

1995

Interdepartmental
Committee
Report

New Zealand Aluminium Smelters Limited



**REPORT TO THE INTERDEPARTMENTAL COMMITTEE
ON ENVIRONMENTAL EFFECTS OF THE TIWAI ALUMINIUM SMELTER
FOR THE YEAR ENDING 31 DECEMBER 1995**

**MEETING AT TIWAI
14 MAY 1996**

**THE INFORMATION CONTAINED IN THIS REPORT IS CONFIDENTIAL TO
THE MEMBERS OF THE INTERDEPARTMENTAL COMMITTEE**



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Summary

1995 was a very busy year with the upgrade, however the smelter's operation was relatively stable. As a result the effect of the smelter emissions on the surrounding environment was similar to recent years.

It is pleasing to note the average rate of total particulate discharged from the main stack continued the downward trend evident over the last three years. The discharge rate of fluoride, both gaseous and particulate, remains stable at the levels reached in 1988 and 1992 respectively.

The meteorological conditions were similar to 1994 but with slightly lighter winds on average. The direction of the winds was less heavily skewed to the west and north-west than in 1994.

No significant new trends were observed in the effects attributable to the smelter's emissions on livestock or vegetation on the grazing monitoring farms.

In spite of the smelter's stable performance, with respect to source emissions, a small number of the sites used to measure the smelter's effects on the environment did not reflect a similar stable trend. Most notable are the average fluoride concentrations in both the grazed grass and cattle urine on GMF 4. The annual average of both continued a historical upward trend. This is not easily explained. It is important to note that these trends, as with all measures of the effects of the discharges of fluoride from the smelter's main stack, are expected to reflect the dramatic reduction of these emissions that will follow the introduction of the dry scrubbers during 1996.

The nature of the liquid discharges, as with their effects on the environment, remains similar to previous years.

On 11 October 1995 the Southland Regional Council resolved that NZAS be advised that it is the Council's opinion that the cathode pad contamination plume be allowed to continue to recover by natural dispersion alone. Ongoing monitoring of this recovery is continuing.

A 12-month trial of air sparging as a remediation strategy for the underground diesel spill is scheduled to be completed in April 1996. The investigations into the success of this strategy are due to be completed by early June 1996. This investigation will also review the effectiveness of the natural (unassisted) bioremediation of this plume.

Chapter 1

Introduction

1995 has been an extremely busy year at NZAS with the year being dominated by the present upgrade. The new equipment and buildings that have been installed and constructed as part of this upgrade are already changing the physical character of the smelter. Once commissioned these will also change and dramatically improve the smelter's environmental performance.

In spite of the demands the upgrade has placed on resources, NZAS continued its commitment to measuring, understanding and improving its environmental performance.

This report collects together the important outcomes of this effort.

The format of this report is similar to recent years. It contains detailed summaries of the source emission monitoring followed by the data collected to assess the effects of those emissions on the surrounding environment. Where appropriate, trend analysis and explanatory comments are included.

The permits for the smelter's liquid discharges expired during 1995. As applications for new discharge consents were lodged with the Southland Regional Council six months prior to the expiry date the existing conditions remain in force until the applications are decided .

NZAS also successfully applied for a consent for its landfill and water discharge from the switchyard area. Routine monitoring of the effects of the landfill on the environment will commence in 1996.

Chapter 2

Discharges to Air

Introduction

Discharges into air from the smelter and wharf are covered by Air Discharge Permit Number 93566 issued by the Southland Regional Council issued on 26 April 1994.

This chapter covers:

- monitoring results of the main stack discharges,
- monitoring results of the potroom roof louvre discharges,
- summary of the fluoride discharges into air,
- baghouse discharges,
- carbon baking furnace discharge to the main stack,
- Ringleman number, and
- sulphur contents of raw materials and fuels used in the aluminium smelting process.

2.1 Main Stack Discharges

Monitoring results

The table below shows the main stack monitoring results for 1995.

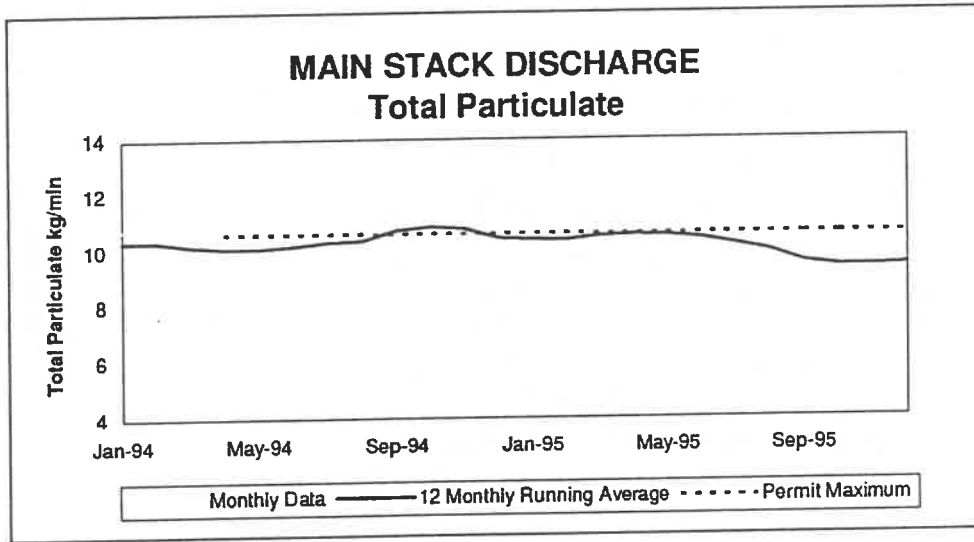
Parameter	Units	Permit	1995 annual average	1995 maximum
Gas flow rate	Sm ³ /min	-	58450	61300
Total particulate				
• Month average	kg/min	-		10.89
• 12 month average	kg/min	10.60	9.45	10.55
Gaseous fluoride				
• Month average	kg/min	-		4.04
• 12 month average	kg/min	3.90	3.74	3.78
Particulate fluoride				
• Month average	kg/min	-		3.07
• 12 month average	kg/min	3.30	2.62	2.64
Sulphur dioxide				
• Month average	kg/min	-	10.75	11.24
Total condensable hydrocarbons				
• Month average	kg/min	-	0.34	0.43

2.1 Main Stack Discharges, Continued

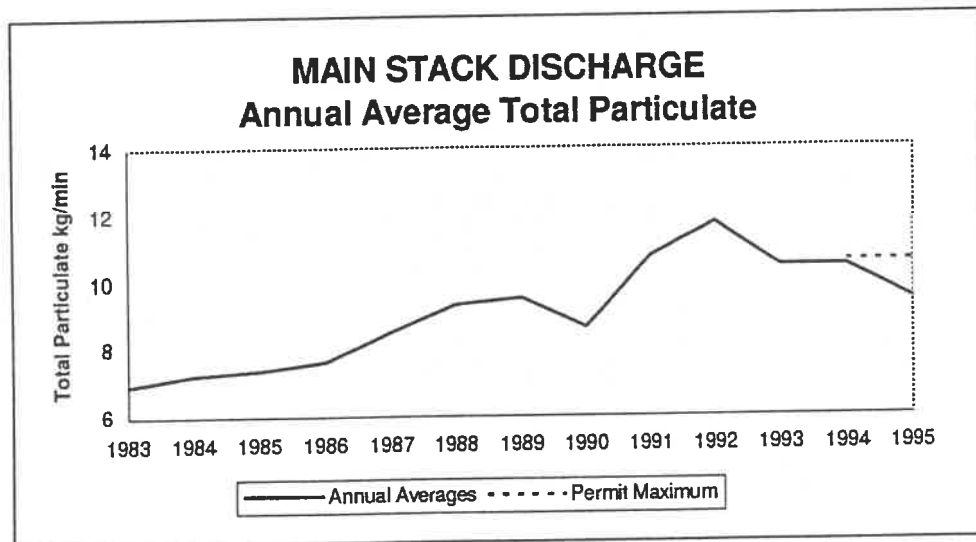
Total particulate

Standard: Total particulate twelve month running average not to exceed 10.60 kg/min.

The following graph shows both the average monthly and twelve month running average main stack total particulate discharge during 1994 and 1995.



The following graph shows the annual average main stack total particulate discharge.

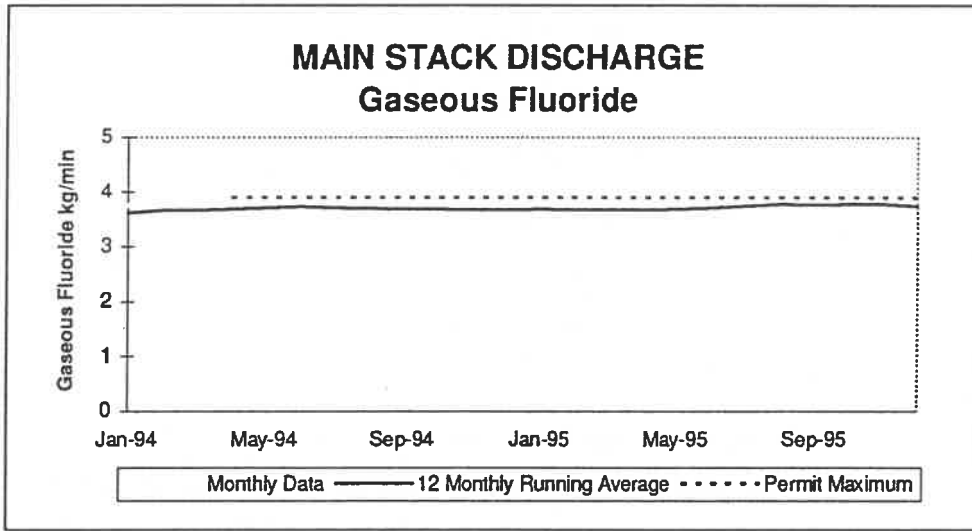


2.1 Main Stack Discharges, Continued

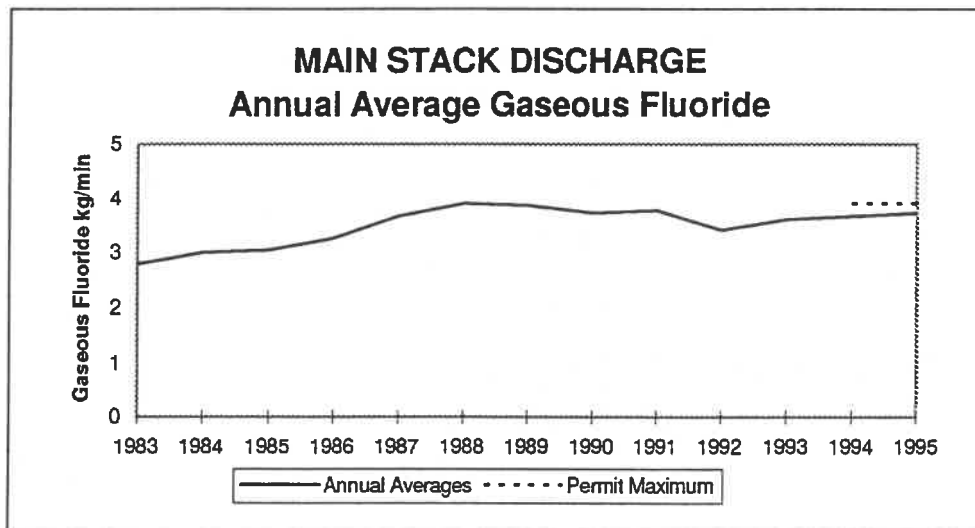
Gaseous fluoride

Standard: Gaseous fluoride twelve month running average not to exceed 3.90 kg/min.

The following graph shows both the average monthly and twelve month running average main stack gaseous fluoride discharge during 1994 and 1995.



The following graph shows the annual average main stack gaseous fluoride discharge.

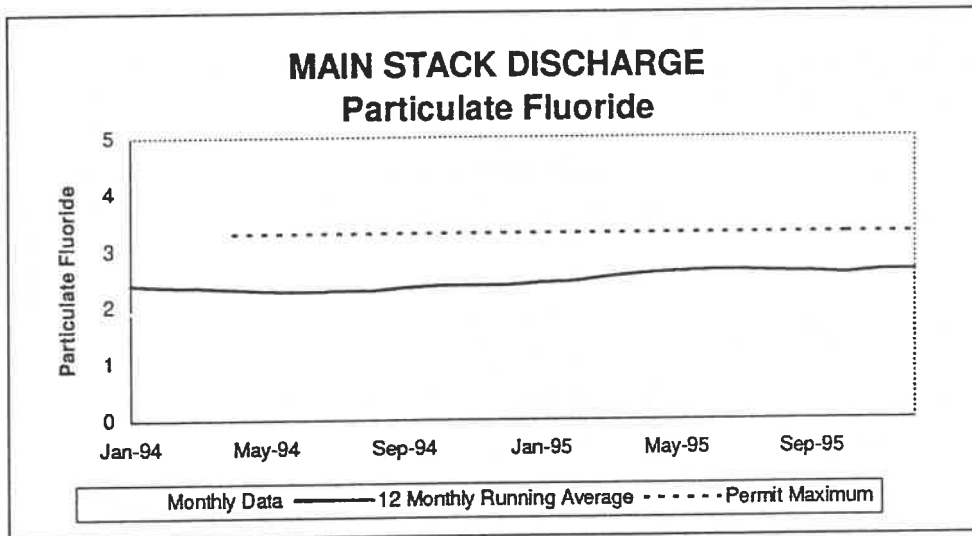


2.1 Main Stack Discharges, Continued

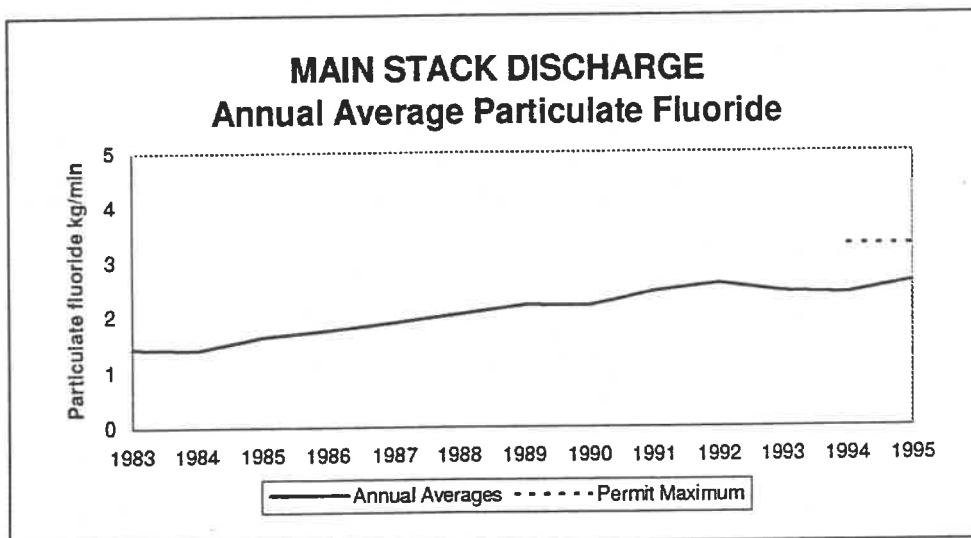
Particulate fluoride

Standard: Particulate fluoride twelve month running average not to exceed 3.30 kg/min.

The following graph shows both the average monthly and twelve month running average main stack particulate fluoride discharge during 1994 and 1995.



The following graph shows the annual average main stack particulate fluoride discharge.



2.1 Main Stack Discharges, Continued

Comments

Total particulate

The main stack total particulate discharge was within the permit standard throughout 1995 and continued the downward trend evident over the last 3 years.

Gaseous fluoride

The main stack gaseous fluoride discharge was stable and within the permit standard throughout 1995.

The alumina injection fume scrubbing system was managed to use the least amount of alumina required to meet both the total particulate and gaseous fluoride permit standards.

Particulate fluoride

The main stack particulate fluoride discharge was stable and within the permit standard throughout 1995.

Dry scrubbing

The commissioning trials for the first two dry scrubbing reactors were started in mid December. The dry scrubbing reactors are being used to process Potroom 3B discharges. The alumina injection fume scrubbing system was shutdown at the time the trials were started.

2.2 Potroom Roof Louvre Discharges

Monitoring results

The table below shows the potroom roof louvre monitoring results for 1995.

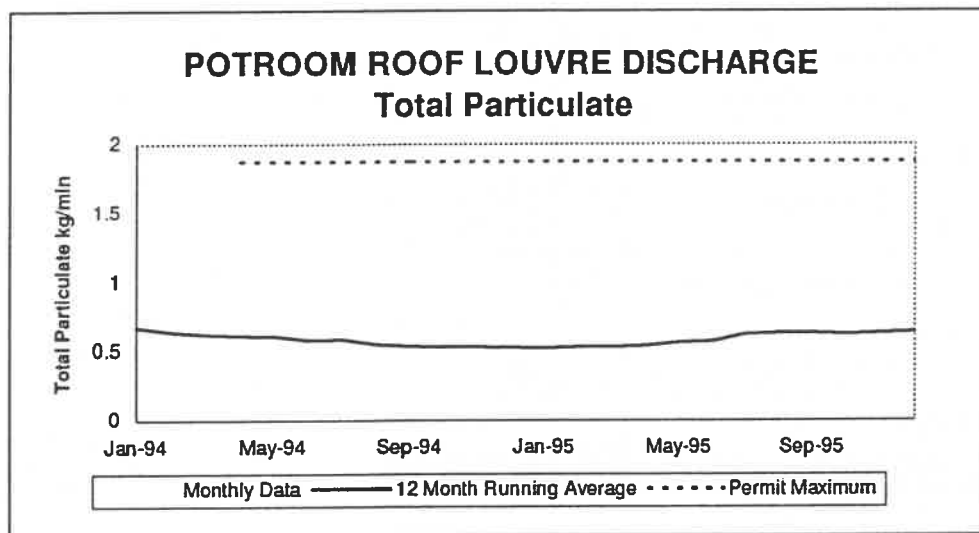
Parameter	Units	Permit	1995 annual average	1995 maximum
Total particulate				
• Month average	kg/min	-		1.19
• 12 month average	kg/min	1.87	0.64	0.64
Gaseous fluoride				
• Month average	kg/min	-		0.22
• 12 month average	kg/min	0.233	0.13	0.17
Particulate fluoride				
• Month average	kg/min	-		0.26
• 12 month average	kg/min	0.233	0.14	0.14
Sulphur dioxide				
• Month average	kg/min	-	0.39	0.60

2.2 Potroom Roof Louvre Discharges, Continued

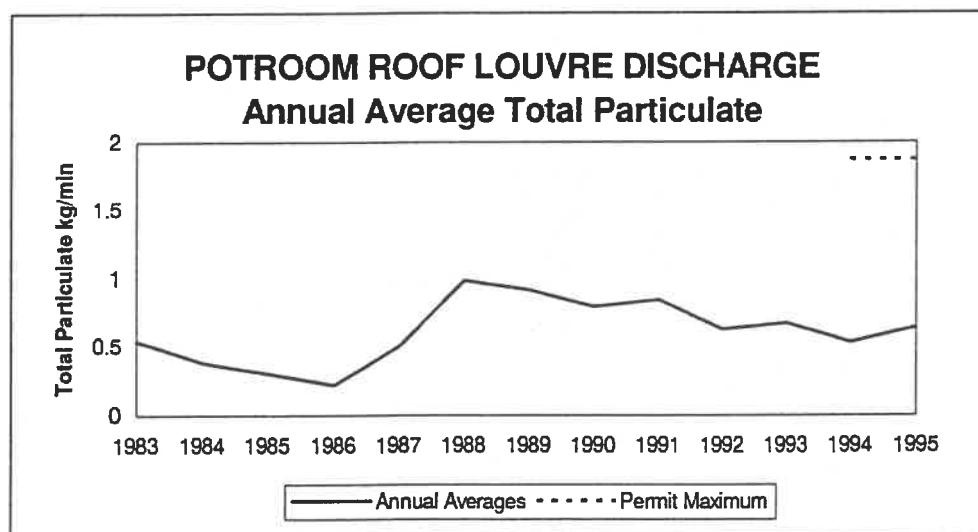
Total particulate

Standard: Total particulate twelve month running average not to exceed 1.87 kg/min.

The following graph shows both the average monthly and twelve month running average potroom roof louvre total particulate discharge during 1994 and 1995.



The following graph shows the annual average potroom roof louvre total particulate discharge.

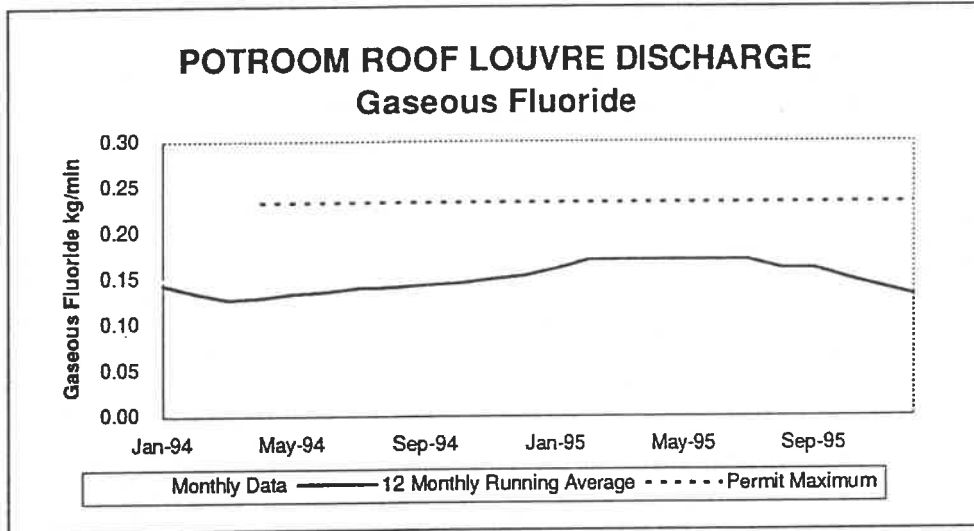


2.2 Potroom Roof Louvre Discharges, Continued

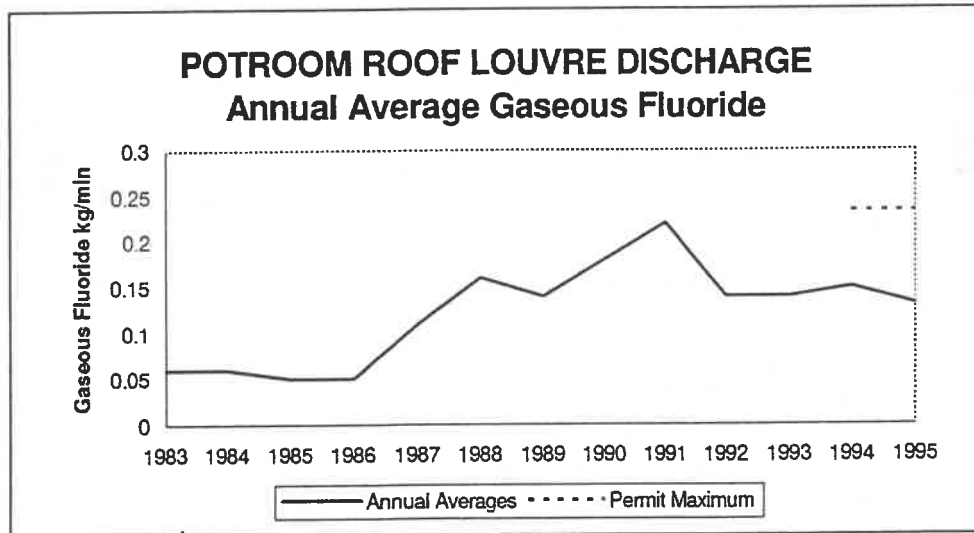
Gaseous fluoride

Standard: Gaseous fluoride twelve month running average not to exceed 0.233 kg/min.

The following graph shows both the average monthly and twelve month running average potroom roof louvre gaseous fluoride discharge during 1994 and 1995.



The following graph shows the annual average potroom roof louvre gaseous fluoride discharge.

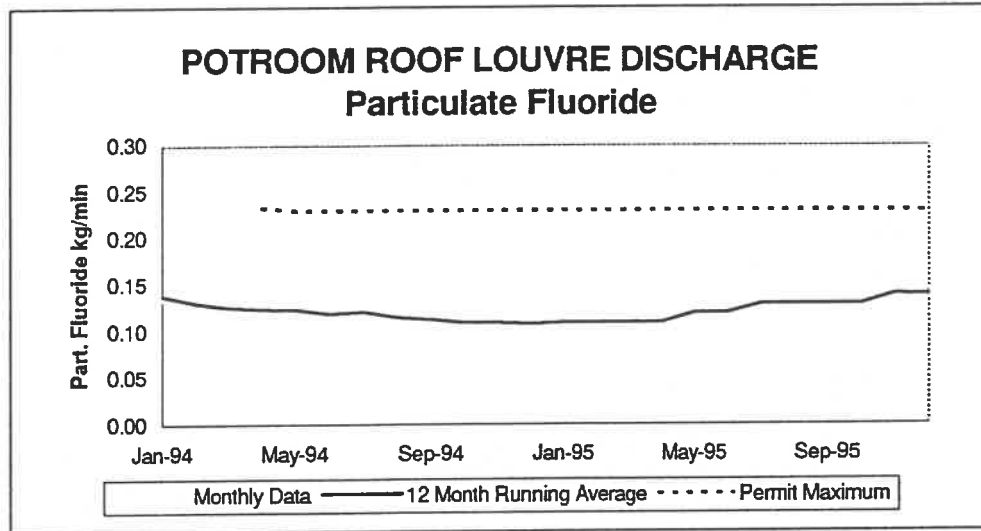


2.2 Potroom Roof Louvre Discharges, Continued

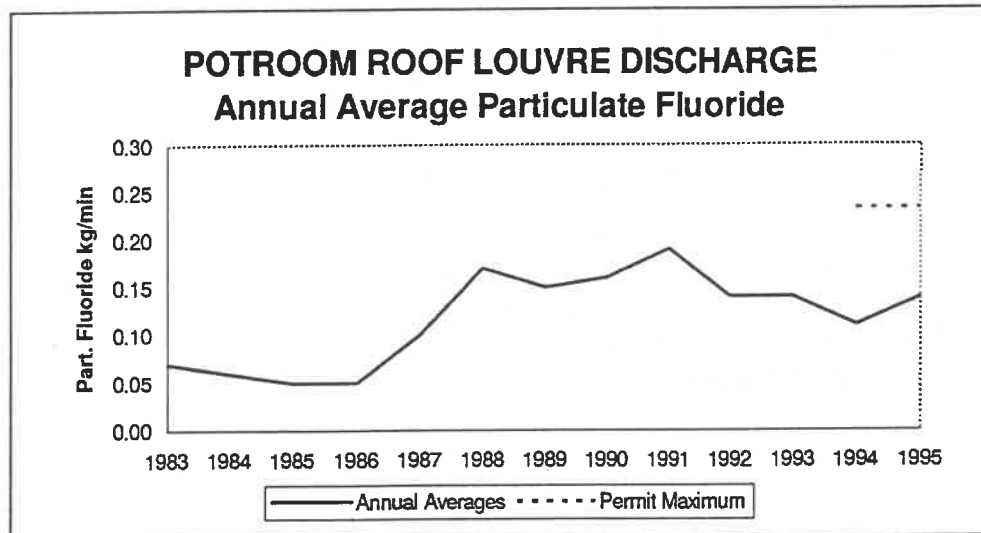
Particulate fluoride

Standard: Particulate fluoride twelve month running average not to exceed 0.233 kg/min.

The following graph shows both the average monthly and twelve month running average potroom roof louvre particulate fluoride discharge during 1994 and 1995.



The following graph shows the annual average potroom roof louvre particulate fluoride discharge.



2.2 Potroom Roof Louvre Discharges, Continued

Comments

Potroom roof louvre discharges were within permit standards throughout 1995.

New hoods and doors were fitted progressively to the reduction cells during 1995. The refit program was completed in January 1996. The hood and door refit coincided with a decrease in the Potroom roof louvre discharge measured since August.

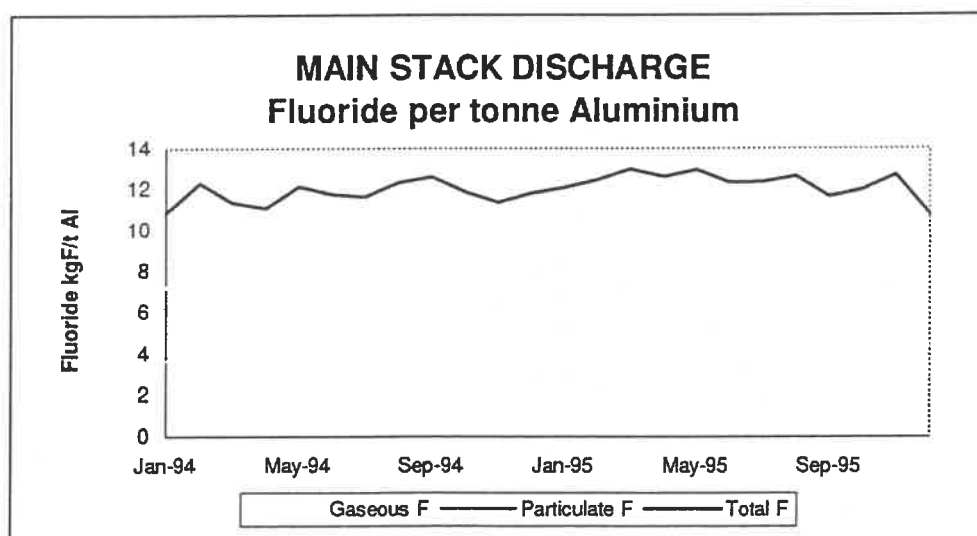
2.3 Fluoride Discharges

Performance data

The following table shows the fluoride discharges expressed as a ratio of hot aluminium metal production during 1995.

Parameter	Units	1995 average	1995 monthly maximum
Main stack			
• Gaseous fluoride	kg/t Al	7.24	7.79
• Particulate fluoride	kg/t Al	5.08	5.94
• Total fluoride	kg/t Al	12.30	12.99
Potroom roof louvre			
• Gaseous fluoride	kg/t Al	0.25	0.42
• Particulate fluoride	kg/t Al	0.27	0.50
• Total fluoride	kg/t Al	0.52	0.79
Plant			
• Gaseous fluoride	kg/t Al	7.50	8.21
• Particulate fluoride	kg/t Al	5.35	6.23
• Total fluoride	kg/t Al	12.84	13.60

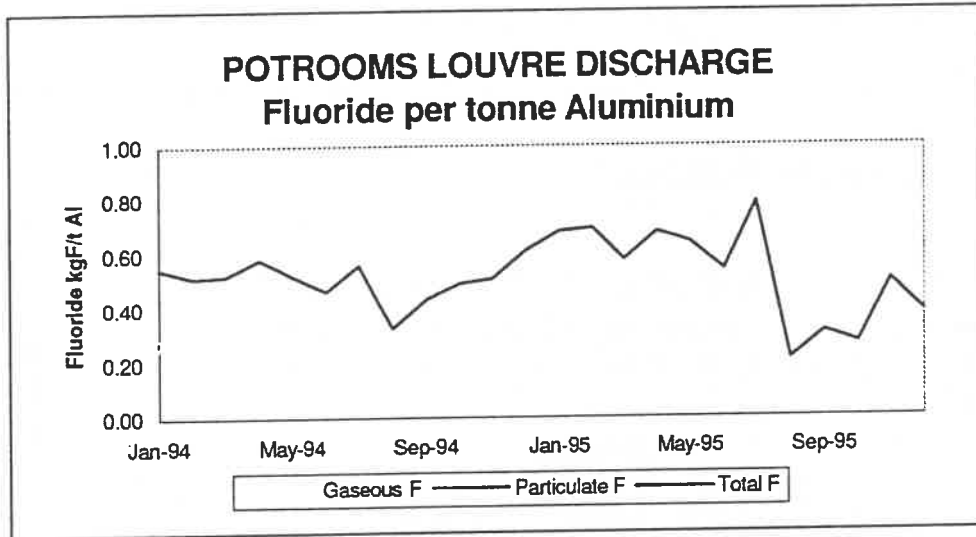
The following graph shows the average monthly main stack fluoride discharge during 1994 and 1995.



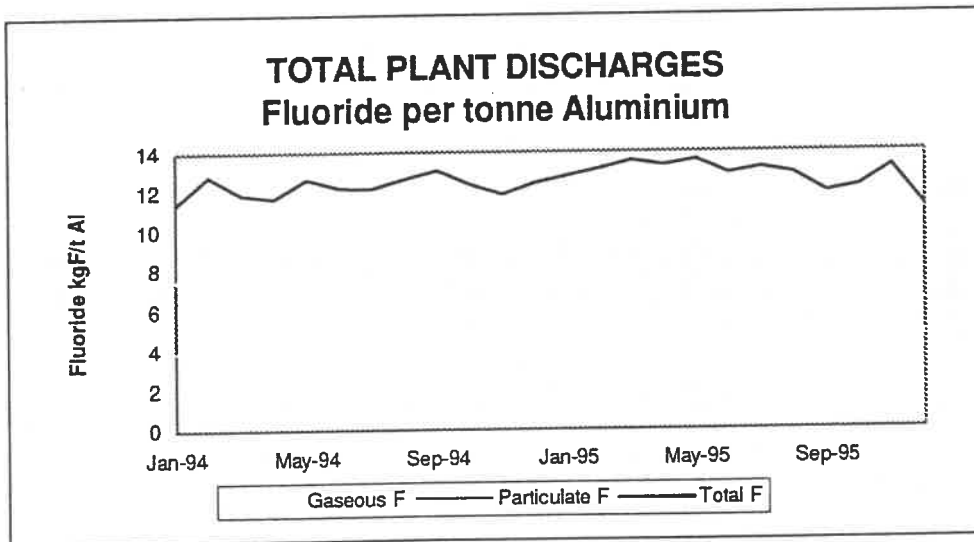
2.3 Fluoride Discharges, Continued

Performance data, continued

The following graph shows the average monthly potroom roof louvre fluoride discharge during 1994 and 1995.



The following graph shows the average monthly total plant fluoride discharge during 1994 and 1995.



Fluoride discharges from the plant were stable throughout 1995.

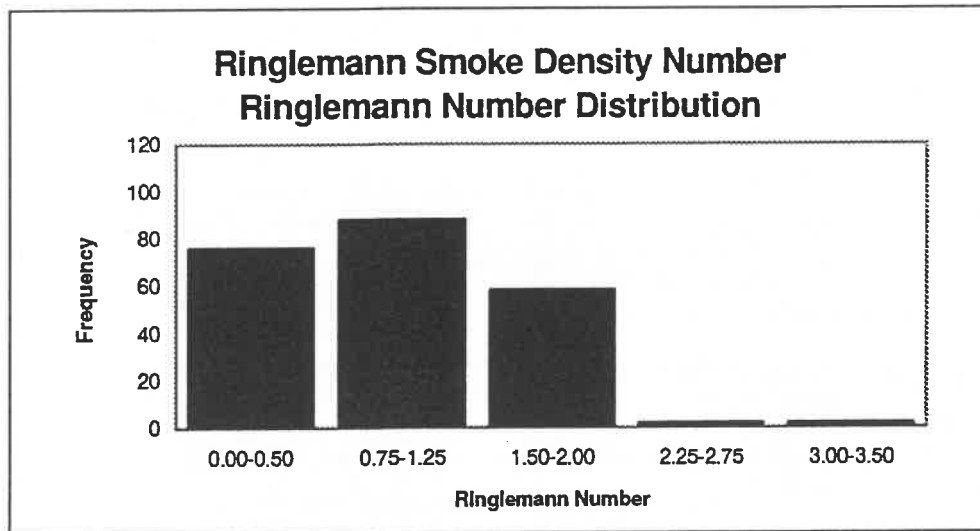
2.4 Baghouse Discharges

The regular inspection of the baghouse discharges continued during 1995. These inspections support the on-going operational surveillance of this equipment that ensures the required standards are maintained.

