INFO-0210/REV. 8

REPORT

RADIOACTIVE EMISSION DATA FROM CANADIAN NUCLEAR GENERATING STATIONS 1988 TO 1997

Compiled by
Radiation and Environmental Protection Division
Directorate of Environmental and Human Performance Assessment
Atomic Energy Control Board
Ottawa, Canada

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November 1998

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Canada

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Introduction

All nuclear generating stations (NGSs) release small quantities of radioactivity in a controlled manner into both the atmosphere (as gaseous effluents) and adjoining water bodies (as liquid effluents). The purpose of this document is to report on the magnitude of these emissions for each operating NGS in Canada and to indicate how these emissions compare with the relevant limitations imposed by the Atomic Energy Control Board (AECB) as part of its regulatory and licensing program. The data show that the levels of emissions of gaseous and liquid effluents from all currently operating NGSs are well below the values mandated by the AECB. In fact, since 1987 no emissions have exceeded 1% of those values.

This is the eighth revision of INFO-0210. The first edition was published in September 1986, covering the period 1972 to 1985. Subsequent revised editions were published in September 1987 (Rev. 1), March 1989 (Rev. 2), January 1990 (Rev. 3), March 1993 (Rev. 4), September 1994 (Rev. 5), July 1996 (Rev. 6) and May 1997 (Rev. 7).

The present report incorporates histograms for each NGS displaying the annual gaseous emissions containing tritium, in the form of tritium oxide, noble gases, iodine-131, and radioactive particulates, as well as the annual liquid emissions containing tritium, in the form of tritium oxide, and gross beta-gamma activity. In addition, for Pickering "A" and Gentilly-2 NGSs annual emissions of carbon-14 are depicted, and for Darlington NGS, airborne emissions of elemental tritium (HT) since 1988 are shown. Darlington is required to monitor and report airborne emissions of elemental tritium as a result of the operation of the Tritium Removal Facility.

This revision presents the data for the ten-year interval 1988-97. Earlier data is available in INFO-0210/Rev. 6.

In each case, the emission data are compared to the Derived Emission Limits (see below for an explanation of this term) in order that the data may be placed in perspective.

Derived Emission Limits

Radioactive material released into the environment through gaseous and liquid effluents from NGSs can potentially result in radiation doses to members of the public as a result of direct irradiation, inhalation of contaminated air, or ingestion of contaminated food or water. Such doses are subject to statutory dose limits for members of the public, which are set out in Schedule II of the *Atomic Energy Control Regulations* and are reproduced in Table 1 below.

Table 1
Annual Dose Limits for Members of the Public

Organ or Tissue	Dose
Whole body, gonads, red bone marrow	5 mSv (0.5 rem)
Skin, bone, thyroid	30 mSv (3 rem) (50% of this value for children)
Extremities	75 mSv (7.5 rem)
Other single organs or tissues	15 mSv (1.5 rem)

The magnitude of the doses to which members of the public may be exposed as a result of routine emissions from NGSs are too low to measure directly in order to determine compliance with these regulations. To ensure that the public dose limit is not exceeded, the amount of radioactive materials released in effluents from nuclear facilities is limited directly. These effluent limits are derived from the public dose limit and are referred to as Derived Emission Limits (DELs). Further, operating targets for effluent releases are set based on the ALARA principle (i.e. that doses be kept As Low As Reasonably Achievable, taking social and economic factors into account), and are typically a small fraction of the DELs.

Table 2
Derived Emission Limits for Gaseous Effluents

	Tritium[a] (TBq[b] × 10^4)	**Iodine-131** (TBq)	**Noble Gases** (TBq-MeV[c] × 10^4)	**Particulates** (TBq)	**Carbon-14** (TBq × 10^3)
Point Lepreau	43.0	9.9	7.3	5.2	3.3
Bruce "A"	38.0	1.2	25.0	2.7	2.8
Bruce "B"	47.0	1.3	61.0	4.8	3.0
Darlington	21.0 730.0[d]	0.6	21.0	4.4	1.4
Pickering "A"	34.0	2.4	8.3	5.0	8.8
Pickering "B"	34.0	2.4	8.3	5.0	8.8
Gentilly-2	44.0	1.3	17.0	1.9	0.91

Notes
a. Tritium-oxide.
b. 1 TBq = 27 curies.
c. TBq-MeV (terabecquerel-million electron volts).
d. DEL for elemental tritium gas resulting from operation of the Tritium Removal Facility at Darlington NGS.

The DELs are set by consideration of the exposure pathways through the environment by which radioactive material could reach the most exposed members of the public after being released from the facility. This group of the public is referred to as the "critical group" and is defined to be representative of those individuals in the population expected to receive the highest dose as a result of their age, diet, lifestyle, location, etc.

Since 1987, DEL calculations have been based on a method recommended by the Canadian Standards Association (CSA) in document CAN/CSA-N288.1-M87. The CSA method was developed with the assistance of the AECB; however, the AECB may place additional requirements on the analysis, for example, if the availability of certain site-specific information can enable better estimates of environmental transfer processes. The CSA approach takes into account many more environmental pathways than did the previous methods of calculating DELs, and allows for the use of more site-specific data. More realistic assumptions were incorporated into the method, for example, the use of shielding factors and occupancy times. Environmental transfer parameters for individual radionuclides were also updated. These changes made it necessary for licensees to revise the DELs which had been calculated prior to 1987. In so doing, licensees also reviewed the assumptions affecting the exposure of critical groups and adjusted them where necessary to make them more representative, e.g. location and lifestyle habits of critical groups, location of dairy farms. In addition, licensees may have used more site-specific data obtained from their routine environmental monitoring programs, such as liquid dispersion factors, or surveys of the local population. The net effect of these various changes on the DELs has been that some DELs increased, while others decreased, depending on the relative importance of the various pathways or parameters to a particular radionuclide. These resulting changes to DELs are depicted in the figures of this report, as represented by the 1% DEL lines. As new information on dose calculation methods or parameters becomes available, the DELs may require subsequent revisions. The current DELs for all Canadian NGSs are listed in Tables 2 and 3.

NGSs maintain operating targets of approximately 1% of the specified DELs. Although DELs are expressed on an annual basis, the rates of emissions are further controlled by limiting gaseous emissions to weekly DELs (i.e. annual DEL/52) and by limiting liquid emissions to monthly DELs (i.e. annual DEL/12).

Emission Data

Licensees measure and report their emissions in different ways. Some report actual releases for a wide variety of fission and activation products, while most report the major contributors such as tritium, iodine-131, noble gases and particulates, and combine the rest under the title of gross beta-gamma activity. For the latter two activities, the most restrictive radionuclides of the groups are used as the basis for the DELs.

In this report, radioactive emission data are presented as either gaseous or liquid effluent emissions. The figures and tables in this document show the annual emissions relative to 1% of the DELs for each NGS.

All values with the exception of those associated with the noble gases are reported in units of terabecquerels (TBq, where 1TBq = 27 curies). Since noble gases are inert and are not absorbed by the human body, one can measure the external dose from the mean gamma ray energy per disintegration of all noble gases present. Therefore, the emissions are expressed as terabecquerel-million electron volts (TBq-MeV).

The use of ND in the following histograms and tables is to indicate that radioactive emissions were not detected in that particular year. In certain cases, the values are too low to actually show up in the illustration.

Terminology

Because this report contains certain words or expressions that may not be readily understandable by all readers, we have provided a brief glossary on page 33.

Scientific Notation

Because of the magnitude of the numbers used in nuclear energy, it is often more convenient to express them in scientific rather than decimal notation. Examples follow:

100 000	10^5
1 260 000	1.3×10^6 or
	13.0×10^5 (to 2 significant figures)
0.003473	3.5×10^{-3} (to 2 significant figures)

Table 3
Derived Emission Limits for Liquid Effluents

	Tritium[a] ($TBq^b \times 10^6$)	**Gross Beta-Gamma** (TBq)	**Carbon-14** ($TBq \times 10^2$)
Point Lepreau	16.0[c]	16.0	3.0
Bruce “A”	1.7	20.0	4.5
Bruce “B”	3.0	23.0	4.8
Darlington	5.3	130.0	32.0
Pickering “A”	0.83	9.7	1.4
Pickering “B”	0.83	9.7	1.4
Gentilly-2	1.2	5.3	1.0

Notes
a. Tritium-oxide.
b. 1 TBq = 27 curies.
c. The DEL for tritium in liquid effluent at Point Lepreau is higher than for the other NGSs because the effluent is discharged to sea water thus eliminating the drinking water pathway to humans.

The Point Lepreau NGS facility consists of one nuclear reactor which started up in 1982. It is located in New Brunswick on Point Lepreau, which extends into the Bay of Fundy.

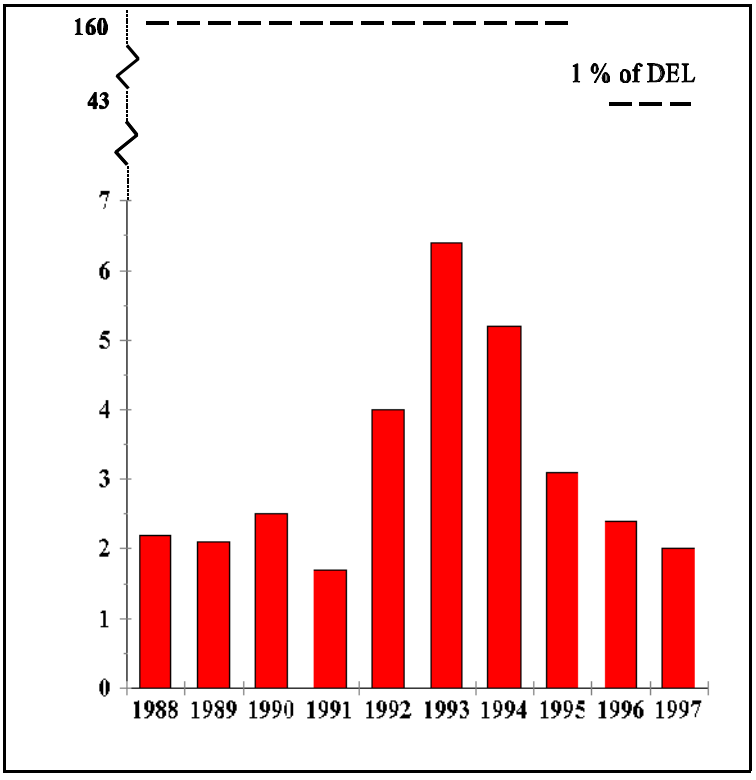
Radioactive emission data for Point Lepreau NGS are presented in the following histograms, covering the period of 1988 to 1997, for both gaseous and liquid effluents. The pertinent items in the gaseous effluents are tritium, in the form of tritium oxide (Figure 1.1), iodine-131 (Figure 1.2), noble gases (Figure 1.3) and radioactive particulates (Figure 1.4); while those in the liquid effluents are tritium, in the form of tritium oxide (Figure 1.5) and gross beta-gamma activity (Figure 1.6).

There were no measurable emissions of iodine-131 for 1987, 1990 and 1995, of noble gases for 1989 and 1990, or of radioactive particulates from 1986 to 1991, and for 1995 and 1996.

It should be noted that the DEL for tritium in the liquid effluent is higher than that for the other NGSs (see Table 3 on page 3). This occurs because the effluent goes directly to sea water thus eliminating the drinking water pathway to humans.

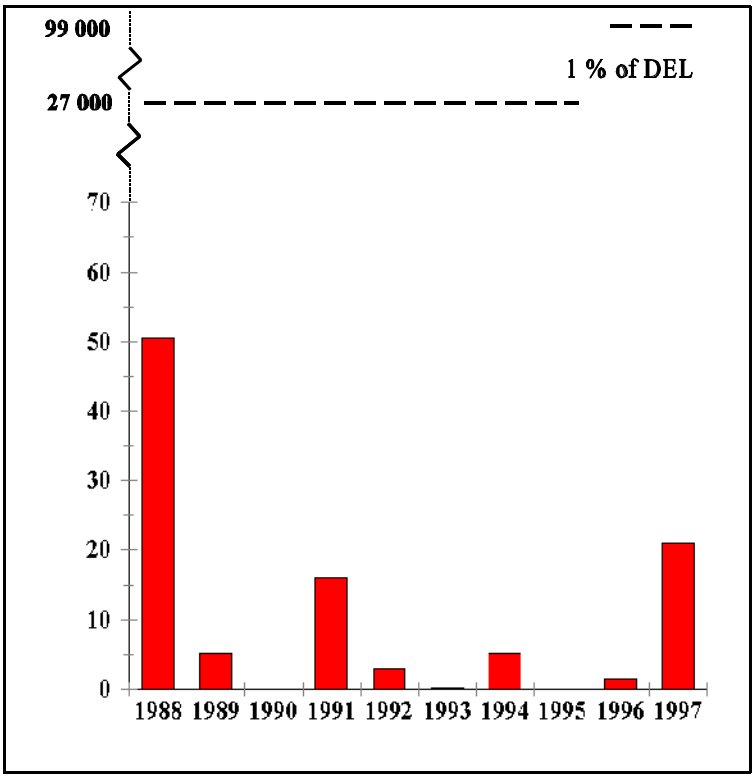
The DELs for Point Lepreau were revised in 1996.

FIGURE 1.1 Tritium Oxide Gaseous Effluent, Point Lepreau, 1988-97
(TBq × 10^2)



Year	TBq × 10^2
1988	2.2
1989	2.1
1990	2.5
1991	1.7
1992	4.0
1993	6.4
1994	5.2
1995	3.1
1996	2.4
1997	2.0

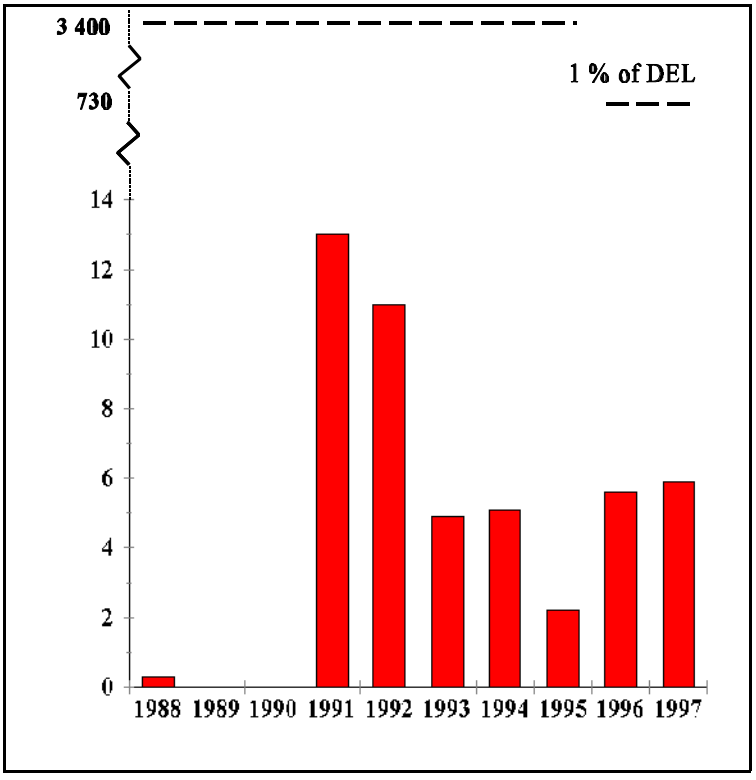
FIGURE 1.2 Iodine-131 Gaseous Effluent, Point Lepreau, 1988-97
(TBq × 10^{-6})



Year	TBq × 10^{-6}
1988	51.0
1989	5.2
1990	ND*
1991	16.0
1992	3.0
1993	0.19
1994	5.1
1995	ND
1996	1.5
1997	21.0

*ND: not detected.

