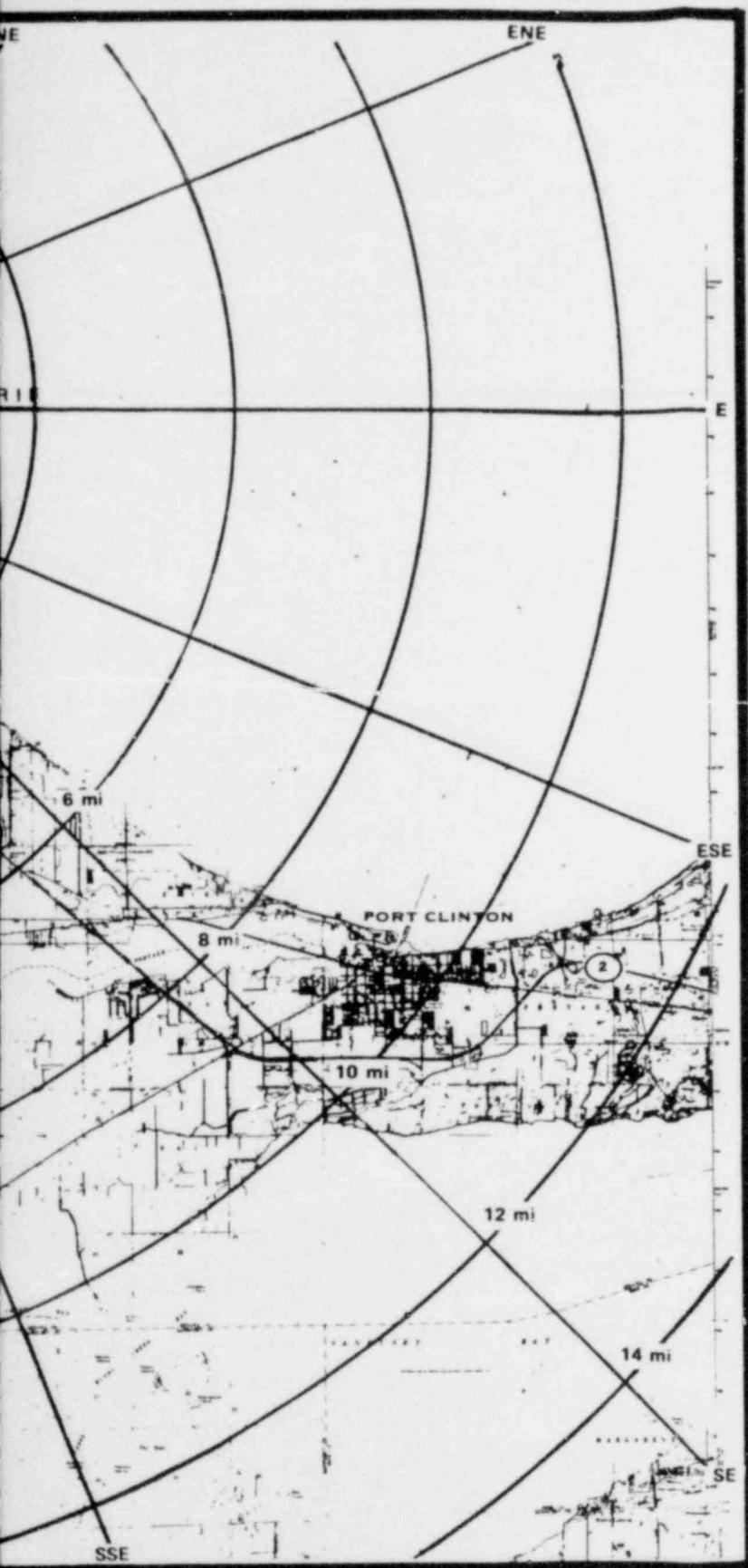
DB-1

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1
PREDICTED ANNUAL INCREASE IN GROUND LEVEL REDUCED VISIBILITY TO 1000 METERS (0.62 MILES)
OR LESS (HOURS PER YEAR) FROM THE OPERATION OF NATURAL DRAFT COOLING TOWER

FIGURE 5.1-11



POOR ORIGINAL



POOR ORIGINAL

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1

PREDICTED VISIBLE PLUME
(HOURS PER YEAR) FROM THE
OPERATION OF NATURAL DRAFT
COOLING TOWER

FIGURE 5.1-12

5.2 RADIOLOGICAL IMPACT ON BIOTA OTHER THAN MAN

This section of the Environmental Report is directed toward analysis of the potential radiological impact on local flora and fauna due to the normal operation of the Davis-Besse Nuclear Power Station Unit No. 1. Potential radiological impact to man is discussed in Section 5.3. Both this section and Section 5.3 refer extensively to Appendix 5A, "Off-Site Radiation Exposure Due to the Operation of the Davis-Besse Nuclear Power Station Unit No. 1." Appendix 5A is primarily an analysis of potential radiological impact to man, but also contains information which is relevant to this section. Appendix 5A is based on the expected radioactivity release rates from Unit No. 1. These release rates are based on 0.1% failed fuel cladding.

5.2.1 EXPOSURE PATHWAYS

A schematic diagram of exposure pathways for man is presented in Figure 1 of Appendix 5A. This exposure pathway diagram also applies to the local flora and fauna in the region of the Davis-Besse facility. The specific exposure pathways considered to be significant for flora and fauna in the site vicinity are listed below:

For gaseous effluents:

- a. External exposure to radioactivity in the air.
- b. External exposure to radioactive materials deposited on the ground.
- c. Internal exposure due to inhalation of radioactivity in the air.
- d. Internal exposure due to food chain transport of radioactivity deposited on the ground.

For liquid effluents:

- a. External exposure to radioactivity in water or adsorbed on bottom sediment.

- b. Internal exposure due to ingestion of radioactivity in water.
- c. Internal exposure due to ingestion of food chain organisms.

All of the above exposure pathways are evaluated in detail in Appendix 5A, for man. Appendix 5A also contains a detailed evaluation of the maximum potential doses to aquatic biota due to liquid effluents (aquatic biota are not significantly affected by gaseous effluents). The external exposure pathways for gaseous effluents will result in essentially the same doses to terrestrial biota that have been estimated for man, as presented in Appendix 5A.

For the purposes of this section, an estimate must be made of the potential exposure to terrestrial biota due to the inhalation and food chain transport of gaseous releases, and due to the ingestion of water and contaminated aquatic biota for liquid releases. The life form most likely to receive the maximum dose from the combination of all potential exposure pathways is a small mammal or species of waterfowl. Since part of the site is a wildlife refuge, these maximum dose receptors are assumed to be present in the immediate site vicinity 100% of the year.

5.2.2 RADIOACTIVITY IN THE ENVIRONMENT

Due to the normal releases of radioactive effluents in both gaseous and liquid form from the Davis-Besse site, small incremental additions to normal environmental levels of radioactivity and specific isotopes will be present in and around the site environment. The environmental media which will be affected include: air, ground, ground forage, terrestrial food chains, water, bottom and shoreline sediments, and aquatic food chains.

The isotopes that will be released in gaseous effluents and are physically capable of ground deposition and involvement in terrestrial food chains

include all particulates and halogens (iodines). Maximum offsite ground concentrations for these releases have been evaluated and are presented in Appendix 5A. Only three isotopes (^{131}I , ^{133}I , and ^{137}Cs) have been determined to develop significant ground concentrations. The estimated maximum offsite ground concentrations for these isotopes in the year 2020 are: $4.2 \times 10^{-8} \mu\text{Ci}/\text{cm}^2$ for ^{131}I , $1.9 \times 10^{-9} \mu\text{Ci}/\text{cm}^2$ for ^{133}I , and $4.7 \times 10^{-10} \mu\text{Ci}/\text{cm}^2$ for ^{137}Cs . Only fractions of these activity levels will be available for food chain transport by way of contaminated forage. Assuming a weathering half-life on forage of 14 days,⁽¹⁾ and also assuming that only 25% of the deposited activity is deposited on vegetation,⁽¹⁾ the resulting equilibrium forage concentrations at the same location are $6.6 \times 10^{-9} \mu\text{Ci}/\text{cm}^2$ for ^{131}I , $4.3 \times 10^{-10} \mu\text{Ci}/\text{cm}^2$ for ^{133}I , and $2.3 \times 10^{-12} \mu\text{Ci}/\text{cm}^2$ for ^{137}Cs (assuming no root uptake).

Annual average discharge concentrations to Lake Erie for all isotopes released in liquid effluents are presented in Appendix 5A. It is conservatively assumed that activity concentrations that develop in bottom and shoreline sediments will be approximately 1,000 times the annual average discharge concentrations for all isotopes except tritium. Tritium, released in the chemical form of water, will not concentrate in bottom or shoreline sediments. Maximum concentrations of isotopes in aquatic biota (plants, invertebrates) are assumed to be equal to the annual average discharge concentration times the appropriate concentration factor (CF). Concentration factors used in Appendix 5A are taken from "Concentration Factors of Chemical Elements in Edible Aquatic Organisms" (UCRL-50564, Rev. 1).⁽²⁾

5.2.3 DOSE RATE ESTIMATES

Table VIII of Appendix 5A summarizes the maximum individual human doses calculated to result from gaseous effluents from the Davis-Besse Nuclear Power Station Unit No. 1. External and internal doses due to inhalation are based on the highest site boundary χ/Q on land, 5.17×10^{-6} sec/m³. Higher values of χ/Q , and higher dose rates, would result at locations closer to the containment structure. Therefore, maximum dose rates due to gaseous releases, for flora and fauna, are conservatively estimated here using the highest annual average value of χ/Q , in any direction, at a representative distance of 400 m. The maximum annual average χ/Q at this distance is 1.70×10^{-5} sec/m³, to the north-northeast. This χ/Q is about 3.3 times the value used in Appendix 5A to estimate maximum potential human doses. From Table VIII of Appendix 5A it can be seen that the major sources of whole body radiation are cloud immersion and tritium inhalation, with cloud immersion contributing over 92% of the total human whole body dose from all gaseous exposure pathways. Since flora and fauna would receive the same external dose rate as a human, at the same location, it can be assumed that the total "whole body" exposure to flora and fauna at the closer-in location would amount to about 3.3 times the calculated total for man at the site boundary. This total dose to flora and fauna, from all gaseous pathways, amounts to about 5.0 mrad/yr. For very thin plants and grasses, the beta component of the source must be included as for the "skin" dose calculation for humans in Appendix 5A. Including external beta radiation, the maximum dose to flora and fauna is estimated to be less than 8 mrad/yr.

Maximum individual doses to humans due to liquid effluents from the Davis-Besse site are summarized in Table XIV of Appendix 5A. However, as the

major doses are due to internal, rather than external, exposure pathways, these doses are not directly applicable to aquatic biota or terrestrial life forms.

Appendix 5A contains a detailed evaluation of the maximum potential doses to aquatic biota from all internal and external sources. These doses, presented in Table XVI of Appendix 5A, are based on very conservative assumptions regarding dilution and reconcentration. The highest total dose calculated is that for a bottom-feeding fish and amounts to about 28 mrad/yr. For comparison, the calculated total dose to a free-swimming fish (not affected by contaminated bottom sediment) is only about 2.5 mrad/yr. Other dose totals for invertebrates and microorganisms are also presented in Appendix 5A, along with a discussion of the assumptions and models used in the calculations.

A further calculation has been performed specifically for presentation in this section. It was assumed that a 1,000-g animal or waterfowl would ingest 100 g/day of edible fish flesh. The activity concentrations in the fish flesh were assumed to be given by the product of the annual average discharge concentration and the appropriate CF. The whole body dose to the fish-eating animal was then calculated for each radioisotope using the following formula:

$$D(\text{rad/yr}) = \left(C_w \right) (CF) \left(\frac{T}{0.693} \right) \left(100 \frac{\text{grams}}{\text{day}} \right) (E) \left(\frac{1}{m} \right) \left(1.87 \times 10^4 \right)$$

where:

C_w = the annual average discharge concentration, $\mu\text{Ci/g}$

CF = the applicable concentration factor

T = the effective half-life of the isotope in the human body*, days

E = the effective energy in the human body*, MeV/dis

*Values used for effective half-life and effective energy are those applicable for the whole body of man, in lieu of more appropriate data.

m = the receptor mass, 1,000 g, and
 1.87×10^4 = the necessary conversion constant.

The calculated internal dose for this hypothetical situation amounts to about 12.8 mrad/yr. If the animal were to receive an additional dose of 12.8 mrad/yr, primarily from external sources, the total dose would then be about 25.6 mrad/yr.

Although maximum potential doses to aquatic and terrestrial fauna have been evaluated with great conservatism, no calculated dose amounts to more than a few percent of the limit set by 10 CFR Part 20 for maximum permissible exposure of man, 500 mrem/yr. A summary of the estimated maximum total doses to biota other than man is presented in Table 5.2-1. The calculated doses are also small in comparison to those due to natural background radiation. It is concluded that in all probability there will be no detectable radiological impact on the flora and fauna in the site vicinity.

TABLE 5.2-1

SUMMARY OF TOTAL DOSES TO BIOTA OTHER THAN MAN

Biota Type	Estimated Maximum Annual Dose, mrad	1
Plants, grasses, leaves	8	
Small fish-eating animal	26	
Other terrestrial biota	5.0	
Bottom-feeding fish	28	
Free-swimming fish	2.4	

REFERENCES

1. "Final Environmental Statement Concerning Proposed Rulemaking Action: Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Practicable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," Directorate of Regulatory Standards, U.S. AEC, WASH-1258, (July 1973).
2. Thompson, S.E., et al., "Concentration Factors of Chemical Elements in Edible Aquatic Organisms," UCRL-50564 Rev. 1, (October 1972).

5.3 RADIOLOGICAL IMPACT ON MAN

This section of the Environmental Report is directed toward an analysis of the potential radiological impact to man due to the normal operation of the Davis-Besse Nuclear Power Station Unit No. 1. Potential radiological impact to man is fully discussed and evaluated in detail in Appendix 5A, "Off-Site Radiation Exposure Due to the Operation of the Davis-Besse Nuclear Power Station Unit No. 1." Extensive reference is made here to Appendix 5A. The radioactivity release rates on which this section and Appendix 5A are based are presented in Section 3.5.

5.3.1 EXPOSURE PATHWAYS

The various environmental pathways by which man can be exposed to routine radioactive releases from central station nuclear generating facilities, such as Davis-Besse, are presented in schematic form in Figure 1 of Appendix 5A. Appendix 5A provides a discussion and evaluation of radiation exposure to man for routine gaseous radioactive releases via the following pathways: (1) external exposure to radioactivity in the air, (2) external exposure to radioactivity deposited on the ground, (3) internal exposure due to the inhalation of radioactivity in air, and (4) internal exposure due to potential food chain transport of radioactivity deposited on the ground. The following pathways of exposure to man for liquid radioactive releases are also fully discussed and evaluated in detail in Appendix 5A: (1) internal exposure due to the ingestion of radioactivity in water, (2) internal exposure due to the ingestion of radioactivity in fish, (3) external exposure due to immersion (swimming) in radioactive water, and (4) external exposure due to sunbathing or walking on nearby beaches. Other minor pathways of human exposure have been ignored due to their insignificance in relation to those given detailed consideration.

5.3.2 LIQUID EFFLUENTS

Table IX of Appendix 5A presents the expected annual radioactivity discharge from Unit No. 1 (by isotope). Also presented in this table are the estimated annual discharge concentrations of all isotopes for Unit No. 1. Dilution factors applicable to known potable water intakes within 50 mi of the site are calculated and presented in Table XI of Appendix 5A; the calculational model by which the dilution factors have been derived is also presented in Appendix 5A.

Table XIV of Appendix 5A summarizes the calculated maximum individual doses due to liquid effluents for: (1) water ingestion, (2) fish ingestion, (3) swimming, and (4) sunbathing. The details of each analysis and the models used to calculate the doses for each pathway are given in Appendix 5A. The maximum individual dose totals for all pathways of exposure for liquid releases amount to 1.2 mrem/yr for the whole body, 1.6 mrem/yr for the body surface, 1.4 mrem/yr for the liver, and 2.2 mrem/yr for the thyroid, which has been determined to be the critical organ for doses due to liquid effluents. The limit for maximum individual offsite radiation exposure due to liquid effluents, in the proposed Appendix I to 10 CFR Part 50, is 5 mrem/yr to the whole body or any organ.⁽¹⁾ The calculated doses due to normal liquid radioactive effluents from the Davis-Besse Nuclear Power Station Unit No. 1 are all within this proposed limit. Exposure to the general population has been estimated for the two most significant population exposure pathways, water ingestion and fish ingestion. The calculated whole body population exposures for these two pathways are presented in Table 5.3-1.

TABLE 5.3-1
 POTENTIAL POPULATION EXPOSURE FROM LIQUID EFFLUENTS
 (Man-rem/yr)

Year	Water Ingestion	Fish Ingestion	Total
1980	0.07	0.003	0.07
2000	0.08	0.007	0.09
2020	0.10	0.021	0.12

The assumptions, mathematical models, and other particulars of the calculation for these population exposure rates, along with other doses due to liquid effluents, are fully discussed in Appendix 5A.

5.3.3 GASEOUS EFFLUENTS

Table VIII of Appendix 5A summarizes the calculated maximum individual dose rates due to gaseous releases for the following exposure pathways: (1) external exposure due to cloud immersion, (2) external exposure due to particulate and iodine deposition, (3) exposure due to inhalation of iodine, tritium, and particulates, and (4) milk ingestion from the nearest actual cow, located about 2.4 mi to the west-southwest of the site. All maximum individual doses due to gaseous releases (except milk ingestion) have been evaluated at the location on the site boundary with the highest annual average χ/Q . This location is about 780 m to the north-northeast of the Unit No. 1 containment structure. The annual average χ/Q at this distance and direction is about 5.2×10^{-6} sec/m³. The total maximum individual exposure rates due to all pathways for gaseous effluents combined are: 1.5 mrem/yr to the whole body, 2.3 mrem/yr to the body surface, and 2.1 mrem/yr to the adult thyroid. The total dose to a

child's thyroid for all pathways combined is estimated to be 3.2 mrem/yr. The models, assumptions, and other particulars concerning these dose estimates are discussed in detail in Appendix 5A. These maximum individual dose rates, due to station operation, represent only a few percent of the average annual dose due to naturally occurring background radiation. Limits for maximum individual offsite radiation exposure, due to gaseous effluents, are specified in the proposed Appendix I to 10 CFR Part 50. The proposed limits are 5 mrem/yr to the whole body, and 15 mrem/yr to the body surface or any other specific body organ. The calculated maximum individual offsite doses due to gaseous effluents from the Davis-Besse Nuclear Power Station Unit No. 1 are below these limits. Table VI of Appendix 5A summarizes the calculated doses for gaseous releases to the general population within 50 mi of the site. The pathways considered in evaluating population exposure were external exposure due to cloud immersion and particulate and halogen deposition. The total whole body population exposure due to these two pathways is presented in Table 5.3-2.

TABLE 5.3-2
POTENTIAL POPULATION EXPOSURE FROM GASEOUS RELEASES
(Man-rem/yr)

Year	Cloud Immersion	Particulate Deposition	Total
1980	3.9	0.09	4.0
2000	4.6	0.10	4.7
2020	5.5	0.12	5.6

The estimated per capita whole body doses due to gaseous releases, within 50 mi of the site, for the years 1980, 2000, and 2020 are all about 0.002 mrem/yr. This per capita dose is negligible in comparison with natural background radiation exposure. Details of these and other dose calculations are contained in Appendix 5A.

5.3.4 DIRECT RADIATION

5.3.4.1 Radiation from Facility

Calculations of direct radiation dose rates expected in areas external to major facility structures have ascertained that the principal source of site boundary exposure will be that due to radioactivity contained in the borated water storage tank. This tank is located in an open area and is not enclosed. Site boundary dose rates from radioactive materials inside the containment structure, auxiliary building, and primary water storage tank are negligible by comparison. The dose at the nearest site boundary from the borated water storage tank (about 750 m), based on the expected equilibrium activity levels, has been estimated to be about 3.3×10^{-7} mrem/hr, or about 0.003 mrem/yr. This incremental dose rate amounts to only about 0.6% of the calculated maximum whole body dose rate due to gaseous radioactive effluents.

The dose from the borated water storage tank was first evaluated at a distance of 10 ft, assuming an infinite slab source geometry. The dose rate at 10 ft was then extrapolated out to the maximum site boundary distance by assuming the dose to be caused by a point source and accounting for attenuation and buildup in the air.

As the calculated maximum site boundary direct radiation dose rate is negligible in comparison with the doses due to gaseous radioactive releases,

further consideration of direct radiation exposure to the surrounding population as a whole, or to specific locations, is inappropriate.

5.3.4.2 Transportation of Radioactive Materials

5.3.4.2.1 New Fuel Shipments

The initial fuel assemblies will be provided by the Babcock and Wilcox facility near Lynchburg, Virginia. The distance from Lynchburg to the station site is about 450 mi by road. The route of transport has yet to be defined.

The initial fuel loading for the reactor will require 177 fuel assemblies. The new fuel will be shipped via truck in AEC-DOT approved containers with two assemblies per reusable container and six containers per truck. The initial deliveries will require 15 truck shipments, with about five shipments or an average of 52 fuel assemblies per year thereafter. The specific frequency for shipments of replacement fuel and/or duration will depend on the manufacturing facilities schedule, the site capacity to receive same, and/or economic conditions.

5.3.4.2.2 Irradiated Fuel Shipments

Definite plans have not yet been formalized with respect to the spent-fuel reprocessor. The commercial reprocessing industry today consists of one plant not yet operating and one shut down for modification and expansion. They are located in Barnwell, South Carolina, and West Valley, New York, respectively. It is likely that one of these locations will be the shipping destination of irradiated fuel from the Davis-Besse Nuclear Power Station Unit No. 1. Approximate distances from the station to the above locations are listed in Table 5.3-3.

TABLE 5.3-3

APPROXIMATE DISTANCES FOR SHIPMENT OF RADIOACTIVE MATERIALS
FROM THE DAVIS-BESSE NUCLEAR POWER STATION

<u>Fuel Reprocessors</u>	<u>Distances (mi)</u>
Barnwell, South Carolina	800
West Valley, New York	300
<u>Low-Level Solid-Waste Burial Sites</u>	
Richland, Washington	2,200
Beatty, Nevada	1,900
Sheffield, Illinois	340
Morehead, Kentucky	300
Barnwell, South Carolina	800
West Valley, New York	300

Spent-fuel shipping casks are presently designed in three categories:

- a. Legal weight truck casks, generally designed for only one PWR fuel assembly
- b. Overweight truck casks, designed for up to three PWR fuel assemblies
- c. Rail shipping casks, designed for 7 to 12 PWR fuel assemblies.

At the present time, use of a licensed rail shipping cask holding seven PWR assemblies is expected. Thus, for the unit, the expected number of shipments is eight to nine per year; however, truck shipments could range from 20 to 52 per year from each unit, or rail shipments could range from five to nine per year. The above calculations assume that the reactor will generate about 52 irradiated fuel assemblies per year.

5.3.4.2.3 Shipment of Other Radioactive Wastes

As with shipments of new and irradiated fuel, the location of the low-level waste burial site has not yet been selected. Present commercial burial sites in the U.S. are in Richland, Washington; Beatty, Nevada; Sheffield, Illinois; Morehead, Kentucky; Barnwell, South Carolina; and West Valley, New York. Approximate distances from the Davis-Besse Nuclear Power Station Unit No. 1 to these locations are listed in Table 5.3-3.

Quantities of the various types of materials expected to be shipped are presented in Table 3.8-1.

About 3,000 ft³ of significantly radioactive wastes and about 1,000 ft³ of low-level wastes will be shipped yearly from the Davis-Besse Nuclear Power Station Unit No. 1. This will involve approximately 24 to 30 shipments per year to one of the commercial burial sites identified above.

5.3.5 SUMMARY OF ANNUAL RADIATION DOSES

The total integrated whole body dose to the population within 50 mi of the facility, due to all gaseous and liquid radioactive effluents combined, is estimated to amount to 4.0 man-rem/yr in 1980, 4.7 man-rem/yr in the year 2000, and 5.6 man-rem/yr in the year 2020. Almost all of this estimated exposure is due to the radioactive gaseous effluents. Population exposure due to radioactive liquid effluents and direct radiation is negligible.

The estimated average per capita whole body dose rates due to station operation, within 50 mi of the site, for the years 1980, 2000, and 2020 are all about 0.002 mrem/yr.

REFERENCE

1. USAEC. Concluding Statement of Position of the Regulatory Staff, Public Rulemaking Hearing on: Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Practicable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactors. Docket No. RM-50-2. February 20, 1974.

5.4 EFFECTS OF CHEMICAL AND BIOCIDES DISCHARGES

The total water supply for all equipment, personnel, and makeup requirements for the Davis-Besse Nuclear Power Station Unit No. 1 will be taken from Lake Erie. All process effluents from the Unit will be released to Lake Erie. The discharge will be through a slot-type orifice to impart a velocity to the effluent to promote rapid dilution and mixing with the lake water.

5.4.1

As the water passes through the various systems in the Unit there will be only a slight change in its chemical composition caused by the addition of neutralizing chemicals. The dissolved solids concentration in the discharge water will be approximately equal to twice that of lake water because of evaporative loss of water in the cooling tower. The anticipated average monthly flows through the water systems of the unit, excluding dilution flow (unaltered lake water) to the collection box, indicates that 99.5% of the discharge water will come from the closed condenser cooling water system. Table 5.4-1 compares the maximum concentrations of the constituents in the discharge water with the composition of the lake water, and water quality standards set by the Ohio Environmental Protection Agency (EPA).

Since the constituents of the dissolved solids are essentially the same as those of lake water and their concentration in the discharge water will be reduced within a very small area of the lake in proportion to the reduction in excess temperature of the discharge, they will cause no adverse effects on the lake or lake biota.

The highest water quality criteria for any water use under the jurisdiction of the Ohio EPA have been applied to Lake Erie. These criteria are federally approved with the exception of the dissolved oxygen content and the temperature.

TABLE 5.4-1

COMPARISON OF INFLUENT WATER, DISCHARGE WATER AND APPLICABLE STANDARDS

	Influent Lake Water	Unit Discharge Water	Water Quality Standard
Bacteria	Unknown	0	1000/100 ml monthly avg 2400/100 ml any day
Threshold Odor	--	*	24 at 60°C daily avg
Dissolved Solids	234 mg/l	470 mg/l 488 mg/l**	500 mg/l monthly avg 750 mg/l any time
Suspended Solids	28 mg/l	45 mg/l	Free from substances that will settle to form putrescent or otherwise objection- able sludge
Dissolved Oxygen	10 mg/l	7.1+	5 mg/l 16 of 24 hr 3 mg/l at any time
pH	8.1	8.0	6.5-8.5 preferred 5-9 daily avg

*The concentration in the station effluent will be the same or less than the concentration present in the influent lake water.

**Maximum concentration based on maximum discharge flow from all systems occurring at the same time with a 10,000 gpm dilution flow.

+The dissolved oxygen content in the discharge water will correspond to the saturation temperature limit for the cooling tower water. This value corresponds to the maximum expected cooling tower outlet temperature.

These water quality standards have four minimum conditions applicable to all waters, at all places, and at all times. They are delineated below:

- a. "Free from substances attributed to municipal, industrial, or other discharges, or agricultural practices that will settle to form putrescent or otherwise objectionable sludge deposits."

No substance in the discharge from the station will settle. In fact, the discharge will contain less solids, by weight, than taken into the station in the intake water. This reduction is due primarily to the settling that takes place in the cooling tower basin and settling basin.

- b. "Free from floating debris, oil, scum, and other floating materials attributable to municipal, industrial, or other discharges, or agricultural practices in amounts sufficient to be unsightly or deleterious."

No debris, oil, scum, or other floating material will be discharged from the Davis-Besse Station. Oil separators will be installed on the floor drainage system to prevent accidental spills from entering the drainage system. Concrete walls surround the fuel oil storage tanks for the auxiliary boilers and emergency generator to prevent fuel oil from entering the storm drain system.

- c. "Free from material attributable to municipal, industrial or other discharges, or agricultural practices producing color, odor, or other conditions in such degree as to create a nuisance."

There will be no odor- or color-producing materials discharged from the Unit.

- d. "Free from substances attributable to municipal, industrial or other discharges, or agricultural practices in concentrations or combinations which are toxic or harmful to human, animal, plant, or aquatic life."

The quantities and concentrations of the liquid effluents from the Unit are set forth in Section 3.6. The chemical constituents and their relative concentrations in the effluent are essentially the same as the lake water at edge of the mixing zone and accordingly will not be harmful to aquatic life. The quality of the effluents from the Unit, relative to the specific water quality criteria, is presented in the following sections.

5.4.1.1 Bacteria

The water criteria for bacteria specifies that coliform content must not be over 1000/100 ml as a monthly average, and this may not be exceeded in more than 20% of the samples in a month or over 2400/100 ml on any day. Of all water to be released from the Unit, the only potential source of coliform bacteria is in the sewage discharges. The sewage treatment plant will process all sanitary wastes and provide both primary and secondary treatment. In addition, effluent from the sewage treatment plant will be chlorinated to maintain a 1 mg/l concentration of free residual chlorine that will result in a zero release of coliform to the lake. Since chlorine will be periodically added to the closed condenser cooling water system any coliform bacteria present in the influent lake water will be removed.

5.4.1.2 Threshold Odor Number

Threshold odor is not a consideration since no odor-containing substances will be added to the effluent.

5.4.1.3 Dissolved Solids

The water standard criteria for dissolved solids state that there will not be more than 500 mg/l as a monthly average value or over 750 mg/l at any time. The principal source of dissolved solids in the effluent from the unit is from the cooling tower blowdown. The level of dissolved solids from this system is dependent on the level contained in the lake water

coming into the Unit. Based on the average value of 234 mg/l for dissolved solids in the lake water, the maximum average monthly dissolved concentration will be about 470 mg/l.

5.4.1.4 Chemical Constituents

The water quality standards contain limits on specific chemical constituents: arsenic, barium, cadmium, chromium, cyanide, fluoride, lead, selenium, and silver. No releases from the Unit discharge systems will contain any of these chemicals except for possible traces in the form of radionuclides.

5.4.1.5 Dissolved Oxygen

The Ohio standards pertaining to dissolved oxygen content (DO) have not been federally approved; however, the criteria state that there not be less than 5 mg/l in 16 of 24 hr and that there be not less than 3 mg/l at any time. Since nearly all of the undiluted discharge from the Unit will be from the cooling tower, DO in the discharge water will be controlled by cooling tower conditions. The cooling tower blowdown, which has had prolonged and intimate contact with air drawn through the tower, will always be saturated with oxygen, with the dissolved oxygen concentration corresponding to the saturation temperature limit. At the maximum tower outlet temperature expected, the oxygen will be 7.1 mg/l.

5.4.1.6 pH

Ohio water quality standards call for a preferred pH range of 6.5 to 8.5, with the daily average within a range of 5 to 9.

The pH of the closed condenser cooling water system will be controlled to a set value, and since the largest quantity of discharge water is from this system, the pH of the discharge water from the units will be a nearly constant 8.0.

5.4.1.7 Toxic Substance

No toxic substances will be used in the station and released to the discharge stream, other than as discussed in this chapter.

5.4.2 BIOCIDE DISCHARGES

The addition of chlorine to the circulating water for cleaning the closed condenser cooling water system will be controlled to maintain 0.5 mg/l residual free chlorine during the chlorination periods at the condenser outlet. Free chlorine in the discharge water will be minimal, and the total residual chlorine will be maintained at a 0.1 mg/l. If required, sodium sulfite, a dechlorination agent, will be used to achieve this limit.

5.4.3 OTHER WATER USE AND DISCHARGE EFFECTS

5.4.3.1 Cooling Tower Drift

The analytical model used to predict the ground deposition of the dissolved solids in the drift released by the cooling towers is the NUS FOG computer code, which has previously been submitted to the A.E.C. ⁽¹⁾ The analysis was based on Toledo Express Airport data. The total rate of dissolved solids released by a system (mass per unit time) is a function of:

- a. The volume flow rate of condenser circulating water (480,000 gpm)
- b. The drift rate expressed as a percentage of the above water flow rate (0.01 percent)
- c. The concentration of dissolved solids within the circulating water (465 mg/l).

Due to the high release height of the drift from the natural draft tower, over 99% of the dissolved solids released from this system will be carried downwind over 20 kilometers. At these large distances the deposition rate in mass/area-time is extremely small. The maximum predicted dissolved-solids deposition from the Davis-Besse Station cooling system is less than

DB-1

0.03 lb/acre-year. Due to the very small deposition rates, no adverse effect on crops, other local terrestrial ecosystems, or local groundwater is anticipated.

The total dissolved solids released in drift from the cooling tower is approximately 270 lbs/day.

DB-1

REFERENCES

1. Toledo Edison Company, Environmental Report, Davis-Besse Nuclear Power Station - Units No. 2 and 3.

5.7 OTHER ENVIRONMENTAL EFFECTS

5.7.1 NOISE

The present sound level in the environs of the site will be affected by the operational noise of the station, principally that from the natural draft cooling tower, the transformers and related electrical equipment in the switchyard, and the turbines, motors, and pumps within the main structure of Unit No. 1.

The dominant noise source will be the natural draft cooling tower, which has a characteristic noise similar to that of a waterfall. Water falling onto the tower fill and thence into the basin, the airflow through the tower, and the circulating pumps and motors produce the noise.

The noise due to the operation of Unit No. 1 has been predicted by using the methods described in Section 6.2.6. The contribution of each noise source to the background noise levels discussed in Section 2.9 has been calculated on a grid with the NUS computer code SOCON, using as inputs the sound power level and grid coordinates of each noise source. The resultant grid point values for the Davis-Besse site were used to construct A-weighted daytime sound-pressure-level contours on a site map (Figure 5.7-1) that includes background noise levels. Figure 5.7-2 shows the values for nighttime, including background noise levels.

The noise-sensitive land use in the form of residences, churches, schools, and hospitals is shown on the base maps in the USGS format. Most houses along the shore of Lake Erie directly north of the site have been abandoned due to recent high lake levels. The houses directly south of the site are summer and/or weekend cottages, many of which have been abandoned. The estimated population within each 5-dBA sound level contour located within

2.5 mi of the site center resulting from the background noise levels and the operational noise levels is given in Table 5.7-1.

The maximum sound level along the site boundary is predicted to be 58 dBA during the daytime period at a point on the west boundary bordering Rt. 2 and 57 dBA during the nighttime period at a point on the north boundary nearest the natural draft cooling tower.

A comparison of the background noise levels and the operational noise levels with the HUD and EPA noise criteria, discussed in Section 6.2.6, is presented in Table 5.7-2, which gives the population for which each noise criterion is exceeded. No persons are expected to be exposed to noise levels exceeding the HUD "normally acceptable" noise criterion.

5.7.1.1 Environmental Factors Affecting Noise Levels

Several environmental factors will tend to reduce or mask the predicted noise levels due to station operation. The model assumes hemispherical spreading of sound waves and atmospheric attenuation. Since hemispherical spreading of sound waves implies perfect ground reflection, the model is conservative in that no credit is taken for ground absorption, which could reduce the predicted values by as much as 3 dBA. Furthermore, no attenuation due to topographical features, vegetation screens, or intervening structures has been assumed. These elements would reduce the predicted sound pressure values.

Meteorological conditions will affect the noise levels at any location, resulting generally in lower sound pressure levels than predicted. Vertical temperature and wind gradients will affect the directivity of the noise source due to the variation of the speed of sound with height. Certain conditions can create a shadow zone into which no sound can penetrate.

TABLE 5.7-1
ESTIMATED POPULATION WITHIN EACH
NOISE LEVEL CONTOUR

Population Within Each Noise Level Contour								
Contour (dBA)	Daytime Background		Nighttime Background		Daytime Operation		Nighttime Operation	
	A	B	A	B	A	B	A	B
> <u>35</u>	---	---	165	412	---	---	231	---
> <u>40</u>	238	412	66	337	243	412	121	412
> <u>45</u>	143	337	0	254	163	365	19	313
> <u>50</u>	73	217	0	180	75	273	10	207
> <u>55</u>	49	7	0	0	53	7	0	0
> <u>60</u>	0	0	0	0	0	0	0	0
> <u>65</u>	0	0	0	0	0	0	0	0
> <u>70</u>	0	0	0	0	0	0	0	0

A = Permanent population.

B = Weekend or seasonal population not counting permanent population.

TABLE 5.7-2

COMPARISON OF NOISE LEVELS IN THE VICINITY
OF THE DAVIS-BESSE SITE WITH HUD AND
EPA NOISE CRITERIA

Population Exceeding Noise Criteria								
Noise Criterion	Daytime Background		Nighttime Background		Daytime Operation		Operation	
	A	B	A	B	A	B	A	B
HUD "acceptable" (<u><</u> 45 dBA)	143	337	0	254	163	365	19	313
EPA (<u><</u> 55 dBA)	49	7	0	0	53	7	0	0
HUD "normally acceptable" (45-65 dBA)	0	0	0	0	0	0	0	0

A = Permanent population.

B = Weekend or seasonal population not counting permanent population.

5.7-4

DB-1

A shadow zone is most commonly encountered upwind from the source, where the wind gradient refracts the sound waves upward. Downwind, the wind gradient refracts the sound waves downward, and no shadow zone is produced. On a sunny day with moderate winds, the sound level inside the shadow is typically 20 to 30 dB lower than for the same distance downwind of the source.

Temperature-induced sound refraction tends to be symmetrical about the source. A shadow zone may completely encircle a source during unstable conditions with a strong negative temperature gradient and low wind speeds, such as on a calm, sunny day. However, there will be no shadow zone during stable conditions with a strong positive temperature gradient and low wind speeds as on a clear, calm night.

When sound is propagated through the atmosphere during moderate winds, or with precipitation present, the background noise levels at the receptor may increase appreciably due to the sound generated by the wind or rain. When snow is on the ground, the background levels normally present are frequently effectively muffled. All of the factors discussed above will either mask or reduce the predicted Unit No. 1 operation noise levels.

5.7.2 URANIUM FUEL CYCLE IMPACTS

Title 10 Part 51.20(e) requires that the contribution of the environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials, and management of low- and high-level wastes related to uranium fuel cycle activities to the environmental costs of licensing the nuclear power reactors be included in the Environmental Report by inclusion of Table S-3 as it appeared in the

September 17, 1974, Federal Register (Table 5.7-3). No further discussion
of environmental effects is required.

