New Zealand Aluminium Smelters Limited

Interdepartmental Committee Report

1994

REPORT TO THE INTERDEPARTMENTAL COMMITTEE ON ENVIRONMENTAL EFFECTS OF THE TIWAI ALUMINIUM SMELTER FOR THE YEAR ENDING 31 DECEMBER 1994

MEETING AT TIWAI
9 MAY 1995

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

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Introduction

This year's report to the IDC is set against a background of significant commitments by NZAS to the improvement of the environmental performance of the smelter. The staged introduction of dry scrubbers, due to be completed by January 1997, will dramatically reduce the impact of the Main Stack discharges on the receiving environment. Once the Comtor facility is commissioned (targeted for September 1996) NZAS will join the relatively small number of smelters world wide that actively treat their spent cathode linings as opposed to simply stockpiling or dumping them.

In April of 1994, a new 12 year discharge and coastal permit for discharges to air was granted to NZAS. This has introduced a number of changes to the basis on which most source emissions and some receiving environment monitoring results are reported. The significant changes are:

- a move to reporting in terms of mass discharged rather than concentrations,
- the use of running 12 month averages for measuring permit standard compliance for most source emission monitoring, and
- the introduction of guidelines, the exceeding of which requires further investigation or other action without constituting a non compliance.

In this report, unless otherwise stated, all references to permit conditions refer to the new permit. Where a significant event took place during the first three-and-a-half months of 1994, when the previous permit was in force, specific reference is made to that permit.

All historical data has been converted to be consistent with the units and reporting methods used in the new discharge permit.

The changes to the NZAS environmental monitoring programme as recommended by the IDC were introduced during 1994. The most significant changes were:

- the removal of GMF 8, 9 and 13,
- the addition of two new dairy farms GMF 14 and 16,
- the addition of:
  - pine needle sampling,
  - sea water quality monitoring, and
  - ambient air particulate fluoride monitoring

  to the NZAS monitoring programme, and
- the addition of a new ambient air monitoring station at the eastern end of the Waituna Lagoon.

These changes are reflected in the content of this year's report.

Summary

In 1994 the overall effect of the smelter on the surrounding environment was similar to that observed in 1993. This reflects the similar nature and magnitude of the discharges from the smelter in 1994 as compared to 1993.

The average rate of fluoride discharge from the Main Stack, in both gaseous and particulate forms, was similar to recent years. The average rate of total particulate discharge from the Main Stack was very similar to 1993 and less than 1991 and 1992. This is in spite of a significant upward excursion in the rate of discharge in September of 1994.

Reductions in the discharge rates of gaseous and particulate fluoride from the potroom roof louvres achieved 1992 and 1993 were maintained in 1994.

The concentration of fluoride in the ambient air remained very low at all monitoring sites off Tiwai Peninsula. At the Buddle Road site the maximum seven day average concentration was 29% of the permitted level, at Waituna; 11% of the permitted level, and at Bluff the maximum seven day average concentration was only 6% of the permitted level.

As can be expected, with little change in the magnitude of the source emissions from the smelter, there was little change in the effects observed in the receiving environment.

No significant new trends were observed in the effects attributable to the smelter's emissions on livestock or vegetation on the Grazing Monitoring Farms.

As with previous years the fluoride levels in the north stormwater drain exceeded the permit standard. This and other liquid discharge issues will be addressed in the upcoming liquid discharge consent application.

Chapter 2

Discharges to Air

Introduction

The discharges into air from the smelter were covered by Air Discharge Permit No. HD/19/0006/88 until 26 April 1994 when a new permit was issued.

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

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 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 1994.

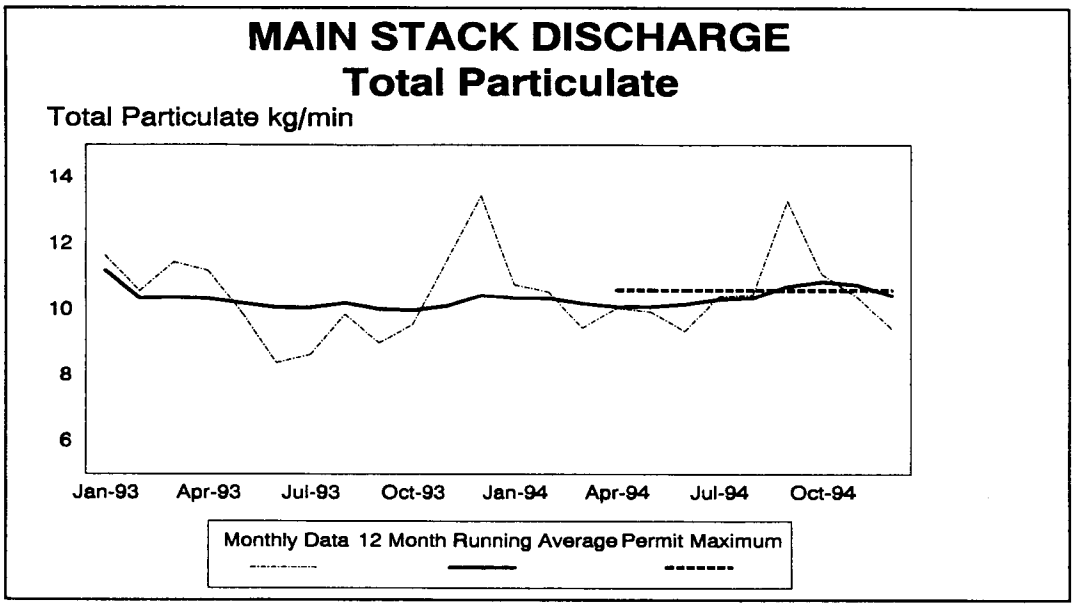
Parameter	Units	Permit	1994 annual average	1994 running average maximum
Gas flow rate	Sm^3/min	-	59 310	61 630
Total particulate • Month average • 12 month average	 kg/min kg/min	 - 10.60	 10.44	 13.32 10.86
Gaseous fluoride • Month average • 12 month average	 kg/min kg/min	 - 3.90	 3.68	 4.23 3.73
Particulate fluoride • Month average • 12 month average	 kg/min kg/min	 - 3.30	 2.37	 2.90 2.40
Sulphur dioxide	kg/min	-	10.63	11.11
Total condensable hydrocarbons	kg/min	-	0.33	0.39

2.1 Main Stack Discharges, Continued

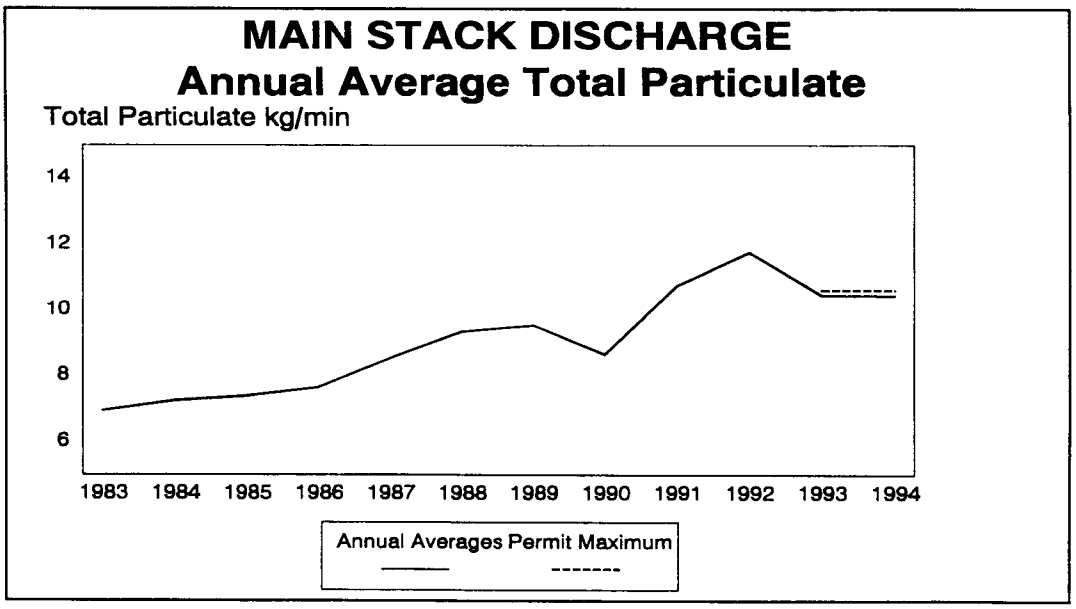
Total particulate

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 1993 and 1994.



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

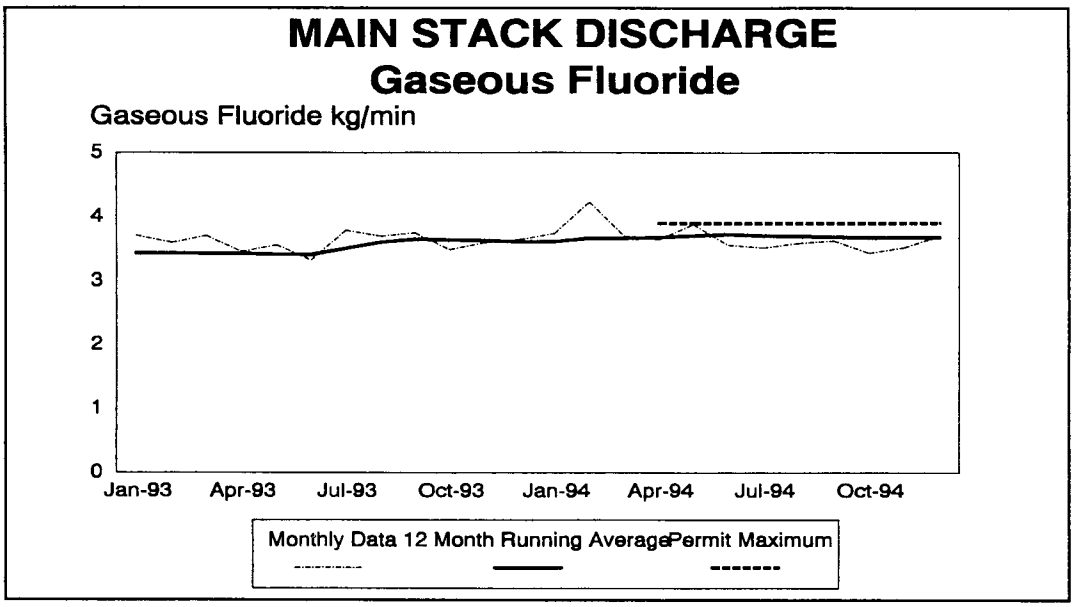


2.1 Main Stack Discharges, Continued

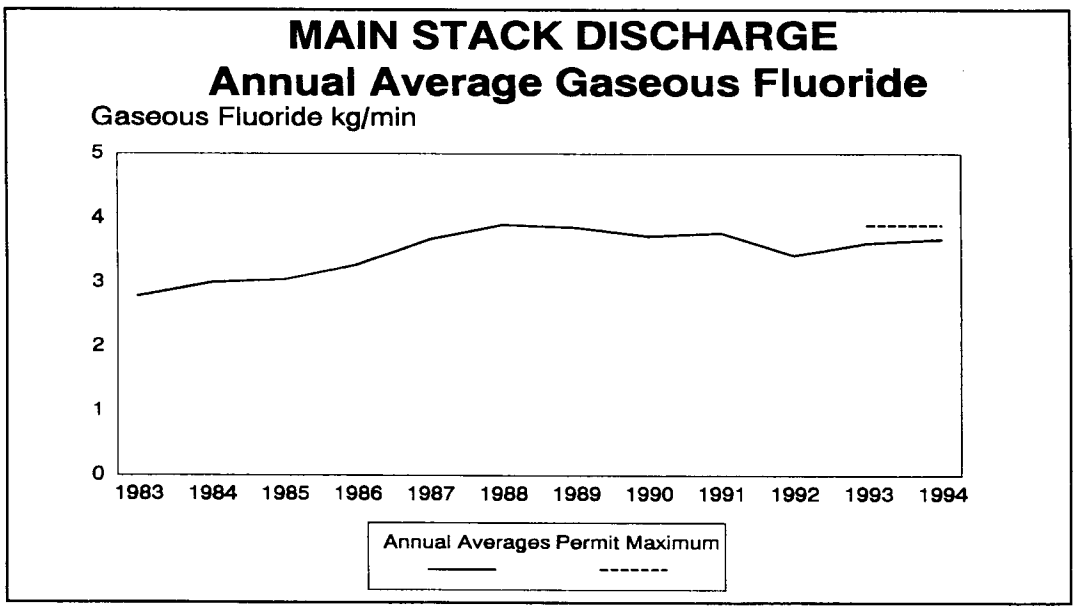
Gaseous fluoride

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

The following graph shows both the average monthly and twelve month running average main stack gaseous fluoride discharge during 1993 and 1994.



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

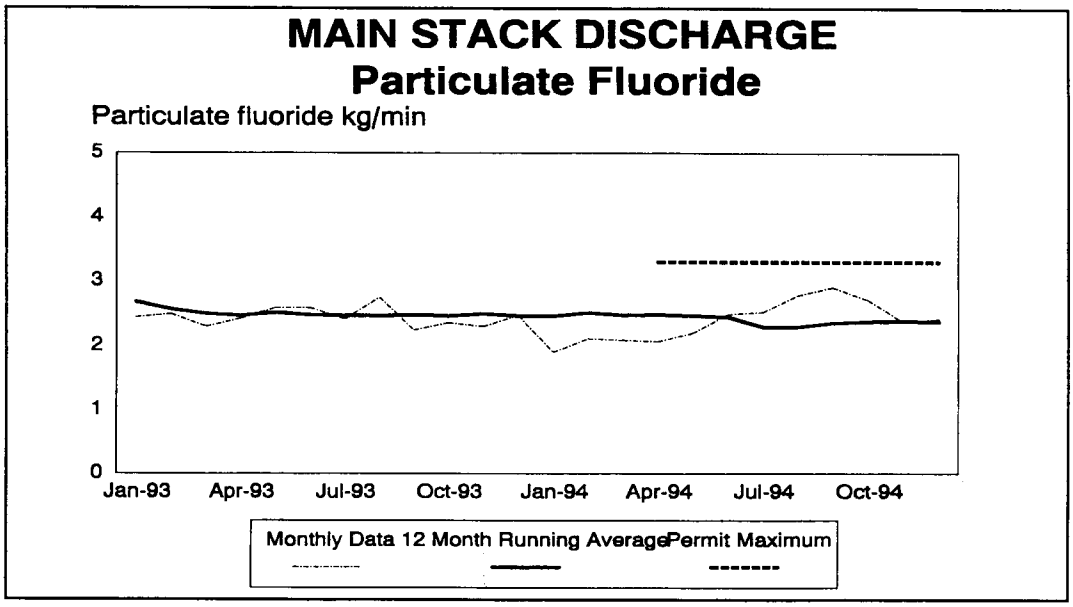


2.1 Main Stack Discharges, Continued

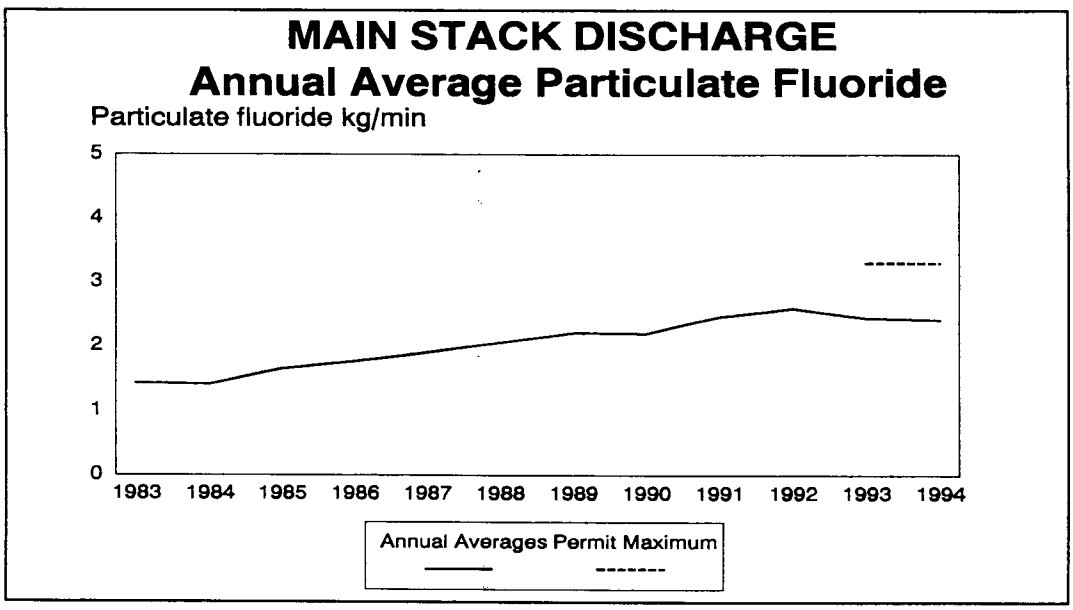
Particulate fluoride

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 1993 and 1994.