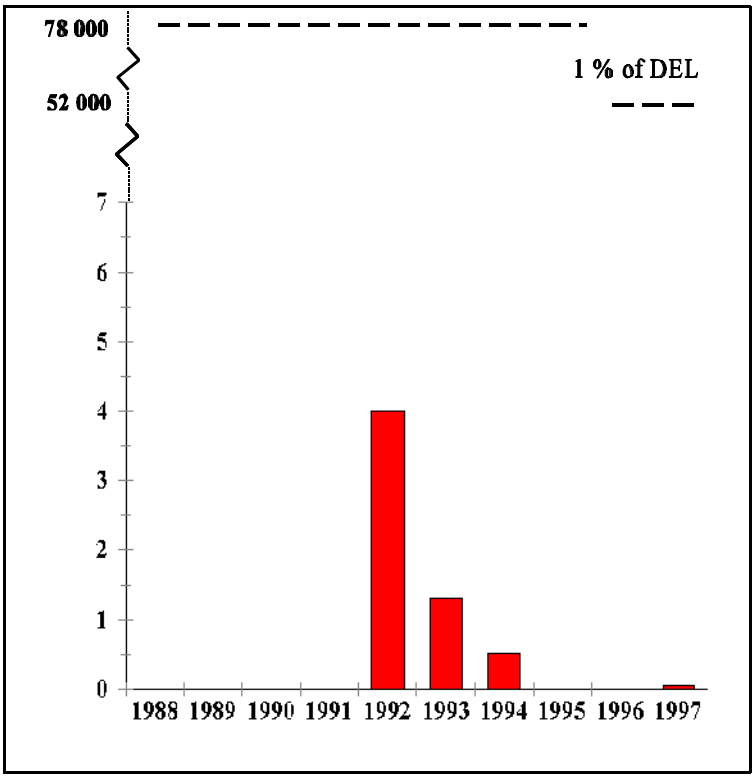
FIGURE 1.3 Noble Gas Effluent, Point Lepreau, 1988-97
(TBq-MeV)



Year	TBq-MeV
1988	0.3
1989	ND*
1990	ND
1991	13.0
1992	11.0
1993	4.9
1994	5.1
1995	2.2
1996	5.6
1997	5.9

*ND: not detected.

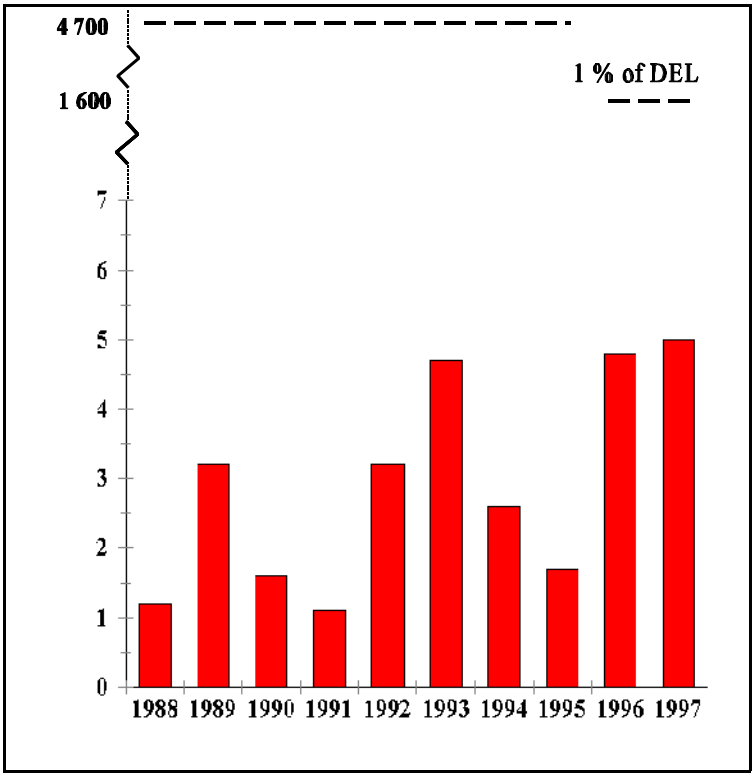
FIGURE 1.4 Radioactive Particulates in Gaseous Effluent, Point Lepreau, 1988-97
(TBq × 10^{-6})



Year	TBq × 10^{-6}
1988	ND*
1989	ND
1990	ND
1991	ND
1992	4.0
1993	1.3
1994	0.52
1995	ND
1996	ND
1997	0.05

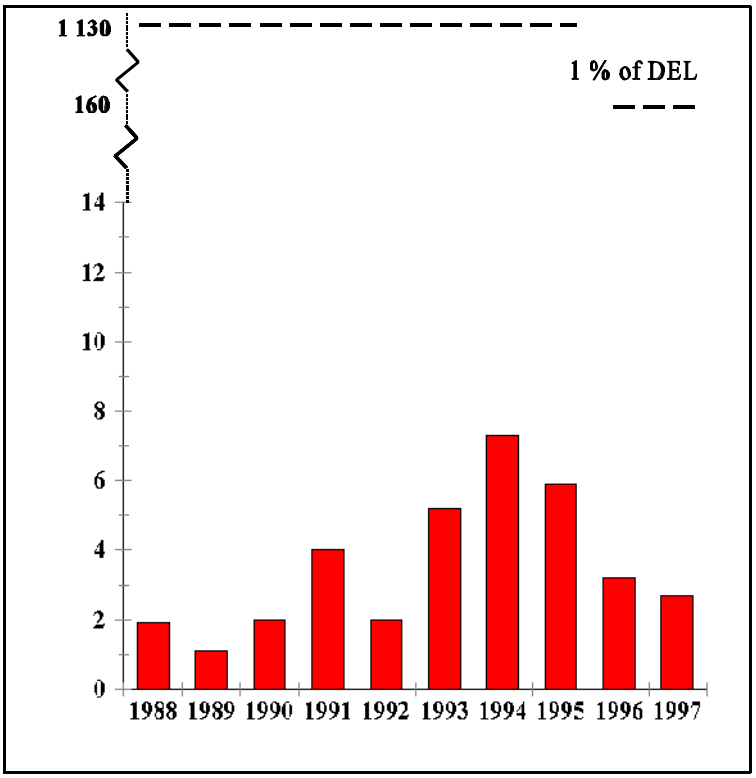
*ND: not detected.

FIGURE 1.5 Tritium Oxide Liquid Effluent, Point Lepreau, 1988-97
(TBq × 10^{2})



Year	TBq × 10^{2}
1988	1.2
1989	3.2
1990	1.6
1991	1.1
1992	3.2
1993	4.7
1994	2.6
1995	1.7
1996	4.8
1997	5.0

FIGURE 1.6 Gross Beta-Gamma Activity in Liquid Effluent, Point Lepreau, 1988-97
(TBq × 10^{-3})

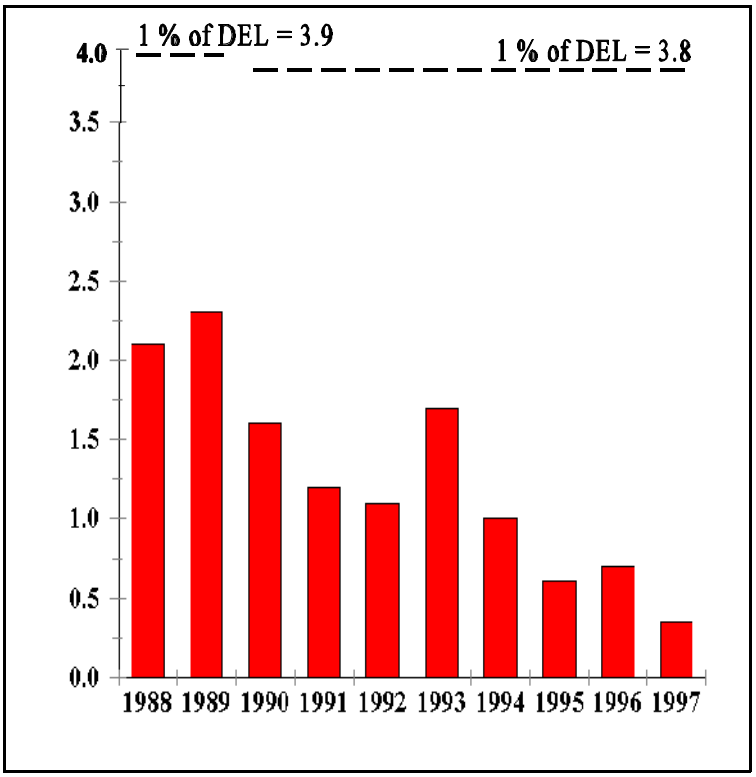


Year	TBq × 10^{-3}
1988	1.9
1989	1.1
1990	2.0
1991	4.0
1992	2.0
1993	5.2
1994	7.3
1995	5.9
1996	3.2
1997	2.7

The Bruce "A" NGS facility consists of four nuclear reactors which started up in 1976. It is located in Ontario on the shore of Lake Huron near the town of Kincardine.

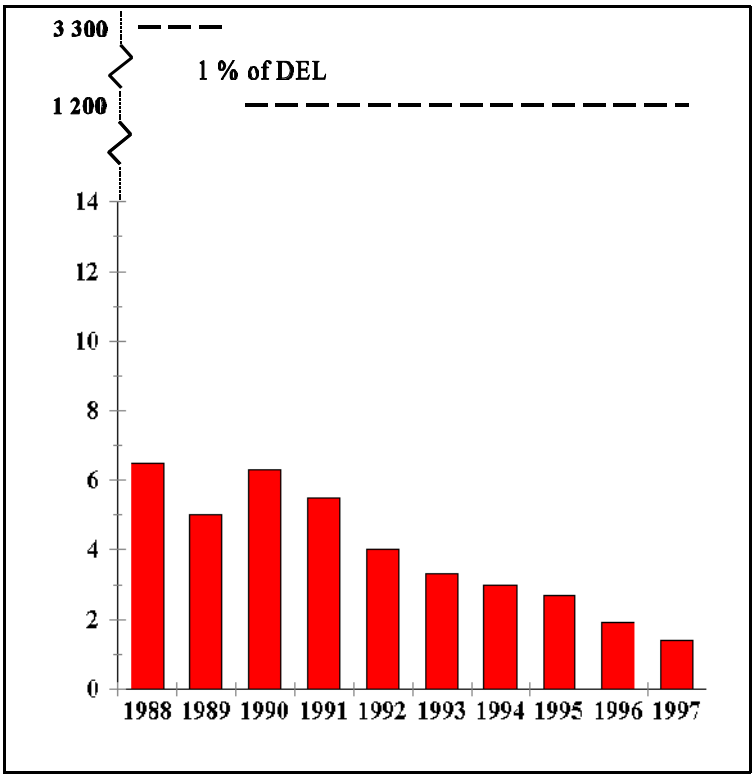
Radioactive emission data for Bruce "A" NGS are presented in the following histograms, covering the period of 1988 to 1997, for both gaseous and liquid effluents. The pertinent items in the gaseous effluents are tritium, in the form of tritium oxide (Figure 2.1), iodine-131 (Figure 2.2), noble gases (Figure 2.3) and radioactive particulates (Figure 2.4); while those in the liquid effluents are tritium, in the form of tritium oxide (Figure 2.5) and gross beta-gamma activity (Figure 2.6).

FIGURE 2.1 Tritium Oxide Gaseous Effluent, Bruce A , 1988-97
(TBq × 10^3)



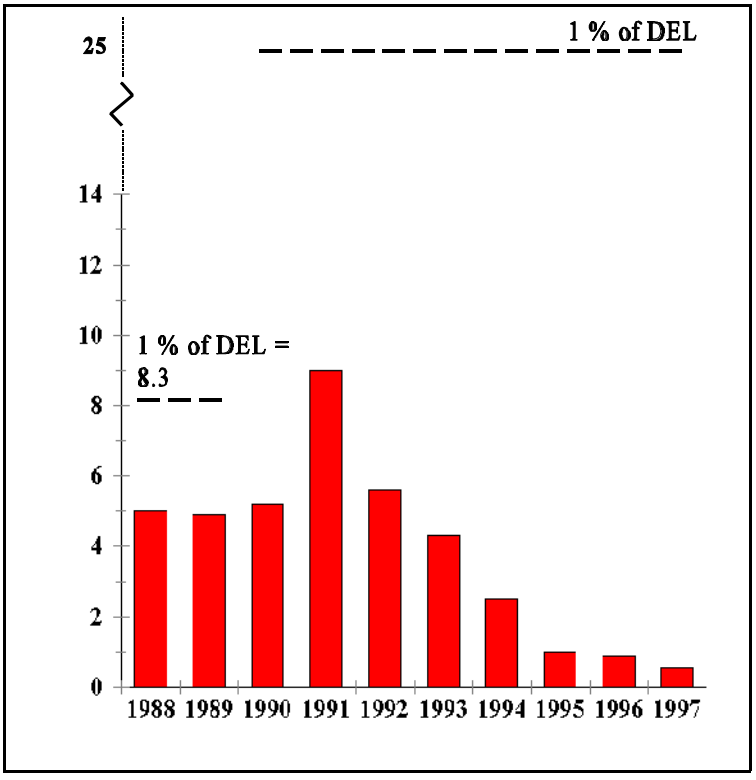
Year	TBq × 10^3
1988	2.1
1989	2.3
1990	1.6
1991	1.2
1992	1.1
1993	1.7
1994	1.0
1995	0.61
1996	0.7
1997	0.35

FIGURE 2.2 Iodine-131 Gaseous Effluent, Bruce A , 1988-97
(TBq × 10^{-5})