TABLE 5.7-3

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS FOR URANIUM FUEL CYCLE*
(Normalized to Model LWR Annual Fuel Requirement)

Natural Resource Use	Total	Maximum Effect per Annual Fuel Requirement of Model 1,000 MWe LWR
Land (acres):		
Temporarily committed.....	63	
Undisturbed area.....	45	
Disturbed area.....	18	Equivalent to 90 MWe coal-fired powerplant.
Permanently committed.....	4.6	
Overburden moved (millions of MT)....	2.7	Equivalent to 90 MWe coal-fired powerplant.
Water (millions of gallons):		
Discharged to air.....	156	~2 percent model 1,000 MWe LWR with cooling tower.
Discharged to water bodies.....	11,040	
Discharged to ground.....	123	
Total.....	11,319	<4 percent of model 1,000 MWe LWR with once-through cooling.
Fossil fuel:		
Electrical energy (thousands of MW-hour).	317	<5 percent of model 1,000 MWe LWR output.
Equivalent coal (thousands of MT).	115	Equivalent to the consumption of a 45 MWe coal-fired powerplant.
Natural gas (millions of scf).....	92	<0.2 percent of model 1,000 MWe energy output.
Effluents--chemical (MT):		
Gases (including entrainment):		
SO ₂	4,400	
NO _x ²	1,177	Equivalent to emissions from 45 MWe coal-fired plant for a year.
Hydrocarbons.....	13.5	
CO.....	28.7	
Particulates.....	1,156	
Other Gases:		
F.....	.72	Principally from UF ₆ production enrichment and reprocessing. Concentration within range of state standards--below level that has effects on human health.
Liquids:		
SO ₄ ²⁻	10.3	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are: NH ₃ --600 cfs NO ₃ -- 20 cfs Fluoride--70 cfs
NO ₃ ⁻	26.7	
Fluoride.....	12.9	
Ca ²⁺	5.4	
Zn ²⁺	8.6	
Ka ⁺	16.9	
NH ₃	11.5	
Fe.....	.4	
Tailings solutions (thousands of MT).	240	From mills only--no significant effluents to environment.
Solids.....	91,000	Principally from mills--no significant effluents to environment.
Effluents--Radiological (curies):		
Gases (including entrainment):		
Rn-222.....	75	Principally from mills--maximum annual dose rate <4 percent of average natural background within 5 mi of mill. Results in 0.06 man-rem per annual fuel requirement.
Ra-226.....	.02	
Th-230.....	.02	
Uranium.....	.032	
Tritium (thousand).....	16.7	Principally from fuel reprocessing plants--Whole body dose is 6 man-rem per annual fuel requirements for population within 50 mi radius. This is <0.007 percent of average natural background dose to this population. Release from Federal Waste Repository of 0.005 Ci/yr has been included in fission products and transuranics total.
Kr-85 (thousands).....	250	
I-129.....	.0024	
I-131.....	.024	
Fission products and transuranics	1.01	
Liquids:		
Uranium and daughters.....	2.1	Principally from milling--included in tailings liquor and returned to ground--no effluents; therefore, no effect on environment.
Ra-226.....	.0034	From UF ₆ production--concentration 5 percent of 10 CFR 20 for total processing of 27.5 model LWR annual fuel requirements.
Th-230.....	.0015	
Th-234.....	.01	From fuel fabrication plants--concentration 10 percent of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Ku-106 ³15	From reprocessing plants--maximum concentration 4 percent of 10 CFR 20 for total reprocessing of 26 annual fuel requirements for model LWR.
Tritium (thousands).....	2.5	
Solids (buried):		
Other than high level.....	601	All except 1 Ci comes from mills--included in tailings returned to ground--no significant effluent to the environment. 1 Ci from conversion and fuel fabrication is buried.
Thermal (billions Btu).....	3,360	<7 percent of model 1,000 MWe LWR.
Transportation (man-rem): Exposure of workers and general public.....	.334	

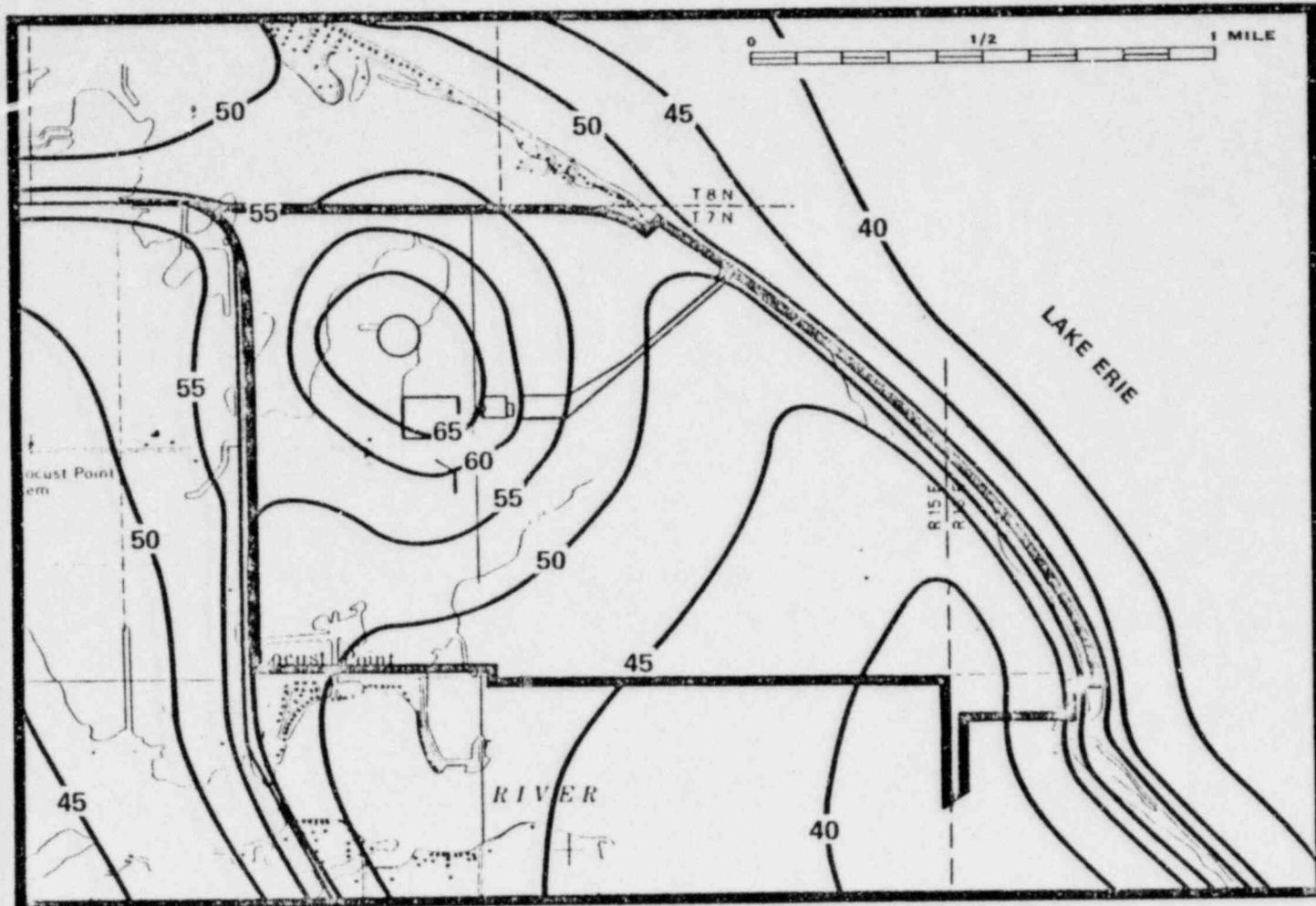
* Table 5-3 from the Federal Register, Vol. 39, No. 181, September 17, 1974.

¹ Estimated effluents based upon combustion of equivalent coal for power generation.

² 1.2 percent from natural gas use and process.

³ Ce-137 (0.075 Ci/AFR) and Sr-90 (0.004 Ci/AFR) are also emitted.

POOR ORIGINAL



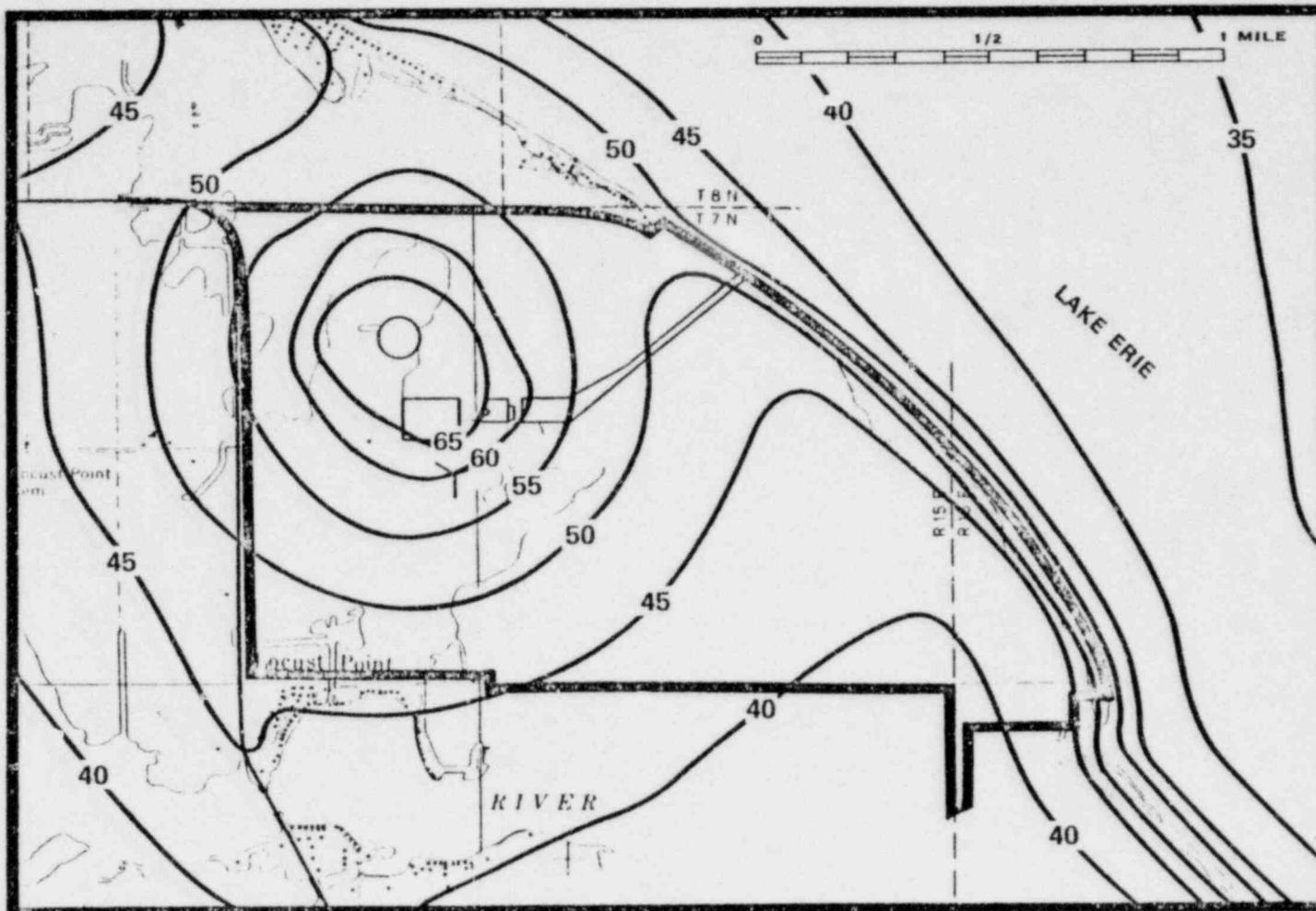
DB-1

POOR ORIGINAL

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1
 DAYTIME OPERATION SOUND PRESSURE LEVEL CONTOURS (dBA)

FIGURE 5.7-1

POOR ORIGINAL



DB-1

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1
NIGHTTIME OPERATION SOUND PRESSURE LEVEL CONTOURS (dBA)

FIGURE 5.7-2

APPENDIX 5A

OFF-SITE RADIATION EXPOSURE
DUE TO THE OPERATION OF THE
DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

OFF-SITE RADIATION EXPOSURE DUE TO THE OPERATION OF
THE DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

Prepared for
The Toledo Edison Company

By
Dan E. Martin and Bruce J. Hickle

September 1974

Environmental Safeguards Division

NUS CORPORATION
4 Research Place
Rockville, Maryland 20850

Approved: Robert L. Schlegel
Robert L. Schlegel
Radiological Systems and
Effluent Impact Section

TABLE OF CONTENTS

	<u>PAGE</u>
I. INTRODUCTION	1
II. SUMMARY AND CONCLUSIONS	4
A. Maximum Individual Exposure	4
B. Population Exposure	6
C. Exposure of Aquatic and Other Organisms	6
D. Conclusions	7
III. RADIATION EXPOSURE FROM GASEOUS EFFLUENTS	8
A. Estimated Gaseous Effluents	8
B. External Exposure from Gaseous Effluents	8
1. Maximum Individual External Exposure	9
2. External Population Exposure	13
C. Internal Exposure from Gaseous Effluents	14
1. Exposure from Inhalation	15
2. Exposure from Ingestion	16
D. Summary of Exposure from Gaseous Releases	21
IV. RADIATION EXPOSURE FROM LIQUID EFFLUENTS	22
A. Estimated Liquid Effluents and Concentrations	22
B. Maximum Individual Radiation Exposure from Liquid Effluents	24
1. Internal Exposure from Water Ingestion	25
2. Internal Exposure from Fish Ingestion	26
3. External Exposure from Swimming	27
4. Radiation Exposure from Other Sources	30
5. Summary of Maximum Individual Exposure From Liquid Releases	34
C. Population Radiation Exposure from Liquid Effluents	34
1. Population Exposure from Water Ingestion	35
2. Population Exposure from Fish Ingestion	36

TABLE OF CONTENTS (Continued)

	<u>PAGE</u>
D. Radiation Exposure of Aquatic Bio-Systems	37
V. DOSE TOTALS AND COMPARISON WITH FEDERAL REGULATIONS AND NATURAL BACKGROUND	41
REFERENCES	43
APPENDIX A	65
APPENDIX B	74

LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
I	Estimated Airborne Effluents from Davis-Besse Nuclear Power Station Unit No. 1	47
II	External Exposure Due to Ground Deposition of Particulates and Iodines	48
III	Estimated 0-50 Mile Population Distribution, 1980	49
IV	Estimated 0-50 Mile Population Distribution, 2000	50
V	Estimated 0-50 Mile Population Distribution, 2020	51
VI	External Population Exposure Due to Gaseous Releases from Davis-Besse Nuclear Power Station Unit No. 1	52
VII	Annual Average X/Q Values, 0-50 Miles	53
VIII	Summary of Maximum Individual Exposure Rates Due to Gaseous Releases from Davis-Besse Nuclear Power Station Unit No. 1	54
IX	Estimated Liquid Effluents and Concentrations from Davis-Besse Nuclear Power Station Unit No. 1	55
X	Annual Average Wind Direction Frequencies at the Davis-Besse Site	56
XI	Applicable Dilution Factors for Potable Water Intakes Within 50 Miles	57
XII	Maximum Internal Body Organ Exposure from the Ingestion of Water and Fish	58
XIII	Concentration Factors for Effluent Radionuclides in Fish	59
XIV	Summary of Maximum Individual Exposure Rates Due to Liquid Releases from Davis-Besse Nuclear Power Station Unit No. 1	60
XV	Data Used to Estimate Population Exposure from Water Ingestion	61

LIST OF TABLES (Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
XVI	Radiation Exposure of Aquatic Biota	62
XVII	Maximum Individual Dose Totals from Davis-Besse Nuclear Power Station Unit No. 1 and Comparison with Federal Regulations and Natural Background Exposure	63
XVIII	Whole Body Population Dose Totals from Davis-Besse Nuclear Power Station Unit No. 1 and Comparison with Federal Regulations and Natural Background Exposure	64

LIST OF FIGURES

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1	Exposure Pathways	3

I. INTRODUCTION

The Davis-Besse Nuclear Power Station will occupy a site area of approximately 954 acres situated on the southwest shore of Lake Erie. The site itself is mostly marshland and will be partially used as a natural wildlife refuge. The nearest large population center is Toledo, Ohio, located about 20 miles west of the plant. Smaller population centers near the site are Fremont, to the south, and Sandusky, to the southeast. Large areas of land around the site are only sparsely populated and support a mostly agricultural economy. Recreational activities such as sport fishing and duck hunting are popular in the region of the site.

It is the purpose of this report to evaluate the radiological impact of normal releases from the Davis-Besse Nuclear Power Station Unit No. 1 on the population and wildlife living in the region of the site. Maximum potential individual radiation exposure rates are evaluated as well as the total integrated population exposures within a 50-mile radius of the facility. Exposure pathways considered include all significant environmental and biological mechanisms by which activity released from Unit No. 1 could conceivably reach the public. Figure 1, Exposure Pathways, presents a visual illustration of those exposure pathways of greatest significance for central station nuclear generating facilities such as Davis-Besse.

This study is based on the annual activity releases (by isotope) that are presented in Section 3.5.

Since the applicable regulations are based on a consideration of average annual dose, this study is directed at determining the doses delivered in a typical year of operation. The estimated doses to individuals and the

population are compared to existing and proposed dose guidelines, to normal background radiation doses, and to other ordinarily acceptable radiation exposure levels. Computational methods employed are in general those suggested or recommended by such bodies as the IAEA, the USAEC, and the ICRP, where such methods are available. In situations where the lack of knowledge has precluded accuracy, conservative assumptions have been made in an attempt to eliminate the possibility of underestimating the particular exposure level.

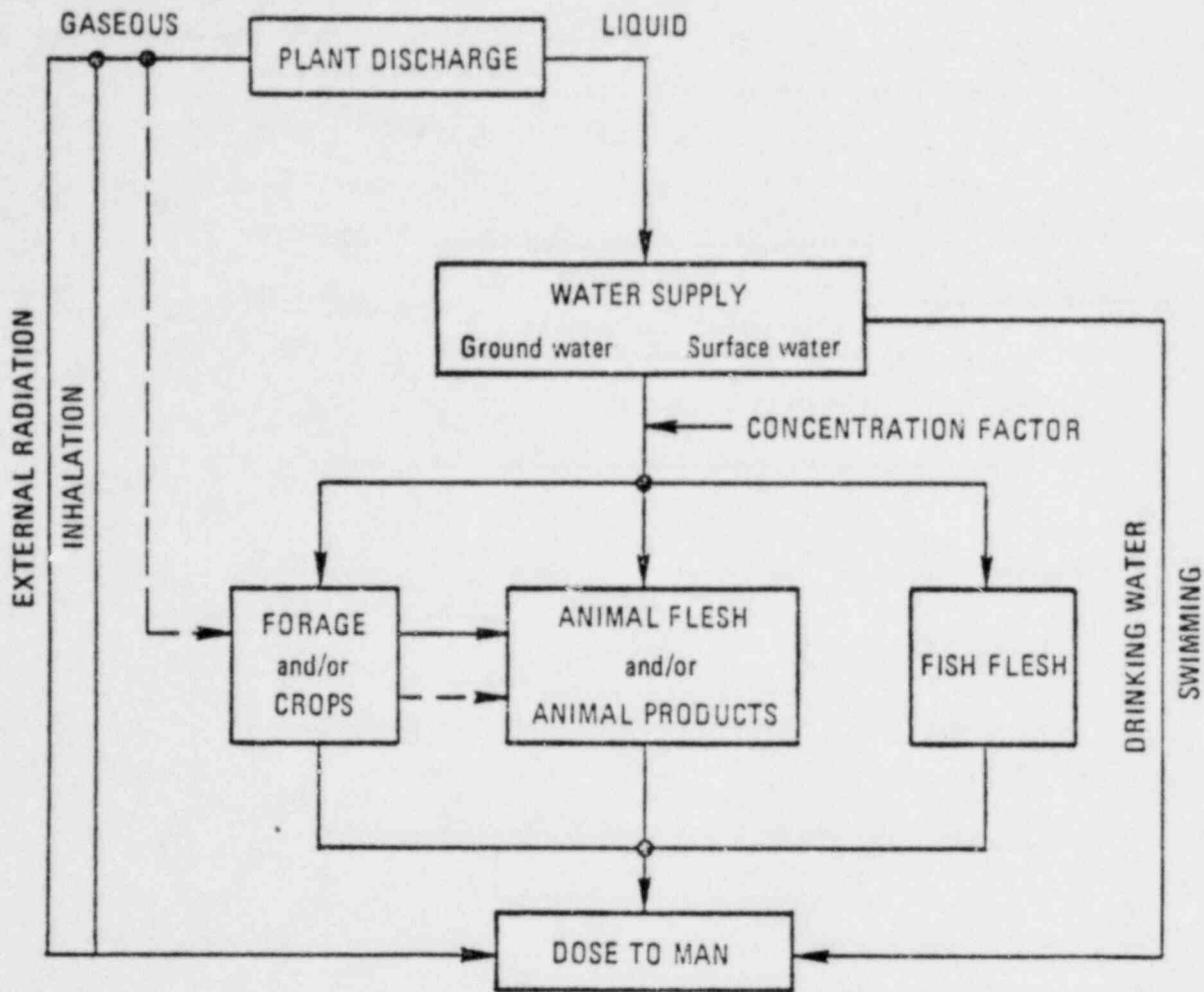


FIGURE 1
EXPOSURE PATHWAYS

II. SUMMARY AND CONCLUSIONS

This report evaluates the maximum expected radiation exposure to the general public or to individuals thereof resulting from the operation of the Davis-Besse Nuclear Power Station Unit No. 1. The expected release rates are based on 0.1% defective fuel cladding.⁽¹⁾ Conservative environmental dilution and concentration factors have been used so that the annual doses calculated in this study are the maximum values that could reasonably be expected to occur due to the normal operation of the Davis-Besse Nuclear Power Station Unit No. 1.

All calculated human exposure levels resulting from the operation of Davis-Besse Nuclear Power Station Unit No. 1 have been found to amount to only small fractions of normally accepted levels of radiation exposure. The applicable limits set by law in 10 CFR 20⁽²⁾ for maximum permissible exposure have not been exceeded or even closely approached.

A. Maximum Individual Exposure

For gaseous releases exposure rates have been calculated for the following exposure pathways: external exposure from cloud immersion and particulate deposition; internal exposure from the inhalation of tritium, iodine, and particulates; and internal exposure from potential food chain transport of iodine and particulates. For liquid releases the exposure pathways examined include water ingestion, fish ingestion, swimming, and sunbathing. The maximum potential whole body exposure to an adult individual from all these sources has been calculated to be 2.7 mrem per year, based on the expected

| 1

release rates and milk ingestion at the nearest known grazing location. The critical organ exposure total from all sources has been estimated to be 4.3 mrem per year to the thyroid. The exposure total to the body surface from all sources has been estimated to be only slightly lower, 3.9 mrem per year. | 1

In assessing the significance of the above exposure totals it should be noted that they represent the sum of the maximum exposure rates for several different exposure pathways, each of which has been evaluated with a high degree of conservatism. It is highly improbable that any individual will ever receive the maximum potential exposure from any of the pathways examined. The probability that any individual will receive them all simultaneously is negligible. Thus, the totals presented only represent upper bounds to the potential exposure, and should not be construed to represent likely exposure rates.

These maximum potential exposure rates are small in comparison with ordinary and acceptable individual radiation exposure levels. For instance, the annual whole body exposure from naturally occurring background radiation in the United States averages about 130 mrem per year.⁽³⁾ The exposure to an individual from a single chest X-ray may be as much as 170 mrem.⁽³⁾ Wearing a particular kind of watch may yield an incremental annual whole body dose of 4 mrem.⁽³⁾ The inhabitation of a stone or masonry dwelling rather than a frame house has been calculated to yield an average additional annual whole body dose of 40 mrem and a maximum annual incremental exposure of over 500 mrem.⁽⁴⁾ Thus, the maximum potential incremental exposure to man from plant contributed radioactivity represents only a small fraction of exposure increments common to ordinary experience.

B. Population Exposure

The largest source of population exposure from the expected plant effluents is due to the external radiation received from the released radiogases. The annual whole body exposure to the surrounding population from this pathway, combined with that due to the particulate releases, is calculated to total 5.5 man-rem in the year 2020. This total is almost fifty times the population exposure calculated to result in that year from liquid releases, including exposure from water and fish ingestion. |1

Total exposure from both gaseous and liquid releases is calculated to range from 4.0 man-rem per year in 1980 to 5.6 man-rem per year in 2020. These exposure rates are dwarfed by the total due to natural background radiation, estimated at 435,000 man-rem per year in the year 2020. |1

C. Exposure of Aquatic and Other Organisms

The maximum potential radiation exposure of aquatic biota has been evaluated on an extremely conservative basis. The calculated exposure levels, presented in Table XVI, are based on the continuous presence in Lake Erie of the annual average discharge concentrations of all radionuclides. Also, it has been assumed that radioactivity concentrations in the sediment may be as much as a thousand times those in the ambient water. These assumptions maximize the potential exposure levels to aquatic biota and minimize the probability of occurrence. The maximum resulting exposure rate is about 28 mrad per year to bottom-feeding fish.

The dose to bottom-dwelling invertebrates is calculated to be about 27 mrad per year, using the same conservative basis. Most of this exposure is due to the high levels of radioactivity assumed to exist in the bottom sediment.

For a fish which does not normally dwell at the lake bottom, the annual exposure from all internal and external sources is calculated to be 2.5 mrad.

If credit is taken for dilution of the discharge in the lake, the dose estimates are substantially reduced. These reduced exposure levels are much more realistic in terms of expectancy than those based on widely pervasive undiluted discharge concentrations.

Regarding terrestrial animals, they will be subject to radiation exposure via the same pathways that have been extensively evaluated for man. There will be essentially no difference in the calculated external exposure rates, and it is not expected that internal exposure will be significantly different.

This analysis has resulted in no estimated exposure level which approaches the guideline in 10 CFR 20⁽²⁾ for the maximum permissible radiation exposure of man (500 mrem/yr.). In view of this and the extreme conservatism of the models and assumptions employed in the derivation of the doses, it is concluded that no significant radiological hazard to the aquatic population of Lake Erie or to other wildlife will occur due to the operation of the Davis-Besse Nuclear Power Station Unit No. 1.

D. Conclusions

All known environmental and biological phenomena which could possibly lead to significant radiation exposure of man have been investigated in detail. The calculation models, assumed biological parameters, and environmental concentration and dilution factors have all been conservative in nature. Therefore, the calculated exposure rates to which man might potentially be subject are the highest that could reasonably be expected to occur from the operation of Davis-Besse Unit No. 1. These rates comply with all applicable Federal Regulations and the proposed amendments to 10 CFR Part 50 embodied as Appendix I.

III. RADIATION EXPOSURE FROM GASEOUS EFFLUENTS

There are a number of pathways through which persons offsite may be exposed to the gaseous radioactivity released from nuclear power plants. From Figure I, three general pathways may be identified: direct radiation exposure, inhalation exposure, and exposure through food chains. The relative importance of these exposure pathways is determined by the isotopic composition and quantities of the released radiogases as well as the site environment.

A. Estimated Gaseous Effluents

The estimated annual gaseous release for the Davis-Besse Nuclear Power Station Unit No. 1 is presented in Table I. The values are presented in Section 3.5.

For the purposes of this report, all gaseous releases are assumed to occur at ground level and to be continuous rather than intermittent, although intermittent releases under more favorable meteorological conditions could further reduce the calculated exposures.

B. External Exposure from Gaseous Effluents

From Table I it can be seen that the gaseous activity releases are expected to be comprised of noble gases, iodines and other particulate matter, and tritium. Two modes of external exposure have been considered for these releases. For tritium and the noble gases the critical mode of external exposure is from direct radiation due to ambient air concentrations. For

particulates and iodines the critical external exposure is from the buildup of these materials on or in the ground due to the phenomenon of ground deposition.

Neither the noble gases nor tritium will deposit onto the ground under normal conditions. This exposure pathway is therefore treated only for iodines and particulates. The calculation of external exposure due to the radioactive cloud has, however, included all released radioactive materials.

1. Maximum Individual External Exposure

The site boundary external dose rate depends in general on the source terms, the applicable atmospheric diffusion, and the receptor characteristics. For the purpose of estimating the maximum potential annual exposure a hypothetical "maximum individual" is assumed to reside at the site boundary continuously over the full period of one year. The individual is also assumed to be unshielded by clothing or housing which would normally provide a dose reduction factor of 2 or more.

All forms of external exposure will depend directly upon the annual average site boundary air concentrations, which in turn depend on the atmospheric dispersion parameter, x/Q (sec/m^3). The maximum value of x/Q at the Davis-Besse site boundary, for annual average meteorology, has been determined to be $5.17 \times 10^{-6} \text{ sec}/\text{m}^3$. This value applies at a location on the site boundary to the north-northeast of the Unit No. 1 containment structure. The meteorological data from which this value was calculated were collected on the site over the period December 1, 1969, to November 30, 1970, at a height above ground of 20 feet. The meteorological data and the annual average x/Q values are discussed in Section 2.3.5 of the Davis-Besse Nuclear Power Station Unit No. 1 Final Safety Analysis Report.

a. External Exposure from the Radioactive Cloud

When immersed in a cloud of radioactive material, a receptor individual will be subject to penetrating gamma radiation as well as short range beta radiation. Irradiation by gamma rays will generally yield a relatively homogeneous exposure of the whole body. The beta rays of concern here will yield exposure only of the outermost tissues of the human body;⁽⁵⁾ this is due to their short range in human flesh, which is on the order of one centimeter or less. Human tissues at risk from beta radiation include the skin, the lens of the eye, and, for the more energetic betas, male gonads.

In order to estimate the potential exposure rate the "infinite sphere" model has been used, as recommended by the International Commission on Radiological Protection (ICRP) and other authoritative bodies.^(6,7) The basic assumption of the model is that the absorbed dose rate at any point inside an infinite homogeneous sphere of uniform radioactivity concentration is equal to the energy release per unit mass. The concentrations are taken to be equal to the annual average at the location of interest. The dose rate to a ground level receptor from a surrounding cloud of radioactivity is taken to be one half that given by the infinite sphere approach. This is because, for gamma radiation, the receptor is only irradiated from one half the total available solid angle; for beta radiation the factor of 0.5 accounts for the self-shielding of the human body. The dose rate is also adjusted upward by a factor of 1.13 to account for the increased stopping power of human tissue relative to air.⁽⁶⁾ Use of this model has been demonstrated to lead to conservative results.⁽⁸⁾

Assuming that only gamma radiation will contribute to whole body exposure, the resulting maximum site boundary whole body exposure rate due to cloud immersion has been calculated to be 1.4 mrem per year. This exposure rate |1

is based upon the maximum site boundary λ/Q value of 5.17×10^{-6} sec/m³, the release rates presented in Table I, and the use of the infinite sphere model. The sources of disintegration energies and formulas used in the calculation are presented in Appendix A. The exposure to the skin, lens of the eye, and gonads, based on both beta and gamma exposure, is calculated to be 2.1 mrem per year. It may be noted that of the total exposure, only a very small fraction is due to materials other than the noble gases. |1

b. External Exposure from Ground Deposition of Particulates and Halogens

The natural deposition of particulates and iodines onto grasses and soils is a familiar and important phenomenon. The rate of deposition can be obtained from the annual average air concentration by application of a quantity known as the deposition velocity. The continuous deposition onto ground of a radioactive material will cause a monotonically increasing ground concentration which will eventually approach a limiting, or equilibrium value. This equilibrium ground concentration will be reached when the loss due to radioactive decay just balances the rate of deposition. For the very long lived isotopes this condition will not be reached within the expected station lifetime. Thus, ground concentrations have been calculated at the site boundary for each of the particulate and iodine isotopes in Table I for the years 1980, 2000, and 2020.

Proper dose conversion parameters have been applied to estimate the beta and gamma exposure rates at the critical height of 1 meter above ground level. (9,10) The maximum ground concentrations and resulting exposure rates (for significant isotopes) resulting from these calculations are presented in Table II. Beta exposure has been reduced by a factor of 2 to account for self-shielding of the human body. (5)

As before, only the gamma component of the total exposure rate is assumed to yield whole body radiation. It can be seen from Table II that only three isotopes contribute substantially to the whole body exposure rate. These isotopes are: I-131, I-133, and Cs-137. The total whole body exposure rate is calculated to be 0.032 mrem/yr in 1980, 0.032 mrem/yr in the year 2000, and 0.032 mrem/yr in the year 2020. | 1

The exposure rate to the body surface will be increased by the beta component and is therefore higher than the whole body exposure rate. The isotopes contributing significant beta exposure are: I-131 and I-133. The total body surface exposure from beta and gamma sources is calculated to be 0.066 mrem/yr in 1980, 0.067 mrem/yr in the year 2000, and 0.068 mrem/yr in the year 2020. | 1

In analyzing the exposure resulting from this pathway, it has been assumed that once deposited on the ground, all isotopes except Cs-137 will remain at the surface. Due to its very long half-life and the natural phenomena of percolation cesium fallout on soil eventually establishes a concentration in soil ($\mu\text{Ci}/\text{cm}^3$) which is depth dependent. Analysis of Cs-137 concentrations in soil due to fallout has established that the typical distribution is such that the ground concentration decreases exponentially as the depth increases. ^(11, 12) An investigation by Beck ⁽¹²⁾ has revealed that this distribution is attained in a relatively short interval (1 to 2 years) and can be described mathematically by a relaxation length which will vary from place to place depending upon local conditions of soil and precipitation. A normal range is from 3 to 8 centimeters. ⁽¹²⁾ As shorter relaxation lengths imply that the average depth of penetration is less, thus reducing the available shielding, a value of 3 centimeters has been used in this analysis. The details of the calculation and the equations used are fully presented in Appendix A.

The results of the calculations are presented in Table VI. As for maximum individual exposure, the doses resulting from cloud immersion are much higher than those due to particulate deposition. No allowance has been made for plume depletion as the particulate matter is transported away from the site. At the large distances involved plume depletion during transport will be effective in reducing the dose rates although no credit for this phenomena is taken here. It is interesting that although the total population exposure is shown to increase in time, the per capita exposure remains almost constant.

The segment average dose rate has been taken to be the dose rate of the geometric midpoint of the segment. Annual average x/Q values have been used to estimate segment average dose rates. Values presented in Section 2.3.5 of the Davis-Besse Nuclear Power Station Unit No. 1 Final Safety Analysis Report were logarithmically interpolated to arrive at x/Q values when necessary. The x/Q values utilized in this analysis are presented here in Table VII. |1

C. Internal Exposure from Gaseous Effluents

The radioactive content of the gases released at Davis-Besse must be either inhaled, ingested, or absorbed through the skin in order to yield internal radiation exposure. Skin absorption is significant only for the released tritium which in the form of HTO can pass through the skin with relative ease.⁽¹⁷⁾ Exposure through ingestion requires the physical transport of the radioactive materials through some form of food chain. In this regard, only the released iodines and particulates are of concern.

Since the noble gases do not react chemically with other substances under normal conditions, there is no physical basis for their transport through food chains or reconcentration within the human body for these gases.

In terms of continued inhalation and absorption in the body, both krypton and xenon may develop in physical solution, chiefly in the body water and fat. ⁽¹⁸⁾ Several human exposure experiments revealed that inhalation of relatively large amounts of radioactive noble gases resulted in very low tissue exposures. ^(19,20) In general, it may be estimated that the internal dose from radioactive noble gases dissolved in body tissue following inhalation from a cloud is negligible, i.e., less than 1% of the associated external whole body dose. ⁽²¹⁾ Thus, the resultant doses from exposure to noble gases are considered to be external whole body doses only.

Potential exposure due to inhalation is of relative importance only for the released tritium and iodine. However, it has been evaluated for other particulate discharges as well.

1. Exposure from Inhalation

Exposure due to inhalation of tritium, iodine, and other particulates will depend directly on the estimated daily inhalation intake. This quantity can be obtained by multiplying the annual average air concentration times the volumetric breathing rate. The necessary equation is as shown below:

$$A(\text{ Ci/day}) = Q(\text{ Ci/yr}) \times x/Q(\text{ sec/m}^3) \times \text{BR}(\text{ m}^3/\text{ sec}) \times \frac{1 \text{ yr}}{365.25 \text{ days}}$$

The quantity BR is the breathing rate which for the standard man is equal to $2.32 \times 10^{-4} \text{ m}^3/\text{ sec}$. ⁽⁶⁾

a. Iodine Inhalation

The formula above has been used to estimate the rate of iodine activity intake at the site boundary by a maximum individual. Due to the preferential

concentration of iodine in the thyroid gland, the resulting whole body dose is negligible in comparison to the resulting thyroid exposure, which is calculated to be 0.51 mrem per year for an adult. Due to the small size of the thyroid gland in a child (the thyroid exposure is inversely proportional to the mass of the thyroid), the thyroid exposure via this pathway is increased for a small child, amounting to 0.82 mrem per year. The calculational model and equations used to arrive at these exposure estimates, and all others in this section of the report, are presented in Appendix A of the report. The dose conversion parameters used to estimate adult thyroid exposure are those contained in the AEC publication TID 14844, "Calculation of Distance Factors for Power and Test Reactor Sites."⁽²²⁾ These parameters are presented below and illustrate the relative importance of I-131 for this exposure pathway:

<u>Iodine Isotopes</u>	<u>Rem per Curie Inhaled</u> ⁽²²⁾
I-131	1.48×10^6
I-132	5.35×10^4
I-133	4.00×10^5
I-134	2.50×10^4
I-135	1.24×10^5

The greater dose-effectiveness of I-131 is due primarily to its relatively long eight day half-life in comparison to the other isotopes.

• b. Tritium Inhalation

The average amount of tritium inhaled daily by a standard man at the site boundary has been determined to be 9.46×10^{-3} microcuries per day. However, due to the phenomenon of skin absorption this intake does not represent the total source. As estimated by the ICRP⁽⁶⁾ the total tritium intake from inhalation and skin absorption can be conservatively determined

to be equal to twice that due to inhalation alone. As there is essentially no difference in the exposure from this mode of tritium uptake by the body and that due to tritium intake via water ingestion, the resulting exposure has been computed using methods and equations outlined in Appendix B. The total daily tritium intake has been taken to be 1.89×10^{-3} microcuries per day. |1

The resulting exposure has been determined to be 0.088 mrem per year the whole body. The maximum calculated organ dose has been determined to be 0.11 mrem per year to the thyroid. Doses to other organs except the bone are between the exposure rates for the thyroid and whole body. The bone dose has been computed to be 0.053 mrem per year. |1

c. Particulate Inhalation

The maximum potential whole body, skin, and thyroid doses due to the inhalation of released particulates have also been evaluated. The doses calculated to arise from this source-pathway combination are negligible in comparison to those discussed above due to iodines and tritium. The calculated maximum annual average adult whole body dose due to particulate inhalation is 7.93×10^{-6} mrem per year. The calculated skin and thyroid doses are also 7.93×10^{-6} mrem per year.

2. Exposure from Ingestion

The radioactive particulate and iodine emissions from Davis-Besse are expected to be involved in food chain transport to man after ground deposition. The potential uptake in food crops of several of the released isotopes is a well documented phenomena.⁽²³⁾ However, the critical exposure pathway to man is via the milk route,^(13,15) especially for the isotopes

of greatest concern here, I-131, I-133, and Cs-137. As can be seen in Table II, these three isotopes constitute very nearly all of the ground activity resulting from particulate deposition. Actually, I-131 alone accounts for most of the activity. Material deposited on the ground may be present in the grasses ingested by grazing cows. This will be caused by direct foliar retention and uptake from the soil by roots. After ingestion by the cow, these radioactive materials will be transferred to the cow's milk which may be subsequently ingested by man. The potential intake by man will depend on the assumed milk ingestion rate and the activity concentration of the milk produced. In estimating the potential activity levels in milk, the method of Bryant⁽¹³⁾ has been used for Cs-137. The potential I-131 and I-133 concentrations have been obtained using a different model which is discussed later.

The potential Cs-137 milk activity level has been estimated using the following equation:

$$C(\text{pCi/l}) = P_r F_r + P_d F_d$$

where:

- C = the resulting milk concentration, pCi/l
- F_r = the rate of deposition, mCi/km²-yr
- F_d = the deposit in the previous two years, mCi/km²
- P_r = the deposition rate factor, (pCi/l)/(mCi/km²-yr)
- P_d = the soil factor, (pCi/l)/(mCi/km²)

The above formulation has arisen from an analysis of data from surveys of milk contamination due to Cs-137 fallout on pasture. The parameters P_r and

P_d are proportionality factors and are designed to account for grass contamination by direct foliar retention and plant base absorption (P_r), as well as indirect contamination by uptake from soil (P_d). Values of these proportionality factors have been estimated by the method of least squares to be 3.6 for P_r and 0.65 for P_d .⁽¹³⁾

The meaning of the parameter F_d is related to the ability of cesium to percolate downward in soil, as previously discussed in relation to external exposure from particulate deposition. It should be noted that Bryant's formula is strictly empirical in nature; i.e., it is designed for the exclusive purpose of describing the best available scientific data.

The nearest known location of grazing milk cattle is approximately 2.4 miles to the WSW of the station. At this location the annual average X/Q value is 1.09×10^{-7} sec/m³. Using a deposition velocity of 0.2 cm/sec the calculated maximum potential milk concentration of Cs-137, due to Davis-Besse, is 1.03×10^{-4} pCi per liter.