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



2.1 Main Stack Discharges, Continued

Comments

Total particulate

The previous main stack total particulate permit condition of 175 mg/Sm^3 was exceeded in January and February 1994. The following actions were taken to reduce the total particulate discharge from the main stack:

- an improved particulate pre collector for multicyclones 2B, 3A, and 3B was installed in February 1994,
- filters were replaced in the secondary air baghouse in February 1994,
- multicyclone paraclones were inspected and worn paraclones blanked off, and
- improved procedures for emptying the multicylcone dust hoppers were initiated.

The new main stack total particulate permit condition of 10.60 kg/min was exceeded during September, October, and November 1994. There were two reasons for these violations:

- the premature failure of bags in the secondary air baghouse, and
- erosion of paraclones in the multicyclones servicing line 3.

The bags in the baghouse were replaced in January 1994 and previous experience indicated a life expectancy for the bags of four years. The premature bag failure was found to be due to the high pressure differential across the baghouse. Modifications to the baghouse to reduce the pressure differential have been completed.

The eroded paraclones were repaired within three days of the problem being detected.

A triboelectric particulate probe has been purchased. The probe will be installed on the outlet of the baghouse during March 1995. The probe will detect any increases in particulate discharge.

Gaseous fluoride

The previous permit standard of 65 mg/Sm^3 for the main stack gaseous fluoride discharge was exceeded in January and February 1994. The reason for the violations was the higher temperature and humidity experienced during summer.

The main stack gaseous fluoride discharge was stable and within the permit standard for the remainder of the year.

2.1 Main Stack Discharges, Continued

Comments, continued

Gaseous fluoride, continued

Investigation of the operational problems associated with the continuous main stack gaseous fluoride analyser was initiated during 1994. A number of changes have been recommended which should improve the precision and reliability of the analyser. Trial work continues and is anticipated to be completed in the first half of 1995. The recommendations for the changes are scheduled for implementation in 1995.

Investigation into improved alumina injection to control the gaseous fluoride discharge continued during the year. The work has stopped pending the results of the work on the main stack continuous fluoride analyser. This analyser has been used to control the alumina injection rate.

Particulate fluoride

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

Dry scrubbing

A decision to install the Comalco Torbed dry scrubbing system was made in late November 1994.

Work is now in hand to complete the installation of stage one of the scrubbing system by the end of October 1995. Stage one will provide fume treatment for Potrooms 3A and 3B.

2.2 Potroom Roof Louvre Discharges

Monitoring results

The table below shows the potroom roof louvre monitoring results for 1994.

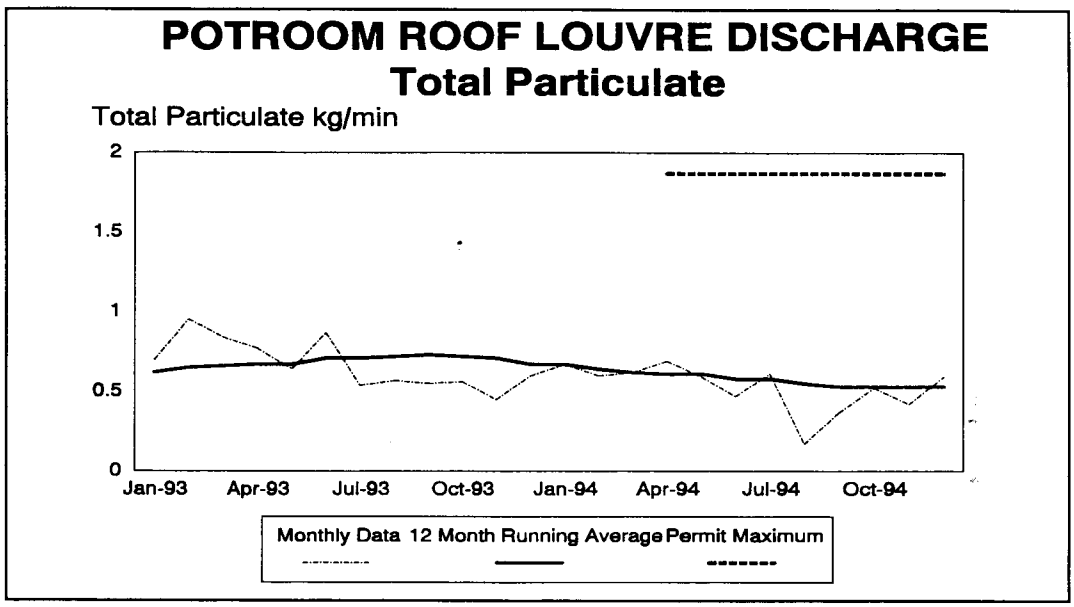
Parameter	Units	Permit	1994 annual average	1994 running average maximum
Total particulate				
• Month average	kg/min	-		0.69
• 12 month average	kg/min	1.87	0.53	0.67
Gaseous fluoride				
• Month average	kg/min	-		0.21
• 12 month average	kg/min	0.233	0.15	0.15
Particulate fluoride				
• Month average	kg/min	-		0.14
• 12 month average	kg/min	0.233	0.11	0.14
Sulphur dioxide	kg/min	-	0.46	0.54

2.2 Potroom Roof Louvre Discharges, Continued

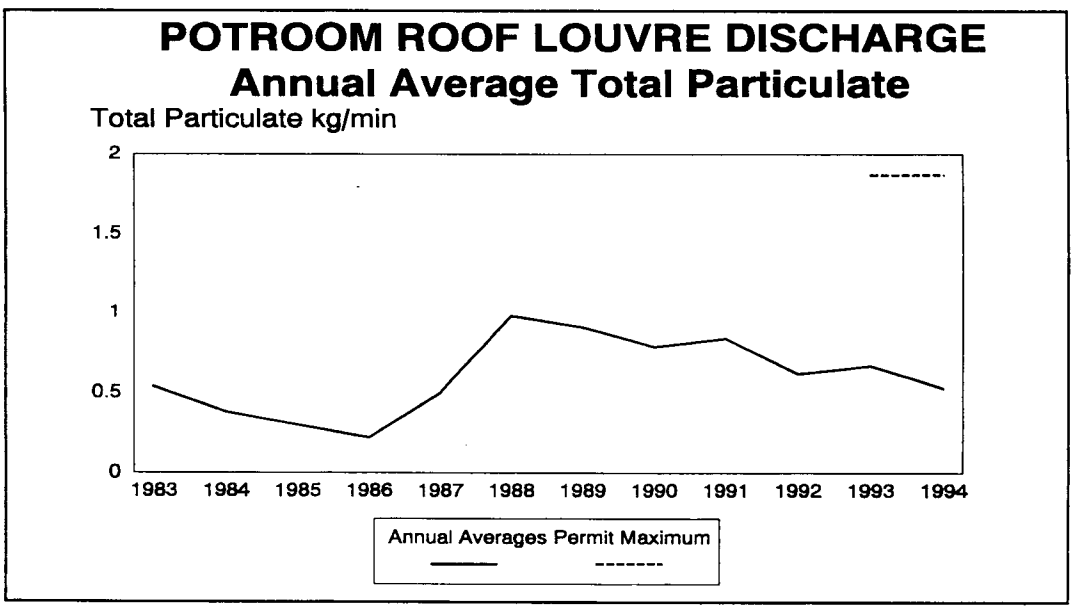
Total particulate

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 1993 and 1994.



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

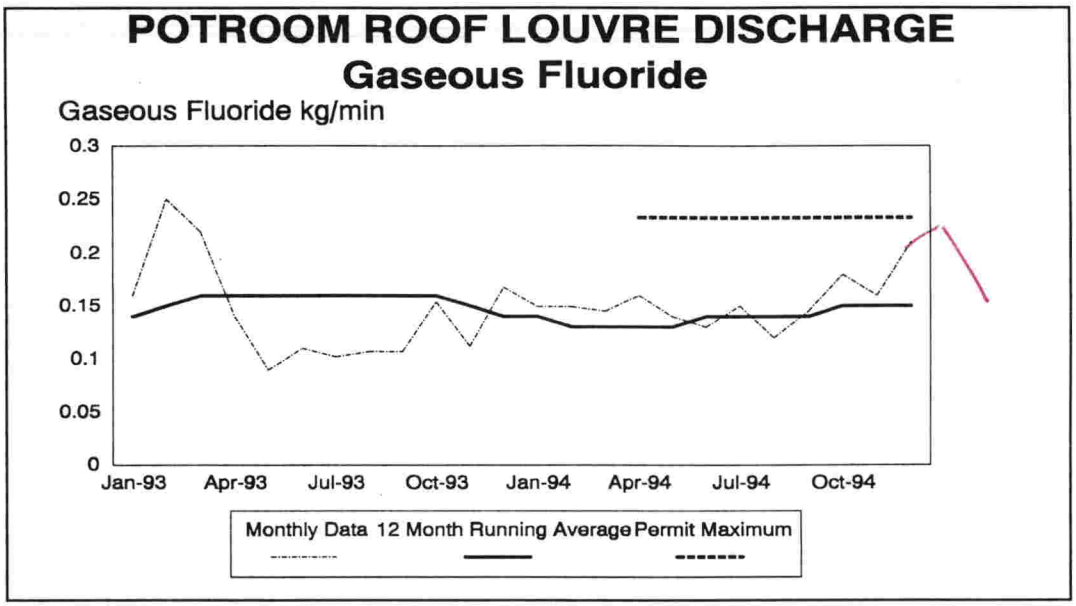


2.2 Potroom Roof Louvre Discharges, Continued

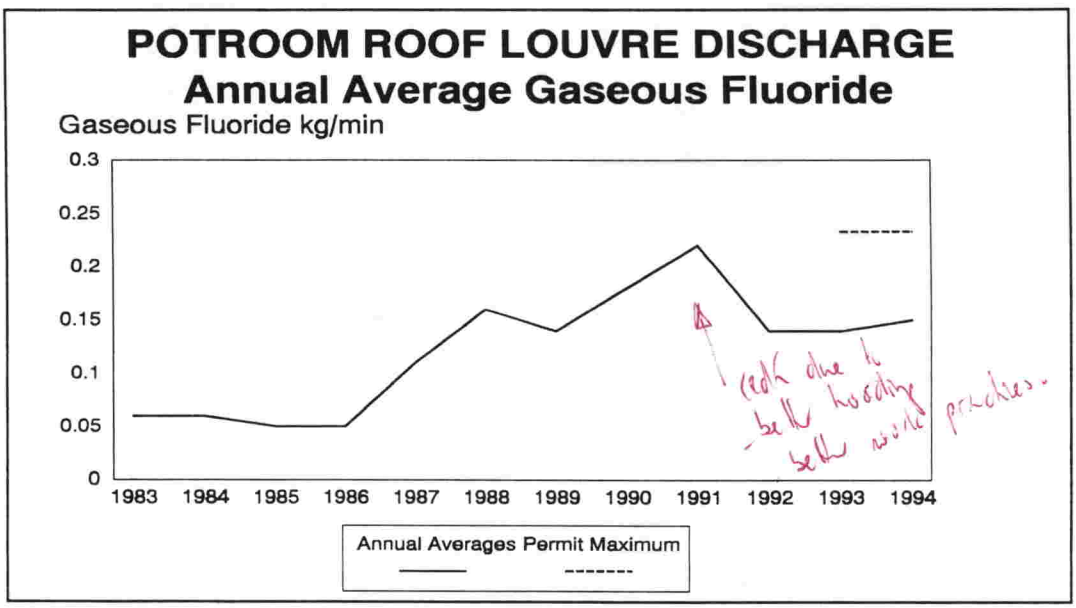
Gaseous fluoride

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 1993 and 1994.



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

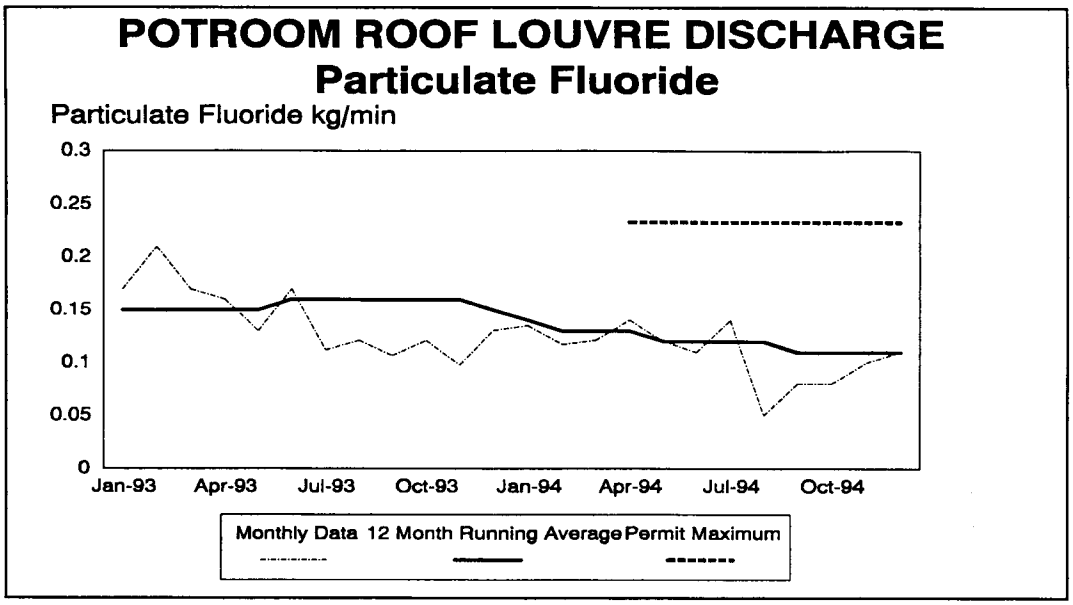


2.2 Potroom Roof Louvre Discharges, Continued

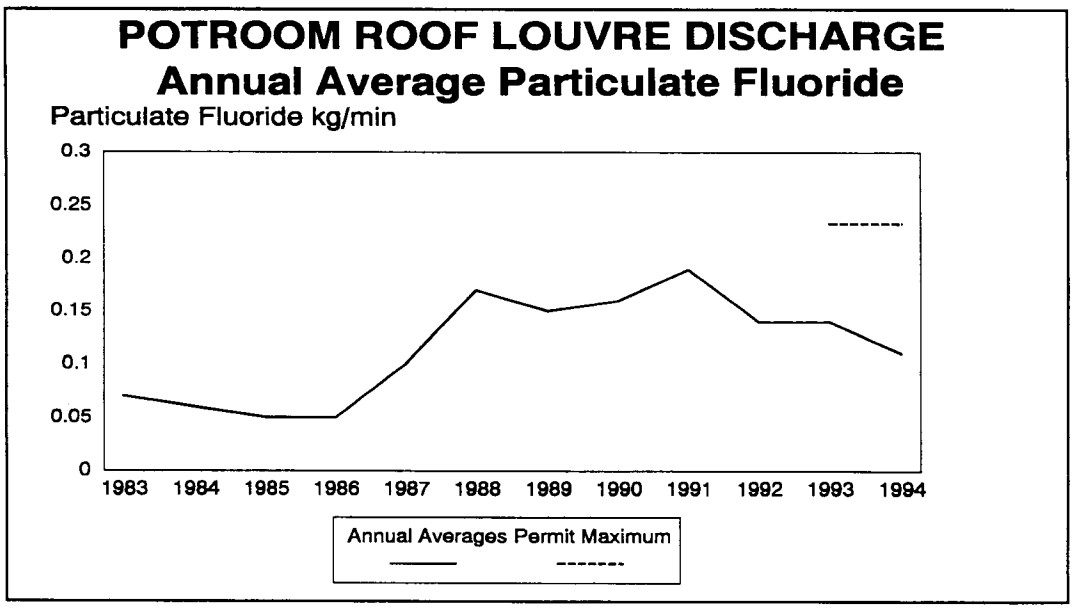
Particulate fluoride

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 1993 and 1994.



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 1994. The discharges were stable apart from the gaseous fluoride discharge which was higher during the fourth quarter than during the previous nine months. This situation is being assessed to determine if there is an underlying cause for the change.

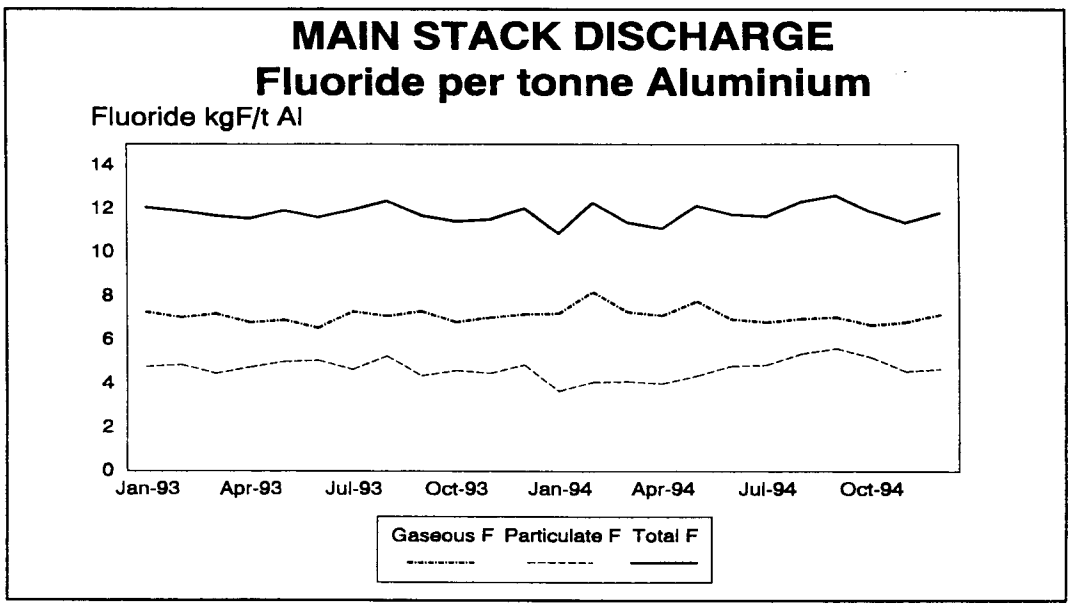
2.3 Fluoride Discharges

Performance data

The following table shows the fluoride discharges expressed as a ratio of hot aluminium metal production during 1994.