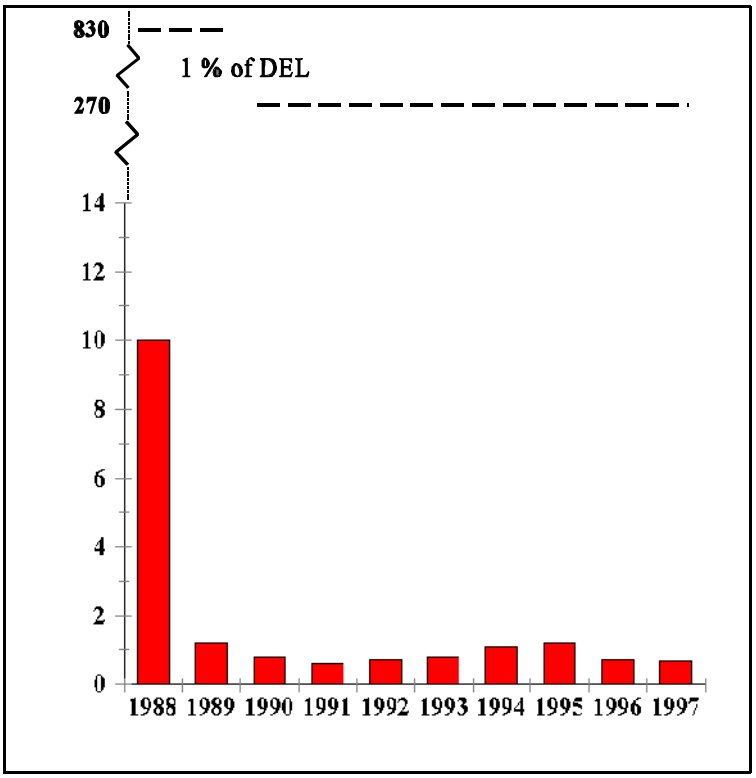
Year	TBq × 10^{-5}
1988	6.5
1989	5.0
1990	6.3
1991	5.5
1992	4.0
1993	3.3
1994	3.0
1995	2.7
1996	1.9
1997	1.4

FIGURE 2.3 Noble Gas Effluent, Bruce A , 1988-97
(TBq-MeV × 10^{2})



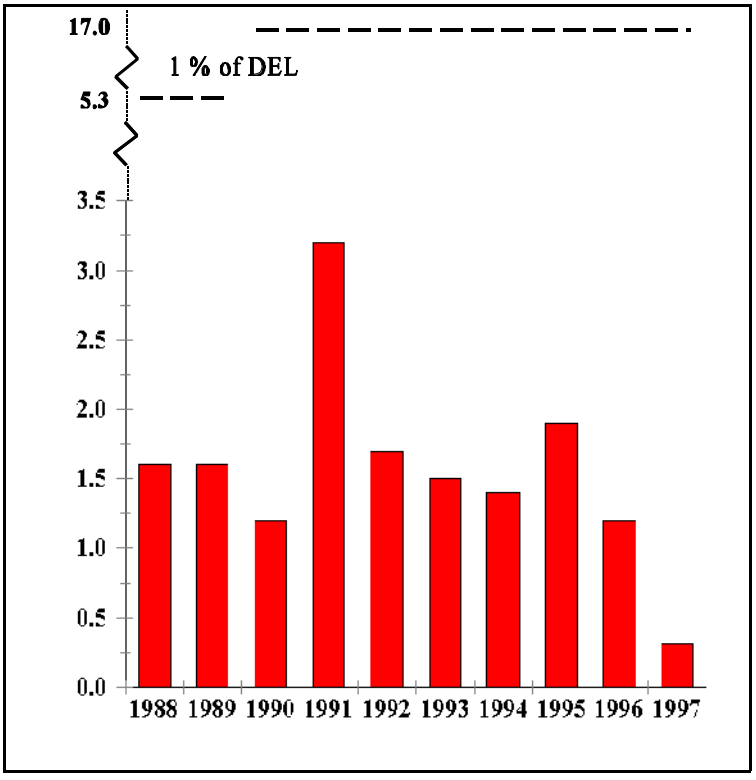
Year	TBq-MeV × 10^{2}
1988	5.0
1989	4.9
1990	5.2
1991	9.0
1992	5.6
1993	4.3
1994	2.5
1995	1.0
1996	0.88
1997	0.54

FIGURE 2.4 Radioactive Particulates in Gaseous Effluent, Bruce A , 1988-97
(TBq × 10^{-4})



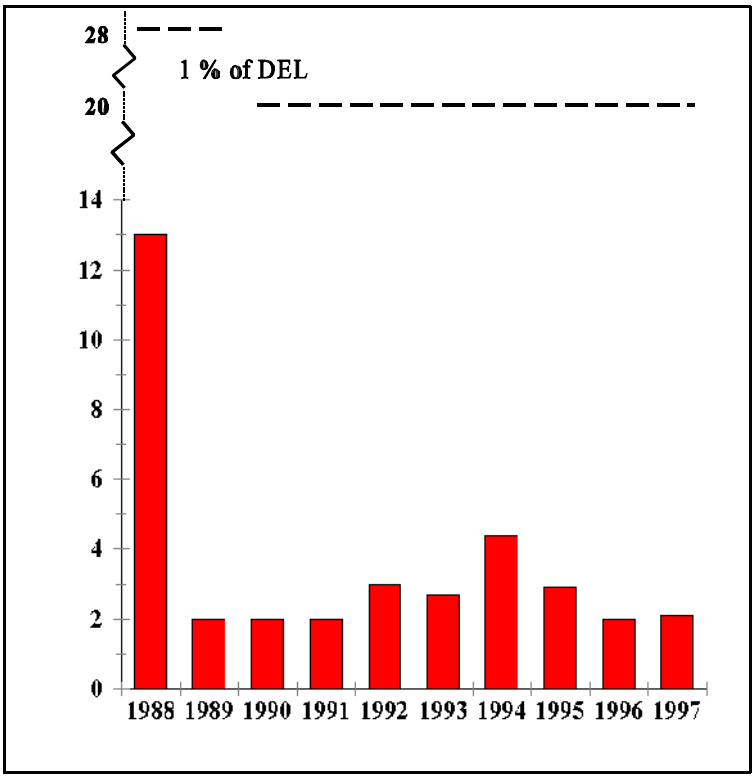
Year	TBq × 10^{-4}
1988	10.0
1989	1.2
1990	0.81
1991	0.63
1992	0.72
1993	0.79
1994	1.1
1995	1.2
1996	0.72
1997	0.7

FIGURE 2.5 Tritium Oxide Liquid Effluent, Bruce A , 1988-97
(TBq × 10^{3})



Year	TBq × 10^{3}
1988	1.6
1989	1.6
1990	1.2
1991	3.2
1992	1.7
1993	1.5
1994	1.4
1995	1.9
1996	1.2
1997	0.31

FIGURE 2.6 Gross Beta-Gamma Activity in Liquid Effluent, Bruce A , 1988-97
(TBq × 10^{-2})

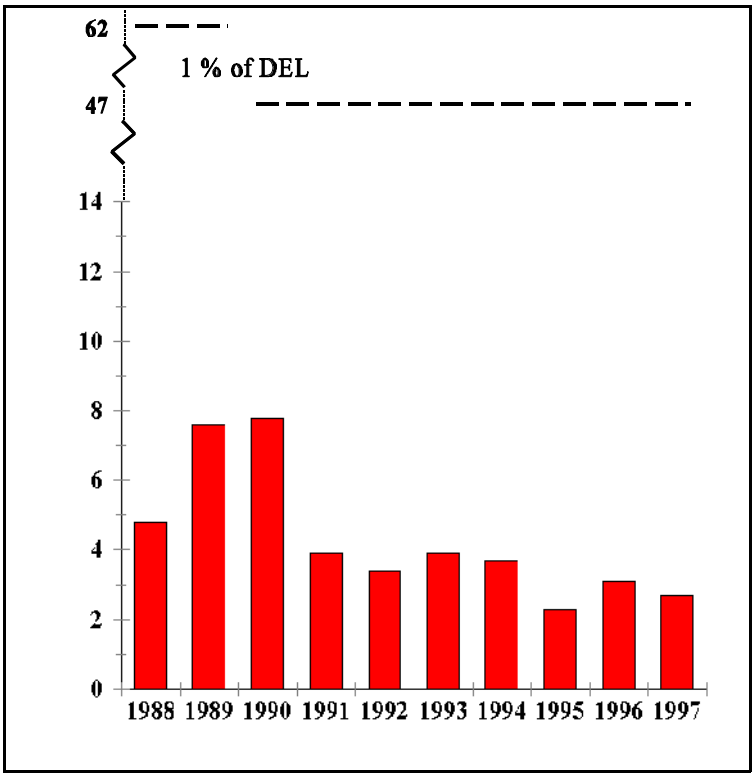


Year	TBq × 10^{-2}
1988	13.0
1989	2.0
1990	2.0
1991	2.0
1992	3.0
1993	2.7
1994	4.4
1995	2.9
1996	2.0
1997	2.1

The Bruce "B" NGS facility consists of four nuclear reactors which started up in 1984. It is located in Ontario on the shore of Lake Huron near the town of Kincardine.

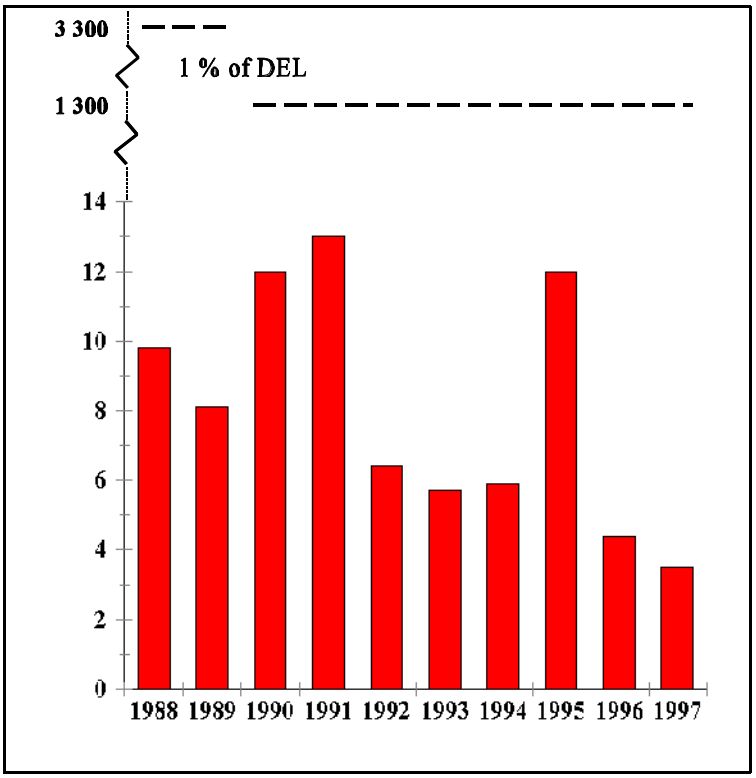
Radioactive emission data for Bruce "B" NGS are presented in the following histograms, covering the period of 1988 to 1997, for both gaseous and liquid effluents. The pertinent items in the gaseous effluents are tritium, in the form of tritium oxide (Figure 3.1), iodine-131 (Figure 3.2), noble gases (Figure 3.3) and radioactive particulates (Figure 3.4); while those in the liquid effluents are tritium, in the form of tritium oxide (Figure 3.5) and gross beta-gamma activity (Figure 3.6).

FIGURE 3.1 Tritium Oxide Gaseous Effluent, Bruce B , 1988-97
(TBq × 10^2)



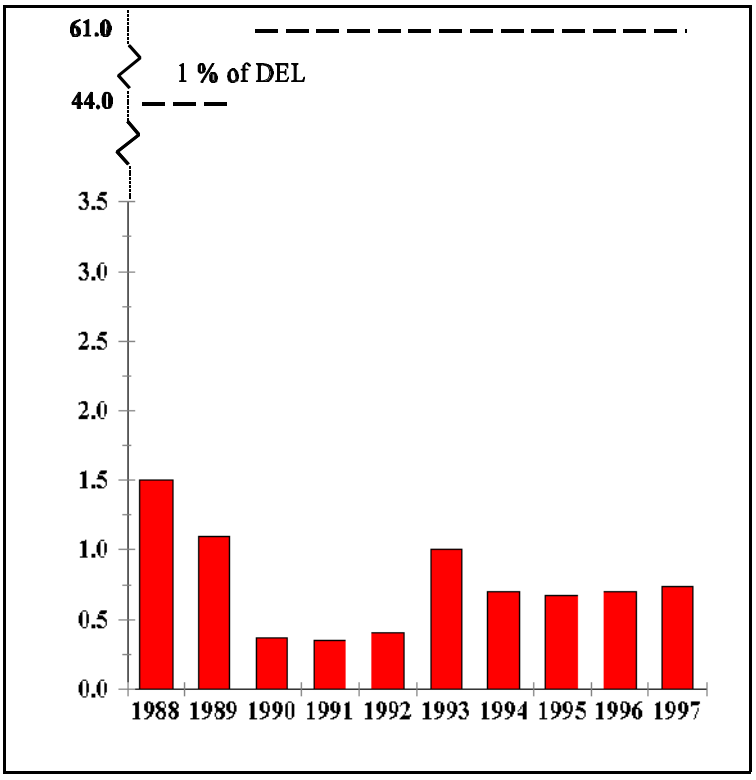
Year	TBq × 10^2
1988	4.8
1989	7.6
1990	7.8
1991	3.9
1992	3.4
1993	3.9
1994	3.7
1995	2.3
1996	3.1
1997	2.7

FIGURE 3.2 Iodine-131 Gaseous Effluent, Bruce B , 1988-97
(TBq × 10^{-5})



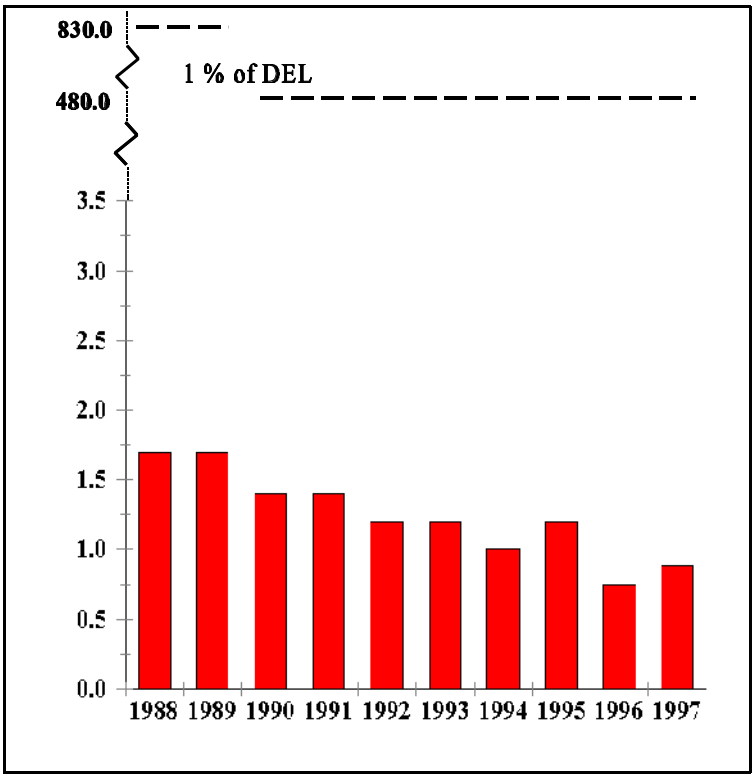
Year	TBq × 10^{-5}
1988	9.8
1989	8.1
1990	12.0
1991	13.0
1992	6.4
1993	5.7
1994	5.9
1995	12.0
1996	4.4
1997	3.5