The maximum potential I-131 and I-133 milk concentrations are based on a different model, using an assumed deposition velocity of 1×10^{-2} meters per second.^(14, 15) The formula necessary to compute these concentrations is presented below:

$$C(\text{pCi/l}) = Q(\text{Ci/yr}) \times \left(\frac{\text{sec}}{\text{m}^3} \right) v_g \left(\frac{\text{m}}{\text{sec}} \right) \frac{T_g(\text{days})}{0.693} \frac{K [(\text{pCi/l})/(\text{pCi/m}^2)]}{365.25 \text{ days/yr}}$$

$$\dots \times 10^{12} (\text{pCi/Ci})$$

where:

C = the resulting milk concentration, pCi/l

Q = the source term, Ci/yr

- x/Q = the atmospheric dispersion factor, sec/m^3
 V_g = the deposition velocity, m/sec
 T_g = the effective halflife on the ground, days, and
 K = the milk to grass activity ratio, $(\mu\text{Ci}/\text{l})/(\mu\text{Ci}/\text{m}^2)$

The effective halflife on grass for I-131 is obtained by combining the halflife due to weathering, about 13 to 14 days, ^(15,24,25) with the radiological halflife of about 8 days. The resulting value of T_g is 5 days. The value of K has been estimated from field data obtained by Booker ⁽¹⁶⁾ following the Windscale accident of 1959 and is taken to be 0.091 $(\text{pCi}/\text{l})/(\text{pCi}/\text{m}^2)$. Use of these values and the above formula leads to an estimated maximum potential I-131 milk concentration of 1.52 pCi per liter. | 1

For I-133 the value of T_g is approximately equal to the radiological halflife of 0.867 days. The value of K for I-133 is taken to be half that for I-131, ⁽²⁶⁾ or 0.045 $(\text{pCi}/\text{l})/(\text{pCi}/\text{m}^2)$. The resulting maximum potential I-133 milk concentration is then 0.017 pCi per liter. | 1

The above calculated milk activity levels will apply only during the six months of the year that milk cattle usually graze on open pasture. ⁽²⁷⁾ During the remainder of the year, milk activity levels due to Davis-Besse are assumed to be negligible. Assuming a daily milk ingestion rate of 0.5 liters per day, an adult might ingest up to 0.009 pCi of Cs-137, 46.2 pCi of I-131, and 3.29 pCi of I-133. A young child, drinking milk at an average of 1.0 liters per day might ingest twice as much activity as an adult. The resulting doses are greatest to the human thyroid gland, amounting to 0.090 mrem/yr for an adult and 0.88 mrem/yr for a child. Potential exposure to the whole body or other organs is negligible in comparison to the potential thyroid exposure. The methods and equations utilized to evaluate the doses for this pathway are presented in the appendices of this report. | 1

D. Summary of Exposure from Gaseous Releases

In an effort to unify the results of this section of the report, Table VIII has been drawn up, illustrating the calculated maximum individual exposure rates from the maximum expected gaseous releases for the whole body, body surface, and thyroid. Results are presented for adult and child exposure and are primarily based on exposure at the worst site boundary location. Doses due to milk ingestion (food chain transport) have been calculated for the nearest known actual grazing location of milk cattle.

The greatest total exposure rate from all pathways combined is calculated for the body surface. The total body surface dose rate from all pathways, for gaseous effluents, amounts to an estimated 2.3 mrem per year for an adult or a small child. Almost all of this exposure, 2.1 mrem per year, is estimated to occur due to cloud immersion. Doses due to cloud immersion have been conservatively calculated using the ICRP "infinite sphere" model and assuming that all beta and gamma radiations contribute to the total dose.

Population exposure totals have been calculated for both external exposure pathways and have been presented earlier in Table VI. As internal exposure is generally less significant than external exposure, the exception being the milk ingestion pathway, population exposure has not been calculated for internal exposure. Exposure to iodine, via inhalation or ingestion does not cause a significant whole body exposure which is the primary concern for exposure of large population groups. (6)

IV. RADIATION EXPOSURE FROM LIQUID EFFLUENTS

When it becomes necessary to discharge liquid radwaste from the Davis-Besse Nuclear Power Station Unit No. 1, it is planned that the liquid waste will be injected into a dilution flow consisting of: 1) the normal cooling tower blow-down flow and 2) an extra dilution flow of approximately 10,000 gpm.⁽²⁸⁾

The annual average cooling tower blowdown flow is expected to be 8,125 gpm.⁽²⁸⁾ Thus, the average total dilution flow into which radwaste will be released amounts to an estimated 18,125 gpm. This dilution flow rate and an assumed mixing factor of 0.8⁽¹⁾ have been used to derive annual average discharge concentrations of radioactivity from estimated total annual activity releases. The estimated annual activity releases and the calculated annual average discharge concentrations for liquid effluents are presented in Table IX.

A. Estimated Liquid Effluents and Concentrations

In this report maximum potential individual exposure is conservatively based on the estimated annual average discharge concentrations of radioactivity as presented in Table IX. Also of concern is the total integrated population exposure due to liquid releases of activity. Since the population groups affected are at relatively large distances from the site, it is necessary to obtain some estimate of the maximum radioactivity concentrations due to the plant as a function of lake transport distance and direction.

The modified Fickian dispersion model provides an adequate mathematical approach for predicting minimum dispersion effects in Lake Erie as a function of distance and direction.

It yields the following equation for predicting the plume centerline concentrations:

$$C(x) = \frac{1.59 \times 10^{-3} Qf}{x}$$

where:

- $C(x)$ = average centerline concentration, $\mu\text{Ci/cc}$
- Q = point source continuous release source term, $\mu\text{Ci/sec}$
- x = the downstream distance, centimeters, and
- f = frequency of surface flow in the direction of interest.

Due to the mathematical nature of the model, concentration predictions obtained with it are too high near the point of release. Its use here is restricted to distances large enough to avoid the region of initial mixing.

The concentration predictions must be weighted by an assumed frequency of flow in the direction of interest. Annual average wind directional frequencies, presented in Table X of this report, have been used to establish the necessary values of the parameter "f". Winds out of the following directions are assumed to produce a surface current lake flow to the WNW, towards Toledo and Oregon: SSE, SE, ESE, and E. Winds out of the ENE, NE, NNE, N, and NNW are assumed to produce surface currents to the SSE, towards Camp Perry, Port Clinton, and Sandusky. Thus, the frequency of flow towards Toledo, after accounting for calms, is about 17%, and about 21% towards Camp Perry.

Effective dilution factors have been obtained for the locations of concern by taking the ratio of the annual average discharge concentration for tritium and the concentrations predicted by the model. At the maximum expected station

liquid release rate of 350 curies per year the annual average discharge concentration for tritium is calculated to be 1.24×10^{-5} $\mu\text{Ci/cc}$. The predicted tritium concentrations at the locations of interest and the derived dilution factors are presented below in Table XI. The derived effective dilution factors are utilized to predict the annual average radioactivity concentrations at the potable water intakes for the given locations.

B. Maximum Individual Radiation Exposure from Liquid Effluents

In the region of the Davis-Besse site, Lake Erie contains some pollutants from industrial and municipal wastes. In the immediate vicinity of the site (at the point of discharge) it is not expected that any individual will consume as potable water the station liquid effluent either before or after discharge to Lake Erie. Nor is it expected that any individual will swim extensively in these same waters, although this is very much more likely than the water ingestion mentioned above. However, for the purpose of establishing the maximum potential individual radiation exposure due to the normal operation of the Davis-Besse Nuclear Power Station Unit No. 1, the following "maximum individual" is hypothesized:

- 1) the maximum individual is assumed to consume 1.2 liters daily of the Unit No. 1 liquid discharge. This water ingestion represents the tap water intake that will adequately sustain an average adult male, as determined by the ICRP;⁽⁶⁾
- 2) the maximum individual is assumed to consume 50 grams daily of fish grown since birth in waters containing annual average discharge concentrations of all radionuclides; and
- 3) the maximum individual is assumed to swim 200 hours per year in waters containing the annual average discharge concentrations of all radionuclides.

Other less significant exposure pathways are also considered.

1. Internal Exposure from Water Ingestion

Although it is extremely unlikely that any individual will ever drink water directly from the Unit No. 1 discharge, maximum individual exposure is calculated on this basis and presented as an upper limit to the potential drinking water ingestion dose. The assumed intake rate is 1.2 liters per day. This represents the entire daily tap water requirement of a "standard man", as recommended by the ICRP.⁽⁶⁾

The ingestion of radionuclides will generally cause an uneven distribution of dose within the human body. Some elements, hydrogen in particular, become rather evenly distributed. Others, such as iodine or cesium, are preferentially taken up by certain body organs. These phenomena produce particular organ doses which can be either higher or lower than the associated whole body dose.

The array of particular organ doses due to the hypothesized water ingestion has been calculated using the NUS computer code DOSCAL. The results of this calculation are summarized in Table XII, "Internal Body Organ Exposure from Ingestion of Water and Fish". Calculational methods used in DOSCAL are generally those advocated by such bodies as the ICRP, the IAEA (International Atomic Energy Agency) and the USAEC.

The highest dose to the maximum individual from this route of exposure is calculated to be 1.4 mrem per year to the thyroid. Of this total about 64% is due to tritium. The remainder is almost entirely due to the five isotopes of iodine. The total annual whole body exposure from this route is calculated to be 0.69 mrem of which over 99% is due to tritium alone.

It should be noted that the nearest known potable water intake, from the point of discharge, is located about 5.8 kilometers distant to the southeast. Concentrations of radionuclides at the water intakes at this location have been conservatively estimated to be a factor of 2400 lower than at discharge. Thus, the actual expected doses from water ingestion are at least a factor of 2400 lower than the maximum hypothetical doses. Water treatment facilities often have the capacity to substantially reduce radioactive content in water prior to distribution to the public.⁽²⁹⁾ No credit is assumed either for this or for radioactive decay in transit.

2. Internal Exposure from Fish Ingestion

A number of factors are required to compute the internal doses from ingestion of fish which might conceivably contain radioactivity from the Unit No. 1 liquid effluents. In addition to the activity concentrations in the waters of interest, the concentration of the activity in the fish and the amount consumed must be established.

Aquatic organisms, through biological processes, have the ability to concentrate radionuclides. This concentration of activity in aquatic organisms, which are in turn ingested by man, must be considered in determining the possible dose to man. The ratio of the concentration of a radionuclide in an aquatic organism to that in the ambient water is known as the concentration factor (CF). The concentration factor varies among the different radionuclides. Also, the concentration may vary considerably between different organs of an organism. For the dose calculations in this report, appropriate concentration factors were used for the edible portions of fish and are shown in Table XIII.

In order to determine the dose to humans, the quantity of fish eaten must be estimated. The dose model used postulates that the maximum individual consumes 50 grams of fish flesh every day. This is about equal to the seafood consumption reported for commercial fishermen⁽³¹⁾ and about four times the annual per capita consumption of seafood in the United States.⁽³²⁾

The various maximum doses to an individual have been calculated by the NUS computer code DOSCAL and are presented in Table XII. The ingested fish was assumed to have concentrations of all radionuclides in the edible flesh equal to the annual average discharge concentration times the appropriate concentration factor. The highest dose calculated for this exposure pathway amounts to 0.43 mrem per year to the thyroid. Whole body exposure from this exposure pathway is calculated to amount to 0.10 mrem per year.

There is a low probability of any individual receiving the exposures summarized above, for several reasons. First, rapid dispersion of the heated effluents containing these radionuclides will occur, thus eliminating any sizeable area of Lake Erie as having annual average concentrations of radioactivity approaching the annual average discharge concentrations. Second, the probability of an individual eating fish obtained only from a single location is very low. Finally, fish are highly mobile and are not likely to remain near the discharge point throughout the year, particularly in the warmer seasons; in winter, access for fishing is likely to be limited. In view of these facts, fish ingestion doses presented above are considered to be quite conservative.

3. External Exposure from Swimming

The external exposure of an individual by submersion in waters containing the radioactive effluents of the Davis-Besse Unit No. 1 is presented only to

further insure the completeness of this report. Not only is such exposure extremely unlikely, but the direct irradiation of humans while swimming presents only a minor exposure pathway. The radionuclide that will be present in the station discharge in the highest concentration is tritium which yields only weak beta radiation upon decay. The beta particles emitted from decaying tritium nuclei do not have sufficient energy to penetrate the human skin and therefore, cannot contribute externally to a whole body dose. As with external exposure from gaseous releases, the beta component of the total exposure is assumed to irradiate only the body surface. Only gamma radiation is assumed to contribute to whole body exposure.

The external exposure to swimmers may be conservatively estimated by assuming that the swimmer is completely immersed in an infinite medium of uniform concentration and receives the same dose as the water itself. The expression for the dose rate is given for each radionuclide by:

$$R(\text{rem/hour}) = \frac{C_w}{\rho_w} \bar{E}_{\beta,\gamma} (3600 \frac{\text{sec}}{\text{hour}}) (3.7 \times 10^4 \frac{\text{dis}}{\text{sec}-\mu\text{Ci}}) \dots$$

$$\dots (1.6 \times 10^{-6} \frac{\text{ergs}}{\text{MeV}}) (10^{-2} \frac{\text{gm-rad}}{\text{erg}}) (\text{RBE}) (\text{gf})$$

where:

- C_w = the concentration in water of the radionuclide, $\mu\text{Ci}/\text{cc}$;
 ρ_w = the density of the water, 1.0 grams/cc;
 $\bar{E}_{\beta,\gamma}$ = the average disintegration energy (beta or gamma) of the radionuclide, MeV;
 RBE = the "relative biological effectiveness" for the radiation involved, rem/rad;⁽⁶⁾
 and gf = the "geometry factor".

Utilization of the model to compute human exposure from swimming involves the following assumptions which tend to overestimate the dose:

- 1) the receptor is surrounded by a body of water of infinite dimension;
- 2) the concentrations of radioactivity are everywhere uniform.

The value of the RBE is unity for all radiations of interest except for the weak tritium betas for which the RBE is equal to 1.7.⁽⁶⁾ The geometry factor is designed to account for the fraction of the total solid angle from which radiation may be received. For gamma radiation the value of gf is taken to be unity for all radionuclides. This is conservative because the receptor is usually near the surface where gamma radiation from the water comes only from half the total solid angle. For beta particles the gf is taken to be equal to 0.5. This is done to account for the significant self-shielding of the human body against fission product beta radiation; the fission product betas of concern here have a range in human flesh on the order of one centimeter or less.

Tritium, which emits no gammas and only very soft betas, contributes only an external skin dose. The infinite sphere model remains applicable and the dose may be calculated with the equation given above. However, due to the fact that the normally held water in the skin and the water external to the skin rapidly equilibrate through exchange processes the value of the gf is taken to be unity; i.e., beta irradiation of the skin from tritium comes from all directions.*

* Tritiated water has been found to pass through the skin with a half-time of about three minutes.⁽¹⁷⁾ Tritium passing into the body in this manner is negligible in comparison to the tritium uptake via water ingestion, assumed to be 1200 cc's/day.

Application of the above method yields a whole body submersion dose rate from gamma radiation of 3.9×10^{-6} mrem per hour. The associated body surface exposure rate is much higher, largely due to the tritium component, amounting to 2.7×10^{-4} mrem per hour. Assuming that the maximum individual will swim 200 hours per year in the discharge region, the potential annual exposure from this pathway is about 8.0×10^{-4} mrem per year to the whole body and 0.055 mrem per year to the body surface.

4. Radiation Exposure from Other Sources

Two remaining exposure pathways for liquid radwaste are discussed in this section. These pathways are of lesser significance than those previously discussed. Other exposure pathways of negligible significance and therefore not discussed further are:

- 1) the drinking of lake water by animals, flesh from which is subsequently eaten by man;
- 2) the uptake of lake water in crops, via irrigation, which are subsequently eaten by man; and
- 3) the seepage of lake water into the ground water table from which water may be taken via wells.

These exposure pathways are ignored due to their relative insignificance in comparison to the pathways considered.

A potentially significant exposure pathway does exist for persons sunbathing or walking along the shore of the lake. The radionuclides in the liquid wastes discharged to Lake Erie by the Davis-Besse Unit No. 1 can be expected to accumulate to some degree on the bottom sediments and the shoreline sand. The affected area would be limited to approximately the area of the shore between the low and high water marks.

The concentrations of the radionuclides on the shore are influenced by the dilution that occurs in the lake, the chemical composition of the effluent as well as the aquatic environment, and the sorptive capacity of the shoreline soil, which is usually expressed as a concentration factor between water and soil. The ability of soils to concentrate radioactive materials differs widely from one element to another. Radionuclides are removed from solution primarily by adsorption and ion exchange. Generally, the fine grained bottom sediments are more effective sorbers of radionuclides than are the coarser grained sands.

The largest discharges of radioactive liquids to the environment have been made from the Windscale site in England and at Hanford in the United States. Smaller discharges have been made from the Oak Ridge National Laboratory into the Clinch River and from the Savannah River Plant. At Windscale, where the principal radioactive effluents are fission products derived from the reprocessing of spent fuel elements, the discharges are made directly to the marine environment whereas the Hanford wastes are discharged to the Columbia River some several hundred miles from the Pacific Ocean.

Extensive environmental monitoring programs of these sites have resulted in the development of appropriate concentration factors for only a very few radionuclides.^(33,34) The highest concentration factor reported by Preston and Jeffries⁽³³⁾ is 530 and applies only to zirconium and niobium. The same source lists the measured concentration factor for cesium in shoreline sand as 65, and ten times that figure for cesium in bottom silt.

However, Saddington suggests a CF of 1000 for cesium in bottom sediment,⁽³⁴⁾ and although this is not an experimental value, for conservatism it is used here not only for cesium, but for all other radionuclides, except tritium. Tritium, released in the form of water, cannot concentrate in shoreline sand.

For gamma radiation, it was assumed that an individual lying on the shore would receive half the dose that he would receive if he were completely immersed in the sand.* A calculation similar to the swimming dose calculation with sand as the infinite medium and with the concentration factor of 10^3 applied results in a maximum potential whole body dose rate of 1.9×10^{-3} mrem per hour for sunbathing along the lakeshore. Assuming an exposure period of 200 hours per year, the annual whole body dose to a sunbather would be 0.39 mrem. This dose is calculated on the basis of annual average discharge concentrations, neglecting significant dilution occurring during transport to the nearest beach. The associated annual body surface exposure is 0.63 mrem per year.

The remaining pathway to consider involves the transfer of activity ingested in lake water by a cow to the secreted milk, which is then ingested by a human. In order to evaluate this route of exposure, it is very conservatively assumed that the milking cattle obtain all of their drinking water from the station discharge. It can be estimated that the water requirement (exclusive of milk) for a cow is approximately 50 milliliters per kilogram of body weight.⁽³⁵⁾ For a 1000 pound (454 kg) animal, this yields a water intake of about 22.7 liters/day.

Considering the lactating cow to produce about 18.2 liters of milk per day and taking the milk to be about 87% water, the total water intake for a lactating animal is estimated to be approximately 38.5 liters/day.

Of the radionuclides present in the water, only the alkaline earths, alkali metals and iodines need to be considered. The other elements are effectively

* The "geometry factor" is taken to be 0.5 for both beta and gamma radiation from this source.

discriminated against by the cow. ⁽³⁶⁾ The concentration in the milk is estimated as the product of the concentration in water, the cow's intake of water, and the coefficient of transfer. The coefficient of transfer is defined as the fraction of the daily intake secreted per liter of milk. The values used are listed below:

<u>Element</u>	<u>Coefficient of Transfer</u> ⁽³⁶⁾
Sr	.001
I	.01
Cs	.025
Ba	.002

The concentration of tritium in the secreted milk is assumed to be 0.87 times the concentration in the water ingested by the cow. The highest transfer coefficient is that of cesium (0.025). Since a person may be assumed to ingest a maximum of one liter of milk daily, on the average, the daily activity intake of Cs in microcuries will be given by:

$$I (\mu\text{Ci/day}) = C_w \left[\text{Cs} \frac{\mu\text{Ci}}{\text{cc}} \right] \left[38.5 \times 10^3 \frac{\text{cc}}{\text{day}} \right] \left[.025 \frac{\mu\text{Ci/liter}}{\mu\text{Ci/day}} \right] \dots$$

$$\dots \left[1.0 \text{ liter/day} \right] = \left[962.5 \frac{\text{cc}}{\text{day}} \right] \times C_w \left[\frac{\mu\text{Ci}}{\text{cc}} \right]$$

Where $C_w \left[\text{Cs} \frac{\mu\text{Ci}}{\text{cc}} \right]$ is the concentration of cesium activity in the water ingested by the cow. This can be compared to the daily cesium intake due to a man drinking 1.2 liter/day of the same water the cow drinks, which is given by:

$$I (\mu\text{Ci/day}) = \left(1200 \frac{\text{cc}}{\text{day}} \right) \times C_w \left(\mu\text{Ci/cc} \right)$$

This brief analysis demonstrates that the dose from the ingestion of milk from a cow drinking the lake water is somewhat less than the human dose from drinking the water directly. Since drinking one liter of milk per day might replace an equivalent amount of water intake in the individual liquid ingestion rate of 1.2 liters per day discussed earlier, the doses from this pathway are not analyzed further.

5. Summary of Maximum Individual Exposure from Liquid Releases

Table XIV presents and totals the various exposure rates calculated to result from the Davis-Besse Unit No. 1 liquid radioactivity releases. All exposure rates presented are based on an adult receptor. They are also based on the annual average discharge concentrations, which is extremely conservative. Substantial dilution immediately on discharge will effectively reduce the activity concentrations in the immediate vicinity of the site, thus reducing the potential exposure rates.

The maximum calculated individual exposure from all sources considered amounts to 2.2 mrem per year to the thyroid. The total whole body exposure amounts to 1.2 mrem per year.

C. Population Radiation Exposure from Liquid Effluents

As a measure of the radiological well-being of the general public, the total integrated whole body population exposure, in units of man-rem per year, is the most pertinent index of the impact of the liquid effluents. Population exposure may accrue from all the individual exposure pathways previously considered. However, only two of these pathways are considered significant in terms of population exposure from liquid effluents. Detailed consideration is given to the population exposure derived from potable water intake and fish ingestion.

Sources of exposure not considered significant in terms of population exposure are:

- 1) swimming in, sunbathing near, or walking along the lake;
- 2) ingestion of milk from cows drinking from the lake;
- 3) other exposure pathways not considered in terms of maximum individual exposure.

The exclusion of these three categories of radiation exposure is primarily based on their relative insignificance in comparison to the pathways considered.

1. Population Exposure from Water Ingestion

Table XV presents a tabulation of the pertinent data necessary to estimate the total plant induced population exposure from water ingestion. The data includes the names of locations using Lake Erie as a source of potable water, the estimated number of people served, the distance of the intake from the station, the applicable dilution factor, and the estimated per capita whole body dose rate via water ingestion. Also given is the population exposure in man-rem, obtained by multiplying the per capita dose rate by the number of exposed individuals.

Since the population dose rate obtained in Table XV is based on population data applicable for the year 1970, the population dose calculated is not applicable for future years. The estimated population dose due to water ingestion for the year 1980 has been estimated by multiplying the 1970 population dose times the ratio of the expected population within 50 miles of the site for 1980 to that estimated for 1970. This ratioing technique was also used to estimate the population dose due to water ingestion that will occur

in the years 2000, and 2020. The following results have been obtained:

Whole Body Population Exposure Due to Water Ingestion	
<u>Year</u>	<u>Population Dose, man-rem/yr</u>
1980	0.21
2000	0.24
2020	0.29

Per capita dose rates have been obtained by assuming each individual to drink 1.2 liters daily of water obtained from Lake Erie. The radioactivity concentrations of the water ingested are assumed to be given by the discharge concentration divided by the effective dilution factor.

2. Population Exposure from Fish Ingestion

An accurate estimate of the population exposure to be expected from fish ingestion cannot be derived from the data available. However, an upper limit to this exposure has been estimated based on the following assumptions:

- 1) only the commercial fish catch in Ohio Fishing District 1 (from Toledo to Huron) contributes to the dose;
- 2) one fourth of the total annual sport fish catch from the Ohio waters of Lake Erie contributes to the dose;
- 3) of all the fish caught, only one third of the live weight is edible;
and
- 4) the applicable dilution factor is taken to be 2807 in all cases.

Of the above four assumptions, only the last requires further explanation. The dilution factor chosen is applicable for a direction into which the surface discharge flows 20% of the time, at a distance of five miles. Thus, on the

average, all fish contributing to the dose are conservatively assumed to be caught at a distance of only five miles from the station discharge.

The 1970 commercial fish catch from Ohio Fishing District 1 totalled 2,380,543 pounds,⁽³⁷⁾ over 29% of the total catch in all five Ohio districts for that year. One fourth of the estimated 1970 sport fish catch for all Ohio waters of Lake Erie amounts to 3,243,750 pounds.⁽³⁸⁾ Thus, the total annual fish catch assumed to be affected by the station discharge is 5,624,293 pounds of which 1,874,764 pounds is assumed edible. Application of the assumed average effective dilution factor of 2807 yields a whole body population exposure of 0.0017 man-rem, based on 1970 fishing statistics.

In order to extrapolate beyond the year 1970, it has been arbitrarily assumed that the total affected fish catch (pounds per year) will increase by 5% annually. Based on this assumption the estimated whole body population dose due to fish ingestion is 0.0027 man-rem/yr in 1980, 0.007 man-rem/yr in the year 2000, and 0.020 man-rem/yr in the year 2020.

D. Radiation Exposure of Aquatic Bio-Systems

This section of the report is directed toward an evaluation of the radiological impact of liquid effluents upon the various life forms inhabiting Lake Erie in the region of the facility. The long range effect of continuous small releases of radioactive materials will be an incremental increase in the normally occurring environmental levels. These increases will be most pronounced in situations where the radionuclides may tend to concentrate.

An organism inhabiting the lake near the site will be subject to plant contributed radiation from three different sources. Internally, radiations from

radioisotopes which may have concentrated within the organism will contribute to the total annual exposure. Externally, this organism will be affected by the radiations from the surrounding water body, and possibly also from the lake bottom where concentration factors (CF's) may be effective in increasing radiation fields.

The receptor organisms at risk from this exposure vary in size, feeding habits, habitual location and other characteristics important in the determination of dose. Calculations have shown that the maximum radiation exposure received by any aquatic organism will be that delivered to life forms inhabiting the lake bottom where sediment concentrations of the released radioisotopes may be orders of magnitude above those in the ambient water.

In the immediate vicinity of the discharge, stationary biota may be subject to annual average concentrations approaching in magnitude those projected for the discharge itself. This situation can only occur in a very small region owing to the rapid dilution. Using the CF for shoreline sands of 1000 (discussed earlier) for all discharged radioisotopes except tritium, the maximum external dose rate from gamma radiation, to a receptor point at the lake bottom, is 17 mrad per year. Almost all of this dose arises from the assumption of concentrations in bottom sediments a factor of 1000 higher than annual average discharge concentrations. The gamma component is discussed separately because the beta component, although less significant, is more complex to deal with.

For very small organisms such as algae and micro-organisms the beta dose can be considered a whole body dose, with even weak tritium betas contributing. In such a case the external beta dose at the lake bottom amounts to 11 mrad per year. If the organism is large enough so that external H-3 causes no whole body exposure, the dose rate is reduced to 8.2 mrad per year.

The above external dose rates apply only to organisms normally dwelling at the lake bottom. For all organisms normally dwelling at sufficient height above the lake bottom (about 5 meters) so that they are shielded from the gamma radiation from material sorbed on the lake bottom, the external dose rates are reduced by about a factor of 500.

Using computer code DOSCAL, the annual internal exposure received by a fish living in waters containing discharge concentrations of radioactivity has been calculated to be 3.09 mrad per year. Invertebrates are calculated to receive internal exposure amounting to 2.35 mrad per year. Microorganisms are assumed to receive essentially no internal radiation.

The doses from all the sources considered are compiled and presented in Table XVI, "Radiation Exposure of Aquatic Biota." These doses were calculated using the annual average concentrations at discharge for all radionuclides and take no credit for any dilution of the discharge in the lake. These dose estimates are thus maximum potential exposure rates at the point of discharge.

In any evaluation of the magnitude of the dose rates presented, the conservatism of the calculational procedures and assumptions should be kept in mind. Also to be considered is the relative radiosensitivity of the aquatic population. Within the aquatic population, the more primitive forms, such as unicellular organisms and macrophytes, are the most radioresistant; fish and amphibians are more radiosensitive. Eggs and larvae in their early developmental stages are the most radiosensitive, and therefore, constitute the most critical group in the aquatic population. (39)

A multitude of studies have been made to determine the effect on fish eggs and larvae chronically irradiated by immersion in low-level radionuclide solutions.

An investigation by Polikarpov⁽⁴⁰⁾ has yielded interesting results. It was found that the death rate of fresh water fish eggs was not increased even when immersed in a 10^{-6} $\mu\text{Ci/cc}$ solution of Sr-90, almost three orders of magnitude times the total non-tritium annual average discharge concentration estimated for the Davis-Besse Nuclear Power Station Unit No. 1.

V. DOSE TOTALS AND COMPARISON WITH FEDERAL REGULATIONS AND NATURAL BACKGROUND

The doses calculated to occur due to the operation of the Davis-Besse Nuclear Power Station Unit No. 1 can best be brought into perspective by a comparison with exposure levels already present from naturally occurring background radiation.

The Environmental Protection Agency⁽³⁾ has published estimates of state-wide average whole body radiation doses from three sources; 1) cosmic radiation, 2) naturally occurring terrestrial radiation, and 3) internal radiation from naturally occurring radioisotopes incorporated into the human body. For the State of Ohio, the respective annual doses from these three sources are 50 mrem, 65 mrem, and 25 mrem, respectively. Thus in Ohio, the average whole body dose from natural background radiation amounts to 140 mrem annually, slightly higher than the national average of 130 mrem per year.⁽³⁾

In other states, the annual whole body background dose is reported to range upwards from 100 mrem/year in Louisiana to 250 mrem/year in Colorado. The Special Studies Group has also found that medical exposure in the USA averaged 90 mrem/year in 1970.⁽³⁾ The annual average exposure from television sets is reported to be 0.1 mrem. The total whole body population exposure occurring as a result of increased cosmic radiation during commercial air travel is estimated at 90,000 man-rem in the USA during 1969.⁽⁴¹⁾

Title 10 Part 20 of the Code of Federal Regulations limits the allowable exposure to individuals of the general population to 500 millirems annually. The per capita dose to any substantial section of the population is not allowed

to exceed one third of this value, about 170 millirems annually. These legal guidelines together with the above exposure levels due to natural and man-made radiation provide a basis on which comparison of the incremental doses due to the operation of the Davis-Besse Unit No. 1 may be adequately drawn. Such a comparison is presented in Tables XVII and XVIII.

In Table XVII, the calculated total adult exposures from gaseous and liquid releases are compiled and compared to applicable standards. For the expected release rates, the total whole body exposure from all considered gaseous and liquid pathways amounts to 2.7 mrem per year, only about 0.5% of the current | 1 legal limit imposed under 10 CFR 20. This exposure represents about 2% of the estimated average whole body exposure from natural background over the entire State of Ohio. Critical organ exposure totals have not been found to be greatly different from whole body exposure totals.

The total population exposure due to both gaseous and liquid releases is presented in Table XVIII. It can be seen there that the resulting exposures represent only very small fractions of the exposure permissible under 10 CFR 20, or the exposure due to naturally occurring background radiation. This indicates that the Davis-Besse Unit No. 1 is expected to have only a negligible radiological impact on the surrounding population.

REFERENCES

1. Personal communications from Mr. W.H. Mable, Bechtel Associates Professional Corporation, Gaithersburg, Md., to Mr. Roy S. Denham, NUS Corporation, March-May, 1974.
2. Chapter 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation".
3. Special Studies Group, Office of Radiation Programs, EPA, "Estimates of Ionizing Radiation Doses in the United States, 1960 - 2000", 2nd printing, (1971).
4. Blatz, H., Radiation Hygiene Handbook, McGraw-Hill (1959).
5. Hine, G.J., and G.L. Brownell (editors), Radiation Dosimetry, Academic Press, New York (1956).
6. ICRP Publication 2, "Report of Committee II on Permissible Dose for Internal Radiation", International Commission on Radiological Protection, Pergamon Press, New York (1959).
7. "Radioactive Waste Disposal Into the Sea", International Atomic Energy Agency, Safety Series No. 5, Vienna (1961).
8. Slade, D.H. (editor), "Meteorology and Atomic Energy, 1968". U.S. AEC, Division of Technical Information, TID-24190 (July 1968).
9. Crocker, G.R., et al., "Factors for the Calculation of Infinite Plane Exposure Rates from Gamma Radiation", Health Physics, Vol. 12, No. 9 (September 1966).
10. Turner, W.D., "The EXREM II Computer Code for Estimating External Doses to Populations from Construction of a Sea-Level Canal with Nuclear Explosives", Union Carbide Corporation, Computing Technology Center, Oak Ridge, Tennessee, CTC-8 (July 1969).
11. Beck, H.L., "Environmental Gamma Radiation from Deposited Fission Products", Health Physics, Vol. 12, pp. 313-323 (March 1966).
12. Personal communication from Mr. Harold L. Beck, Health and Safety Laboratories, New York, to Mr. Dan E. Martin, NUS Corporation, Rockville, Md. (March 19, 1973).

13. Bryant, P.M., "Derivation of Working Limits for Continuous Release Rates of Sr-90 and Cs-137 to Atmosphere in a Milk Producing Area", Health Physics, Vol. 12, pp. 1393-1405 (1966).
14. Gamertsfelder, Carl, "Additional Testimony of Dr. Carl Gamertsfelder Concerning Requests for Information and Data", U.S. AEC Rulemaking Hearings on the Proposed Appendix I to 10 CFR 50, Staff Exhibit 8 (April 1972).
15. Bryant, P.M., "Data for Assessments Concerning Controlled and Accidental Releases of I-131 and Cs-137 to Atmosphere", Health Physics, Vol. 17, No. 1 (July 1969).
16. Burnett, J.J., "A Derivation of the 'Factor of 700' for I-131", Health Physics, Vol. 18, No. 1 (January 1970).
17. Pinson, E.A., and W.H. Langham, "Physiology and Toxicology of Tritium in Man", Journal of Applied Physiology, Vol. 10, (January 1957 - May 1957).
18. Hytten, F.E., K. Taylor and N. Taggart, "Measurement of Total Body Fat in Man by Absorption of Kr-85", Clinical Science, Vol. 31 (1966).
19. Tobias, C.A., H.B. Jones, J.H. Lawrence and J.G. Hamilton, "The Uptake and Elimination of Krypton and Other Inert Gases by the Human Body", Journal of Clinical Investigation 28:1375-1385.
20. Lassen, N.A., "Assessment of Tissue Radiation Dose in Clinical Use of Radioactive Inert Gases, With Examples of Absorbed Doses from ^3H , ^{85}Kr , and ^{133}Xe ", Minerva Nucleare Vol. 8 (1964).
21. Hendrickson, M.M., "The Dose From ^{85}Kr Released to the Earth's Atmosphere", in "Environmental Aspects of Nuclear Power Stations", IAEA Symposium, New York (August 1970).
22. DiNunno, J.J., et al., "Calculation of Distance Factors for Power and Test Reactor Sites", TID-14844, U.S. AEC (1962).
23. Garner, R. John, "Transfer of Radioactive Materials from the Terrestrial Environment to Animals and Man", Environmental Protection Agency, CRC Press (1972).

24. "Background Material for the Development of Radiation Protection Standards", Federal Radiation Council, Report No. 5 (July 1964).
25. "Background Material for the Development of Radiation Protection Standards", Federal Radiation Council, Report No. 2 (September 1961).
26. Garner, R.J., "A Mathematical Analysis of the Transfer of Fission Products to Cow's Milk", Health Physics, Vol. 13; pp. 205-212 (1967).
27. Personal communication from Mr. Glenn Maddy, Sandusky County Extension Agent, Fremont, Ohio, to Mr. Lawrence Kolbicka, NUS Corporation, Rockville, Md., March 21, 1973.
28. Telephonic conversation between Mr. C.L. Mekbel, Toledo Edison Co., and Messrs. Dan E. Martin, Bruce J. Hickie, and Bob Schlegel, NUS Corporation, Rockville, Md., September 24, 1974.
29. Fletcher, J.F., and W.L. Dotson, "HERMES, A Digital Computer Code for Estimating Regional Radiological Effects from the Nuclear Power Industry", U.S. AEC, Hanford Engineering Development Laboratory (December 1971).
30. Thompson, S.E., et al., "Concentration Factors of Chemical Elements in Edible Aquatic Organisms", UCRL-50564 Rev. 1 (October, 1972).
31. Cowser, K.W., and W.S. Snyder, "Safety Analysis of Radionuclide Release to the Clinch River", ORNL-3721, Supplement 3 (1966).
32. Riley, F., "Fisheries of the United States, 1970", U.S. Department of Commerce, NOAA, NMFS-5600 (March 1971).
33. Preston, A. and D.F. Jefferies, "Aquatic Aspects in Chronic and Acute Contamination Situations", in Environmental Contamination by Radicactive Materials, IAEA Symposium, Vienna (1969).
34. Glueckauf, E. (editor), "Atomic Energy Waste", published by Interscience Publishers Inc., New York (1961).
35. Spector, W.S., "Handbook of Biological Data", W.B. Saunders Company (1961).
36. Perez, L.J. and P.B. Robinson, "Estimates of Iodine-131 Thyroid Doses from Gross Beta Radioactivity in Milk Samples Collected at St. George, Utah, 1953", USDHEW, PHS (December 1967), SIB-6705.

37. "Commercial Fish Landings Lake Erie-1970", Ohio Dept. of Natural Resources and Wildlife, Publication 200 (1971).
38. Personal communication from Mr. R.L. Scholl, Ohio Div. of Wildlife, to Mr. Lowell Roe, Toledo Edison Co., October 22, 1971.
39. Donaldson, L.R. and R.F. Foster, "Effects of Radiation on Aquatic Organisms" in Chapter 10 of The Effects of Atomic Radiation on Oceanography and Fisheries, NAS NRC Publication 551 (1957).
40. Polikarpov, G.G., Radioecology of Aquatic Organisms, Reinhold, New York (1966).
41. Goldman, M.I., "Statement by Dr. Morton I. Goldman on Behalf of the Consolidated Utility Group in the U.S. Atomic Energy Commission Rulemaking Hearing on Proposed Appendix I", Germantown, Maryland (March 17, 1972).