2.5 Carbon Baking Furnace Discharges

Carbon Baking Furnace discharges to air during 1995 were similar to those of 1994.

2.6 Ringlemann Number



Until obscuration by the discharge from the main stack can be measured photoelectrically, Ringlemann observations will continue to be used.

A report on the investigation into methods for continuing measurement of main stack opacity of discharge was provided to the Southland Regional Council in January 1996.

NZAS was unable to produce an effective "grey" Ringlemann chart. All observations recorded were using the standard Ringlemann chart.

2.7 Sulphur Content of Raw Materials and Fuels

The following table shows the maximum, minimum, and average sulphur content of raw materials and fuels delivered to the smelter during 1995.

Material	Units	Permit Maximum	1995 Annual Average	1995 maximum	1995 minimum
Petroleum coke	%	3.0	2.77	2.87	2.74
Packing/metallurgical coke	%	2.0	0.35	0.35	0.35
Pitch	%	1.0	0.45	0.47	0.42
Heavy fuel oil	%	3.5	2.21	2.40	1.92

Comments

All shipments of raw materials and fuels during 1995 met permit standards for sulphur content.

Chapter 3

Dispersion and Effects of Discharges to Air

Introduction

The discharges into air from the smelter and wharf are covered by Air Discharge Permit No. 93566 issued by the Southland Regional Council on 26 April 1994.

This chapter covers:

- meteorological conditions,
- ambient air gaseous and particulate fluoride,
- atmospheric deposition,
- fluoride in ungrazed grasses,
- fluoride in pinus radiata,
- the Grazing Monitor Project,
- the Tiwai Experimental Farms, and
- pasture fluoride analysis methods

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3.1 Meteorological Conditions

The mean wind frequency diagram on the following page shows that the 1995 wind pattern was dominated by westerly and north westerly winds.

The following table shows the predominant winds and total rainfall recorded for each month during 1995.

Month	Predominant Wind Direction	Rainfall (mm)
January	West and northwest	50
February	West and northwest	42
March	West and northwest	162
April	Variable	18
May	West, northwest and north	103
June	East	162
July	West and northwest	142
August	Variable	70
September	Northwest and north	88
October	West and northwest	96
November	West	38
December	West and northwest	125

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3.1 Meteorological Conditions

The mean wind frequency diagram on the following page shows that the 1995 wind pattern was dominated by westerly and north westerly winds.

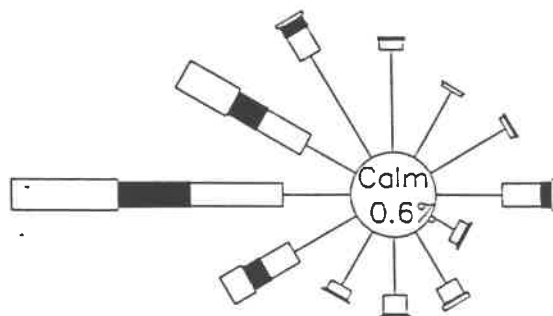
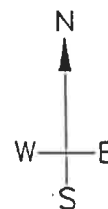
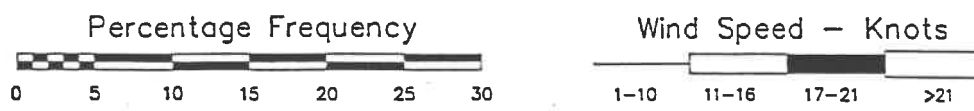
The following table shows the predominant winds and total rainfall recorded for each month during 1995.

Month	Predominant Wind Direction	Rainfall (mm)
January	West and northwest	50
February	West and northwest	42
March	West and northwest	162
April	Variable	18
May	West, northwest and north	103
June	East	162
July	West and northwest	142
August	Variable	70
September	Northwest and north	88
October	South west and west	96
November	Southwest and west	38
December	West	125

3.1 Meteorological Conditions, Continued

NEW ZEALAND ALUMINIUM SMELTERS LIMITED – TIWAI POINT
 WORKPLACE AND ENVIRONMENTAL MONITORING OUTPUT TEAM
 MEAN WIND FREQUENCY (%) OF SURFACE WIND DIRECTIONS
 MONTH: YEAR 1995

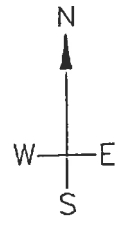
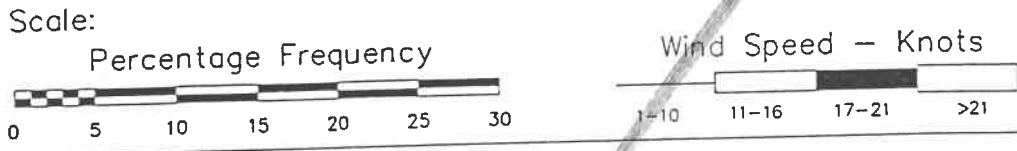
Scale:



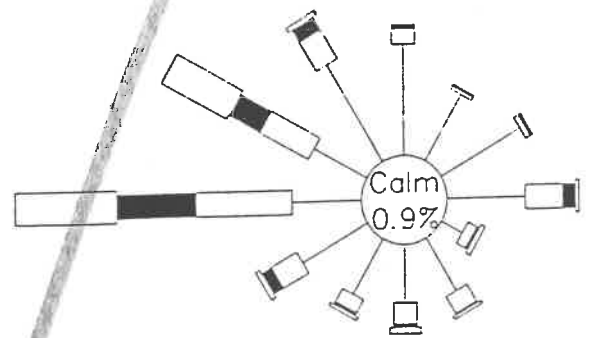
% Time at	
1-10 Knots	55.7
11-16 Knots	20.1
17-21 Knots	10.9
>21 Knots	13.2
Calm	0.6

3.1 Meteorological Conditions, Continued

NEW ZEALAND ALUMINIUM SMELTERS LIMITED - TIWAI POINT
 WORKPLACE AND ENVIRONMENTAL MONITORING OUTPUT TEAM
 MEAN WIND FREQUENCY (%) OF SURFACE WIND DIRECTIONS
 : YEAR 1995



MISSIVE MAY 1997



% Time at	
1-10 Knots	54.5
11-16 Knots	20.9
17-21 Knots	10.9
>21 Knots	12.8
Calm	0.9

3.2 Ambient Air Fluoride

Introduction

This section covers the monitoring of ambient air for gaseous fluoride and particulate fluoride concentrations at six monitoring sites and progress on projects to investigate the environmental effects of the smelter's discharges into air.

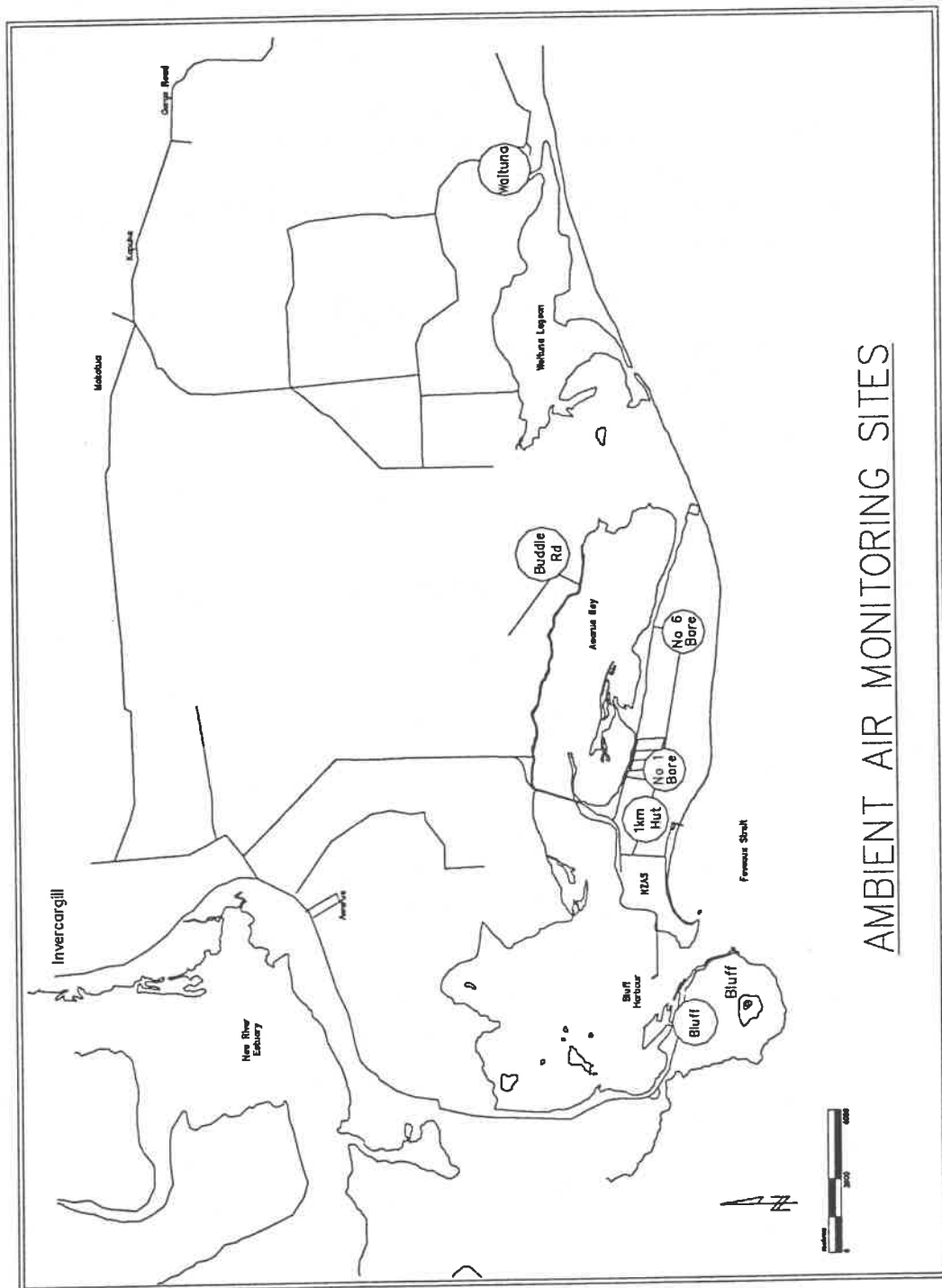
Site locations

The locations of the monitoring sites are shown in the map on the following page.

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3.2 Ambient Air Fluoride, Continued

Site locations, continued



AMBIENT AIR MONITORING SITES

3.2 Ambient Air Fluoride, Continued

Permit standards

The standards for ambient air gaseous fluoride covered by the air discharge permit are:

- 24 hour average 2.0 $\mu\text{g}/\text{m}^3$
- 7 day average 1.0 $\mu\text{g}/\text{m}^3$
- One month average 0.5 $\mu\text{g}/\text{m}^3$

The 24-hour average is not to be exceeded on more than eight days in any twelve consecutive months.

The standards apply to measurements on land off Tiwai Peninsula and on Tiwai Peninsula east of Comalco New Zealand Limited's freehold land.

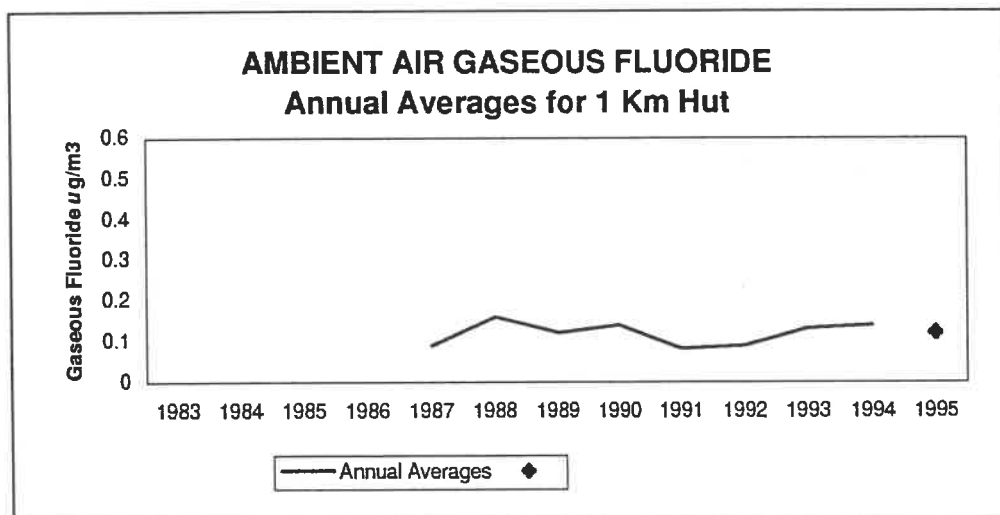
3.2.1 1 Kilometre Hut

Monitoring results

Reviews of the ambient gaseous fluoride concentrations at the 1 km hut and the operation of the Kyoto HF-18 analyser identified faults with the analyser which were the probable cause of the step change in the data in March 1995. All the data from March to December 1995 was probably affected by the faults and NZAS has withdrawn the data from the air discharge permit reports.

The review of the Kyoto HF-18 operation indicated that after March, the analyser was measuring approximately 42% of the gaseous fluoride concentration measured by the impregnated filter method.

The following graph shows the annual average ambient air fluoride concentrations at the 1 km hut. The 1995 average concentration of $0.12 \mu\text{g}/\text{m}^3$ shown on the graph is a corrected value with the results after March being increased to correct the error.

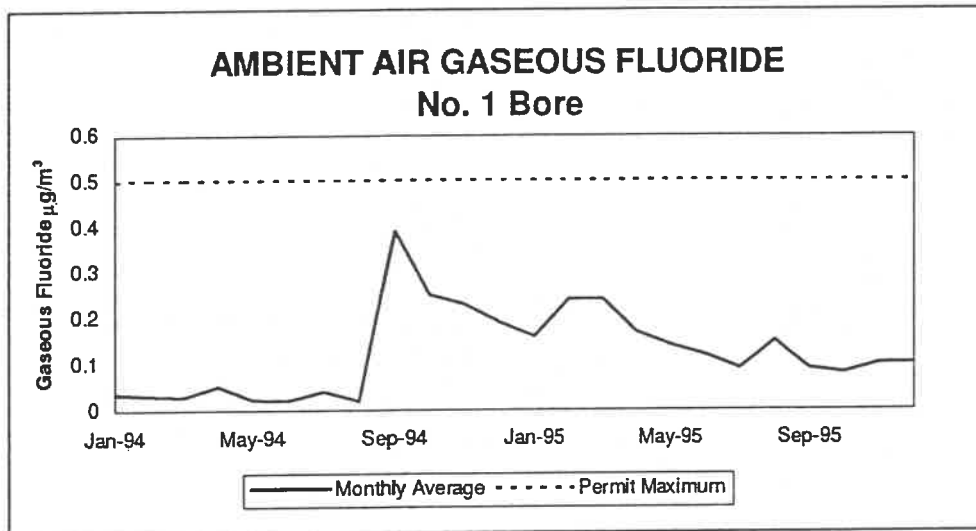


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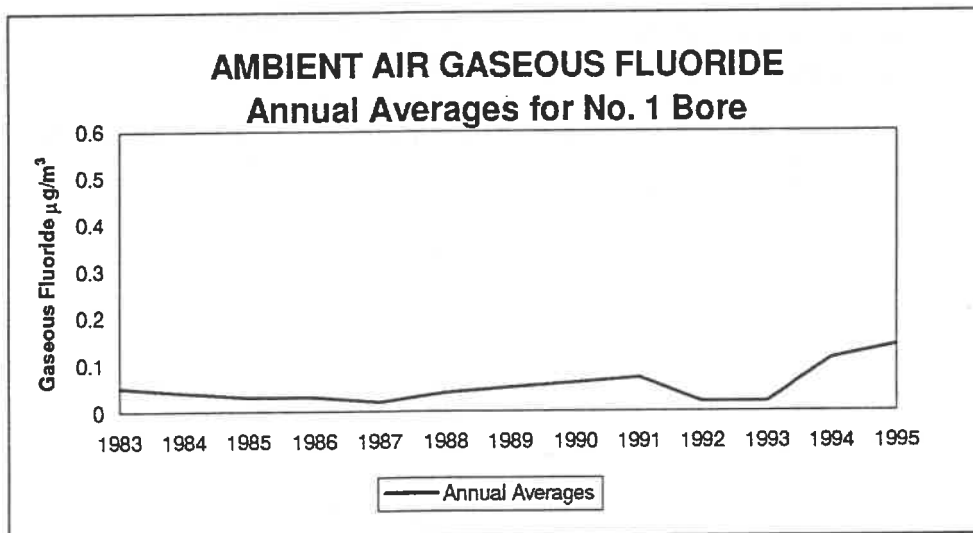
3.2.2 No. 1 Bore

Monitoring results

The following graph shows the monthly average ambient air gaseous fluoride concentration measured at the No.1 Bore site during 1994 and 1995.

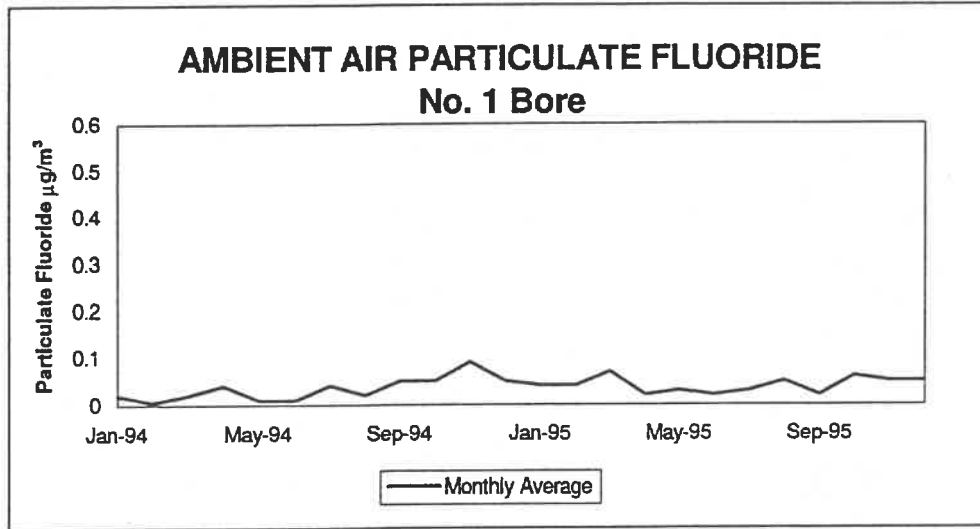


The following graph shows the annual average ambient air gaseous fluoride concentration measured at the No.1 Bore site.



3.2.2 No.1 Bore, continued

The following graph shows the monthly average ambient air particulate fluoride concentration measured at the No.1 Bore site during 1994 and 1995.



Comments

The 1995 average gaseous fluoride concentration of the ambient air at the No. 1 Bore was $0.14 \mu\text{g}/\text{m}^3$.

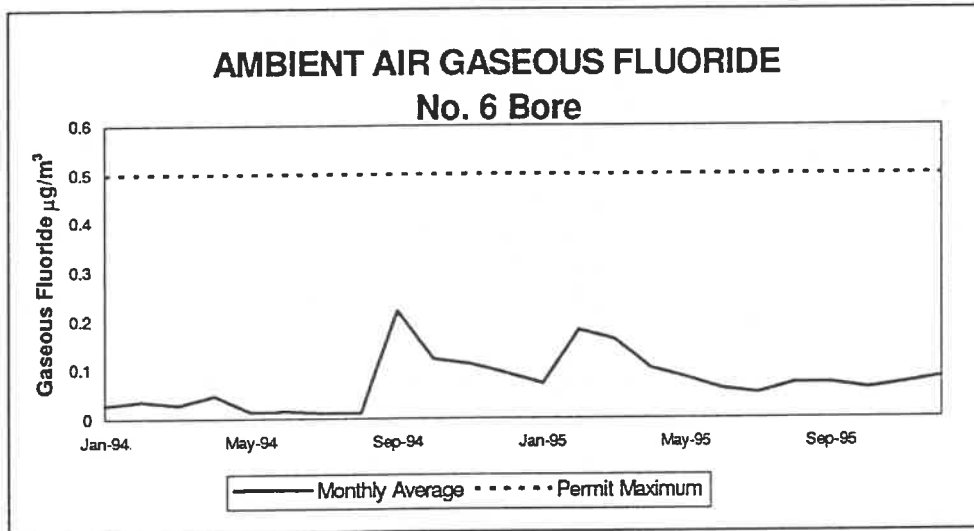
The highest seven day gaseous fluoride concentration was $0.36 \mu\text{g}/\text{m}^3$, measured in March. All permit standards were met at this site.

The particulate fluoride results for 1995 were within the expected range for this site.

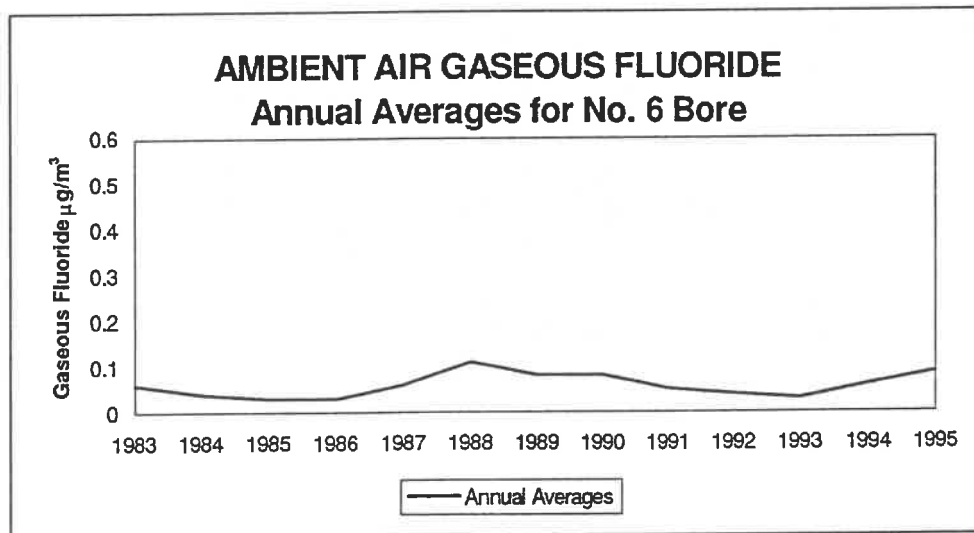
3.2.3 No.6 Bore

Monitoring results

The following graph shows the monthly average ambient air gaseous fluoride concentration measured at the No.6 Bore site during 1994 and 1995.



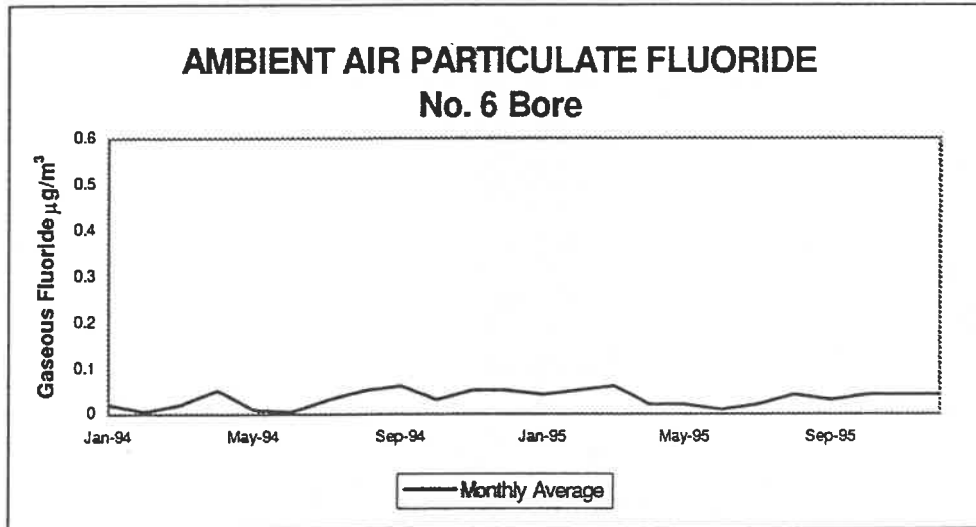
The following graph shows the annual average ambient air gaseous fluoride concentration measured at the No.6 Bore site.



3.2.3 No.6 Bore, continued

Monitoring results, continued

The following graph shows the monthly average ambient air particulate fluoride concentration measured at the No.6 Bore site during 1994 and 1995.



Comments

The 1995 average gaseous fluoride concentration of the ambient air at the No. 6 Bore was 0.09 µg/m³.

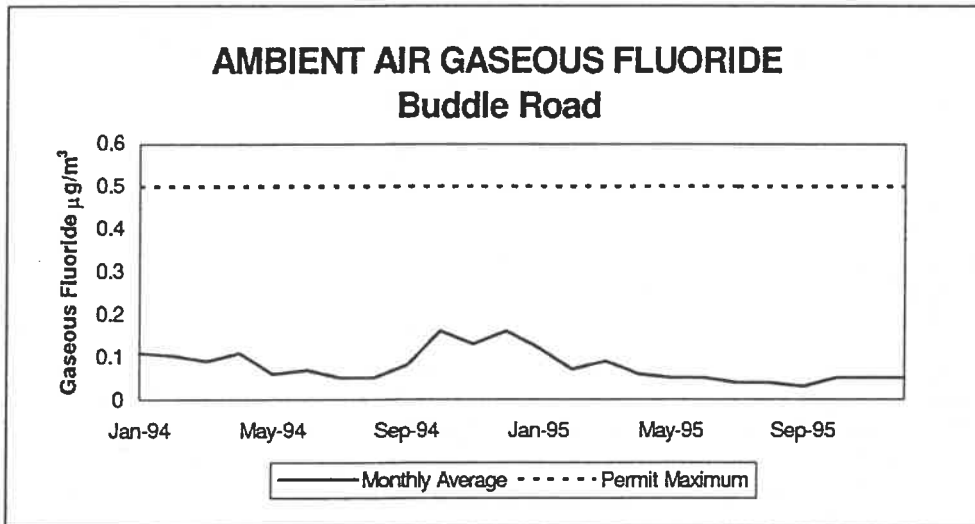
The highest seven day gaseous fluoride concentration was 0.26 µg/m³, measured in February. All permit standards were met at this site.

The particulate fluoride results for 1995 were within the expected range for this site..

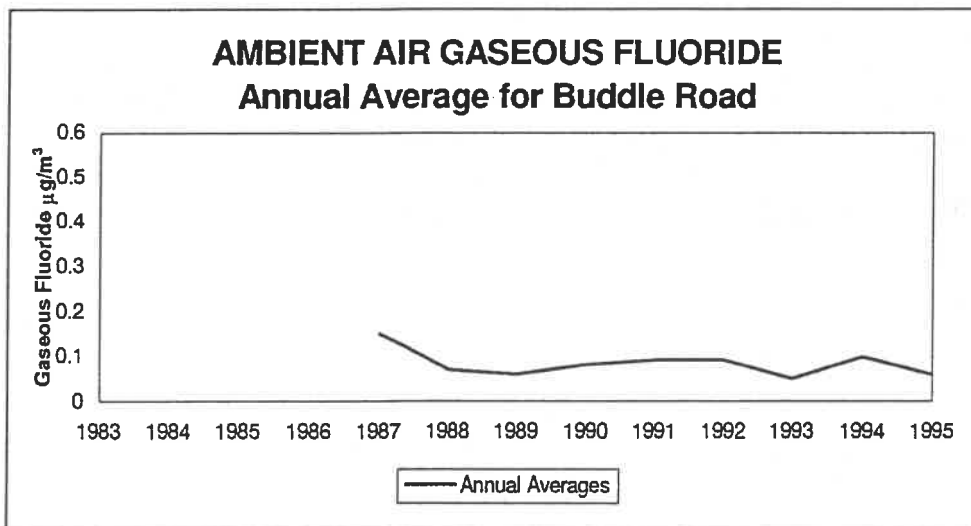
3.2.4 Buddle Road

Monitoring results

The following graph shows the monthly average gaseous fluoride concentration measured at the Buddle road site during 1994 and 1995.



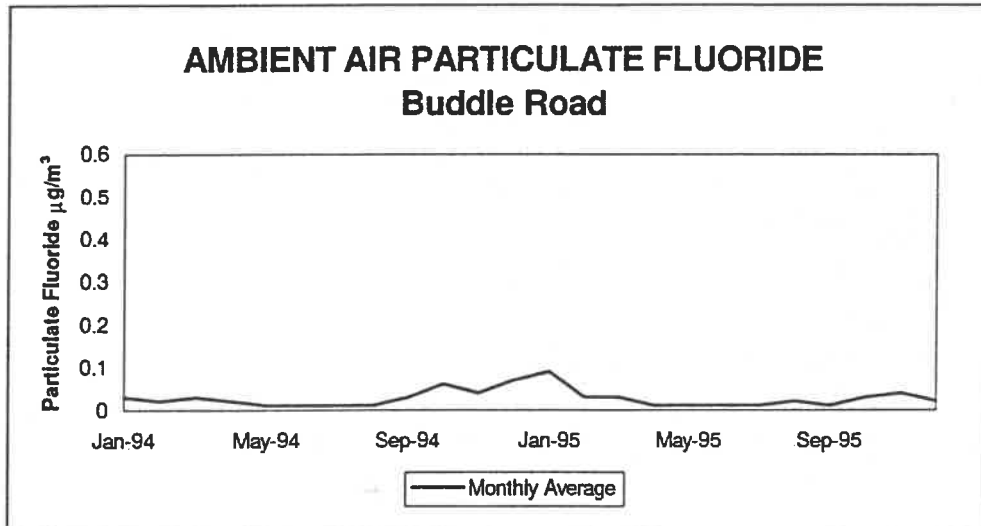
The following graph shows the annual average gaseous fluoride concentration measured at the Buddle Road site.



3.2.4 Buddle Road, continued

Monitoring results, continued

The following graph shows the monthly average particulate fluoride concentration measured at the Buddle Road site during 1994 and 1995.



Comments

The 1995 average gaseous fluoride concentration of the ambient air at Buddle Road was $0.06 \mu\text{g}/\text{m}^3$.

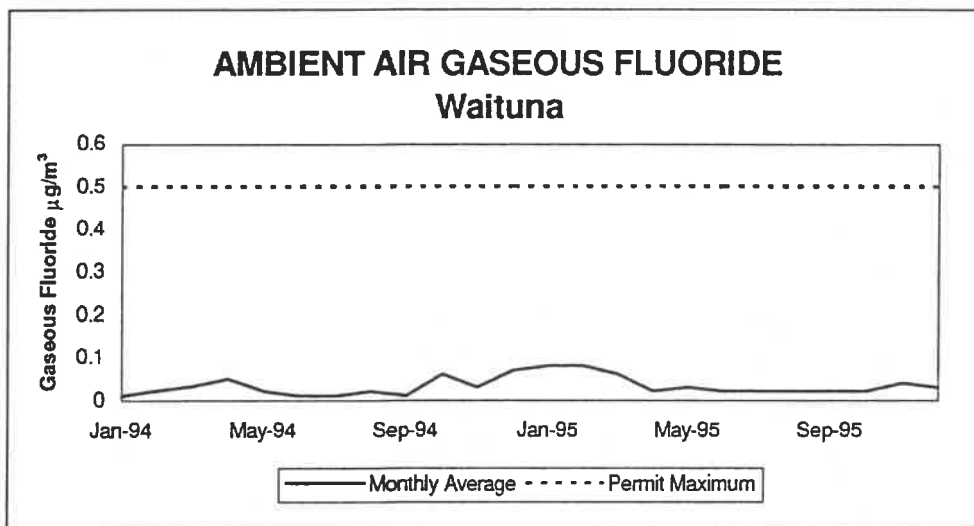
The highest seven day gaseous fluoride concentration was $0.24 \mu\text{g}/\text{m}^3$, measured in January. All permit standards were met at this site.

The particulate fluoride results for 1995 were within the expected range for this site.

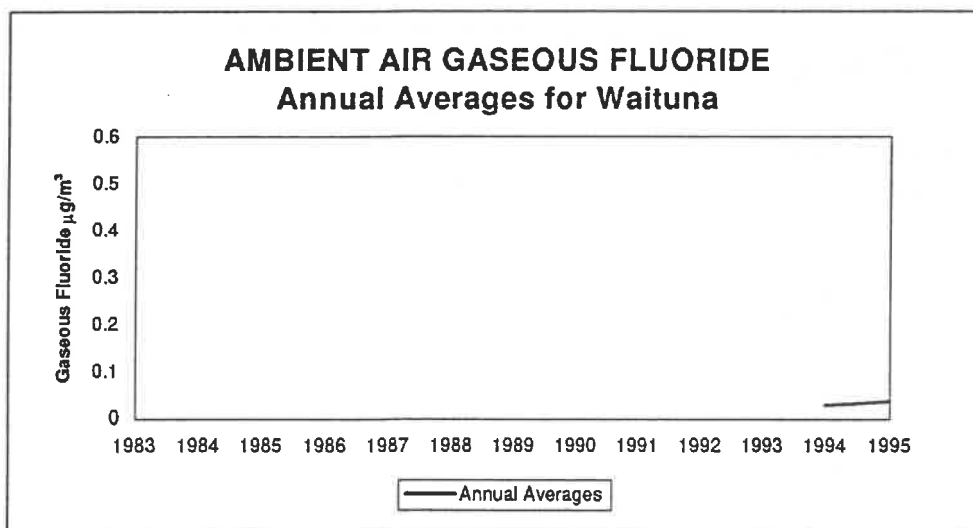
3.2.5 Waituna

Monitoring results

The following graph shows the monthly average gaseous fluoride concentration measured at the Waituna site during 1994 and 1995.

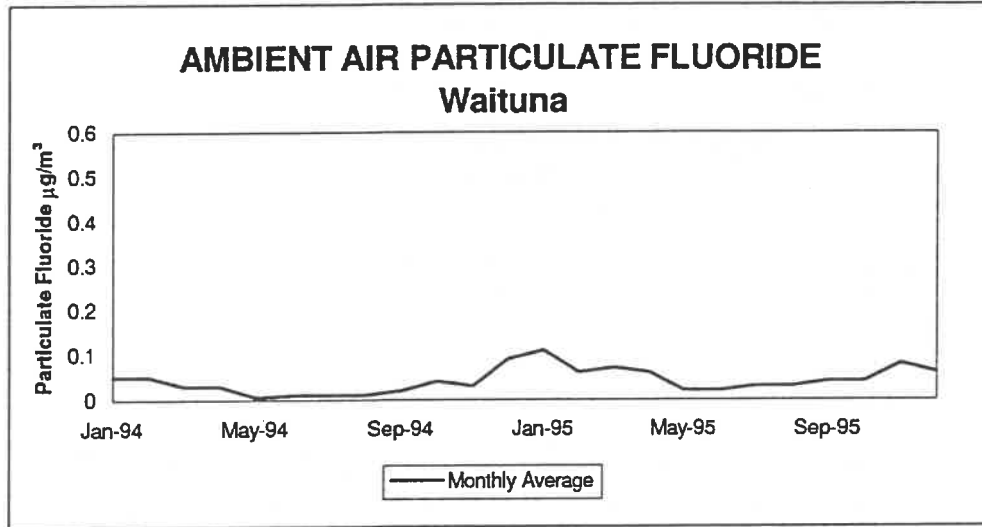


The following graph shows the annual average gaseous fluoride concentration measured at the Waituna site.