FIGURE 3.3 Noble Gas Effluent, Bruce B , 1988-97
(TBq-MeV × 10^{2})



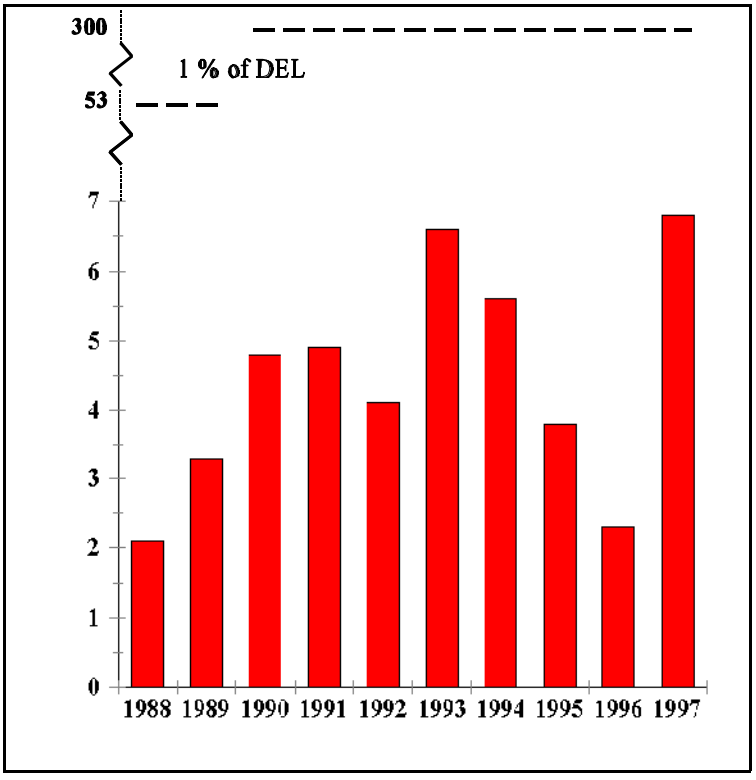
Year	TBq-MeV × 10^{2}
1988	1.5
1989	1.1
1990	0.37
1991	0.35
1992	0.41
1993	1.0
1994	0.7
1995	0.67
1996	0.7
1997	0.74

FIGURE 3.4 Radioactive Particulates in Gaseous Effluent, Bruce B , 1988-97
(TBq × 10^{-4})



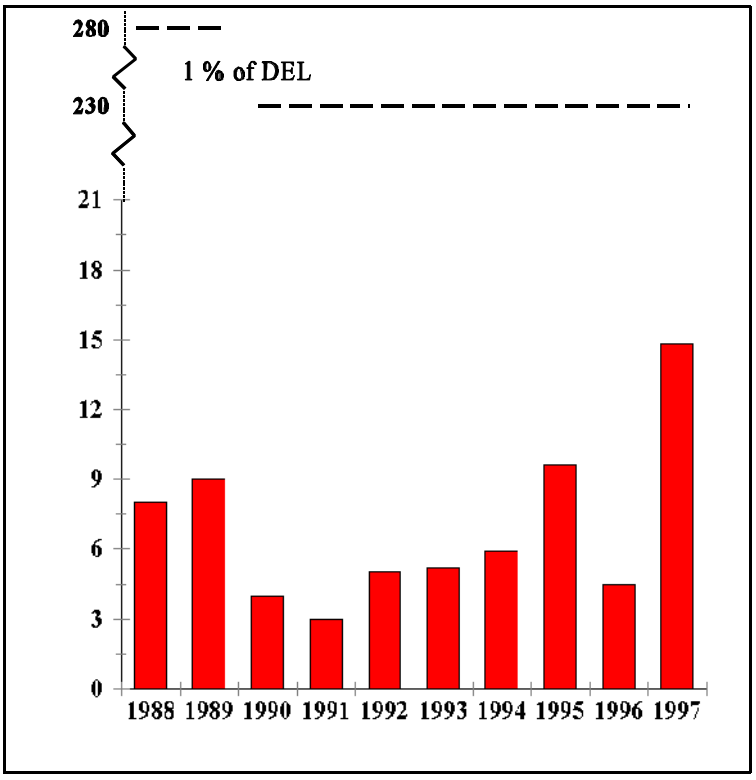
Year	TBq × 10^{-4}
1988	1.7
1989	1.7
1990	1.4
1991	1.4
1992	1.2
1993	1.2
1994	1.0
1995	1.2
1996	0.75
1997	0.88

FIGURE 3.5 Tritium Oxide Liquid Effluent, Bruce B , 1988-97
(TBq × 10^{2})



Year	TBq × 10^{2}
1988	2.1
1989	3.3
1990	4.8
1991	4.9
1992	4.1
1993	6.6
1994	5.6
1995	3.8
1996	2.3
1997	6.8

FIGURE 3.6 Gross Beta-Gamma Activity in Liquid Effluent, Bruce B , 1988-97
(TBq × 10^{-3})



Year	TBq × 10^{-3}
1988	8.0
1989	9.0
1990	4.0
1991	3.0
1992	5.0
1993	5.2
1994	5.9
1995	9.6
1996	4.5
1997	14.8

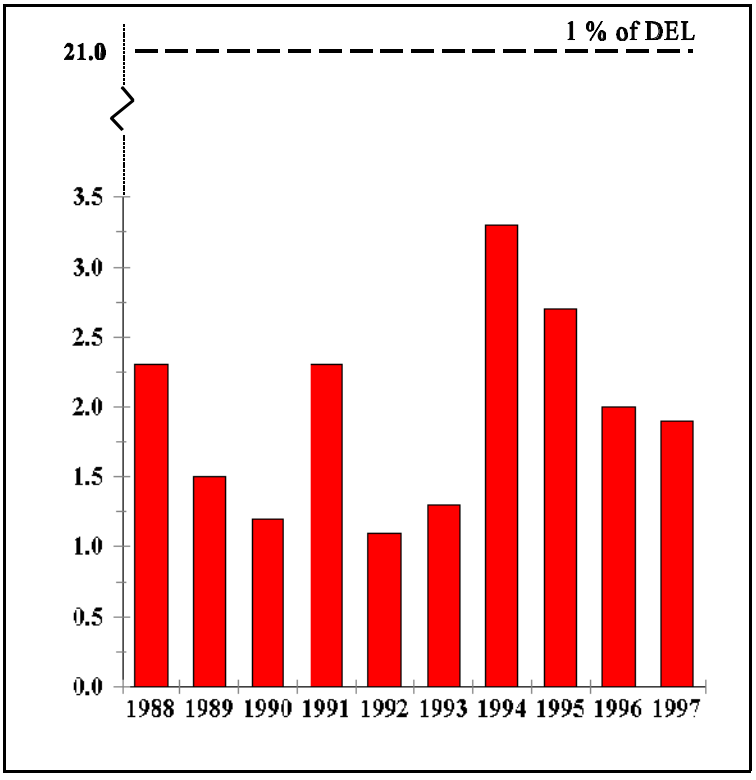
The Darlington NGS facility consists of four nuclear reactors, the first of which started up in 1989, and a Tritium Removal Facility (TRF) which started up in 1988. Both facilities are located in Ontario on the shore of Lake Ontario near the town of Bowmanville.

Radioactive emission data for Darlington NGS are presented in the following histograms, covering the period of 1988 to 1997, for both gaseous and liquid effluents. The pertinent items in the gaseous effluents are tritium, in the form of tritium oxide (Figure 4.1), iodine-131 (Figure 4.2), noble gases (Figure 4.3) and radioactive particulates (Figure 4.4); while those in the liquid effluents are tritium, in the form of tritium oxide (Figure 4.5) and gross beta-gamma activity (Figure 4.6).

In addition, the operation of the TRF has necessitated the requirement to determine a DEL for elemental tritium, as well as to report its annual emissions (Figure 4.7).

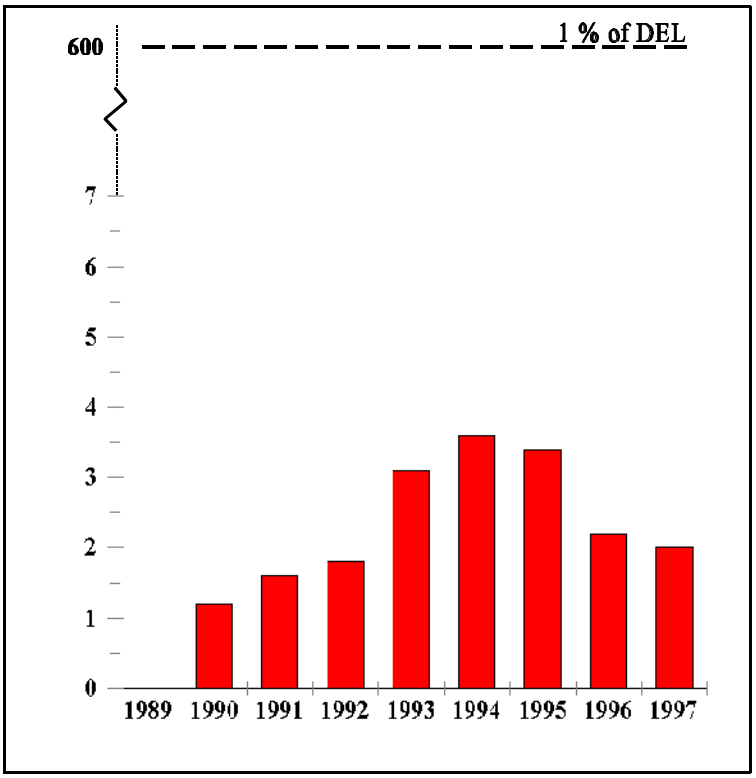
Gaseous effluent emissions of tritium in both elemental and oxide forms occurred during 1988 due to the operation of the TRF. There were no measurable emissions of iodine-131, noble gases or radioactive particulates for 1989. Likewise, there were no measurable emissions of gross beta-gamma activity for 1989.

FIGURE 4.1 Tritium Oxide Gaseous Effluent, Darlington, 1988-97
(TBq × 10^2)



Year	TBq × 10^2
1988	2.3
1989	1.5
1990	1.2
1991	2.3
1992	1.1
1993	1.3
1994	3.3
1995	2.7
1996	2.0
1997	1.9

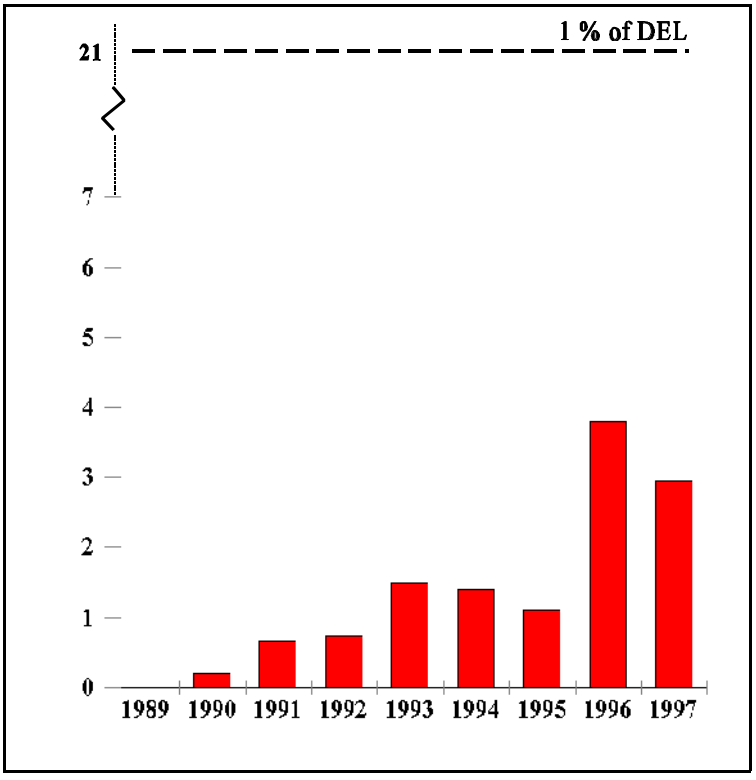
FIGURE 4.2 Iodine-131 Gaseous Effluent, Darlington, 1989-97
(TBq × 10^{-5})



Year	TBq × 10^{-5}
1989	ND*
1990	1.2
1991	1.6
1992	1.8
1993	3.1
1994	3.6
1995	3.4
1996	2.2
1997	2.0

*ND: not detected.

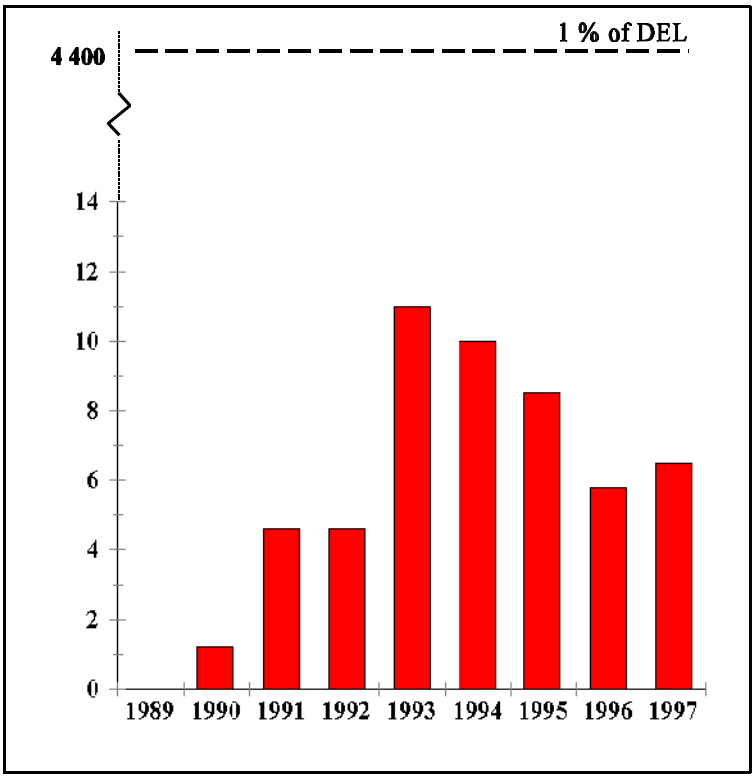
FIGURE 4.3 Noble Gas Effluent, Darlington, 1989-97
(TBq-MeV × 10^{2})



Year	TBq-MeV × 10^{2}
1989	ND*
1990	0.21
1991	0.67
1992	0.73
1993	1.5
1994	1.4
1995	1.1
1996	3.8
1997	2.95

*ND: not detected.