TABLE I

ESTIMATED AIRBORNE EFFLUENTS
FROM DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

<u>Isotope</u>	<u>Estimated Annual Release, ⁽¹⁾ Ci/yr</u>
Noble Gases: Ar-41	4.17
Kr-83m	1.00
Kr-85m	5.52
Kr-85	2.32 + 2
Kr-87	2.95
Kr-88	9.56
Xe-131m	5.52 + 1
Xe-133m	1.59 + 1
Xe-133	1.62 + 3
Xe-135m	2.06 + 3
Xe-135	2.11 + 2
Xe-138	1.72
Iodines: I-131	2.52 -1
I-132	4.94 -2
I-133	1.08 -1
I-134	9.66 -3
I-135	4.59 -2
Particulates: Cr-51	9.26-6
Mn-54	1.05-6
Fe-55	3.66-5
Fe-59	1.05-6
Co-58	5.58-5
Co-60	2.98-7
Rb-88	7.37-4
Sr-89	1.73-6
Sr-90	5.58-8
Sr-91	1.02-5
Sr-92	2.98-6
Y-90	2.52-8
Y-91	5.53-7
Zr-95	7.24-5
Mo-99	3.89-4
Cs-134	3.18-5
Cs-136	2.38-5
Cs-137	9.56-5
Cs-138	2.14-4
Ba-137m	1.12-5
Ba-139	2.47-5
Ba-140	2.16-6
La-140	8.98-7
Ce-144	1.98-7
Tritium: H-3	2.88 + 2

1

1

TABLE II

EXTERNAL EXPOSURE DUE TO GROUND DISPOSITION OF PARTICULATES AND IODINES

Isotope	Maximum Offsite Ground Concentrations, Ci/cm ²			Calculated Doses to Man at 1 Meter Above Ground*, mr/yr					
	1980	2000	2020	Year 1980		Year 2000		Year 2020	
				Beta	Gamma	Beta	Gamma	Beta	Gamma
I-131	4.15-8	4.15-8	4.15-8	2.46-2	2.98-2	2.46-2	2.98-2	2.46-2	2.98-2
I-133	1.90-9	1.90-9	1.90-9	9.09-3	1.93-3	9.09-3	1.93-3	9.09-3	1.93-3
Co-58	1.62-11	1.62-11	1.62-11	none	2.24-5	none	2.24-5	none	2.24-5
Co-60	1.12-12	2.24-12	2.32-12	1.05-6	4.34-6	2.09-6	8.63-6	2.17-6	8.95-6
Sr-89	3.61-13	3.61-13	3.61-13	2.09-6	none	2.09-6	none	2.09-6	none
Sr-90	2.71-13	1.08-12	1.58-12	5.14-8	none	2.05-7	none	3.01-7	none
Zr-95	1.95-11	1.95-11	1.95-11	1.67-5	2.39-5	1.67-5	2.39-5	1.67-5	2.39-5
Cs-134	7.98-11	9.81-11	9.81-11	1.19-4	2.10-4	1.46-4	2.58-4	1.46-4	2.58-4
Cs-136	1.27-12	1.27-12	1.27-12	1.83-7	4.80-6	1.83-7	4.80-6	1.83-7	4.80-6
Cs-137	4.69-10	1.89-9	2.78-9	2.02-4	1.76-4	8.16-4	7.10-4	1.20-3	1.05-3
TOTALS				3.41-2	3.22-2	3.46-2	3.27-2	3.51-2	3.30-2

1

DB-1

1

48

TABLE III
ESTIMATED 0 - 50 MILE POPULATION DISTRIBUTION, 1980

POPULATION EXPOSURE DUE TO AIRBORNE RELEASES, DAVIS-BESSE 1

THE POPULATION DATA ON THIS PAGE IS THAT ESTIMATED FOR THE YEAR 1980

DIR.	0-1 MILFS	1-2 MILFS	2-3 MILFS	3-4 MILFS	4-5 MILES	5-10 MILES	10-20 MILES	20-30 MILFS	30-40 MILFS	40-50 MILFS	DIRECTIONAL TOTAL
NW	24	0	0	0	0	0	0	812	1802A	21656	40520
NE	1	0	0	0	0	0	0	0	915A	13339	22500
ENF	0	0	0	0	0	0	531	0	0	0	531
F	0	0	0	0	0	0	1659	106	0	11819	13584
ESE	0	0	0	0	0	0	11017	50124	17696	181265	260102
SE	0	0	0	0	103	7053	6046	6732	24642	10488	55064
SSF	0	38	40	73	79	1136	3980	14183	5277	18039	42745
S	9	38	55	45	64	794	27872	6971	30536	7100	73484
SW	16	31	31	48	69	3911	4605	4081	24787	9423	47402
SW	14	0	26	45	50	962	8789	8778	7969	52875	79508
WSW	0	8	8	31	45	989	7438	10643	37482	11645	68289
W	18	48	26	43	69	875	14022	257288	46337	17458	335980
NW	0	26	130	0	0	649	12624	210980	41467	11804	277680
N4	3	114	31	0	0	0	0	42710	15625	18015	76498
NW	50	16	0	0	0	0	0	17200	33909	115552	166727
N	8	0	0	0	0	0	0	83	51772	612324	664187
ANNULUS TOTAL	141	319	347	285	479	16169	98483	631091	364685	1112802	2224801

TABLE IV
ESTIMATED 0 - 50 MILE POPULATION DISTRIBUTION, 2000

POPULATION EXPOSURE DUE TO AIRBORNE RELEASES, DAVIS-BESSF 1

THE POPULATION DATA ON THIS PAGE IS THAT ESTIMATED FOR THE YEAR 2000

DIR.	0-1 MILES	1-2 MILFS	2-3 MILES	3-4 MILFS	4-5 MILES	5-10 MILFS	10-20 MILFS	20-30 MILFS	30-40 MILFS	40-50 MILES	DIRECTIONS TOTAL
NW	27	0	0	0	0	0	0	1143	25344	30402	57046
NE	3	0	0	0	0	0	0	0	12494	18741	31674
EVF	0	0	0	0	0	0	504	0	0	0	504
E	0	0	0	0	0	0	1444	110	0	15539	17517
ESF	0	0	0	0	0	0	12542	6127	21463	217915	333447
SE	0	0	0	0	114	7416	7110	8134	27517	11489	62380
SSE	0	42	44	81	87	1260	4413	15440	5682	20365	47414
S	10	42	61	50	71	842	31701	7705	32130	7744	40398
SSW	17	35	35	53	77	4334	5235	4434	26444	10222	51290
SW	15	0	29	50	54	1066	11429	4434	10921	67214	100717
WSW	0	9	4	35	50	1094	8630	14684	51395	14191	90103
W	15	53	29	48	50	748	17070	296598	52144	21490	344277
NW	0	29	144	0	0	727	14185	240423	50147	13255	314910
NW	3	126	35	0	0	0	0	56025	20497	24865	101551
NW	54	17	0	0	0	0	0	22542	38527	117092	178254
N	9	0	0	0	0	0	0	109	58102	703416	761634
ANNUAL TOTAL	155	353	386	317	512	17929	113255	740947	433451	1314278	2621603

TABLE V
ESTIMATED 0 - 50 MILE POPULATION DISTRIBUTION, 2020

POPULATION EXPOSURE DUE TO AIRBORNE RELEASES, DAVIS-BRESSE 1

THE POPULATION DATA ON THIS PAGE IS THAT ESTIMATED FOR THE YEAR 2020

DIR.	0-1 MILS	1-2 MILS	2-3 MILES	3-4 MILS	4-5 MILES	5-10 MILS	10-20 MILES	20-30 MILS	30-40 MILS	40-50 MILS	DIRECTIONAL TOTAL
NNE	50	0	0	0	0	0	0	1609	35740	42933	80312
NE	4	0	0	0	0	0	0	0	18155	26444	44603
ENE	0	0	0	0	0	0	654	0	0	0	654
E	0	0	0	0	0	0	2065	147	0	19746	22004
ESE	0	0	0	0	0	0	14283	74114	25192	302580	417169
SE	0	0	0	0	126	6686	8324	9734	30794	13059	70727
SEF	0	46	49	90	97	1400	5022	17732	6145	23020	53401
S	12	46	68	55	79	982	36073	4503	33959	4484	88292
SSW	19	39	39	54	85	4817	5954	5237	28344	11133	55727
SW	17	0	32	55	62	1185	11239	14455	14291	83590	124926
WSW	0	10	10	34	55	1218	9990	19305	67276	17097	115000
W	17	59	32	53	85	832	20549	341470	58773	26092	487962
NNW	0	32	160	0	0	817	15966	274065	60055	14911	366006
NW	4	141	39	0	0	0	0	71224	26058	32683	130149
NNW	62	19	0	0	0	0	0	28683	43799	118450	191413
N	10	0	0	0	0	0	0	138	66972	831502	894422
ANNUAL TOTAL	175	392	429	551	549	19937	130120	466466	516544	1571964	3106971

TABLE VI

EXTERNAL POPULATION EXPOSURE DUE TO GASEOUS RELEASES
FROM DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

External Population Doses Within 50 Miles, man-rem/yr

Year	Cloud Immersion		Particulate Deposition		Total		1
	Whole Body	Body Surface	Whole Body	Body Surface	Whole Body	Body Surface	
1980	3.9	5.8	0.087	0.180	4.0	6.0	
2000	4.6	6.9	0.103	0.212	4.7	7.1	
2020	5.5	8.2	0.123	0.254	5.6	8.4	

Average Per Capita Doses Within 50 Miles, mrem/yr

Year	Cloud Immersion		Particulate Deposition		Total		1
	Whole Body	Body Surface	Whole Body	Body Surface	Whole Body	Body Surface	
1980	1.8-3	2.6-3	3.9-5	8.1-5	1.8-3	2.7-3	
2000	1.8-3	2.6-3	3.9-5	8.1-5	1.8-3	2.7-3	
2020	1.8-3	2.6-3	4.0-5	8.1-5	1.8-3	2.7-3	

52

DB-1

TABLE VII

ANNUAL AVERAGE X/Q VALUES, 0 - 50 MILES

POPULATION EXPOSURE DUE TO AIRBORNE RELEASES, DAVIS-RESSE 1

THE FOLLOWING VALUES OF X/Q HAVE BEEN USED IN THE ANALYSIS.
THEY ARE APPROPRIATE FOR A RELEASE HEIGHT OF 0 METERS.

DIR.	0-1 MILES	1-2 MILES	2-3 MILES	3-4 MILES	4-5 MILES	5-10 MILES	10-20 MILES	20-30 MILES	30-40 MILES	40-50 MILES
NNE	4.9940E-06	8.8820E-07	4.3190E-07	2.7870E-07	2.0290E-07	1.0610E-07	4.4330E-08	2.3500E-08	1.5500E-08	1.1400E-08
NE	4.2000E-06	7.4670E-07	3.6430E-07	2.3450E-07	1.7040E-07	8.8620E-08	3.6840E-08	1.9500E-08	1.2800E-08	9.4200E-09
ENE	3.3980E-06	6.0800E-07	2.9450E-07	1.8870E-07	1.3650E-07	7.0490E-08	2.9080E-08	1.5300E-08	1.0100E-08	7.3700E-09
E	2.5200E-06	4.4680E-07	2.1550E-07	1.3820E-07	1.0070E-07	5.1960E-08	2.1540E-08	1.1300E-08	7.4900E-09	5.4800E-09
ESE	1.6290E-06	2.9600E-07	1.4250E-07	9.0760E-08	6.5360E-08	3.3480E-08	1.3690E-08	7.2000E-09	4.6900E-09	3.4300E-09
SE	9.8450E-07	1.8700E-07	9.0880E-08	5.7200E-08	4.0660E-08	2.0320E-08	8.0720E-09	4.1400E-09	2.6800E-09	1.9500E-09
SSE	8.5060E-07	1.5650E-07	7.5540E-08	4.8050E-08	3.4510E-08	1.7600E-08	7.1730E-09	3.7300E-09	2.4400E-09	1.7800E-09
S	6.5500E-07	1.2110E-07	5.8040E-08	3.6470E-08	2.5940E-08	1.2960E-08	5.1510E-09	2.6400E-09	1.7100E-09	1.2400E-09
SSW	9.4940E-07	1.7340E-07	8.2420E-08	5.1360E-08	3.6280E-08	1.7920E-08	7.0320E-09	3.5800E-09	2.3100E-09	1.6700E-09
SW	7.8030E-07	1.4420E-07	6.8920E-08	4.2860E-08	3.0190E-08	1.4810E-08	5.7550E-09	2.9100E-09	1.8700E-09	1.3500E-09
WSW	1.1350E-06	2.1470E-07	1.0370E-07	6.4610E-08	4.5500E-08	2.2320E-08	8.6870E-09	4.3900E-09	2.8200E-09	2.0400E-09
W	1.3550E-06	2.6430E-07	1.2730E-07	7.9180E-08	5.5680E-08	2.7240E-08	1.0580E-08	5.3200E-09	3.4100E-09	2.4600E-09
WNW	1.6480E-06	3.1390E-07	1.5240E-07	9.6040E-08	6.8360E-08	3.4250E-08	1.3660E-08	7.0100E-09	4.5500E-09	3.3100E-09
NW	1.9890E-06	3.6240E-07	1.7820E-07	1.1470E-07	8.3210E-08	4.3170E-08	1.7880E-08	9.4300E-09	6.2200E-09	4.5600E-09
NNW	1.7180E-06	3.2000E-07	1.5790E-07	1.0100E-07	7.2840E-08	3.7370E-08	1.5290E-08	8.0000E-09	5.2500E-09	3.8400E-09
N	3.4070E-06	6.2510E-07	3.0810E-07	1.9780E-07	1.4320E-07	7.4010E-08	3.0520E-08	1.6000E-08	1.0600E-08	7.7400E-09

TABLE VIII

SUMMARY OF MAXIMUM INDIVIDUAL EXPOSURE RATES DUE TO GASEOUS RELEASES
FROM DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

Exposure Pathway	Child, mrem/yr			Adult, mrem/yr		
	Whole Body	Body Surface	Thyroid	Whole Body	Body Surface	Thyroid
Cloud immersion	1.4	2.1	1.4	1.4	2.1	1.4
External from particulate deposition (year 2020)	0.033	0.068	0.033	0.033	0.068	0.033
Iodine inhalation	0.00068	0.00068	0.82	0.00090	0.00090	0.51
Tritium inhalation	0.088	0.10	0.11	0.088	0.10	0.11
Particulate inhalation	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
Milk ingestion (nearest cow)	0.00073	0.00073	0.88	0.00017	0.00017	0.090
Exposure totals (all pathways combined)	1.5	2.3	3.2	1.5	2.3	2.1

54

DB-1

TABLE X
ANNUAL AVERAGE WIND DIRECTION FREQUENCIES
AT THE DAVIS-BESSE SITE

<u>Direction</u>	<u>Frequency, %</u>
NNE	4.07
NEE	3.97
ENE	5.36
E	6.37
ESE	4.81
SE	2.69
SSE	2.55
S	6.80
SSW	11.93
SW	12.92
WSW	12.69
W	7.12
WNW	4.99
NW	4.33
NNW	3.96
N	2.91
CALM	2.54

TABLE XI

APPLICABLE DILUTION FACTORS FOR POTABLE WATER INTAKES WITHIN 50 MILES

<u>Potable Water Intake</u>	<u>Location Relative to Davis-Besse</u>	<u>Estimated Frequency of Surface Flow Towards Intake</u>	<u>Predicted H-3 Concentration, $\mu\text{Ci/cc}$</u>	<u>Derived Dilution Factor</u>
Erle Ind. Park	3.6 mi SE	0.17	5.17-9	2,398
Camp Perry	4.6 mi SE	0.17	4.07-9	3,047
Port Clinton	8.6 mi SE	0.17	2.17-9	5,714
Toledo	12.0 mi W	0.21	1.92-9	6,458
Oregon	12.0 mi W	0.21	1.92-9	6,458
Sandusky	21.0 mi ESE	0.17	8.87-10	13,980
Monroe	27.0 mi NNW	0.21	8.53-10	14,537
Huron	30.0 mi ESE	0.17	6.20-10	20,000
Kingsville	36.0 mi NNE	0.21	6.40-10	19,375
Vermilion	38.0 mi ESE	0.17	4.90-10	25,306
Leamington	41.0 mi NE	0.13	3.47-10	35,735
Lorain	48.0 mi ESE	0.17	3.87-10	32,041
Wheatley	50.0 mi NE	0.13	2.85-10	43,509

TABLE XII

MAXIMUM INTERNAL BODY ORGAN EXPOSURE
FROM THE INGESTION OF WATER AND FISH

<u>Body Organ</u>	<u>Exposure from Water Ingestion, mrem/year</u>	<u>Exposure from Fish Ingestion, mrem/year</u>
Whole Body	0.69	0.10
Lungs	0.89	0.053
Liver	0.85	0.20
Spleen	0.88	0.17
Kidney	0.89	0.095
Bone	0.42	0.12
Muscle	0.89	0.17
Pancreas	0.90	0.11
Thyroid	1.40	0.43
Small Intestine	0.90	0.04
Upper Large Intestine	0.90	0.11
Lower Large Intestine	0.90	0.11

Notes about this table: Doses presented here are based on the annual average radioactivity concentration of the Unit No.1 discharge. Liquid exposure is based on an intake of 1.2 liters per day. Fish ingestion is postulated to be 50 grams per day. Other body organs for which doses were calculated but not found to substantially differ from those presented are the testes, ovaries, prostate, heart, brain, skin, and stomach.

TABLE XIII
 CONCENTRATION FACTORS FOR EFFLUENT
 RADIONUCLIDES IN FISH

<u>Element</u>	<u>Concentration Factor in Freshwater Fish*</u>
H	0.90
Cr	200
Mn	400
Co	50
Fe	100
Rb	2000
Sr	30
Y	25
Zr	3.33
Mo	10
I	15
Cs	2000
Ba	4
La	25
Ce	1

* All concentration factors used in this report for fresh-water organisms are those compiled and presented in UCRL-50564, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms," Rev. 1.⁽³⁰⁾

TABLE XIV

SUMMARY OF MAXIMUM INDIVIDUAL EXPOSURE RATES DUE TO LIQUID RELEASES
FROM DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

(Exposure Rates Calculated for Adults, mrem/yr)

Exposure Pathway	Exposure from Expected Releases			
	Whole Body	Body Surface	Liver	Thyroid
Water Ingestion	0.69	0.82	0.85	1.4
Fish Ingestion	0.10	0.11	0.20	0.43
Swimming	0.0008	0.055	0.0008	0.0008
Sunbathing	0.39	0.63	0.39	0.39
EXPOSURE TOTALS	1.2	1.6	1.4	2.2

TABLE XV

DATA USED TO ESTIMATE POPULATION EXPOSURE FROM WATER INGESTION

<u>Potable Water Intake</u>	<u>Population Affected*</u>	<u>Applicable Dilution Factor</u>	<u>Per Capita Whole Body Dose, mrem/yr</u>	<u>Population Dose, man-rem/yr</u>
Erie Industrial Park	435	2,398	2.9-4	1.2-4
Camp Perry	1,000	3,047	2.3-4	2.3-4
Port Clinton	12,000	5,714	1.2-4	1.4-3
Toledo	500,000	6,458	1.1-4	5.3-2
Oregon	16,000	6,458	1.1-4	1.7-3
Sandusky	47,000	13,980	4.9-5	2.3-3
Monroe	40,000	14,537	4.8-5	1.9-3
Huron	7,500	20,000	3.5-5	2.6-4
Kingsville	1,400	19,375	3.6-5	5.0-5
Vermilion	9,000	25,306	2.7-5	2.5-4
Leamington	10,000	35,735	1.9-5	1.9-4
Lorain	85,000	32,041	2.2-5	1.8-3
Wheatley	1,059	43,509	1.6-5	<u>1.7-5</u>
<hr/>				
TOTALS	730,394			6.4-2

* Based on 1970 data.

TABLE XVI

RADIATION EXPOSURE OF AQUATIC BIOTA

Maximum Potential Annual Radiation Exposure, mrad/year

Receptor	External Exposure	Internal Exposure	From All Sources
Sediment Level Micro-organisms	28	0	28
Bottom-Feeding Fish	25	2.5	28
Bottom-Dwelling Invertebrates	25	1.9	27
Free-Floating Micro-organisms	2.4	0	2.4
Free-Swimming Fish	0.042	2.5	2.5
Free-Swimming Invertebrates	0.042	1.9	1.9

NOTE: Maximum potential doses are calculated using the annual average discharge concentrations.

TABLE XVII

MAXIMUM INDIVIDUAL DOSE TOTALS FROM DAVIS-BESSE NUCLEAR
POWER STATION UNIT NO. 1 AND COMPARISON WITH
FEDERAL REGULATIONS AND NATURAL BACKGROUND EXPOSURE

(All Exposure^s for Adults, mrem/yr)

	<u>Whole Body</u>	<u>Body Surface</u>	<u>Thyroid</u>	
I. Exposure Due to Unit No. 1				
Gaseous Exposure (yr 2020)	1.5	2.3	2.1	1
Liquid Exposure	<u>1.2</u>	<u>1.6</u>	<u>2.2</u>	
Unit No. 1 Totals	2.7	3.9	4.3	1
II. Allowable Exposure Under 10 CFR 20	500	500	500	
III. Natural Background Exposure in Ohio	140	140	140	

TABLE XVIII

WHOLE BODY POPULATION DOSE TOTALS FROM DAVIS-BESSE
 NUCLEAR POWER STATION UNIT NO. 1 AND COMPARISON
 WITH FEDERAL REGULATIONS AND NATURAL BACKGROUND EXPOSURE

(All Exposures for Adults, in Man-Rem/yr to the Whole Body)

	Year 1980	Year 2000	Year 2020	
I. Exposure Due to Unit No. 1				
Gaseous Exposure	3.9	4.6	5.5	¹
Liquid Exposure	<u>0.071</u>	<u>0.088</u>	<u>0.12</u>	
Unit No. 1 Totals	4.0	4.7	5.6	¹
II. Allowable Exposure Under 10 CFR 20	378,000	446,000	528,000	
III. Exposure Due To Natural Background*	311,000	367,000	435,000	

* Natural background exposure is based on 140 mrem per year per person.

APPENDIX A

COMPUTATIONAL METHODS FOR DOSES RESULTING FROM GASEOUS EFFLUENTS
FROM DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1A. Whole Body and Body Surface Cloud Immersion Dose

The gaseous radioactive effluents consist primarily of the noble gases krypton and xenon. Exposure of a man to an atmosphere contaminated with radioactive isotopes of these elements is assumed to result only in an external, whole body dose, from submersion in the radioactive cloud. Since these elements are not incorporated into the human body to a significant degree, there are only negligible resultant internal doses.⁽¹⁾ The noble gases and all other gaseous releases have been included in the calculation of external exposure due to immersion in the radioactive cloud. The resulting dose is proportional to the ground level concentration of radioactivity and can be computed using the ICRP recommended semi-infinite sphere model.⁽²⁾ The following relationship was used to determine the dose rate from this exposure pathway:

$$D(\text{rem/year}) = 0.259 \times (X/Q) \times \sum_i E_i Q_i$$

where:

X/Q = the applicable annual average atmospheric dispersion parameter, sec/m^3 ;

E_i = the average disintegration energy* of the i th radionuclide, either beta or gamma;

Q_i = the annual average activity release for the i th radionuclide, Ci/year ; and

0.259 = the constant necessary to yield the dose rate in rem/year .

* Data on disintegration energies was obtained primarily from NEDO-12037, "Summary of Gamma and Beta Energy and Intensity Data", by Meek and Gilbert (Jan. 1970); where necessary data was obtained from the "Table of Isotopes".⁽³⁾

The normalization constant, 0.259, is given by the following equation:

$$0.259 = \frac{1}{2}(1.6 \times 10^{-6} \text{ ergs/MeV}) (10^{-2} \text{ gram rads/erg}) (1 \text{ rem/rad}) \dots$$

$$\dots (1.13) (3.7 \times 10^{10} \text{ dis/sec Ci}) \left(\frac{1}{1.293 \times 10^3 \text{ grams air/m}^3} \right)$$

where:

- $\frac{1}{2}$ = the geometry factor accounting for the fact that the receptor is irradiated from half the total available solid angle; and
- 1.13 = a factor to account for the increased stopping power of tissue relative to air for β 's and secondary electrons produced by x- and γ - radiation. ⁽²⁾

The above formula was used for maximum individual exposure and for population exposure. Beta radiation was assumed to irradiate only the body surface. The estimated population distributions within 50 miles of the station for the years 1980, 2000, and 2020 were used for this purpose. For each of the 160 population segments (16 sectors x 10 annuli) into which the 50 mile population is distributed, an annual average segment dose rate was established. This was taken to be the dose rate at the geometric midpoint of the segment. The annual segment population exposure is thus the product of the segment population and the segment average dose rate. Summing the individual segment population exposure over all 160 segments yields the total population exposure within 50 miles of the station.

The average value of X/Q for a specific segment was taken to be that for the distance of the midpoint of that segment from the station. For example, the average X/Q for a sector 10 - 20 miles in a given direction was taken to be

that for a distance of 15 miles in the given direction. The numerical values for X/Q used in this evaluation were obtained from the meteorological data presented in Section 2.3.5 of the Davis-Besse Units No. 2 and 3 PSAR.

B. External Exposure From Particulate Deposition

The following equation was used to compute the necessary ground activity concentrations as a function of time for each particulate and iodine isotope released:

$$C_g (\mu\text{Ci}/\text{cm}^2) = R \left(X/Q V_g \right) (10^6 \mu\text{Ci}/\text{Ci}) (10^{-4} \text{m}^2/\text{cm}^2) \left[\frac{1 - e^{-\lambda t}}{\lambda} \right]$$

where:

- R = the release rate, Ci/yr
- X/Q = the applicable atmospheric dispersion parameter, sec/m^3
- V_g = the deposition velocity, m/sec
- λ = the radiological decay constant, $(\text{yr})^{-1}$
- t = time, yr

After calculating the required ground concentrations, proper dose conversion factors were applied to obtain the resulting beta and gamma exposure rates at the critical height of one meter. Dose conversion factors for gamma radiation for all isotopes but Cs-137 were obtained directly out of "Factors for the Calculation of Infinite Plane Exposure Rates from Gamma Radiation", by Crocker, et al.⁽⁴⁾ Only gamma radiation was assumed to irradiate the whole body.

Beta dose conversion factors were calculated using the equation given in EXREM II.⁽⁵⁾ The calculated beta exposure rates were then reduced by a factor

of two to account for the effect of selfshielding of the human body. Maximum and average beta energies were obtained from the "Radiological Health Handbook".⁽⁶⁾

Cs-137 was found to be a critical isotope for this exposure pathway. Various analyses of ground concentrations due to fallout Cs-137 have made apparent the ability of cesium to penetrate into soil after initial deposition.⁽⁷⁾ The concentration distribution with depth can usually be described in terms of the relaxation length, the volume concentration decreasing exponentially with soil depth. This distribution is obtained relatively rapidly after deposition, usually within one to two years.⁽⁸⁾ The range of the relaxation length is usually from three to eight centimeters, the value in a particular instance depending on local precipitation, soil type, and other variables.⁽⁸⁾ As the external dose rates vary inversely to the value of the relaxation length, the value used in this analysis was conservatively taken to be three centimeters.

The dose conversion factor for gamma radiation from Cs-137 is necessarily dependent upon the relaxation length. The dose conversion factor appropriate for a three centimeter relaxation length was obtained from data published by Beck,⁽⁹⁾ and is equal to $0.0429 \text{ (r/hr)/}(\mu\text{Ci/cm}^2)$. The beta component of the Cs-137 radiation was conservatively estimated by assuming that only the activity in the top centimeter of soil could contribute to the dose. A distance of one centimeter in soil represents about 80 half-thicknesses for 0.2 MeV betas; the average beta disintegration energy for Cs-137 is 0.195 MeV.⁽⁶⁾

C. Internal Exposure Due to Inhalation

Exposure rates have been computed for inhalation of iodine, tritium and particulates. In each case, the first step in the calculation has been to estimate

the daily activity intake via inhalation. The amount of activity reaching the body following inhalation has been estimated using the following formula:

$$A (\mu \text{ Ci/day}) = Q \left(\frac{X}{Q} \right) (B) \left(\frac{1 \text{ yr}}{365.25 \text{ days}} \right) \left(10^6 \frac{\mu \text{ Ci}}{\text{Ci}} \right)$$

where:

- Q = the release rate, Ci/yr;
- X/Q = the applicable atmospheric dispersion parameter, sec/m³; and
- B = the breathing rate, m³/sec;

The value of B for an adult was taken to be $2.32 \times 10^{-4} \text{ m}^3/\text{sec}$ which is equivalent to the value of $20 \text{ m}^3/\text{day}$ recommended by the ICRP.⁽²⁾ Since the more critical receptor for this pathway is a young child, especially for I-131, an estimate of child exposure was also made. The breathing rate for a young child was taken to be $6 \text{ m}^3/\text{day}$.^(10,11)

1. Exposure Due to Tritium Inhalation

As tritium can rapidly be absorbed through the human skin, inhalation is not the only source of tritium intake.⁽¹²⁾ As recommended by the ICRP⁽²⁾ the total tritium intake via inhalation and skin absorption is taken to be twice that due to inhalation alone.

Having established the rate of tritium intake, the resulting adult exposure was obtained using methods outlined in Appendix B. Exposure to a child was assumed to be identical to that for an adult.

2. Exposure Due to Radioiodine Inhalation

For adults, the daily intake via inhalation of the various radioiodines was estimated using the formula given above. The dose conversion factors already presented in the body of the report were used to arrive at the thyroid exposure rates. Other organ doses and the whole body dose were obtained using methods given in Appendix B. For child thyroid exposure it was necessary to calculate proper dose conversion factors. The equation used is given below:

$$DCF_i \text{ (rem/Ci)} = f_a \left(\frac{T_{\text{eff } i}}{0.693} \right) \left(\frac{3.7 \times 10^{10} \frac{\text{dis}}{\text{sec-}\mu\text{Ci}}}{m} \right) \left(8.64 \times 10^4 \frac{\text{sec}}{\text{day}} \right) \\ E_{\text{eff}} \frac{\text{(MeV)}}{\text{dis}} \left(1.6 \times 10^{-8} \frac{\text{g-rem}}{\text{MeV}} \right)$$

where:

- $DCF_i \text{ (rem/ci)}$ = the dose conversion factor for the i th iodine isotope, rem/Ci inhaled;
- f_a = the fraction reaching the thyroid via inhalation;
- $T_{\text{eff } i}$ = the effective biological halflife in the thyroid, days;
- $E_{\text{eff } i}$ = the effective disintegration energy, MeV/dis; and
- m = the mass of the thyroid gland, grams.

The value of f_a was taken to be 0.23, the value given in ICRP II for adult iodine inhalation.⁽²⁾ The fraction of iodine reaching the thyroid does not vary significantly with age.⁽¹³⁾ The values of T_{eff} for each iodine isotope were obtained by combining the radiological halflife with the assumed 8-day biological halflife for iodine in the thyroid.⁽¹¹⁾ The values of the effective

energy were taken to be those given by Bryant⁽¹⁰⁾ for all iodine isotopes except I-131. The effective energy of I-131 was taken to be 0.21 MeV as estimated by Rohwer and Kaye.⁽¹¹⁾ The dose conversion factors so calculated were applied to estimate the maximum potential child thyroid exposure via inhalation.

3. Exposure Due to Food Chain Transport

The manner in which the daily activity intakes for this pathway were established is described fully in the text of this report. For adult exposure, these intake rates were converted to exposure rates by the DOSCAL code. For child thyroid exposure from I-131 and I-133 the dose conversion parameters already developed to compute inhalation thyroid exposure were used. It was necessary only to replace f_a with f_w , the fraction of ingested iodine reaching the thyroid. The value of f_w was taken to be 0.3, as given by the ICRP⁽²⁾ and recommended by the FRC.⁽¹³⁾ The whole body child exposure due to Cs-134 and Cs-137 was calculated in the same manner as for particulate inhalation, again using the dosimetric data provided by Bryant.⁽¹⁰⁾

APPENDIX A REFERENCES

1. Hendrickson, M.M., "The Dose From ^{85}Kr Released to the Earth's Atmosphere", in Environmental Aspects of Nuclear Power Stations, IAEA Symposium, New York (August 1970).
2. ICRP Publication 2, "Report of Committee II on Permissible Dose for Internal Radiation", International Commission on Radiological Protection, Pergamon Press, New York (1959).
3. Lederer, C.M., et al., "Table of Isotopes", Sixth Edition, Wiley (1967)
4. Crocker, G.R., et al., "Factors for the Calculation of Infinite Plane Exposure Rates from Gamma Radiation", Health Physics, Vol. 12, pp. 1327-1332 (1966).
5. Turner, W.D., "The EXREM II Computer Code for Estimating External Doses to Populations From Construction of a Sea-Level Canal With Nuclear Explosives", Union Carbide Corporation, Oak Ridge, CTC-8 (July 1969).
6. "Radiation Health Handbook", Public Health Service, U.S. DHEW, (Revised January, 1970).
7. Beck, H.L., "Environmental Gamma Radiation from Deposited Fission Products", Health Physics, Vol. 12, pp. 313-323 (March 1966).
8. Personal communication from Mr. Harold L. Beck, Health and Safety Laboratories, New York, to Mr. Dan E. Martin, NUS Corporation, Rockville, Md. (March 19, 1973).
9. Beck, H.L., J. DeCampo, C. Gogalak, "In Situ Ge (Li) and Na I (Tl) Gamma Ray Spectrometry", Health and Safety Laboratory, HASL-258 (September 1972).
10. Bryant, P.M., "Data for Assessments Concerning Controlled and Accidental Releases of I-131 and Cs-137 to Atmosphere", Health Physics, Vol. 17, No. 1 (July 1969).
11. Rohwer, P.S., S.V. Kaye, "Age-Dependent Models for Estimating Internal Dose in Feasibility Evaluations of Plowshare Events", Oak Ridge National Laboratory, ORNL-TM-2229 (1968).

12. Pinson, E.A., and W. H. Langham, "Physiology and Toxicology of Tritium in Man", *Journal of Applied Physiology*, Volume 10, (January 1957 - May 1957).
13. FRC Report No. 2, "Background Material for the Development of Radiation Protection Standards", (September 1961).

APPENDIX B

COMPUTATIONAL METHODS FOR DOSES
 RESULTING FROM LIQUID EFFLUENTS
 FROM DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

A. Whole Body and Body Organ Exposure from Water Ingestion

The ICRP has established the maximum average liquid intake of the standard man at 1.2 liters per day. ⁽¹⁾ The standard man is assumed to have a total body mass of 70 kilograms, ⁽¹⁾ hence, the 1.2 liter daily liquid intake represents a daily renewal of 1.7% of the body mass.

The daily intake of the i^{th} radionuclide, A_i (Ci/day) from the hypothesized 1.2 liter daily ingestion of cooling tower blowdown and dilution water, can be found from the maximum expected discharge concentration, C_i ($\mu\text{Ci}/\text{cc}$), by the following formula:

$$A_i (\mu\text{Ci}/\text{day}) = 1200 (\text{cc}/\text{day}) \times C_i (\mu\text{Ci}/\text{cc})$$

For the whole body, and for all body organs of interest for the particular element, the equilibrium body (organ) burden, Q (μCi), can be computed from the daily intake and other information.

$$Q (\mu\text{Ci}) = \frac{Af_w}{\lambda_{\text{eff}}} = \frac{Af_w T_{\text{eff}}}{.693}$$

where:

A = intake rate, $\mu\text{Ci}/\text{day}$;

f_w = fraction of intake reaching organ of interest; ⁽¹⁾

λ_{eff} = effective (radioactive decay plus biological elimination rate) decay constant, days⁻¹

T_{eff} = effective half-life, ⁽¹⁾ days.

This can be combined with the general equation for determining dose rate, R mrem/year, to an organ from an organ burden Q:

$$R = \left(\Sigma E f \text{ (RBE)} n \frac{\text{MeV}}{\text{dis}} \right) \left(\frac{3.7 \times 10^4 \text{ dis}}{\text{sec} \cdot \text{Ci}} \right) \left(\frac{1}{M \text{ grams}} \right) Q \mu\text{Ci}$$

$$\left(\frac{1.6 \times 10^{-6} \text{ ergs}}{\text{MeV}} \right) \left(\frac{\text{gm} \cdot \text{rem}}{100 \text{ ergs}} \right) \left(\frac{3.16 \times 10^7 \text{ sec}}{\text{year}} \right) \left(\frac{10^3 \text{ mrem}}{\text{rem}} \right)$$

$$R = \frac{1.87 \times 10^7 \Sigma E f \text{ (RBE)} n Q}{M} \text{ mrem/year}$$

where:

$\Sigma E f \text{ (RBE)} n$ = effective energy, MeV, for the body organ of interest;

M = mass of body organ of interest.

Therefore, for the total body with a mass of 70,000 grams, ⁽¹⁾ the result is:

$$R = 3.845 \times 10^2 \Sigma E f \text{ (RBE)} n f_w T_{\text{eff}}^{-1} A$$

For a given radioisotope, the values of the effective energy, effective half-life, fraction reaching the organ, and the organ mass vary with the particular organ under consideration. Table B-1 lists the ICRP values of mass and effective radius of the body organs considered in this report.

Using data given in the ICRP Report of Committee II ⁽¹⁾ for values of $\Sigma E f \text{ (RBE)} n$, T_{eff} and f_w the annual dose rate due to each ingested radioisotope was determined for the whole body and all the body organs of interest for the particular element, with the exception of the gastrointestinal tract.

TABLE B-1

ICRP VALUES FOR ORGAN MASS AND EFFECTIVE RADIUS⁽¹⁾

<u>Body Organ</u>	<u>Organ Mass grams</u>	<u>Effective Radius cm</u>
Whole Body	70,000	30
Body Water	43,000	30
Lungs (2)	1,000	10
Liver	1,700	10
Spleen	150	7
Kidneys (2)	300	7
Bone	7,000	5
Muscle	30,000	30
Pancreas	70	5
Thyroid	20	3
Testes (2)	40	3
Ovaries (2)	8	3
Prostate	20	3
Stomach	250	10
Small Intestine	1,100	30
Upper Large Intestine	135	5
Lower Large Intestine	150	5

Doses to the GI-tract were calculated by the method of "MPC ratiocing" wherein the ratio of the actual concentration and the MPC⁽¹⁾ are multiplied by the dose derived by the GI-tract from ingestion of water at MPC levels (15 rem/year).

Once the above outlined calculations are accomplished, the doses may be totaled. The dose to a particular organ is made up of the following three components:

- 1) the dose to the particular organ from all those isotopes for which the particular organ dose is calculable;
- 2) the whole body dose from all other isotopes except tritium; and
- 3) the dose from tritium.

The third component of the organ dose, the dose from tritium, depends on the organ. For tritium, released in the chemical form of water, it is possible from ICRP data to compute a whole body dose and a "body water" dose. The "body water" is a fictitious organ hypothesized for the purpose of establishing MPC values for tritium. In actuality water is distributed throughout the body, most body organs being comprised of roughly 80% water.⁽²⁾ The calculation of a dose to the body water from tritium assumes that 100% of the tritium disintegration energy is absorbed in the body water, not accounting for energy absorbed in non-aqueous tissues. The computational method used assumes that the body organ dose from tritium is equal to the body water dose, calculated using ICRP II criteria, times the fractional water content of the organ (grams water/gram organ). The mass water fractions used for the various organs are presented in Table B-2 of this document. The body water distribution as presented in Table B-2 and used in the NUS computer code DOSCAL appears to be quite adequate; the total body mass and total body water mass are very close to the values estimated in ICRP II.⁽¹⁾

TABLE B-2

ESTIMATED BODY WATER DISTRIBUTION BY ORGAN IN STANDARD MAN

Body Organ	Organ Mass grams ¹⁾	Organ Mass Water		Organ Water Content, grams
		range ²⁾	Fraction, % value used ^{3,5)}	
DOSCAL organs:				
brain	1,500	70-85	77.5	1,163
lungs (two)	1,000	78-80	79.0	790
heart	300	71-80	75.5	227
muscle	30,000	74-84	79.0	23,700
bone	7,000	30-44	37.0	2,590
skin	6,100	70-75	72.5	4,423
liver	1,700	73-77	75.0	1,275
spleen	150	76-81	78.5	118
kidneys (two)	300	78-79	78.5	236
pancreas	70	none given	80.0	56
thyroid	20	none given	80.0	16
GI-tract	2,000	none given	80.0	1,000
testes (two)	40	84.0	84.0	34
ovaries (two)	8	80.5	80.5	6.4
prostate	20	82.5	82.5	17
Other organs:				
blood	5,400	77-81	70.6	4,244
fat	10,000	none given	20 (4)	2,000
lymphatic tissue	700	none given	80.0	560
bone marrow	3,000	14.0	14.0	420
Totals	70,000			43,000

- Notes: 1) Values for organ mass are from ICRP
 2) Range values for organ mass water fraction are from the Handbook of Biological Data⁽²⁾, except as noted.
 3) The arithmetic mean value of the range is used in DOSCAL, unless only a single value is given.
 4) This value is from "The Physiology and Toxicology and Tritium in Man" by Pinson and Langham⁽³⁾.
 5) Where better data is not available, the organ is estimated to be 80% water.