3.2.5 Waituna, continued

The following graph shows the monthly average particulate fluoride concentration measured at the Waituna site during 1994 and 1995.



Comments

The 1995 average gaseous fluoride concentration of the ambient air at the Waituna Hut was $0.04 \mu\text{g}/\text{m}^3$.

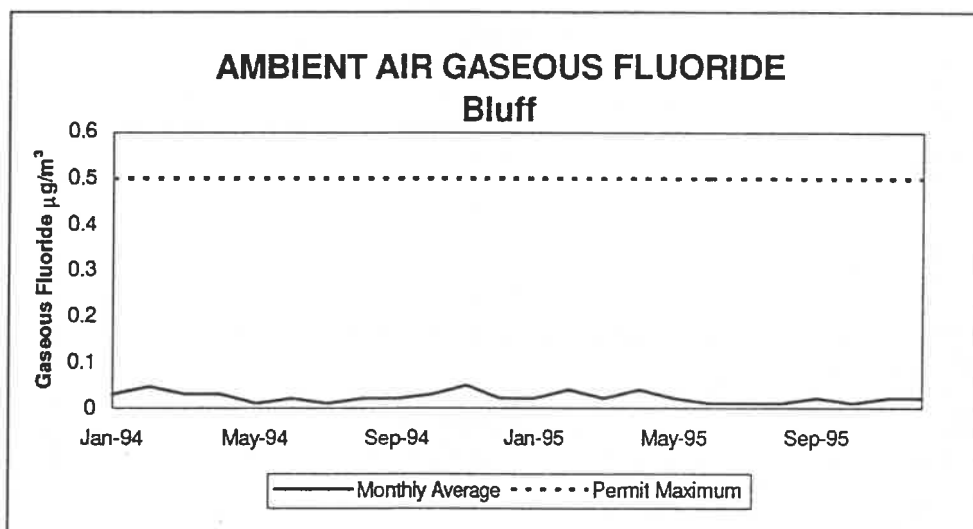
The highest seven day gaseous fluoride concentration was $0.17 \mu\text{g}/\text{m}^3$, measured in January. All permit standards were met at this site.

The particulate fluoride results for 1995 were low and within the expected range for this site.

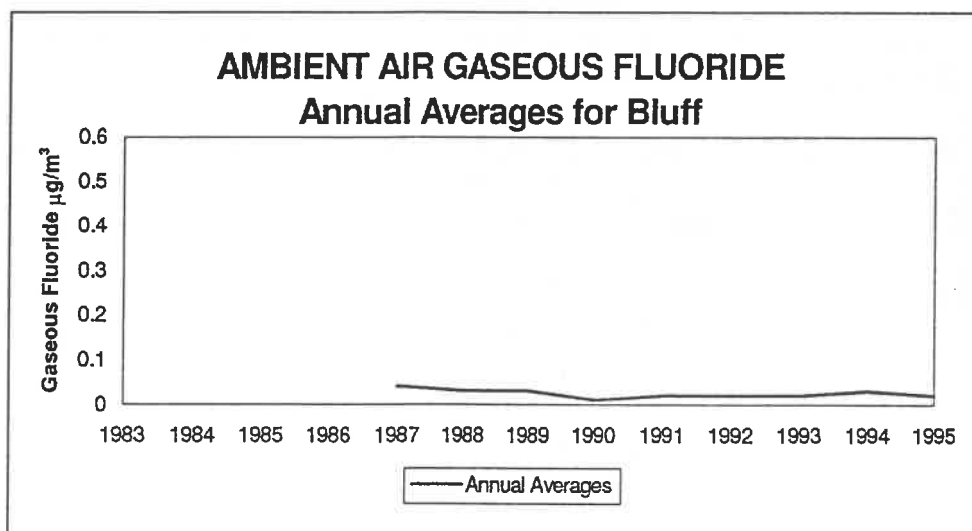
3.2.6 Bluff

Monitoring results

The following graph shows the monthly average gaseous fluoride concentration measured at the Bluff site during 1994 and 1995.

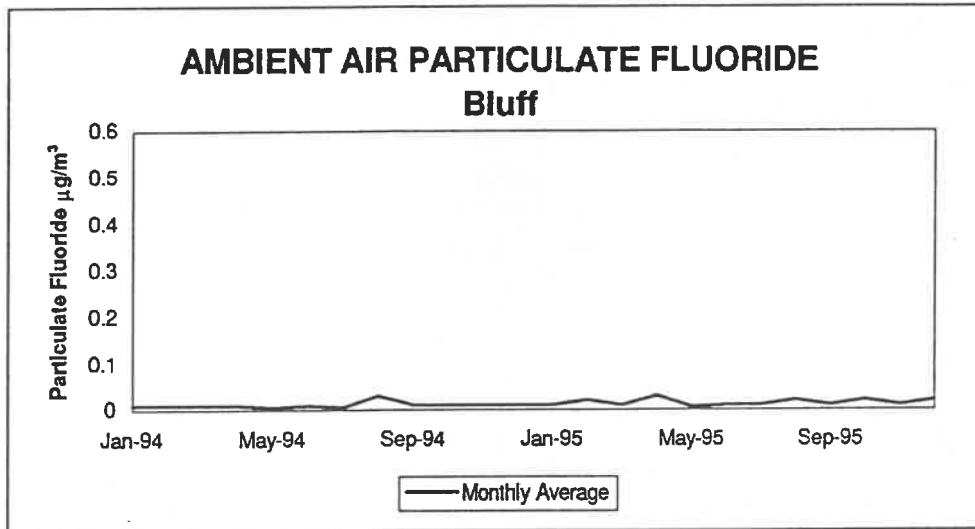


The following graph shows the annual average gaseous fluoride concentration measured at the Bluff site.



3.2.6 Bluff, continued

The following graph shows the monthly average particulate fluoride concentration measured at the Bluff site during 1994 and 1995.



Comments

The 1995 average gaseous fluoride concentration of the ambient air at the Bluff Hut was $0.02 \mu\text{g}/\text{m}^3$.

The highest seven day concentration was $0.06 \mu\text{g}/\text{m}^3$, measured in February and April. All permit standards were met at this site.

The particulate fluoride results for 1995 were within the expected range for this site.

3.2.7 BLP Model Prediction

Dames and Moore are contracted to the smelter to model the dispersion of the smelter's discharges to air. The Buoyant Line and Point Source (BLP) model was chosen to predict the dispersion of gaseous fluoride discharges.

The predicted mean ambient air gaseous fluoride concentrations caused by the discharge from the smelter during 1995 are shown on the map on the following page.

The following table shows a comparison between the model's predicted annual average fluoride concentrations at the smelter's ambient air monitoring sites and the actual concentrations found.

Site	Predicted 1995 Annual Average Ambient Air Gaseous Fluoride Concentration $\mu\text{g}/\text{m}^3$	Actual Annual 1995 Average Ambient Air Gaseous Fluoride Concentration $\mu\text{g}/\text{m}^3$
1 Km Hut	0.076	0.06
No.1 Bore	0.035	0.14
No.6 Bore	0.071	0.09
Buddle Road	0.040	0.06
Waituna	0.049	0.04
Bluff	0.050	0.02

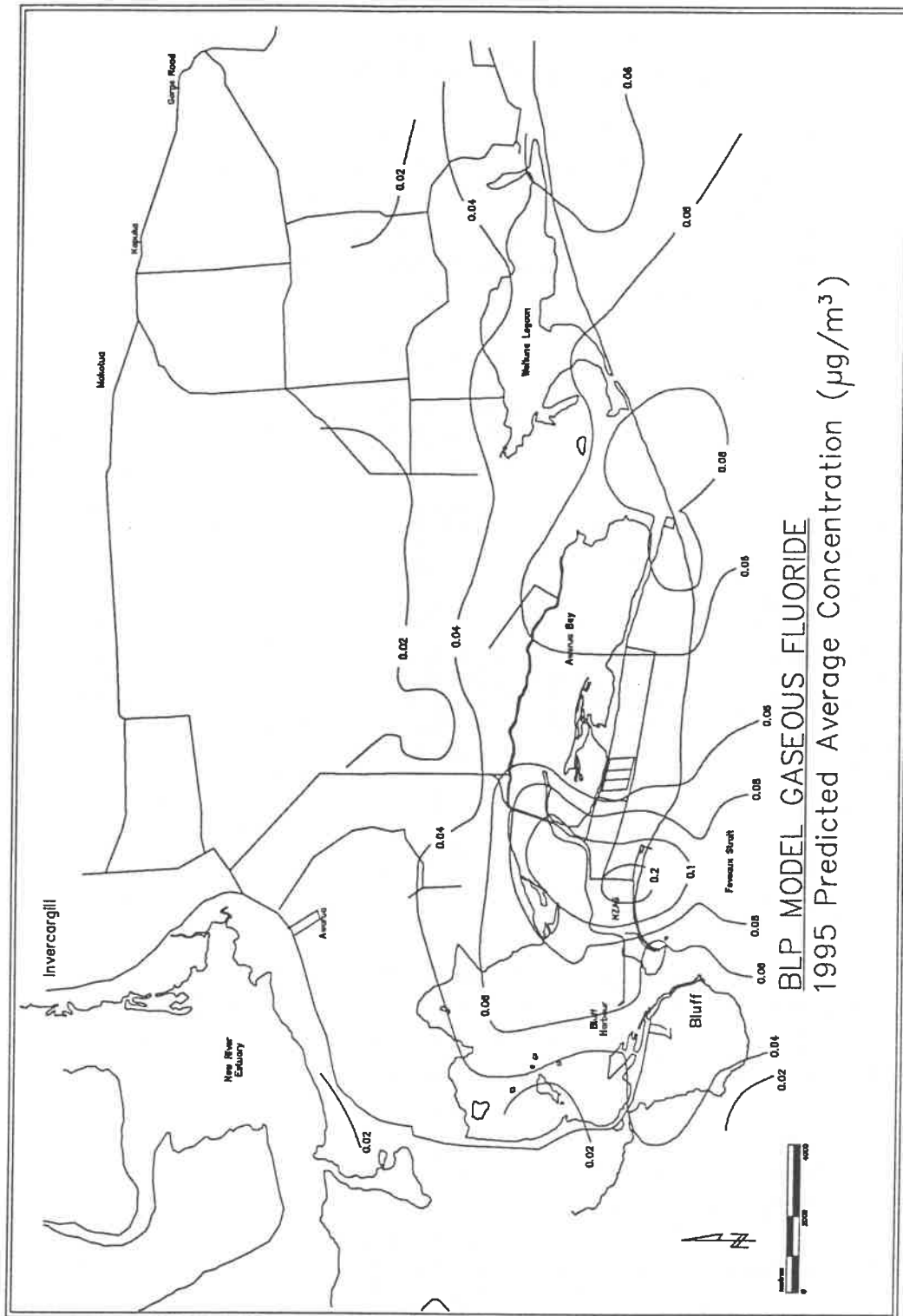
Comments

The predicted ambient air gaseous fluoride concentrations were generally in agreement with the actual results measured during 1995. The largest difference between measured and predicted values occurred at the No.1 Bore site. The difference may be explained by a combination of possible factors:

- errors in the meteorological data,
- uncertainty in stability estimates, and
- missing data during critical periods.

The automated weather station at Tiwai Point was damaged by lightning in August 1995. A replacement station was installed during September. The replacement equipment is hired from NIWA and is a standard unit used elsewhere in New Zealand by NIWA as part of the meteorological network.

3.2.7 BLP Model Prediction, continued



3.3 Atmospheric Deposition

Introduction

This section covers the monitoring of atmospheric deposit gauges at nine monitoring sites. The following three maps show the location of monitoring sites, average of the 1995 monthly fluoride and the average reactive aluminium results.

The sources of deposited fluoride include

- NZAS operations,
- burning of fossil fuels,
- application of fertiliser, and
- wind borne salt spray and dusts.

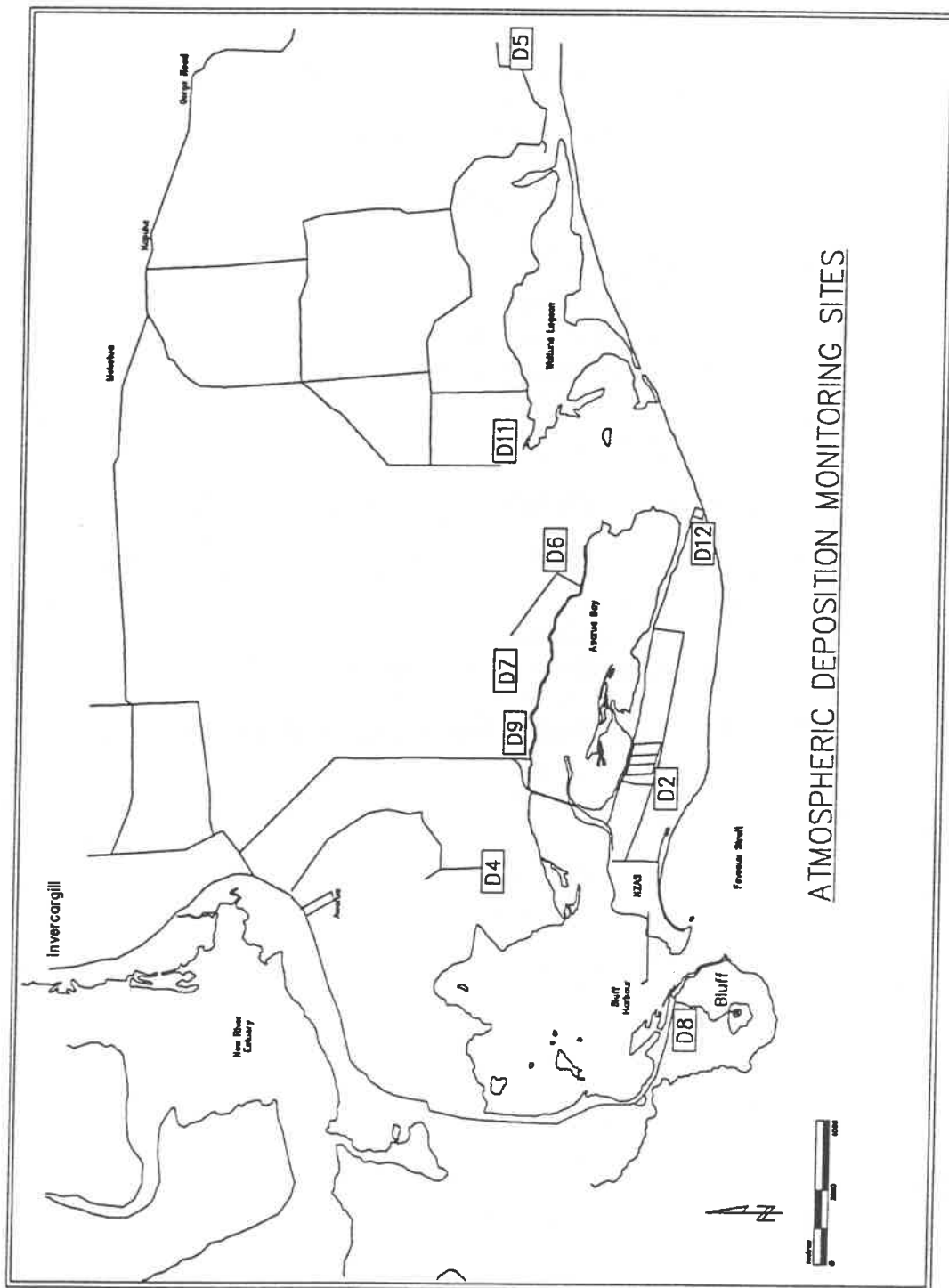
Permit guidelines

The guidelines for atmospheric deposition covered by the Air Discharge Permit are:

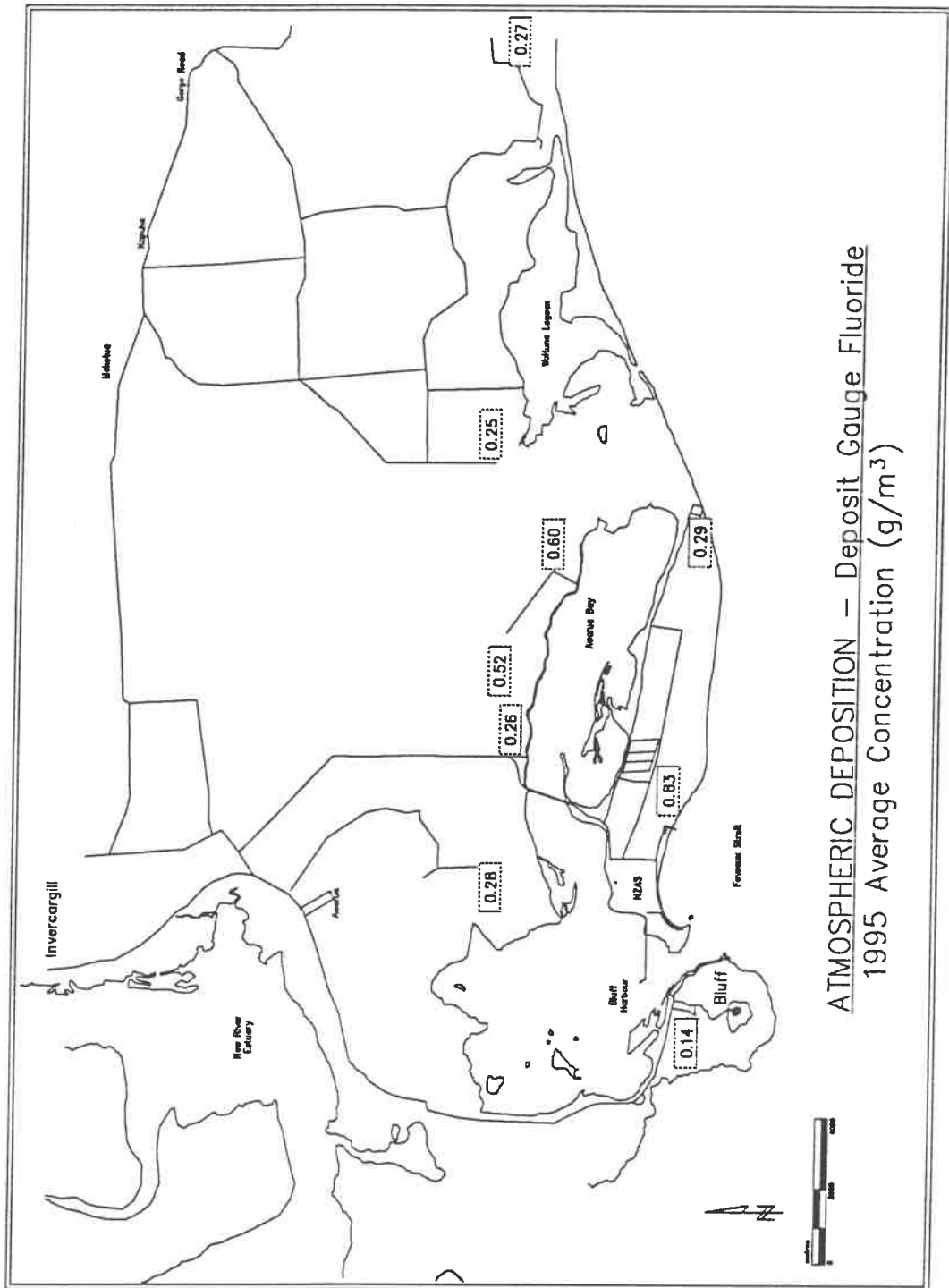
- fluoride 0.9 to 1.1 g/m³, and
- reactive aluminium
 - aesthetic highest desirable 0.05 g/m³
 - aesthetic excessive 0.20 g/m³

The guidelines apply only to land off Tiwai Peninsula.

3.3 Atmospheric Deposition, Continued

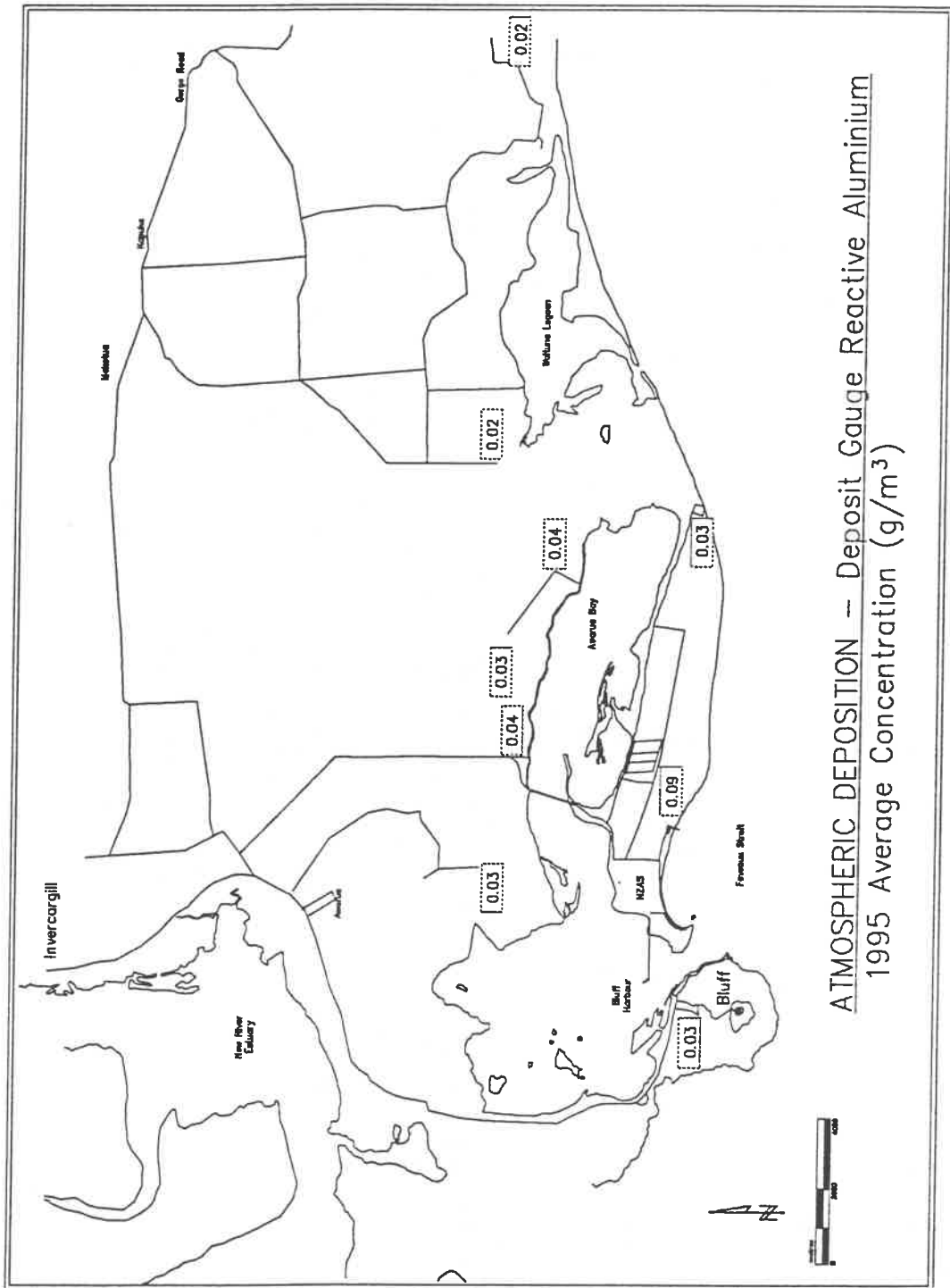


3.3 Atmospheric Deposition, Continued



ATMOSPHERIC DEPOSITION – Deposit Gauge Fluoride
1995 Average Concentration (g/m³)

3.3 Atmospheric Deposition, Continued



3.3 Atmospheric Deposition, Continued

Comment

The atmospheric deposition of fluoride and reactive aluminium was similar to previous years. The site with the greatest rate of fluoride deposition was D2 (No.1 Bore). This is the closest site downwind of the smelter. Even at this site the average concentration of fluoride (0.83 g/m^3) was towards the lower end of the range of fluoride concentrations recommended for oral health by the NZ Public Health Commission.

3.4 Fluoride in Ungrazed Grasses

Introduction

This section covers the monitoring of fluoride in ungrazed grasses at 25 monitoring sites located at Bluff, Green Hills, Awarua Plains, Waituna Wetlands and Tiwai Peninsula.

Permit guidelines

The guidelines in ungrazed grasses (on an unwashed, dry weight basis) on land off Tiwai Peninsula are detailed below. These guidelines came into effect in April 1994.

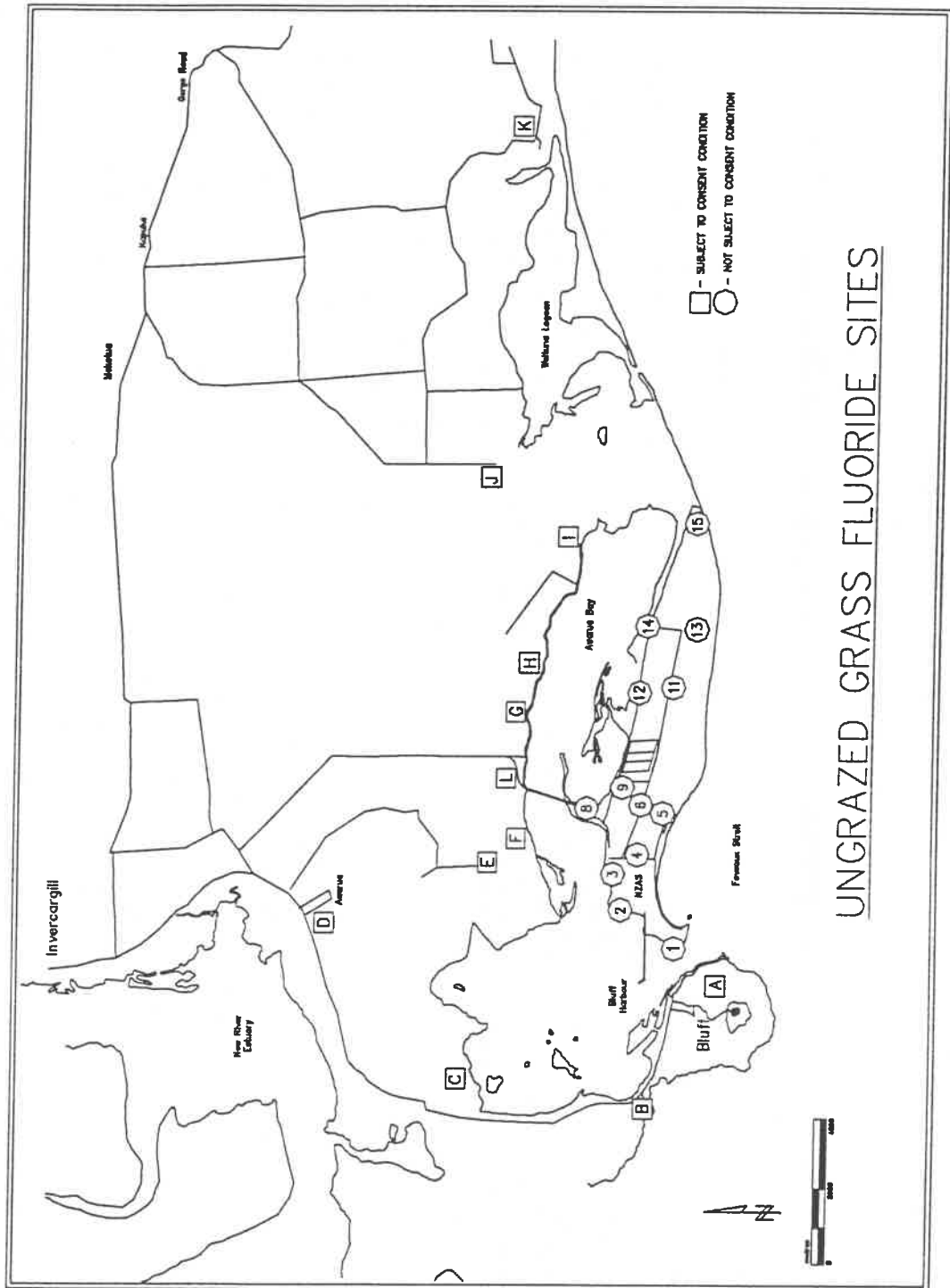
- A monthly sample shall not exceed 80 mg/kg more than once in any 12 consecutive months.
- Average of any two consecutive months shall not exceed 60 mg/kg.
- Running average of any 12 consecutive months shall not exceed 40 mg/kg.

Monitoring results

The ungrazed grass monitoring sites are shown on the map on the following page. This is followed by a map showing the annual average fluoride results at these sites for 1995.

3.4 Fluoride in Ungrazed Grasses, Continued

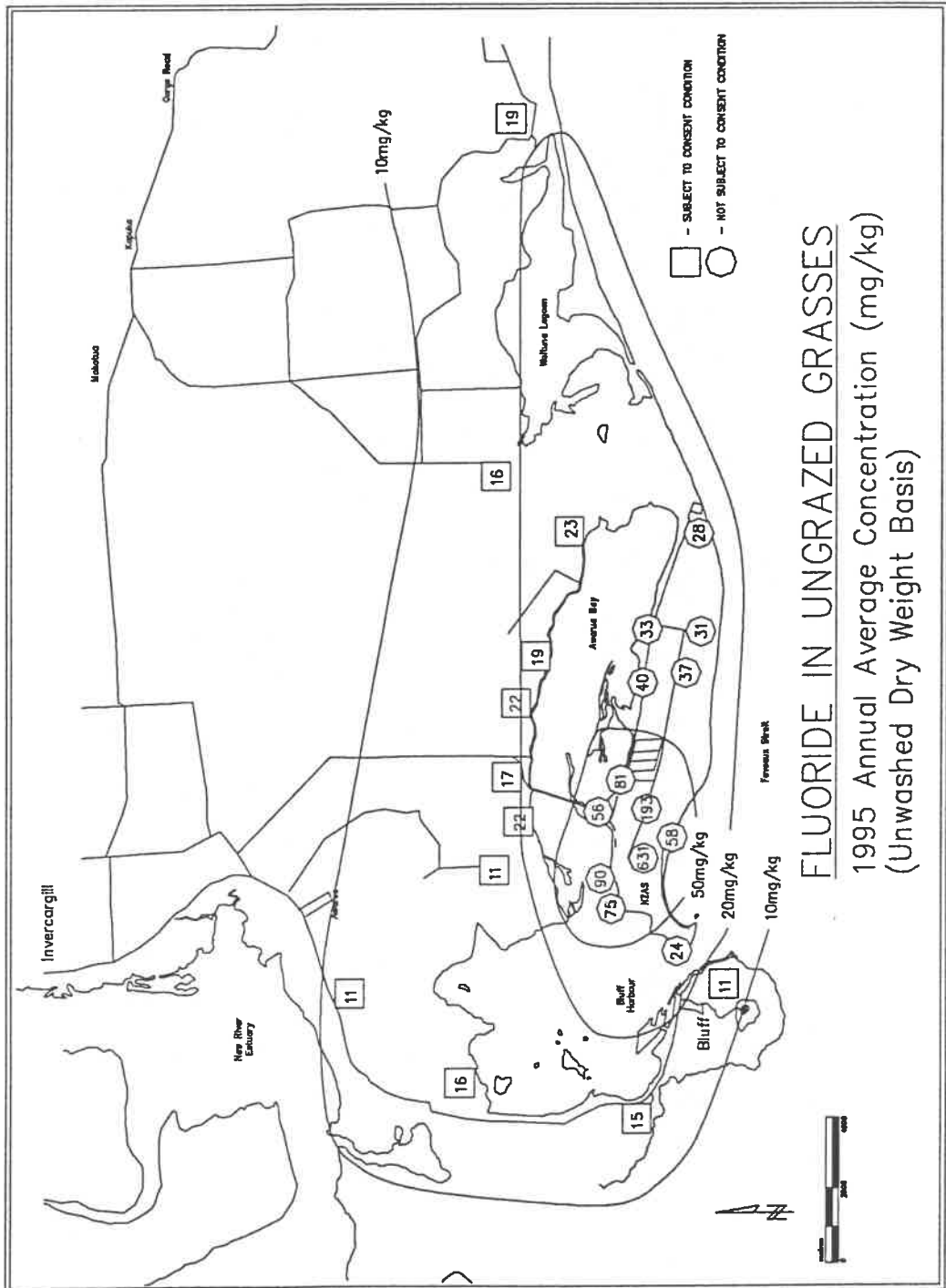
Monitoring Results, continued



UNGRAZED GRASS FLUORIDE SITES

3.4 Fluoride in Ungrazed Grasses, Continued

Monitoring Results, continued



3.4 Fluoride in Ungrazed Grasses, Continued

Monitoring results

The table below shows maximum monthly fluoride concentrations for sites off Tiwai Peninsula.

Sites off Tiwai Peninsula	Permit Guidelines	Maximum Monthly Result mg/kg
Ungrazed Grass Site A	80	28
Ungrazed Grass Site B	80	50
Ungrazed Grass Site C	80	48
Ungrazed Grass Site D	80	21
Ungrazed Grass Site E	80	16
Ungrazed Grass Site F	80	41
Ungrazed Grass Site G	80	35
Ungrazed Grass Site H	80	33
Ungrazed Grass Site I	80	29
Ungrazed Grass Site J	80	26
Ungrazed Grass Site K	80	45
Ungrazed Grass Site L	80	32

The fluoride concentration in ungrazed grass was within the permit guidelines for all sites during 1995.

3.4 Fluoride in Ungrazed Grasses, Continued

Monitoring results, continued

The table below shows maximum 2 monthly running average fluoride concentrations for sites off Tiwai Peninsula.

Sites off Tiwai Peninsula	Permit Guidelines	Maximum 2 Monthly Average mg/kg
Ungrazed Grass Site A	60	20
Ungrazed Grass Site B	60	33
Ungrazed Grass Site C	60	32
Ungrazed Grass Site D	60	17
Ungrazed Grass Site E	60	14
Ungrazed Grass Site F	60	34
Ungrazed Grass Site G	60	31
Ungrazed Grass Site H	60	32
Ungrazed Grass Site I	60	48
Ungrazed Grass Site J	60	33
Ungrazed Grass Site K	60	34
Ungrazed Grass Site L	60	26

The average bimonthly fluoride concentration in ungrazed grass was within the permit guideline for all sites during 1995.

3.4 Fluoride in Ungrazed Grasses, Continued

Monitoring results, continued

The table below shows maximum 12 monthly running average fluoride concentrations for sites off Tiwai Peninsula.

Sites off Tiwai Peninsula	Permit Guideline	Maximum 12 Monthly Average mg/kg
Ungrazed Grass Site A	40	12
Ungrazed Grass Site B	40	15
Ungrazed Grass Site C	40	26
Ungrazed Grass Site D	40	12
Ungrazed Grass Site E	40	11
Ungrazed Grass Site F	40	23
Ungrazed Grass Site G	40	24
Ungrazed Grass Site H	40	20
Ungrazed Grass Site I	40	28
Ungrazed Grass Site J	40	18
Ungrazed Grass Site K	40	19
Ungrazed Grass Site L	40	19

The twelve month average fluoride concentration in ungrazed grass was within the permit guideline for all sites during 1995.

Comments

The fluoride concentration in ungrazed grass was similar to previous years.

3.5 Fluoride in Pinus Radiata

Introduction

This section covers the monitoring of fluoride in pinus radiata at 15 monitoring sites. The location of these sites is shown on the following page.