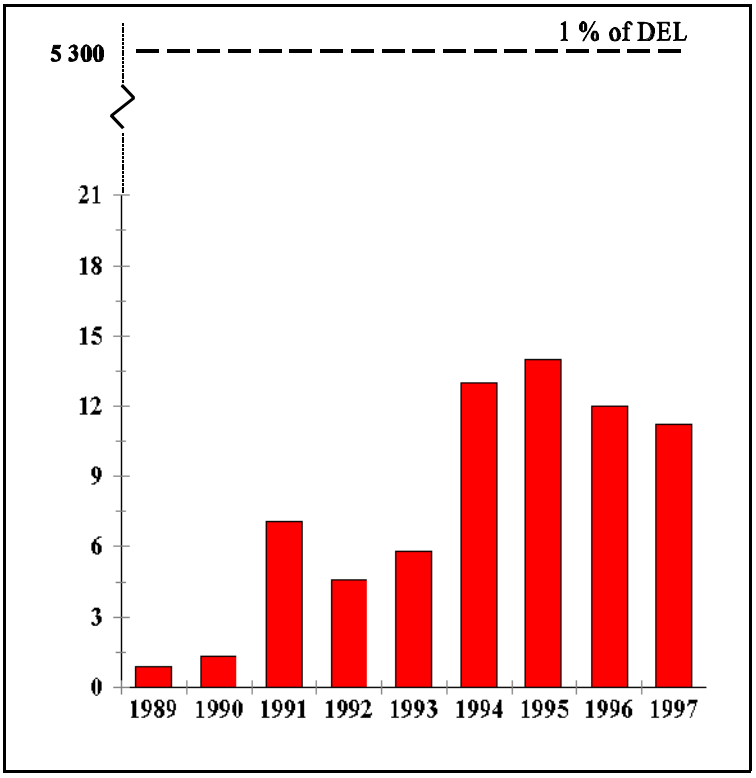
FIGURE 4.4 Radioactive Particulates in Gaseous Effluent, Darlington, 1989-97
(TBq × 10^{-5})



Year	TBq × 10^{-5}
1989	ND*
1990	1.2
1991	4.6
1992	4.6
1993	11.0
1994	10.0
1995	8.5
1996	5.8
1997	6.5

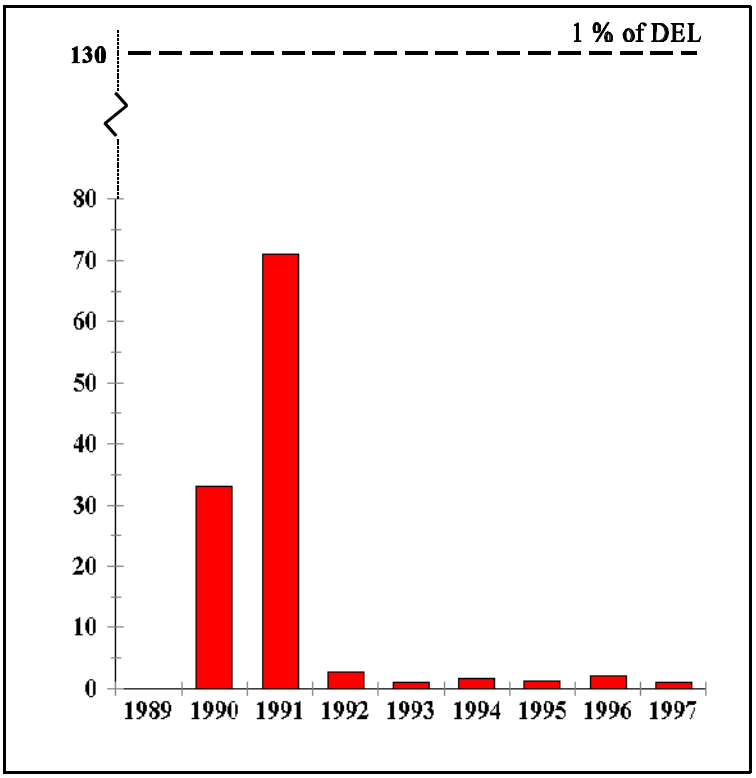
*ND: not detected.

FIGURE 4.5 Tritium Oxide Liquid Effluent, Darlington, 1989-97
(TBq × 10^{1})



Year	TBq × 10^{1}
1989	0.89
1990	1.3
1991	7.1
1992	4.6
1993	5.8
1994	13.0
1995	14.0
1996	12.0
1997	11.2

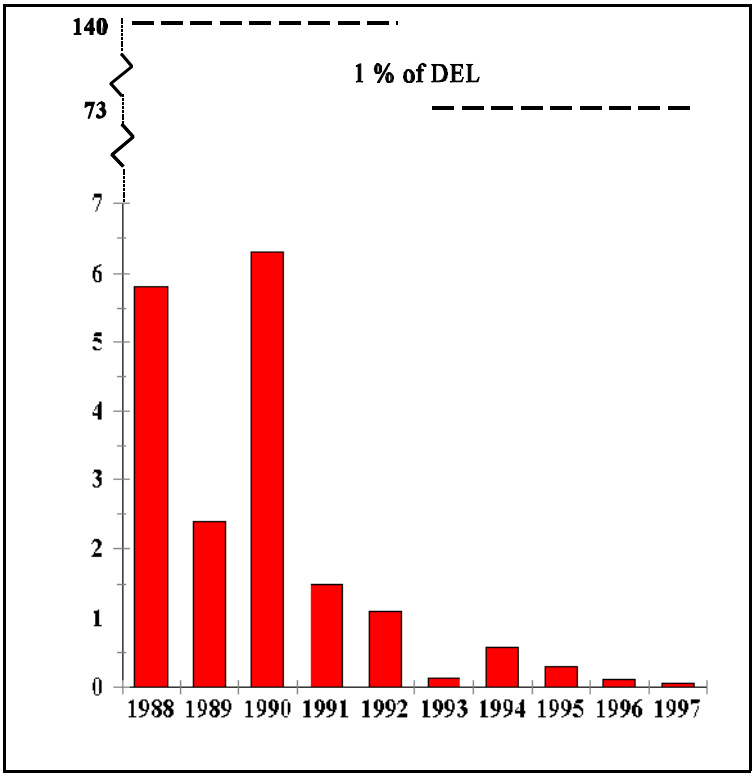
FIGURE 4.6 Gross Beta-Gamma Activity in Liquid Effluent, Darlington, 1989-97
(TBq × 10^{-2})



Year	TBq × 10^{-2}
1989	ND*
1990	33.0
1991	71.0
1992	2.7
1993	1.1
1994	1.6
1995	1.2
1996	2.0
1997	0.98

*ND: not detected.

FIGURE 4.7 Elemental Tritium Gaseous Effluent, Darlington, 1988-97
(TBq × 10^{3})



Year	TBq × 10^{3}
1988	5.8
1989	2.4
1990	6.3
1991	1.5
1992	1.1
1993	0.13
1994	0.56
1995	0.29
1996	0.1
1997	0.05

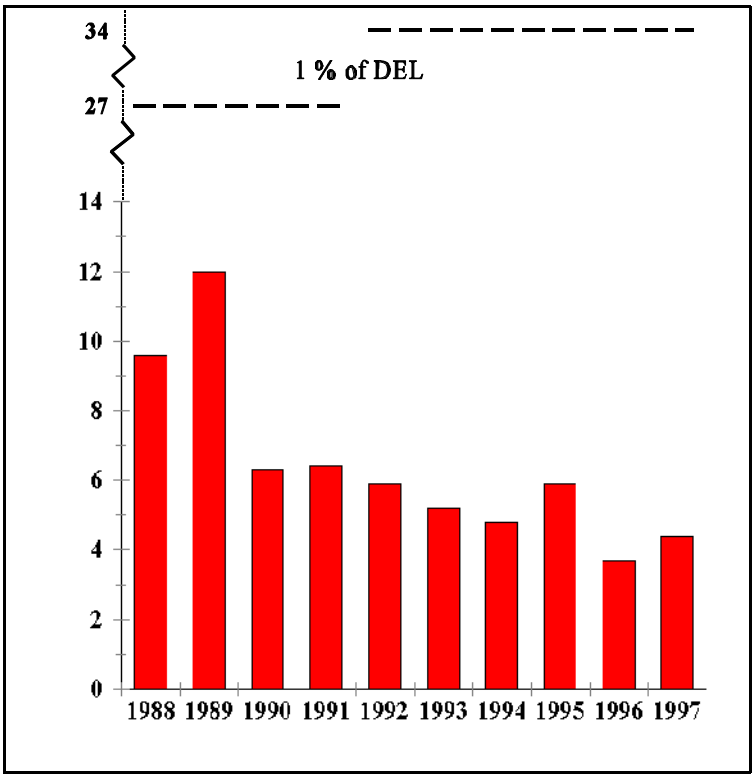
The Pickering "A" NGS facility consists of four nuclear reactors which started up in 1971. It is located in Ontario on the shore of Lake Ontario near the town of Pickering.

Radioactive emission data for Pickering "A" NGS are presented in the following histograms, covering the period of 1988 to 1997, for both gaseous and liquid effluents. The pertinent items in the gaseous effluents are tritium, in the form of tritium oxide (Figure 5.1), iodine-131 (Figure 5.2), noble gases (Figure 5.3), radioactive particulates (Figure 5.4) and carbon-14 (Figure 5.5).

The pertinent items in the liquid effluents are tritium, in the form of tritium oxide (Figure 5.6) and gross beta-gamma activity (Figure 5.7).

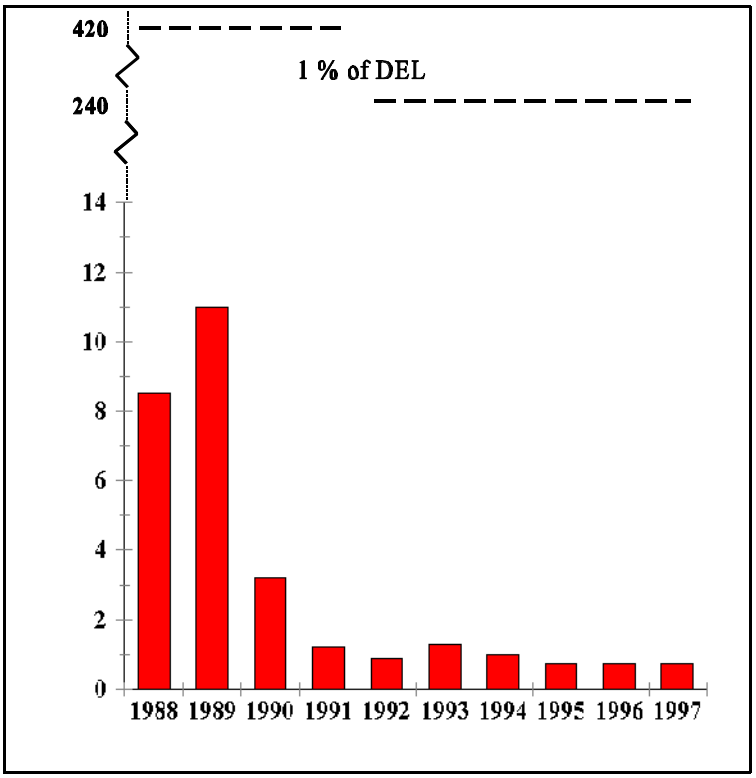
In October 1992, Pickering "A" DELs were revised and incorporated into its licence. Although in certain instances, the revised DELs were greater than the existing DELs (e.g. tritiated water in gaseous effluent), the station operating targets were not permitted to increase. In those cases where the revised DEL was less than the existing DEL, the station operating target was required to decrease proportionately.

FIGURE 5.1 Tritium Oxide Gaseous Effluent, Pickering A , 1988-97
(TBq × 10^2)



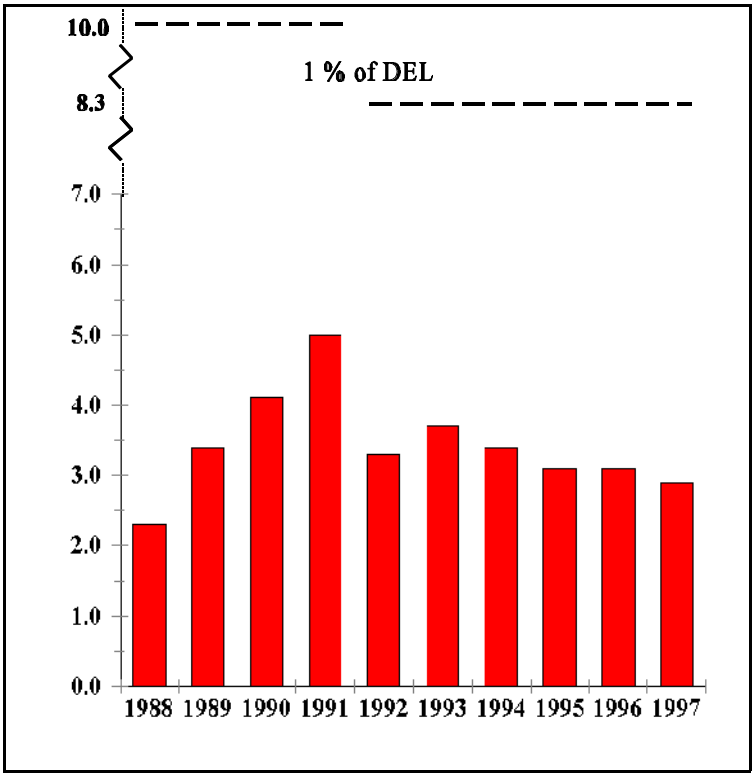
Year	TBq × 10^2
1988	9.6
1989	12.0
1990	6.3
1991	6.4
1992	5.9
1993	5.2
1994	4.8
1995	5.9
1996	3.7
1997	4.4

FIGURE 5.2 Iodine-131 Gaseous Effluent, Pickering A , 1988-97
(TBq × 10^{-4})