B. Whole Body and Body Organ Exposure from Fish Ingestion

Aquatic life forms will concentrate various elements within their bodies in proportion to the concentration of the element in the water in which they live. The ratio of the concentration of the element in the organism to the concentration in water is defined as the concentration factor, or CF. The CF generally depends on the element being concentrated, the species of organism, and the environment in which it lives. Maximum CF's for fish, shellfish and plants in seawater and fresh water have been tabulated⁽⁴⁾ and are used here to estimate the maximum activity of individual radioisotopes in fish.

For the purpose of estimating the maximum dose an individual might obtain from eating fish it was assumed that an individual might consume a maximum average of 50 grams of fish daily. Thus, the daily activity intake of the i^{th} radionuclide would be given by:

$$A_i \text{ (}\mu\text{Ci/day)} = C_i \text{ (}\mu\text{Ci/cc)} (CF)_i 1.0 \text{ (cc/gram)} (50 \text{ grams/day)}$$

Once the daily activity intake is established, the equilibrium body (organ) burden and the concurrent whole body and organ doses are calculated in the same manner as presented in Part A of this appendix.

APPENDIX B REFERENCES

1. ICRP Publication 2, "Report of Committee II on Permissible Doses for Internal Radiation", International Commission on Radiological Protection, Pergamon Press, New York (1959).
2. Spector, W.S., "Handbook of Biological Data", W.B. Saunders Company (1961).
3. Langham, W.H., and Pinson, E.A., "Physiology and Toxicology of Tritium in Man", Journal of Applied Physiology, Volume 10 (January 1957-May 1957).
4. Thompson, S.E., et al., "Concentration Factors of Chemical Elements in Edible Aquatic Organisms", UCRL-50564 Rev 1. (October, 1972).

6.1.5 RADIOLOGICAL SURVEYS

United States Atomic Energy Commission regulations require that nuclear power plants be designed, constructed, and operated so as to keep levels of radioactive material in effluents to unrestricted areas as low as practically achievable (10 CFR Part 50.34a). To assure that such releases are kept as low as practicable, each license authorizing reactor operation includes technical specifications (10 CFR Part 50.36a) governing the release of radioactive effluents.

Inplant monitoring is utilized to assure that these predetermined release limits are not exceeded. However, as a precaution against unexpected and undefined processes in force in the environment which might allow undue accumulation of radioactivity in any sector of man's environment, a program for monitoring of the plant environs is also included in the environmental technical specifications.

The regulations governing the quantities of radioactivity in reactor effluents allow nuclear power plants to contribute, at most, an exposure increase of only a few percent above that due to normal background radioactivity.

Background levels at any one location are not constant but vary with time as they are influenced by external events such as cosmic ray bombardment, weapons test fallout, and atmospheric variations. These levels also can vary spatially within relatively short distances reflecting variation in the geological composition. Because of these spatial and temporal variations, the radiological surveys of the station environs are divided into a preoperational and an operational phase. The preoperational phase of the program of sampling and measuring radioactivity in various media permits a general characterization of the radiation levels and concentrations prevailing prior to unit operation along with an indication of the degree of

natural variation to be expected. The operational phase of the program obtains data which, when considered along with the data obtained in the pre-operational phase, assist in the evaluation of the radiological impact of unit operation.

Implementation of the preoperational monitoring program fulfills the following objectives:

1. personnel training
2. evaluation of procedures, equipment and techniques
3. identification of probable critical pathways to be monitored after the units are in operation
4. measurement of background levels and their variations along anticipated critical pathways in the areas surrounding the station.

The preoperational phase of the radiological survey program will provide a minimum of two years data prior to the issuance of an operating license.

The program for Davis-Besse Station Unit No. 1, the primary basis for the data presented in Section 2.8 of this report, is described in Sections

6.1.5.1, et seq.

6.1.5.1 Program Description

The Preoperational Environmental Radiological Monitoring Program is being conducted by Industrial Bio-Test Laboratories, Inc., for the Toledo Edison Company. The program began in July 1972, and will continue until the issuance of an operating license. It includes onsite & offsite collection and radiometric analyses of airborne particles, airborne iodine, ambient gamma radiation, surface and ground water, precipitation, soil and bottom sediments, fish, clams, food crops, vegetation, milk, meat, and wildlife. Samples are collected and measurements are made at 29 selected locations on or around the site. The sampling locations on the site periphery are shown in Figure 6.1-1. The sampling locations beyond the site periphery are

shown on Figure 6.1-2. Table 6.1-1 lists the locations of the sampling points, and their distance and direction from the site. The program schedule indicating where specific samples are collected and the sampling frequency are shown in Table 6.1-2.

6.1.5.2 Rationale for the Selection of Sampling Locations

The selection of sampling locations and types of samples was based upon a review of the available information specific to the area and the general region. This information included data on land use, meteorology, hydrology, demography, ecology, and regional radioactivity monitoring programs sponsored by government agencies. The initial program identifying the critical exposure pathways for the area, sampling points, and the number and kinds of samples was then reviewed with various departments of the State of Ohio and the Environmental Protection Agency. Their recommendations were considered in the final program summarized in Table 6.1-2.

Air samples and thermoluminescent dosimeters (TLD) locations were selected by examination of the prevailing wind direction and predicted maximum ground level deposition patterns determined from data compiled onsite. Additional locations were established to measure levels at nearby population centers. Water sampling points were selected to include the monitoring of nearby potable water intakes as possible exposure pathways to large populations. Wells sampled in the program were selected on the basis of their proximity to the station, hydrological considerations, and water use. Fish and clam samples were taken because there is a fishing industry on Lake Erie in the general area of the Davis-Besse site, and an indigenous population of fresh-water clams is present. Bottom sediments were sampled for indications of the long-term buildup of radioactivity. Because of the agricultural activity in the area, milk, food crops, animal feed, and domestic meat will be

TABLE 6.1-1
 RADIOLOGICAL MONITORING PROGRAM
 SAMPLING LOCATIONS
 (Page 1 of 2)

Sampling Point	Location*
T-1	Site boundary, NE of station, near intake canal
T-2	Site boundary, E of station
T-3	Site boundary, Toussaint River and storm drainage point outfall SE of station
T-4	Site boundary, S of station, near Locust Point and Toussaint River
T-5	Main entrance to site
T-6	Site boundary, NW of station
T-7	Sand Beach, 0.9 mi NNW of site
T-8	Earl Moore Farm, 3.2 mi WSW of site
T-9	Oak Harbor, 6.8 mi SW of site
T-10	Erie Industrial Park, 6.5 mi SE of site
T-11	Port Clinton, 11.5 mi SE of site
T-12	Toledo, 23.5 mi WNW of site
T-13	(Deleted)
T-14	Township school, 3.8 mi WSW of site
T-15	Lacarne, 5.6 mi SSE of site
T-16	Put-In-Bay Winery, 15.3 mi ENE of site
T-17	Irv Fick's onsite well, 0.7 mi SW of station
T-18	Hess Sunoco Garage, 1.3 mi S of site
T-19	Miller Farm, 3.7 mi S of site
T-20	Daup Farm, 5.4 mi SSE of site
T-21	Haynes Farm, 3.6 mi ESW of site
T-22	Peter Farm, 2.6 mi SW of site
T-23	Put-In-Bay Lighthouse, 14.3 mi ENE of site
T-24	Sandusky, 24.9 mi SE of site

TABLE 6.1-1 (Page 2 of 2)

Sampling Point	Location
T-25	Winter Farm, 1.3 mi S of site
T-26	Fostoria, 35 .1 mi SW of site
T-27	Magee Marsh, 5.3 mi WNW of site
T-28	Unit 1 treated water supply, onsite
T-29	Lake Erie, Intake Area, 1.5 mi NE of site
T-30	Lake Erie, Discharge Area, 0.9 mi ENE of site

*Distance measured from center of shield building of Unit No. 1.

TABLE 6.1-2
 ENVIRONMENTAL MONITORING PROGRAM
 (Page 1 of 4)

Type of Sample	Locations and Sampling Points	Sample Frequency	Analyses
AIRBORNE PARTICULATES	T-1 Site boundary near intake canal and Sand Beach NE direction	Weekly	Gross alpha Gross beta
	T-2 Site boundary beach E of station		Note: Gamma spectral analysis when beta activity 10pCi/m ³
	T-3 Site boundary Toussaint River and storm drainage pt. outfall SE of station		on <u>quarterly composite</u> of all filters
	T-4 Site boundary, S of station near Locust Point and Toussaint River		Gamma spectral analysis
	T-7 Sand Beach, 0.9 mi NNW of site		
	T-8 Earl Moore Farm		
	T-9 Oak Harbor		
	T-10 Erie Industrial Park		
	T-11 Port Clinton		
	T-12 Toledo		
	T-23 Put-in-Bay		
	T-27 Magee Marsh		
AIRBORNE IODINE	T-1	Weekly	Gamma Spectral analysis on charcoal canister for ¹³¹ I
	T-2		
	T-3		
	T-4		
	T-7		
	T-8		
	T-9		
	T-10		
	T-11		
	T-12		
T-23			
T-27			
AMBIENT GAMMA RADIATION LEVELS	T-1	Monthly, Quarterly, And Annually	Gamma dose
	T-2		
	T-3		
	T-4		
	T-5 Main entrance to site		
	T-6 NW corner of site boundary		
	T-7		
	T-8		

TABLE 6.1-2 (Page 2 of 4)

Type of Sample	Locations and Sampling Points	Sample Frequency	Analyses
	T-9		
	T-10		
	T-11		
	T-12		
	T-14 Township School		
	T-15 Lacarne		
	T-23		
	T-24 Sandusky		
	T-26 Fostoria		
	T-27 Magee Marsh		
UNTREATED SURFACE WATER	T-1 Water from station intake to lake opposite intake canal	Weekly Grab* Composited Monthly	Gross alpha and gross beta in dissolved and suspended fractions Tritium
	T-2 In lake east of station		
	T-3 In river opposite (storm drainage outfall in river)		
	T-10 Erie Industrial Park Water intake		Note: Gamma spectral analysis when gross beta >10pCi/l.
	T-11 Port Clinton intake water		Radium determination when gross alpha >3pCi/l.
	T-12 Toledo water intake		
			On quarterly composite ⁹⁰ Sr. gamma spectral analysis
TREATED SURFACE WATER	T-10 Erie Industrial Park tapwater	Weekly Grab Composited Monthly	Gross alpha and gross beta in dissolved and suspended fractions Tritium
	T-11 Port Clinton tapwater		
	T-12 Toledo tapwater		
	T-28 Unit 1 treated water supply		
			Note: Gamma spectral analysis when gross beta >10pCi/l. Radium determination when gross alpha >3pCi/l

TABLE 6.1-2 (Page 3 of 4)

Type of Sample	Locations and Sampling Points	Sample Frequency	Analyses
			On quarterly composite ⁹⁰ Sr. gamma spectral analysis
GROUND WATER	T-7 Beach well-sand beach	Quarterly*	Gross alpha and gross beta in dissolved and suspended fractions Tritium ⁹⁰ Sr and gamma spect ^a l analysis
	T-17 Irv Fick's on-site well		
	T-27 Magee Marsh		
	T-18 Hess Sunoco Garage		
PRECIP-ITATION	T-1	Monthly* Composite	Gross beta Tritium Note: gamma spectral analysis when gross beta >10pCi/l Radium determination when gross alpha >3pCi/l
	T-23		
BOTTOM SEDIMENTS	T-1	Quarterly*	Gross beta Gross alpha ⁹⁰ Sr Gamma spectral analysis
	T-29		
	T-30		
FISH (Three species of fish, min.)	Lake Erie in vicinity of site near T-1	Quarterly*	Flesh-Gross beta Gamma spectral analysis Bone- ⁹⁰ Sr
	Toussaint River near storm drainage outfall by T-3		
CLAMS (flesh only)	Lake Erie in vicinity of site near T-1	Quarterly	Gross beta Gamma spectral analysis

TABLE 6.1-2 (Page 4 of 4)

Type of Sample	Locations and Sampling Points	Sample Frequency	Analyses
FRUITS AND VEGETABLES	T-8 T-19 Miller Farm T-25 Winter Farm	Semi-Annually	Edible portion Gross beta Gross alpha Gamma spectral analysis ⁹⁰ Sr
MILK	T-8 T-20 Daup Farm T-21 Haynes Farm T-12 Toledo (milk pro- cessing plant) T-24 Sandusky (milk pro- cessing plant)	Monthly	Gross beta ⁸⁹ Sr ⁹⁰ Sr Gamma spectral analysis Calcium
DOMESTIC MEAT	T-22 Peter Farm	Semi-Annually	Flesh-Gross beta Gamma spectral analysis
WILDLIFE (min of two species)	Onsite	Semi-Annually	Flesh-Gross beta Gamma spectral analysis Bone- ⁹⁰ Sr
SOILS	T-1 Beach sand T-8 T-19 T-20	Semi-Annually	Gross beta Gamma spectral analysis ⁹⁰ Sr
WINE	T-16 Put-In-Bay Winery	Annually	Gross Beta Gross alpha ⁹⁰ Sr Gamma spectral analysis
ANIMAL FEED	T-8 T-21	Semi-Annually	Gross alpha Gross beta ⁹⁰ Sr Gamma spectral analysis
WATERFOWL	Vicinity of site	Annually	Flesh-gross beta and gamma spectral analysis Bone- ⁹⁰ Sr
SMARTWEED	Vicinity of site	Annually	Gross alpha, gross beta, gamma spectral analysis ⁹⁰ Sr

*Except when ice conditions prohibit sampling

examined on nearby farms.

6.1.5.3 Sampling Methodology

A description of the procedures and equipment used to collect samples for the program described in Table 6.1-2 follows.

a. Airborne Particulates

Twelve air sampling locations have been established in the vicinity of the station. The airborne particulate samples are collected on 47 mm diameter membrane filters with 0.8 micron pore size. Gast vacuum air pumps are used to filter air at the rate of 1 cu ft/min. The filters are collected weekly and placed individually in protective glassine envelopes, and mailed to Bio-Test for radiometric analysis. The following information is recorded on each envelope: (a) date, (b) time, (c) vacuum gage reading, and (e) cumulative hours. The filters are counted about 5 days after collection to allow for decay of short-lived radioactive isotopes. To minimize counting variables, all samples are counted on the same instrument.

b. Airborne Iodine

Each air sampler is equipped with a charcoal trap in line after the filter holder. The collection starting dates are the same as for the particulate filters. The charcoal at each operating location is changed at the same time as the particulate filters and dispatched to Bio-Test for analysis. The samples are analyzed immediately after arrival at the laboratory.

c. Ambient Gamma Radiation Levels

The integrated gamma radiation background is measured with TLDs. They are packaged with five chips to a dosimeter. TLDs are placed at 18 location and are exchanged monthly, quarterly, and annually. Each shipment of new TLDs includes an in-transit control which is returned to the laboratory with those from the field.

DB-1

d. Untreated Surface Water

One-gallon samples of untreated water from Lake Erie are collected weekly from three filtration plants and at three onsite locations. The samples are composited monthly, analyzed for gross alpha and gross beta activities in suspended and dissolved solids fractions, and analyzed for tritium. Quarterly composites are gamma-scanned and analyzed for ^{90}Sr .

e. Treated Surface Water

One-gallon samples of treated water are collected weekly from the filtration plants and analyzed for gross alpha and gross beta activities in total residue, and for tritium. Quarterly composites are gamma-scanned and analyzed for ^{90}Sr .

f. Groundwater

One-gallon water samples are collected quarterly from wells at four locations. The gross alpha and gross beta activities are determined in the suspended and dissolved solids fractions of each sample. The tritium content is established by direct counting of samples, using liquid scintillation techniques. Strontium-90 activity is determined by milking ^{90}Y . The samples are also gamma-scanned for identification and quantification of gamma-emitting isotopes.

g. Precipitation

Monthly precipitation samples are collected, when available, from onsite and at Put-In-Bay Lighthouse. The samples are analyzed for gross beta activity. The tritium activity is determined by direct counting using liquid scintillation techniques.

h. Bottom Sediments

Bottom sediments are collected in Lake Erie from three locations in the vicinity of the site. The samples are gamma-scanned and analyzed for gross alpha, gross beta, and ^{90}Sr activities.

DB-1

i. Fish

A minimum of three varieties of fish are collected three times per year from Lake Erie in the vicinity of the Site (T-1) and from the Toussaint River near the storm drain outfall. The fish bones are analyzed for ^{90}Sr .

j. Clams

When available, a sample of clams is obtained near the site. The muscles are gamma-scanned and analyzed for gross beta activity.

k. Fruits or Vegetables

A minimum of two varieties of fruits and vegetables normally consumed by man are collected semiannually from three farms. The samples are gamma-scanned and analyzed for gross alpha, gross beta, and ^{90}Sr .

l. Animal Feed

Grass samples and animal feed are gathered from two farms. The same analyses used for fruits and vegetables are performed.

m. Milk

One-gallon milk samples are taken monthly from herds which graze within 5 mi. of the station site, and from processing plants in Toledo and Sandusky. Ten milliliters of 37% formaldehyde solution are added to each gallon of milk as a preservative before shipment. The samples are analyzed for gross beta, ^{131}I , ^{140}Ba , ^{40}K , ^{89}Sr and ^{90}Sr and for stable calcium and potassium.

n. Domestic Meat

A beef sample is purchased from the Peter Farm semiannually, and the flesh is gammascanned and analyzed for gross beta activity.

o. Wildlife

A minimum of two representative species of fauna are collected near the site. The muscles are separated from the bones and are gamma-scanned and analyzed for gross beta; the bones are analyzed for ^{90}Sr .

p. Soil

Soil samples from three dairy farms are collected semiannually from the top 2 in. of soil where vegetation is not growing. They are scanned for gamma activity and analyzed for gross beta activity and ^{90}Sr .

q. Wine

A wine sample is obtained annually from the Put-In-Bay Winery. The wine is gamma-scanned and analyzed for gross alpha, gross beta, and ^{90}Sr activities.

r. Waterfowl

Ducks are collected annually in the vicinity of the site. Analyses are the same as for wildlife.

s. Smartweed

Samples of smartweed will be collected annually from the site. Analyses are the same as for fruits and vegetables.

6.1.5.4 Laboratory Capability

The required analyses on samples collected during the program are performed by Bio-Test Laboratories, Inc., at Northbrook, Illinois. Their laboratory is equipped with the instrumentation needed to measure the radioactivity in the samples. Following is a partial list of the counting equipment at their facility:

- a. Widebeta-II Proportional Counter
- b. Liquid Scintillation Counter
- c. Harshaw model 2000 TLD Reader
- d. 4 x 4 in. NaI Detector coupled to a 512-channel pulse height analyzer
- e. 86.8 cm³ GeLi Detector coupled to 4096-channel pulse height analyzer
- f. Packard Automatic Gamma Counter model 5957.

6.1.5.5 Radiochemical Analytical Procedures

These procedures are equal to or exceed those recommended by the U. S. A.E.C. Health and Safety Laboratory. (1)

6.1.5.5.1 Airborne Particulates

a. Gross Alpha and Gross Beta

The sample is stored for 3 days, from the day of collection, to allow for decay of short-lived radon and thorium daughters.

The 47-mm filter is placed on a stainless steel planchet and the samples counted in a Beckman Widebeta-II Proportional Counter. The activity is calculated in pCi/m^3 and corrected for the counter efficiency.

b. Gamma Analyses by NaI(Tl) Detector

The filter is placed on a 4 x 4 in. NaI crystal detector and the gamma spectrum is determined by using 512 channels of the gamma spectrometer with a setting of 5 keV per channel. Gamma-emitters (if present) are identified by their specific energy peaks.

c. Gamma Analyses by Ge(Li) Detector

The filter is placed on an 86.8 cm^3 detector. The gamma spectrum is determined by using a 4096 channel gamma spectrometer with a setting of 0.5 keV per channel. Gamma-emitters (if present) are identified by their specific energy peaks.

d. Strontium-90

Strontium and barium carriers are added to the composited filter paper samples and fused with sodium hydroxide and sodium carbonate. The melt is taken up in distilled water and washed and treated with sodium carbonate to yield a precipitate of alkaline earth carbonates. Silicates are removed by dehydration with nitric acid; the carbonate is converted to nitrates. Radium with barium is precipitated as a chromate; calcium is then separated by pre-

precipitation in nitric acid, and rare earth impurities are removed by adding a scavenger solution. Strontium carbonate is precipitated and dissolved in nitric acid. Yttrium carrier is added, and the resultant solution stored for 90y ingrowth. The strontium is precipitated again and separated from 70% nitric acid with the yttrium nitrate in the supernate. Yttrium nitrate is finally converted into yttrium oxalate and collected on a glass fiber filter for counting.

6.1.5.5.2 Airborne Iodine

The charcoal is transferred to a plastic scintillation vial. The vial is placed in the Automatic Gamma Counter (Packard Instrument Co. model 5975) and counted. The time is recorded and the calculated concentrations corrected for decay.

6.1.5.5.3 Thermoluminescent Dosimeter (TLD)

The TLD crystal is placed on the crystal holder and the current read between 140° and 250°C. The reading is repeated and the second reading subtracted from the first. The intransit control reading is subtracted to obtain the net reading. The exposure in mR is calculated using the calibration curve obtained with the TLD crystals exposed to a known source of radium.

6.1.5.5.4 Water

a. Gross Alpha and Gross Beta in Total Residue

The sample is evaporated in a beaker to a small volume and then transferred to a 2-in. stainless steel planchet, where it is completely evaporated. The planchet is then baked in the muffle furnace to a dark cherry red color (550°C), cooled in a desiccator and the residue counted in a Beckman Widebeta-II Proportional Counter. The gross alpha and beta activity in the total residue is calculated in pCi/l, and corrected for efficiency, self-absorption, and volume.

DB-1

b. Gross Alpha and Gross Beta in Suspended and Dissolved Solids

One liter of water is filtered through a 47-mm diameter, 0.8 micron pore size, membrane filter. The filter paper is dried, placed in the stainless steel planchet, and a few drops of solution consisting of lucite dissolved in acetone are added. When dry, the filtrate is counted in a Widebeta-II Proportional Counter.

The filtrate is evaporated to a small volume, which is quantitatively transferred to a 2-in. stainless steel planchet, where it is completely evaporated. The planchet is then baked in the muffle furnace to a dark cherry red color (550°C), cooled in a desiccator and counted.

c. Tritium (Direct Counting)

A 10- to 50-ml water sample is completely distilled. Three milliliters of the distilled sample and 18 ml of scintillation medium are transferred into a vial and counted in a Liquid Scintillation Counter for 8 to 12 hours, depending on sample activity.

d. Strontium-90

An acidified sample of clear water, with stable strontium and calcium carriers, is treated with oxalic acid at pH 3.0 to precipitate insoluble oxalates. The oxalates are dissolved in nitric acid and strontium nitrate is separated from calcium as a precipitate in a 70% solution of nitric acid. The residue is purified by adding iron and rare earth carriers and then precipitating them as hydroxides. After a second precipitation with strontium nitrate from a 70% solution of nitric acid, the nitrates are dissolved in water, precipitated as strontium carbonate, filtered, and counted. The precipitate is then dissolved in nitric acid and the yttrium carrier is added, and stored for ingrowth of ^{90}Y . The strontium is precipitated again, separated from a 70% solution of nitric acid with yttrium nitrate in the supernate.

6.1.5.5.7 Milk

- a. Iodine-131, Barium-140, Cesium-137, Potassium-40, and Stable Potassium by Gamma Spectroscopy

An aliquot of the milk sample is poured into a Marinelli-type beaker and counted on a 4 x 4 in. NaI (Tl) crystal. The isotopes are identified by their specific energy peaks and their activities are calculated using the simultaneous equations.

- b. Strontium-89, Strontium-90, and Calcium

The sample is aged for at least 2 weeks to allow the ^{90}Y daughter ingrowth. Carriers are added to 1 liter of milk and then yttrium is separated from strontium, barium, and calcium by passing the milk sample successively through cation- and anion-exchange resin columns. Yttrium, which is retained by the anion-exchange resin, is eluted with HCl and precipitated as the oxalate. The precipitate is weighted to determine the recovery of the yttrium carrier and then counted for ^{90}Y activity. The ^{90}Sr level is calculated from the data.

Strontium, barium, and calcium are eluted from the cation-exchange resin with a NaCl solution, diluted, and precipitated as carbonates. These carbonates are converted to nitrates and precipitated as strontium and barium nitrates. The nitrate precipitate is dissolved and the barium is precipitated as the chromate.

From the supernate, strontium is precipitated as the nitrate, dissolved in water, and precipitated again as strontium nitrate. The nitrate is converted to the oxalate, filtered and weighed to determine the strontium carrier recovery, and counted for total radiostrontium. Total radiostrontium and ^{90}Y are counted in the Beckman Widebeta--II Proportional Counter. The concentration of ^{89}Sr is calculated as the difference between the activ-

DB-1

For counting total radiostrontium, ^{90}Y , or both, each fraction is precipitated separately as an oxalate and collected on a glass fiber filter or planchet.

6.1.5.5.5 Precipitation

a. Gross Beta

Solids and liquids are placed in a beaker, evaporated to a small volume, and transferred to a tared planchet for counting.

b. Tritium (Direct Counting)

The same procedure described in paragraph 6.1.5.5.4, item c, is followed.

6.1.5.5.6 Bottom Sediments and Soil

a. Gross Alpha and Gross Beta

The sample is dried, ground, and sieved. Between 100 and 200 mg of sample are placed into a 2-in. planchet and counted in a Beckman Widebeta-II Proportional Counter. The activity is calculated and corrected for efficiency and self-absorption.

b. Gamma Scan by Ge(Li) Detector

One-half to 1.0 kg of the sample is dried and ground, then put into 1-pint container, placed on the detector, and counted.

c. Strontium-90

The sample is fused with sodium carbonate and sodium hydroxide, then dissolved in hydrochloric acid (HCl). The strontium is purified by removing the existing yttrium, using the tri-butyl phosphate (TBP) extraction method. It is held for 1 to 2 weeks to allow for new yttrium ingrowth, after which the TBP extraction is repeated to separate ^{90}Y . The ^{90}Sr is counted and calculated from the ^{90}Y activity.

ity for total radiostrontium and the activity due to ^{90}Sr .

Calcium is determined from an aliquot of the cation-exchange column eluent described above. After dilution, calcium oxalate is precipitated and dissolved in diluted HCl. The oxalate is titrated with standardized potassium permanganate, and the calcium calculated.

6.1.5.5.8 Domestic Meat, Fish, Clams, and Wildlife
Gross Beta, Strontium-90, and Gamma Scan

The flesh is separated from bones and ashed at 400°C ; the bones are ashed at 600°C . The same procedures are followed as for soil.

6.1.5.5.9 Food Crops and Vegetation

a. Gross Alpha and Gross Beta

The sample is dried and ground. Between 100 and 200 mg of the dry sample are transferred to a stainless steel planchet and counted in a Beckman Widebeta-II Proportional Counter, then corrected for efficiency and self-absorption.

b. Gamma Analyses by NaI(Tl) Detector

Two to 3 kg of the sample are dried and ground. A 1-pint container is used to hold 450 cc of the sample and placed on a 4 x 4 in. NaI crystal detector. It is gamma-scanned, using 512 channels of a Gamma Spectrometer calibrated at 5 keV per channel. Gamma-emitters, if present, are identified by their specific energy peaks.

c. Gamma Analyses by Ge(Li) Detector

Between 2 and 3 kg of the sample are dried and ground. A 1-pint container holding 450 cc of the sample is placed on the detector and counted. The gamma spectrum is determined by using a 4096-channel gamma spectrometer with a setting of 0.5 keV per channel. Gamma-emitters, if present, are identified by their specific energy peaks.

d. Strontium-90

The ashed sample is dissolved in HCl. The strontium is purified by removing the existing yttrium, using the TBP extraction method, and set aside for 1 to 2 weeks to allow for new yttrium ingrowth. The TBP extraction is then repeated to separate the ^{90}Y , after which the ^{90}Sr is counted and calculated from the ^{90}Y activity.

6.1.5.5.10 Wine

Gross Alpha, Gross Beta, Strontium 90, and Gamma Scan

One liter of wine or grape juice is completely evaporated in a beaker. A few milliliters of sulfuric acid (H_2SO_4) are added and digested over a hot plate, and ashed at 600°C . The same analytical procedures used for vegetation samples are followed.

6.1.5.6 Minimum Detectable Concentration

The nominal minimum sensitivity for the various analyses performed in this program are listed in Table 6.1-3.

TABLE 6.1-3
 RADIOCHEMICAL ANALYTICAL SENSITIVITIES
 (Page 1 of 3)

Type of Sample	Analyses	Aliquot Analysis	Minimum Sensitivity *
Air Particulates	Gross alpha	280 m ³	0.0004 pCi/m ³
	Gross beta	280 m ³	0.001 pCi/m ³
Airborne Radiiodine	¹³¹ I	280 m ³	0.02 pCi/m ³
Ambient Gamma	TLD		1.0 mrem
Water	Gross alpha, s.s.**	1.0 liter	0.2 pCi/l
	Gross alpha, d.s.†	0.5 liter	0.5 pCi/l
	Gross beta, s.s.**	1.0 liter	0.3 pCi/l
	Gross beta, d.s.†	0.5 liter	0.6 pCi/l
	⁸⁹ Sr	1.0 liter	1.0 pCi/l
	⁹⁰ Sr	1.0 liter	0.5 pCi/l
	⁴⁰ K (Flame photometry)		0.1 pCi/l
	¹³⁷ Cs (gamma)	3.5 liter	3.5 pCi/l
	¹³⁷ Cs (chemical sep)	1.0 liter	0.5 pCi/l
	²²⁶ Ra	1.0 liter	0.2 pCi/l
	Tritium	0.25 liter	2.0 TU or 6.4 pCi/l
	¹³¹ I (gamma)	3.5 liter	3.1 pCi/l
	¹³¹ I (chemical sep)	2.0 liter	0.3 pCi/l
Vegetables	⁸⁹ Sr	5.0 g (ash)	1.0 pCi/g ash
	⁸⁹ Sr	5.0 g (ash)	0.1 pCi/g dry
	⁸⁹ Sr	5.0 g (ash)	0.007 pCi/g wet
	⁹⁰ Sr	5.0 g (ash)	0.5 pCi/g ash
	⁹⁰ Sr	5.0 g (ash)	0.05 pCi/g dry
	⁹⁰ Sr	5.0 g (ash)	0.004 pCi/g wet
	¹³⁷ Cs (gamma)	300.0 g (dry)	0.05 pCi/g dry
	¹³⁷ Cs (gamma)	300.0 g (dry)	0.003 pCi/g wet

*Minimum sensitivity (MS) is defined in equation (1) as the activity concentration in pCi/vol. which is detectable under specific conditions of sample volume, background, counting time, chemical yield, correction factors (self-absorption) and counting efficiency.

$$MS = \frac{MDA}{\text{Eff.} \times \text{Ch.Y} \times \text{Vol.} \times \text{C.F.} \times 2.22} \quad (1)$$

where minimum detectable activity (MDA) is defined in equation (2) as that amount of activity in counts per minute (cpm) which, in the same counting time, gives a count rate that is different from the background count by 3 times the standard deviation of the background count.

$$MDA = 3 \sqrt{\frac{N_b}{t_b}} \quad (2)$$

where:

$$\begin{aligned} t_b &= t_g \\ N_b &= \text{count rate of background} \\ t_b &= \text{counting time of background} \\ t_g &= \text{counting time of sample plus background} \end{aligned}$$

**s.s. = suspended solids.
 †d.s. = dissolved solids.

TABLE 6.1-3 (Page 2 of 3)

Type of Sample	Analyses	Aliquot Analysis	Minimum Sensitivity	
<u>Ge(ii) Detector</u>				
Air	^{144}Ce	3000 m^3	0.004 pCi/m^3	
Particulates	^{141}Ce	3000 m^3	0.0008 pCi/m^3	
	^7Be	3000 m^3	0.005 pCi/m^3	
	^{103}Ru	3000 m^3	0.0006 pCi/m^3	
	^{106}Ru	3000 m^3	0.004 pCi/m^3	
	^{137}Cs	3000 m^3	0.0006 pCi/m^3	
	^{95}Zr	3000 m^3	0.0009 pCi/m^3	
	^{95}Nb	3000 m^3	0.0006 pCi/m^3	
	Bottom sediments and soil	^{137}Cs	700.0 g dry	0.06 $\text{pCi}/\text{g dry}$
^{40}K		700.0 g dry	0.70 $\text{pCi}/\text{g dry}$	
Vegetation Grass	^{144}Ce	175.0 g dry	0.5 $\text{pCi}/\text{g dry}$	
	^{141}Ce	175.0 g dry	0.2 $\text{pCi}/\text{g dry}$	
	^7Be	175.0 g dry	0.8 $\text{pCi}/\text{g dry}$	
	^{103}Ru	175.0 g dry	0.1 $\text{pCi}/\text{g dry}$	
	^{106}Ru	175.0 g dry	0.5 $\text{pCi}/\text{g dry}$	
	^{131}I	175.0 g dry	0.1 $\text{pCi}/\text{g dry}$	
	^{137}Cs	175.0 g dry	0.1 $\text{pCi}/\text{g dry}$	
Bottom sediments and soil	^{131}I	500.0 g	0.02 $\text{pCi}/\text{g dry}$	
	^{40}K	500.0 g	0.15 $\text{pCi}/\text{g dry}$	
	Calcium		0.1 $\text{mg}/\text{g dry}$	
Bottom organisms	Gross alpha	0.1 g	1.6 $\text{pCi}/\text{g dry}$	
	Gross beta	0.2 g	1.4 $\text{pCi}/\text{g dry}$	
	^{89}Sr	5.0 g	1.0 $\text{pCi}/\text{g dry}$	
	^{90}Sr (gamma)	5.0 g	0.5 $\text{pCi}/\text{g dry}$	
	^{137}Cs (gamma)	- g	0.1 $\text{pCi}/\text{g dry}$	
Vegetation Grass	Gross alpha	0.1 g (ash)	2.5 $\text{pCi}/\text{g ash}$	
	Gross alpha	0.1 g (ash)	0.2 $\text{pCi}/\text{g dry}$	
	Gross alpha	0.1 g (ash)	0.08 $\text{pCi}/\text{g wet}$	
	Gross beta	0.2 g (ash)	1.6 $\text{pCi}/\text{g ash}$	
	Gross beta	0.2 g (ash)	0.13 $\text{pCi}/\text{g dry}$	
	Gross beta	0.2 g (ash)	0.05 $\text{pCi}/\text{g wet}$	
	^{89}Sr	5.0 g (ash)	1.0 $\text{pCi}/\text{g ash}$	
	^{89}Sr	5.0 g (ash)	0.1 $\text{pCi}/\text{g dry}$	
	^{89}Sr	5.0 g (ash)	0.04 $\text{pCi}/\text{g wet}$	
	^{90}Sr	5.0 g (ash)	0.5 $\text{pCi}/\text{g ash}$	
	^{90}Sr	5.0 g (ash)	0.05 $\text{pCi}/\text{g dry}$	
	^{90}Sr	5.0 g (ash)	0.02 $\text{pCi}/\text{g dry}$	
	^{137}Cs (gamma)	100-200 g (dry)	0.08 $\text{pCi}/\text{g dry}$	
	^{137}Cs (gamma)	100-200 g (dry)	0.03 $\text{pCi}/\text{g wet}$	
	Vegetables Tomatoes Pumpkin Eggplant Red beets Green beans	Gross alpha	0.1 g (ash)	2.5 $\text{pCi}/\text{g ash}$
		Gross alpha	0.1 g (ash)	0.25 $\text{pCi}/\text{g dry}$
		Gross alpha	0.1 g (ash)	0.02 $\text{pCi}/\text{g wet}$
		Gross beta	0.2 g (ash)	1.6 $\text{pCi}/\text{g ash}$
		Gross beta	0.2 g (ash)	0.16 $\text{pCi}/\text{g dry}$
Gross beta		0.2 g (ash)	0.01 $\text{pCi}/\text{g wet}$	
Gross beta		0.2 g (ash)		
Meat & Fish (muscle)	Gross alpha	0.1 g (ash)	1.6 $\text{pCi}/\text{g dry or ash}$	
	Gross alpha	0.1 g (ash)	0.02 $\text{pCi}/\text{g wet}$	
	Gross beta	0.2 g (ash)	1.4 $\text{pCi}/\text{g ash}$	
	Gross beta	0.2 g (ash)	0.014 $\text{pCi}/\text{g wet}$	
	^{89}Sr	5.0 g (ash)	0.015 $\text{pCi}/\text{g wet}$	
	^{90}Sr	5.0 g (ash)	0.007 $\text{pCi}/\text{g wet}$	
	^{137}Cs (gamma)	10.0 g (ash)	0.01 $\text{pCi}/\text{g wet}$	
	^{40}K (gamma)	10.0 g (ash)	0.1 $\text{pCi}/\text{g wet}$	

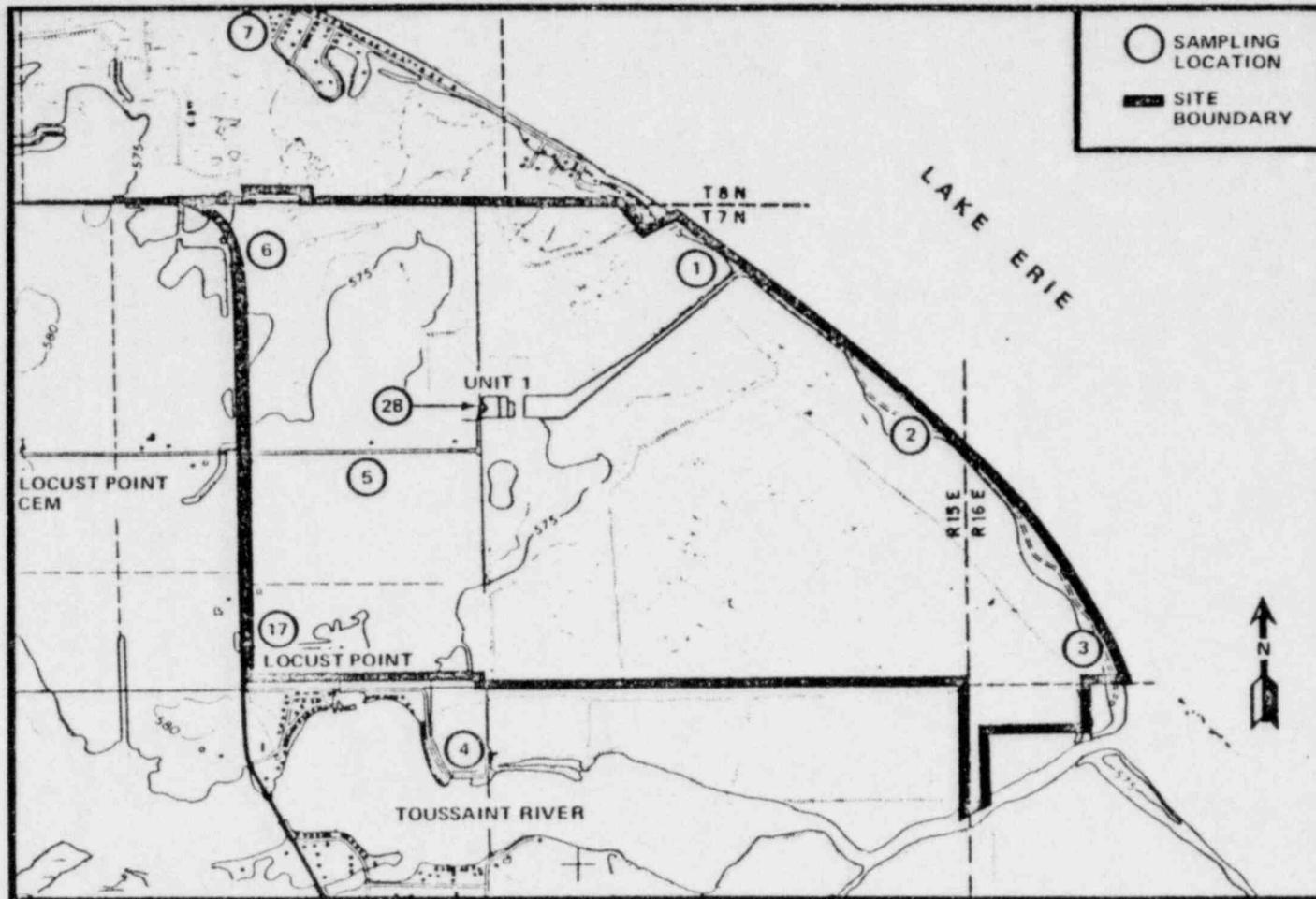
TABLE 6.1-3 (Page 3 of 3)