Parameter	Units	1994 average	1994 monthly maximum
Main stack			
• Gaseous fluoride	kg/t Al	7.16	8.20
• Particulate fluoride	kg/t Al	4.61	5.61
• Total fluoride	kg/t Al	11.77	12.62
Potroom roof louvre			
• Gaseous fluoride	kg/t Al	0.30	0.34
• Particulate fluoride	kg/t Al	0.21	0.27
• Total fluoride	kg/t Al	0.51	0.58
Plant			
• Gaseous fluoride	kg/t Al	7.45	8.49
• Particulate fluoride	kg/t Al	4.82	5.76
• Total fluoride	kg/t Al	12.28	13.06

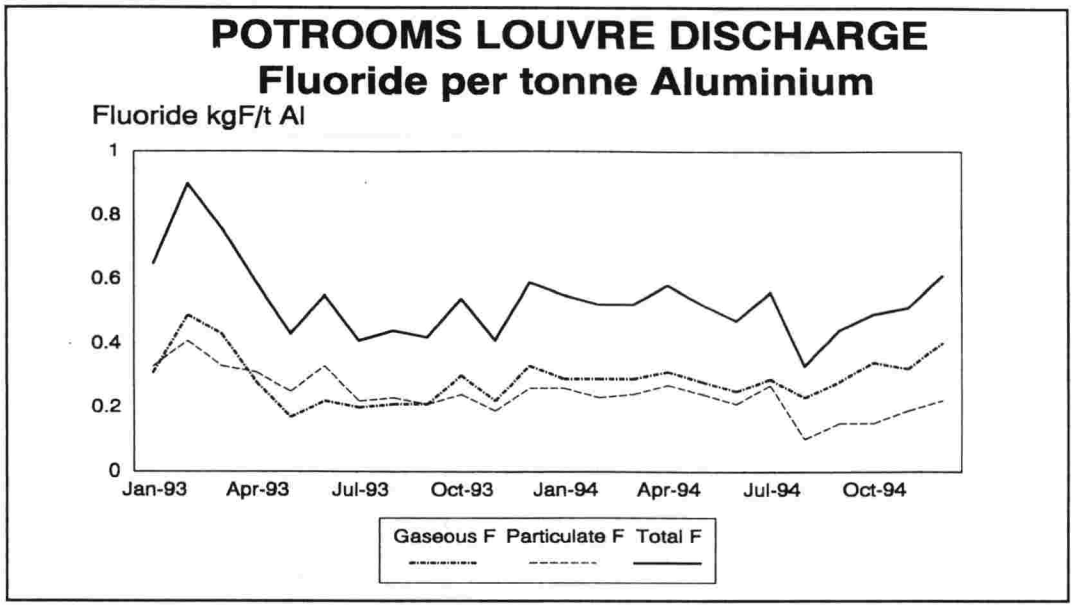
The following graph shows the average monthly main stack fluoride discharge during 1993 and 1994.



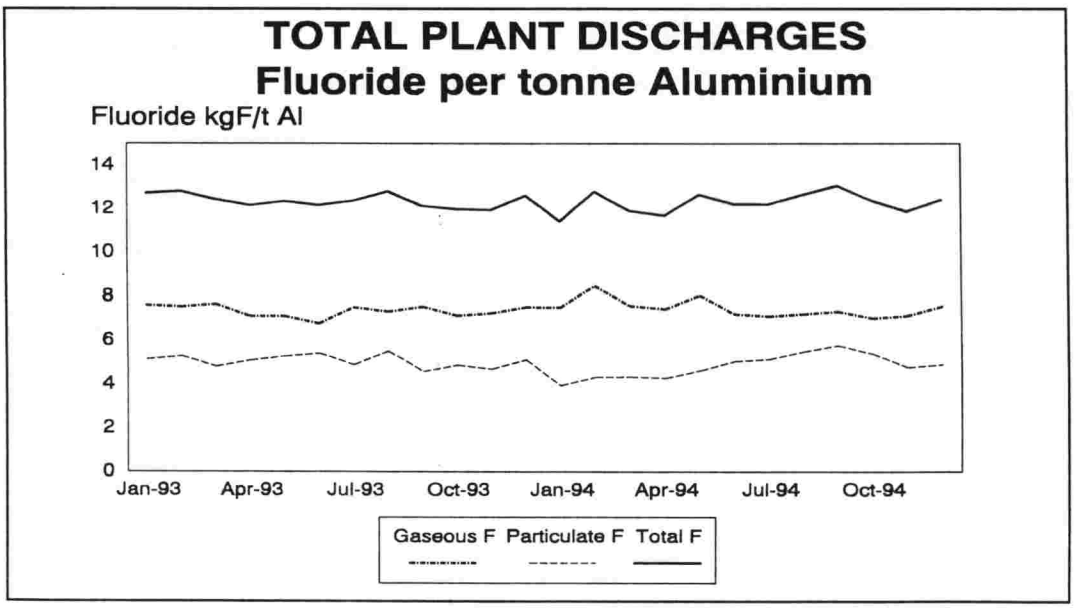
2.3 Fluoride Discharges, Continued

Performance data, continued

The following graph shows the average monthly potroom roof louvre fluoride discharge during 1993 and 1994.



The following graph shows the average monthly total plant fluoride discharge during 1993 and 1994.



2.3 Fluoride Discharges, Continued

Comments

Fluoride discharges from the plant were stable throughout 1994.

2.4 Baghouse Discharges

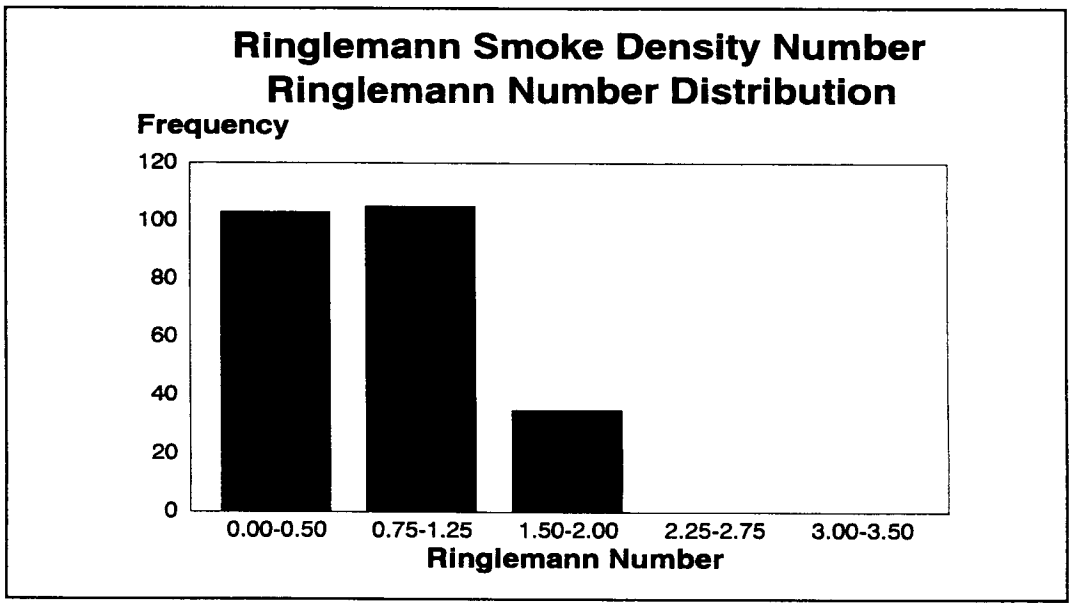
The regular inspection of the baghouse discharges continued during 1994. These inspections support the on-going operational surveillance of this equipment that ensure the required standards are maintained.

Baghouse total particulate discharges will be sampled during 1995 to quantitively determine discharge rates. This will enable the smelter to confirm that the visual observations are an effective measure of permit standard compliance.

2.5 Carbon Baking Furnace Discharges

As stated in last year's report the conditioning tower of the electrostatic precipitator (ESP) was blown down in late 1993 during high winds. A new tower was constructed and commissioned in April 1994. During the time the tower was being constructed the ESP operated with the conditioning tower isolated.

2.6 Ringlemann Number



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

2.6 Ringleman Number, Continued

During 1994 it was identified that the grey colour of the emissions from the main stack renders the standard Ringlemann smoke charts inappropriate for measuring obscuration. Enquiries by the Southland Regional Council confirmed there is no longer a facility in New Zealand to train observers in smoke obscuration.

To improve the quality of the Ringlemann observations, NZAS is developing a grey Ringlemann chart. The chart is being designed to allow differing sky colours to be used as backgrounds. The effectiveness of the chart will be reviewed in early 1995.

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 1994.

Material	Units	Permit Maximum	1994 Annual Average	1994 maximum	1994 minimum
Petroleum coke	%	3.0	2.84	2.9	2.76
Packing/metallurgical coke	%	2.0	0.34	0.36	0.32
Pitch	%	1.0	0.43	0.44	0.41
Heavy fuel oil	%	3.5	2.30	2.61	1.92

Comments

All shipments of raw materials and fuels during 1994 met permit standards for sulphur content.

Chapter 3

Dispersion and Effects of Discharges to Air

Introduction

Discharges into air from the smelter were covered by Air Discharge Permit No. HD/19/0006/88 until 26 April 1994 when a new permit was issued. The discharges into air from the smelter and wharf are now covered by Air Discharge Permit No. 93566 issued by the Southland Regional Council.

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

3.1 Meteorological Conditions

The mean wind frequency diagram on the following page shows that the 1994 wind pattern was dominated by westerly and north westerly winds.

The following table shows the predominant winds for each month during 1994.

Month	Predominant Wind Direction
January	West
February	South east and west
March	West and north west
April	West and north west
May	West and north west
June	West and strong east
July	West and north west
August	Strong north west
September	West and north west
October	West and north west
November	West and north west
December	West

Reissued May 1997

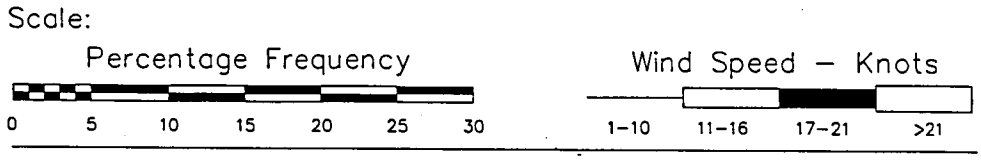
3.1 Meteorological Conditions

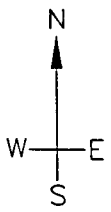
The mean wind frequency diagram on the following page shows that the 1995 wind pattern was dominated by westerly and north westerly winds.

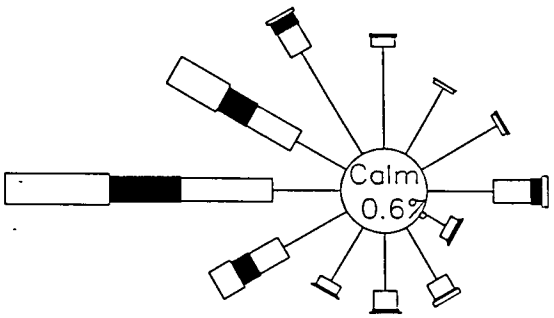
The following table shows the predominant winds and total rainfall recorded for each month during 1995.

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

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



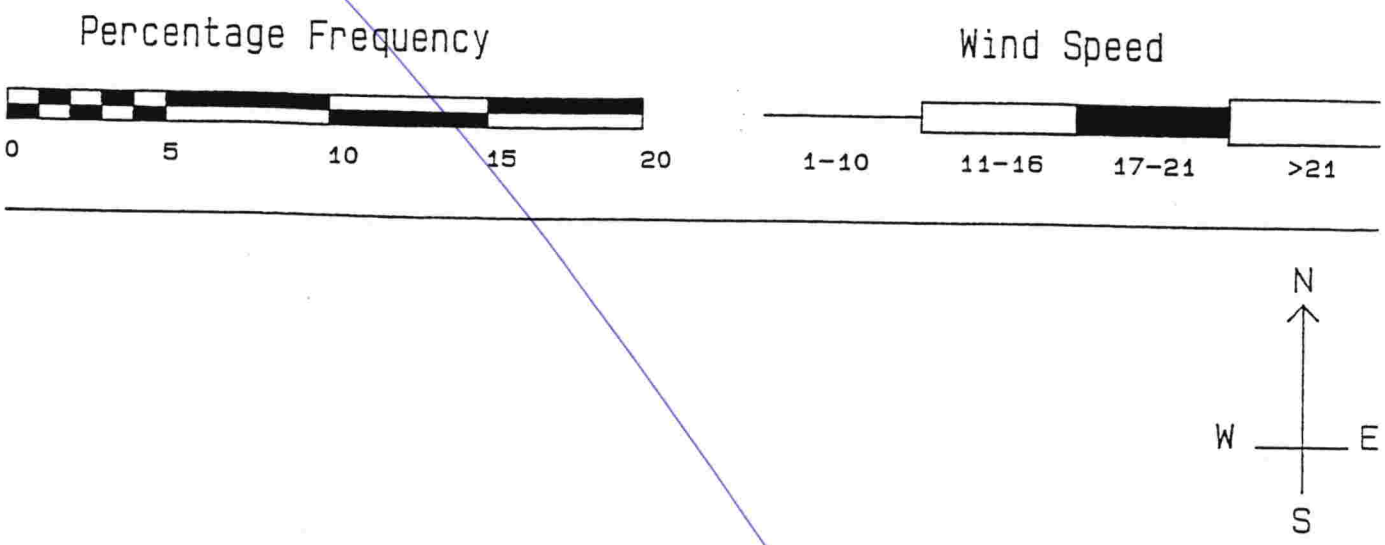




% Time at	
1–10 Knots	55.7
11–16 Knots	20.1
17–21 Knots	10.9
>21 Knots	13.2
Calm	0.6

MEAN WIND FREQUENCY (%) OF SURFACE WIND DIRECTIONS

Year 1994



% Time at	
1-10 Knots	50.8
11-16 Knots	18.8
17-21 Knots	12.1
>21 Knots	17.8
Calm	.5

Reissued May 1997

3.2 Ambient Air Gaseous Fluoride

Introduction

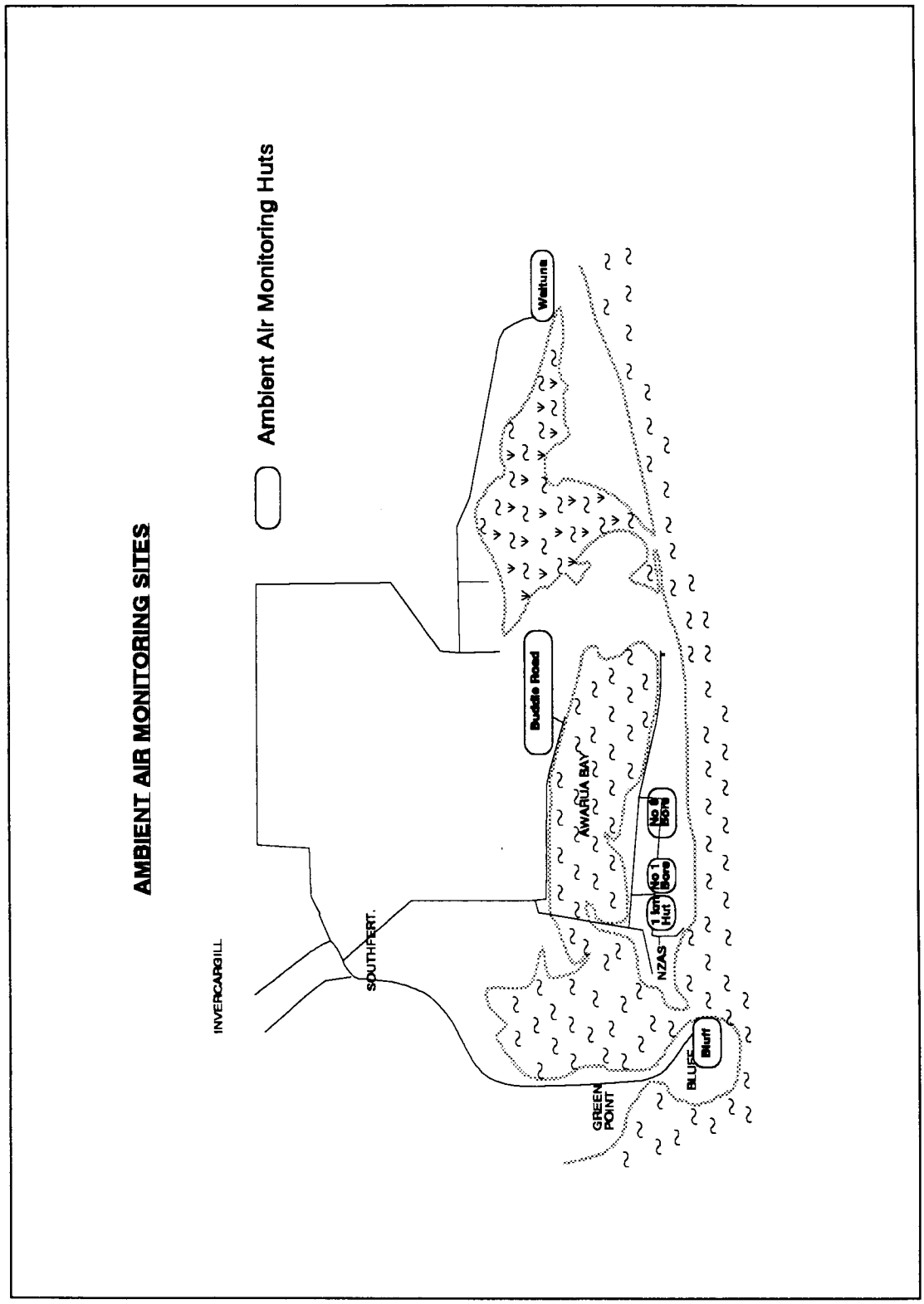
This section covers the monitoring of ambient air for gaseous fluoride and particulate fluoride concentrations at six monitoring sites and progress on projects to investigate the environmental effects of the smelter's discharges into air.