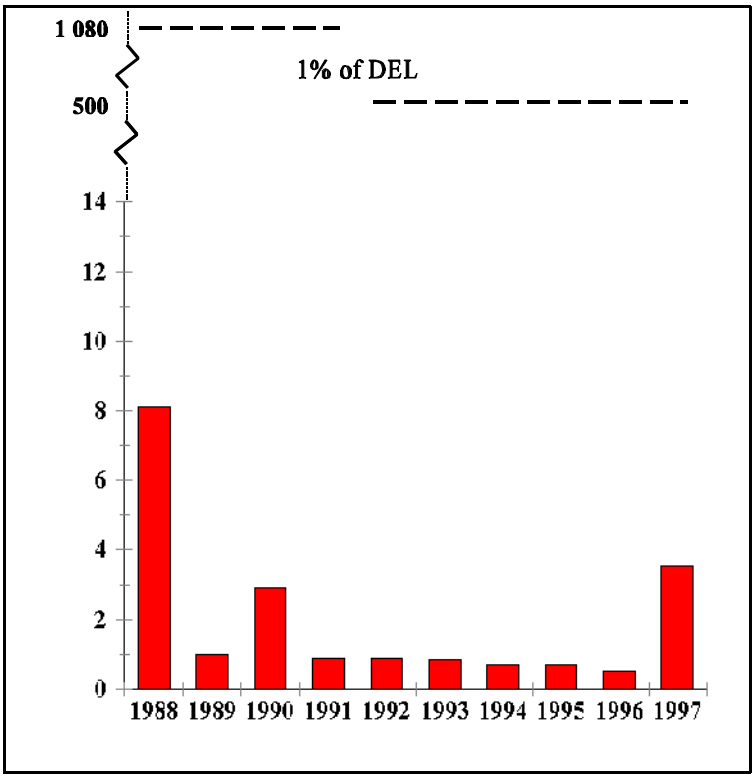
Year	TBq × 10^{-4}
1988	8.5
1989	11.0
1990	3.2
1991	1.2
1992	0.89
1993	1.3
1994	1.0
1995	0.74
1996	0.73
1997	0.74

FIGURE 5.3 Noble Gas Effluent, Pickering A , 1988-97
(TBq-MeV × 10^{2})



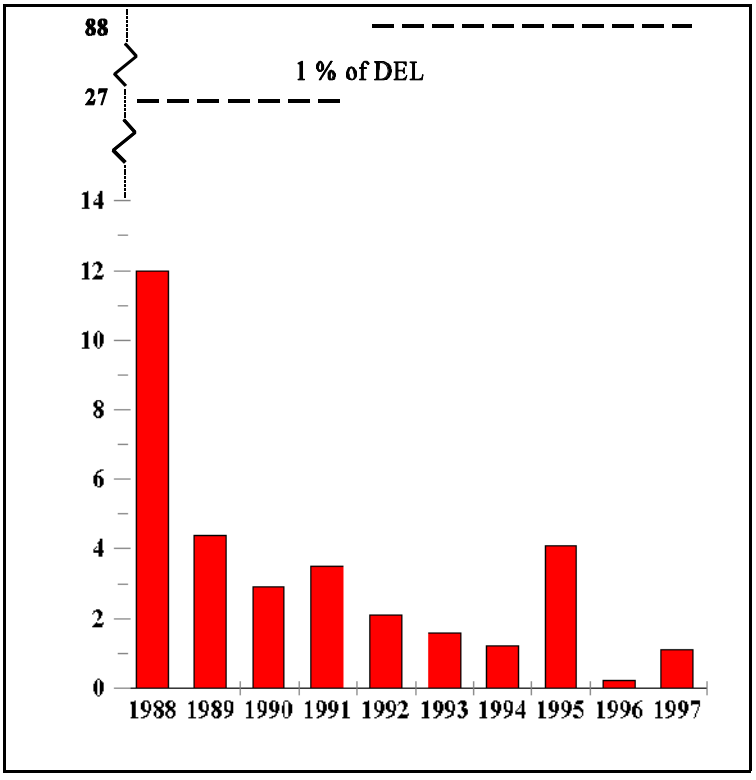
Year	TBq-MeV × 10^{2}
1988	2.3
1989	3.4
1990	4.1
1991	5.0
1992	3.3
1993	3.7
1994	3.4
1995	3.1
1996	3.1
1997	2.9

FIGURE 5.4 Radioactive Particulates in Gaseous Effluent, Pickering A , 1988-97
(TBq × 10^{-4})



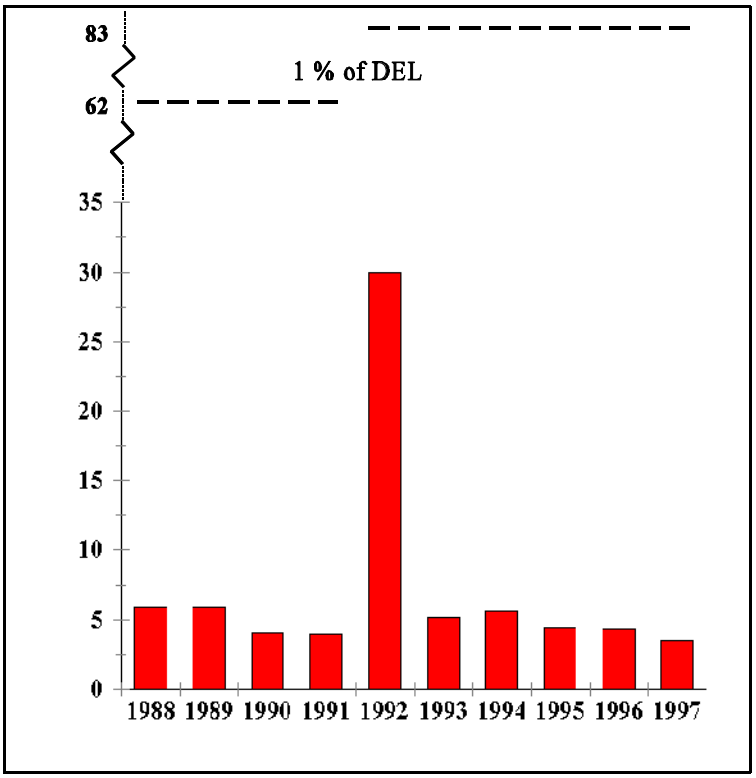
Year	TBq × 10^{-4}
1988	8.1
1989	1.0
1990	2.9
1991	0.87
1992	0.89
1993	0.85
1994	0.7
1995	0.7
1996	0.51
1997	3.55

FIGURE 5.5 Carbon-14 in Gaseous Effluent, Pickering A , 1988-97
(TBq)



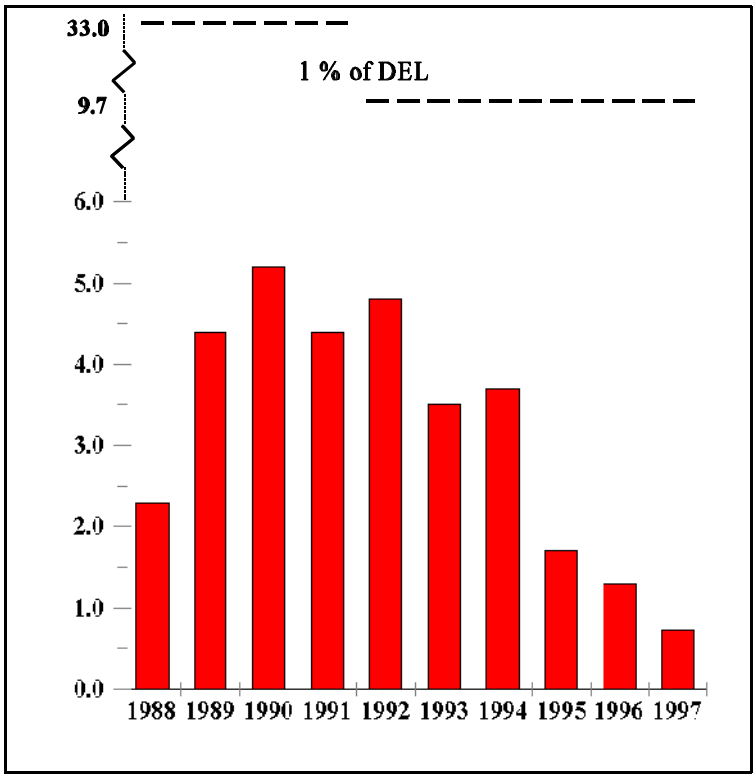
Year	TBq
1988	12.0
1989	4.4
1990	2.9
1991	3.5
1992	2.1
1993	1.6
1994	1.2
1995	4.1
1996	0.23
1997	1.1

FIGURE 5.6 Tritium Oxide Liquid Effluent, Pickering A , 1988-97
(TBq × 10^2)



Year	TBq × 10^2
1988	5.9
1989	5.9
1990	4.1
1991	4.0
1992	30.0
1993	5.2
1994	5.6
1995	4.4
1996	4.3
1997	3.5

FIGURE 5.7 Gross Beta-Gamma Activity in Liquid Effluent, Pickering A , 1988-97
(TBq × 10^{-2})



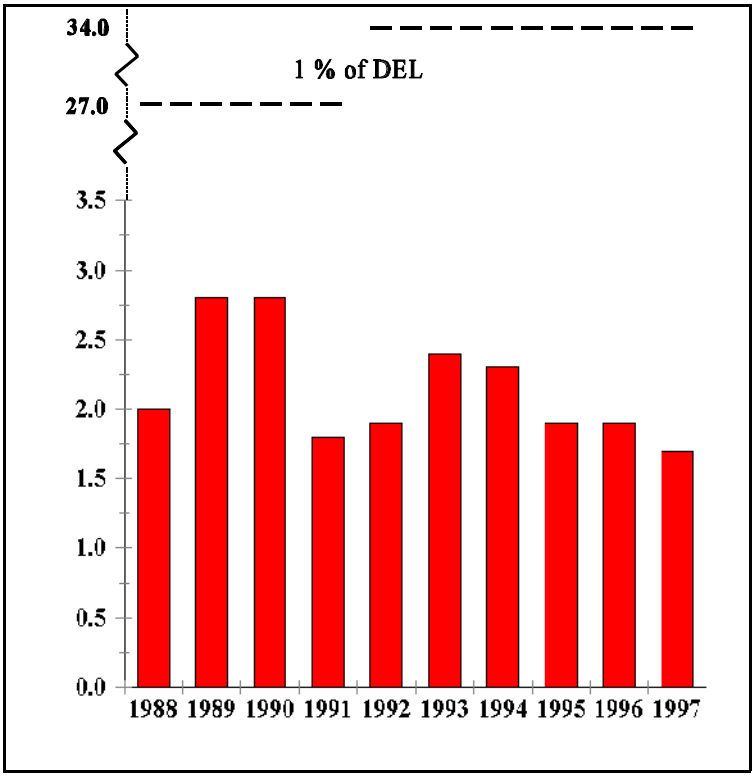
Year	TBq × 10^{-2}
1988	2.3
1989	4.4
1990	5.2
1991	4.4
1992	4.8
1993	3.5
1994	3.7
1995	1.7
1996	1.3
1997	0.73

The Pickering "B" NGS facility consists of four nuclear reactors which started up in 1982. It is located in Ontario on the shore of Lake Ontario near the town of Pickering.

Radioactive emission data for Pickering "B" NGS are presented in the following histograms, covering the period of 1988 to 1997, for both gaseous and liquid effluents. The pertinent items in the gaseous effluents are tritium, in the form of tritium oxide (Figure 6.1), iodine-131 (Figure 6.2), noble gases (Figure 6.3) and radioactive particulates (Figure 6.4); while those in the liquid effluents are tritium, in the form of tritium oxide (Figure 6.5) and gross beta-gamma activity (Figure 6.6). Gross beta-gamma activities in liquid effluents were not at measurable levels in 1996.

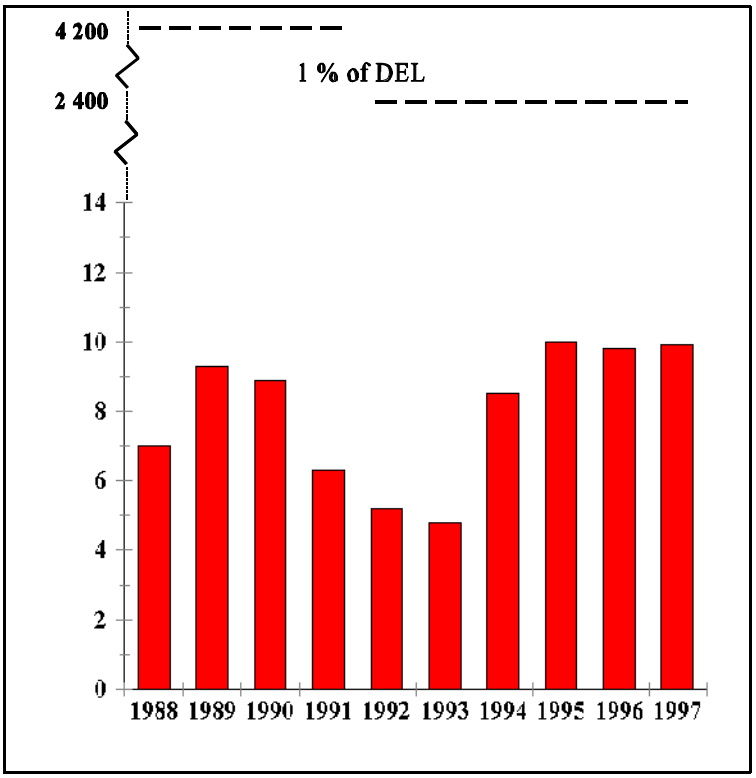
In October 1992, Pickering "B" DELs were revised and incorporated into its licence. Although in certain instances, the revised DELs were greater than the existing DELs (e.g. tritiated water in gaseous effluent), the station operating targets were not permitted to increase. In those cases where the revised DEL was less than the existing DEL, the station operating target was required to decrease proportionately.