Type of Sample	Analyses	Aliquot Analysis	Minimum Sensitivity
Meat & Fish (bones)	Gross alpha	0.1 g (ash)	0.8 pCi/g dry
	Gross beta	0.2 g (ash)	0.7 pCi/g dry
	⁸⁹ Sr	5.0 g (ash)	0.5 pCi/g dry
	⁹⁰ Sr	5.0 g (ash)	0.25 pCi/g dry
Milk	Gross beta	1.0 liters	1.5 pCi/l
	¹³¹ I (gamma)	3.5 liters	3.1 pCi/l
	¹³¹ I (chem. sep.)	2.0 liters	0.5 pCi/l
	¹⁴⁰ Ba-La (gamma)	3.5 liters	3.1 pCi/l
	¹³⁷ Cs (gamma)	3.5 liters	3.5 pCi/l
	⁴⁰ K (gamma)	3.5 liters	35.0 pCi/l
	⁸⁹ Sr	1.0 liters	1.0 pCi/l
	⁹⁰ Sr	1.0 liters	0.5 pCi/l
	Ca	20.0 ml	0.010 g/l
Bottom sediments and soil	Gross alpha	0.1 g	1.6 pCi/g dry
	Gross beta	0.2 g	1.4 pCi/g dry
	⁸⁹ Sr	5.0 g	0.3 pCi/g dry
	⁹⁰ Sr	5.0 g	0.15 pCi/g dry
	¹³⁷ Cs (gamma)	500.0 g	0.03 pCi/g dry
Vegetation Grass	⁹⁵ Zr	175.0 g dry	0.2 pCi/g dry
	⁴⁰ K	175.0 g dry	1.0 pCi/g dry

DB-1

REFERENCES

1. Manual of Standard Procedures, NYO-4700, Edited by John H. Harley, 1971, Health and Safety Laboratory, U.S.A.E.C.

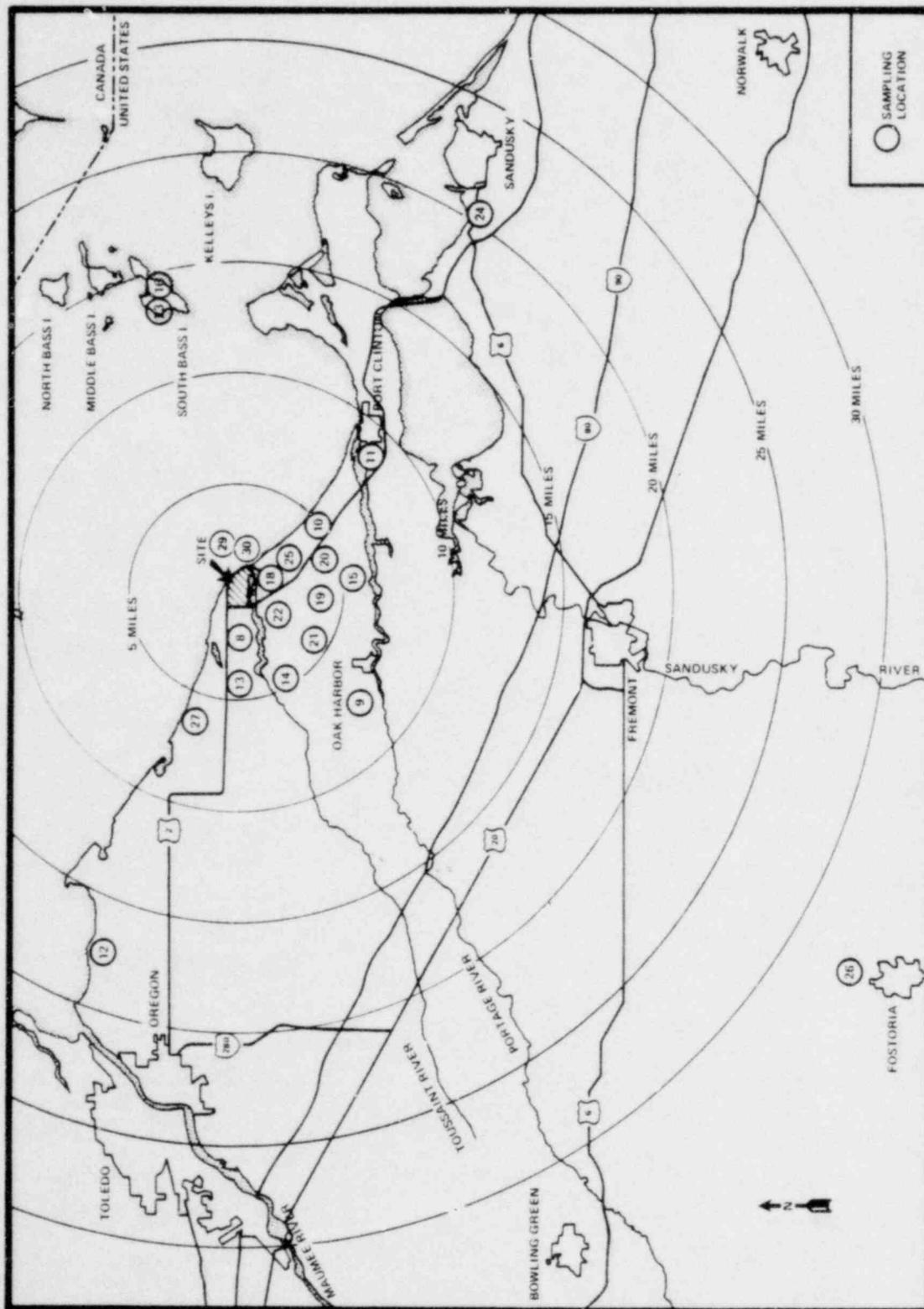


DB-1

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO.1

SAMPLING LOCATIONS ON THE SITE PERIPHERY

FIGURE 6.1-1



DAVIS-BESSE NUCLEAR POWER STATION UNIT NO.1

SAMPLING LOCATIONS (EXCEPTING THOSE ON THE SITE PERIPHERY)

FIGURE 6.1-2

6.2 APPLICANT'S PROPOSED MONITORING PROGRAM

6.2.1 RADIOLOGICAL MONITORING

6.2.1.1 Station Effluent Monitoring System

Unit No. 1 of the Davis-Besse Nuclear Power Station will be equipped with inplant monitoring devices to maintain continuous surveillance of radioactivity levels in liquid and gaseous unit effluents and in selected process streams. This monitoring system is designed to ensure compliance with the requirement of the Code of Federal Regulations (CFR), Title 10, Parts 20 and 50, Regulatory Guide 1.21, and General Design Criterion 64. To supplement the system there will be a sampling program to obtain specific samples for laboratory analysis.

The continuous monitoring system is designed to perform the following functions:

- a. Continuously detect and record the radioactivity levels in all unit effluent streams and in selected process streams before mixing in the station discharge.
- b. Provide operating personnel with a continuous indication of the gamma-emitting radioactivity in selected unit areas during both normal operation and postulated abnormal occurrences.
- c. Provide audible and visible alarms in the control room for all monitored points, and initiate protective functions, as required, on activity level increases exceeding release limits established to meet station technical specifications.
- d. Provide redundant systems allowing the measurement of unit effluents, both at their point of release and at their potential activity source points within the unit before mixing in the station discharge. Separate, independent, and redundant instruments are

d. (continued)

provided for certain unit and process measurements to increase the level of confidence in the measurements. The monitors' ranges are selected to accommodate all operational modes, including transients, accidents, and post-accident conditions.

The monitors comprising the system are listed in Tables 6.2-1 and 6.2-2.

These tables list the process and effluent radioactivity monitors for liquid and for gaseous and airborne isotopes and particulate matter, specifying the detector types, measurements ranges, and sensitivities according to the predominant isotope in a particular system.

The only unmonitored gaseous effluent with any potential for release of radioactivity is the ventilation from the turbine building. It is expected that the turbine building gaseous activity will be extremely low. The only potential source of activity in the turbine building would be through significant primary to secondary leakage, which would be detected promptly by the steam system monitors.

The routine samples taken for laboratory analysis which guide the operation of the reactor coolant system, the makeup and purification system, the chemical addition system, and the process steam system also provide a means of monitoring these effluent streams. Many of these samples flow to a central location in the auxiliary building so that access to the containment vessel for this purpose is not required during power operation. The results of analysis are used for regulating boron concentration, evaluating the integrity of fuel rods and the performance of the purification radwaste demineralizers, and regulating chemical additions to the reactor coolant. The sampling program is designed to sample the reactor coolant system and the reactor auxiliary systems during normal unit power and shutdown operation.

TABLE 6.2-1
LIQUID RADIATION MONITORS

System Designation	Required Measurements	Sensitivity* c/cc	Range**		Back-Ground (mR/h)	Type Detector	Maximum Flowrate (gpm) of Monitored Stream
			c/cc	ppm			
Reactor Coolant Purification System, Failed Fuel Detector	¹³⁷ Cs and gross gamma	2.3×10^{-6}	1.64×10^{-7}	$10 \text{ to } 10^6$	100	Gamma scintillation off-line	150
			to				
Miscellaneous Liquid Radwaste	¹³⁷ Cs	0.85×10^{-6}	1.64×10^{-7}	$10 \text{ to } 10^6$	100	Gamma scintillation off-line	70
			to				
			1.64×10^{-2}				
Clean Liquid Radwaste	¹³¹ I	0.61×10^{-6}	1.2×10^{-7}	$10 \text{ to } 10^6$	100	Gamma scintillation off-line	70
			to				
			1.2×10^{-2}				
Clean Liquid Radwaste	¹³⁷ Cs	4×10^{-7}	1.38×10^{-7}	$10 \text{ to } 10^6$	10	Gamma scintillation off-line	70
			to				
			1.38×10^{-2}				
Clean Liquid Radwaste	¹³¹ I	3×10^{-7}	1.04×10^{-7}	$10 \text{ to } 10^6$	10	Gamma scintillation off-line	70
			to				
			1.04×10^{-2}				
Component Cooling Water	¹³⁷ Cs and gross gamma	1.01×10^{-6}	2.3×10^{-7}	$10 \text{ to } 10^6$	0.5	Gamma scintillation off-line	7.9×10^3
			to				
			2.3×10^{-2}				
Service Water Discharge Header	¹³¹ I and gross gamma	0.54×10^{-6}	1.2×10^{-7}	$10 \text{ to } 10^6$	Negligible	Gamma scintillation off-line	2×10^4
			to				
			1.2×10^{-2}				
Station Effluent	¹³¹ I and gross gamma	0.54×10^{-6}	1.2×10^{-7}	$10 \text{ to } 10^6$	Negligible	Gamma scintillation off-line	4.8×10^4
			to				
			1.2×10^{-2}				
Station Intake canal Forebay	¹³¹ I and gross gamma	0.54×10^{-6}	1.2×10^{-7}	$10 \text{ to } 10^6$	Negligible	Gamma scintillation off-line	9×10^4
			to				
			1.2×10^{-2}				

*Minimum detectable sensitivity based on 99% confidence level for 0.562 MeV gamma activity in mR/h backgrounds stated in the fifth column of this table at standard pressure and ambient temperatures.

**Scale range in pCi/cc for isotopic spectrometry analysis and in ppm (10^{-6}) for gross radioactivity.

TABLE 6.2-2
GASEOUS AND AIRBORNE RADIATION MONITORS (Page 1 of 2)

System Designation	Required Measurements	Sensitivity* r/cp	Range**		Back-ground (cp/h)	Type Detector	Maximum Flowrate (acfm) of Monitored Stream
			d/pc	cpm			
Unit Vent	Particulate matter	2.7×10^{-12}	1.6×10^{-12} to 1.6×10^{-7}	10 to 10^6	0.5	Moving paper tape particulate filter-detector beta scintillation	6.3 to 7.1×10^4
	^{131}I	1×10^{-11} in 12 h	10^{-11} to 10^{-6}	10 to 10^6	0.5	Fixed charcoal filter-detector gamma scintillation	
	^{133}Xe	2×10^{-7}	1.75×10^{-7} to 1.75×10^{-2}	10 to 10^6	0.5	Beta scintillation	6.3 to 7.1×10^4
Containment Vessel	Particulate matter	1.3×10^{-11}	1.6×10^{-12} to 1.6×10^{-7}	10 to 10^6	10	Moving paper tape particulate filter-detector beta scintillation	Not applicable
	^{133}Xe	2.8×10^{-7}	1.75×10^{-7} to 1.75×10^{-2}	10 to 10^6	10	Beta scintillation	Not applicable
Condenser Vacuum System Discharge	^{133}Xe	9×10^{-6}	2×10^{-6} to 0.2	10 to 10^6	0.5	Gamma scintillation	0 to 10^2 15 (norm.)
	^{133}Xe	2×10^{-7}	1.75×10^{-7} to 1.75×10^{-2}	10 to 10^6		Beta scintillation	0 to 10^2 15 (norm.)
Radioactive Waste Gas Discharge	^{85}Kr	1.4×10^{-4}	2.8×10^{-5} to 2.8	10 to 10^6	100	In-line gamma scintillation	50
	^{133}Xe	6.7×10^{-7}	1.75×10^{-7} to 1.75×10^{-2}	10 to 10^6		Off-line beta scintillation	50
Fuel Handling Area, Exhaust System	Particulate matter	2.7×10^{-12}	1.6×10^{-12} to 1.6×10^{-7}	10 to 10^6	0.5	Moving paper tape particulate filter-detector, beta scintillation	2×10^4
	^{131}I	1×10^{-11} in 12 h	10^{-11} to 10^{-6}	10 to 10^6	0.5	Fixed charcoal filter-detector, gamma scintillation	2×10^4
	^{133}Xe	2×10^{-7}	1.75×10^{-7} to 1.75×10^{-2}	10 to 10^6	0.5	Beta scintillation	2×10^4
Radioactive Waste Area, Exhaust System	Particulate matter	2.7×10^{-12}	1.6×10^{-12} to 1.6×10^{-7}	10 to 10^6	0.5	Moving paper tape particulate filter-detector, beta scintillation	4.4×10^4

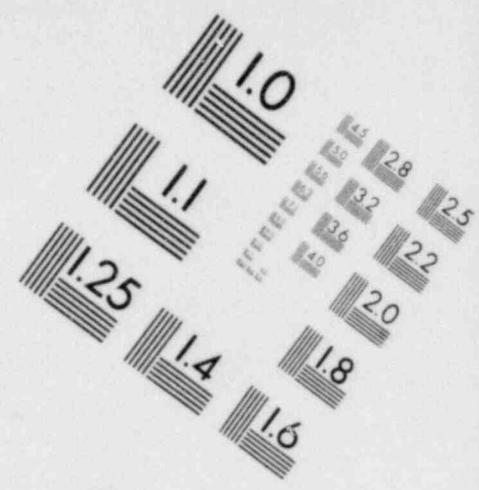
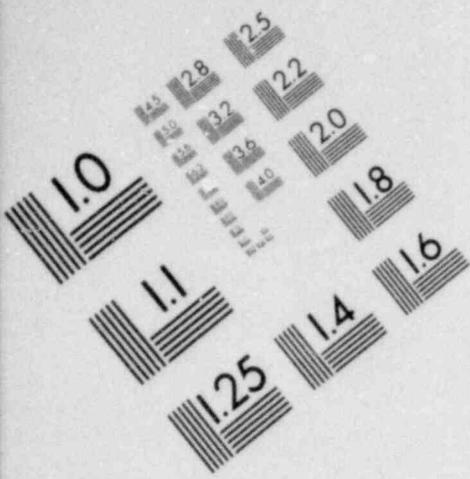
TABLE 6.2-2 (Page 2 of 2)

System Designation	Required Measurements	Sensitivity* d/gc	Range**		Back-ground (nB/h)	Type Detector	Maximum Flowrate (scfm) of Monitored Stream
			d/gc	cpm			
Mechanical Penetration Rooms, Purge System	^{131}I	1×10^{-11} in 12 h	10^{-11} to 10^{-6}	10 to 10^6	0.5	Fixed charcoal filter-detector gamma scintillation	4.4×10^4
	^{133}Xe	2×10^{-7}	1.75×10^{-7} to 1.75×10^{-2}	10 to 10^6	0.5	Beta scintillation	4.4×10^4
	Particulate matter	2.7×10^{-12}	1.6×10^{-12} to 1.6×10^{-7}	10 to 10^6	0.5	Moving paper tape particulate filter-detector, gamma beta scintillation	5×10^4 Roga plus 5×10^3 LOCA*
	^{131}I	1×10^{-11} in 12 h	10^{-11} to 10^{-6}	10 to 10^6	0.5	Fixed charcoal filter-detector, gamma scintillation	
	^{133}Xe	2×10^{-7}	1.75×10^{-7} to 1.75×10^{-2}	10 to 10^6	0.5	Beta scintillation	
Control Room, Emergency Ventilation System	Particulate matter	2.7×10^{-12}	1.6×10^{-12} to 1.6×10^{-7}	10 to 10^6	0.5	Moving paper tape particulate filter-detector, beta scintillation	2.9×10^3 /each system
	^{131}I	1×10^{-11} in 12 h	10^{-11} to 10^{-6}	10 to 10^6		Fixed charcoal filter-detector, gamma scintillation	
	^{133}Xe	2×10^{-7}	1.75×10^{-7} to 1.75×10^{-2}	10 to 10^6		Beta scintillation	

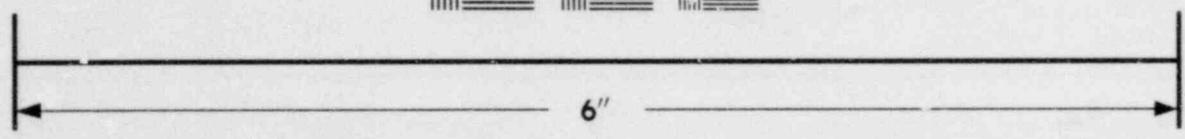
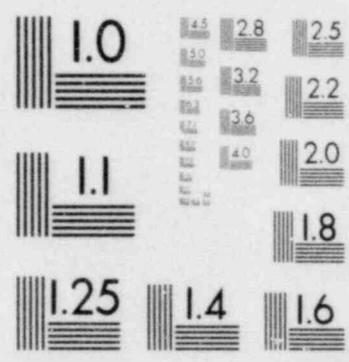
*Minimum detectable sensitivity based on 99% confidence level for 0.662 MeV gamma activity in nB/h backgrounds stated in the fifth column of this table at standard pressure and ambient temperatures.

**Scale range in pCi/dv for isotopic spectrometry analysis and in cps (10^{-6}) for gross radioactivity.

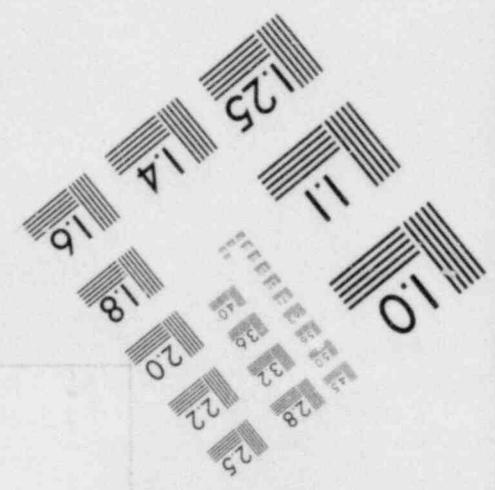
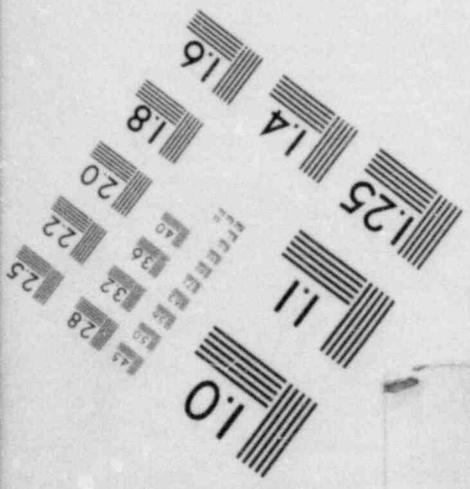
* Loss of coolant accident.

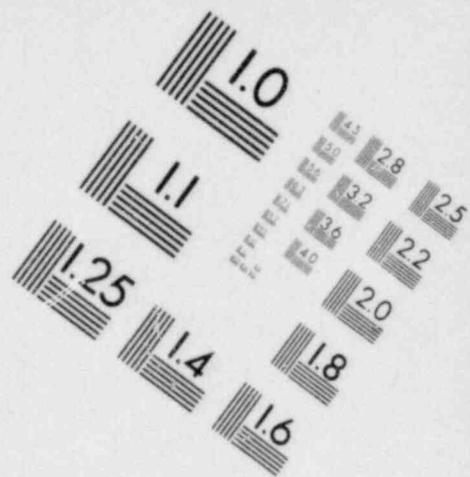
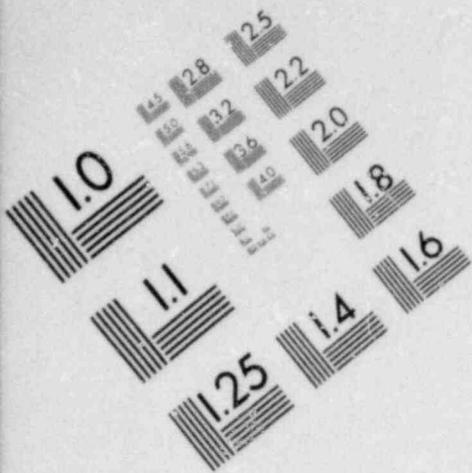


**IMAGE EVALUATION
TEST TARGET (MT-3)**

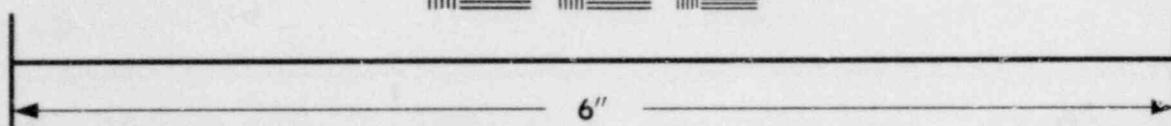
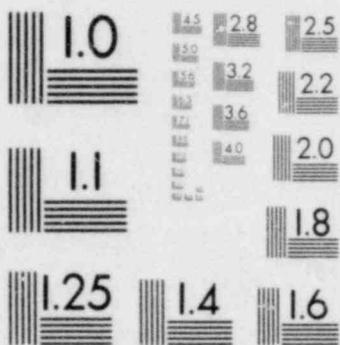


MICROCOPY RESOLUTION TEST CHART

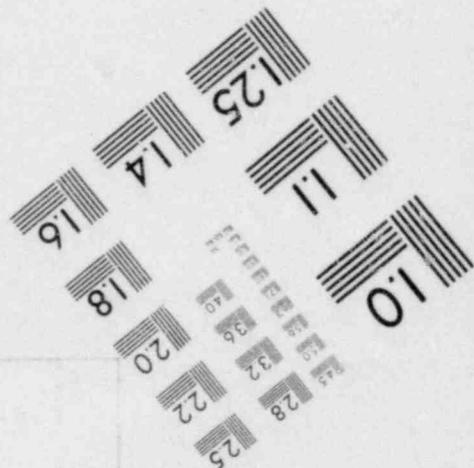
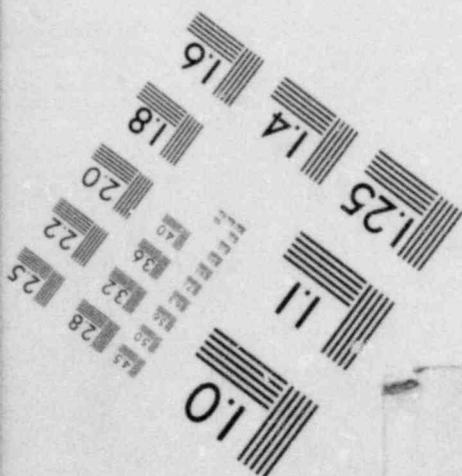




**IMAGE EVALUATION
TEST TARGET (MT-3)**



MICROCOPY RESOLUTION TEST CHART



In the event of a loss-of-coolant accident, samples of the recirculating coolant are taken from the discharge of the decay heat removal pumps. The sampling system is manually operated on an intermittent basis under conditions ranging from full power to cold shutdown operation. In the event of this type of accident, the sampling system is isolated at the containment boundary by the containment isolation system.

During normal operation, liquid and vapor samples will be taken routinely from the following points:

a. Liquid

- (1) Purification demineralizer inlet (reactor coolant)
- (2) Borated water storage tank (local grab sample)
- (3) Core flooding tanks
- (4) Spent fuel pool (local grab sample)
- (5) Steam generator secondary side (secondary coolant)
- (6) Boric acid addition tanks (local grab sample)
- (7) Radwaste system (local grab samples)
- (8) Cooling tower blowdown (local grab sample)

b. Vapor and Gas

- (1) Waste gas decay tanks (local grab samples)
- (2) Unit vent (local grab sample).

Many of the samples are collected in containers designed for use at full operating temperatures and pressure and at flow velocities which ensure transport of suspended particles where appropriate. The sample lines are purged prior to sampling to ensure that representative samples are obtained. The sampling frequency and the analyses are listed in Table 6.2-3.

To prevent any release of dissolved radioactive gases in these samples, the sampling station is equipped with a hood provided with an off-gas vent to the

TABLE 6.2-3

PARAMETERS TO BE MONITORED AND SAMPLE FREQUENCY

<u>ITEM</u>	<u>CHECK</u>	<u>FREQUENCY</u>
1. Reactor Coolant	a. Gross Beta-Gamma Activity ⁽¹⁾ b. Radiochemical Analysis c. \bar{E} Determination ⁽²⁾ d. Tritium Concentration e. Chemistry (Cl, F and O ₂) f. Boron Concentration	3 times/week Monthly (6) Semiannually Monthly (6) 3 times/week (6) 2 times/week (7)
2. Borated Water Storage Tank	Boron Concentration	Monthly and after each makeup
3. Core Flooding Tanks	Boron Concentration	Monthly and after each makeup (7)
4. Spent Fuel Pool	Boron Concentration	Monthly and after each makeup (8)
5. Secondary Coolant	a. Gross Beta-Gamma Activity b. Iodine Analysis ⁽³⁾ c. pH d. Conductivity	Weekly (6) Weekly Weekly
6. Boric Acid Addition Tanks	Boron Concentration	Weekly
7. Miscellaneous Waste Monitor Tank, Detergent Waste Drain Tank, and Clean Waste Monitor Tanks	a. Gross Beta-Gamma Activity b. Gamma Isotopic Analysis c. Gamma Scan d. Tritium Concentration	Prior to release of each batch Monthly (5) Monthly (5) Monthly (5)
8. Waste Gas Decay Tanks	a. Gamma isotopic Analysis b. Gross Gamma Activity	Quarterly Prior to release of each batch
9. Station Vent	Iodine ¹³¹ and Particulate Radioactivity ⁽⁴⁾	Weekly
10. Cooling Tower Blowdown	Gross Beta-Gamma Activity	Monthly
(1) When radioactivity level is greater than 20 percent of the limits of the limits of Technical Specification 3.1.4 the sampling frequency shall be increased to a minimum of once each day.		
(2) \bar{E} determination will be started when gross beta - gamma activity analysis indicates greater than 10 Ci/ml and will be redetermined each 10 Ci/ml increase in gross beta-gamma activity analysis. A radiochemical analysis for this purpose shall consist of a quantitative measurement of 95% of the radionuclides in reactor coolant with half-lives greater than 30 minutes.		
(3) When gross beta - gamma activity increases by a factor of two above background, an iodine analysis will be made and performed thereafter when the gross beta - gamma activity increases by 10 percent.		
(4) When iodine or particulate radioactivity levels exceed 10 percent of limit in Technical Specification 3.10 the sampling frequency shall be increased to a minimum of once each day.		
(5) This analysis will be performed on a monthly composite sample made up of representative portions from each batch.		
(6) Not applicable if reactor is in a cold shutdown condition for a period exceeding the sample frequency.		
(7) Applicable only when fuel is in the reactor.		
(8) Applicable only when fuel is in the spent fuel pool.		

radioactive materials that can be released to the environment. Inplant monitoring devices will assure that these predetermined release limits are not exceeded (see Section 6.2.1.1). However, as a precaution against unexpected and undefined processes in the environment which might allow undue accumulation of radioactivity in any sector of man's environment, a program for monitoring of the plant environs is also included in the environmental technical specifications. The operational surveillance program for the Davis-Besse Nuclear Power Station Unit 1 will be initiated coincident with issuance of the Operating License. The Atomic Energy Commission (AEC) Regulatory Guide 4.1 (January 18, 1973) indicates that information obtained from such operational monitoring programs will be used in conjunction with inplant data on radioactivity effluents to evaluate the effectiveness of measures taken to control releases.

The Applicant has prepared recommended Environmental Technical Specifications which have been submitted to the AEC for its consideration and use in preparing the Environmental Technical Specifications ultimately included as Appendix B of the Operating License. The radiological program specified in the Applicant's Environmental Technical Specifications will be essentially the same as those proposed for the preoperational program (Section 6.1.5).

However, some changes in the program, such as in sampling location or frequency, may occur as a result of information acquired during the preoperational program. The emphasis of the operational program is to assist as required by 10 CFR Part 20.201 in verification of inplant effluent control, and to obtain information which may be used to provide limited confirmation of the estimates of population exposure as required by 10 CFR Part 50.36a and General Design Criterion of Appendix A, 10 CFR Part 50.

radwaste area ventilation system. Liquid wastes from the sampling station are drained to the miscellaneous liquid radioactive waste disposal system. In addition to those taken from the routine sample points, samples can also be taken from the following points for monitoring equipment performance and reactor end radwaste systems. The normal parameters that will be monitored with these samples are shown in Table 6.2-3.

a. Reactor Optional Sample Points

- (1) Purification demineralizer outlet
- (2) Makeup tank, liquid
- (3) Makeup tank, gas
- (4) Pressurizer vapor and liquid space
- (5) Pressurizer quench tank
- (6) Seal return coolers outlet
- (7) Makeup filters outlet
- (8) Primary water storage tank
- (9) Boric acid mix tank
- (10) Lithium Hydroxide mix tank
- (11) Reactor coolant drain tank

b. Radwaste Optional Sample Points

- (1) Miscellaneous waste evaporator storage tank
- (2) Waste evaporator distillate
- (3) Waste evaporator bottoms
- (4) Miscellaneous liquid waste monitor tank
- (5) Degasifier inlet
- (6) Degasifier outlet
- (7) Clean Waste receiver tanks
- (8) Primary demineralizer outlet
- (9) Primary demineralizer filter outlet
- (10) Clean waste polishing demineralizer outlet
- (11) Deborating demineralizers outlet
- (12) Spent fuel pool demineralizer inlet
- (13) Spent fuel pool demineralizer outlet
- (14) Spent fuel pool filter outlet
- (15) Boric acid evaporator distillate
- (16) Boric acid evaporator concentrate
- (17) Concentrate demineralizer outlet
- (18) Concentrate storage tank
- (19) Spent resin storage tank.

6.2.1.2 Environmental Radiological Monitoring

Detailed Environmental Technical Specifications, which will be made part of the terms of the Operating License, will place limits upon the amount of

To accomplish this, the sampling frequency of the preoperational program is generally maintained during the first fuel cycle in an attempt to verify any projected correlation between effluent and activity observed in environmental media. After this period, the program will be reevaluated to determine if the sampling frequency and number of types of samples can be reduced.

6.2.1.2.1 Sampling Media, Collection Frequency and Analyses

Table 6.1-2 summarizes the operational program as presently conceived. Figures 6.1-1 and 6.1-2 show sampling locations on and around the site and station.

6.2.1.2.2 Analytical Sensitivity

The outline of the analytical procedures is presented in Section 6.1.5. The corresponding analytical sensitivities for these analyses are listed in Table 6.1-3. The limits are presented in this table as nominal values and may change, depending upon the availability of samples, counting time, and development of improved techniques.

6.2.1.2.3 Reporting of Results

The results obtained from the operational environmental monitoring program will be submitted in accordance with the requirements of the Environmental Technical Specifications. The beginning of the first reporting period will coincide with the issuance of the Operating License. In the initial report, all assumptions, parameters, and methods used to measure and report radioactivity concentrations and radiation levels will be listed. Changes in these values will be included in subsequent reports. If some analytical results are not completed in time to comply with the foregoing reporting schedule, the report will specify this fact. The missing data will be reported in the succeeding report.

The format for reporting analytical results on samples of environmental media will include the following information.

a. Sample Type

For biological samples, species and common names will be given, including those of the tissue or material analyzed. For nonbiological samples, the type will be identified and the weight or volume sampled will be given where appropriate.

b. Sample Locations

A sampling location will be indicated for each sample and a map showing these locations will be supplied.

c. Collection Period

Collection dates or periods will be listed with all samples.

d. Radioactivity

Only quantitatively identified radionuclides will be reported. These are radionuclides in which the 95% confidence limits are less than the net calculated concentration. The radioactivity will be reported in units of concentration (i.e., pCi/l or pCi/g, specifying wet or dry weight). Estimates of the error associated with the measurement of concentration will also be reported.

6.2.2 Chemical Effluent Monitoring

The Davis-Besse Nuclear Power Station Unit No. 1 has been designed to provide a single discharge of liquid process effluents to Lake Erie using a single collection box and discharge pipe to facilitate monitoring and control.

There is a drainage ditch to the Toussaint River that carries storm water runoff. Certain floor drains from non-radioactive areas will be passed through oil interceptors before discharging to the storm drainage system.

The Davis-Besse Nuclear Power Station Unit No. 1 has been designed to minimize environmental impacts, and the anticipated environmental effects of chemical discharges are insignificant (See Section 5.4). All water systems utilize high purity water, potable water, or natural lake water; and no chromates, other toxic metals, or nutrient chemicals will be used. Nevertheless, all effluent streams will be monitored for chemical discharges. This monitoring program will include monitoring for substances already present in the intake water, since it is primarily these chemicals which will be present in the discharge stream. In addition, the intake stream itself will be monitored for comparative purposes. This program will, in turn, be supported by the ecological monitoring program discussed in Section 6.2.5. The discharge pipe to Lake Erie will be sampled using a composite sampler that collects a weekly composite sample. The weekly testing, sample type, and analytical methods are listed in Table 6.2-4. Portions of the weekly composite samples will be retained for further testing on a monthly basis. The monthly testing, sample type, and analytical methods are also listed in Table 6.2-4.

The storm drainage ditch to the Toussaint River will be grab sampled on a weekly basis. The testing that will be performed is listed below. Analytical procedures are the same as those listed in Table 6.2-4.

Weekly Tests on Storm Drainage Ditch

pH
Turbidity
Oil & Grease
Dissolved Oxygen

The analytical instrumentation and sensitivity of the various tests are listed in the referenced analytical procedures.

TABLE 6.2-4

SAMPLING AND TESTING SCHEDULE FOR STATION DISCHARGE PIPE
(Page 1 of 2)

Parameter	Sample Type	Analytical Method
<u>Weekly Tests</u>		
Chlorine Residual	Grab	Std. Methods, 13th Edition, 204A (1971)
Conductivity	Composite	ASTM D1125-64
Dissolved Solids	"	Methods of Chemical Analysis of Water and Wastes, U. S. Environmental Protection Agency, P. 275 (1971)
Oxygen	Grab	Std. Methods, 13th Edition, 218B (1971)
pH	"	ASTM D1293-65
Phosphorous (as P)	Composite	Std. Methods, 13th Edition, 223F (1971)
Suspended Solids	"	Std. Methods, 13th Edition, 224C (1971)
Total Volatile Solids	"	Std. Methods, 13th Edition, 224B (1971)
Total Solids	"	Std. Methods, 13th Edition, 224 (1971)
Turbidity	"	Std. Methods, 13th Edition, 163A (1971)
<u>Monthly Tests</u>		
Alkalinity (as CaCO ₃)	Composite	Std. Methods, 13th Edition, 102 (1971)
Ammonia (as N)	"	Std. Methods, 13th Edition, 132B (1971)
Arsenic	"	Std. Methods, 13th Edition, 104A (1971)
B.O.D.	"	Std. Methods, 13th Edition, 219 (1971)
Calcium	"	Std. Methods, 13th Edition, 110C (1971)
Chlorides	"	Std. Methods, 13th Edition, 112B (1971)
Chromium	"	Std. Methods, 13th Edition, 117A (1971)
C.O.D.	"	Std. Methods, 13th Edition, 220 (1971)
Total Coliform	"	Std. Methods, 13th Edition, 406 (1971)
Total Hardness	"	Std. Methods, 13th Edition, 122B (1971)
Iron	"	Std. Methods, 13th Edition, 124A (1971)

6.2-13

DB-1

TABLE 6.2-4 (Page 2 of 2)

Parameter	Sample Type	Analytical Method
Monthly Tests		
Kjeldahl Nitrogen	Composite	Std. Methods, 13th Edition, 216 (1971)
Magnesium	"	(Difference Between Total Hardness & Calcium Hardness)
Manganese	"	Std. Methods, 13th Edition, 128B (1971)
Mercury	"	ASTM D 3223-73
Nitrate (as N)	"	ASTM D992-71
Oil & Grease	"	ASTM D2778-70 Using Carbon Tetrachloride
Organic Nitrogen	"	Std. Methods, 13th Edition, 215 (1971)
Potassium	"	ASTM D1428-64
Sodium	"	ASTM D1428-64
Sulfate	"	ASTM D516-68, Method C
Zinc	"	Std. Methods, 13th Edition, Method 165B (1971)

6.2-14

DB-1

No State or Federal monitoring requirements have been placed upon Unit operation; however, the above described Chemical Effluent Monitoring Program is expected to provide the analytical data to fulfill any future monitoring requests of these agencies.

6.2.3 THERMAL EFFLUENT MONITORING

All liquid thermal effluents from the Davis-Besse Nuclear Power Station, Unit No. 1, will be discharged to Lake Erie through a single collection box and discharge pipe, allowing easy monitoring of the discharge stream temperature rise above ambient lake temperature (Δt). Temperature elements with a range of 32° to 212°F and a sensitivity of 0.1°F will be provided in the intake canal, at the end of the intake pipe, and in the discharge pipe.

These measurements of ambient lake and discharge temperatures will be read continuously by the unit computer which will calculate Δt . The ambient lake temperature, discharge temperature and Δt will be logged hourly by the unit computer.

6.2.4 METEOROLOGICAL MONITORING

Meteorological monitoring will be provided by a 340 foot free-standing meteorological tower and a 35 foot satellite tower, both complying with Regulatory Guide 1.23, and installed in the southwest sector of the site. Wind direction and speed will be measured at the 250 foot and 340 foot levels on the free-standing tower and at the 35 foot level on the satellite tower. Temperature differences from 35 feet to 250 feet and 35 feet to 340 feet and dewpoint temperature at 35 feet and 340 feet are measured on the 340 foot free-standing tower. Table 6.2-5 and 6.2-6 present locations and specifications of the equipment on the 35 foot satellite tower and 340 foot tower. These two towers became fully operational on August 1, 1974 and one full year of data from these towers will be available in the fall of 1975.