Site locations

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

3.2 Ambient Air Gaseous Fluoride, Continued

Site locations, continued



3.2 Ambient Air Gaseous Fluoride, Continued

Permit standards

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

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

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.

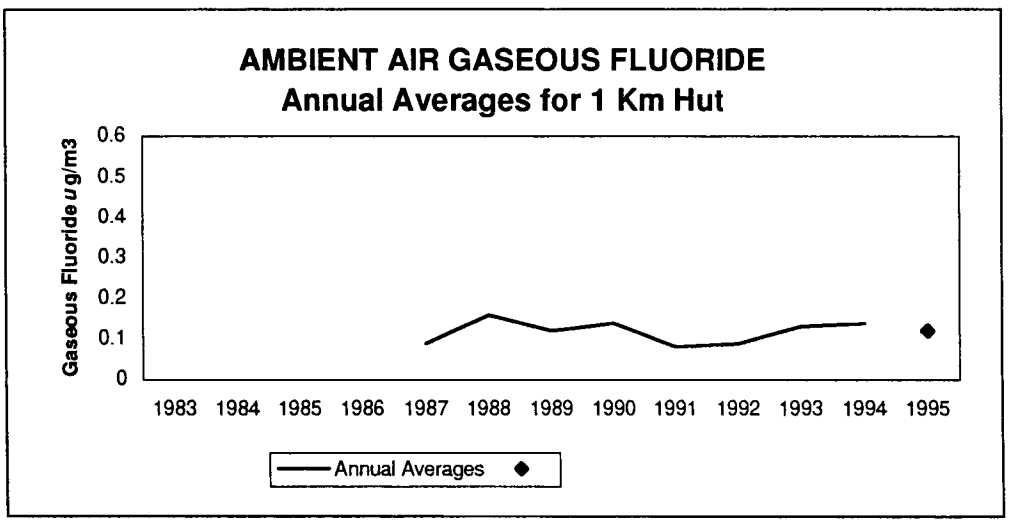
3.2.1 1 Kilometre Hut

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.

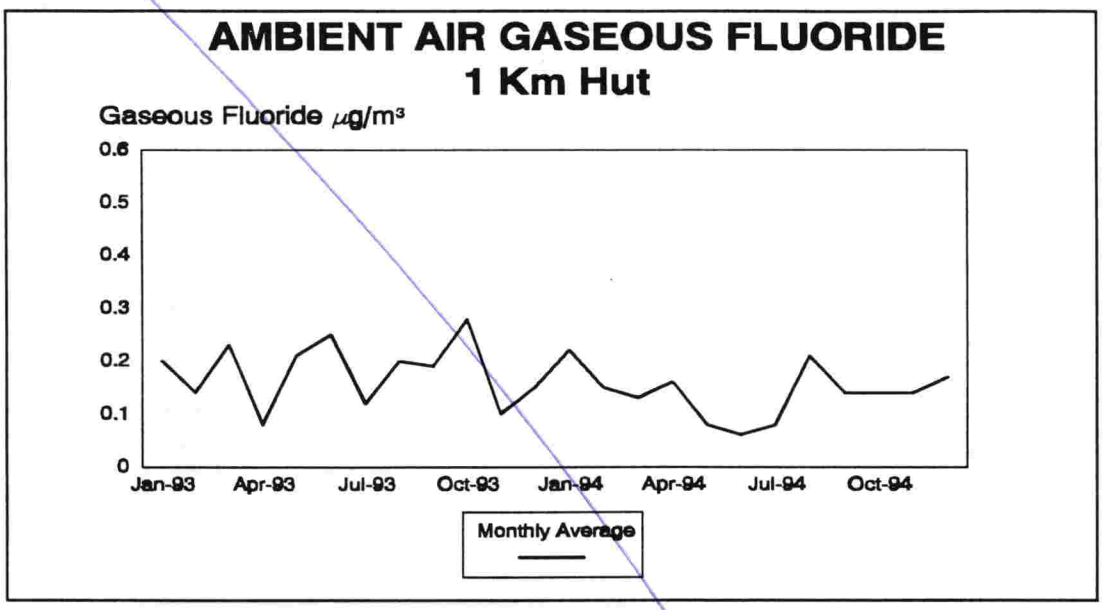
The review of the Kyoto HF-18 operation indicated that after March, the analyser was measuring approximately 42% of the gaseous fluoride concentration measured by the impregnated filter method.

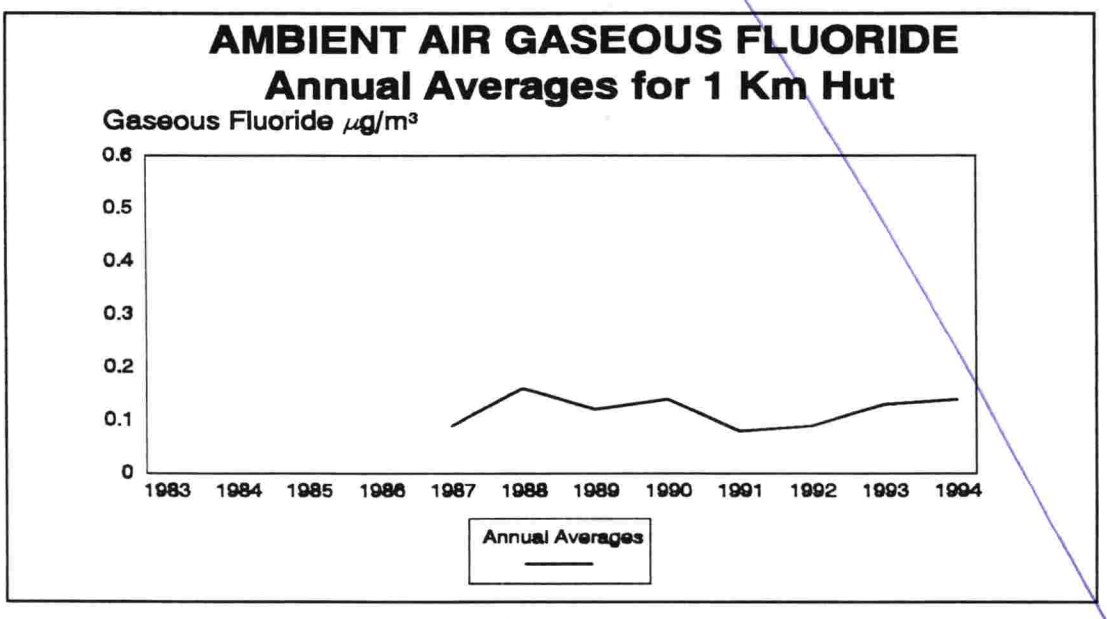
The following graph shows the annual average ambient air fluoride concentrations at the 1 km hut. The 1995 average concentration of 0.12 ug/mg^3 shown on the graph is a corrected value with the results after March being increased to correct the error.



3.2.1 1 Kilometre Hut

Monitoring results





Reissued May 1997

3.2.1 1 Kilometre Hut, continued

Comments

The 1994 average gaseous fluoride concentration of the ambient air at the 1 Kilometre Hut was 0.15 $\mu g/m^3$.

The following table shows the maximum gaseous fluoride results for 1994.

Ambient Air Gaseous Fluoride	Units	Permit	1994 Maximum
12 Hour	$\mu g/m^3$	-	1.04
24 Hour	$\mu g/m^3$	-	1.00
7 Day	$\mu g/m^3$	-	0.38

The maximum 24-hour average concentration measured at the 1 Kilometre Hut site was 1.0 $\mu g/m^3$. Although the permit standards do not apply to this site the maximum is below the maximum allowed within the permit for all other sites. As this is the closest site to the smelter it is inferred that the permit condition has not been exceeded at any other site.

After difficulties with the Kyoto HF-18 gaseous fluoride analyser, a 24 hour sampler was modified to take 12 hour samples as a backup.

Trials to compare the two are continuing. Statistical analysis of the first three month results shows there is no significant difference between the two methods.

Reissued May 1997.

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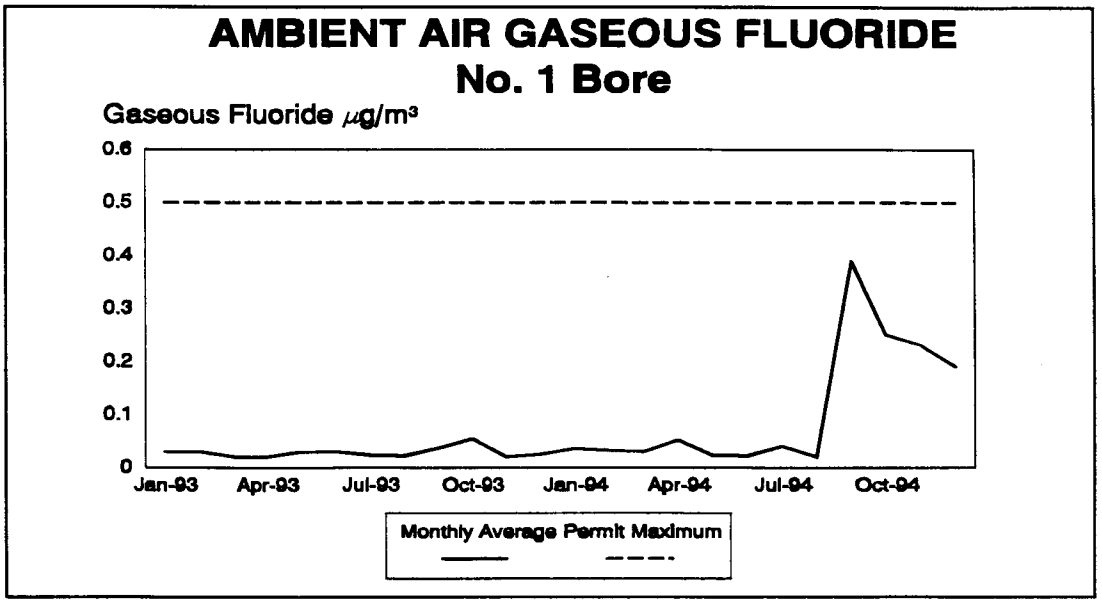
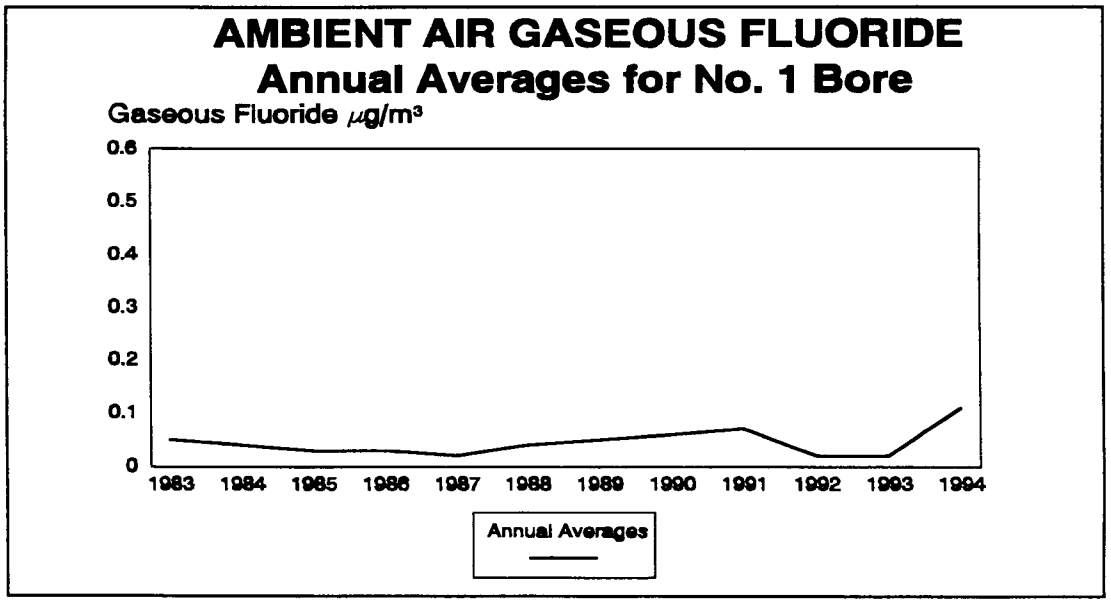
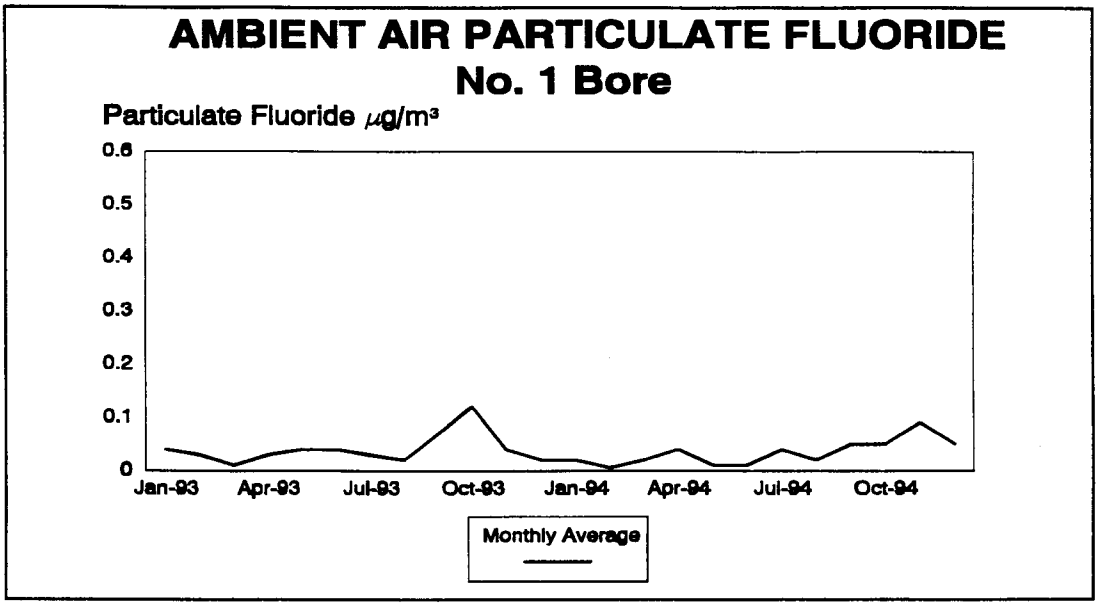
3.2.2 No. 1 Bore

Monitoring results







Comments

The 1994 average gaseous fluoride concentration of the ambient air at the No. 1 Bore was 0.11 µg/m^3.

The highest seven day concentration was 0.65 µg/m^3, measured in September. All permit standards were met at this site.

The particulate fluoride results for 1994 were within the expected range.

The sampling position at this station was raised in September 1994 following discussions at the Comalco Fluoride Forum. It was raised about 1 m above ground level air turbulence influences. The sample line tube was also replaced with teflon tubing.

The high result for September coincides with these changes. The change in sample height has since been shown not to be the cause of the high results. Initial work indicates that fluoride may be leaching out of the teflon. Work is under way to verify this and corrective action will be taken if necessary.