Monitoring results

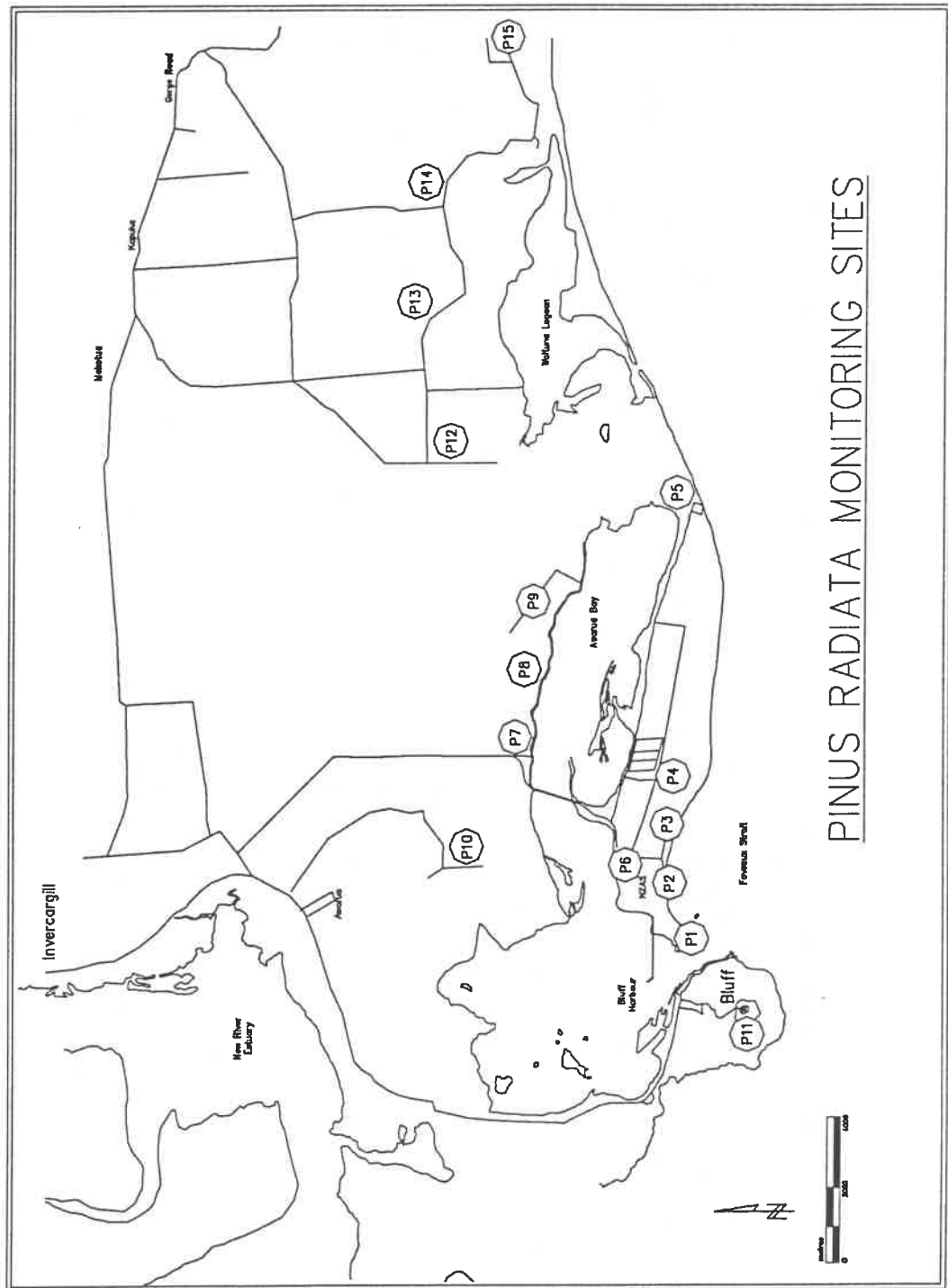
This is followed by a map showing the annual average fluoride in pinus radiata needle. Samples are taken quarterly and the four results for 1995 were averaged to give the annual average.

Comments

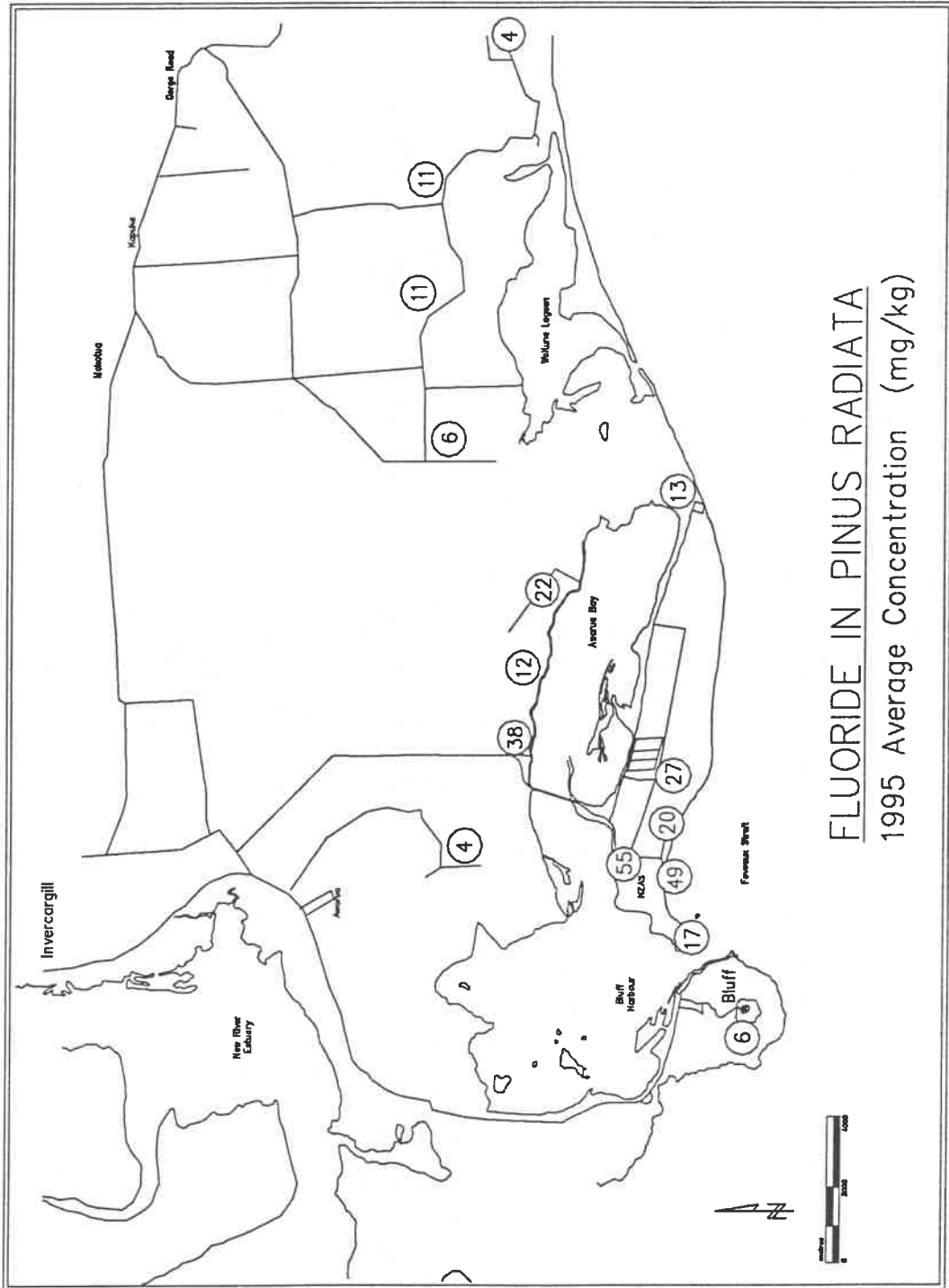
Pinus radiata needles between one and two years of age are sampled quarterly. The guideline for fluoride in washed pinus radiata needles on land off Tiwai Peninsula is 75 mg/kg.

All fluoride results are less than the permit guideline.

3.5 Fluoride in Pinus Radiata, Continued



3.5 Fluoride in Pinus Radiata, Continued



3.6 Grazing Monitor Project

Introduction

This section covers the monitoring of:

- fluoride in grazed pasture,
- fluoride in cattle urine,
- fluoride in cattle bone, and
- cattle dental effects.

The Grazing Monitor Project was established in 1969 prior to the smelter being commissioned. The project has continued since then, with modifications, as part of the smelter's Environmental Monitoring Program.

The Air Discharge Permit requires that fluoride in grazed pasture be monitored at nine sites off Tiwai Peninsula. Currently ten sites are monitored are. These are:

- Grazing Monitor Farm No. 1,
- Grazing Monitor Farm No. 2,
- Grazing Monitor Farm No. 3,
- Grazing Monitor Farm No. 4,
- Grazing Monitor Farm No. 10,
- Grazing Monitor Farm No. 11,
- Grazing Monitor Farm No. 12,
- Grazing Monitor Farm No. 14,
- Grazing Monitor Farm No. 15, and
- Grazing Monitor Farm No. 16.

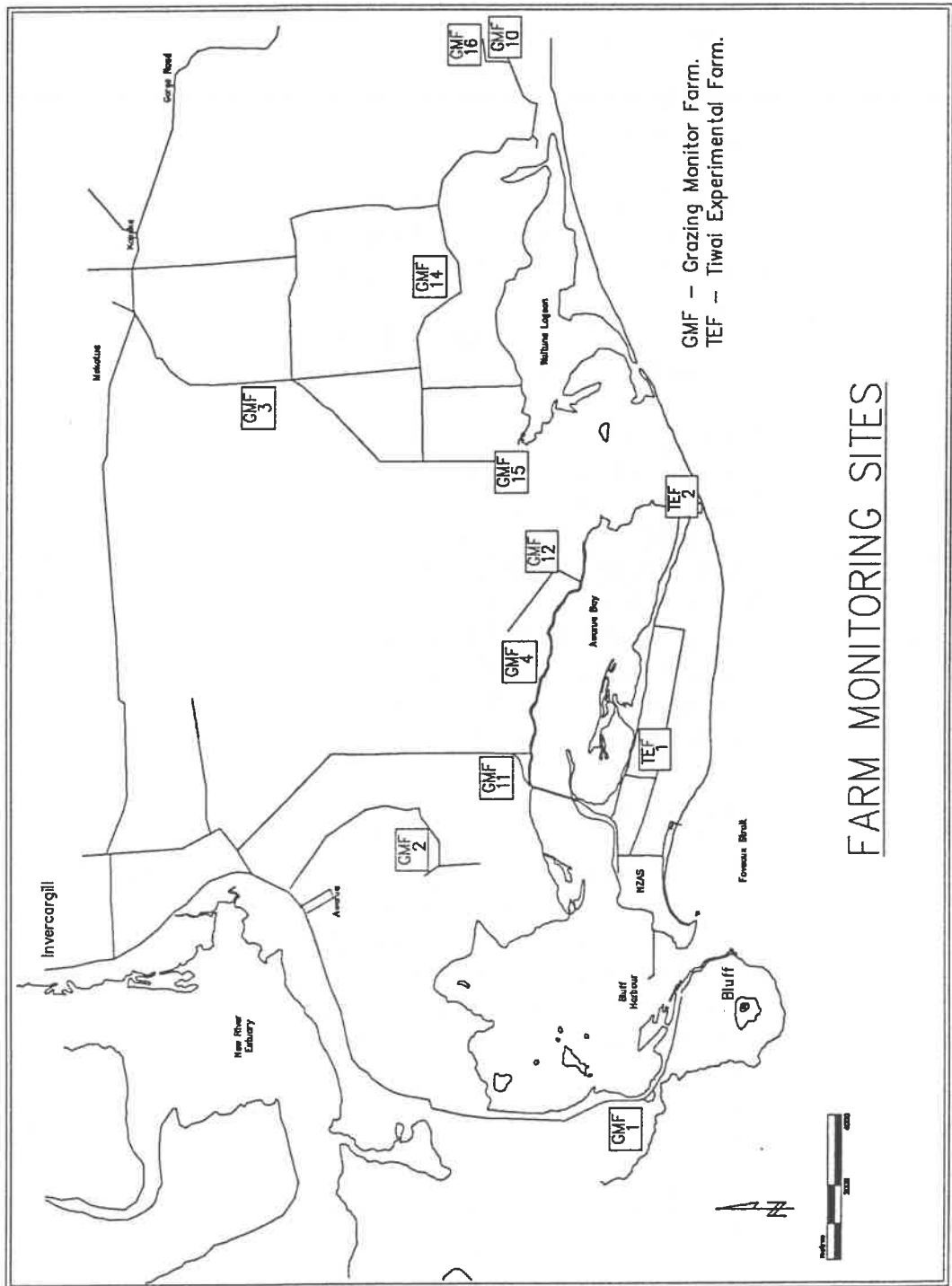
Grazing Monitor Farm No. 10 (GMF10) and GMF16 are two sites on the same farm at the east end of Waituna Lagoon. Monitoring at the GMF 16 site began in mid 1994 when this farm was included in the livestock monitoring program. A new grazed grass monitoring site (GMF16), which is more representative of the grass the milk production cows eat, was selected. The existing site on this farm (GMF10) is a house paddock and not routinely used for feeding production stock. It is proposed that GMF10 will be removed from the program once the relationship between the two sites is determined.

The following map shows the location of the farms included in the Grazing Monitor Project.

Also included in the map are the locations of the two Tiwai Experimental Farms.

3.6 Grazing Monitor Project, Continued

Introduction, continued



FARM MONITORING SITES

3.6 Grazing Monitor Project, Continued

Introduction, continued

The Air Discharge Permit requires that cattle be monitored on two dairy and two beef farms. The dairy farms monitored are:

- GMF14, and
- GMF16.

The two beef farms monitored are:

- GMF1, and
- GMF4.

The cattle parameters to be monitored to comply with the Air Discharge Permit are:

- urinary fluoride,
- bone fluoride, and
- dental effects.

Permit standards

The permit contains a number of standards. A standard is defined in the permit as a limit which is not to be breached.

The standards for fluoride in grazed pasture (on an unwashed, dry weight basis) on land off Tiwai Peninsula are:

- monthly sample shall not exceed 80 mg/kg more than once in any 12 consecutive months.
- the average of any two consecutive months samples shall not exceed 60 mg/kg, and
- running averages of monthly samples for a period of twelve months shall not exceed 40 mg/kg.

3.6 Grazing Monitor Project, Continued

Permit guidelines

The permit also contains a number of guidelines. A guideline is defined in the permit as a level which is set on best current knowledge, the exceeding of which requires further investigation or other action. Exceeding a guideline does not constitute non-compliance.

The guidelines for animal health monitoring are:

- urinary fluoride in dairy and beef cattle should not exceed 10 mg/L corrected to S.G. 1.030,
- bone fluoride concentrations as measured in metacarpal/metatarsal bones are:
 - * 1605 mg/kg for two year olds,
 - * 2379 mg/kg for four year olds, and
 - * 2794 mg/kg for six year olds.

The bone samples collected for measuring fluoride concentrations are from tail bone biopsies and the results are converted to metacarpal/ metatarsal fluoride concentration by the following conversion.

Fluoride (F) in dry fat free metacarpal/metatarsal bone = F in ashed tailbone * 0.5.

3.6.1 Grazing Monitor Farm No.1

The following information is contained in this section:

- fluoride in grazed pasture,
- cattle urinary fluoride,
- cattle bone fluoride,
- cattle dental effects, and
- comments on the monitoring.

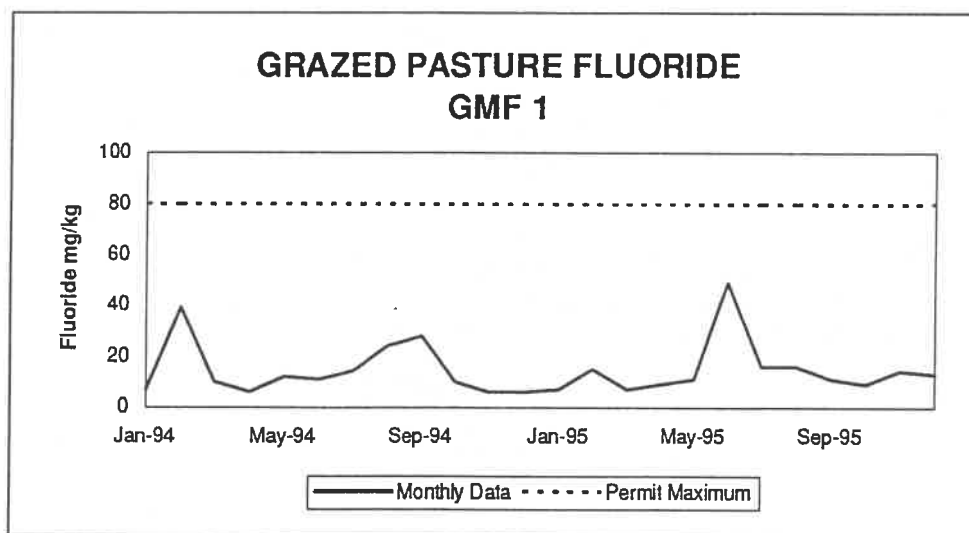
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1995.

	Units	Permit	1995 maximum
Monthly sample	mg/kg	80	49
Two monthly average	mg/kg	60	33
Running twelve monthly average	mg/kg	40	16

The annual average for 1995 was 15 mg/kg.

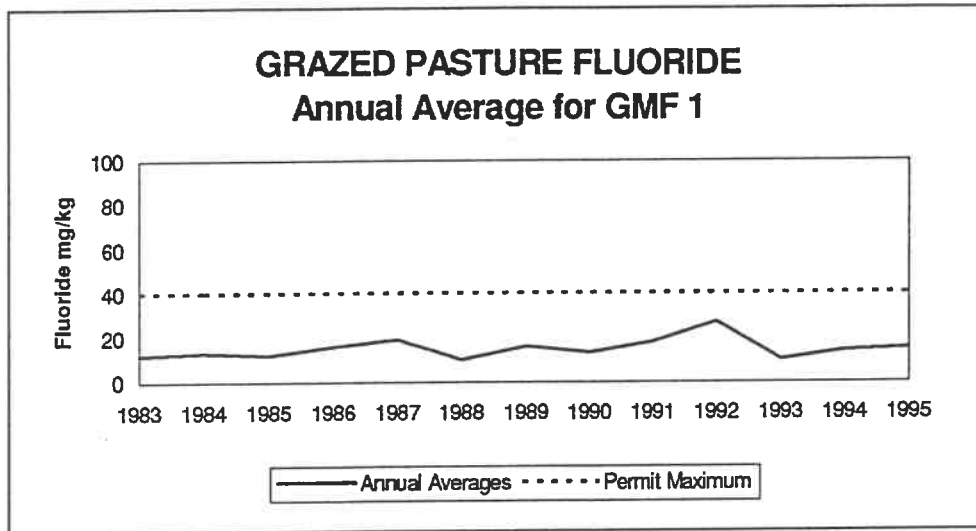
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1995



3.6.1 Grazing Monitor Farm No.1, continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Cattle urinary fluoride

The following table summarises the results of cattle urinary fluoride monitoring during 1995.

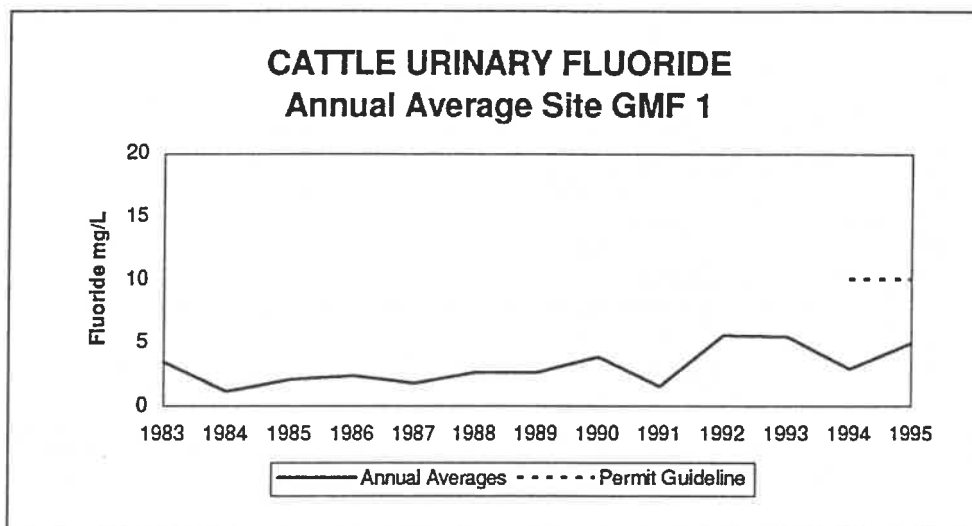
	Units	Permit Guideline	Result
Average fluoride concentration	mg/L		5.0
Maximum fluoride concentration	mg/L	10	8.0
Minimum fluoride concentration	mg/L	-	2.9
No. of samples		-	9

No samples collected exceeded the permit guideline.

3.6.1 Grazing Monitor Farm No.1, continued

Cattle urinary fluoride, continued

The following graph shows the annual average for fluoride in cattle urine.



Cattle bone fluoride

The following table shows the results of bone fluoride monitoring during 1995.

Identification	Age	Units	Permit Guideline	Fluoride
No 9	2	mg/kg	1605	775
103	2	mg/kg	1605	750
101	4	mg/kg	2379	1000
No 2	7	mg/kg	-	1025

Note: The bone fluoride concentration is converted to dry fat free metacarpal/metatarsal.

3.6.1 Grazing Monitor Farm No.1, continued

Cattle dental effects

The following table summarises the results of the dental inspection of cattle during 1995.

	Results
Average tooth score	2
Maximum tooth score	2
Minimum tooth score	2
No. of cattle inspected	7

Note: The tooth scoring system follows the method of Suttie, and only permanent incisors are included in the table. The teeth inspected were in cattle aged from two to seven years, and all scored as 2. These teeth will have formed between 1988 and 1993.

Comments

The results of the monitoring on this farm were all within the permit standards and guidelines during 1995. The results of grazed pasture fluoride, cattle urinary fluoride, and cattle dental effects monitoring were within the range experienced on this farm over the previous five years. The fluoride concentration of bone in a four year old cow and a seven year old cow were both above 1000mgF/kg. This was higher than in recent years. However the concentrations are lower than samples from similar aged animals grazing on GMF1 in 1980.

3.6.2 Grazing Monitor Farm No. 2

The following information is contained in this section:

- fluoride in grazed pasture, and
- comments on the monitoring.

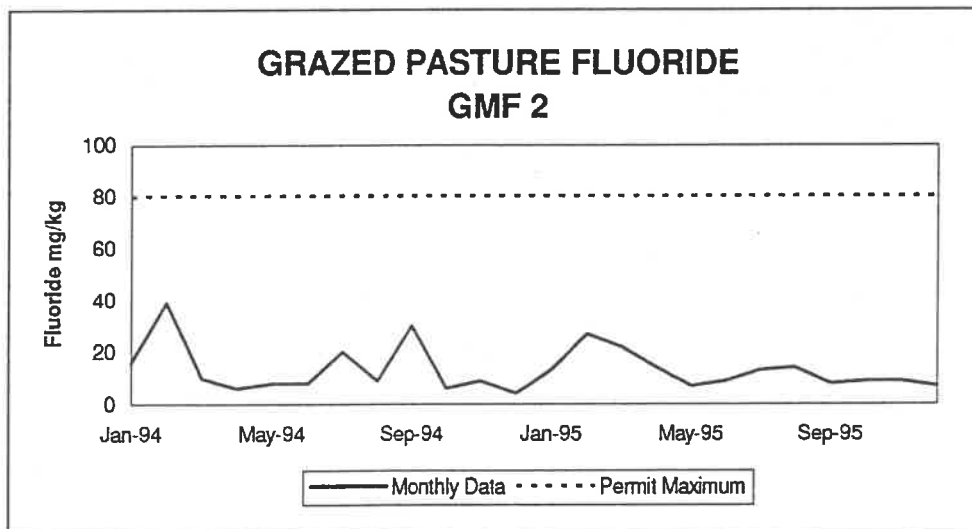
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1995.

	Units	Permit	1995 maximum
Monthly sample	mg/kg	80	27
Two monthly average	mg/kg	60	25
Twelve monthly average	mg/kg	40	14

The annual average for 1995 was 13 mg/kg.

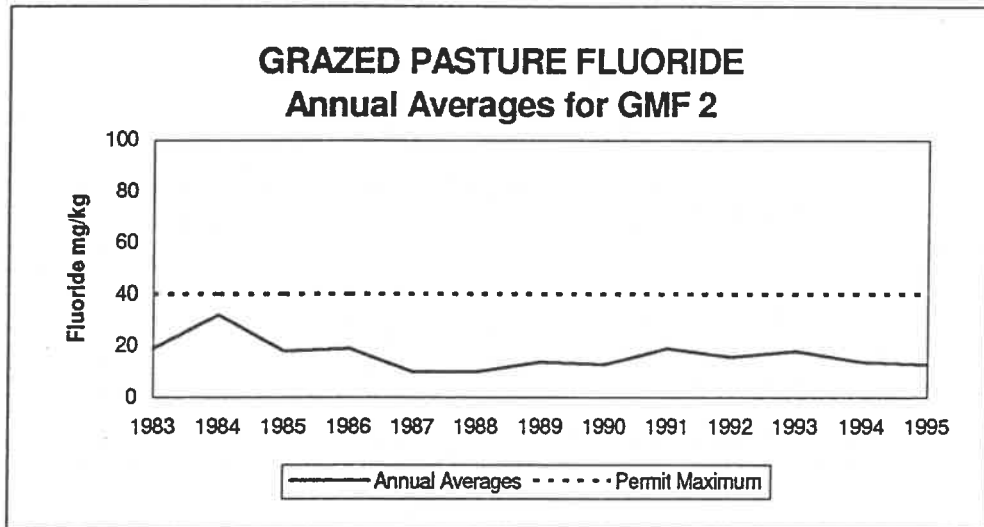
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1994 and 1995.



3.6.2 Grazing Monitor Farm No. 2, continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Comments

The fluoride in grazed pasture was within the permit standards for this farm during 1995 and no trends are evident.

3.6.3 Grazing Monitor Farm No. 3

The following information is contained in this section:

- fluoride in grazed pasture, and
- comments on the monitoring.

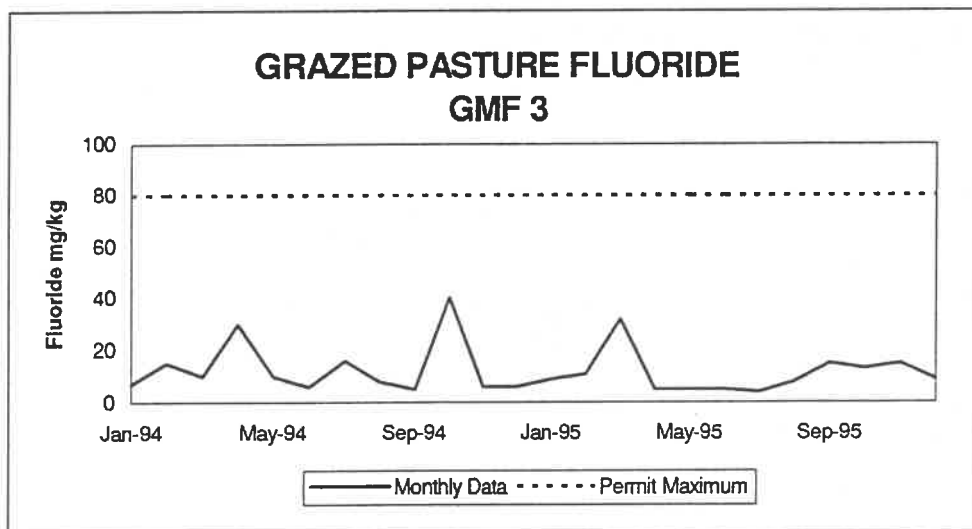
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1995.

	Units	Permit	1995 maximum
Monthly sample	mg/kg	80	32
Two monthly average	mg/kg	60	22
Twelve monthly average	mg/kg	40	15

The annual average for 1995 was 11 mg/kg.

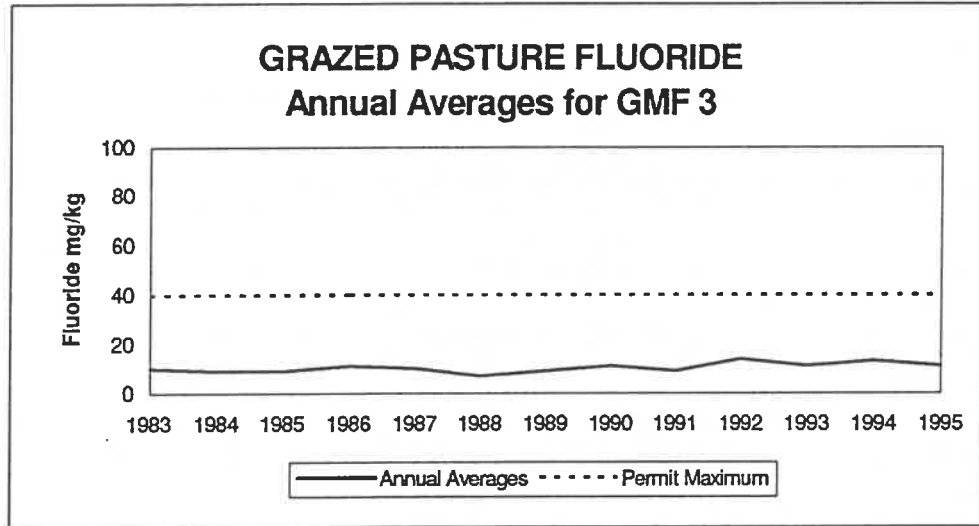
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1994 and 1995.



3.6.3 Grazing Monitor Farm No. 3, continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Comments

The fluoride in grazed pasture was within the permit standards for this farm during 1995 and no trends are evident.

3.6.4 Grazing Monitor Farm No. 4

The following information is contained in this section:

- fluoride in grazed pasture,
- cattle urinary fluoride,
- cattle bone fluoride,
- cattle dental effects, and
- comments on the monitoring.

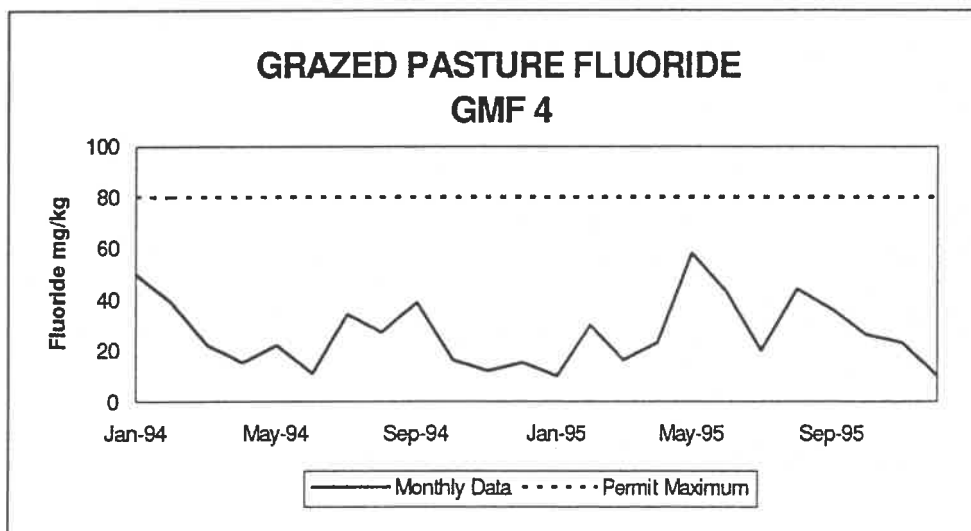
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1995.

	Units	Permit	1995 maximum
Monthly sample	mg/kg	80	58
Two monthly average	mg/kg	60	51
Running twelve monthly average	mg/kg	40	29

The annual average for 1995 was 28 mg/kg.

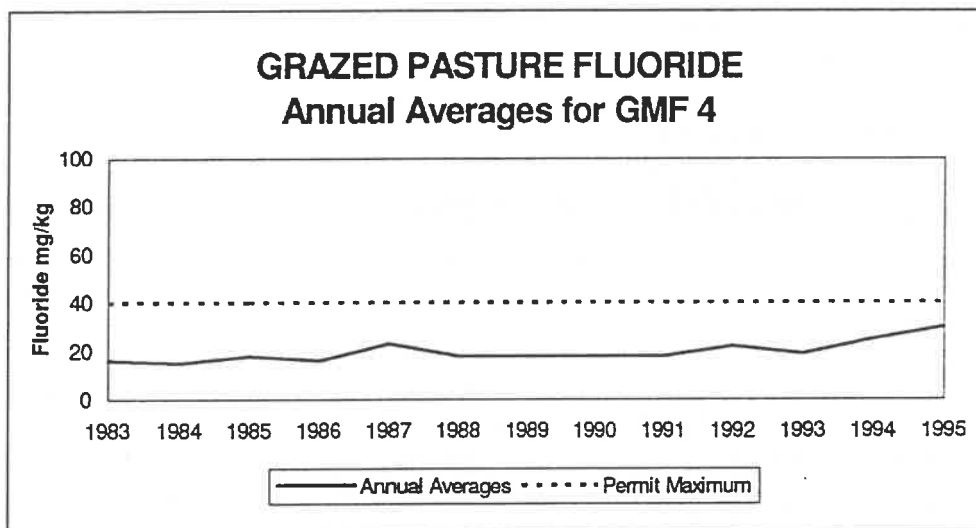
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1994 and 1995.



3.6.4 Grazing Monitor Farm No. 4, continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Cattle urinary fluoride

The following table summarises the results of cattle urinary fluoride monitoring during 1995.

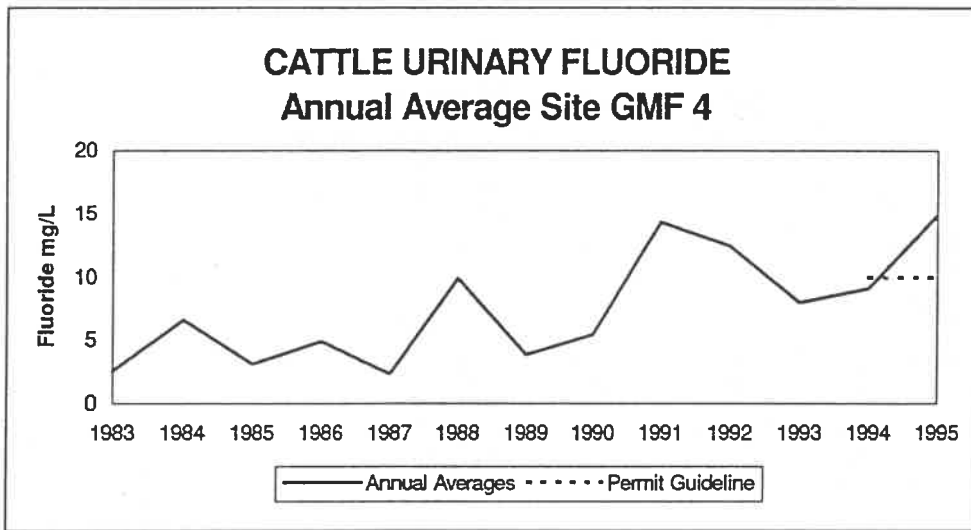
	Units	Permit Guideline	Result
Average fluoride concentration	mg/L	-	14.9
Maximum fluoride concentration	mg/L	10	31.1
Minimum fluoride concentration	mg/L	-	3.9
No. of samples		-	10

Of the 10 samples collected, 4 exceeded the permit guideline.