FIGURE 6.1 Tritium Oxide Gaseous Effluent, Pickering B , 1988-97
(TBq × 10^2)



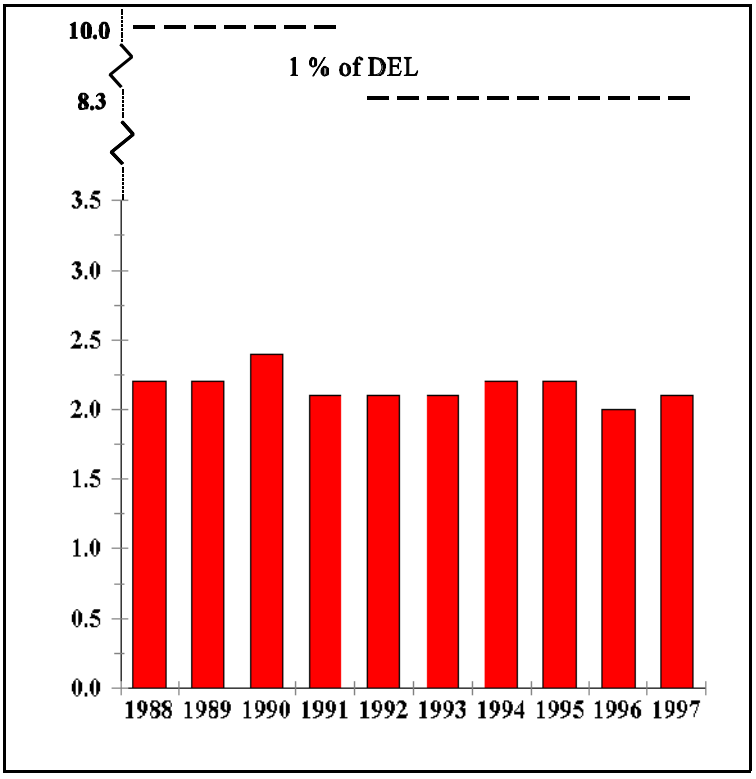
Year	TBq × 10^2
1988	2.0
1989	2.8
1990	2.8
1991	1.8
1992	1.9
1993	2.4
1994	2.3
1995	1.9
1996	1.9
1997	1.7

FIGURE 6.2 Iodine-131 Gaseous Effluent, Pickering B , 1988-97
(TBq × 10^{-5})



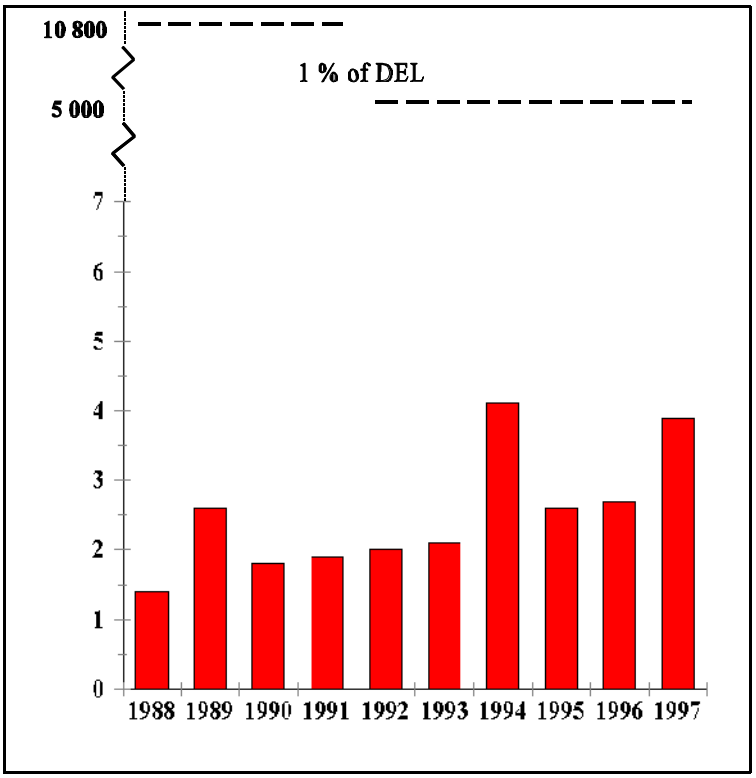
Year	TBq × 10^{-5}
1988	7.0
1989	9.3
1990	8.9
1991	6.3
1992	5.2
1993	4.8
1994	8.5
1995	10.0
1996	9.8
1997	9.9

FIGURE 6.3 Noble Gas Effluent, Pickering B , 1988-97
(TBq-MeV × 10^{2})



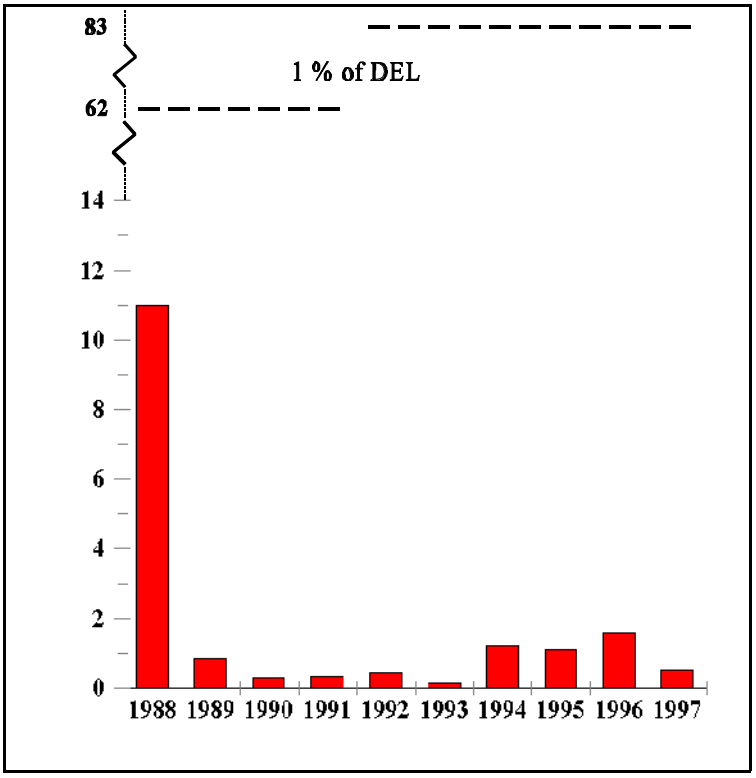
Year	TBq-MeV × 10^{2}
1988	2.2
1989	2.2
1990	2.4
1991	2.1
1992	2.1
1993	2.1
1994	2.2
1995	2.2
1996	2.0
1997	2.1

FIGURE 6.4 Radioactive Particulates in Gaseous Effluent, Pickering B , 1988-97
(TBq × 10^{-5})



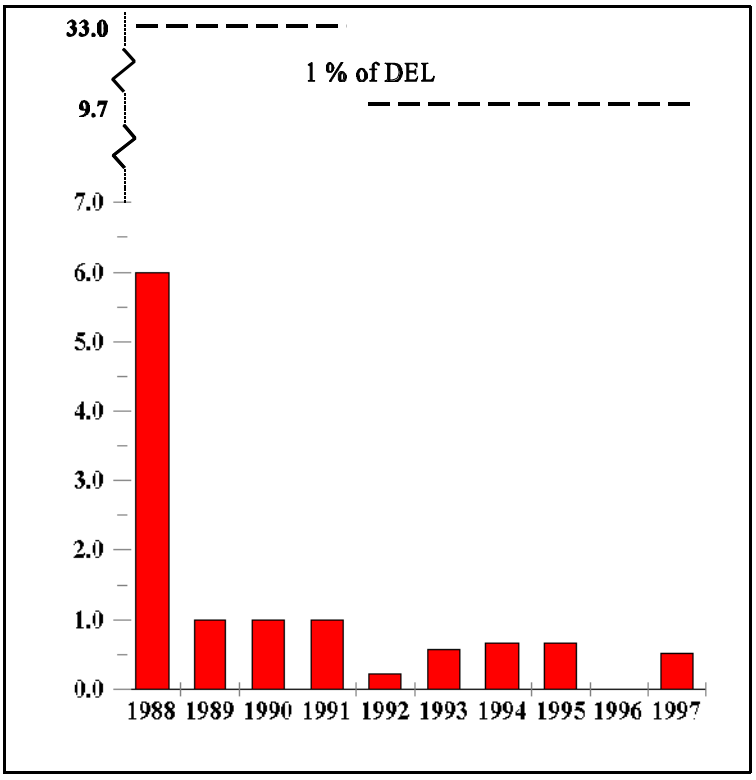
Year	TBq × 10^{-5}
1988	1.4
1989	2.6
1990	1.8
1991	1.9
1992	2.0
1993	2.1
1994	4.1
1995	2.6
1996	2.7
1997	3.9

FIGURE 6.5 Tritium Oxide Liquid Effluent, Pickering B , 1988-97
(TBq × 10^{2})



Year	TBq × 10^{2}
1988	11.0
1989	0.85
1990	0.3
1991	0.32
1992	0.44
1993	0.13
1994	1.2
1995	1.1
1996	1.6
1997	0.5

FIGURE 6.6 Gross Beta-Gamma Activity in Liquid Effluent, Pickering B , 1988-97
(TBq × 10^{-2})



Year	TBq × 10^{-2}
1988	6.0
1989	1.0
1990	1.0
1991	1.0
1992	0.22
1993	0.56
1994	0.67
1995	0.67
1996	ND*
1997	0.52

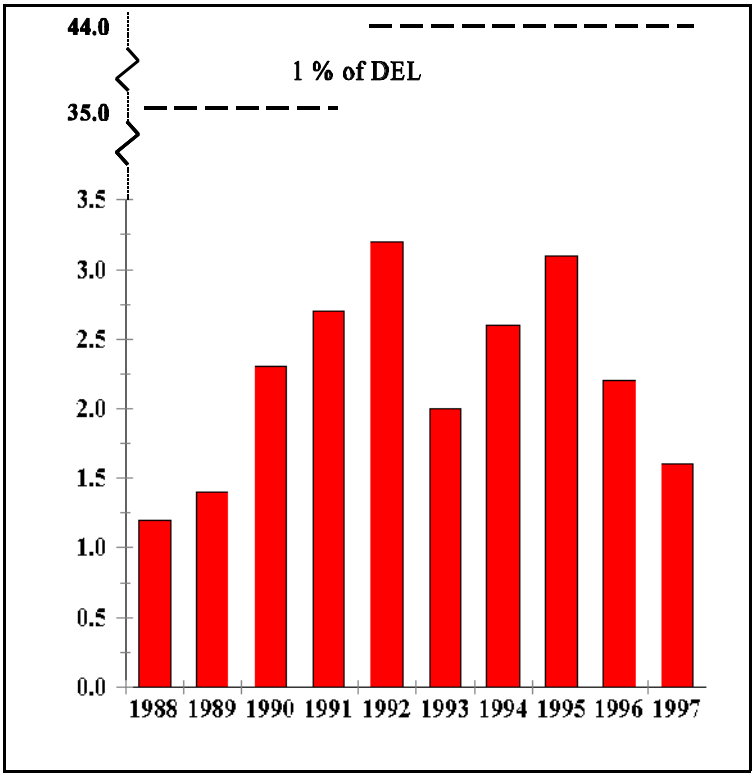
*ND: not detected

The Gentilly-2 NGS facility consists of one nuclear reactor which started up in 1982. It is located in Quebec on the Saint Lawrence River near the city of Trois-Rivières.

Radioactive emission data for Gentilly-2 NGS are presented in the following histograms, covering the period of 1988 to 1997, for both gaseous and liquid effluents. The pertinent items in the gaseous effluents are tritium, in the form of tritium oxide (Figure 7.1), iodine-131 (Figure 7.2), noble gases (Figure 7.3), radioactive particulates (Figure 7.4) and carbon-14 (Figure 7.5); while those in the liquid effluents are tritium, in the form of tritium oxide (Figure 7.6), gross beta-gamma activity (Figure 7.7) and carbon-14 (Figure 7.8). There were no measurable emissions of iodine-131 from 1988 to 1990, and from 1994 to 1997.

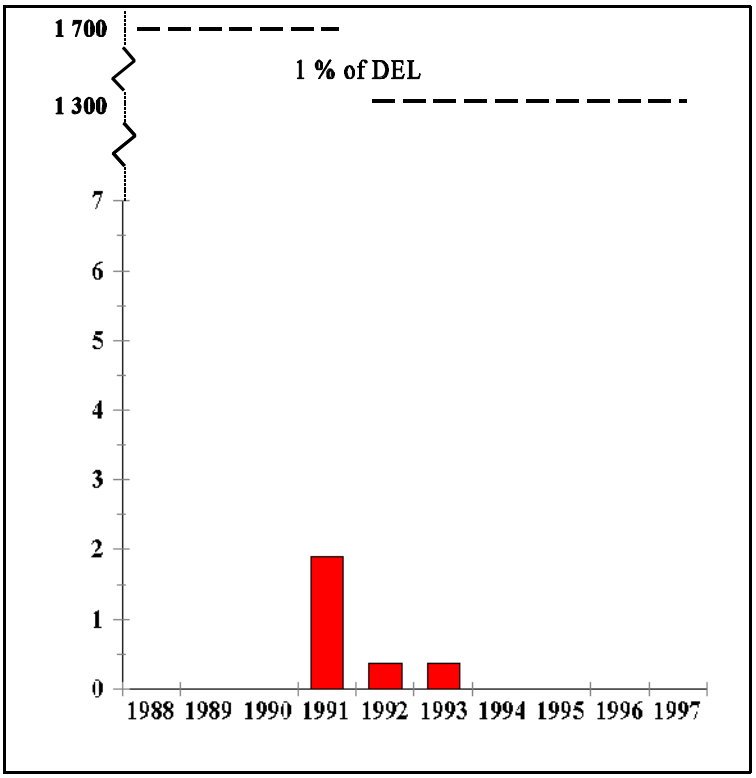
In May 1992, Gentilly-2 DELs were revised and incorporated into its licence. DELs for carbon-14 in gaseous and liquid effluents were introduced in 1992, and therefore only data from 1992 forward appear in Figures 7.5 and 7.8.

FIGURE 7.1 Tritium Oxide Gaseous Effluent, Gentilly-2, 1988-97
(TBq × 10^2)



Year	TBq × 10^2
1988	1.2
1989	1.4
1990	2.3
1991	2.7
1992	3.2
1993	2.0
1994	2.6
1995	3.1
1996	2.2
1997	1.6

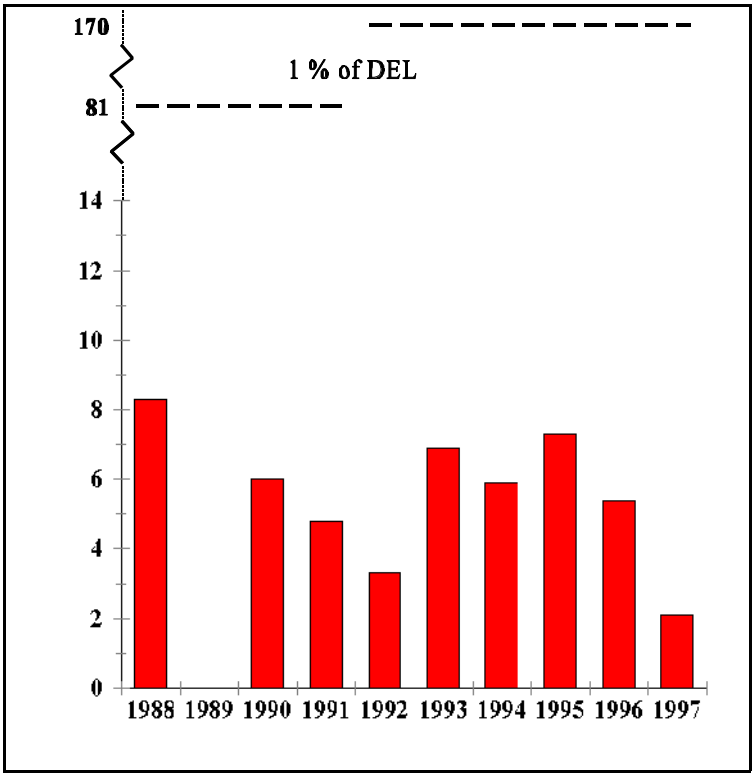
FIGURE 7.2 Iodine-131 Gaseous Effluent, Gentilly-2, 1988-97
(TBq × 10^{-5})



Year	TBq × 10^{-5}
1988	ND*
1989	ND
1990	ND
1991	1.9
1992	0.37
1993	0.37
1994	ND
1995	ND
1996	ND
1997	ND

*ND: not detected.