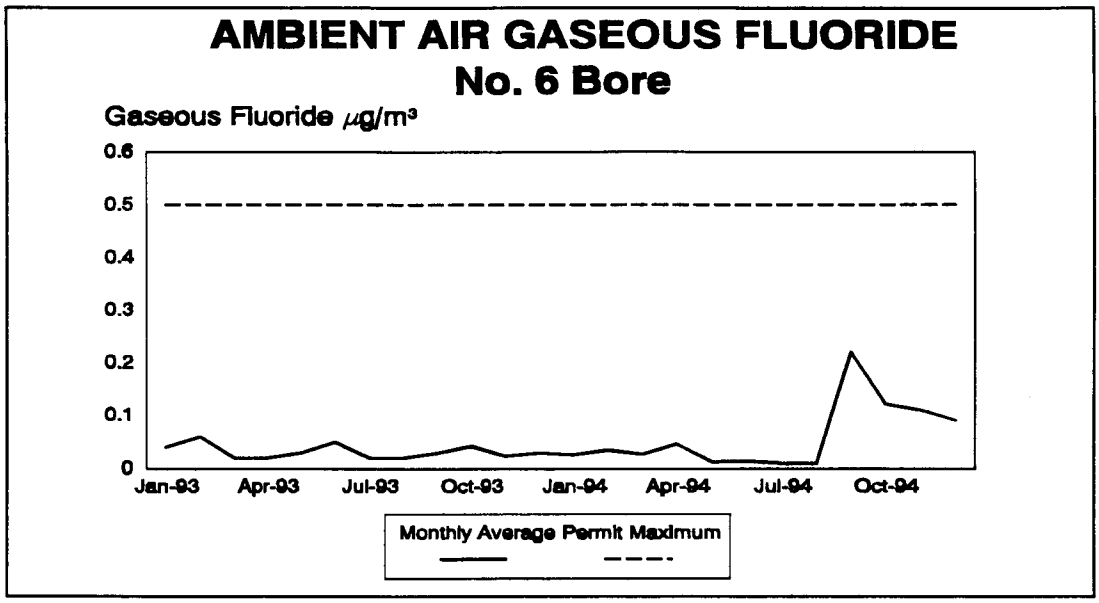
Work will be carried out to improve equipment standards further to meet the Australian standard. Much of the equipment to trial the Australian standard has been obtained and will be installed early 1995. If the Australian standard is adopted, teflon tubing will no longer be used.

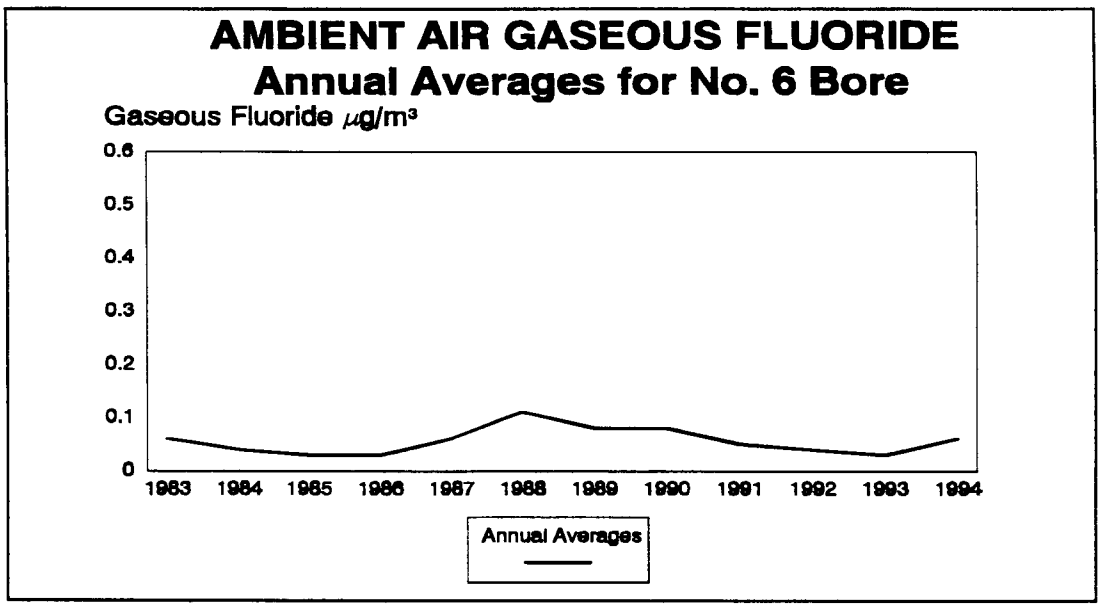
3.2.2 **No.1 Bore**, continued

The current method and the Australian method will operate alongside each other to determine if there is any significant difference between the two methods. Based on these results, a decision will be made whether or not to adopt the standard for other sites.

3.2.3 No.6 Bore

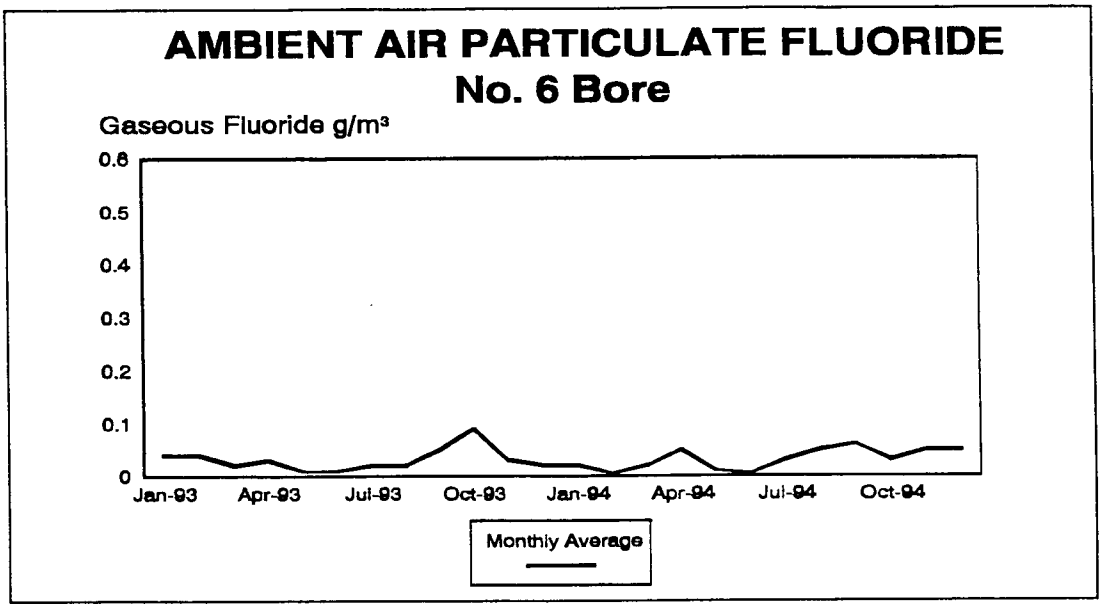
Monitoring results





3.2.3 **No.6 Bore**, continued

Monitoring results, continued



Comments

The 1994 average gaseous fluoride concentration of the ambient air at the No. 6 Bore was 0.06 $\mu g/m^3$.

The highest seven day concentration was 0.34 $\mu g/m^3$, measured in September. All permit standards were met at this site.

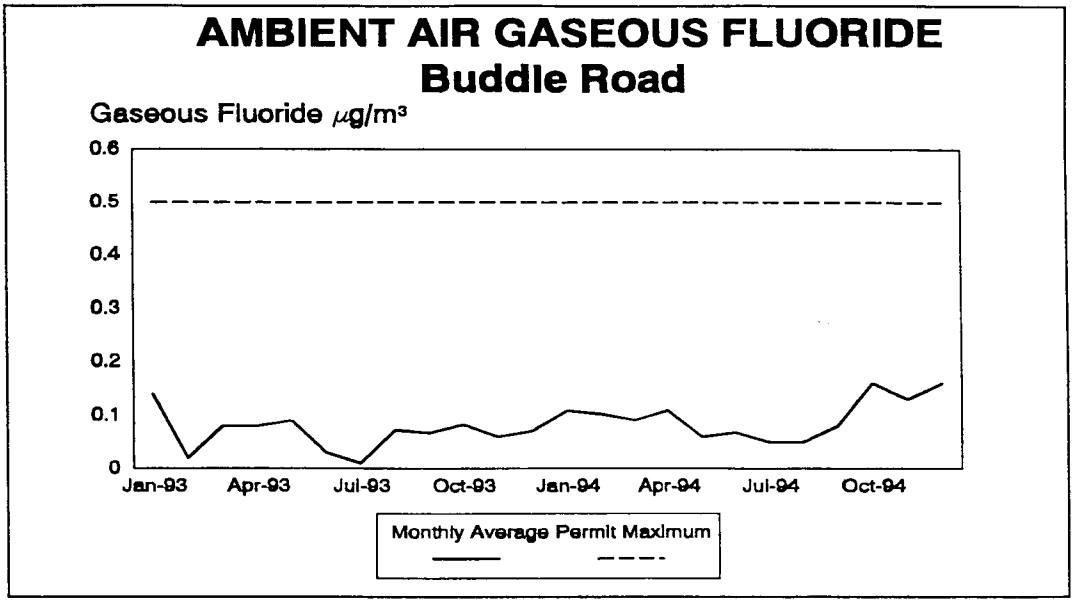
The particulate fluoride results for 1994 were within the expected range.

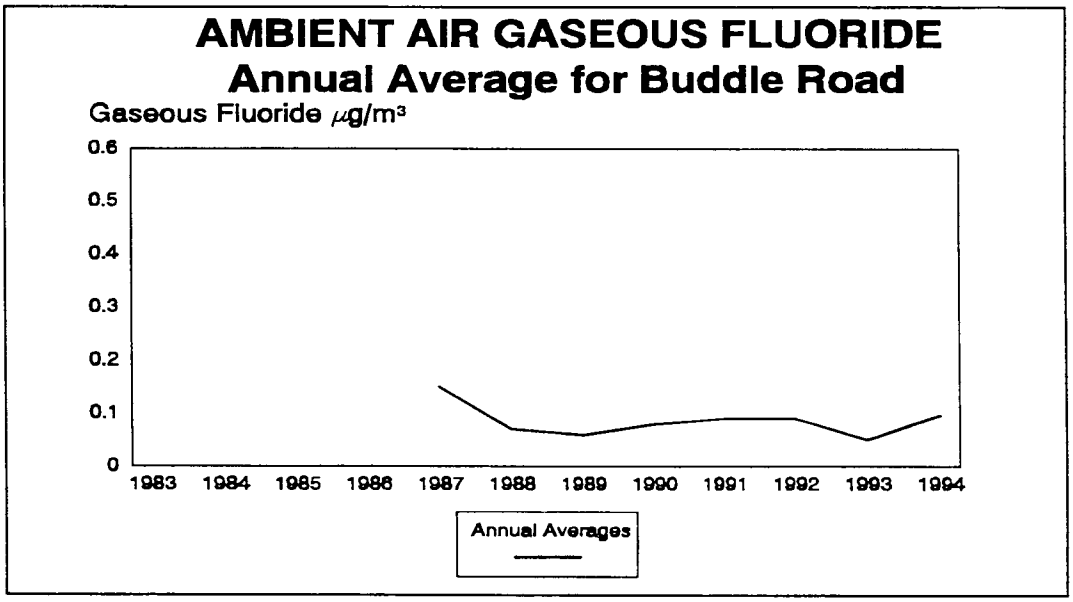
The equipment changes that were made at the No.1 Bore monitoring station were also made at the No.6 Bore. As with No. 1 Bore, there is some question about the validity of the high result for September. It is being investigated in the same manner.

It is also planned to improve this station to meet Australian standards.

3.2.4 Buddle Road

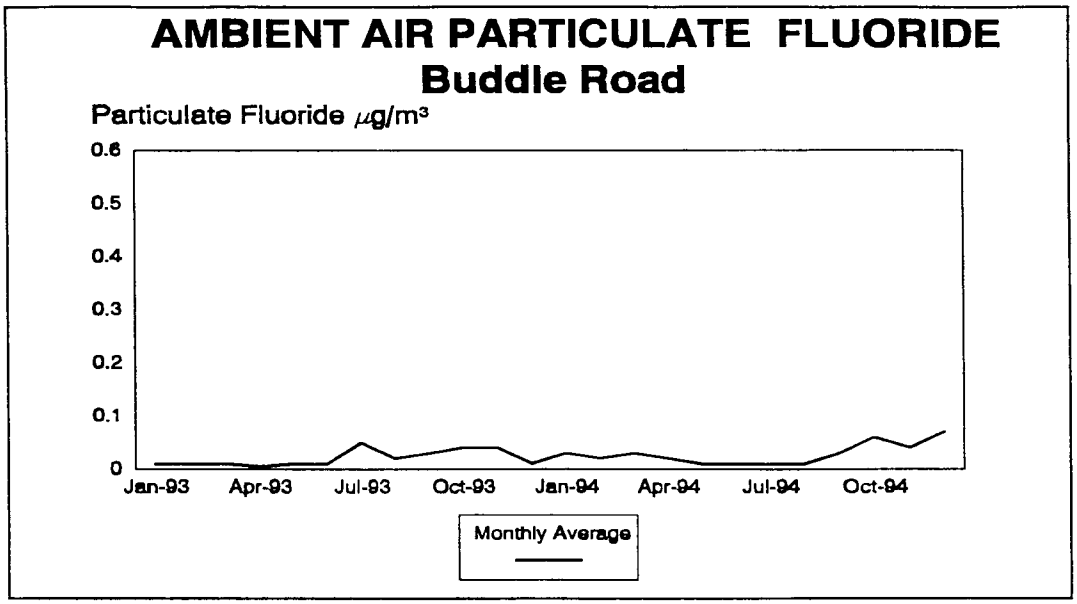
Monitoring results





3.2.4 **Buddle Road**, continued

Monitoring results, continued



Comments

The 1994 average gaseous fluoride concentration of the ambient air at Buddle Road was 0.10 µg/m^3.

The highest seven day concentration was 0.29 µg/m^3, measured in October. All permit standards were met at this site.

The particulate fluoride results for 1994 were within the expected range.

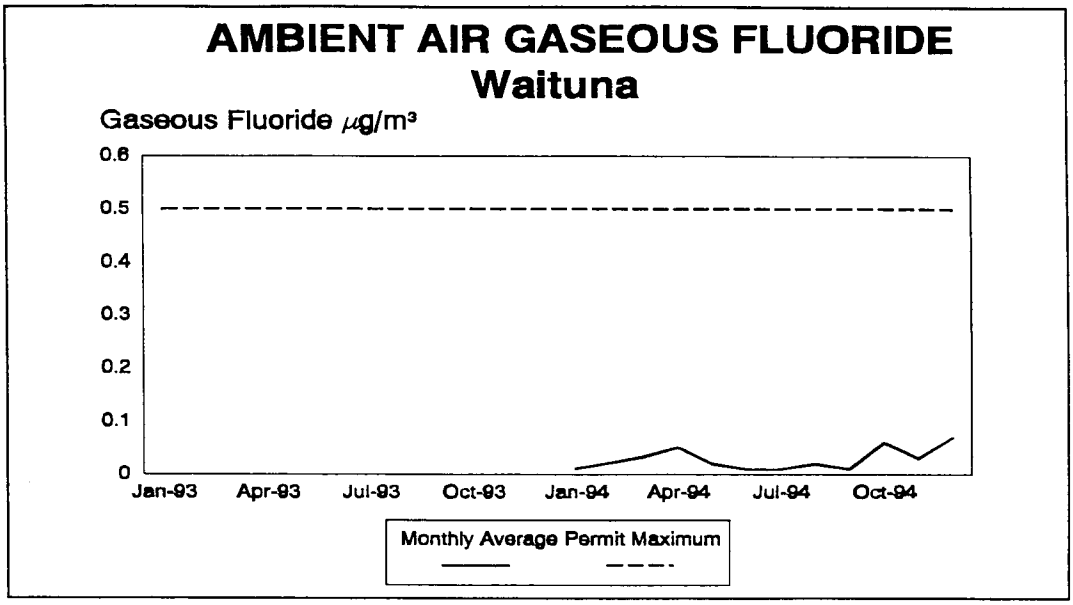
A new monitoring station has been installed at the Buddle Road site.