3.6.4 Grazing Monitor Farm No. 4, continued

Cattle urinary fluoride, continued

The following graph shows the annual average for fluoride in cattle urine.



Cattle bone fluoride

The following table shows the results of bone fluoride monitoring during 1995.

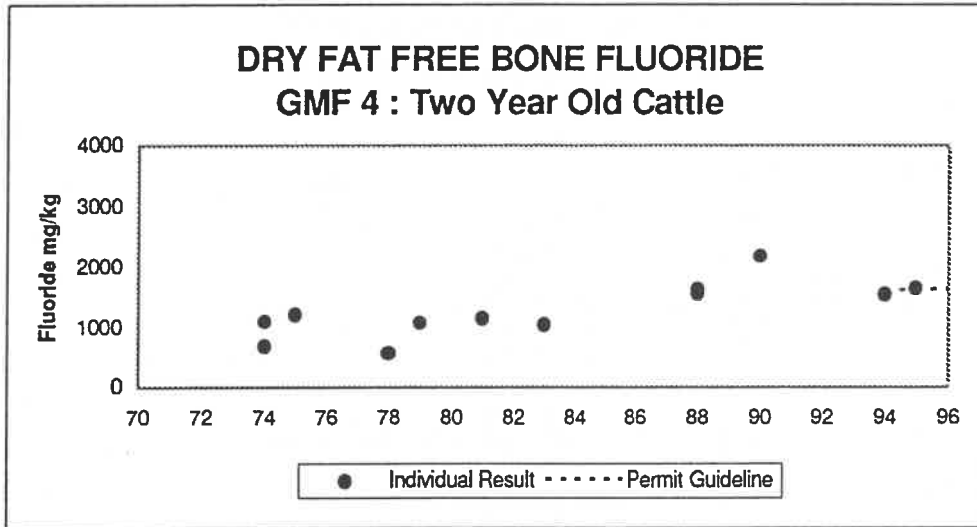
Identification	Age	Units	Permit Guideline	Fluoride
DG 45	9	mg/kg	-	3200
DG 72	2	mg/kg	1605	1625

Note: The bone fluoride concentration is converted to dry fat free metacarpal/metatarsal.

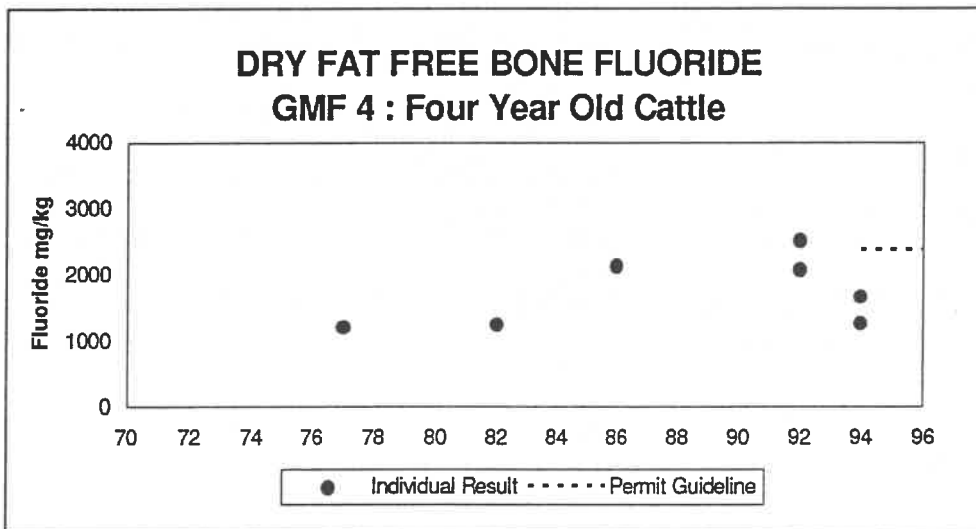
3.6.4 Grazing Monitor Farm No. 4, continued

Cattle bone fluoride, continued

The following graph shows the bone fluoride concentration of individual biopsies collected from two year old cattle since the project began.



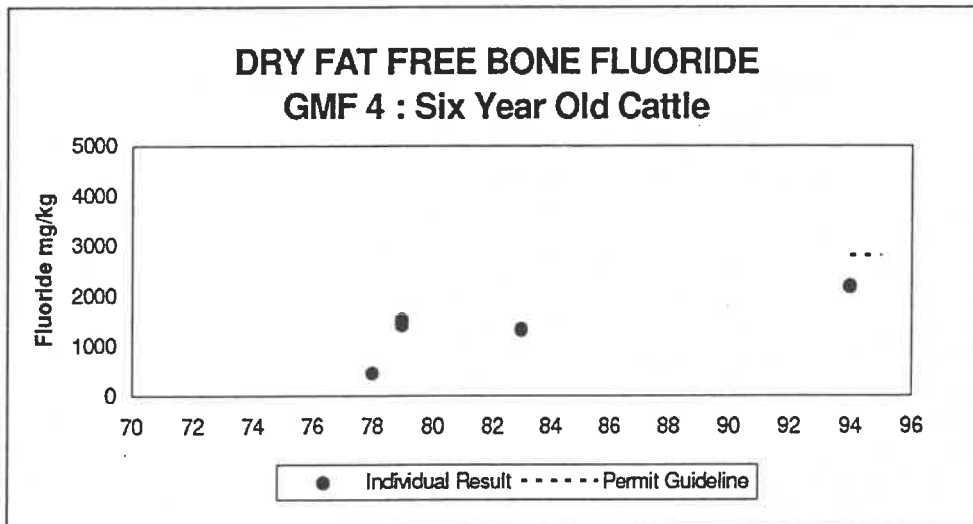
The following graph shows the bone fluoride concentration of individual biopsies collected from four year old cattle since the project began.



3.6.4 Grazing Monitor Farm No. 4, continued

Cattle bone fluoride, continued

The following graph shows the bone fluoride concentration of individual biopsies collected from six year old cattle since the project began.



Cattle dental effects

The following table summarises the results of the dental inspection of cattle on this farm during the past two years. The scores are related to the year during which the tooth was formed.

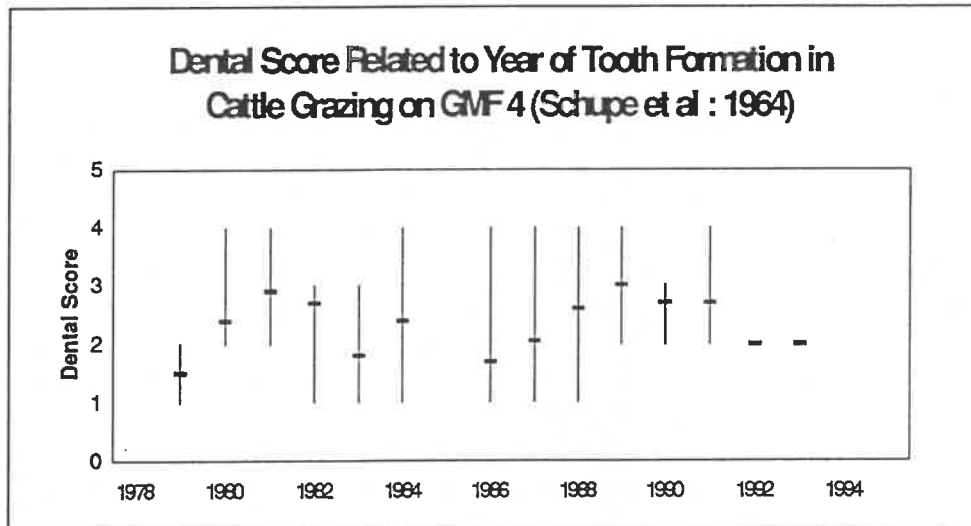
Year of tooth formation	1991	1992	1993
Average tooth score	2.7	2	2
Maximum tooth score	3		
Minimum tooth score	2		
No. of cattle inspected	3	1	1

Note: The tooth scoring system follows the method of Suttie and only permanent incisors are included in the table.

3.6.4 Grazing Monitor Farm No. 4, continued

Cattle dental effects, continued

The following graph shows the average tooth score and range of tooth scores for the teeth of cattle formed since monitoring began.



Comments

Permit standards were met on GMF4 during 1995. However, some of the permit guidelines were exceeded. It is expected that this will be addressed by the reduction in fluoride discharges from the smelter's main stack in the very near future. This is due to the installation of dry scrubbers.

The 1995 monitoring on GMF4 indicates that the farm has been exposed to more fluoride during 1995 than during previous years. The mass of gaseous fluoride discharged from the smelter's main stack has remained relatively constant since 1988 and particulate fluoride has remained relatively stable since 1992. Similarly the potroom roof louvre discharge of gaseous and particulate fluoride is similar to that in 1988 and lower than that of the intervening years. The increased pasture and urinary fluoride concentrations are, therefore, not easily explained.

The annual average grazed pasture fluoride concentration was 28mg/kg on GMF 4 during 1995. This concentration is within the permit 12 month guideline. This is the highest grazed pasture fluoride concentration on this farm. Some of this increase will only be an apparent increase. In the last twelve months a refinement to the method for determining fluoride in pasture used at NZAS, as approved by the Southland Regional Council, was expected to result in an apparent increase of 8-10 % in the fluoride concentration of pasture being analysed. The increase is not evident on the nearby GMF12.

3.6.4 Grazing Monitor Farm No.4, continued

The annual average cattle urinary fluoride concentration was 14.9 mg/L which exceeded the permit guideline of 10 mg/L. This is the highest annual average measured on this farm. The four samples that exceeded the guideline were all collected in March. The concentration of fluoride in the grazed grass sample collected in March did not represent the highest concentration recorded for this farm in 1995. Therefore, little can be inferred about urinary fluoride concentrations in months where the grazed grass fluoride content was higher, other than that the urinary fluoride concentration can be expected to have been higher also.

The bone fluoride concentration measured in a sample collected from a two year old cow during 1995 was 1625 mg/kg which is above the permit guideline of 1605 mg/kg. This result is within the range experienced on this farm over the past nine years. A bone sample collected from a nine year old cow provided a fluoride concentration of 3200 mg/kg. This is the highest bone fluoride concentration determined in cattle grazed on GMF4. Given the age of this animal, this level of fluoride is unlikely to indicate the presence of any adverse effects caused by chronic fluorosis.

The dental effects monitoring resulted in only one recently erupted tooth being inspected. This was scored as a 2 and was in a two year old cow. The three other animals inspected were a seven year old and two nine year olds. The most recent tooth erupted from these animals was formed in 1990.

Work is ongoing to refine the methods of ensuring the preferred range of livestock samples is obtained on this farm.

3.6.5 Grazing Monitor Farm No. 10

The following information is contained in this section:

- fluoride in grazed pasture, and
- comments on the monitoring.

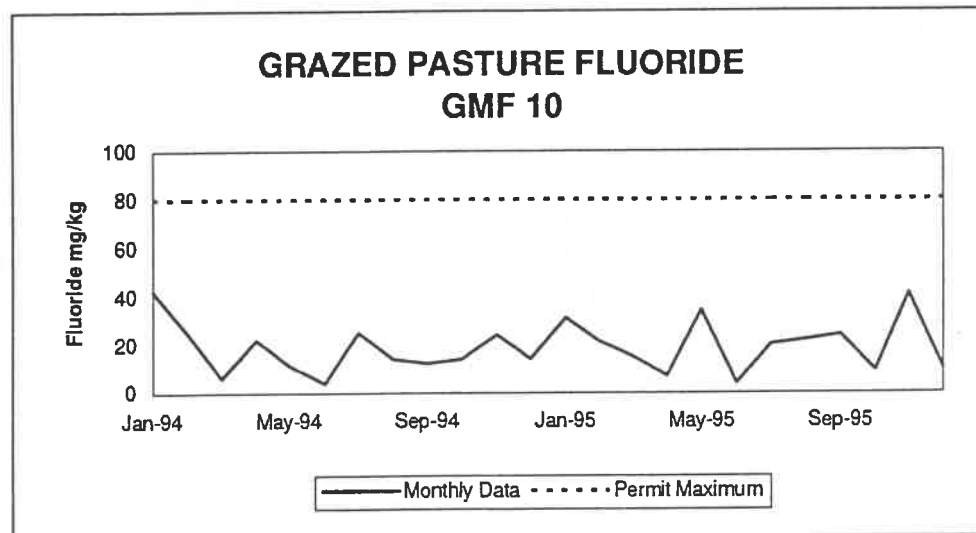
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1995.

	Units	Permit	1995 maximum
Monthly sample	mg/kg	80	41
Two monthly average	mg/kg	60	26
Running twelve monthly average	mg/kg	40	20

The annual average for 1995 was 20 mg/kg.

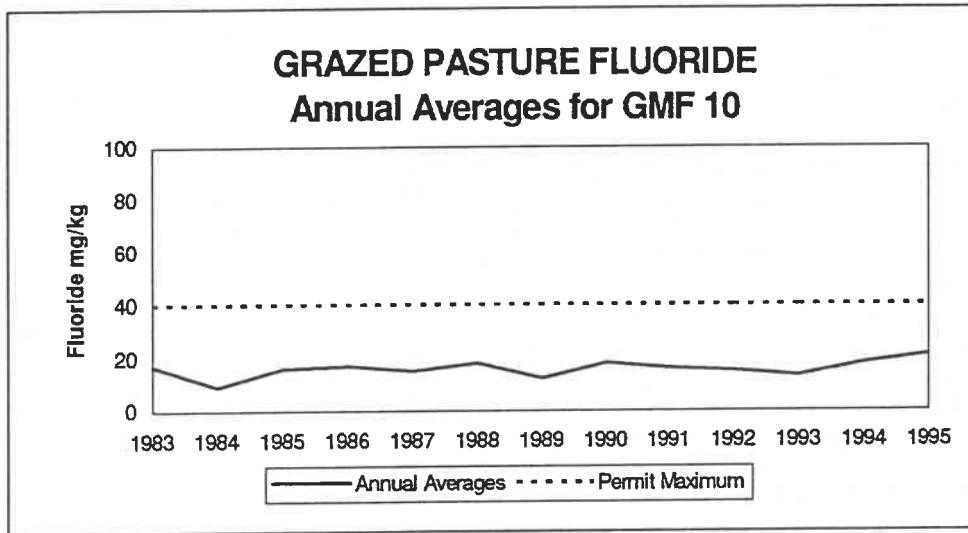
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1994 and 1995.



3.6.5 Grazing Monitor Farm No. 10, continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Comments

The fluoride in grazed pasture was within the permit standards and no trends are evident. The elevated grazed pasture fluoride concentrations measured in May and November were most likely caused by strong westerly winds transporting smelter sourced fluoride material to the farm. This is similar to the situation at nearby GMF 16.

3.6.6 Grazing Monitor Farm No. 11

The following information is contained in this section:

- fluoride in grazed pasture, and
- comments on the monitoring.

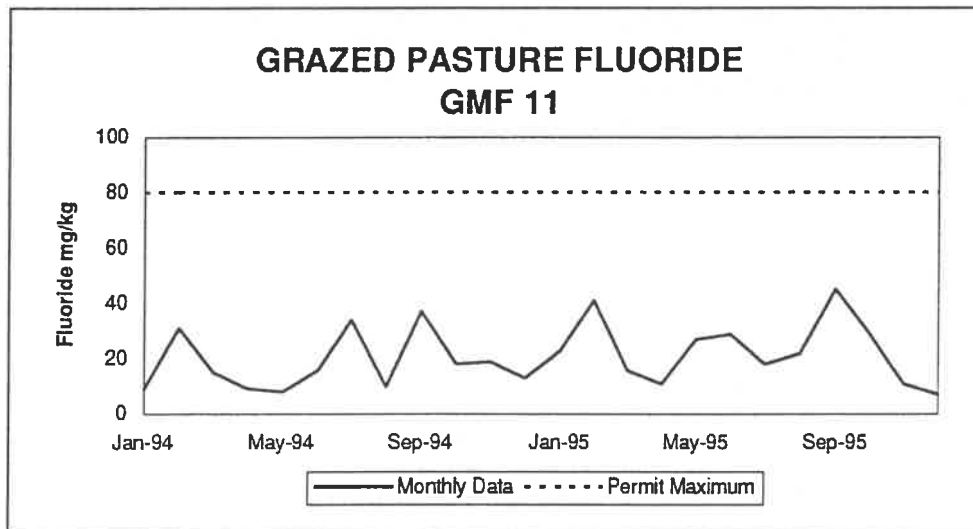
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1995.

	Units	Permit	1995 maximum
Monthly sample	mg/kg	80	45
Two monthly average	mg/kg	60	37
Running twelve monthly average	mg/kg	40	24

The annual average for 1995 was 23 mg/kg.

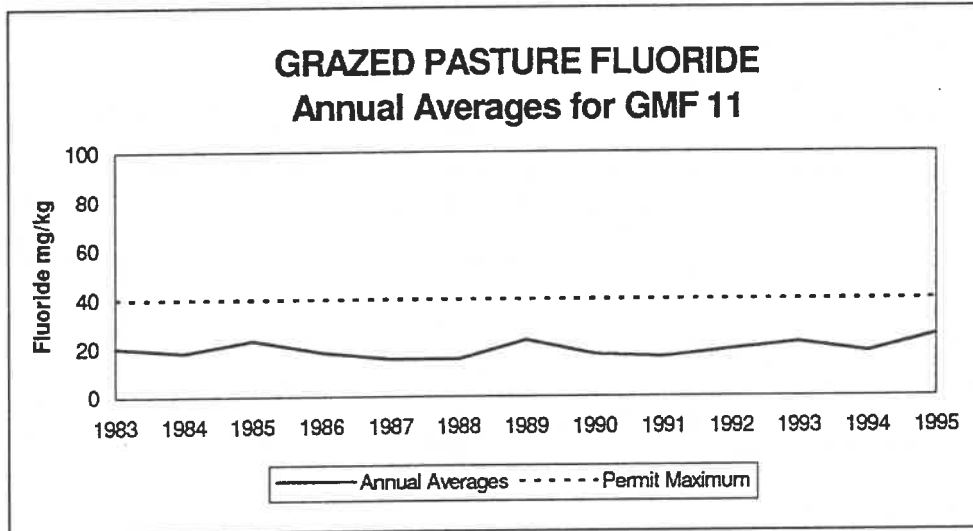
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1994 and 1995.



3.6.6 Grazing Monitor Farm No. 11, continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Comments

The fluoride in grazed pasture was within the permit standards and no trends are evident.

3.6.7 Grazing Monitor Farm No. 12

The following information is contained in this section:

- fluoride in grazed pasture, and
- comments on the monitoring.

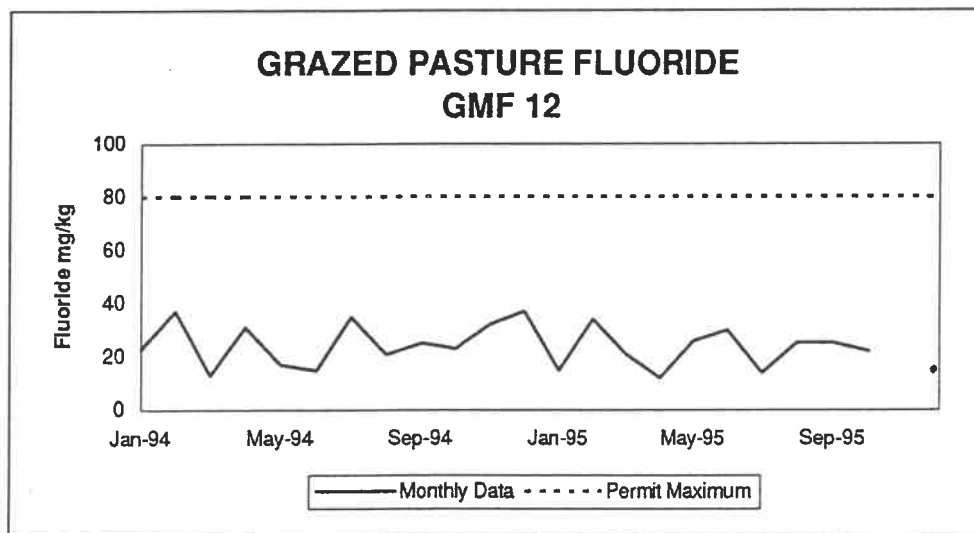
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1995.

	Units	Permit	1995 maximum
Monthly sample	mg/kg	80	34
Two monthly average	mg/kg	60	28
Running twelve monthly average	mg/kg	40	25

The annual average for 1995 was 22 mg/kg.

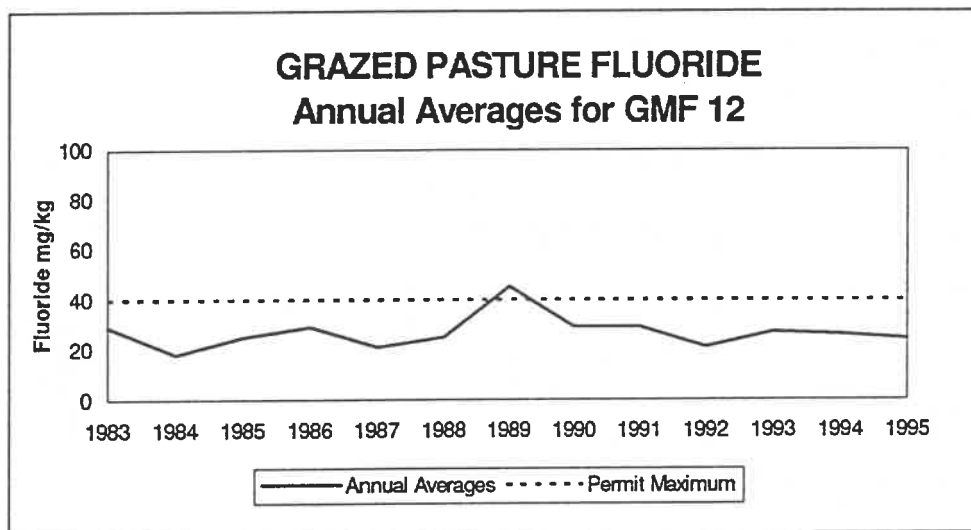
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1994 and 1995.



3.6.7 Grazing Monitor Farm No. 12, continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Comments

The fluoride in grazed pasture was within the permit standards.

The result of the sample collected during November 1995 was excluded as the sample site was fertilised about two weeks before the sample was collected.

Although GMF12 is located close to GMF4, grazed pasture fluoride concentrations do not follow the upward trend evident on GMF4.

3.6.8 Grazing Monitor Farm No. 14

The following information is contained in this section:

- fluoride in grazed pasture,
- cattle urinary fluoride,
- cattle bone fluoride
- cattle dental effects, and
- comments on the monitoring.

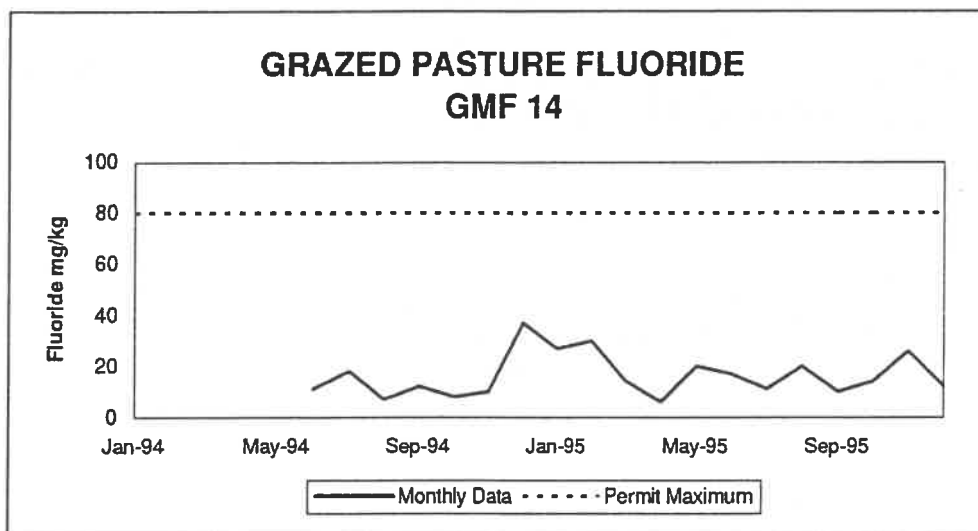
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1995.

	Units	Permit	1995 maximum
Monthly sample	mg/kg	80	30
Two monthly average	mg/kg	60	32
Running twelve monthly average	mg/kg	40	19

The annual average for 1995 was 17 mg/kg.

The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1994 and 1995.



3.6.8 Grazing Monitor Farm No. 14, continued

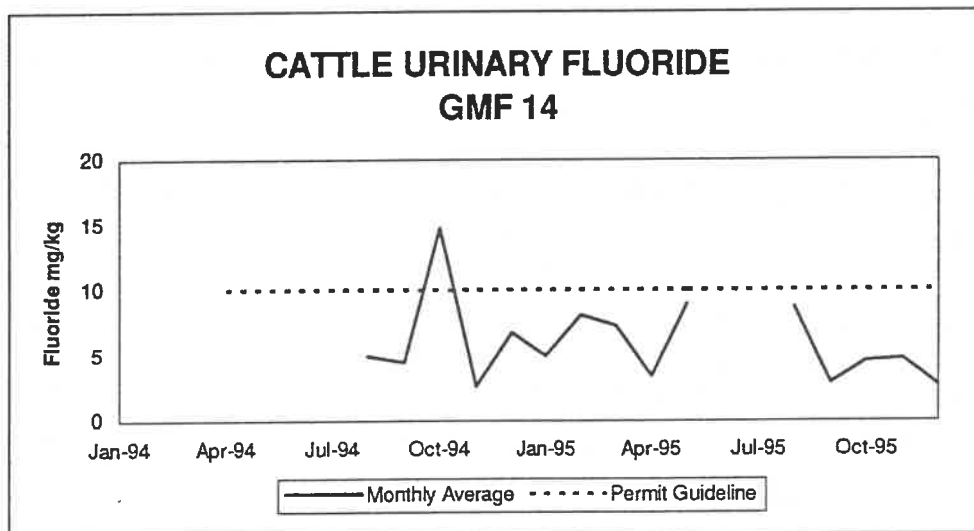
Cattle urinary fluoride

The following table summarises the results of cattle urinary fluoride monitoring during 1995.

	Units	Permit Guideline	Result
Average fluoride concentration	mg/L		5.6
Maximum fluoride concentration	mg/L	10	11.7
Minimum fluoride concentration	mg/L		2.2
No. of samples			45

Of the 45 samples collected, 2 exceeded the permit guideline.

The following graph shows the monthly average for fluoride in cattle urine during 1994 and 1995.



3.6.8 Grazing Monitor Farm No. 14, continued

Cattle bone fluoride

The following table shows the results of bone fluoride monitoring during 1995.

Identification	Age	Units	Permit Guideline	Fluoride
Yellow 311	2	mg/kg	1605	1225
Yellow 1131	2	mg/kg	1605	775
Orange 488	2	mg/kg	1605	1200
Orange 649	2	mg/kg	1605	875

Note: The bone fluoride concentration is converted to dry fat free metacarpal/metatarsal.

Cattle dental effects

The following table summarises the results of the dental inspection during 1995. All cattle inspected were two year olds and the teeth inspected were formed during 1993 and 1994.

Year of tooth formation	1993	1994
Average tooth score	1.8	2
Maximum tooth score	2	2
Minimum tooth score	1	2
No of cattle inspected	4	4

Note: The tooth scoring system follows the method of Suttie and only permanent incisors were included in the table.

Comments

The results of grazed pasture and livestock monitoring were within the permit standards and guidelines.

3.6.8 Grazing Monitor Farm No. 14, continued

Comments, continued

No urine samples were collected during June and July as no cattle were milked during this time. One of the samples that exceeded the permit guideline was collected in May, the other in August. These two months correspond to months when the grass fluoride content was in the upper range for this farm. This would suggest that the urinary fluoride concentration of 11.7 mg/L is also an indication of the upper limit of these concentrations for this farm.

3.6.9 Grazing Monitor Farm No. 15

The following information is contained in this section:

- fluoride in grazed pasture, and
- comments on the monitoring.

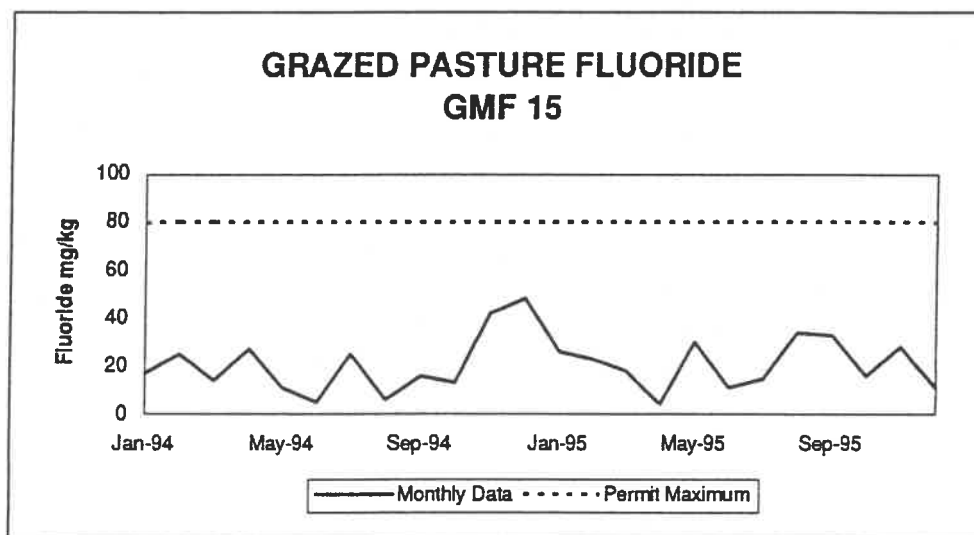
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1995.

	Units	Permit	1995 maximum
Monthly sample	mg/kg	80	34
Two monthly average	mg/kg	60	37
Running twelve monthly average	mg/kg	40	23

The annual average for 1995 was 19 mg/kg.

The following graph shows the results of monthly fluoride monitoring of grazed pasture.



No annual data is presented for years prior to 1995 as this farm was introduced into the GMF project in January 1995. All data collected to date is presented in the previous graph.

Comments

The fluoride in grazed pasture was within the permit standards.

3.6.10 Grazing Monitor Farm No. 16

The following information is contained in this section:

- fluoride in grazed pasture,
- cattle urinary fluoride,
- cattle bone fluoride,
- cattle dental effects, and
- comments on the monitoring.

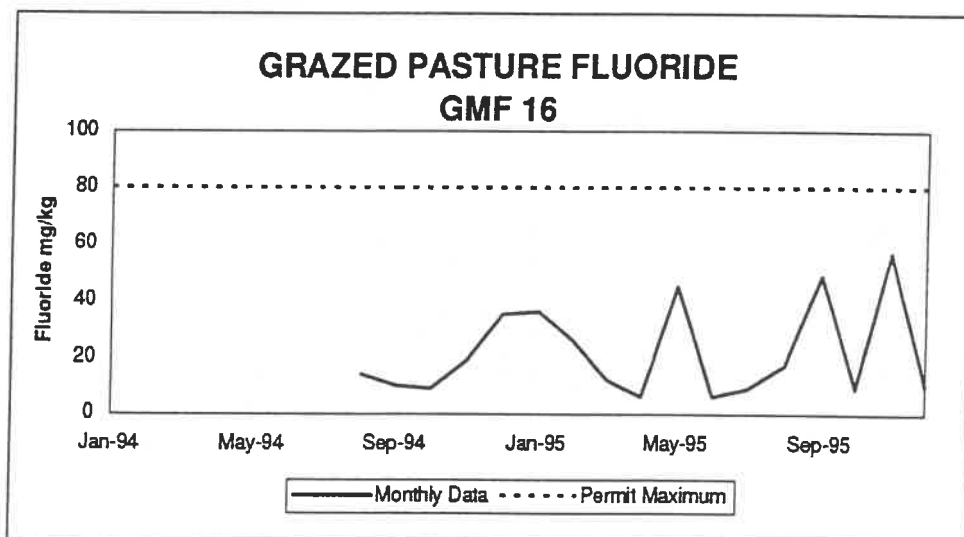
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1995.

	Units	Permit	1995 maximum
Monthly sample	mg/kg	80	57
Two monthly average	mg/kg	60	36
Running twelve monthly average	mg/kg	40	26

The annual average for 1995 was 24 mg/kg.

The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1994 and 1995.



3.6.10 Grazing Monitor Farm No. 16, continued

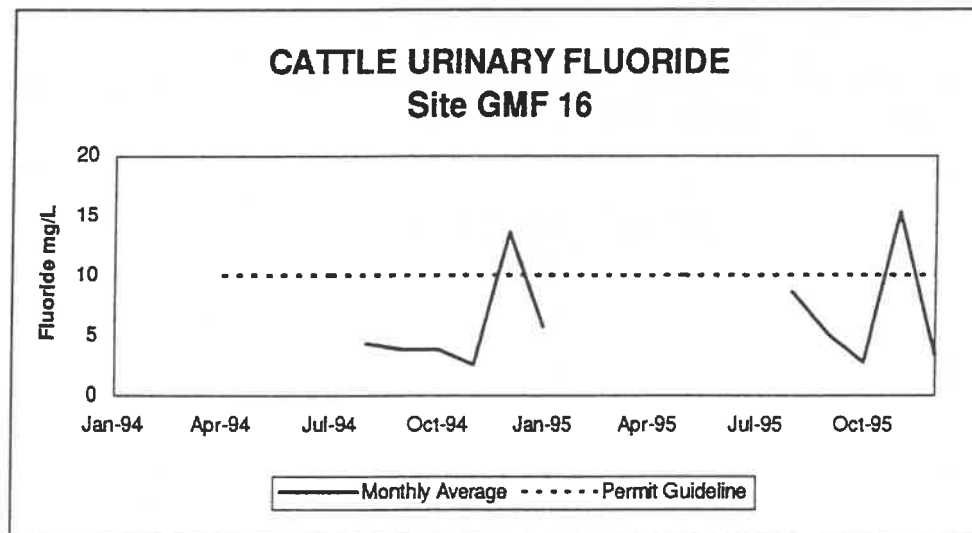
Cattle urinary fluoride

The following table summarises the results of cattle urinary fluoride monitoring during 1995.

	Units	Permit Guideline	Result
Average fluoride concentration	mg/L	-	6.6
Maximum fluoride concentration	mg/L	10	23.6
Minimum fluoride concentration	mg/L	-	1.7
No. of samples		-	32

Of the 32 samples collected, 4 exceeded the permit guideline.

The following graph shows the monthly average for fluoride in cattle urine during 1995.



3.6.10 Grazing Monitor Farm No. 16, continued

Cattle bone fluoride

The following table shows the results of bone fluoride monitoring during 1995.

Identification	Age	Units	Permit Guideline	Fluoride
1	5	mg/kg	-	1025
62	3	mg/kg	-	1100
449	3	mg/kg	-	1100
470	4	mg/kg	2379	950

Note: The bone fluoride concentration is converted to dry fat free metacarpal/metatarsal.

Cattle dental effects

The following table summarises the results of the dental inspection of cattle during 1995. The cattle inspected were aged three to five years. The teeth inspected were formed during the period 1990 to 1993.

Year of tooth formation	1991	1992	1993
Average tooth score	2	2.4	2
Maximum tooth score	2	4	2
Minimum tooth score	2	2	2
No of cattle inspected	2	4	2

Note: The tooth scoring system follows the method of Suttie and only permanent incisors are included in the table.