TABLE 6.2-5

SENSOR LOCATIONS AND SPECIFICATIONS

Parameter	Location of Sensor				Performance Criteria
	0'	35'	250'	340'	
Wind Speed		x*	x	x	Accuracy: $\leq \pm 0.5$ mph Starting threshold: 0.6 mph Distance constant: ~5.0 ft Range: 100 mph (Selectable)
Wind Direction		x*	x	x	Accuracy: $\pm 3.0^\circ$ Starting threshold: 0.75 mph Distance constant: ~5.0 ft Damping Ratio: ~0.5 Range: 0° - 540°
Temperature		x			Accuracy: $\leq \pm 0.5^\circ\text{C}$ ($\pm 0.9^\circ\text{F}$) Range: -20°F to $+100^\circ\text{F}$
Differential Temperature		x			Accuracy: $\leq \pm 0.1^\circ\text{C}$ ($\pm 0.18^\circ\text{F}$) Range: 6°F Resolution: $\leq \pm 0.1^\circ\text{F}$
Dew Point		x		x	Accuracy: $\leq \pm 0.5^\circ\text{C}$ ($\pm 0.9^\circ\text{F}$) Range: -20°F to $+100^\circ\text{F}$
Precipitation		x			Accuracy: $\pm 2\%$ for <u>1 in.</u> hr Resolution: ± 0.01 inch

* On 35-ft satellite tower

DB-1

TABLE 6.2-6

SENSOR MODELS AND MANUFACTURERS

Item	Mfr.	Model
Wind Speed/Direction (Horizontal)	Climet	Wind Direction WD-012-10
		Wind Speed WS-011-1
		Translator 025-2
Temperature	Endevco	4470.114 Universal Sig. Cond.
	Endevco	4472.2 RTD Bridge
	Geotech	M327 Aspirators
	Rosemount	104MB12ADCA four wire RTD
Rainfall	Belfort	Tipping Bucket 5-405H
	NUSonics	Rainfall Integrator with Reset
Dew Point	Cambridge	110SM (Hygrometer)
Multipoint Recorder	Esterline-Angus	E1124E
Strip Recorder	Esterline-Angus	E1102R

6.2.5 ECOLOGICAL MONITORING

The operational phase of the ecological monitoring program for Davis-Besse Unit No. 1 will be a continuation of the preoperational programs and consist of the following aquatic and terrestrial programs. The aquatic monitoring program will include sampling for the determination of chemical, physical, and biological characteristics at selected locations established in the pre-operation phase of the program and shown in Figure 6.2-1. Samples will be collected monthly, during ice free periods, for water quality analysis, plankton, benthos, and fish studies in the vicinity of the intake crib and discharge structures in Lake Erie, and in the marsh area on the site. The analysis and studies to be performed are summarized in Table 6.2-7. These analysis and studies may undergo some modification after evaluation of the data collected during the preoperational program. The aquatic monitoring program will be continued for a minimum of two years after Unit No. 1 begins commercial operation. At the end of this period the results of the program will be evaluated and the need for additional studies determined. The terrestrial monitoring program will have two primary objectives: (1) to monitor the effect of the unit's cooling tower and other structures on migrating birds, and (2) to monitor the effect of cooling tower drift on the land in the cooling tower vicinity. During the migratory periods (i.e. April, May late August, September, and October), the areas around the cooling tower and meteorological tower will be surveyed weekly to determine the number and type of birds, if any, that have been killed by impacting on Unit Structures. The frequency of the surveys will be increased during periods of maximum predicted hazard to migratory birds as related to meteorological conditions (i.e. frontal passage, low ceiling, etc.) Potential effects of cooling tower drift on terrestrial biota will be monitored by

DB-1

TABLE 6.2-7

AQUATIC ENVIRONMENTAL MONITORING PROGRAM
DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

Parameter	Analysis	Frequency	Sampling Location
Water Quality	pH	Monthly	1,8,12
	D.O.		
	B.O.D.		
	Temperature		
	Conductivity		
	Transparency		
	Turbidity		
	Solar Radiation		
	Total Alkalinity		
	Suspended Solids		
	Dissolved Solids		
	Ca		
	Mg		
	Na		
	Cl		
	NO ₃		
SO ₄			
Total P			
SiO ₂			
Plankton	Number & kind of organisms present	Monthly	1,3,6,8,9,10,12,13,14,18
Benthos	Population & generic composition	Monthly	1 thru 20
Fish	Fish collected by the following method will be identified, weighed and measured.		
	4-5 minute trawls	Monthly	between 8 and 12
	3-seines	Monthly	near shore
	2-hoop net sample	Monthly	21,22
	1-gill net left overnight	Monthly	8,12
Ichthyoplankton counted & identified		Monthly	8,12

infrared aerial photography of the area surrounding the site. This photograph will be taken annually in mid to late summer. In addition, meteorological monitoring units will be used to monitor solar radiation, temperature, humidity, evaporation, precipitation and soil temperature at two locations on site; temperature and humidity will also be monitored at a third location at Darby Marsh approximately 6.5 miles southeast of the site. The terrestrial monitoring program may undergo some modification after evaluating the data collected during the preoperational program. The terrestrial monitoring program will be continued for a minimum of two years after Unit No. 1 begins commercial operation with the exception of the infrared aerial photography which will be continued for a minimum of five years. At the end of these periods the results of the program will be evaluated and the need for additional studies determined.

6.2.6 OPERATIONAL NOISE SURVEY

Once Davis-Besse Unit No. 1 is operating at full-load conditions, a noise survey will be conducted. The methods used to conduct this survey will be similar to those used in determining the background noise levels (Section 2.9) and described below. At that time, the noise impact predictions (Section 5.7) can be verified and the final noise impact of the facility can be assessed.

6.2.6.1 Noise Instrumentation

The instrumentation used during the background noise survey consisted of the following:

- a. Bruel and Kjaer Type 2209 Precision Sound Level Meter
- b. Bruel and Kjaer Type 1613 Octave Filter Set
- c. Bruel and Kjaer Type 4145 Condenser Microphone
- d. Bruel and Kjaer Type 4220 Pistonphone

This instrumentation meets the requirements of ANSI S1.4-1971 (1) and IEC 179 (2) for a Type I or precision sound level meter. A 1-inch condenser microphone was used in order that accurate low ambient sound level measurements could be made. The meter was acoustically calibrated using the B & K Pistonphone prior to each measurement period to assure continued accuracy. Fresh batteries were installed in the instrument daily. All measurements were made using an open-celled polyurethane foam wind screen to attenuate the effect of wind generated noise.

6.2.6.2 Data Collection Methods

In devising the methodology to be used for the noise survey, consideration was given to the method devised by the American National Standard Institute (3) which is designated to evaluate the noise in an urban or suburban area where the ambient sound level results from the diffusion of several different noise sources. The survey periods and the number of sampling points were chosen in order to develop an accurate statistical statement of community noise. Sound measurements were made with the precision sound-level meter operated in the A-weighted slow-response mode. The method used in recording each measurement involved the observation of the meter once every five seconds. This was repeated until a statistically reliable sample was obtained. The five-second sampling results in a statistically independent sample because the interval is considerably greater than the meter averaging time. During the survey, hourly readings of the wind speed, wind direction, temperature, and dew point were obtained from the onsite meteorological tower, and supplemental data including the barometric pressure were obtained from nearby airports.

6.2.6.3 Noise Models

Sound is created when a pressure disturbance is propagated through the air in the form of compression waves. Noise may be defined as undesirable sound.

The pressure fluctuation at a point in space, due to sound waves, is measured in terms of the sound pressure level which is defined as

$$L_p = 20 \log_{10} \frac{P}{P_0} \quad (1)$$

where

L_p = sound pressure level, decibels referenced to p_0 (db re p_0)

p = sound pressure, dynes/cm²

P_0 = reference sound pressure, dynes/cm²

The reference sound pressure is taken as 2×10^{-4} dynes/cm² which corresponds to the threshold of hearing.

Sounds are composed of many frequencies with a sound pressure level associated with each frequency, but only those in the frequency range of 20 to 20,000 Hz are perceived by people. To provide a more detailed description of noise, this wide frequency range is usually divided into octave bands whose upper frequencies are twice the lower frequencies. Since the response of people to sound is frequency-dependent, a sound is often measured in terms of the A-weighted sound pressure level (dBA re 2×10^{-4} dynes/cm²), which corresponds to a weighting of the contribution of each frequency according to the frequency response curve of the human ear.

The effect of unit operation upon the present environmental sound levels has been calculated based upon the methods presented below, and the results are presented in Section 5.7.1. The primary noise sources of the proposed facility include the heat dissipation system, transformers, turbines, pumps, and motors. The contribution of each to the ambient sound levels has been estimated and based upon their sound power level. The sound power level of a noise source, which is a measure of the total sound energy radiated by the

source per unit time, is defined by

$$L_w = 10 \log_{10} \frac{W}{W_0} \quad (2)$$

where

L_w = sound power level, db re W_0

W = sound power of the source, watts

W_0 = reference sound power taken as 10^{-12} watts

The sound pressure level defined by Equation (1) is related to the sound power level of a point source with hemispherical sound wave radiation at a distance r from the source by (4,5)

$$L_p = L_w - 20 \log_{10} r + 2.5 - A \quad (3)$$

where

L_p = sound pressure level, db re 2×10^{-4} dynes/cm²

r = distance from source, feet

A = Attenuation effects, db re 2×10^{-4} dynes/cm²

Atmospheric attenuation of sound waves is accounted for by A , which under normal atmospheric conditions is

$$A = 1.7 \times 10^{-6} rf \quad (4)$$

where

f = centerband frequency, Hertz

Equation (4) accounts for the much larger attenuation of high frequencies — such that, far from a source, only the lower frequencies are audible. Using Equations (3) and (4), the expected sound pressure level in each octave bank, at a distance r from a noise source, may be determined by using the manufacturer's information on the sound power level of the source or estimating it by other means. At any specified distance from the site, the

noise contribution of each noise source to the background level was determined by first calculating the resultant sound pressure level in each octave band, and then calculating the A-weighted sound pressure level. This calculational procedure is performed by the NUS computer program SOCON, which uses as input data the coordinates and sound power levels of each noise source and outputs the resultant A-weighted sound pressure levels at an array of points around the site. The resultant values are then used to construct A-weighted sound pressure contours on a site map. When compared to the estimated background environmental sound levels, the noise impact of the facility can be assessed. In evaluating the noise impact of the proposed facility to areas beyond the site boundary, consideration was given to two criteria. The HUD Noise Criteria ⁽⁶⁾ state that levels below 45 dbA are "acceptable" for continuous 24-hr exposure, and levels up to 65 dbA are "normally acceptable" provided that 65 dbA is not exceeded more than 8 hours per day.

The EPA proposed noise levels guidelines ⁽⁷⁾ state that in residential environments the time-weighted day/night outdoor average level, below which no effects on public health and welfare occur due to activity and speech interference, is 55 dbA. Such levels also would protect the majority of the exposed population against annoyance under most conditions.

Stevens, Rosenblith and Bolt suggested another method that compares the ambient noise levels with the intruding noise. ⁽⁸⁾ Since its introduction, the method has been shown to be valid by results of additional studies and it is an approach commonly used by acousticians. It indicates that up to a 5 dbA increase in the ambient will usually not generate any complaints due to annoyance. Up to a 10 dbA increase may cause a slight amount of public reaction.

The above criteria refer to continuous, broad-band noise which denotes the absence of impulsive noises and pure tones. Impulsive noises are of short duration, such as a sonic boom or a plane fly-over. Sounds with pure tones have a large portion of the total sound power concentrated in a narrow frequency range. Both impulsive noises and pure tones tend to be more annoying than broad-band noise.

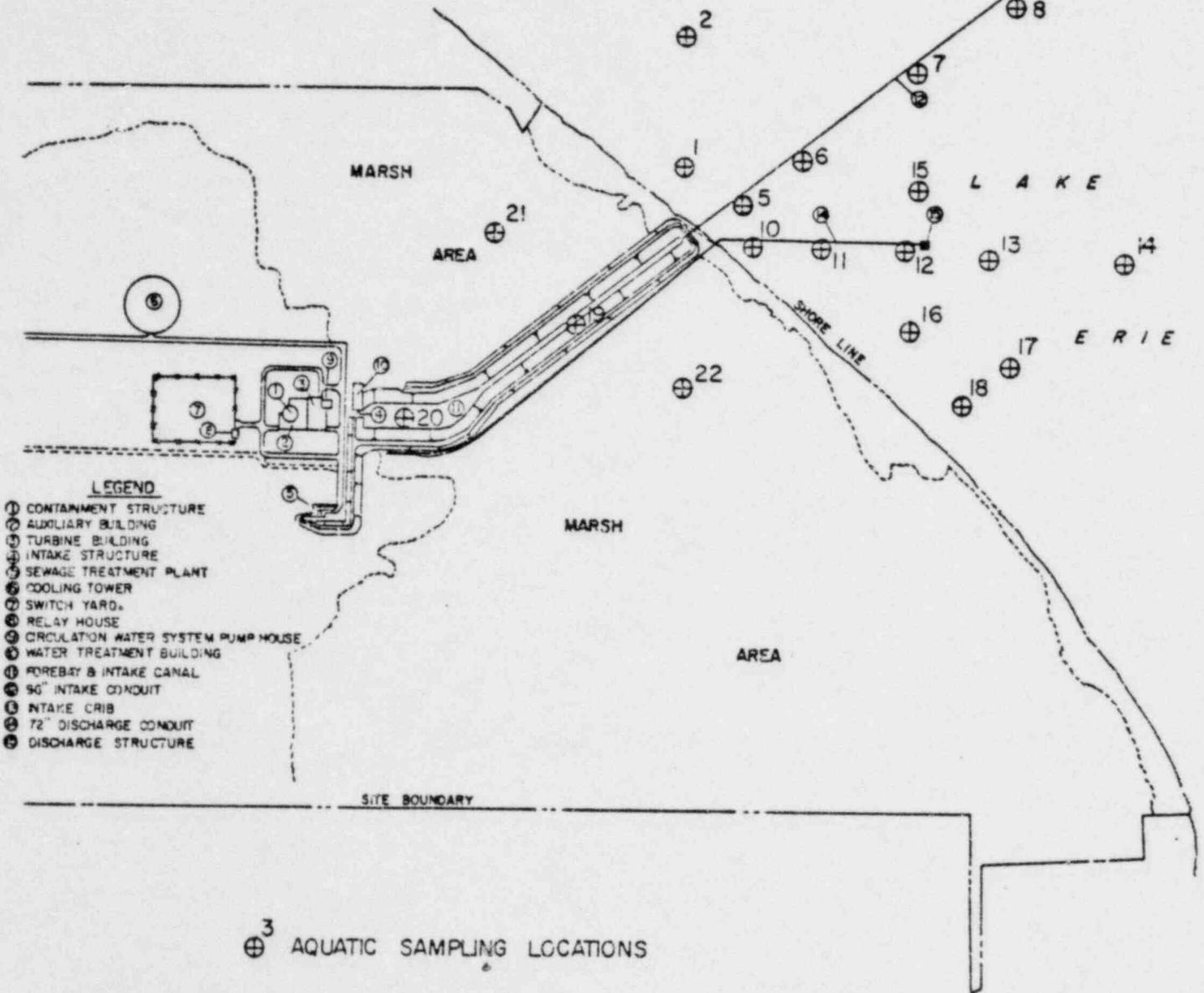
REFERENCES

1. American National Standard Institute, "Specifications for Precision Sound Level Meters, " ANSI S 1.4-1971, 1973.
2. International Organization for Standardization, "Specifications for Precision Sound Level Meters," IEC-179, 1971
3. American National Standard Institute, "Draft Method for Measurement of Community Noise," ANSI S-3-W-5, November 11, 1969.
4. L. L. Beranek, Noise Reduction, McGraw-Hill Book Company, New York 1960.
5. C. M. Harris, Handbook of Noise Control, McGraw-Hill Book Company, New York, 1957.
6. U. S. Department of Housing and Urban Development, "Noise Abatement and Control, Department Policy, Implementation Responsibilities and Standards," Circular 1390.2, July 16, 1971.
7. Environmental Protection Agency, "Information on the Development of Environmental Noise Requirements to Protect Public Health and Welfare with an Adequate Margin of Safety." EPA 550/9-74004 (March, 1974).
8. K. N. Stevens, W. A. Rosenblith, and R. H. Bolt, "A Community's Reaction to Noise, Can it Be Forecasted?" Noise Control, 1 (1), January 1955, pp 63-71.

D 9-1



SITE LOCATION



- LEGEND**
- ① CONTAINMENT STRUCTURE
 - ② AUXILIARY BUILDING
 - ③ TURBINE BUILDING
 - ④ INTAKE STRUCTURE
 - ⑤ SEWAGE TREATMENT PLANT
 - ⑥ COOLING TOWER
 - ⑦ SWITCH YARD
 - ⑧ RELAY HOUSE
 - ⑨ CIRCULATION WATER SYSTEM PUMP HOUSE
 - ⑩ WATER TREATMENT BUILDING
 - ⑪ FOREBAY & INTAKE CANAL
 - ⑫ 96" INTAKE CONDUIT
 - ⑬ INTAKE CRIB
 - ⑭ 72" DISCHARGE CONDUIT
 - ⑮ DISCHARGE STRUCTURE

⊕³ AQUATIC SAMPLING LOCATIONS

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

AQUATIC MONITORING PROGRAM, SAMPLING LOCATIONS

FIGURE 6.2-1

CHAPTER

7.0 ENVIRONMENTAL EFFECTS OF ACCIDENTS

7.1 PLANT ACCIDENTS INVOLVING RADIOACTIVITY

7.1.1 INTRODUCTION

The Atomic Energy Commission (AEC) requires the applicant for a construction or operating license for a nuclear power station to prepare a Safety Analysis Report. This report provides a description of the design, and verification by analysis, that the station systems are adequate to protect the health and safety of the public under all operating conditions. Included in the Safety Analysis Report are analyses of various possible accidents under a set of very conservative assumptions and parameters resulting in estimates of the upper limits of radiological doses to an individual at the boundary of an exclusion zone and at the outer boundary of the low-population zone.

The evaluation of the environmental impact of effluents from a nuclear power station includes considerations of both those that are released as a consequence of normal operations and those that might reasonably be expected to occur as a result of abnormal or accidental events. An evaluation of the potential impact of routine releases is presented in Sections 5.2 and 5.3. This section presents an assessment of the potential impact from a series of accidental events which vary in probability from "likely to occur at some time during the life of the unit" to "highly improbable." The assessment is made within the framework of regulations designed to provide health and safety protection to individuals who may reside at the boundary of the station site, as well as keeping exposures to population groups as low as practicable.

The analyses presented in this section include some of the same accidental events considered in the Safety Analysis Report but are performed using a

set of assumptions, parameters, and methods generally accepted as being more realistic.

The postulated accidents and occurrences are divided into the nine accident classes identified in AEC Regulatory Guide 4.2, as shown in Table 7.1-1.

The environmental impact of the postulated incidents is evaluated using the assumptions set forth in this regulatory guide. Class 1 events (trivial incidents) and Class 2 events (small releases outside containment) are included and evaluated under the routine radioactive releases presented in Chapter 5.

The occurrence of Class 9 accidents involves hypothetical sequences of failures more severe than those postulated for the design basis for reactor protection systems and engineered safety features. It is accepted that the probability of potential accidents in this class is sufficiently remote, and therefore the environmental risk may be considered extremely low. Consequently, it is not necessary under AEC Regulations to discuss Class 9 accidents in the Environmental Report.

7.1.2 ACCIDENT ATMOSPHERIC DISPERSION PARAMETER CALCULATIONS

7.1.2.1 Site Boundary χ/Q Values

Cumulative frequency distributions of the maximum interval average for site boundary χ/Q values have been obtained for the following interval lengths: 1 hr, 2 hr, 8 hr, 16 hr, 72 hr (3 days), and 624 hr (26 days). Plume centerline χ/Q values were used for interval lengths of 1, 2, and 8 hr. Sector average χ/Q values were used for interval lengths of 16, 72, and 624 hr.

The meteorological data upon which the derived cumulative frequency distributions are based were collected onsite during the period December 1, 1969,

TABLE 7.1-1

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

No. of Class	Description	Examples
1.0	Trivial Incidents	Small spills and small leaks inside containment.
2.0	Small Release Outside Containment	Spills, valve leaks and pipe breaks.
3.0	Radwaste System Failure	Equipment failure, serious malfunction, operator error.
4.0	Fission Products to Primary System (BWR)	Fuel failures during normal operation. Transients outside expected range of variables.
5.0	Fission Products to Primary and Secondary Systems (PWR)	Class 4 and steam generator tube leak.
6.0	Refueling Accidents	Dropped fuel assembly, dropped heavy object onto fuel.
7.0	Spent Fuel Handling Accident	Dropped fuel assembly, dropped heavy object onto fuel, dropped cask.
8.0	Accident Initiation Events Considered in Design-Basis Evaluation in the Safety Analysis Report	Reactivity transient, rupture of primary piping, steamline break.
9.0	Hypothetical Events More severe than Class 8	Successive failures of multiple barriers normally provided and maintained.

to November 30, 1970. Wind data were obtained at a height above ground of 20 ft. Vertical temperature lapse rates were measured by $\Delta T_{145',-5'}$. Both horizontal and vertical stability classes were assigned on the basis of ΔT measurements. Observations of calm were assigned the wind direction of the first succeeding noncalm and a wind speed of 0.25 mph. Observations of "no data" were deleted to obtain a consecutive set of 7,168 valid hourly observations, out of a possible total of 8,760. These data were linked, end to beginning, to form an endless cycle.

Cumulative frequency distributions of the maximum interval average χ/Q values, for all interval lengths, were obtained for the boundary of the site exclusion area, which (for Davis-Besse) is the same as the site boundary. For each specific direction, the distance to the site boundary was taken to be the minimum distance from the outside edge of the shield building. The distances to the site boundary used in the calculations are presented in Table 7.1-2. As there is nothing but water beyond the site boundary for at least several tens of miles to the northeast, east-northeast, and east, it is considered highly unlikely that a receptor individual will be at risk in these directions in the event of an accident. For this reason, all winds blowing toward the northeast, east-northeast, or east at the site boundary are assumed to result in zero values of χ/Q .

The required frequency distributions of site boundary χ/Q values were obtained by the following procedure, which was repeated for each interval length:

- a. Hourly χ/Q values were computed at the site boundary for each hourly observation (either all centerline or all sector average).

TABLE 7.1-2

DISTANCE BY DIRECTION TO THE SITE BOUNDARY

<u>Direction</u>	<u>Distance (meters)</u>
NNE	730
NE	825
ENE	960
E	1210
<hr/>	
ESE	1565
SE	1075
SSE	915
S	880
<hr/>	
SSW	900
SW	965
WSW	830
W	815
<hr/>	
WNW	835
NW	870
NNW	740
N	720
<hr/>	

- b. The interval was allowed to begin at each of the 7,168 hourly observations for which valid data were available.
- c. For each interval start time (7,168 possible start times) the interval average value of X/Q in each of the 16 directions was computed and the maximum interval average X/Q was stored in a master file.
- d. After obtaining a complete set of maximum interval average values of X/Q (one per possible start time, 7,168 altogether), the calculated values were ranked from highest to lowest and the various percentile values were obtained.*

The computed cumulative frequency distributions of the maximum interval average for site boundary X/Q values are presented in Table 7.1-3.

7.1.2.2 Population Dose Index Values

The median (50th percentile) population doses resulting from the accidents considered have also been estimated and are presented in Section 7.1.4. For the purpose of estimating median population exposures resulting from accidents, cumulative frequency distributions of the product of population and X/Q were obtained for interval lengths of 1 hr, 2 hr, 8 hr, 16 hr, 72 hr (3 days), and 624 hr (26 days).

Before these distributions could be obtained it was necessary to calculate the sum of population times X/Q , out to a distance of 50 mi from the site, for each valid hourly observation. These hourly values of population times X/Q are denoted by the variable " PXQ " and were obtained by using the following procedures:

* The 50th percentile value, used to compute median doses in this chapter, is defined as that value which is exceeded 50% of the time. In this analysis, the 50th percentile value is the 3,585th highest value in an ordered list of 7,168 values.

TABLE 7.1-3

CUMULATIVE FREQUENCY DISTRIBUTIONS OF MAXIMUM INTERVAL AVERAGE
SITE BOUNDARY χ/Q VALUES

Fraction of Time Indicated Value Is Exceeded	Maximum Interval Average Site Boundary χ/Q Values, sec/m^3					
	1 hour	2 hours	8 hours	16 hours	72 hours	624 hours
0.05	4.40-4*	4.01-4	3.81-4	1.91-4	1.08-4	4.45-5
0.10	1.94-4	1.81-4	2.00-4	9.92-5	7.10-5	4.30-5
0.20	8.24-5	7.80-5	7.97-5	4.88-5	4.38-5	3.19-5
0.30	4.82-5	4.42-5	4.47-5	2.87-5	3.12-5	2.56-5
0.40	2.75-5	2.76-5	3.03-5	1.92-5	2.33-5	2.31-5
0.50	4.85-6	1.39-5	2.01-5	1.32-5	1.78-5	2.18-5
0.60	1.21-6	1.94-6	1.29-5	9.25-6	1.47-5	1.91-5
0.70	zero	3.94-7	7.37-6	6.20-6	1.01-5	1.43-5
0.80	zero	zero	1.10-6	3.83-6	7.10-6	1.14-5
0.90	zero	zero	zero	1.31-6	4.06-6	8.06-6

* $3.61-4 \equiv 3.61 \times 10^{-4}$

Notes:

1. Centerline of the plume χ/Q values used exclusively for interval lengths of 1, 2, and 8 hours.
2. Sector average χ/Q values used exclusively for interval lengths of 16, 72, and 624 hours.
3. Meteorological data base is onsite data collected over the period December 1, 1969 - November 30, 1970.
4. Horizontal stability classes were determined from vertical temperature lapse rates.
5. All winds to the NE, ENE, or E were assumed to result in zero site boundary χ/Q values.
6. The minimum building cross section is $3,129 \text{ m}^2$.

- a. Sector average χ/Q values were computed at each of the 10 distances corresponding to the geometric midpoints of the 10 annuli into which the population within 50 mi of the station is distributed.
- b. Each of the 10 computed χ/Q values was multiplied by the population in the corresponding annulus, in the direction the wind was toward.
- c. The 10 products were summed to arrive at the value of PXQ for each hourly observation.

After values of PXQ were computed for each of the 7,168 valid hourly observations, cumulative frequency distributions of interval average values of the population- χ/Q product were determined for each of the required interval lengths. The following procedure was employed:

- a. The interval was allowed to begin at each of the 7,168 valid hourly observations.
- b. For each interval start time (7,168 possible start times) the interval average value of PXQ was computed by summing the hourly values and dividing by the interval length in hours.
- c. After computing and storing the complete set of 7,168 interval average values of PXQ , the values were ranked and sorted from highest to lowest and the various percentile values were obtained.

The population distribution used as a basis for the calculation is that projected for the year 2020. The computed frequency distributions of the population times χ/Q product are presented in Table 7.1-4. The 50th percentile values of PXQ (in units of man-sec/m³) are used to estimate median population exposure in the same manner as 50th percentile

TABLE 7.1-4

CUMULATIVE FREQUENCY DISTRIBUTIONS OF POPULATION TIMES X/Q

Fraction of Time Indicated Value Is Exceeded	Interval Average Values of Population Times X/Q, man-sec/m ³					
	1 hour	2 hours	8 hours	16 hours	72 hours	624 hours
0.05	1.43-1*	1.59-1	1.63-1	1.31-1	1.40-1	6.51-2
0.10	6.44-2	7.49-2	8.85-2	9.26-2	8.73-2	5.12-2
0.20	2.29-2	2.79-2	3.98-2	4.75-2	4.98-2	4.57-2
0.30	1.08-2	1.33-2	2.20-2	2.96-2	3.68-2	4.00-2
0.40	5.34-3	6.85-3	1.25-2	1.81-2	3.06-2	3.68-2
0.50	2.74-3	3.61-3	7.40-3	1.21-2	2.33-2	3.43-2
0.60	* 8.24-4	1.54-3	4.33-3	7.46-3	1.83-2	3.26-2
0.70	1.06-4	3.33-4	2.42-3	4.79-3	1.37-2	2.96-2
0.80	2.93-5	4.44-5	1.06-3	2.95-3	9.35-3	2.63-2
0.90	6.36-7	5.28-6	1.96-4	1.54-3	5.58-3	2.32-2

* 1.43-1 \equiv 1.43 x 10⁻¹

Notes:

1. Sector average X/Q values used exclusively for all intervals.
2. Population data applicable for the year 2020 used.
3. Meteorological data base is onsite data collected over the period December 1, 1969 - November 30, 1970.

values of maximum interval average of site boundary χ/Q (sec/m³) are used to estimate median maximum individual exposure.

7.1.3 DOSE CALCULATION METHODOLOGY

The radiological impacts of the postulated events are evaluated in terms of radiation doses both to individuals and to the population within 50 mi of the site. The following radiological doses were calculated:

- a. Whole body dose, from external exposure, to an individual at the site boundary
- b. Whole body dose, from external exposure, to the population within 50 mi
- c. Child thyroid inhalation dose at the site boundary
- d. Adult thyroid inhalation dose at the site boundary.

The doses were calculated using the following equations:

- a. Individual Whole Body Dose

$$D_{IWB} = 0.259 \times \sum (E_{\gamma,i} \times Q_i) \times (\chi/Q)_t$$

- b. Population Whole Body Dose

$$D_{PWB} = 0.259 \times \sum (E_{\gamma,i} \times Q_i) \times (P\chi/Q)_t$$

- c. Child Thyroid Inhalation Dose

$$D_{CI} = \sum (DCF_{c,i} \times Q_i \times BR_{c,t} \times (\chi/Q)_t)$$

- d. Adult Thyroid Inhalation Dose

$$D_{AI} = \sum (DCF_{a,i} \times Q_i \times BR_{a,t} \times (\chi/Q)_t)$$

Where:

$BR_{a,t}$ = Average adult breathing rate during the t^{th} time period
(see Table 7.1-5)

$BR_{c,t}$ = Average child breathing rate during the t^{th} time period
(see Table 7.1-5)

D_{AI} = Adult thyroid inhalation dose (rem)

D_{CI} = Child thyroid inhalation dose (rem)

D_{IWB} = Individual whole body dose (rem)

D_{PWB} = Population whole body dose (man-rem)

$DCF_{a,i}$ = Adult thyroid inhalation dose conversion factor (rem/Ci)
(see Table 7.1-6)

$DCF_{c,i}$ = Child thyroid inhalation dose conversion factor (rem/Ci)
(see Table 7.1-6)

$E_{\gamma,i}$ = Average gamma disintegration energy of i^{th} isotope
(MeV/dis) (see Table 7.1-6)

Q_i = Curies of i^{th} isotope released

$(X/Q)_t$ = 50th percentile nondirectional meteorological dispersion
coefficient at the site boundary for the t^{th} release
period (sec/m^3)

$(PXQ)_t$ = 50th percentile nondirectional meteorological dispersion
coefficient times population for the t^{th} release period
($\text{man-sec}/\text{m}^3$) (see Table 7.1-4)

7.1.4 ACCIDENT DISCUSSION

The following sections present a brief description of each accident, including the basic assumptions used in the analysis, a discussion of the likelihood of occurrence of the accident, and the radiological doses

TABLE 7.1-5
AVERAGE BREATHING RATES

Time Period	Breathing Rate (m ³ /sec)	
	Adult	Child
0-1 hr	3.47(-4)*	1.04(-4)
0-2 hr	3.47(-4)	1.04(-4)
0-8 hr	3.47(-4)	1.04(-4)
8-24 hr	1.74(-4)	5.21(-5)
1-4 days	2.31(-4)	6.94(-5)
4-30 days	2.31(-4)	6.94(-5)

* 3.47(-4) \equiv 3.47×10^{-4}

resulting from the accident. Radioactivity concentrations in the reactor coolant (primary system) and in the main steam system (secondary system) which serve as the base or initial condition for all accident analyses are given in Table 7.1-7. Only the iodine and noble gas concentrations appear since there are only gaseous releases associated with the accidents considered in this section. These concentrations are based on continuous steady-state operation with the following conditions:

- a. 2772 MWt power level
- b. 0.5% failed fuel
- c. 20-gpd steam generator tube leak
- d. Two-thirds of total secondary system flow passes through a condensate polishing demineralizer.

TABLE 7.1-6

HALF-LIVES, AVERAGE GAMMA DISINTEGRATION ENERGIES AND
IODINE INHALATION DOSE CONVERSION FACTORS

Isotope	Half-Lives $T_{1/2}$ (hours)	Average Gamma Energies E (MeV/dis)	Iodine Inhalation Dose Conversion Factors	
			Adult (rem/Ci)	Child (rem/Ci)*
I-131	1.93 (+2)**	0.375	1.48 (+6)	7.16 (+6)
I-132	2.28	2.29	5.35 (+4)	5.19 (+5)
I-133	2.1 (+1)	0.636	4.00 (+5)	3.62 (+6)
I-134	8.67 (-1)	2.508	2.50 (+4)	2.51 (+5)
I-135	6.7	1.457	1.24 (+5)	1.19 (+6)
Kr-83m	1.86	0.005		
Kr-85m	4.4	0.156		
Kr-85	9.43 (+4)	0.0021		
Kr-88	2.8	2.00		
Xe-131m	2.86 (+2)	0.022		
Xe-133m	5.52 (+1)	0.0239		
Xe-133	1.26 (+2)	0.0455		
Xe-135m	2.60 (-1)	0.44		
Xe-135	9.2	0.248		
Xe-138	2.33 (-1)	0.932		

* Calculated on the basis of data in Reference 3.
**1.93 (+2) \equiv 1.93 x 10⁺².

TABLE 7.1-7

PRIMARY AND SECONDARY SYSTEM EQUILIBRIUM ACTIVITY CONCENTRATIONS*

Isotope	Primary, $\mu\text{Ci/cc}$	Secondary, $\mu\text{Ci/g}$
I-131	1.24	1.02 (-6)**
I-132	6.20 (-1)	6.30 (-7)
I-133	1.41	1.16 (-6)
I-134	1.64 (-1)	1.22 (-7)
I-135	6.90 (-1)	5.65 (-7)
Kr-83m	1.00 (-1)	7.50 (-8)
Kr-85m	5.45 (-1)	4.18 (-7)
Kr-85	6.60 (-1)	8.75 (-7)
Kr-87	2.98 (-1)	2.20 (-7)
Kr-88	9.55 (-1)	7.20 (-7)
Xe-131m	6.10 (-1)	5.55 (-7)
Xe-133m	9.70 (-1)	7.55 (-7)
Xe-133	8.45 (+1)	6.75 (-5)
Xe-135m	2.54 (-1)	1.65 (-7)
Xe-135	1.56	1.20 (-6)
Xe-138	1.82 (-1)	1.20 (-7)

*Based on: a. 2712 MWt
b. 0.5% failed fuel
c. 20 gpd primary to secondary leak
d. Two-thirds of the total secondary system flow passes through a condensate polishing demineralizer

**1.06(-6) \equiv 1.02×10^{-6}

7.1.4.1 Class 1.0: Trivial Incidents

Radioactivity release events of this class are considered to be minor perturbations of normal operating conditions and are analyzed along with radioactivity releases due to normal operation in Sections 3.5 and 5.3.

7.1.4.2 Class 2.0: Small Release Outside Containment

Radioactivity release events of this class are considered to be minor perturbations of normal operating conditions and are analyzed along with radioactivity releases due to normal operation in Sections 3.5 and 5.3.

7.1.4.3 Class 3.0: Radwaste System Failure

Class 3 accidents are postulated to involve the release of radioactivity to the environment through a failure or malfunction in the radwaste system. The possibility of an equipment failure or serious malfunction is remote, due to the general design of the system, the quality control associated with manufacture and installation of the components of the system, and the in-service inspection performed on the systems. The possibility of an accident due to human error is small, due to the strict administrative controls exercised during operation of the radwaste systems. Thus, no radwaste system failure is anticipated during the life of the station. Nevertheless, in order to demonstrate that failures in this system will not result in significant environmental impact, the following hypothetical events are evaluated.

7.1.4.3.1 Equipment Leakage or Malfunction - (Class 3.1)

This event includes equipment malfunctions and human error which may result in the release of activity from the waste processing system. The incident is defined as the partial release of the liquid or gaseous contents of the

largest storage tanks in the radwaste system. Events involving the waste gas decay tank and the clean waste receiver tank are considered separately below. Although it is possible to identify a number of combinations of operator error and equipment malfunction or failure that might result in a release of some or all of the activity stored in these tanks, this type of event has a low probability of occurrence.

7.1.4.3.1.1 Gaseous Release

This gaseous release is defined as an unspecified leak or malfunction that results in the release of gaseous radioactivity. The parameters and assumptions used in this analysis are:

- a. 25% of the average inventory of the largest waste gas storage tank is assumed to be released.
- b. The airborne radioactivity released from this tank is assumed to be released instantaneously to the environment without filtration.

The activity released to the environment as a result of this accident is given in Table 7.1-8.

The doses that would result from this accident have been calculated to be as follows:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary Dose (rem)	1.5×10^{-4}	2.5×10^{-5}	1.4×10^{-5}
Population Dose (man-rem)	2.2×10^{-2}	--	--

7.1.4.3.1.2 Liquid Release

This liquid release is defined as an unspecified leak or malfunction that occurs in the clean waste receiver tank, which is the largest storage tank

containing radioactive fluids. The tank (the clean waste receiver tank) is sized to hold 103,000 gal. This tank is located in the auxiliary building. The spilled liquid will be collected through floor drains and processed through the miscellaneous radwaste system. No direct release of radioactive liquid will occur. The offsite dose is due entirely to volatilization of iodines.

The parameters and assumptions used in the dose analysis are:

- a. 25% of the average inventory in the clean waste receiver tank is assumed to be spilled.
- b. A liquid/gas partition factor of 500 may be applied to the iodines.
- c. A release period of less than 1 hr is assumed.

The activity released to the environment as a result of this accident is given in Table 7.1-8. From this table it can be seen that the released radioactivity will contribute to the thyroid inhalation doses only.

The doses that would result from this accident have been calculated to be as follows:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary (rem)	--	2.1×10^{-6}	1.2×10^{-6}
Population Dose (man-rem)	--	--	--

| 1

7.1.4.3.2 Release of Waste Gas Storage Tank Contents - (Class 3.2)

This accident is defined as the sudden release of the contents from one waste gas storage tank. The assumptions used in evaluating the consequences of this accident are as follows:

- a. 100% of the inventory of one waste gas storage tank is assumed to be released.
- b. The activity released in this accident is assumed to be released instantaneously to the environment without filtration.

The activities released to the environment are listed in Table 7.1-8.

The offsite doses have been calculated to be as follows:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary Dose (rem)	6.0×10^{-4}	1.0×10^{-4}	5.6×10^{-5}
Population Dose (man-rem)	8.8×10^{-2}	--	--

| 1

7.1.4.3.3 Release of Liquid Waste Storage Tank Contents - (Class 3.3)

This accident is defined as the sudden release of the entire contents of the largest liquid waste storage tank, which is the clean waste receiver tank. As discussed in 7.1.4.3.1.2, no direct release of liquid waste to the environment occurs. Offsite dose results from volatilization of radioiodines.

The assumptions used in the evaluation of the consequences of this accident follow:

- a. 100% of the clean waste receiver tank is assumed to be spilled.
- b. A liquid/gas partition factor of 500 may be applied to the iodines.
- c. The activity released from this tank is assumed to be released instantaneously to the environment without filtration.
- d. A release period of less than 1 hr is assumed.

The activities released to the environment are listed in Table 7.1-8.

The released radioactivity will contribute only to the thyroid inhalation doses.

The calculated offsite doses are presented below:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary Dose (rem)	--	8.4×10^{-6}	4.6×10^{-6}
Population Dose (man-rem)	--	--	--

7.1.4.4 Class 4.0: Fission Products to Primary System (BWR)

Release of fission products to the primary system of a pressurized water reactor does not, in itself, cause releases to the environment. Fission product releases to the primary system in conjunction with steam generator tube leakage are discussed under Class 5.0.