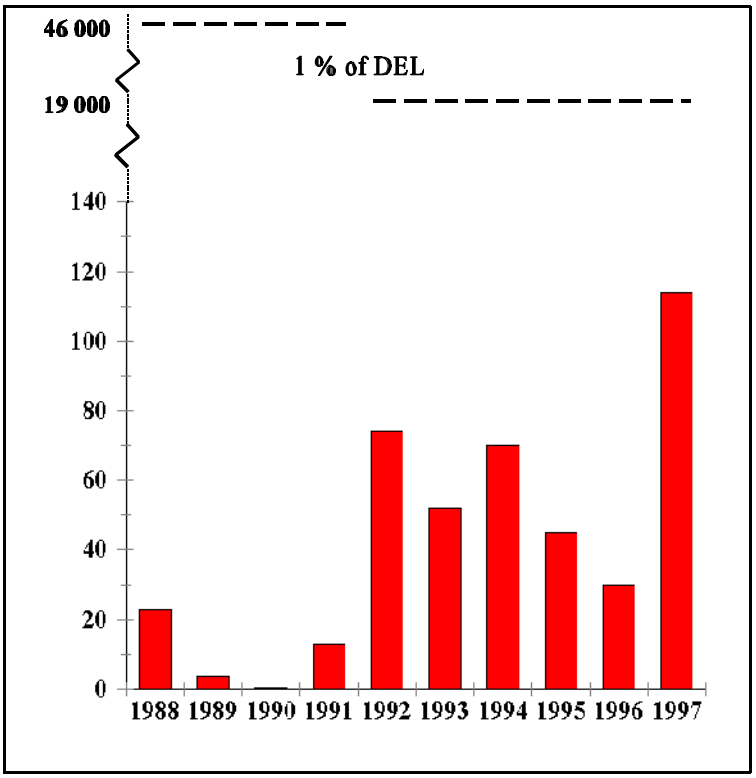
FIGURE 7.3 Noble Gas Effluent, Gentilly-2, 1988-97
(TBq-MeV × 10^{1})



Year	TBq-MeV × 10^{1}
1988	8.3
1989	ND*
1990	6.0
1991	4.8
1992	3.3
1993	6.9
1994	5.9
1995	7.3
1996	5.4
1997	2.1

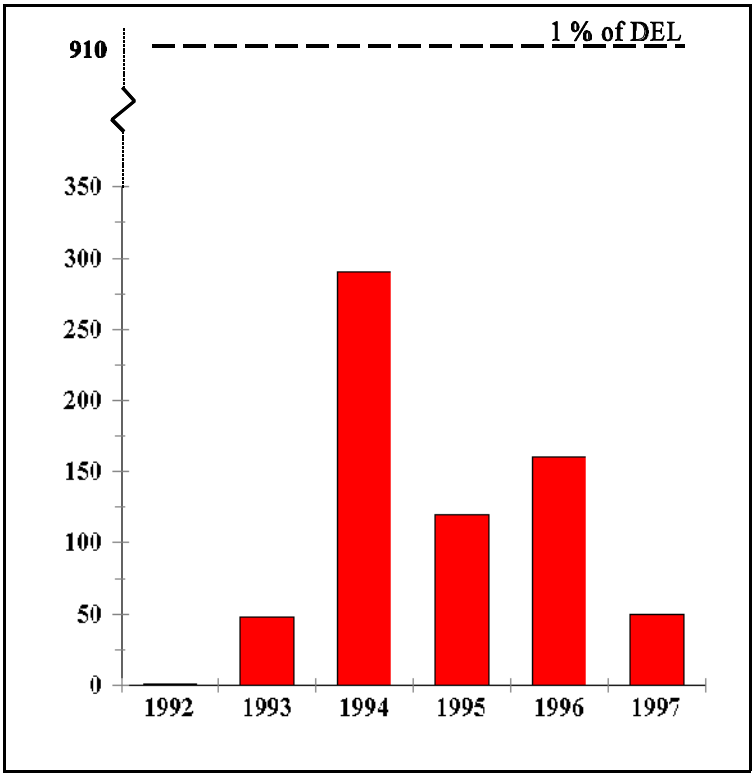
*ND: not detected.

FIGURE 7.4 Radioactive Particulates in Gaseous Effluent, Gentilly-2, 1988-97
(TBq × 10^{-6})



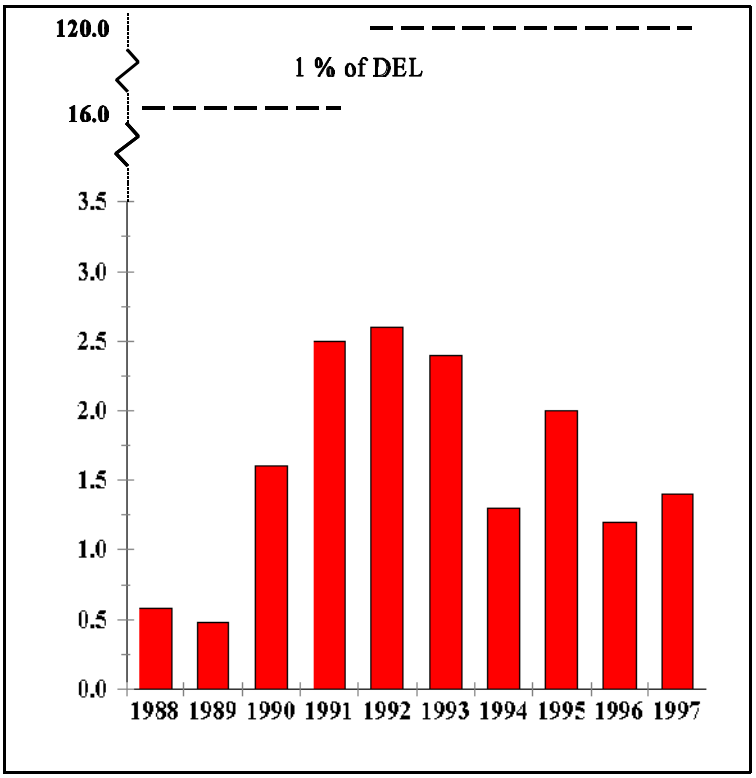
Year	TBq × 10^{-6}
1988	23.0
1989	3.7
1990	0.37
1991	13.0
1992	74.0
1993	52.0
1994	70.0
1995	45.0
1996	30.0
1997	114.0

FIGURE 7.5 Carbon-14 in Gaseous Effluent, Gentilly-2, 1992-97
(TBq × 10^{-2})



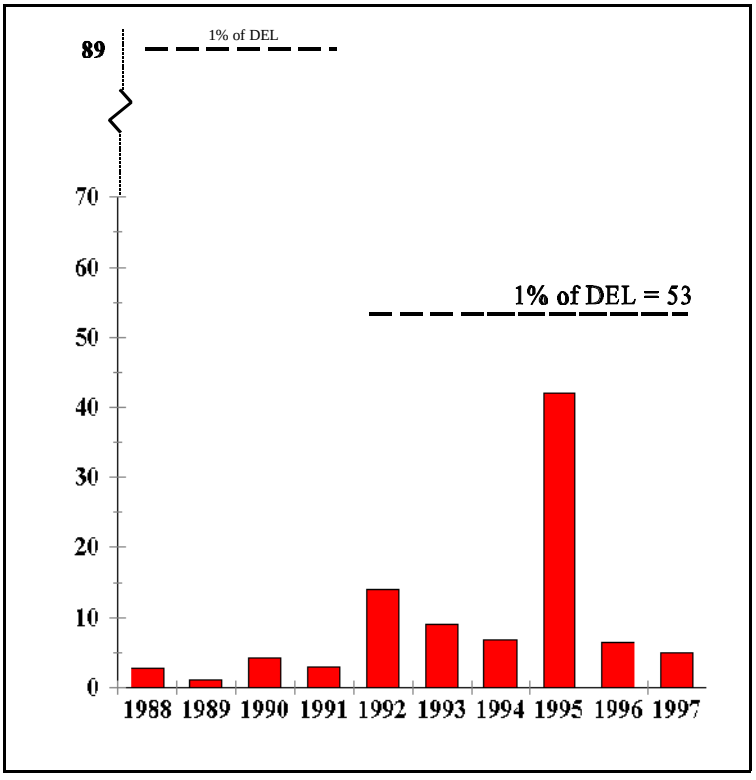
Year	TBq × 10^{-2}
1992	0.74
1993	48.0
1994	290.0
1995	120.0
1996	160.0
1997	50.0

FIGURE 7.6 Tritium Oxide Liquid Effluent, Gentilly-2, 1988-97
(TBq × 10^2)



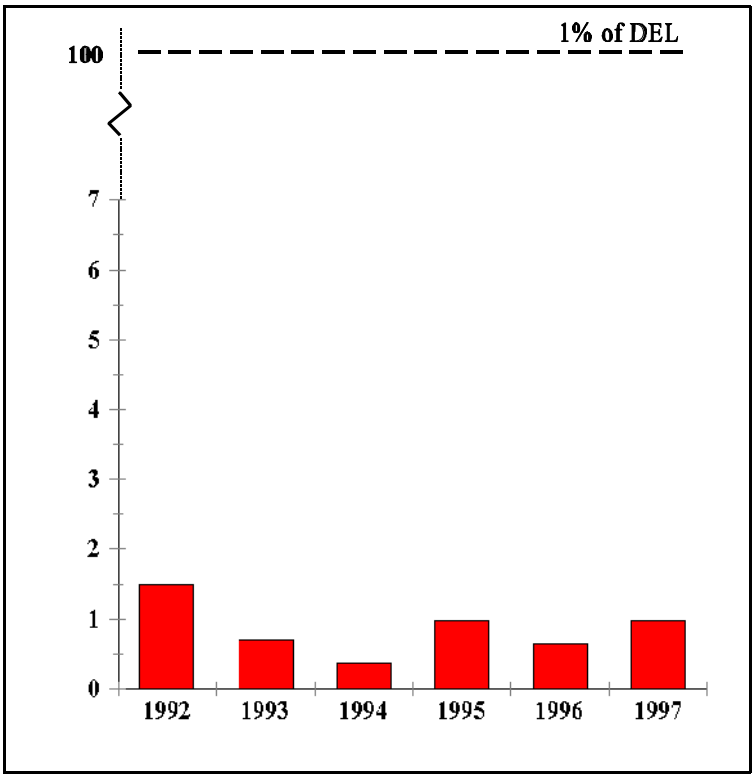
Year	TBq × 10^2
1988	0.58
1989	0.48
1990	1.6
1991	2.5
1992	2.6
1993	2.4
1994	1.3
1995	2.0
1996	1.2
1997	1.4

FIGURE 7.7 Gross Beta-Gamma Activity in Liquid Effluent, Gentilly-2, 1988-97
(TBq × 10^{-3})



Year	TBq × 10^{-3}
1988	2.8
1989	1.1
1990	4.2
1991	3.0
1992	14.0
1993	9.0
1994	6.9
1995	42.0
1996	6.5
1997	5.0

FIGURE 7.8 Carbon-14 in Liquid Effluent, Gentilly-2, 1992-97
(TBq × 10^{-2})



Year	TBq × 10^{-2}
1992	1.5
1993	0.7
1994	0.37
1995	0.97
1996	0.64
1997	0.97

Glossary

Atomic Energy Control Board (AECB): The AECB is Canada's nuclear regulatory authority. The mission of the AECB is to ensure that the use of nuclear energy in Canada does not pose undue risk to health, safety, security and the environment. This is accomplished by controlling the development, application and use of nuclear energy.

becquerel (Bq): The unit of activity under the SI system. It is the rate of radioactive disintegration of a substance. One becquerel of radioactive substance disintegrates by radioactive decay at the rate of one disintegration per second. In this report we use a multiple of this unit (terabecquerel, or 10^{12} Bq).

critical group: A homogeneous group of members of the public identified as being those individuals which are most likely to receive the highest doses from exposure to radioactive materials released by AECB licensees. While the concept of critical group is the same for all nuclear generating stations in Canada, the description of the critical group for each station is unique. It is based on analysis of site-specific radionuclide emissions and exposure pathways.

curie (Ci): The unit for measuring the rate of radioactive decay; it is defined as 3.7×10^{10} disintegrations per second. 1 Ci = 3.7×10^{10} Bq.

decommissioning: The final closing down and putting into a state of safety of a nuclear generating station or other nuclear facility when it has come to the end of its service life.

derived emission limit (DEL): A limit imposed by the AECB on the emission of a radioactive substance from a licensed nuclear facility such that compliance with the DEL gives reasonable assurance that the regulatory dose limit is not exceeded.

dose limit: A limit on radiation dose specified in the *Atomic Energy Control Regulations*.

iodine-131: Radioactive isotope of iodine. There are several radioisotopes of iodine produced during normal operation of a nuclear reactor.

ionizing radiation: Any atomic or subatomic particle or electromagnetic wave having sufficient energy to produce ions (atoms which have become charged due to the loss or gain of electrons) in the material in which it is absorbed. Ionizing radiation includes alpha and beta particles and gamma radiation, as well as neutrons and some other particles.

irradiation: Exposure to radiation.

noble gases: Xenon, argon, krypton, neon, helium. They are chemically inert gases. Radioisotopes of the noble gases are created during the operation of a nuclear reactor.

radioactivity: The spontaneous disintegration of the nucleus of an atom by expulsion of particles. It can be accompanied by electromagnetic radiation. Solids, liquids or gases can be radioactive.

rem (Roentgen equivalent man): The unit used to describe the relative effect of radiation absorbed doses of different ionizing radiations on different body tissues. Under the SI system, the rem is replaced by the sievert (1 rem = 0.01 Sv = 10 mSv).

sievert (Sv): The SI unit corresponding to the rem (1 Sv = 100 rem). The millisievert (mSv) is more appropriate for radiation protection work. The legal dose limit has been established at 5 mSv for a member of the public with respect to any licensed nuclear activity. The limit for atomic radiation workers is 50 mSv per year.

tritium: A radioactive form of hydrogen which is produced both naturally and by human activities. Tritium is produced during normal operation of Canadian nuclear reactors.