3.6.10 Grazing Monitor Farm No. 16, continued

Comments

The fluoride in grazed pasture was within the permit standards.

Three of the four cattle urinary fluoride concentrations that exceeded the permit guideline were collected in November. The fluoride in grazed pasture during November was 57 mg/kg which was the highest for the year. This would suggest that the urinary fluoride concentration of 23.6 mg/L is also indicative of the upper limit of the concentrations for this farm. The high results were most likely caused by strong westerly winds transporting smelter sourced fluoride material to the farm. No urine samples were collected from February to July as the cattle were not milked during this time.

3.7 Tiwai Experimental Farms

Introduction

The Tiwai Experimental Farm (TEF) Project was established to support the Grazing Monitor Farms Project. The aims of the TEF project were:

- to assess the effects of the smelter's discharges to air on sheep, and
- provide local veterinarians with experience in diagnosing fluorosis.

The No. 1 Farm (TEF1) is located on the Tiwai Peninsula, 3.5 kilometres east of the smelter. TEF1 was established in 1971.

The No. 2 Farm (TEF2) is at the east end of the Tiwai Peninsula, about ten kilometres east of the smelter. TEF2 was established in 1973.

The locations of the two Tiwai Experimental Farms are shown on the map in 3.6 Grazing Monitor Project, Introduction.

3.7.1 Tiwai Experimental Farm No.1

The following information is contained in this section:

- fluoride in grazed pasture,
- sheep urinary fluoride,
- sheep bone fluoride
- sheep dental effects,
- animal weights,
- lambing percentage, and
- comments in the monitoring.

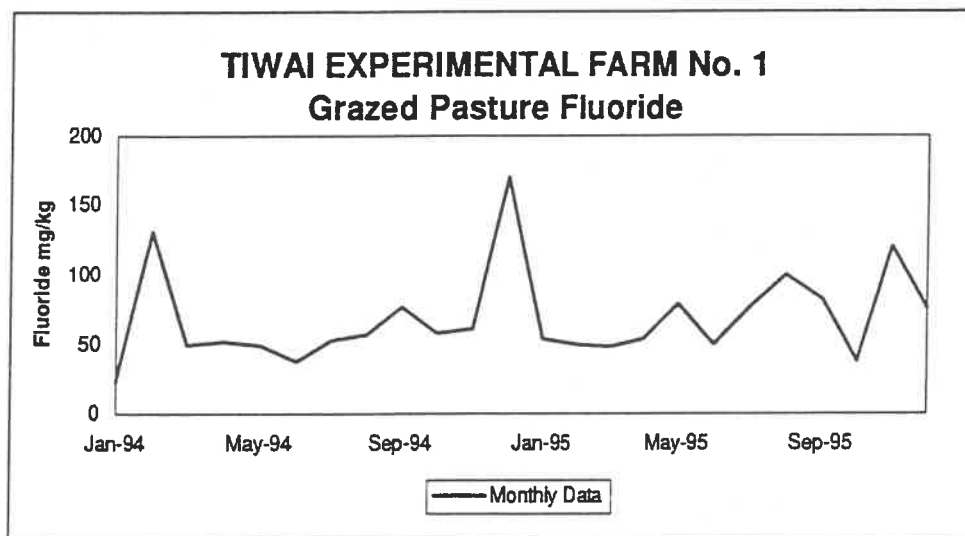
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1995.

	Units	1995 maximum
Monthly sample	mg/kg	120
Two monthly average	mg/kg	112
Twelve monthly running average	mg/kg	77

The annual average for 1995 was 69 mg/kg.

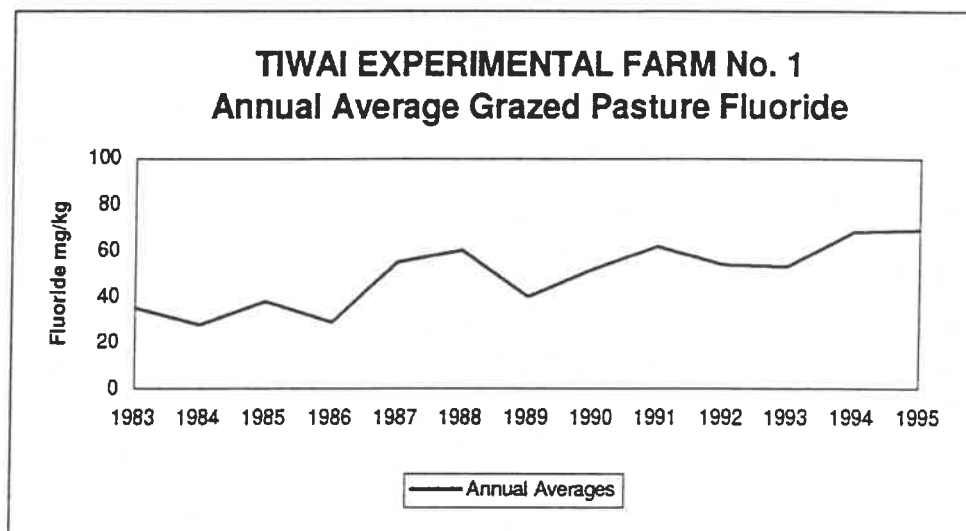
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1994 and 1995.



3.7.1 Tiwai Experimental Farm No.1, continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Sheep urinary fluoride

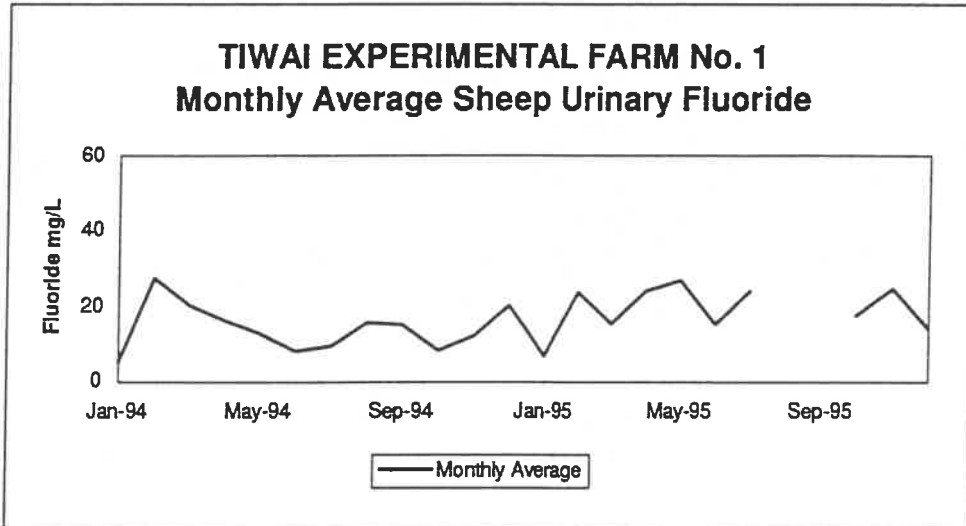
The following table summarises the results of sheep urinary fluoride monitoring on TEF1 during 1995.

	Units	Result
Average fluoride concentration	mg/L	19.2
Maximum fluoride concentration	mg/L	37
Minimum fluoride concentration	mg/L	5.1
No. of samples		115

3.7.1 Tiwai Experimental Farm No.1, continued

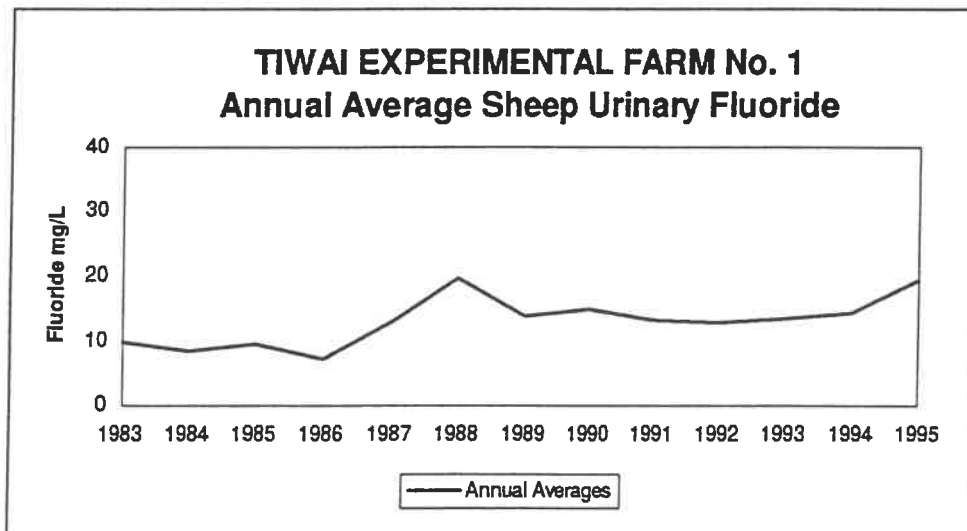
Sheep urinary fluoride, continued

The following graph shows the monthly average sheep urinary fluoride concentration during 1994 and 1995.



Note: No samples were collected during August and September to avoid disrupting the ewes during lambing.

The following graph shows the annual average sheep urinary fluoride concentration.



3.7.1 Tiwai Experimental Farm No.1, continued

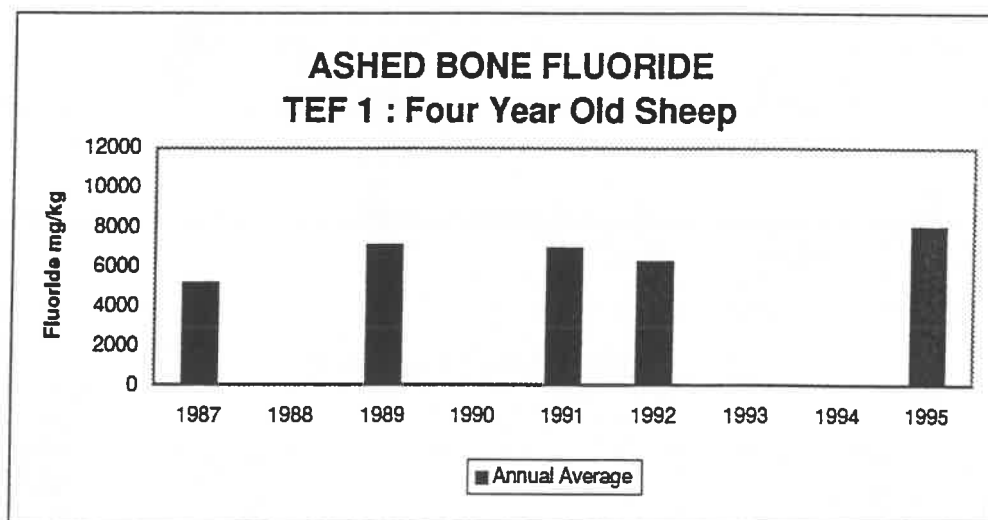
Sheep Bone Fluoride

The following table shows the results of jawbone fluoride monitoring on TEF1 during 1995.

Age	No. of samples	Average Fluoride mg/kg	Maximum Fluoride mg/kg	Minimum Fluoride mg/kg
4	5	8050	9850	6700
5	1	9400		
≥6	2	10050	11050	9000

Note: The bone fluoride concentration is as ashed bone.

The following graph shows the annual average jawbone fluoride concentration of four year old sheep grazing on TEF1 since 1987.

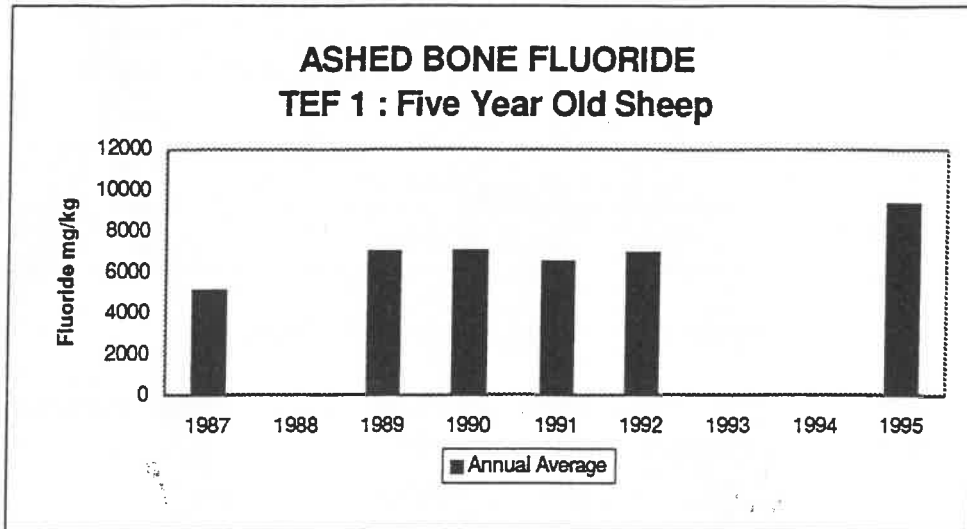


Note: These sheep have grazed on TEF2 for 12 months from about four months of age.

3.7.1 Tiwai Experimental Farm No.1, continued

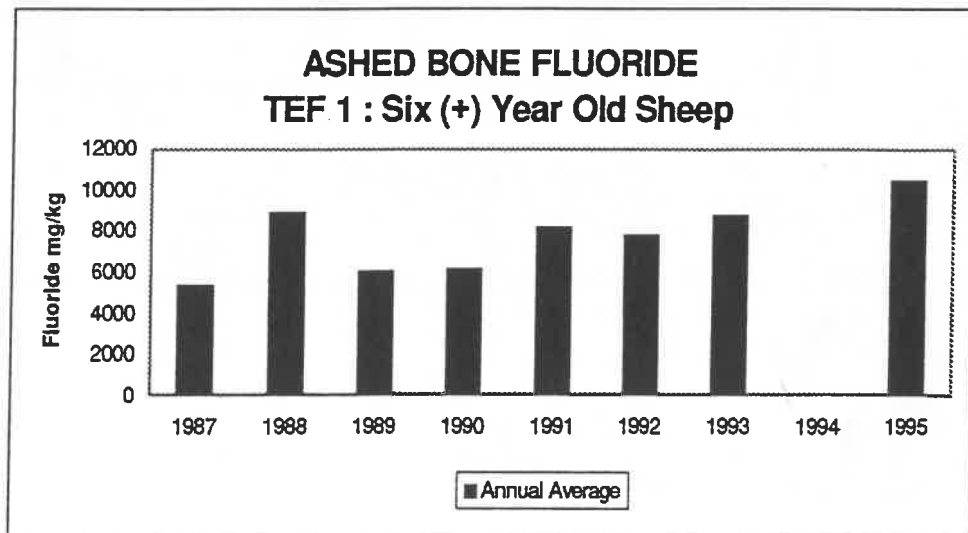
Sheep Bone Fluoride, continued

The following graph shows the annual average jawbone concentration of five year old sheep grazing on TEF 1 since 1987.



Note: These sheep have grazed on TEF2 for 12 months from about four months of age.

The following graph shows the average jawbone concentration of sheep, six years and older, grazing on TEF1 since 1987.



Note: These sheep have grazed on TEF2 for 12 months from about four months of age.

3.7.1 Tiwai Experimental Farm No.1, continued

Sheep dental effects

The following table summarises the results of the dental inspection of sheep. The scores are related to the year during which the tooth was formed. The tooth scores included in the table are those for teeth which were formed on TEF1.

Year of tooth formation	1992	1993	1993	1995
Average tooth score	2.8	3.0	2.7	3.0
Maximum tooth score	3	3	3	4
Minimum tooth score	2	3	2	2
No. of sheep inspected	9	8	7	16

Note: The tooth scoring system follows the method of Suttie and only permanent incisors are included in the table.

Animal weights

The following table shows the maximum, minimum, and average weights of sheep grazing on TEF1 measured during May 1995.

Age of sheep	Number of sheep	Average weight kg	Maximum weight kg	Minimum weight kg
Lambs	16	31.0	39.0	18.0
1 year old	20	58.2	63.0	47.8
2 year old	19	51.7	58.8	42.0
3 year old	10	50.7	57.0	43.4
4 year old	5	50.8	54.0	47.0
5 year old	5	52.0	63.5	44.5
6 year old	2	49.3	58.5	40.1

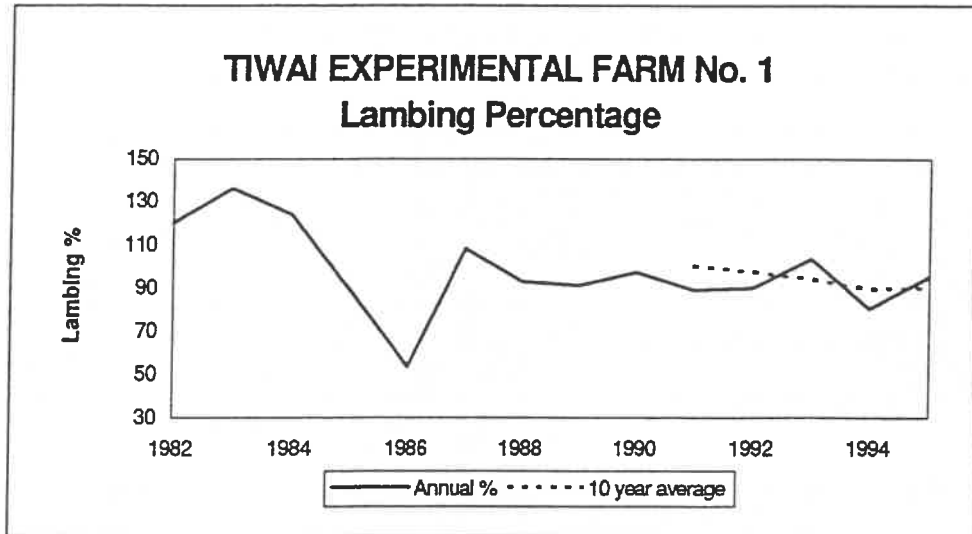
Note: The 1 year old ewes were introduced to the project from outside TEF1 and TEF2.

This is the first time that sheep have been weighed on TEF1.

3.7.1 Tiwai Experimental Farm No.1, continued

Lambing percentage

The following graph shows the lambing percentage recorded at TEF1 since 1982.



Comments

The annual average sheep urinary fluoride concentration measured on TEF1 during 1995 was 30 % higher than that measured during 1994. As the grazed pasture fluoride concentration was similar to previous years this increase in urinary fluoride is expected to be the result of natural variation and not be reflected in future years as a result of the reduction in fluoride discharges from the smelter's main stack. This reduction is due to the installation of dry scrubbers. Sheep jawbone fluoride concentrations were higher in 1995 than in previous years. The increased bone fluoride concentrations show the higher exposure to fluoride on TEF1 over the past eight years.

The lambing percentage for TEF1 was 95 %, up 15 % on 1994. This was within the range of results for TEF1 over the past eight years.

The weight of sheep grazing on TEF1 was measured for the first time during 1995. The average weight of the one year old ewes brought into the TEF project was about 10 % higher than for the next heaviest age group.

Stock management for the TEF project was changed during 1995. This followed the review proposed in the 1994 report. This review involved people from MAF Quality Management and an independent veterinary consultant. TEF1 and TEF2 will be operated identically but separately. There will be no transfer of stock between the two farms in future.

3.7.1 Tiwai Experimental Farm No.1, continued

Comments, continued

One year old ewes from outside the TEF project were added to the flocks on both farms to increase the number of breeding ewes. The lambs grazed on TEF2 during 1995 have been retained on TEF2 for breeding. Only stock born within the TEF project will be sampled.

The following monitoring of the sheep was undertaken during 1995:

- monthly urinary fluoride, except during the lambing period,
- jawbone fluoride, and
- animal weights.

Additional monitoring will be undertaken during 1996, including:

- liver analysis,
- post mortems on recently born lambs, and
- pre lamb blood testing of ewes.

3.7.2 Tiwai Experimental Farm No.2

The following information is contained in this section:

- fluoride in grazed pasture,
- sheep urinary fluoride,
- animal weights,
- lambing percentage, and
- comments in the monitoring.

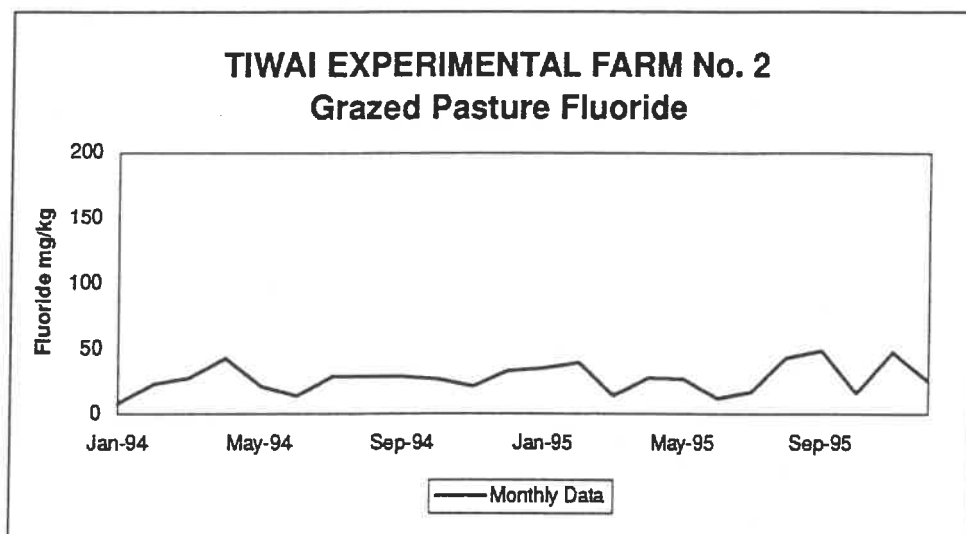
Fluoride in grazed pasture

The following table summarises the maximum grazed pasture monitoring results for 1995.

	Units	1995 maximum
Monthly sample	mg/kg	48
Two monthly average	mg/kg	46
Twelve monthly running average	mg/kg	30

The annual average for 1995 was 29 mg/kg.

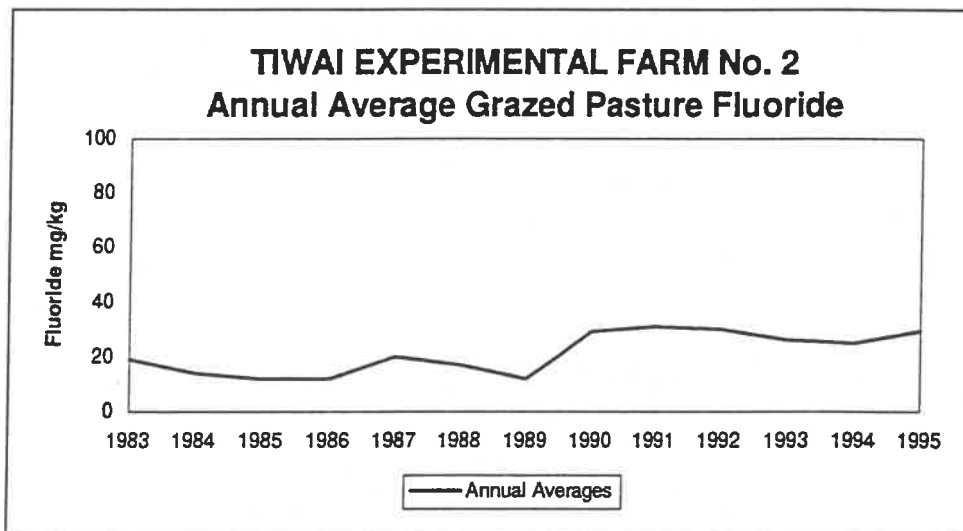
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1994 and 1995.



3.7.2 Tiwai Experimental Farm No.2, continued

Fluoride in grazed pastures, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Sheep urinary fluoride

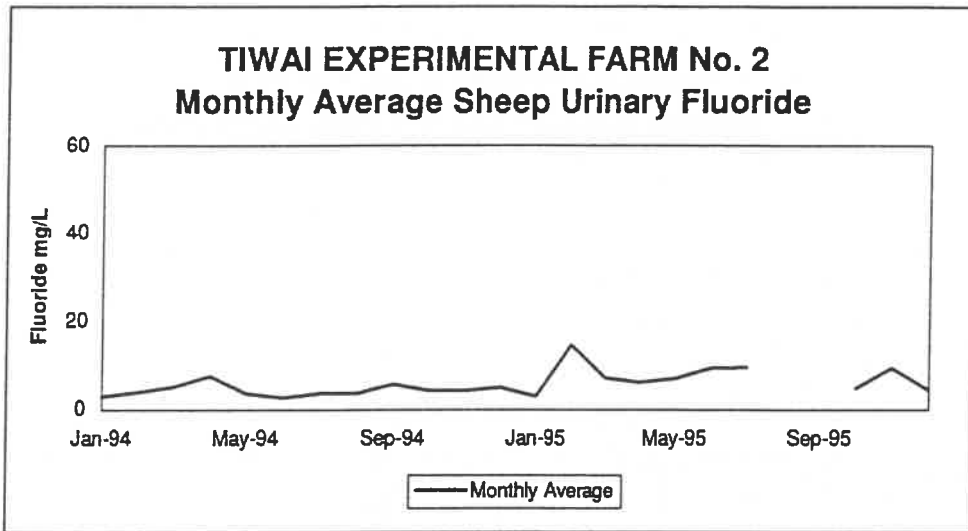
The following table shows the results of sheep urinary fluoride monitoring on TEF 2 during 1995.

	Units	Result
Average fluoride concentration	mg/L	7.6
Maximum fluoride concentration	mg/L	18.2
Minimum fluoride concentration	mg/L	2.7
No. of samples		78

3.7.2 Tiwai Experimental Farm No.2, continued

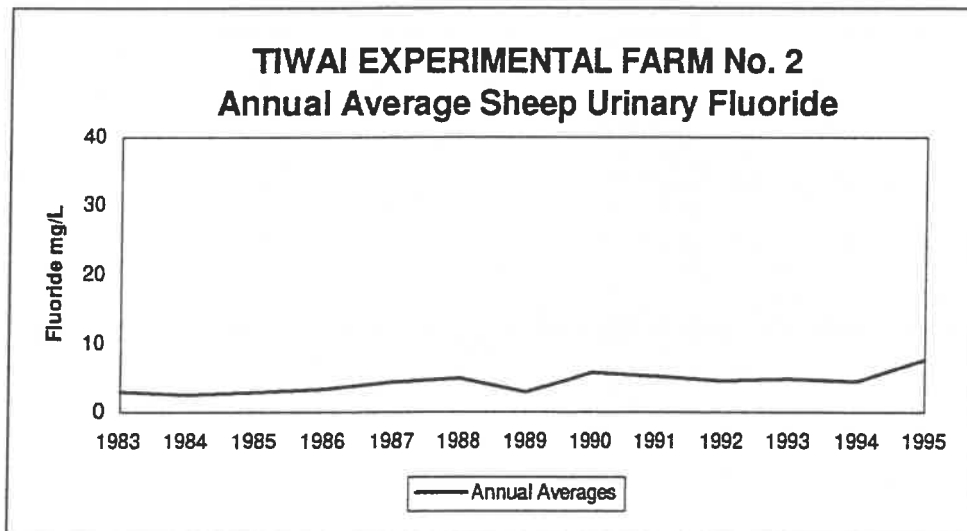
Sheep urinary fluoride, continued

The following graph shows the monthly average sheep urinary fluoride concentration during 1994 and 1995.



Note: No samples were collected during August and September to avoid disrupting the ewes during lambing.

The following graph shows the annual average sheep urinary fluoride concentration.



3.7.2 Tiwai Experimental Farm No.2, continued

Animal weights

The following table shows the maximum, minimum, and average weights of sheep grazing on TEF2 measured during May 1995.

Age of sheep	Number of sheep	Average weight kg	Maximum weight kg	Minimum weight kg
Mixed age ¹	34	72.1	96.0	58.0
1 year old ²	14	51.2	56.5	43.6

Note 1: The mixed age ewes were introduced to the project from outside TEF1 and TEF2.

Note 2: The 1 year old ewes were born on TEF1 but have grazed on TEF2 since being weaned, December 1995

This is the first time that sheep have been weighed on TEF2.

Lambing percentage

The lambing percentage recorded on TEF2 during 1995 was 92%. This is the first year that ewes on TEF2 have lambed.

Comments

The average urinary fluoride concentration of 7.6 mg/L for sheep grazing on TEF2 was higher during 1995 than during 1994 when the average urinary fluoride concentration was 4.5 mg/L. The 1995 average was the highest measured on TEF2 during the past 13 years. The high urinary fluoride concentration occurred even though the average grazed pasture fluoride concentration during 1995 was 29 mg/kg which is similar to the results over the past five years. If the increased urinary fluoride concentration becomes a trend further investigation will be required.

The management of stock on TEF2 was changed during 1995. The details of the changes are outlined in 3.7.1, Comments.

3.8 Pasture Fluoride Analysis Methods

During 1995 a comparative trial was organised by NZAS to measure the fluoride concentration of pasture samples by two different analytical methods. The two methods used were:

- AOAC Method 26 modified and
- ASTM Method 3269 (a total fluoride method).

AOAC Method 26 modified agrees within the expected variation of the method with ASTM Method 3269. NZAS intends to continue using AOAC Method 26 modified to measure fluoride in vegetation samples, and considers this investigation completed.

Sixteen samples were used in the comparison. NZAS analysed the samples using the existing AOAC Method 26 modified. The comparative method, ASTM Method 3269, was undertaken by the laboratory at the Tomago aluminium smelter in Australia

In addition, quality control standards have been prepared and will be in use from January 1996. The samples are for pasture concentrations of 30, 50, and 120 mg F/kg. A set of these samples has been forwarded to the ESR laboratory in Christchurch for use when analysing samples collected by the Southland Regional Council.

Chapter 4

Discharges to Water and Their Effects

Introduction

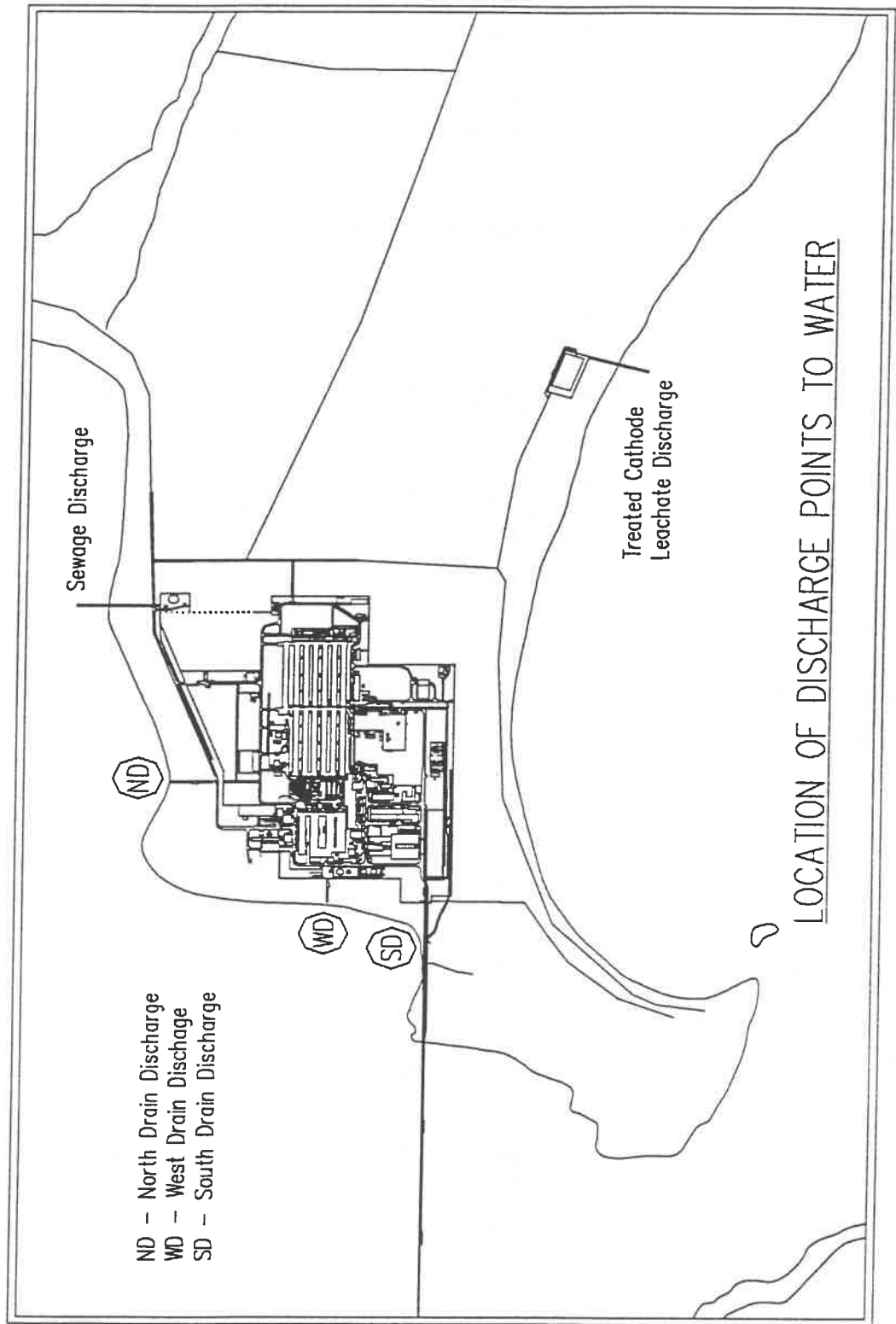
The smelter's liquid discharges are covered by five coastal permits issued by the Southland Regional Council on 24 October 1990.

This chapter gives details of monitoring results for each permit.

Site Locations

The locations of the water discharge monitoring sites are shown in the map on the following page.

Introduction, Continued



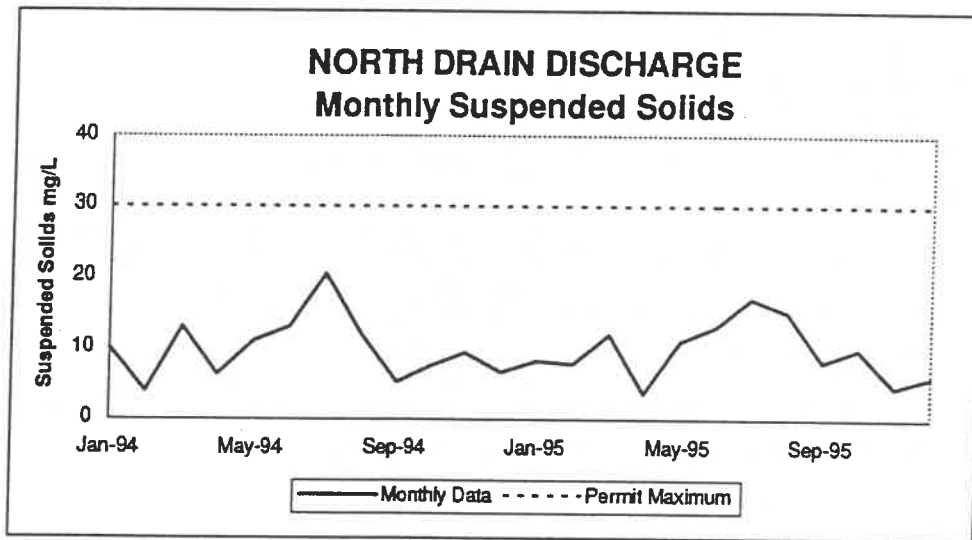
4.1 North Drain Discharges

Introduction

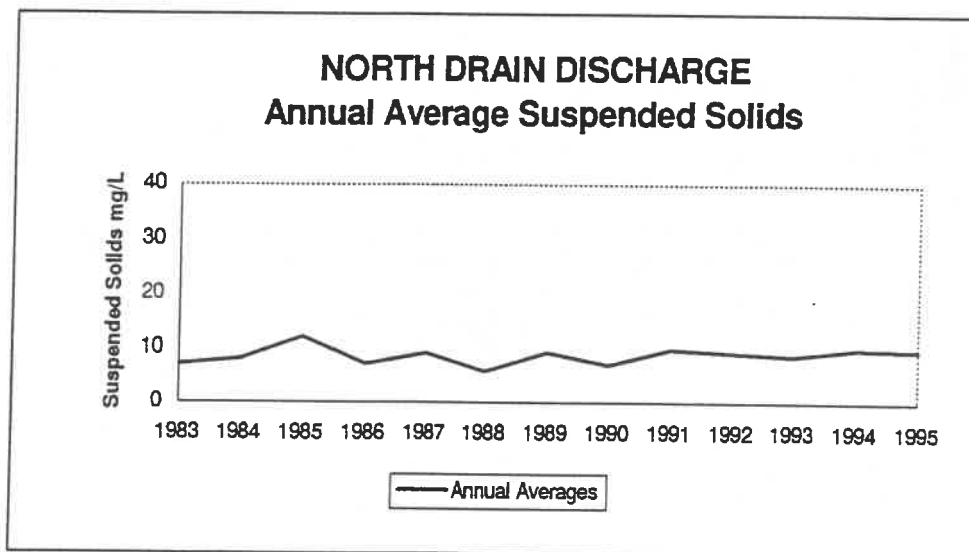
Discharges from the North Drain into Awarua Bay are covered by Coastal Permit Number 90057 issued by the Southland Regional Council on 24 October 1990.