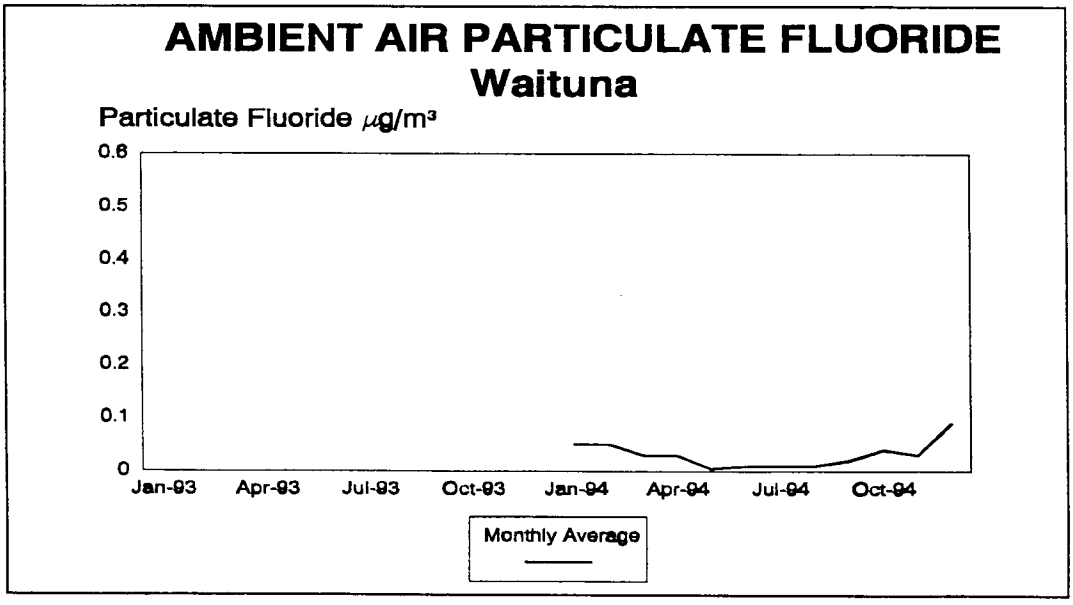
The new station

- improves physical security,
- provides a work place for Southland Regional Council equipment for audit purposes, and
- improves access to equipment by staff.

3.2.5 Waituna

Monitoring results





3.2.5 **Waituna**, continued

Comments

The 1994 average gaseous fluoride concentration of the ambient air at the Waituna Hut was 0.03 $\mu g/m^3$.

The highest seven day concentration was 0.11 $\mu g/m^3$, measured in December. All permit standards were met at this site.

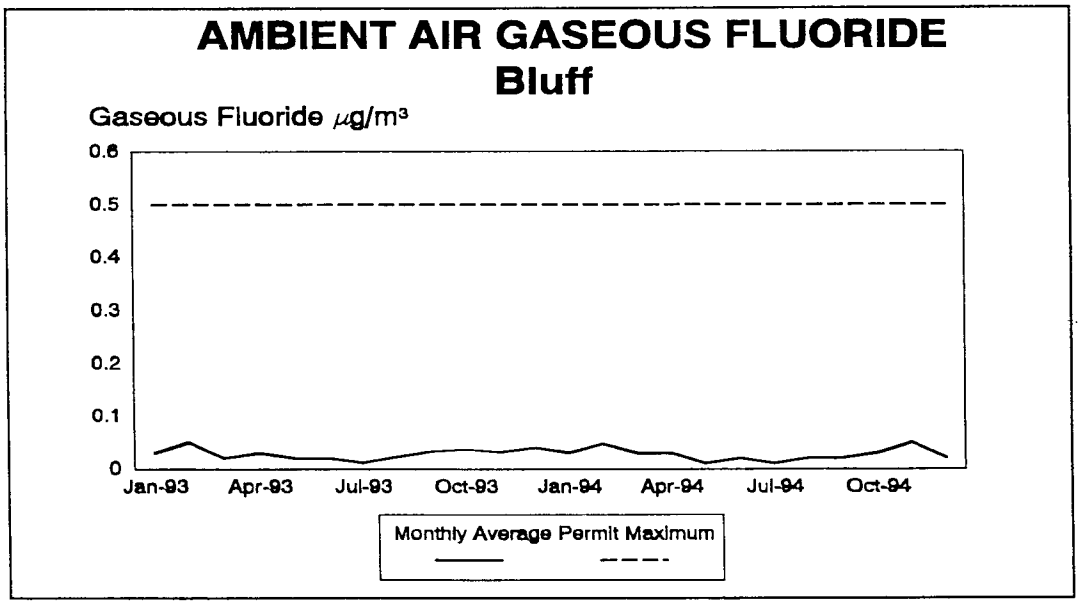
The particulate fluoride results for 1994 were low and within the expected range.

This new monitoring station at the western end of Waituna Lagoon was commissioned in late January.

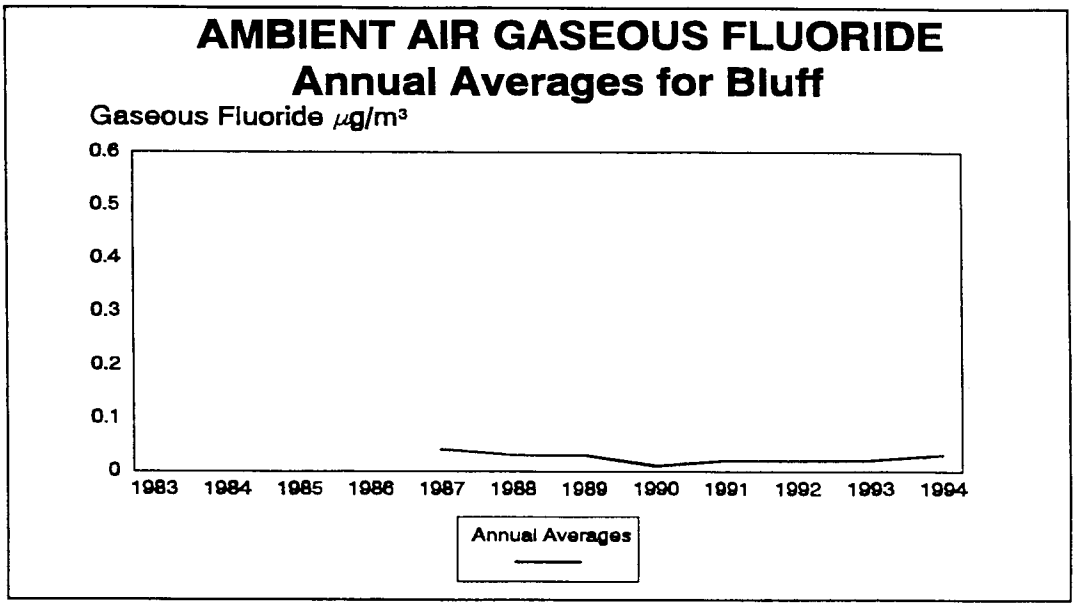
As expected the concentrations of gaseous fluoride in the ambient air are below those recorded at Buddle Road, a site closer to the smelter.

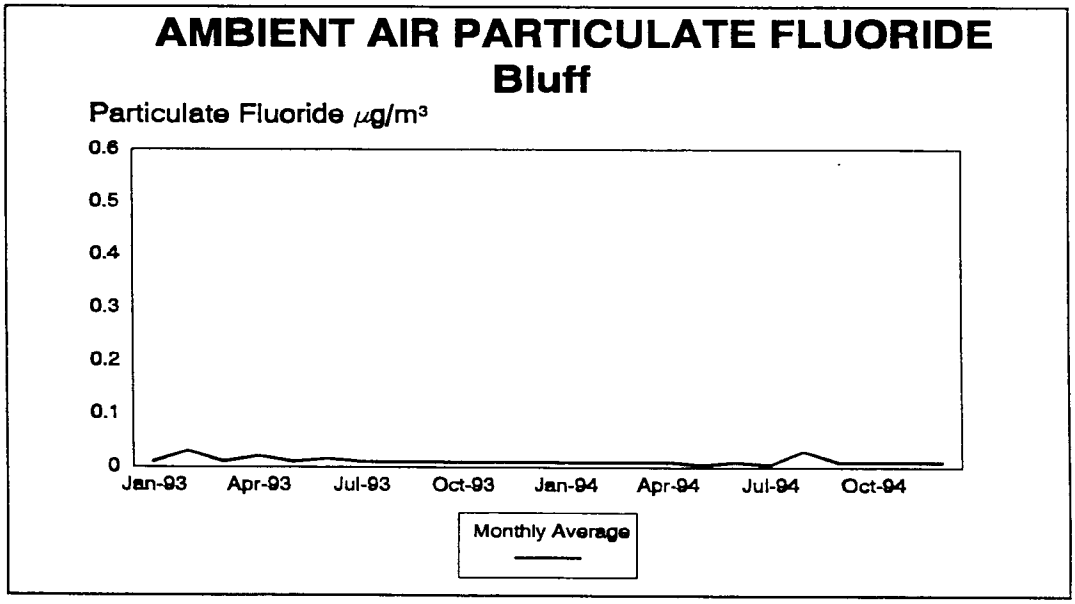
3.2.6 **Bluff**

Monitoring results



Monitoring results, continued





3.2.6 **Bluff**, continued

Comments

The 1994 average gaseous fluoride concentration of the ambient air at the Bluff Hut was 0.03 $\mu g/m^3$.

The highest seven day concentration was 0.06 $\mu g/m^3$, measured in November. All permit standards were met at this site.

The particulate fluoride results for 1994 were within the expected range.

Construction of the replacement of Bluff ambient air monitoring station commenced in the final quarter of 1994. The new station, as for Buddle Road, is designed to

- improve physical security of equipment,
- provide a workplace for the Southland Regional Council equipment for audit purposes, and
- improve access to equipment by staff.

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.

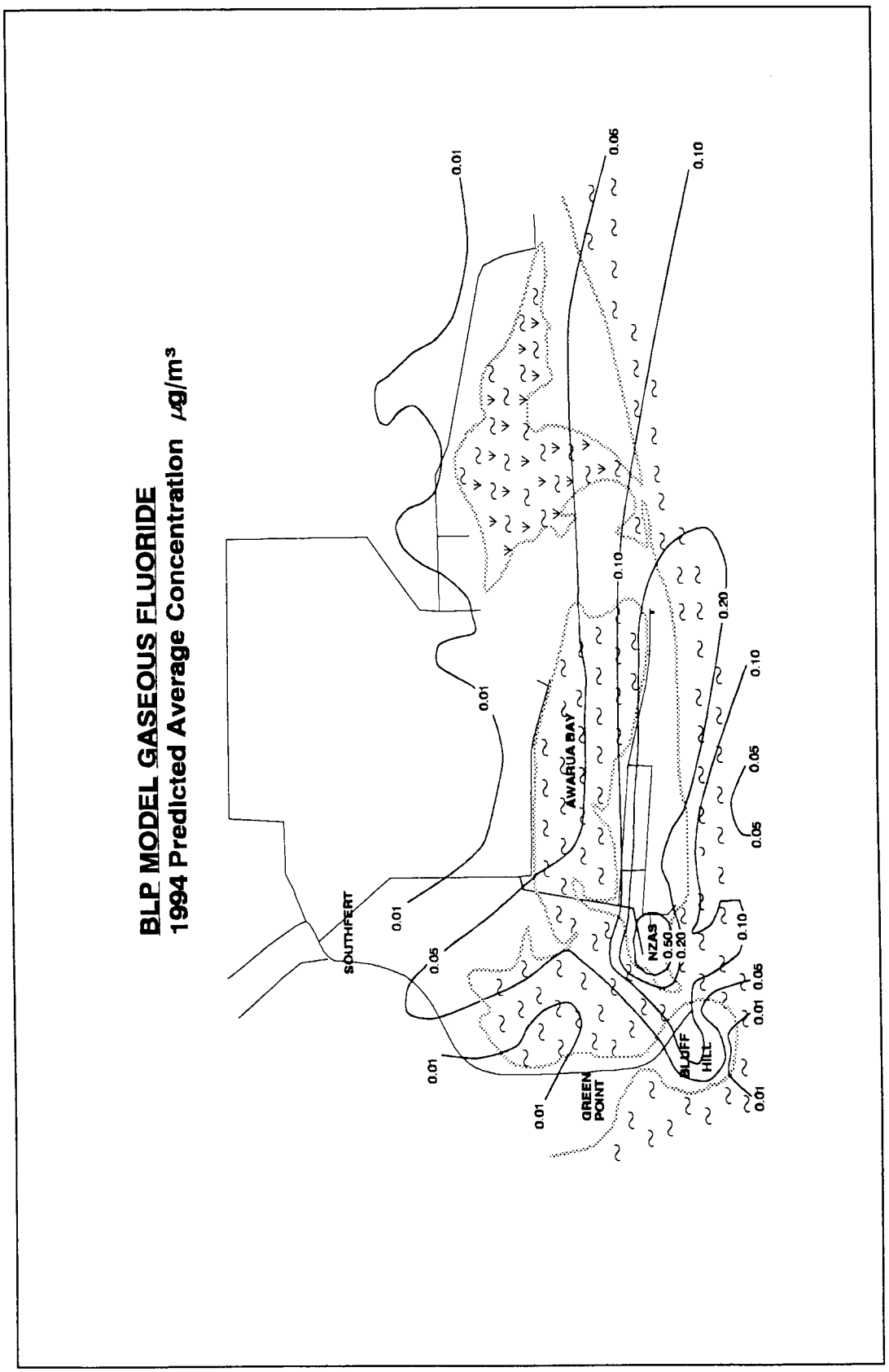
The predicted mean ambient air gaseous fluoride concentrations caused by the discharge from the smelter during 1994 are shown on the map on the following page.

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 1994 Annual Average Ambient Air Gaseous Fluoride Concentration $\mu g/m^3$	Actual Annual 1994 Average Ambient Air Gaseous Fluoride Concentration $\mu g/m^3$
1 Km Hut	0.18	0.15
No.1 Bore	0.24	0.11
No.6 Bore	0.26	0.06
Buddle Road	0.04	0.10
Waituna	0.03	0.03
Bluff	0.07	0.03

The Environmental Study by Dames & Moore indicated a tendency to over predict the fluoride concentration. This trend is evident by the data in the table above. A similar trend was evident in 1993.

NZAS is providing financial support to the project to produce an updated dispersion model. The updated model (AUSPUFF) is now in the beta testing phase and should be available for use in mid 1995.


BLP MODEL GASEOUS FLUORIDE
1994 Predicted Average Concentration µg/m³
SOUTHPERT
AWARUA BAY
NZAS
BLUFF HILL
GREEN POINT
0.01
0.05
0.10
0.20
0.50

3.3 Atmospheric Deposition

Introduction

This section covers the monitoring of atmospheric deposit gauges at nine monitoring sites. The following two maps show the average of the 1994 monthly fluoride and reactive aluminium results.

The sources of deposited fluoride include

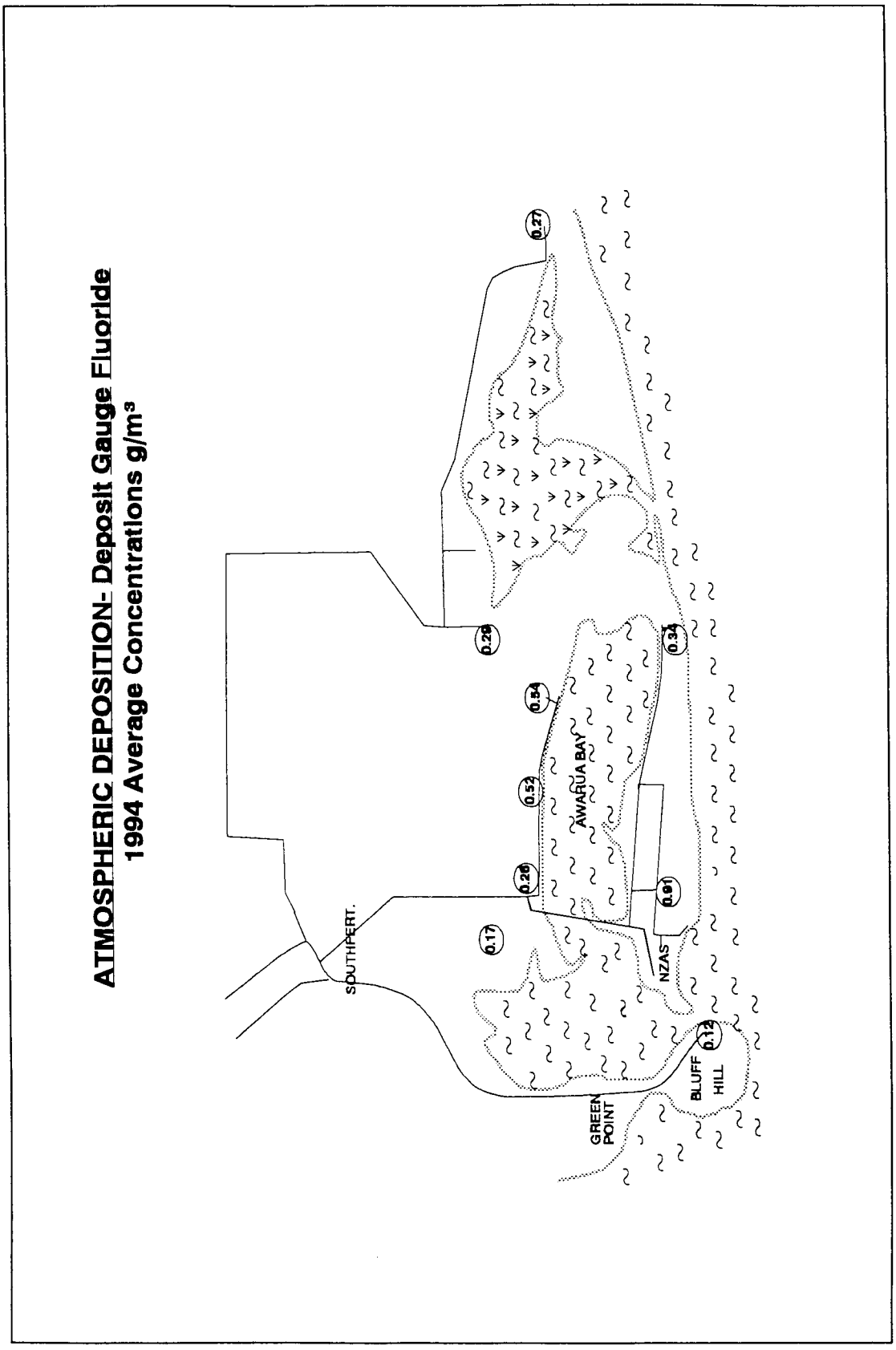
- NZAS operations,
- burning of fossil fuels,
- application of fertiliser, and
- wind borne salt spray and dusts.