7.1.4.5 Class 5.0: Fission Products to Primary and Secondary Systems

7.1.4.5.1 Fuel Cladding Defects and Steam Generator Leak - (Class 5.1)

Releases from these events are included and evaluated, along with routine releases, in Sections 3.5 and 5.3.

7.1.4.5.2 Off-Design Transient That Induces Fuel Failures Above Those Expected and Steam Generator Leak - (Class 5.2)

A transient is postulated that results in the instantaneous release of 0.02% of the core inventory of noble gases and halogens to the reactor coolant.

Due to steam generator leaks, activity propagates throughout the secondary system. Release from the steam system occurs by the normal pathways of system leakage, gland seal condenser, and main condenser air exhaust.

Assumptions and parameters used in the analysis are as follows:

- a. 0.02% of the core inventory of noble gases and halogens is added to the activity initially present in the reactor coolant.

The combined concentration is assumed constant for the duration of the transient.

- b. Steam generator leakage of 20 gpd continues throughout the transient.
- c. Iodine partition factor in the steam generator is 1.0; i.e., no partition is achieved.
- d. Secondary system leakage is 1,700 lb/hr with an iodine partition factor (DF) of 1.0.
- e. Gland seal condenser flow is 800 lb/hr, with an iodine partition factor of 0.001.
- f. All noble gases and 0.1% of the halogens in the steam reaching the condenser (7.05×10^6 lb/hr) are released through the condenser.
- g. The entire transient is assumed to take place over a 9-hr period.

Activity released to the environment as a result of this accident is given in Table 7.1-9.

Mechanisms that can initiate fuel cladding damage during reactor transients are: (1) severe overheating of the fuel rod cladding, caused by inadequate cooling, and (2) flux maldistribution.

Avoidance of fuel cladding damage, from abnormal operational transients, can be verified by demonstrating that the departure from nucleate boiling ratio (DNBR) remains greater than 1.3. Maintaining a DNBR greater than 1.3 is considered a sufficient, but not necessary, condition to ensure that no fuel damage occurs.

A detailed analysis of all anticipated abnormal transients using very conservative assumptions (Chapter 15 of the Davis-Besse Nuclear Power

TABLE 7.1-9
 ACTIVITY RELEASE TO THE ENVIRONMENT
 FOR CLASS 5.0 ACCIDENTS (CURIES)

Isotope	Abnormal Transient and Steam Generator Leak	Steam Generator Tube Rupture
I-131	1.16(-3)*	1.04(-2)
I-132	6.66(-4)	6.73(-3)
I-133	1.31(-3)	1.49(-2)
I-134	1.14(-4)	1.38(-3)
I-135	6.26(-4)	5.86(-3)
Kr-83m	1.36(-1)	8.44(-1)
Kr-85m	4.13(-1)	4.59
Kr-85	3.80(-2)	9.43
Kr-87	7.44(-1)	2.50
Kr-88	1.14	8.02
Xe-131m	2.82(-2)	5.98
Xe-133m	8.14(-2)	8.17
Xe-133	4.60	7.33(+2)
Xe-135m	5.80(-1)	2.14
Xe-135	3.26(-1)	1.31(+1)
Xe-138	2.06	1.53

* 1.16(-3) \equiv 1.16 x 10⁻³

Station Unit No. 1 Final Safety Analysis Report) has shown that a DNBR greater than 1.3 is maintained. The probability of fission product releases above those small quantities released on a continuous basis during normal operation is therefore considered to be small.

Using the assumptions stated, the following offsite doses have been calculated:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary (rem)	2.8×10^{-5}	3.0×10^{-5}	1.6×10^{-5}
Population Dose (man-rem)	1.0×10^{-2}	--	--

| 1

7.1.4.5.3 Steam Generator Tube Rupture - (Class 5.3)

A complete rupture of a single steam generator tube is postulated in this accident. Since the reactor coolant pressure is greater than the secondary side pressure in the steam generator, radioactive reactor coolant is transferred into the secondary system. A portion of this radioactivity is vented to the atmosphere by action of the condenser vacuum pumps. Low pressure in the primary system would cause an automatic reactor trip and actuation of the safety injection system. Final isolation of the affected steam generator, by the operator, is assumed to be accomplished within 34 min. Assumptions and parameters used in this analysis are as follows:

- a. 15% of the initial activity inventory in the primary coolant system reaches the secondary system.
- b. Before the defective steam generator is initially isolated at 30 sec, $1,978 \text{ ft}^3$ of primary coolant leaves the primary system. After initial isolation, the primary system coolant enters the defective steam generator without spreading to the rest of the secondary system.

- c. A steam generator iodine partition factor of 1 is used.
- d. All noble gases and 0.1% of the halogens leaving the steam generator are released to the environment through the condenser.
- e. The primary system volume is 11,450 ft³.
- f. A release period of 8 hr is assumed.

Activity released to the environment as a result of this accident is also given in Table 7.1-9.

The potential for catastrophic failure of a steam generator tube is considered negligible. The pressures calculated to cause a rupture are far in excess of normal operating conditions. Furthermore, it is expected that any failure would be preceded by cracking, caused by corrosion, erosion, or fatigue. Any failure of this nature would produce primary-to-secondary leakage, which would be detected by radioactivity monitoring before tube strength is lost and a rupture develops.

Using the assumptions stated, the following offsite doses have been calculated:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary (rem)	3.1×10^{-4}	2.7×10^{-4}	1.5×10^{-4}
Population Dose (man-rem)	1.1×10^{-1}	--	--

7.1.4.6 Class 6.0: Refueling Accidents

Class 6 accidents are postulated to include refueling accidents inside containment. To demonstrate the potential environmental consequences of this type of accident, two refueling accidents are postulated and evaluated:

- a. A fuel bundle drop
- b. A heavy object drop onto fuel in core.

7.1.4.6.1 Fuel Bundle Drop - (Class 6.1)

A fuel bundle drop is postulated to occur as a result of the mishandling of a spent fuel assembly inside the containment vessel. The accident is assumed to result in damage to one row of fuel rods in the assembly. The radioactivity released from the damaged fuel assembly will bubble through the water covering the assembly where most of the radioactive iodine will be entrained. The remainder of the radioactivity is released to the containment atmosphere where it is vented to the environment through the unit vent. After isolation of the containment vessel, the containment atmosphere is purged through charcoal filters prior to release to the environment.

The possibility of mishandling or dropping a fuel assembly, with subsequent damage to the fuel rods, is minimized by equipment design and detailed operating procedures. The fuel handling manipulators and hoists are designed so that the fuel assembly cannot be raised above a position that provides adequate water depth for safe shielding of all operating personnel. Thus, all fuel handling is underwater, both within the containment and in the spent fuel pool area. Adequate cooling of fuel during underwater handling is provided by convective heat transfer to the surrounding water. Other special precautions include conservative design for fail-safe operation of all handling tools and associated devices used in fuel handling operations, as well as limitation of the motion of cranes used to move fuel assemblies to a low maximum speed. In addition, the design of the fuel assembly itself would be expected to preclude extensive damage to the fuel rods. Thus, damage to a fuel assembly during handling is unlikely and assuming failure of an entire row of rods is a conservative upper limit.

The following assumptions are postulated for this accident:

- a. The gap activity (noble gases and halogens) in one row (15 fuel rods) of fuel pins (208 fuel rods per assembly) is assumed to be released into the water.
- b. A 1-week decay time before the accident occurs is assumed.
- c. Iodine decontamination factor in water is 500; noble gases are not retained by water.
- d. The containment atmosphere is vented at a rate of 50,000 cfm prior to isolation.
- e. The containment free volume is 2.834×10^6 ft³.
- f. The containment is isolated within 10 sec following the accident.
- g. After isolation, the containment is purged at a rate of 16,000 cfm through charcoal filters whose efficiency for radioiodines is 99%.
- h. A release period of 8 hr is assumed.

The activities released to the environment are listed in Table 7.1-10.

The resultant whole body and thyroid inhalation doses are as follows:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary (rem)	4.6×10^{-4}	1.6×10^{-4}	1.1×10^{-4}
Population Dose (man-rem)	1.7×10^{-1}	--	--

7.1.4.6.2 Heavy Object Drop onto Fuel in Core - (Class 6.2)

This accident is assumed to result in damage from dropping a heavy object onto the hottest fuel assembly. The same assumptions apply here as those used in the fuel bundle drop accident, with the exception that (a) 100 hr of decay time is assumed before the object drop occurs, and (b) the whole fuel assembly is assumed to be ruptured.

TABLE 7.1-10

ACTIVITY RELEASE TO THE ENVIRONMENT
FOR CLASS 6.0 ACCIDENTS (CURIES)

Isotope	Fuel Bundle Drop	Heavy Object Drop
I-131	1.07(-2)*	1.89(-1)
I-133	1.61(-5)	2.10(-3)
Kr-85	3.31(+2)	4.59(+3)
Xe-131m	2.99(+1)	4.89(+2)
Xe-133m	6.46	2.10(+2)
Xe-133	1.89(+3)	3.80(+4)
Xe-135	3.06(-4)	7.12(-1)

* 1.07(-2) \equiv 1.07×10^{-2}

The same design and operating considerations would mitigate the possibility and consequences of this accident as were discussed in Section 7.1.4.6.1 for the fuel bundle drop accident. Special lifting fixtures are provided for safe handling of heavy objects, such as the vessel head and internals over the core. Cranes and rigging are adequately sized for the expected loads.

Table 7.1-10 lists the activities released as a result of this accident.

The following offsite whole body and thyroid inhalation doses have been calculated:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary (rem)	9.1×10^{-3}	2.8×10^{-3}	2.0×10^{-3}
Population Dose (man-rem)	3.4	--	--

| 1

7.1.4.7 Class 7.0: Spent Fuel Handling Accidents

Class 7 accidents are postulated to include spent fuel handling accidents outside the containment vessel. This class of accident can occur inside the auxiliary building or on the site grounds. In the case of the latter, this would result in the release of radioactive material directly into the environs if the fuel cask were breached.

In order to demonstrate the potential environmental consequences of this type of accident, the three spent fuel handling accidents listed below are postulated and evaluated.

- a. Fuel assembly drop in fuel storage pool
- b. Heavy object drop onto fuel rack
- c. Fuel cask drop.

7.1.4.7.1 Fuel Assembly Drop in Fuel Storage Pool - (Class 7.1)

In this accident it is postulated that a fuel assembly drop occurs as a result of mishandling the spent fuel assembly in the auxiliary building.

The possibility of a fuel handling incident in the auxiliary building is equally as remote as that within the containment vessel, as discussed in Section 7.1.4.6.1. Design considerations and administrative controls are essentially the same as those discussed earlier. Only one assembly can be handled at a time and the design is such that the assembly is continuously immersed.

Spent fuel at rest in the storage racks is positioned by positive restraints in an always subcritical array (no credit taken for boric acid in the water) and it is impossible to insert a spent fuel assembly in other than prescribed locations.

The following assumptions are postulated for this fuel drop accident:

- a. The gap activity (noble gases and halogens) in one row (15 fuel rods) of fuel pins (203 fuel rods per assembly) is assumed to be released into the water.
- b. A 1-week decay time before the accident occurs is assumed.
- c. Iodine decontamination factor in water is 500.
- d. The fuel handling area is vented at 20,000 cfm without a charcoal filter prior to the accident.
- e. The fuel handling area volume is 620,000 ft³.
- f. The ventilation system is isolated 10 sec after receipt of the high radiation signal.
- g. After the high radiation signal the fuel handling area is purged through charcoal filters whose efficiency for radioiodines is 99%.
- h. A release period of 2 hr is assumed. The released activities are listed in Table 7.1-11.

The resultant whole body and thyroid inhalation doses are:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary (rem)	3.2×10^{-4}	1.3×10^{-4}	9.1×10^{-5}
Population Dose (man-rem)	3.2×10^{-1}	--	--

7.1.4.7.2 Heavy Object Drop Onto Fuel Rack - (Class 7.2)

This accident is defined as the dropping of heavy object onto the spent fuel storage racks in such a manner that all of the fuel rods in an average assembly are damaged. Again, the spent fuel pool water would retain a large fraction of the halogen activity, with any escaping activity being exhausted to the unit vent through charcoal filters. The spent fuel storage area is designed so that it is not necessary, nor is

it possible, to carry heavy objects (such as a spent fuel transfer cask) over the fuel assemblies in the storage racks. Dropping a cask into the spent fuel pool would require four independent, concurrent failures as indicated below:

- a. Failure of the mechanical stops
- b. Failure of the electrical interlock
- c. Failure of a mechanical device on the crane, such as the hook
- d. Failure of the safety slings.

The assumptions used in the analysis of the accident are the same as in Section 7.1.4.7.1, except as follows:

- a. The gap activity (noble gases and halogens) in one fuel assembly is assumed to be released into the water.
- b. A 30-day decay time before the accident occurs is assumed.

The activity released to the environment as a result of this accident is given in Table 7.1-11.

TABLE 7.1-11

ACTIVITY RELEASE TO THE ENVIRONMENT
FOR CLASS 7.0 ACCIDENTS (CURIES)

Isotope	Fuel Bundle Drop	Heavy Object Drop	Fuel Cask Drop
I-131	1.27(-2)*	2.43(-2)	2.40
I-133	1.90(-5)	--	--
Kr-85	3.31(+2)	4.57(+3)	3.14(+4)
Xe-131m	2.99(+1)	1.09(+2)	4.02
Xe-133m	6.46	8.76(-2)	--
Xe-133	1.89(+3)	1.27(+3)	6.46(-2)

* 1.27(-2) \equiv 1.27×10^{-2}

The whole body and thyroid inhalation doses have been calculated to be as follows:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary (rem)	2.5×10^{-4}	2.5×10^{-4}	1.7×10^{-4}
Population Dose (man-rem)	6.5×10^{-2}	--	--

7.1.4.7.3 Fuel Cask Drop - (Class 7.3)

In this accident it is postulated that a fully loaded fuel cask is dropped as it is being transferred out of the auxiliary building. It is assumed that the fall is from such a height that the cask is breached and all of the fuel rods are ruptured, releasing all of the noble gas gap activity directly to the atmosphere. Again, such an accident rarely would be expected to occur because of design constraints and administrative controls. In accordance with DOT regulations, the casks are designed to withstand a 30-ft drop onto an unyielding surface without rupture. Since the cask can withstand any realistically assumed drop, and the assemblies are restrained within the cask, a radioactive release is only remotely possible.

The following assumptions are postulated involving a fuel cask drop:

- a. Gap activity from one fully loaded fuel cask (120-day cooling and decay) is assumed to be released.
- b. It is assumed that a fully loaded fuel cask contains seven fuel assemblies.
- c. A release period of less than 1 hr is assumed.

The released activities are listed in Table 7.1-11.

The whole body and thyroid inhalation doses have been calculated to be as follows:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary (rem)	1.2×10^{-5}	1.2×10^{-3}	8.5×10^{-4}
Population Dose (man-rem)	4.8×10^{-2}	--	--

7.1.4.8 Class 8.0: Accident Initiation Events Considered in Design Basis Evaluation in the Safety Analysis Report

Class 8 accidents are postulated to include various events resulting in a partial degradation of the primary and secondary coolant system pressure boundaries. These accidents are evaluated in Chapter 15 of the Davis-Besse Nuclear Power Station Unit No. 1 Final Safety Analysis Report using highly conservative assumptions and are used as design basis events to establish performance requirements of the engineered safety features. The highly conservative assumptions used in the Safety Analysis Report and AEC Safety Evaluations are not suitable for evaluating the environmental risks of Class 8 events because their use would result in an unrealistic overestimate of the risks. For this reason, events in Class 8 are evaluated here using realistic assumptions. To demonstrate the potential environmental consequences of Class 8 events, the following accidents are postulated and evaluated:

- a. Small primary system pipe break
- b. Large primary system pipe break
- c. Break in instrument line, from primary system, that penetrates the containment
- d. Rod ejection accident
- e. Large steamline break
- f. Small steamline break.

7.1.4.8.1 Small Primary System Pipe Break - (Class 8.1)

In this accident the rupture of a small pipe in the primary system, causing a loss of reactor coolant, is assumed. An automatic reactor trip

and initiation of the unit's emergency core cooling system will occur as the primary system pressure decreases. Although no additional fuel failure should occur, a certain amount of radioactive reactor coolant will be released to the containment vessel. Radioactivity will be partially removed from the containment atmosphere by the containment spray system and by plateout on the containment structures. Nevertheless, some of the remaining radioactivity in the containment atmosphere will be slowly released to the environment through minute leaks. Assumptions and parameters used in this analysis are as follows:

- a. The average reactor coolant inventories of halogens and noble gases are released to the containment at initiation of the accident.
- b. For the effects on iodine of plateout, chemical addition sprays, and gas/liquid partitioning, a reduction factor of 0.05 is applied to the reactor coolant release.
- c. Containment vessel leak rate is:
0.5% volume/day for 0 to 24 hr.
0.25% volume/day for 1 to 30 days.
- d. For the first 65 sec after the accident, all leakage from the containment vessel is assumed to be released without any treatment.
- e. After 65 sec, it is assumed that 94% of the containment leakage is filtered through 99% efficient external charcoal filters.
- f. A release period of 30 days is assumed. *

Initial reactor coolant inventories and time dependent releases of halogens and noble gases for this accident appear in Table 7.1-12.

The loss-of-coolant accident is a design basis accident for the site.

Therefore, factors relating to the prevention and mitigation of this accident are thoroughly discussed in the Safety Analysis Report. Only a few of the more significant considerations are summarized herein.

TABLE 7.1-12
ACTIVITY RELEASE TO THE ENVIRONMENT
FOR CLASS 8.1 ACCIDENTS (CURIES)

Isotope	Initial RCS* Activity (Ci)	Small Primary System Pipe Break Release (Ci)**			
		0-8 hr	8-24 hr	1-4 days	4-30 days
I-131	2.36(-3)	4.02(+2) [†]	4.37(-3)	8.38(-3)	2.48(-2)
I-132	4.71(-4)	2.01(+2)	4.16(-5)	----	----
I-133	2.40(-3)	4.57(+2)	3.14(-3)	2.04(-3)	2.07(-4)
I-134	5.70(-5)	5.30(+1)	----	----	----
I-135	9.18(-4)	2.24(+2)	5.51(-4)	6.49(-5)	----
Kr-83m	1.73(-2)	3.26(+1)	9.20(-4)	----	----
Kr-85m	1.67(-1)	1.77(+2)	6.08(-2)	2.65(-3)	----
Kr-85	3.56(-1)	2.14(+2)	7.10(-1)	1.59	1.32(+1)
Kr-87	3.63(-2)	9.66(+1)	4.61(-4)	----	----
Kr-88	2.24(-1)	3.09(+2)	3.52(-2)	3.41(-4)	----
Xe-131m	3.26(-1)	1.98(+2)	6.32(-1)	1.27	5.05
Xe-133m	4.98(-1)	3.14(+2)	8.56(-1)	1.14	7.66(-1)
Xe-133	3.69(-1)	2.74(+4)	3.91(-1)	1.36(-1)	2.67(-3)
Xe-135m	6.44(-3)	8.2 (+1)	----	----	----
Xe-135	6.32(-1)	5.05(+2)	5.34(-1)	1.13(-1)	4.99(-4)
Xe-138	4.14(-3)	5.90(+1)	----	----	----

*Reactor coolant system.

**Releases of less than 1.0×10^{-2} Ci are negligible.

[†]4.02(+2) = $4.02 \times 10^{+2}$.

The unit is designed, fabricated, and constructed under a comprehensive quality assurance program to ensure compliance with all applicable specifications and codes. All reactor coolant system components are designed and fabricated in accordance with the ASME Boiler and Pressure Vessel Code, Section III. The reactor coolant system is designed to withstand the loads imposed by the design basis loss-of-coolant accident and the safe shutdown earthquake, specified in the Davis-Besse Nuclear Power Station Unit No. 1 Final Safety Analysis Report,⁽⁴⁾ without loss of function required for emergency reactor shutdown and emergency core cooling.

The major reactor coolant system components are designed for a 40-yr operating lifetime. Components are of materials that are compatible with coolant chemistry. Fatigue analyses, based on conservative design cyclic transients and primary stress combinations, have been evaluated in accordance with the applicable codes. Overpressure protection is ensured by ASME Code safety valves.

Engineered safety features act to control and mitigate the consequences of a loss-of-coolant accident for the entire spectrum of break sizes. After installation, the reactor coolant system is hydrostatically tested and leak tested. A series of tests are conducted prior to reactor fueling, during fueling, and following initial criticality.

Technical specifications, operating procedures, and other administrative controls, ensure unit operating conditions within limits previously determined to be acceptable. An extensive in-service inspection program requires periodic surveillance and inspection of safety-related equipment and components during station operation.

From the above discussion it is clear that this accident has a low probability of occurrence.

Using the assumptions stated, the following offsite exposures have been calculated:

	<u>Whole Body</u>	Thyroid (by Inhalation)	
		<u>Child</u>	<u>Adult</u>
Site Boundary (rem)	6.0×10^{-6}	4.4×10^{-4}	2.9×10^{-4}
Population Dose (man-rem)	4.3×10^{-3}	--	--

7.1.4.8.2 Large Primary System Pipe Break - (Class 8.1)

The sequence of events for the large primary system pipe break is essentially the same as that for the small break. However, because of the more rapid loss of reactor coolant, additional fuel failures resulting from clad overheating may occur. For this reason a source term equal to the average radioactivity inventory in the reactor coolant, plus 2% of the core inventory of halogens and noble gases, is assumed. All other assumptions are identical with those for the small pipe break.

Initial reactor coolant inventories and time dependent releases of halogens and noble gases for this accident appear in Table 7.1-13.

The possibility that a large pipe break would occur is much less than the possibility of a small break. The critical crack length (the length of crack that will propagate to rupture) increases as the pipe diameter and wall thickness increase. A larger crack will also produce a greater amount of leakage before rupture. This greater leakage makes detection easier and allows more time for corrective action.

Using the assumptions stated, the following offsite doses have been calculated:

	<u>Whole Body</u>	Thyroid (by Inhalation)	
		<u>Child</u>	<u>Adult</u>
Site Boundary (rem)	1.8×10^{-2}	1.8	1.1
Population Dose (man-rem)	8.7	--	--

TABLE 7.1-13

 ACTIVITY RELEASE TO THE ENVIRONMENT
 FOR CLASS 8.1 ACCIDENTS (CURIES)

Isotope	Initial RCS* Activity (Ci)	Large Primary System Pipe Break			
		0-8 hr	8-24 hr	1-4 days	4-30 days
I-131	1.49(+6) [†]	8.76	1.62(+1)	3.11(+1)	9.20(+1)
I-132	2.18(+6)	5.11	4.51(-1)	1.75(-3)	----
I-133	2.88(+6)	1.51(+1)	1.98(+1)	1.29(+1)	1.31
I-134	3.66(+6)	3.94	5.50(-3)	----	----
I-135	2.80(+6)	1.15(+1)	6.90	8.13(-1)	4.72(-4)
Kr-83m	1.65(+5)	8.76(+1)	4.67	6.01(-3)	----
Kr-85m	4.92(+5)	4.66(+2)	1.69(+2)	7.39	8.72(-5)
Kr-85	1.08(+4)	1.81(+1)	3.60(+1)	8.06(+1)	6.72(+2)
Kr-87	9.08(+5)	3.41(+2)	4.34	3.41(-4)	----
Kr-88	1.37(+6)	9.93(+2)	1.56(+2)	1.51	----
Xe-131m	1.20(+4)	1.98(+1)	3.84(+1)	7.72(+1)	3.07(+2)
Xe-133m	6.93(+4)	1.10(+2)	1.89(+2)	2.51(+2)	1.69(+2)
Xe-133	2.86(+6)	3.86(+3)	4.08(+3)	1.42(+3)	2.79(+1)
Xe-135m	7.06(+5)	5.52(+1)	----	----	----
Xe-135	3.52(+5)	4.41(+2)	3.73(+2)	7.91(+2)	3.48(-1)
Xe-138	2.54(+6)	1.78(+2)	----	----	----

*Reactor coolant system.

**Releases of less than 1.0×10^{-5} Ci are negligible.

[†]1.49(+6) = $1.49 \times 10^{+6}$.

7.1.4.8.3 Break in Instrument Line from Primary System that Penetrates the Containment - (Class 8.2)

With the exception of containment pressure sensing lines, instrument lines are provided with isolation capability inside the containment. The accident has no environmental consequences.

7.1.4.8.4 Rod Ejection Accident - (Class 8.2)

A highly unlikely rupture of the control rod mechanism housing must be postulated for this accident to occur. As a result, minor fuel failures would occur and reactor coolant would be released to the containment.

Sprays and plateout partially reduce the airborne fission product concentration. Nevertheless, some of the remaining radioactivity is slowly released to the atmosphere through minute leaks in the containment.

The sequences of events, and the assumptions used in the calculations for the rod ejection accident, are essentially the same as for the small break.

However, in addition to the average primary coolant radioactivity inventory, 0.2% of the core inventory of noble gases and halogens is released into the primary coolant. The combined source terms, and hence the activity releases for this accident, are presented in Table 7.1-14.

The probability of failure of a control rod mechanism housing is considered very small. A combination of conservative design, preoperational testing, quality control, and periodic inspection gives this assurance.

Using the assumptions stated, the following offsite doses have been calculated:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary (rem)	1.8×10^{-3}	1.8×10^{-1}	1.1×10^{-1}
Population Dose (man-rem)	8.8×10^{-1}	--	--

| 1

TABLE 7.1-14

ACTIVITY RELEASE TO THE ENVIRONMENT
FOR CLASS 8.2 ACCIDENTS (CURIES)

Isotope	Initial RCS* Activity	Rod Ejection Accident			
		0-8 hr	8-24 hr	1-4 days	4-30 days
I-131	1.50(+5) [†]	8.78(-1)	1.63	3.12	9.23
I-132	2.18(+5)	5.11(-1)	4.52(-2)	1.76(-4)	----
I-133	2.88(+5)	1.52	1.98	1.29	1.31(-1)
I-134	3.66(+5)	3.94(-1)	5.51(-4)	----	----
I-135	2.80(+5)	1.15	6.91(-1)	8.14(-2)	4.72(-5)
Kr-83m	1.66(+4)	8.80	4.69(-1)	6.03(-4)	----
Kr-85m	4.94(+4)	4.68(+1)	1.70(+1)	7.41(-1)	----
Kr-85	1.28(+3)	2.13	4.25	9.50	7.92(+1)
Kr-87	9.09(+4)	3.42(+1)	4.34(-1)	3.42(-5)	----
Kr-88	1.37(+5)	9.96(+1)	1.56(+1)	1.51(-1)	----
Xe-131m	1.38(+3)	2.27	4.40	8.87	3.52(+1)
Xe-133m	7.21(+3)	1.14(+1)	1.96(+1)	2.61(+1)	1.76(+1)
Xe-133	2.86(+5)	3.86(+2)	4.09(+2)	1.42(+2)	2.79
Xe-135m	7.07(+4)	5.52	----	----	----
Xe-135	3.57(+4)	4.47(+1)	3.77(+1)	8.01	3.52(-2)
Xe-138	2.54(+5)	1.78(+1)	----	----	----

*Reactor coolant system.

**Releases of less than 1.0×10^{-5} Ci are negligible.

[†]1.50(+5) = $1.50 \times 10^{+5}$.

7.1.4.8.5 Large Steamline Break - (Class 8.3)

This accident is postulated as the complete rupture of a large steamline, which would result in the release of secondary system steam to the atmosphere.

As a consequence of this release, closure of the main steamline isolation valve occurs and reactor scram is initiated automatically. Radioactivity available for release with the steam consists of that initially present in the affected steam generator, plus that which leaks from the primary to the secondary system during the course of the accident, in addition to that which is added from the feedwater system.

The parameters and assumptions that were used in this analysis are as follows:

- a. 1,788 lb of primary coolant leak into the secondary side throughout the assumed 9-hr duration of the transient.
- b. A halogen reduction factor of 0.5 is applied to the primary coolant source during the course of the accident.
- c. A total of 163,500 lb of steam are released to the atmosphere during the course of the accident (130,240 lb from the steam generator with the broken line and 33,260 lb from the unaffected steam generator).

Activity release to the environment as a result of this accident is given in Table 7.1-15.

A steamline break is considered highly unlikely. The steam system valves, fittings, and piping are conservatively designed; the piping is made of ductile material and is completely inspected prior to installation.

TABLE 7.1-15

ACTIVITY RELEASE TO THE ENVIRONMENT
FOR CLASS 8.3 ACCIDENTS (CURIES)

Large Steamline Break	
Isotope	Release (Curies)
I-131	7.04(-1)*
I-132	4.55(-1)
I-133	8.04(-1)
I-134	9.30(-2)
I-135	3.96(-1)
Kr-83m	5.70(-2)
Kr-85m	3.11(-1)
Kr-85	6.37(-1)
Kr-87	1.69(-1)
Kr-88	5.42(-1)
Xe-131m	4.04(-1)
Xe-133m	5.52(-1)
Xe-133	4.95(+1)
Xe-135m	1.45(-1)
Xe-135	8.87(-1)
Xe-138	1.04(-1)

* 7.04(-1) \equiv 7.04 x 10⁻¹

After installation the entire system undergoes hot functional testing, prior to fuel loading. During operation, chemical treatment is used to control deposits and corrosion in the steam generators and steam lines, and reduce the possibility of stress-corrosion cracking and corrosion fatigue.

Using the assumptions stated, the following offsite doses have been calculated:

	<u>Whole Body</u>	<u>Thyroid (by Inhalation)</u>	
		<u>Child</u>	<u>Adult</u>
Site Boundary (rem)	3.4×10^{-5}	1.8×10^{-2}	1.0×10^{-2}
Population Dose (man-rem)	1.3×10^{-2}	--	--

7.1.4.8.6 Small Steamline Break

This accident has not been analyzed separately. The only assumption for this accident that is different from those for the large steamline break is that a halogen reduction factor of 0.1, instead of 0.5, is used for that portion of the accident when the steam generator tubes are covered by feedwater. Since, in the design of a once-through steam generator, the tubes are only partially covered during normal operation, the use of a reduction factor of 0.1 is inappropriate. The environmental consequences of the small steamline break are considered to be essentially the same as those for the large steamline break.

7.1.5 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

Section 7.1.4 of this report discusses the evaluation of the various classes of accidents utilizing the assumptions set forth in AEC Regulatory Guide 4.2. Table 7.1-16 summarizes for the various accidents the whole body population dose within 50 mi of the site and the individual whole body and thyroid doses at the site boundary.

TABLE 7.1-16

SUMMARY OF DOSES RESULTING FROM ACCIDENTS

Accident Class	Description	Whole Body Dose		Thyroid Inhalation Dose at Site Boundary (Rem)	
		Site Boundary (Rem)	To Population Within 50 Miles (man-Rem)	Child	Adult
1.0*	TRIVIAL INCIDENTS	---	---	---	---
2.0*	SMALL RELEASE OUTSIDE CONTAINMENT	---	---	---	---
3.0	RADWASTE SYSTEM FAILURE				
3.1	Equipment Leakage or Malfunction				
	Gases	1.5×10^{-4}	2.2×10^{-2}	2.5×10^{-5}	1.4×10^{-5}
	Liquids	---	---	2.1×10^{-6}	1.2×10^{-6}
3.2	Release of Waste Gas Storage Tank Contents	6.0×10^{-4}	8.8×10^{-2}	1.0×10^{-4}	5.6×10^{-5}
3.3	Release of Liquid Waste Storage Tank Contents	---	---	8.4×10^{-6}	4.6×10^{-6}
4.0	FISSION PRODUCTS TO PRIMARY SYSTEM (BWR)				
5.0	FISSION PRODUCTS TO PRIMARY AND SECONDARY SYSTEMS (PWR)				
5.1*	Fuel Cladding Defects and Steam Generator Leak	---	---	---	---
5.2	Off-design Transients that Induce Fuel Failure Above Those Expected and Steam Generator Leak	2.8×10^{-5}	1.0×10^{-2}	3.0×10^{-5}	1.6×10^{-5}
5.3	Steam Generator Tube Rupture	3.1×10^{-4}	1.1×10^{-1}	2.7×10^{-4}	1.5×10^{-4}
6.0	REFUELING ACCIDENTS				
6.1	Fuel Bundle Drop	4.6×10^{-4}	1.7×10^{-1}	1.6×10^{-4}	1.1×10^{-4}
6.2	Heavy Object Drop Onto Fuel in Core	9.1×10^{-3}	3.4	2.8×10^{-3}	2.0×10^{-3}
7.0	SPENT FUEL HANDLING ACCIDENT				
7.1	Fuel Assembly Drop in Fuel Storage Pool	3.2×10^{-4}	3.2×10^{-1}	1.3×10^{-4}	9.1×10^{-5}
7.2	Heavy Object Drop Onto Fuel Rack	2.5×10^{-4}	6.5×10^{-2}	2.5×10^{-4}	1.7×10^{-4}
7.3	Fuel Cask Drop	1.2×10^{-5}	4.8×10^{-2}	1.2×10^{-3}	8.5×10^{-4}
8.0	ACCIDENT INITIATION EVENTS CONSIDERED IN DESIGN BASIS EVALUATION IN THE SAFETY ANALYSIS REPORT				
8.1	Loss of Coolant Accidents				
	Small Pipe Break	6.0×10^{-6}	4.3×10^{-3}	4.4×10^{-4}	2.9×10^{-4}
	Large Pipe Break	1.8×10^{-2}	8.7	1.8	1.1
	Break in Instrumentation Line from Primary System that Penetrates Containment				
8.2	Control Rod Accidents				
	Rod Ejection Accident (PWR)	1.8×10^{-3}	8.8×10^{-1}	1.8×10^{-1}	1.1×10^{-1}
	Rod Drop Accident (BWR)				
8.3	Steam Line Break Accidents				
	PWR				
	Small Break	3.4×10^{-5}	1.3×10^{-2}	1.8×10^{-2}	1.0×10^{-2}
	Large Break	3.4×10^{-5}	1.3×10^{-2}	1.8×10^{-2}	1.0×10^{-2}
	BWR				

* Incidents included and evaluated under routine releases contained in Section 5.

It can be seen, from the standpoint of site boundary delivered dose, that the most severe accident is a loss of coolant accident involving a large primary system pipe break (Class 8.1). This accident also delivers the highest whole body population dose to persons living within 50 mi of the station site. Thus, the maximum doses resulting from the various accidents at the Davis-Besse site are as follows:

Individual Whole Body Dose	1.8×10^{-2} rem
Whole Body Population Dose	8.7 man-rem
Child Thyroid Inhalation Dose	1.8 rem
Adult Thyroid Inhalation Dose	1.1 rem

Title 10 CFR Part 100 sets forth reference limits of exposure resulting from highly improbable accidental releases of radioactive materials from a reactor facility. This regulation specifies a maximum individual whole body dose of 25 rem, at the exclusion boundary, during the 2 hr immediately following a postulated release. As a frame of reference, it can be seen that the maximum whole body accident dose to an individual is about 0.07% of the 10 CFR 100 limit. The same regulation also specifies a maximum individual exposure limit for the thyroid of 300 rem at the exclusion boundary, in the same 2-hr period. It can be seen that the maximum thyroid inhalation exposure calculated herein is approximately 0.6% of the 10 CFR 100 limit.

REFERENCES

1. M. E. Meed and R. S. Gilbert, Summary of Gamma and Beta Energy and Intensity, NEDO-2037, 1970.
2. J. J. DiNunno et al., Calculation of Distance Factors for Power and Test Reactor Sites, TID-14844, 1962.
3. "International Commission of Radiological Protection", Report of Subcommittee II on Internal Dose.
4. Toledo Edison Company, Davis-Besse Nuclear Power Station Unit No. 1 Final Safety Analysis Report, 1973.

12.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

12.1 LICENSES, PERMITS, AND OTHER APPROVALS

In order to operate and construct the Davis-Besse Nuclear Power Station Unit No. 1 several licenses permits and other approvals are required by Federal, State, and other regional authorities for the protection of the environment. The status of these licenses, permits and other approvals is shown in Table 12.1-1.

TABLE 12.1-1

LICENSES, PERMITS, AND OTHER APPROVALS

<u>LICENSES OR PERMIT</u>	<u>REGULATORY AGENCY</u>	<u>STATUS</u>
<u>Federal</u>		
Construction Permit	U. S. Atomic Energy Commission	Received March 24, 1971
Operating License	U. S. Atomic Energy Commission	Filed December 8, 1972
Dredging of Temporary Barge Canal	U. S. Army Corps of Engineers	Received August 4, 1972
Construction of Offshore Facilities	U. S. Army Corps of Engineers	Received March 27, 1973
Construction of Temporary Offshore Construction Facilities	U. S. Army Corps of Engineers	Received April 23, 1973
Discharge Permit	U. S. Army Corps of Engineers since transferred to USEPA and subsequently Ohio-EPA	Filed August 3, 1972
Aviation Lighting (without cooling tower)	Federal Aviation Administration	Received May 21, 1970
Aviation Lighting for cooling tower	Federal Aviation Administration	Received August 11, 1971
<u>State</u>		
Approval of Water Pollution Control Facilities	Ohio Department of Health	Conditionally Approved June 21, 1971 and Accepted by TECo July 1, 1971. General Approval by OWPCB June 9, 1970
State Water Quality Certification (401)	Ohio Department of Health	Received March 21, 1972
Potable Water Supply (Construction)	Ohio Department of Health	Received November 9, 1971
Sewage Treatment Plant (w/o Surge Tank) (w/ Surge Tank)	Ohio Department of Health Ohio - EPA	Received June 21, 1971 Received May 28, 1974

TABLE 12.1-1

<u>LICENSES OR PERMIT</u>	<u>REGULATORY AGENCY</u>	<u>STATUS</u>
Installation building sanitary drain system	Ohio Department of Health	Received July 27, 1971
Water Treatment Plant (Permanent)	Ohio - EPA	Received October 11, 1974
Building Permit	Ohio Department of Industrial Relations	Received October 20, 1970
Crossing of State Highways		
Transmission Lines	Ohio Department of Highways	Received March 3, 1971
Railroad Spur	Ohio Department of Highways	Received August 3, 1971
Crossing of Ohio Turnpike with Transmission Lines	Ohio Turnpike Commission	Received May 26, 1971
<u>Local</u>		
Building Permit	Ottawa County	Received October 14, 1970
Grade Crossings of Roads and Highways for railroad spur	Ottawa County Engineer	Received August 30, 1971
Building Permit and Certificate of Occupancy for transmission lines	City of Oregon	Received January 19, 1973

12.2 MEETINGS WITH CITIZEN GROUPS

The Toledo Edison Company has actively been carrying on a program of public information concerning the Davis-Besse Nuclear Power Station. During 1972 the Applicant conducted over 73 informal talks and discussions which were held throughout northwestern Ohio. This number exceeded 90 during 1973 and by November 30th 117 presentations had been given in 1974. A list of the locations where these presentations were given is presented below.

1972

Davis-Besse Conference Room
 Toledo
 Ayersville
 Fremont
 Genoa
 Oregon
 Wauseon
 Defiance
 Perrysburg
 Woodville
 Catawba Island
 Clyde
 Port Clinton
 Holgate
 Lyons
 Maumee
 Montpelier
 Oak Harbor
 Findlay
 Rocky Ridge
 Tiffin
 Liberty Center
 Delta
 Waterville
 Hicksville
 Sandusky
 Gibsonburg
 Vickery
 Huron

1973

Davis-Besse Conference Room
 Perrysburg
 Toledo
 Luckey
 Archbold
 Delta
 Elliston
 Clyde
 Fremont
 Oregon
 Lakeside
 Maumee
 Oak Harbor
 Rocky Ridge
 Wauseon
 Stryker
 Swanton
 Fostoria
 Port Clinton
 Elmore

1974

Davis-Besse Conference Room
 Toledo
 Fremont
 Bryan
 Delta
 Wauseon
 Woodville
 Sylvania
 Gibsonburg
 Lindsey
 Green Springs
 Liberty Center

The above presentation has been given to various citizen groups, church, social, business, school groups, and service, conservation, and sports clubs.