Monitoring Results

The following graph shows the monthly average concentration of suspended solids discharged from the North Drain during 1994 and 1995.



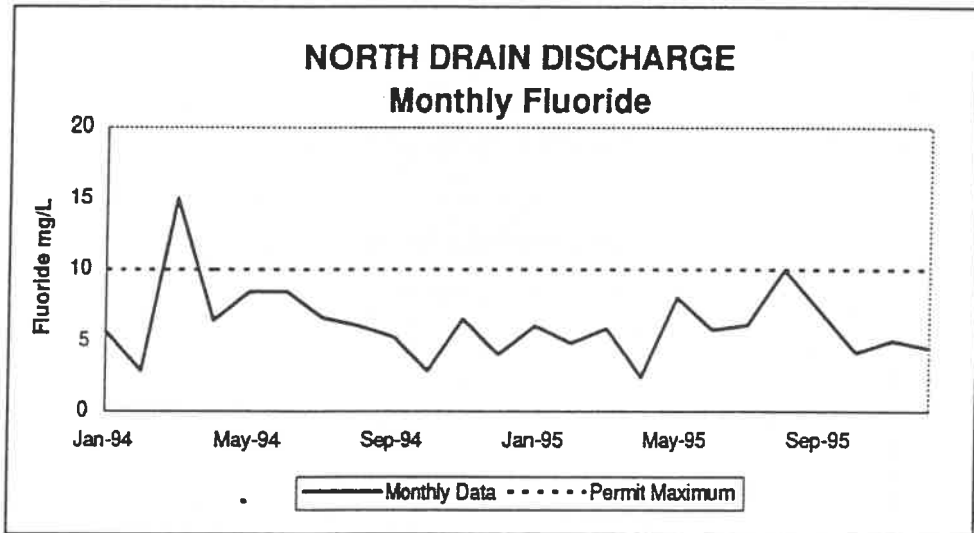
The following graph shows the annual average concentration of suspended solids discharged from the North Drain.



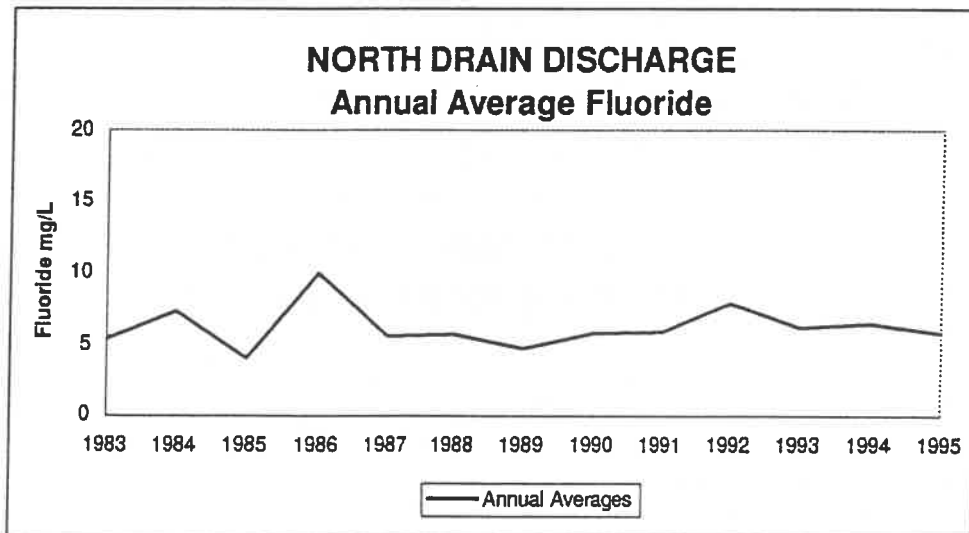
4.1 North Drain Discharges, Continued

Monitoring Results, continued

The following graph shows the monthly average concentration of fluoride discharged from the North Drain during 1994 and 1995.



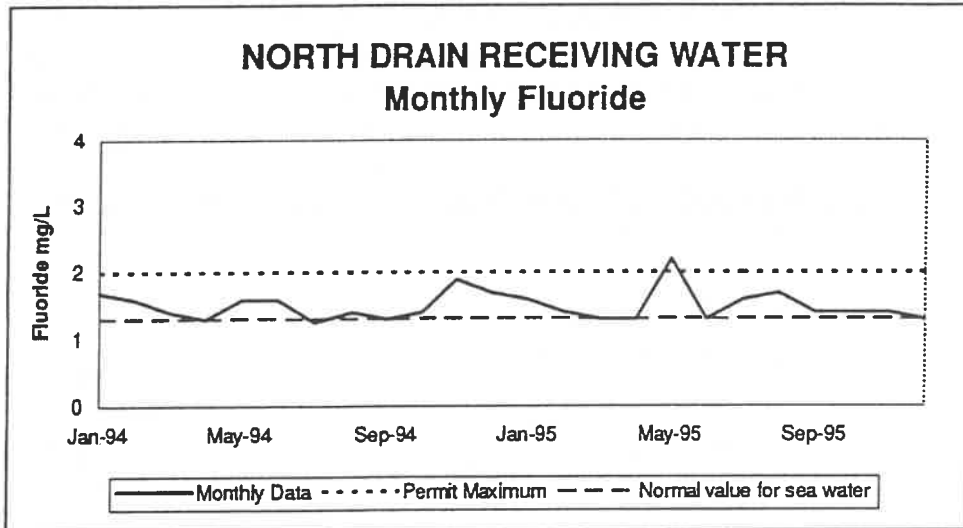
The following graph shows the annual average concentration of fluoride discharged from the North Drain.



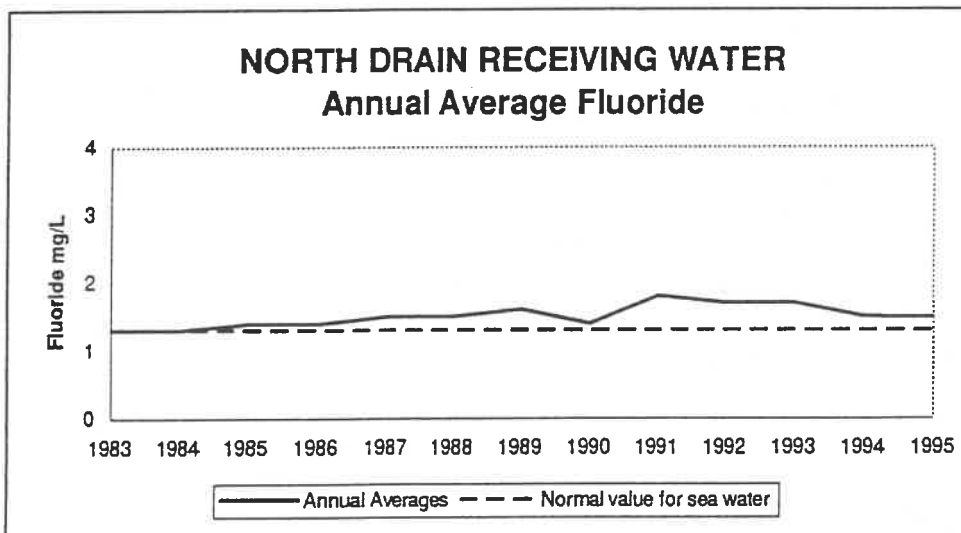
4.1 North Drain Discharges, Continued

Monitoring Results, continued

The following graph shows the monthly average fluoride concentration of the North Drain receiving water.



The following graph shows the annual average fluoride concentration of the North Drain receiving water.



4.1 North Drain Discharges, Continued

Comments

The North Drain receiving water fluoride concentration permit standard was exceeded during May 1995. The high concentration of 2.2 mgF/L was the result of significant rainfall combined with calm conditions. The rainfall produced a drain discharge with a high fluoride content and the calm conditions provided poor receiving water mixing. The effects of weather conditions on the North Drain fluoride discharge was more fully discussed in the 1992 report to the Interdepartmental Committee.

All other North Drain permit standards were complied with during 1995.

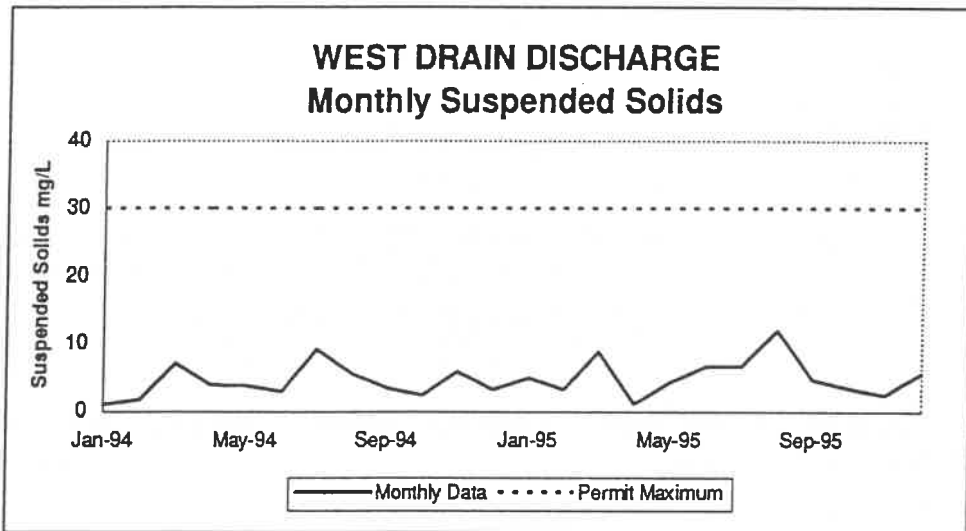
4.2 West Drain Discharges

Introduction

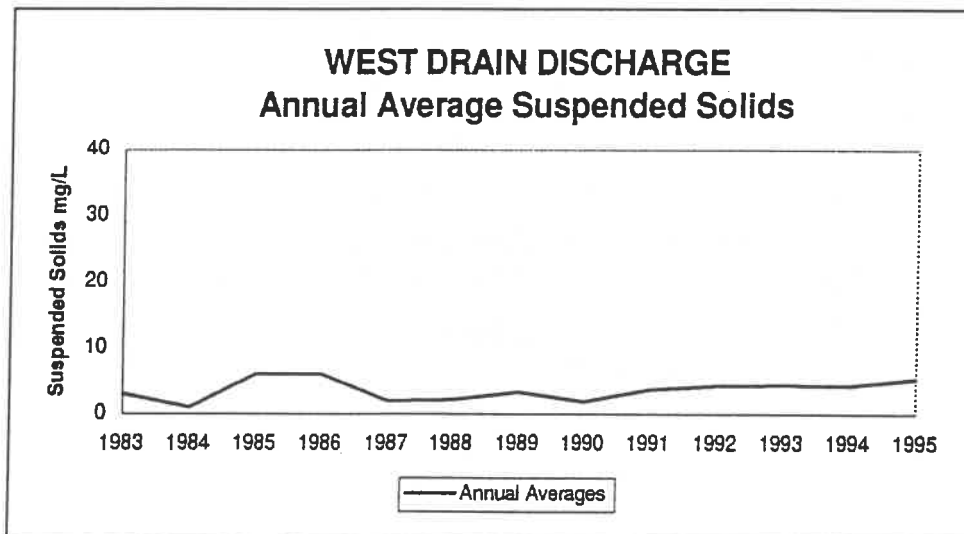
Discharges from the West Drain into Awarua Bay are covered by Coastal Permit Number 90058 issued by the Southland Regional Council on 24 October 1990.

Monitoring Results

The following graph shows the monthly average concentration of suspended solids discharged from the West Drain during 1994 and 1995.



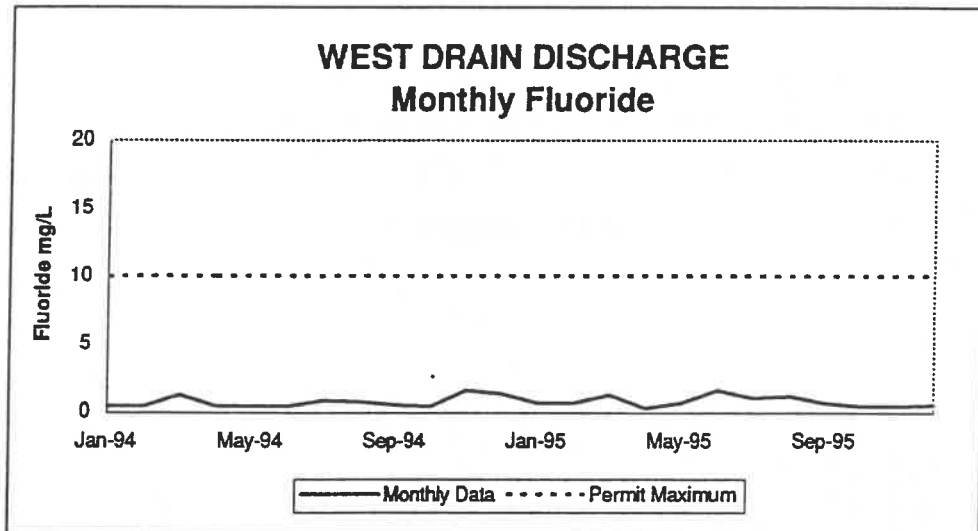
The following graph shows the annual average concentration of suspended solids discharged from the West Drain.



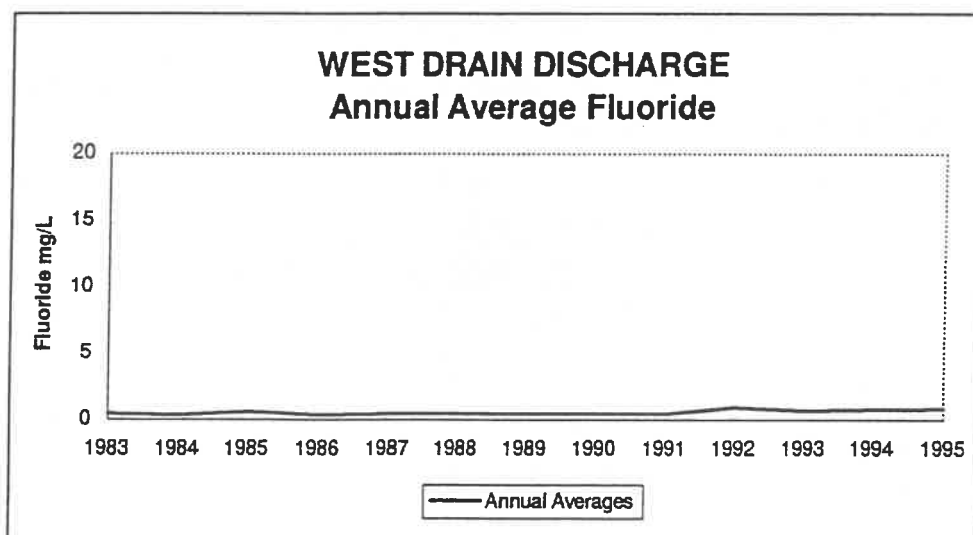
4.2 West Drain Discharges, Continued

Monitoring Results, continued

The following graph shows the monthly average concentration of fluoride discharged from the West Drain during 1994 and 1995.



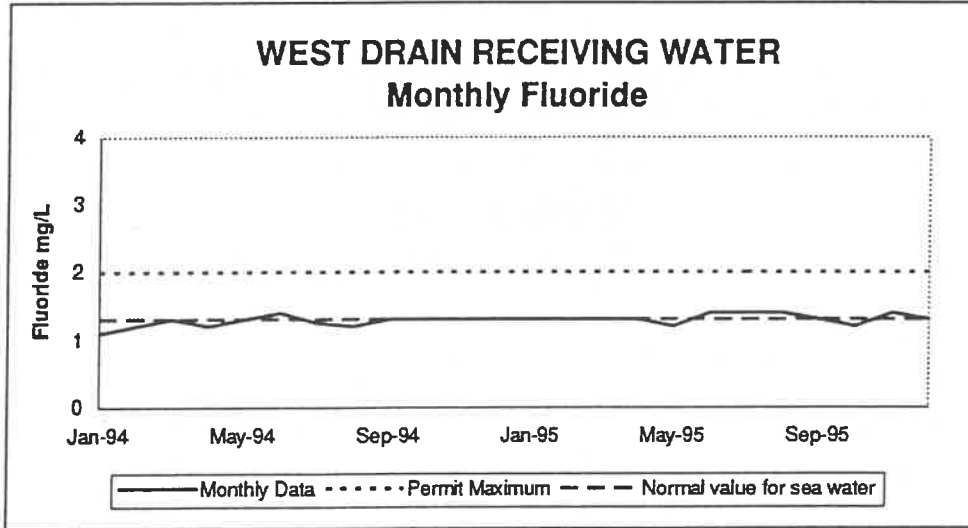
The following graph shows the annual average concentration of fluoride discharged from the West Drain.



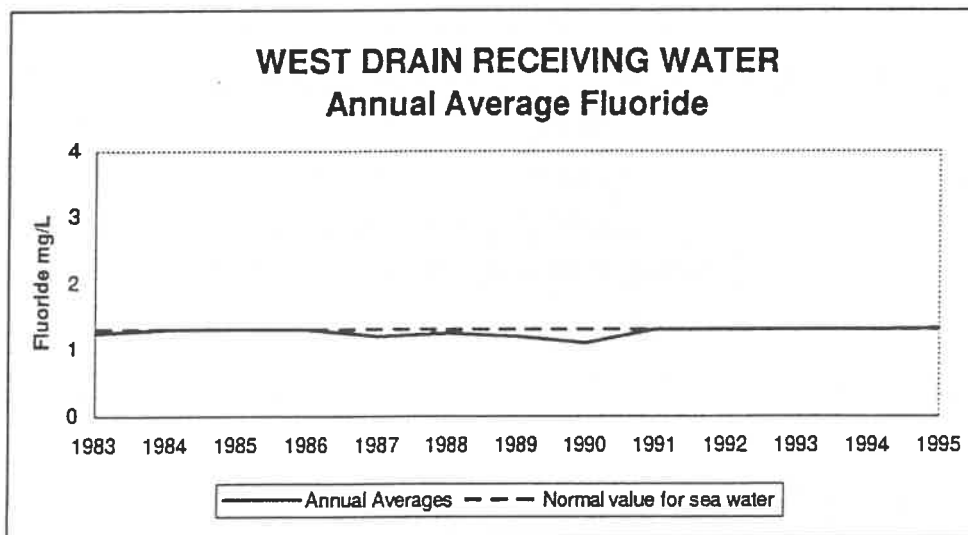
4.2 West Drain Discharges, Continued

Monitoring Results, continued

The following graph shows the monthly average fluoride concentration of the West Drain receiving water during 1994 and 1995.



The following graph shows the annual average fluoride concentration of the West Drain receiving water.



Comments

Discharges from the West Drain during 1995 were stable and within permit standards.

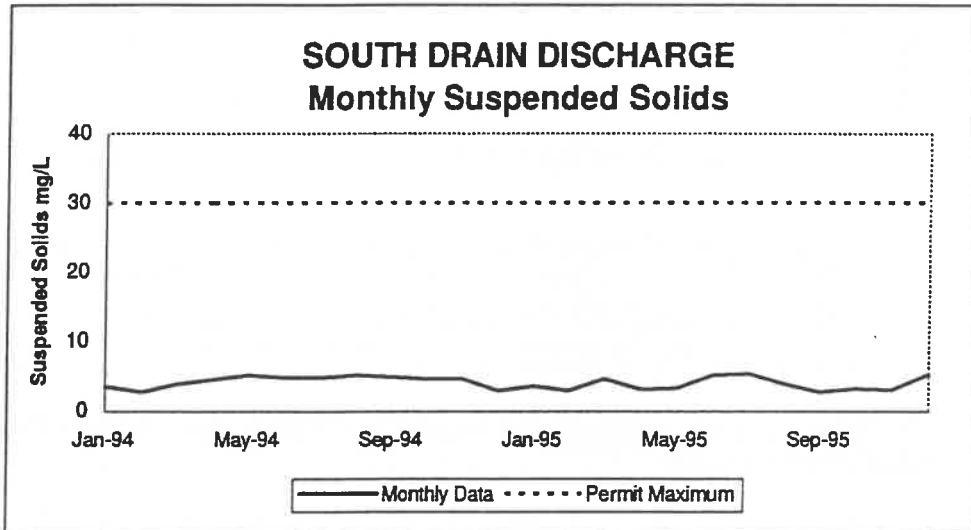
4.3 South Drain Discharges

Introduction

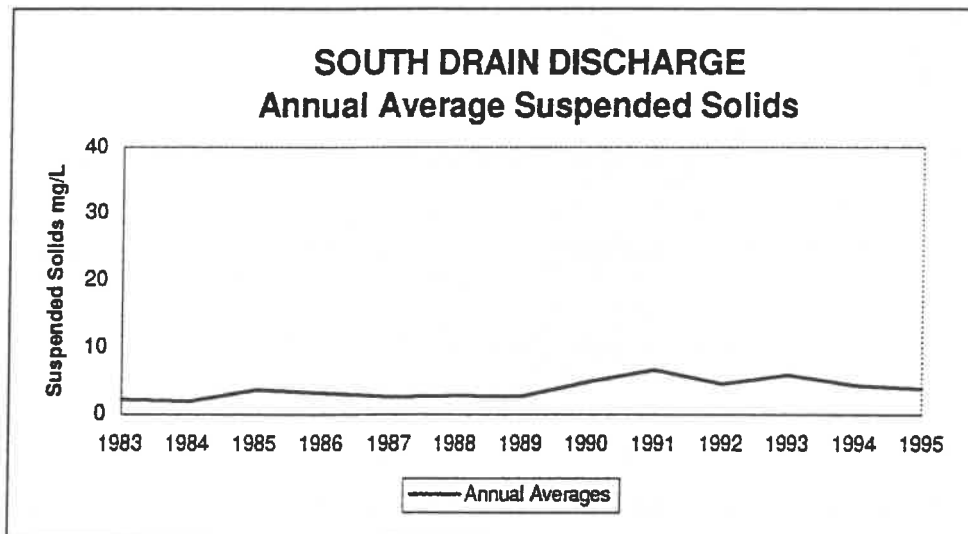
Discharges from the South Drain into Awarua Bay are covered by Coastal Permit Number 90059 issued by the Southland Regional Council on 24 October 1990.

Monitoring Results

The following graph shows the monthly average concentration of suspended solids discharged from the South Drain during 1994 and 1995.



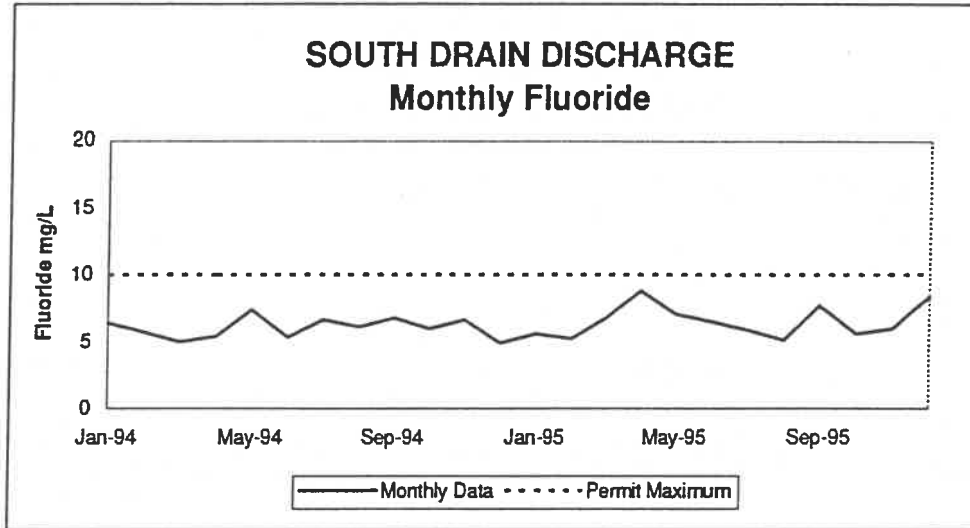
The following graph shows the annual average concentration of suspended solids discharged from the South Drain.



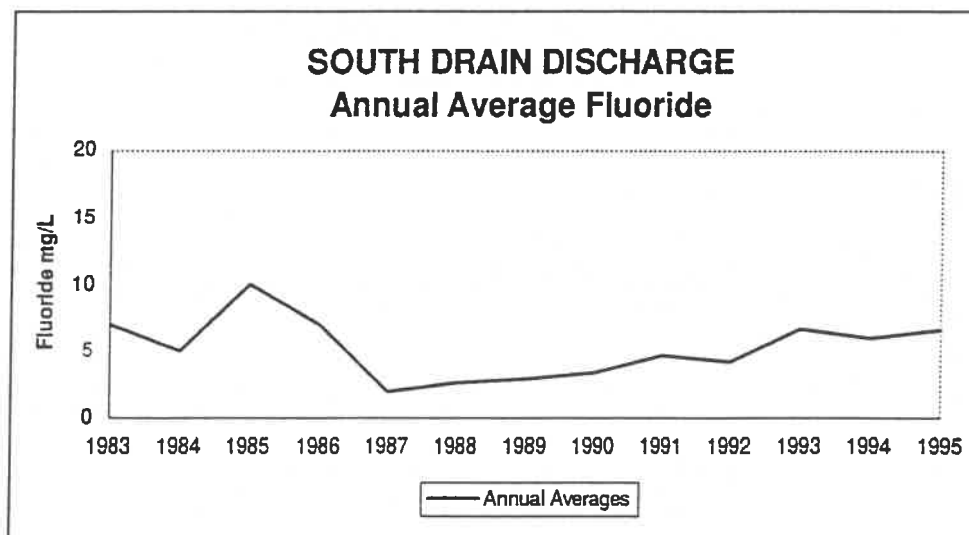
4.3 South Drain Discharges, Continued

Monitoring Results, continued

The following graph shows the monthly average concentration of fluoride discharged from the South Drain during 1994 and 1995.



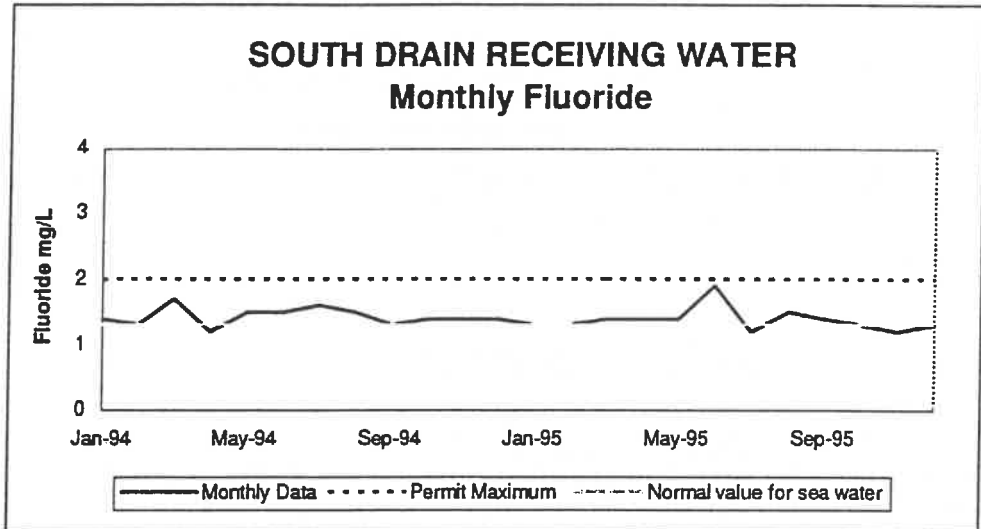
The following graph shows the annual average concentration of fluoride discharged from the South Drain.



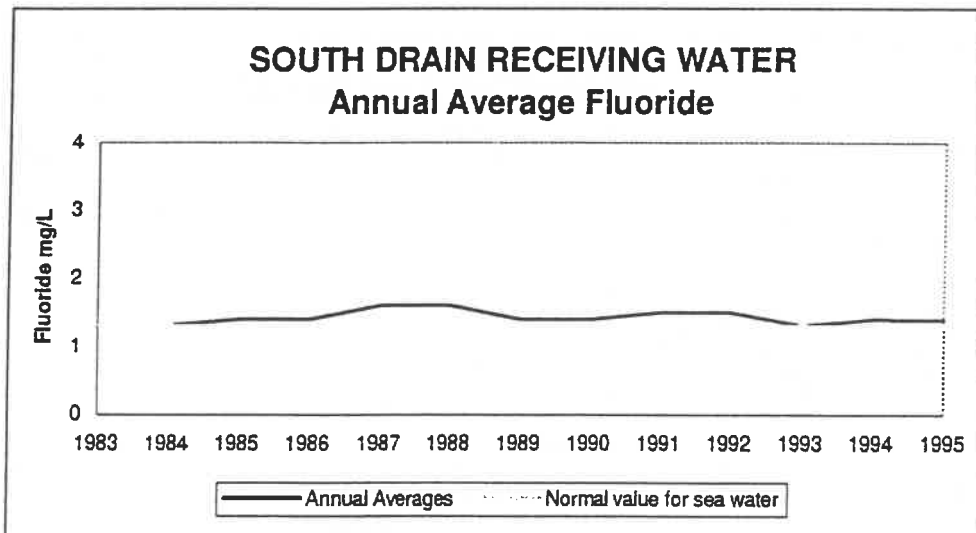
4.3 South Drain Discharges, Continued

Monitoring Results, continued

The following graph shows the monthly average fluoride concentration of the South Drain receiving water during 1994 and 1995.



The following graph shows the annual average fluoride concentration of the South Drain receiving water.



Comments

Discharges from the South Drain during 1995 were stable and within permit standards.

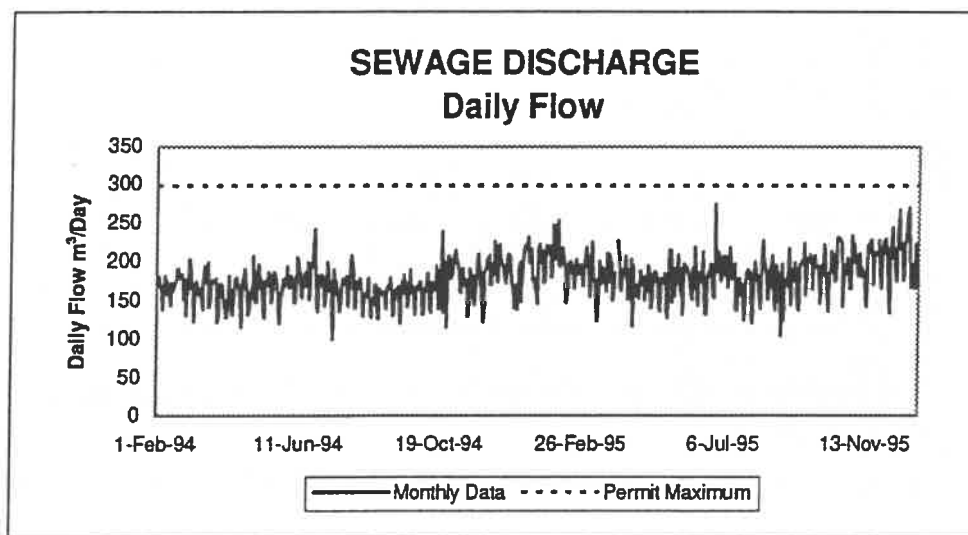
4.4 Treated Sewage Discharges

Introduction

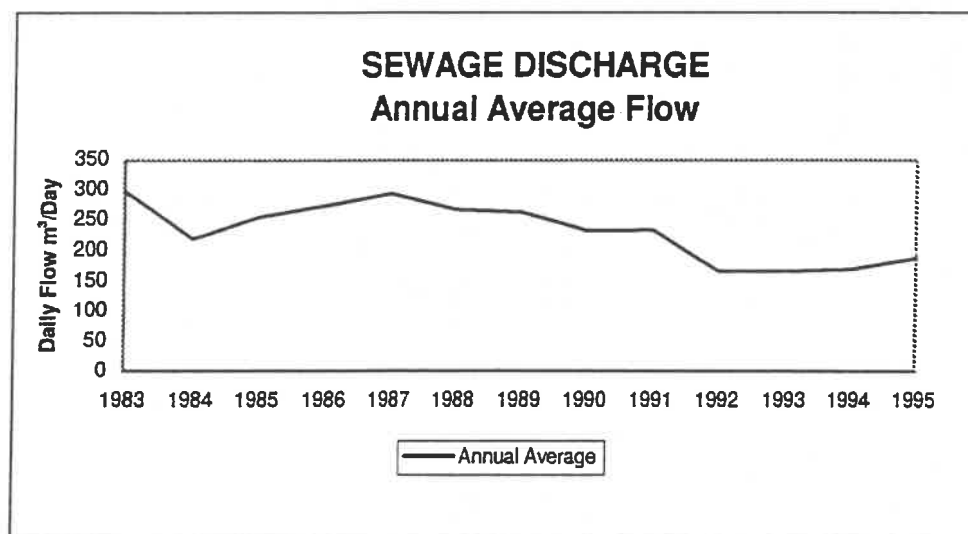
Discharges of treated sewage into Awarua Bay are covered by Coastal Permit Number 90060 issued by the Southland Regional Council on 24 October 1990.

Monitoring Results

The following graph shows the daily sewage discharge flow during 1994 and 1995.