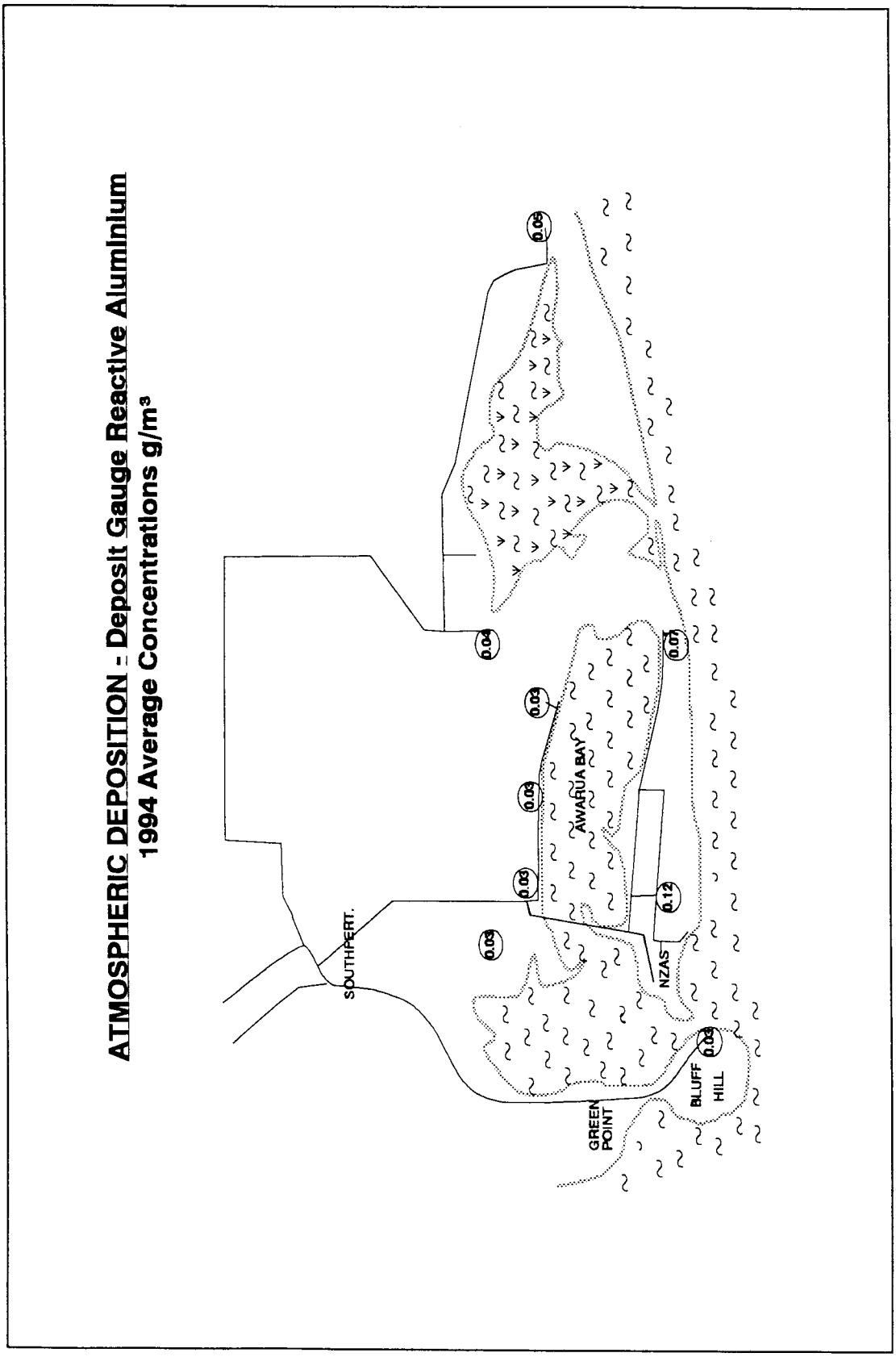
Permit guidelines

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

- fluoride 0.9 to 1.1 g/m^3, and
- reactive aluminium
  aesthetic highest desirable 0.05 g/m^3
  aesthetic excessive 0.20 g/m^3

The guidelines apply only to land off Tiwai Peninsula.


ATMOSPHERIC DEPOSITION- Deposit Gauge Fluoride
1994 Average Concentrations g/m³
0.27
0.28
0.34
0.54
0.52
AWARUA BAY
0.26
0.61
0.17
SOUTHPERT.
NZAS
0.12
BLUFF HILL
GREEN POINT


ATMOSPHERIC DEPOSITION - Deposit Gauge Reactive Aluminium
1994 Average Concentrations g/m³
0.05
0.04
0.07
0.03
0.03
0.03
AWARUA BAY
0.12
0.09
SOUTHFERT.
NZAS
0.08
BLUFF HILL
GREEN POINT

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.

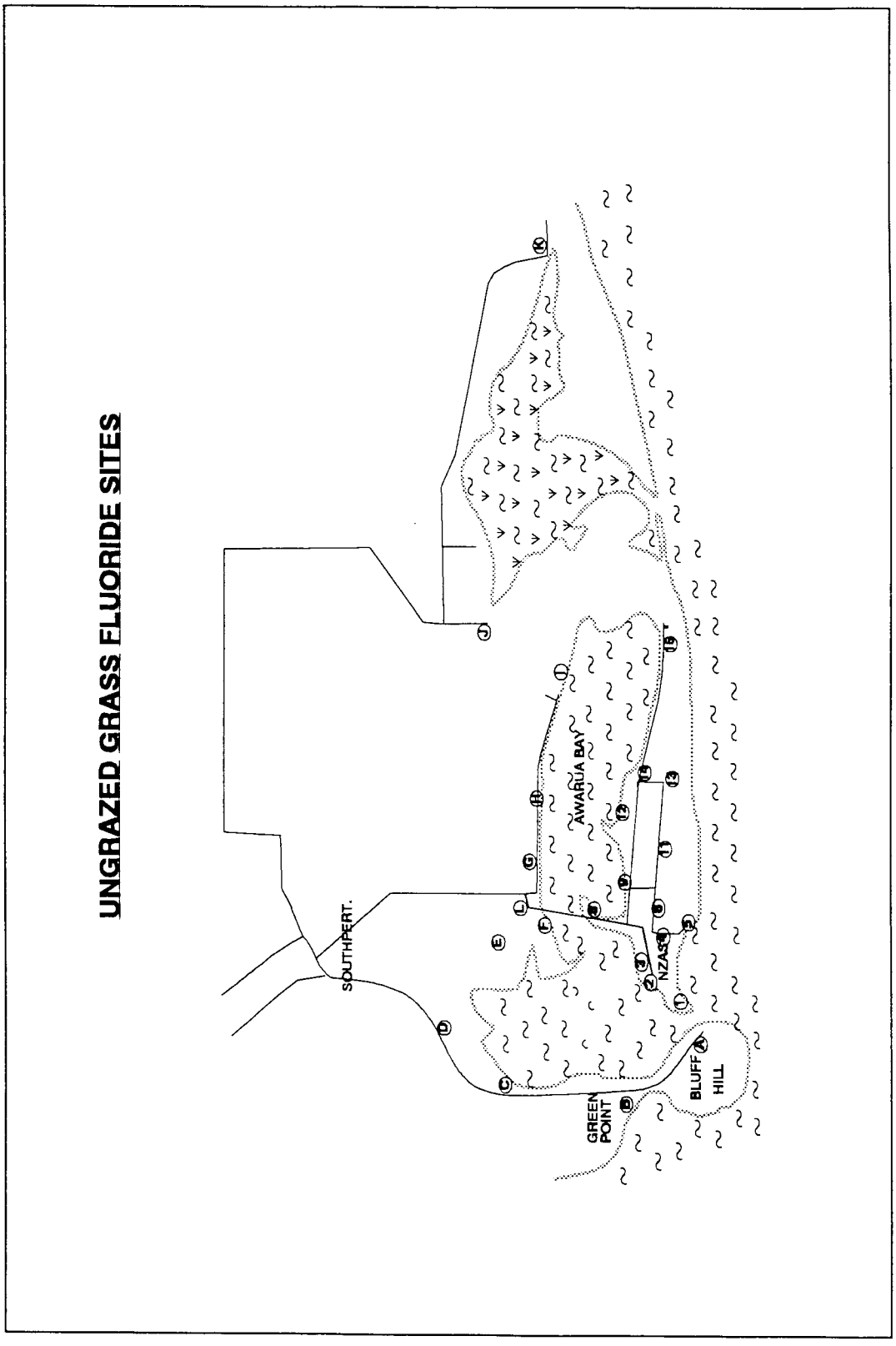
- Monthly sample shall not exceed 80 mg/kg.
- Running average of any two consecutive months shall not exceed 60 mg/kg.
- Running average of any 12 consecutive months shall not exceed 40 mg/kg.

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 1994.

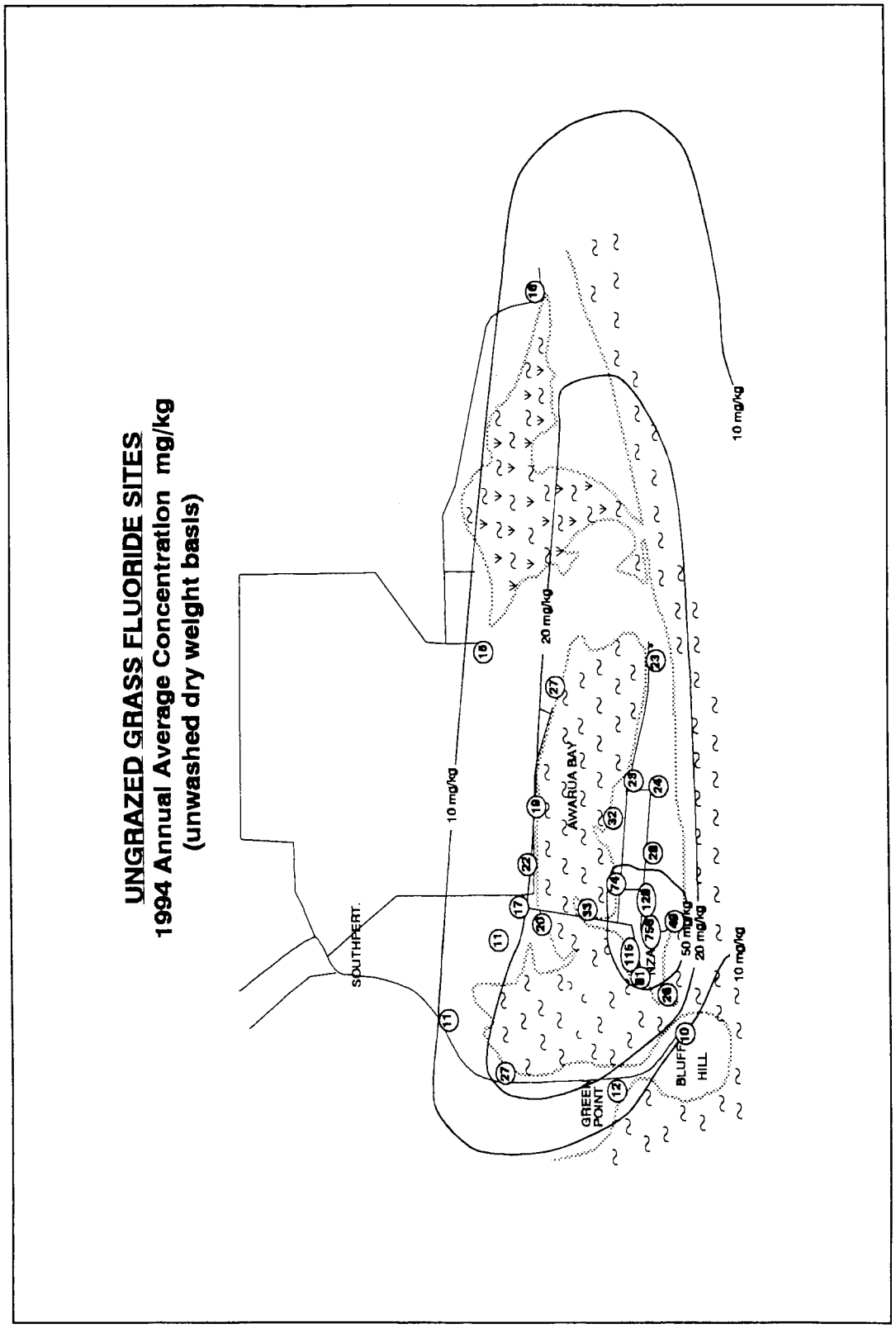
3.4 Fluoride in Ungrazed Grasses, Continued

Monitoring Results, continued



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	16
Ungrazed Grass Site B	80	34
Ungrazed Grass Site C	80	105
Ungrazed Grass Site D	80	25
Ungrazed Grass Site E	80	35
Ungrazed Grass Site F	80	40
Ungrazed Grass Site G	80	35
Ungrazed Grass Site H	80	29
Ungrazed Grass Site I	80	72
Ungrazed Grass Site J	80	41
Ungrazed Grass Site K	80	27
Ungrazed Grass Site L	80	28

The maximum fluoride for Site C was in March. This was before the guidelines came into effect. No explanation for the high result has been found. The guidelines were not exceeded at any time.

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	16
Ungrazed Grass Site B	60	21
Ungrazed Grass Site C	60	74
Ungrazed Grass Site D	60	18
Ungrazed Grass Site E	60	24
Ungrazed Grass Site F	60	28
Ungrazed Grass Site G	60	31
Ungrazed Grass Site H	60	27
Ungrazed Grass Site I	60	46
Ungrazed Grass Site J	60	24
Ungrazed Grass Site K	60	27
Ungrazed Grass Site L	60	23

The permit guideline for the two monthly average was exceeded in April. This is due to the high result recorded in March. See monthly results.

The permit guideline was not exceeded at any other time.

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	11
Ungrazed Grass Site B	40	12
Ungrazed Grass Site C	40	27
Ungrazed Grass Site D	40	15
Ungrazed Grass Site E	40	14
Ungrazed Grass Site F	40	24
Ungrazed Grass Site G	40	27
Ungrazed Grass Site H	40	22
Ungrazed Grass Site I	40	27
Ungrazed Grass Site J	40	15
Ungrazed Grass Site K	40	17
Ungrazed Grass Site L	40	25

The permit guideline was not exceeded during 1994.

3.5 Fluoride in Pinus Radiata

Introduction

This section covers the monitoring of fluoride in pinus radiata at 15 monitoring sites.