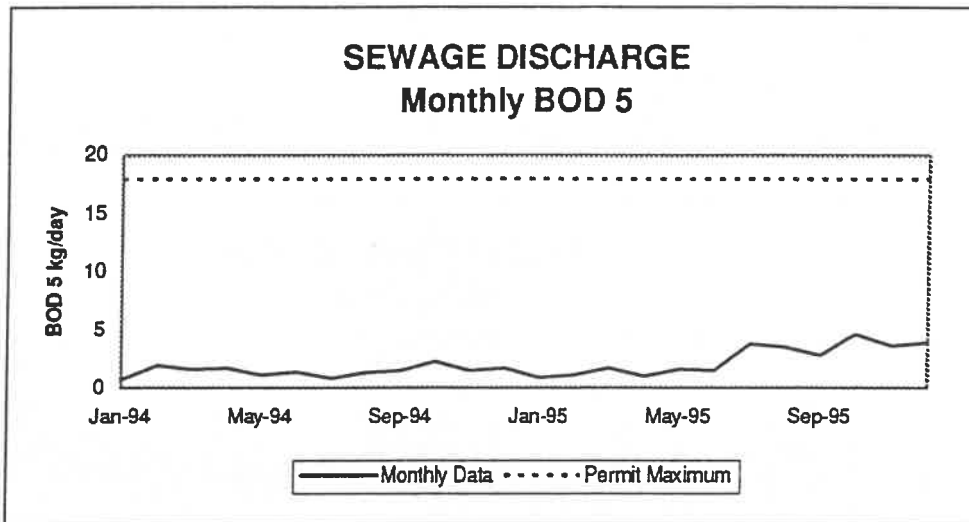
The following graph shows the annual average daily sewage discharge flow.



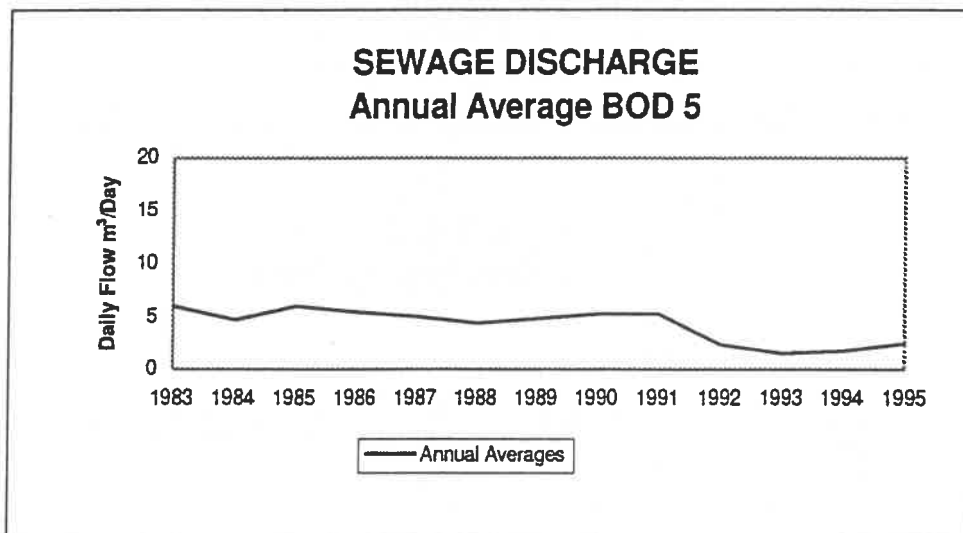
4.4 Treated Sewage Discharges, Continued

Monitoring Results, continued

The following graph shows the monthly BOD 5 discharge from the sewage treatment plant during 1994 and 1995.



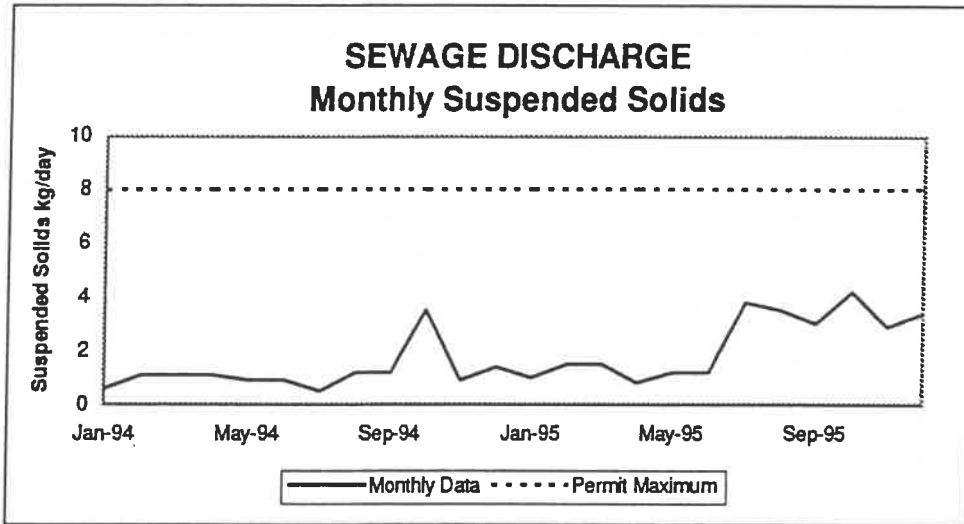
The following graph shows the annual average BOD 5 discharge from the sewage treatment plant.



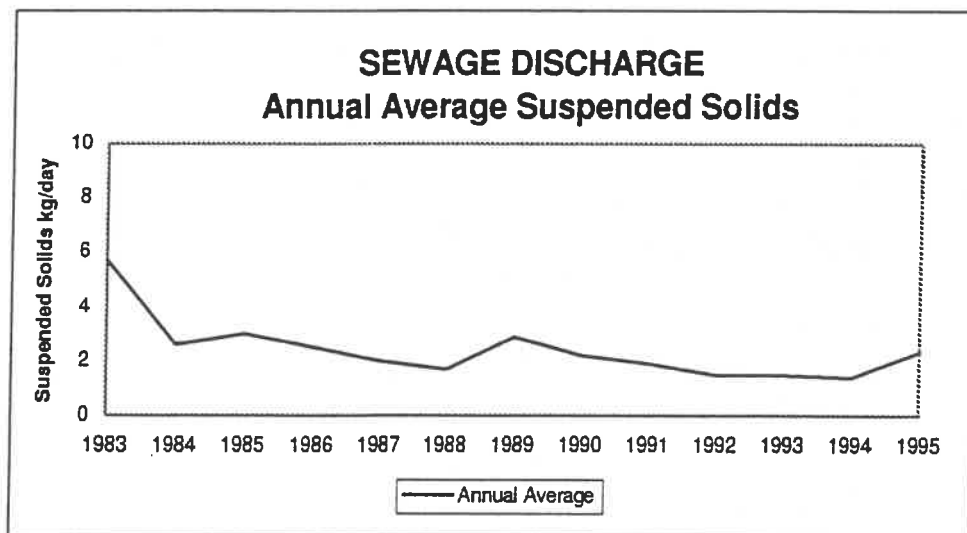
4.4 Treated Sewage Discharges, Continued

Monitoring Results, continued

The following graph shows the monthly suspended solids discharge from the sewage treatment plant during 1994 and 1995.



The following graph shows the annual average suspended solids discharge from the sewage treatment plant.



4.4 Treated Sewage Discharges, Continued

Comments

The increasing sewage discharges in the latter part of 1995 reflected the increased construction activities at NZAS. The discharges are expected to return to stable conditions when the Upgrade activity is finished.

Discharges of treated sewage into Awarua Bay during 1995 were within permit standards.

4.5 Treated Cathode Leachate Discharges

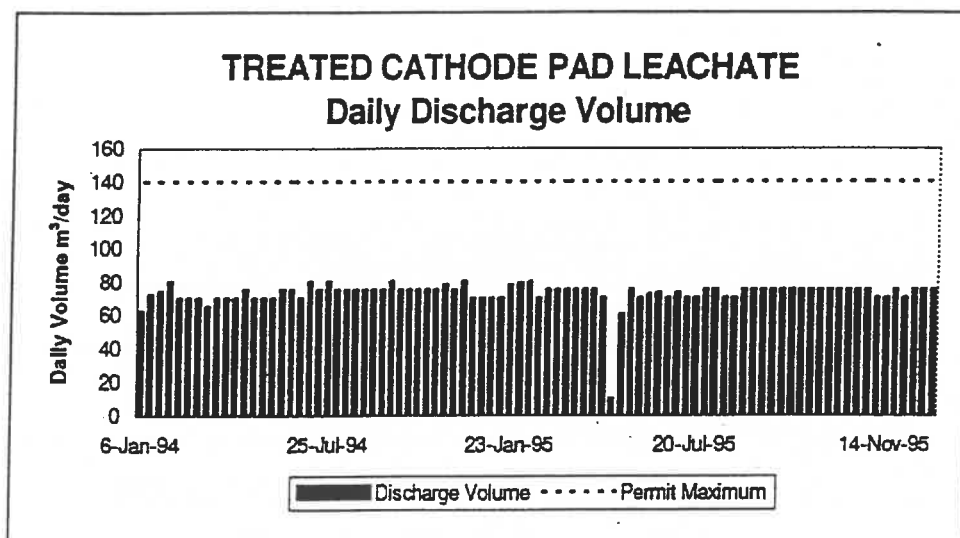
Introduction

Discharge of treated cathode pad leachate into Foveaux Strait is covered by Coastal Permit Number 90061 issued by the Southland Regional Council on 24 October 1990.

4.5.1 Discharge Volumes

Monitoring Results

The following graph shows the volume of individual discharges of treated cathode pad leachate during 1994 and 1995.



Comment

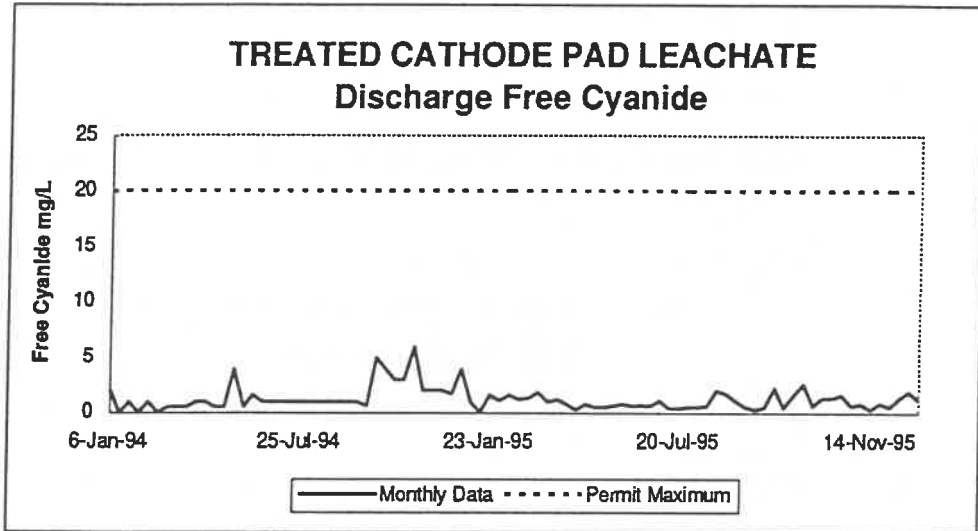
The daily discharge limit of 140 m³/day was not exceeded during 1994.

The number of discharges, and consequently the volume of treated leachate discharged, has decreased since the cathode pad was covered in 1992. The bulk of the discharge is effluent generated by cell shell and cathode bar washing.

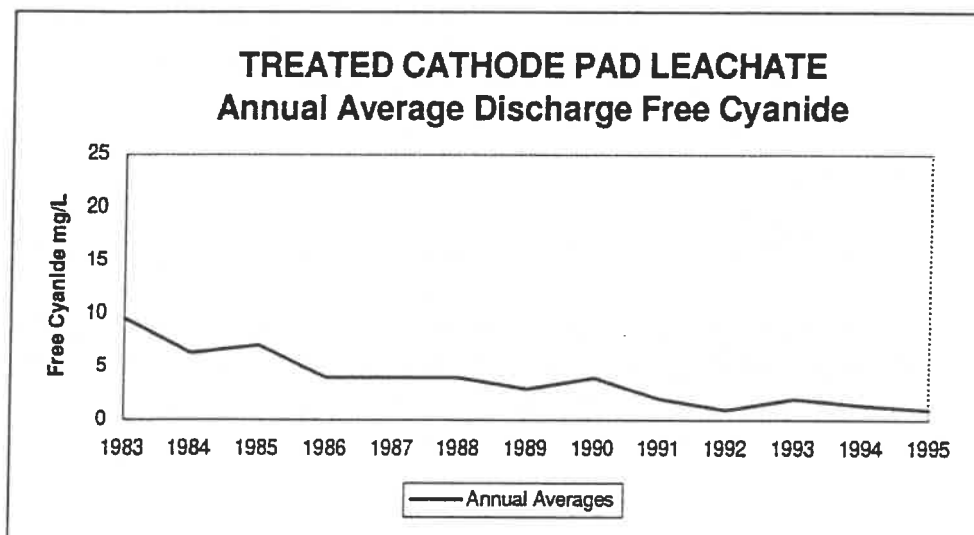
4.5.1 Discharge Free Cyanide

Monitoring Results

The following graph shows the free cyanide concentration of individual discharges of treated cathode pad leachate during 1994 and 1995.



The following graph shows the annual average free cyanide concentration of treated cathode pad leachate discharged.



4.5.1 Discharge Free Cyanide, continued

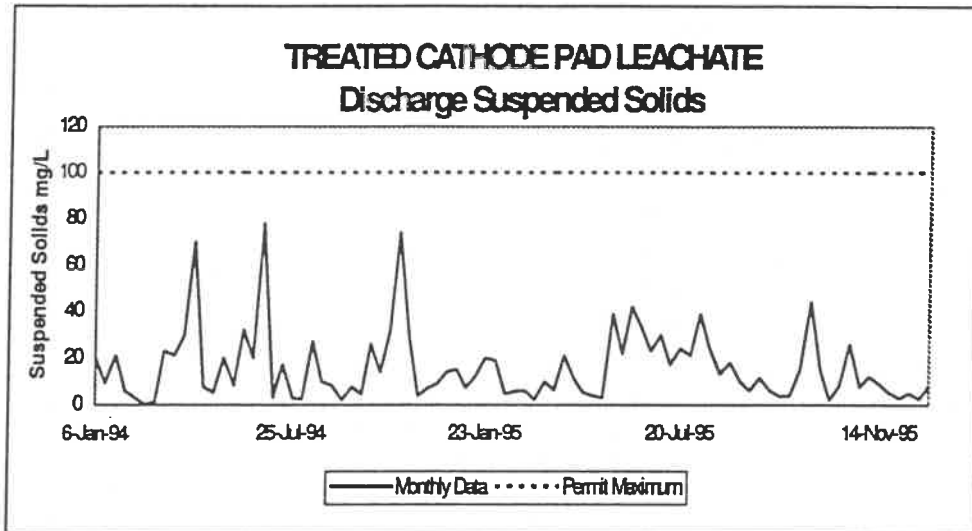
Comments

Discharges into Foveaux Strait during 1995 were within the permit standards.

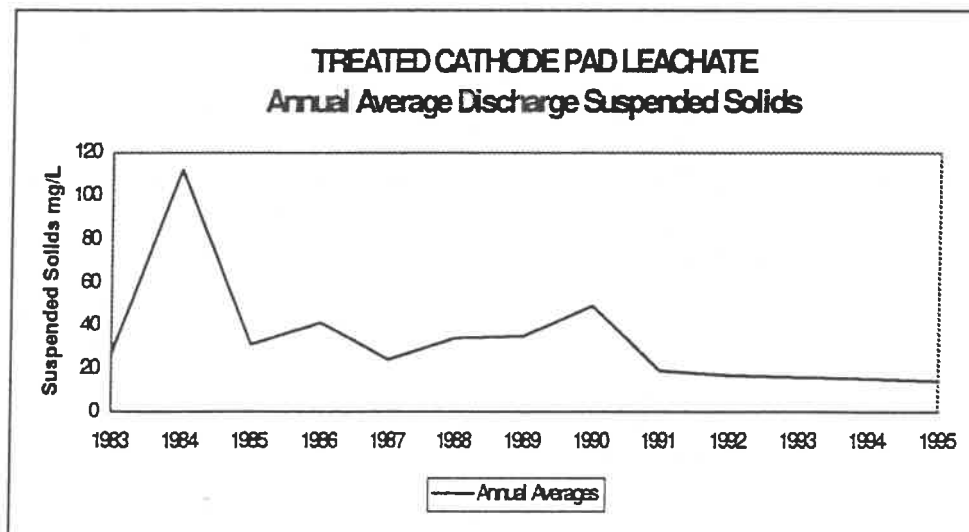
4.5.2 Discharge Suspended Solids

Monitoring Results

The following graph shows the suspended solids concentration of individual discharges of treated cathode pad leachate during 1994 and 1995.



The following graph shows the annual average suspended solids concentration of treated cathode pad leachate discharged.



Comments

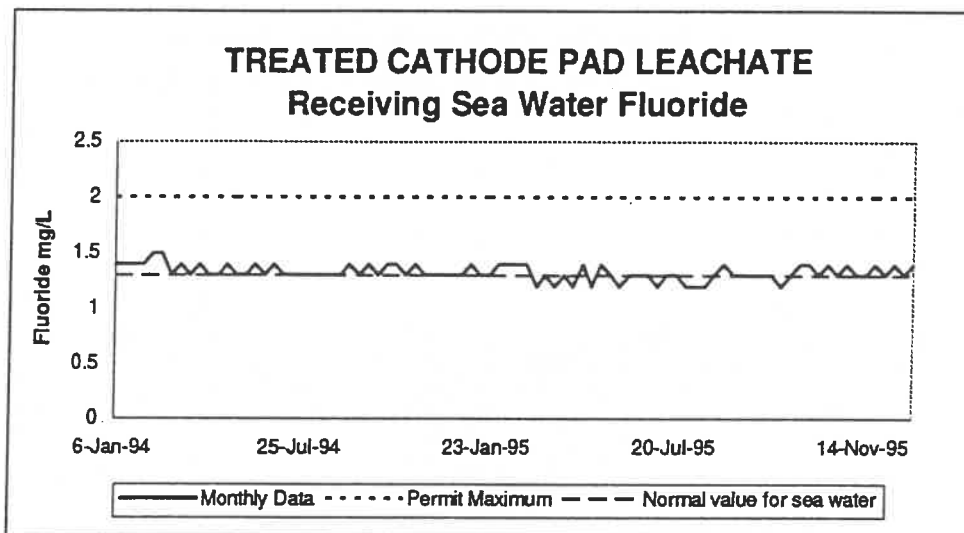
Discharges into Foveaux Strait during 1995 were within the permit standards.

The annual average for 1995 was consistent with the previous three years.

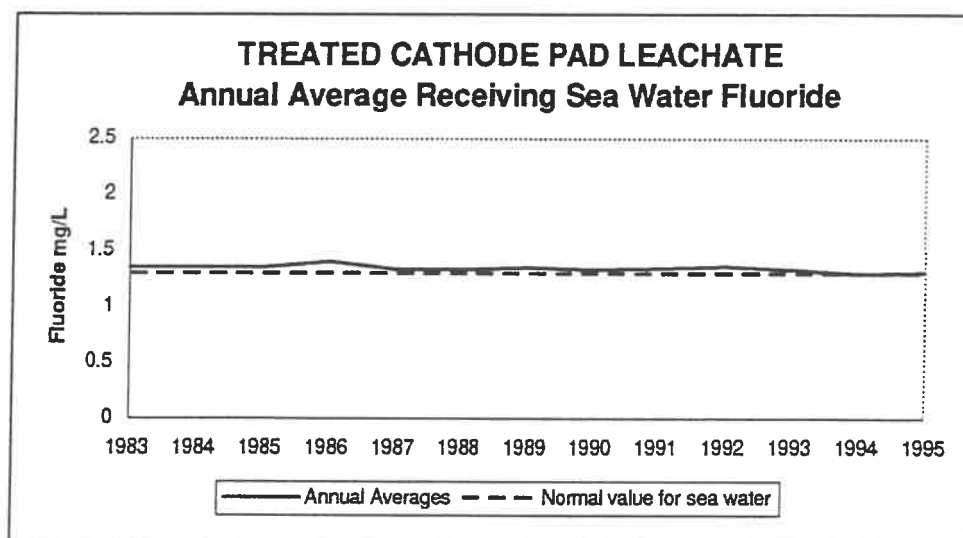
4.5.3 Receiving Seawater Fluoride

Monitoring Results

The following graph shows the fluoride concentration of the receiving sea water during individual discharges of treated cathode pad leachate during 1994 and 1995.



The following graph shows the annual average fluoride concentration of the receiving sea water during the discharge of treated cathode pad leachate.



Comments

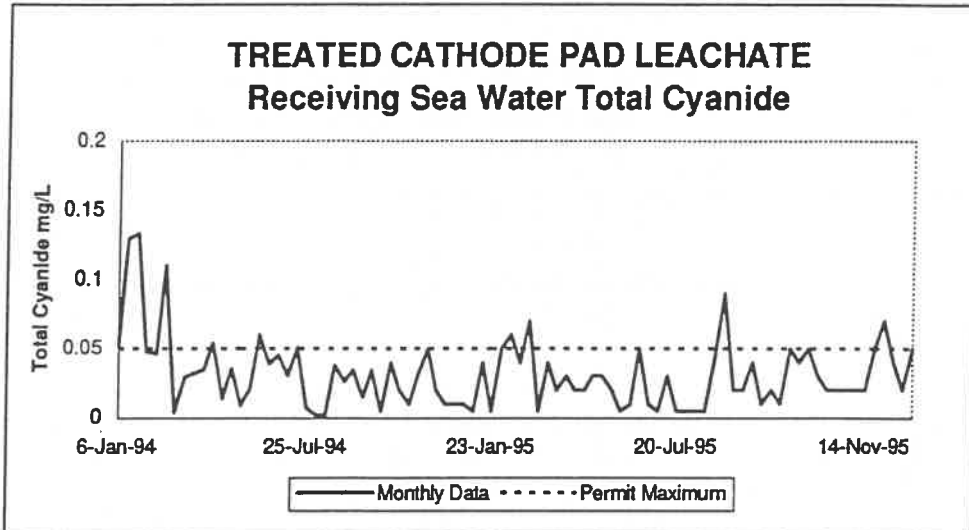
Discharges into Foveaux Strait during 1995 were within the permit standards.

The annual average for 1995 was consistent with the previous ten years.

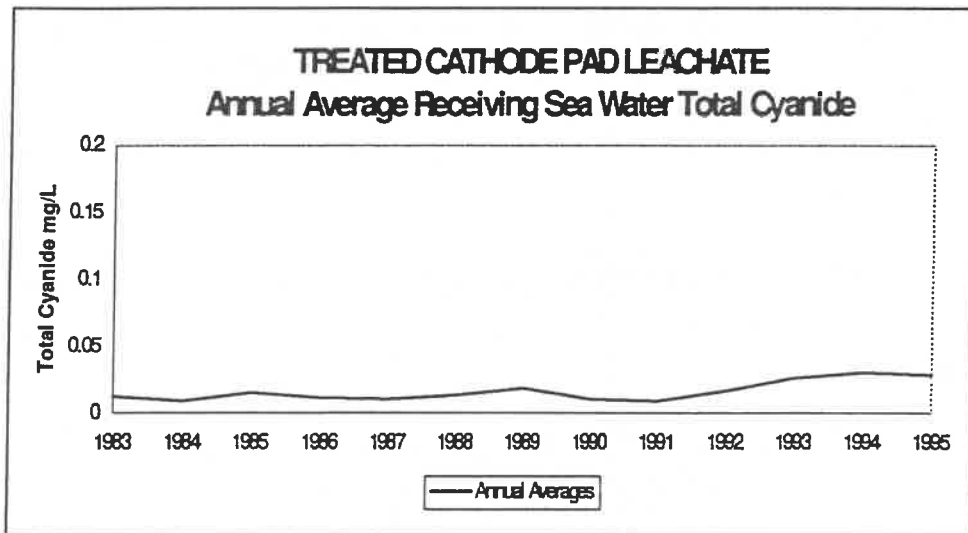
4.5.4 Receiving Seawater Total Cyanide

Monitoring Results

The following graph shows the total cyanide concentration of the receiving sea water during individual discharges of treated cathode pad leachate during 1994 and 1995.



The following graph shows the annual average total cyanide concentration of the receiving sea water during the discharge of treated cathode pad leachate.



Comments

Monitoring results indicated the receiving seawater total cyanide concentrations were above the permit condition four times during 1995. As indicated in previous reports to the Interdepartmental Committee this was most likely due to the seepage of contaminated groundwater onto the beach. The annual average concentration during 1995 was similar to that measured during 1993 and 1994.

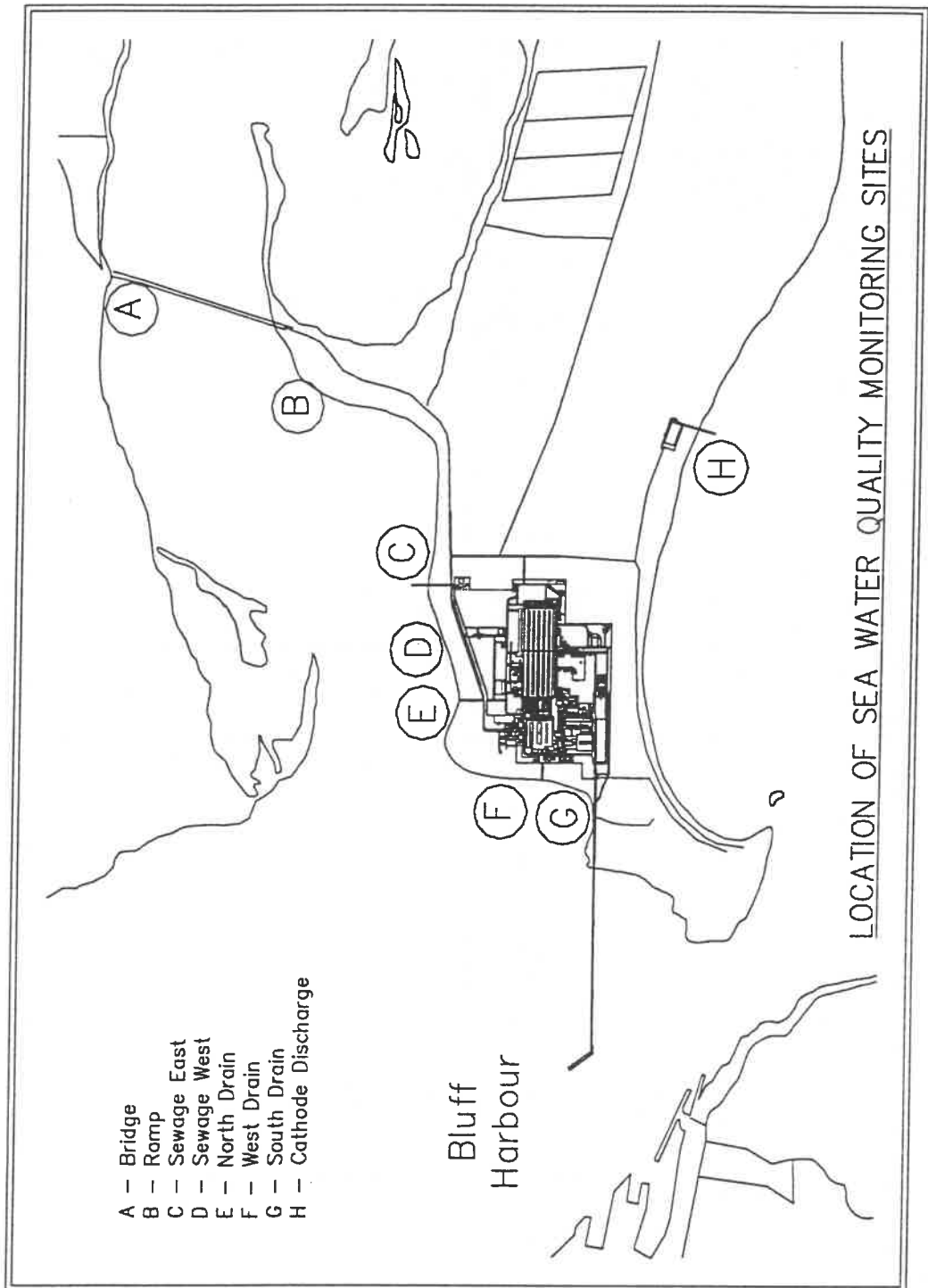
4.6 Sea Water Quality

Introduction

The five coastal permits which cover the various smelter discharges to water all state that Class SB standards shall apply with respect to the receiving water.

Water quality is measured at a number of sites surrounding the smelter. The sites are shown in the map on the following page.

4.6 Sea Water Quality, continued



4.6 Sea Water Quality, Continued

Two types of monitoring are undertaken

- chemical analysis at eight sites, A to H, and
- bacteriological monitoring at four sites, A, B, C, and D.

Each site was sampled five times during February 1995.

4.6 Sea Water Quality, Continued

Temperature

The Class SB standard requires that the natural temperature of water shall not be changed by more than 3°C.

The following table shows the average temperature measured at each site over the five days sampling.

Site	Temperature °C		
	Min.	Average	Max.
A Bridge	14.5	15.7	17.3
B Ramp	13.8	15.1	16.3
C Sewage East	13.3	14.9	16.2
D Sewage West	12.9	14.9	16.0
E North Drain	13.5	15.9	16.2
F West Drain	12.7	14.8	16.4
G South Drain	13.0	15.0	16.8
H Cathode	14.5	15.3	15.7

4.6 Sea Water Quality, Continued

Temperature, continued

The following table shows the range of temperatures over all the Awarua Bay/Bluff Harbour sites (excluding the treated cathode leachate discharge site) on each of the five days sampling took place.

Date	Range of Temperature Measured °C
08-Feb-95	1.8
13-Feb-95	1.3
22-Feb-95	0.5
26-Feb-95	0.9
27-Feb-95	0.8

Comments

All the discharge points for liquid effluent from the smelter discharge into Awarua Bay or the environs of Bluff Harbour. Being an environment dominated by estuarine conditions there is significant variation in the natural temperature, both from site-to-site around Awarua Bay/Bluff Harbour and from day-to-day at any given site. Air temperature, hours of sunshine and wind speed all have an effect on the water temperature. By way of example, the temperature of the samples collected at site A, the bridge, ranged over 2.8 °C during the five days of sampling. This is considered to be natural variation as it is extremely unlikely this site is influenced by the smelter's emissions.

As a result, it is very difficult to determine what is the natural temperature and to what extent the variation in temperature observed in the samples collected near the smelter's discharge points is attributable directly to the smelter discharges.

Although the overall range of temperatures measured exceeded 3°C, on no individual day was the temperature variation measured over all the sites around the bay/harbour area greater than 1.8°C. Therefore, given that the bridge site is unaffected by the smelter's discharges, the amount of variation and the range of temperatures at all these sample sites is considered to be within the natural variation.

The point of discharge for the treated cathode pad leachate is near the entrance to Bluff Harbour and sea water quality is undoubtedly affected by the tidal discharges from Awarua Bay. There was a 1.2°C range in the temperatures measured at this site. Again this is considered to be natural variation.

4.6 Sea Water Quality, Continued

pH

The Class SB standard requires that the natural pH of the water shall not be changed by more than 0.1 and at no time be less than 6.7 or greater than 8.5.

The following table shows the average pH and range of pH measured at each site over the five days sampling.

Site	pH		
	Min.	Average	Max.
A Bridge	8.16	8.2	8.33
B Ramp	8.14	8.2	8.23
C Sewage East	8.11	8.2	8.22
D Sewage West	8.10	8.2	8.21
E North Drain	8.13	8.2	8.19
F West Drain	8.06	8.1	8.15
G South Drain	8.04	8.1	8.15
H Cathode	8.12	8.1	8.20

The following table shows the range of pH measured over all the Awarua Bay/Bluff Harbour sites (excluding the treated cathode leachate discharge site) on each of the five days sampling took place.

Date	Range of pH Measured Over all Sites
08-Feb-95	0.09
13-Feb-95	0.27
22-Feb-95	0.03
26-Feb-95	0.18
27-Feb-95	0.08

4.6 Sea Water Quality, Continued

Comments

As mentioned, all the discharge points for liquid effluent from the smelter discharge into Awarua Bay or the environs of Bluff Harbour. Again the estuarine conditions will result in significant variation in the natural pH, both from site-to-site around Awarua Bay/Bluff Harbour and from day-to-day at any given site. By way of examples, the pH of the samples collected at site A, the bridge, ranged over 0.17 pH units during the five days of sampling. This is considered to be natural variation as, again, it is extremely unlikely this site is influenced by the smelter's discharges. In their study of Awarua Bay, carried out in 1992, Bioresarches observed variations of up to 0.9 pH units between different sampling days for the same bridge site and up to 0.5 pH units in samples collected on the same day from different sites within the Awarua Bay/Bluff Harbour, but remote from the smelter's influence.

As a result, it is very difficult to determine what is the natural pH and to what extent the variation in pH observed in the samples collected near the smelter's discharge points is attributable directly to the smelter's emissions.

At no time was any pH measured outside the range 6.7 to 8.5. The amount of variation and the range of pH values at all the sample sites was within the natural variation observed to date.

The pH of the samples collected from near the treated cathode leachate discharge site varied by 0.08 pH units. This is considered to be due to natural variation.

4.6 Sea Water Quality, Continued

Dissolved oxygen

The Class SB standard requires that the dissolved oxygen concentration is not below 5 mg/L.

Site	Average Dissolved Oxygen mg/L	Minimum Dissolved Oxygen mg/L	Range of Dissolved Oxygen mg/L
A Bridge	7.5	7.3	0.4
B Ramp	7.5	7.3	0.4
C Sewage East	7.5	7.1	0.6
D Sewage West	7.5	7.3	0.5
E North Drain	7.5	7.4	0.3
F West Drain	7.6	7.4	0.8
G South Drain	7.6	7.4	0.9
H Cathode	7.8	7.6	0.3

Comments

At no time was a dissolved oxygen concentration determined to be less than 5 mg/L.

4.6 Sea Water Quality, Continued

Faecal coliforms

The Class SB standard requires that the median faecal coliform concentration is below 200 MPN/100 mL.

Site	Median Faecal Coliform Concentration MPN/100 mL	Maximum Faecal Coliform Concentration MPN/100 mL
A Bridge	2	7
B Ramp	2	4
C Sewage East	2	11
D Sewage West	2	4

Comments

The median faecal coliform concentration at all sites was less than 200 MPN/100 mL.



Chapter 5

Groundwater

5.1 Spent Cathode Pad Leachate

The investigation into the possible extraction of the plume of contaminated groundwater that originated from the existing spent cathode pad was completed in mid 1995.

The principal findings of the investigation were that:

- as there is no effective treatment process, the extraction of the contaminated groundwater and its subsequent discharge into the sea would achieve no environmental benefits, and
- the natural attenuation and dispersion process will result in aquifer remediation over a period of years without adverse effects on the receiving environment.

These findings were reported to the Southland Regional Council. The Council had the report and these findings audited by an independent geo-hydrologist.

The result of this process was that on 11 October 1995 the Southland Regional Council resolved that NZAS be advised that it is the Council's opinion that the cathode pad contamination plume be allowed to continue to recover by natural dispersion alone.

Ongoing monitoring and reporting, on this recovery, is continuing.

5.2 Diesel Leak

A 12 month trial of air sparging as a remediation strategy for the underground diesel spill is scheduled to be completed in April 1996. The object of this trial is to assess the long-term viability of sparging air into the diesel contaminated region from a series of point sources. The aspects under investigation include:

- the mechanics of sparging air into the ground continuously,
- the area of influence of a point source of air, and
- the effectiveness of this as a remediation strategy.

The investigations into the success of this strategy are due to be completed by early June 1996. This investigation will also review the progress of the natural (unassisted) bioremediation of this plume.

5.3 Spent Cell Lining (SCL) Storage Shed

The routine monitoring of the membranes under the SCL storage shed identified that cyanide and fluoride contaminated water had leached through the concrete floor from the cathode bar wash down area. The high density polyethylene membranes installed under the building contained this material and prevented it escaping to the local groundwater. The cause of the leak was identified and repaired, and the small volume of effluent in question was extracted using battery-operated bilge pumps.