Monitoring results

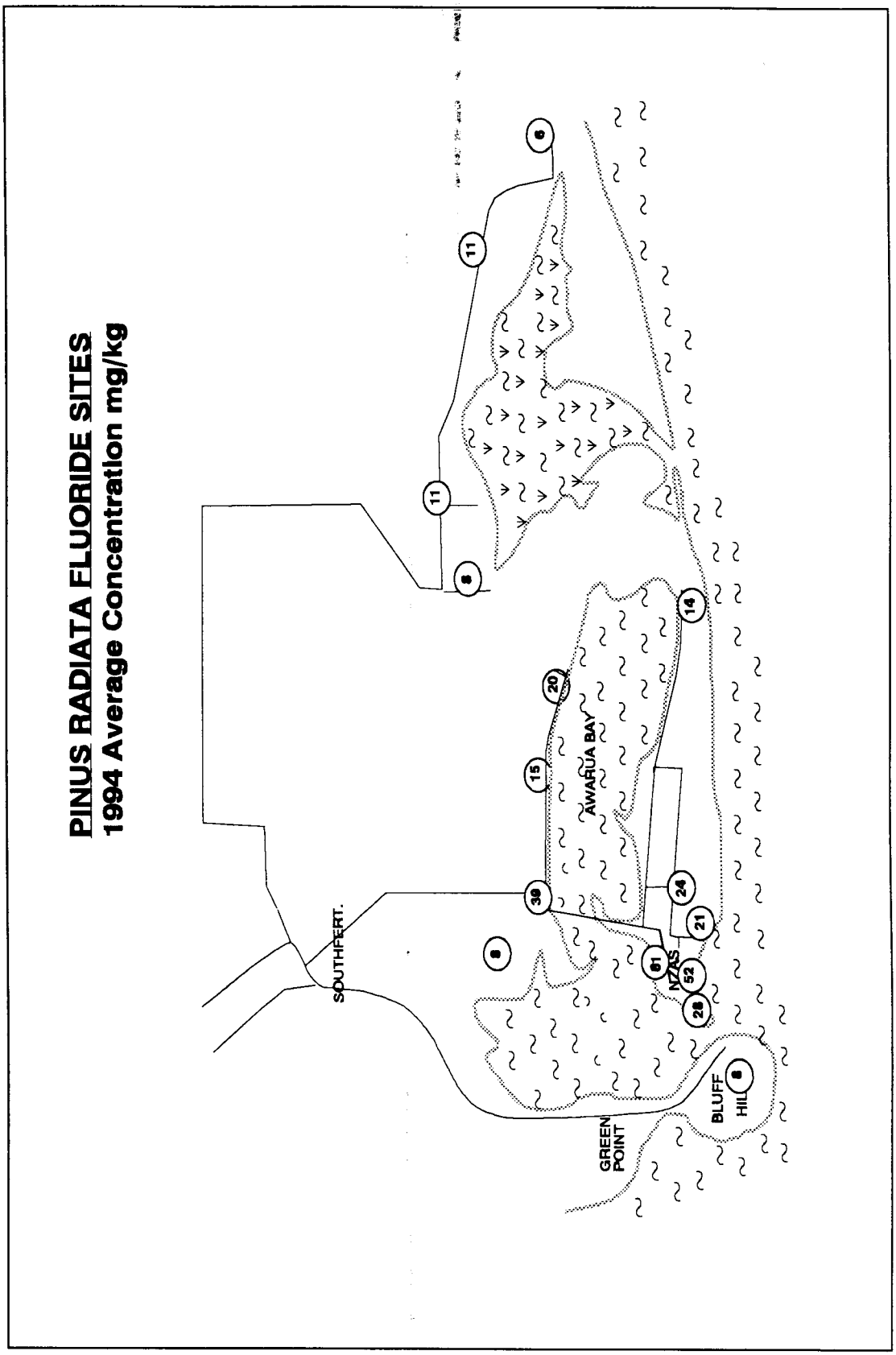
A map showing the annual average fluoride in pinus radiata needles is shown on the following page. Samples are taken quarterly and the four results for 1994 were averaged to give the annual average.

Comments

Pinus radiata needles between one and two years 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



3.6 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. The sites monitored are:

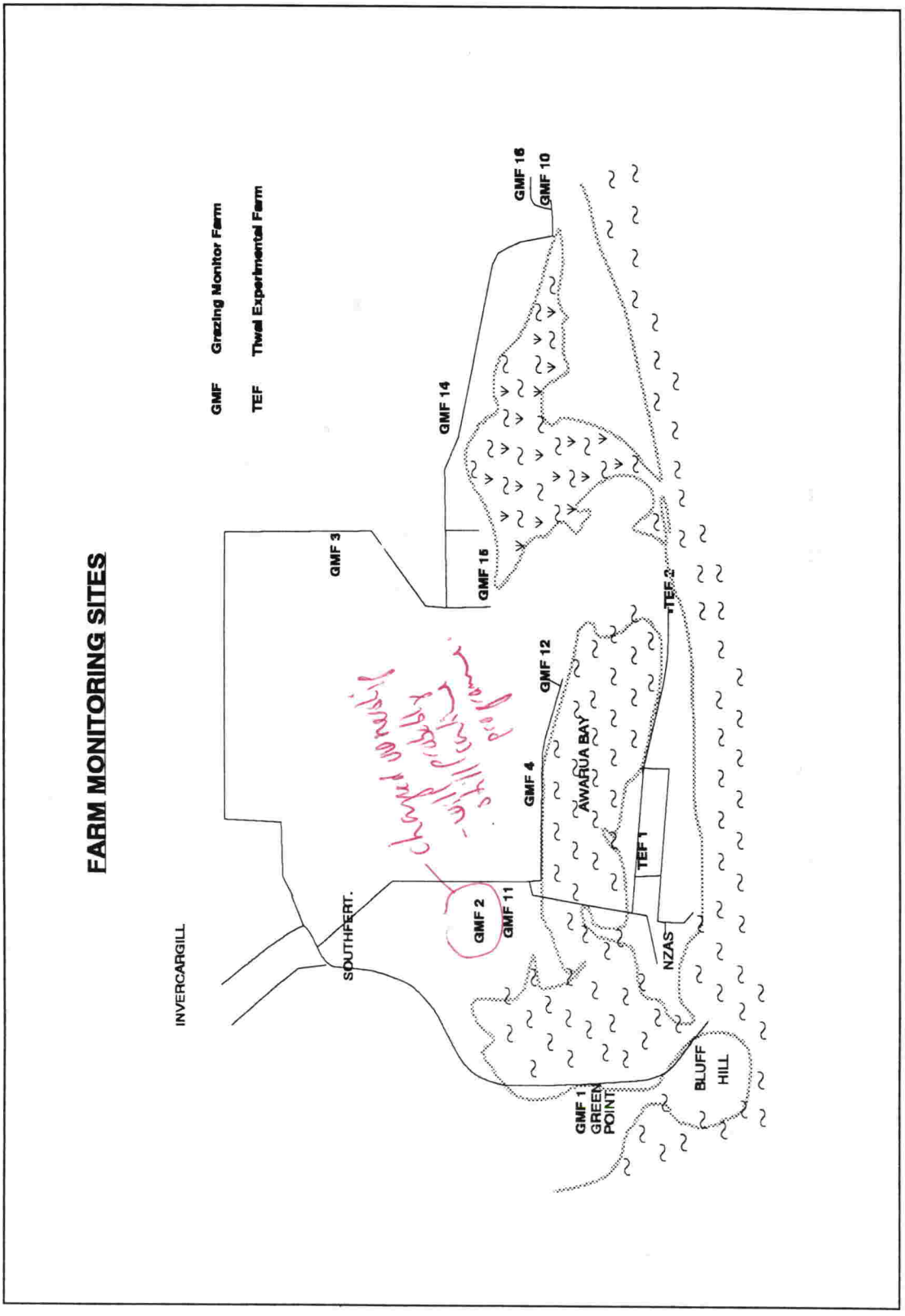
- Grazing Monitor Farm No. 1,
- Grazing Monitor Farm No. 2,
- Grazing Monitor Farm No. 3,
- Grazing Monitor Farm No. 4,
- Grazing Monitor Farm No. 10,
- Grazing Monitor Farm No. 11,
- Grazing Monitor Farm No. 12,
- Grazing Monitor Farm No. 14,
- Grazing Monitor Farm No. 15, and
- Grazing Monitor Farm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

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



3.6 Grazing Monitor Project, Continued

Introduction, continued

Grazing Monitor Farm No. 10 (GMF10) and GMF16 are near neighbouring farms at the east end of Waituna Lagoon. GMF10 will be removed from the program once the relationship between the two farms is determined.

The Air Discharge Permit requires that cattle be monitored on two dairy and two beef farms. The dairy farms 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 standards for fluoride in grazed pasture (on an unwashed, dry weight basis) on land off Tiwai Peninsula are:

- monthly sample must not exceed 80 mg/kg,
- running average of any two consecutive months shall not exceed 60 mg/kg, and
- running average of any twelve consecutive months shall not exceed 40 mg/kg.

Permit guidelines

The guidelines for animal health monitoring are:

- urinary fluoride in dairy and beef cattle is 10 mg/L at S.G. 1.030,
- bone fluoride concentrations are:
    - * 1605 mg/kg for two year olds,
    - * 2379 mg/kg for four year olds, and
    - * 2794 mg/kg for six year olds.

3.6 Grazing Monitor Project, Continued

Permit guidelines, continued

The bone 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 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.

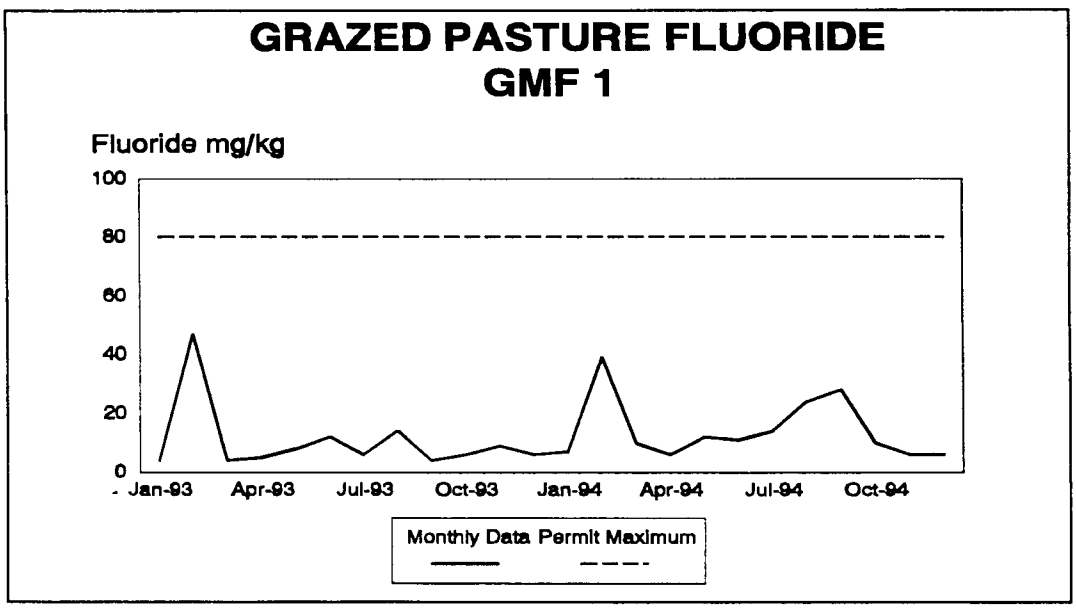
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1994.

	Units	Permit	1994 maximum
Monthly sample	mg/kg	80	39
Two monthly average	mg/kg	60	26
Twelve monthly average	mg/kg	40	15

The annual average for 1994 was 14 mg/kg.

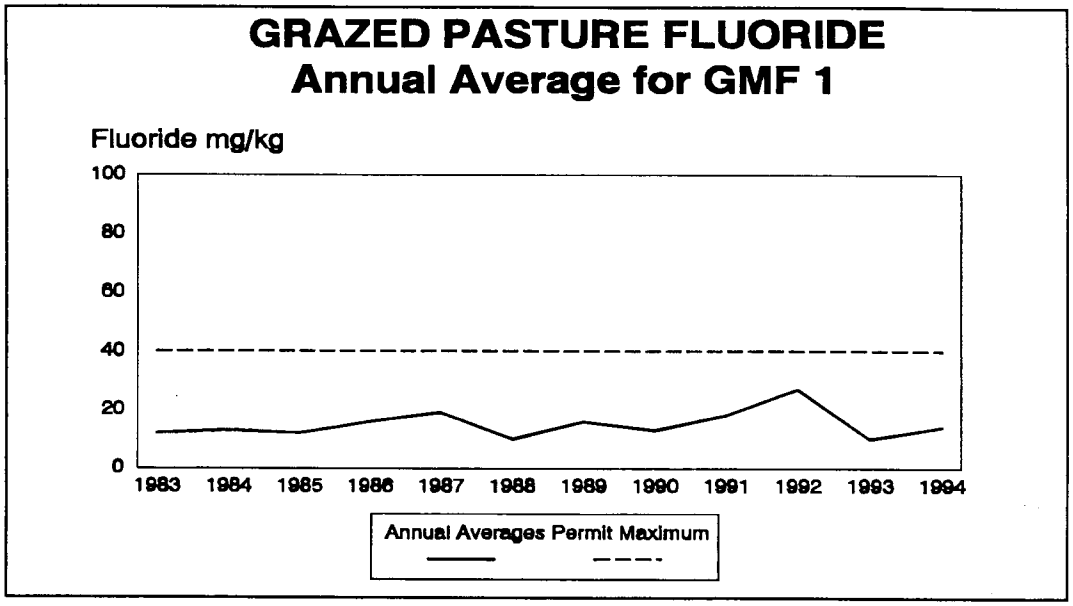
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1993 and 1994.



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

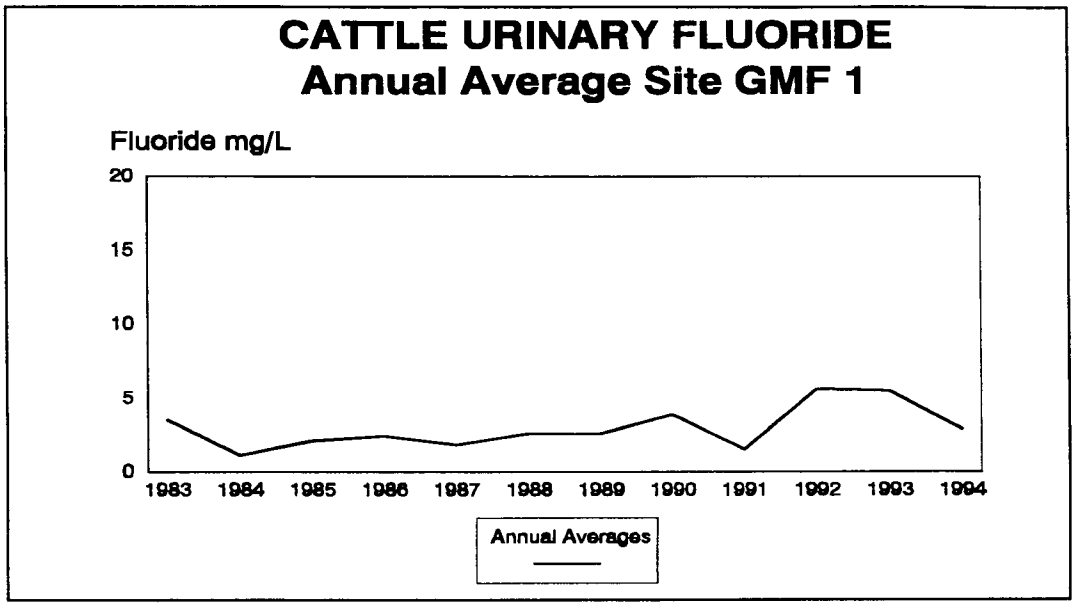
The following table summarises the results of cattle urinary fluoride monitoring during 1994.

	Units	Permit	Result
Average fluoride concentration	mg/L	10	2.9
Maximum fluoride concentration	mg/L	-	4.7
Minimum fluoride concentration	mg/L	-	1.1
No. of samples		-	10

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 bone fluoride monitoring during 1994.

Identification	Age	Units	Permit	Fluoride
2	6	mg/kg	2794	825
8	2	mg/kg	1605	700

Note: the bone fluoride concentration is converted to fat free dry 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 1994.

	Results
Average tooth score	2
Maximum tooth score	2
Minimum tooth score	2
No. of cattle inspected	4

Note: the tooth scoring system follows the method of Suttie.

Comments

The results of the monitoring on this farm were all within the permit standards and guidelines during 1994. The results are within the range experienced on this farm over the previous five years.

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.

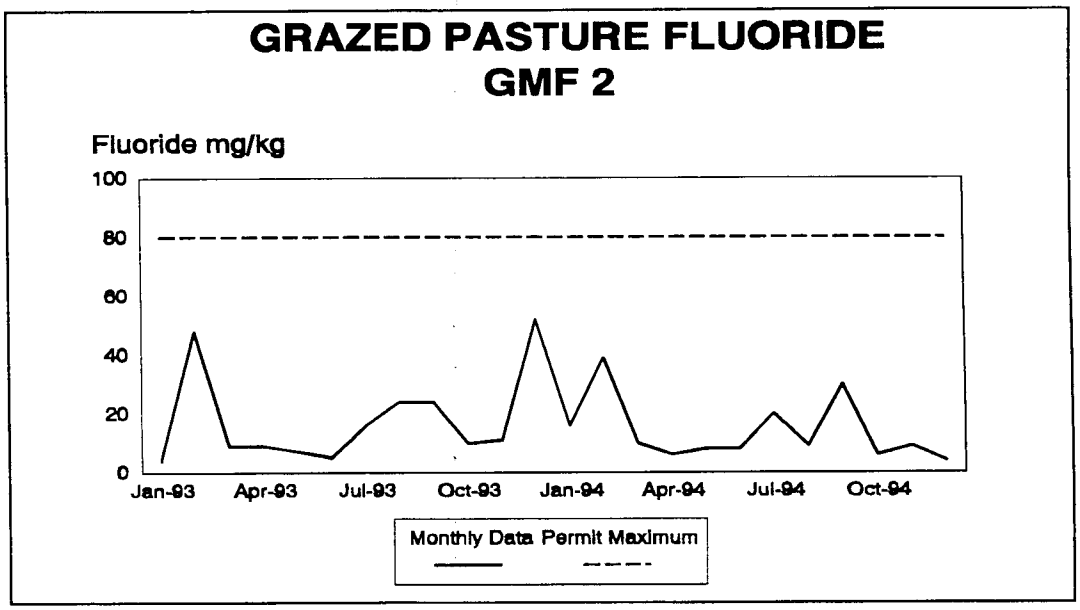
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1994.

	Units	Permit	1994 maximum
Monthly sample	mg/kg	80	39
Two monthly average	mg/kg	60	34
Twelve monthly average	mg/kg	40	19

The annual average for 1994 was 14 mg/kg.

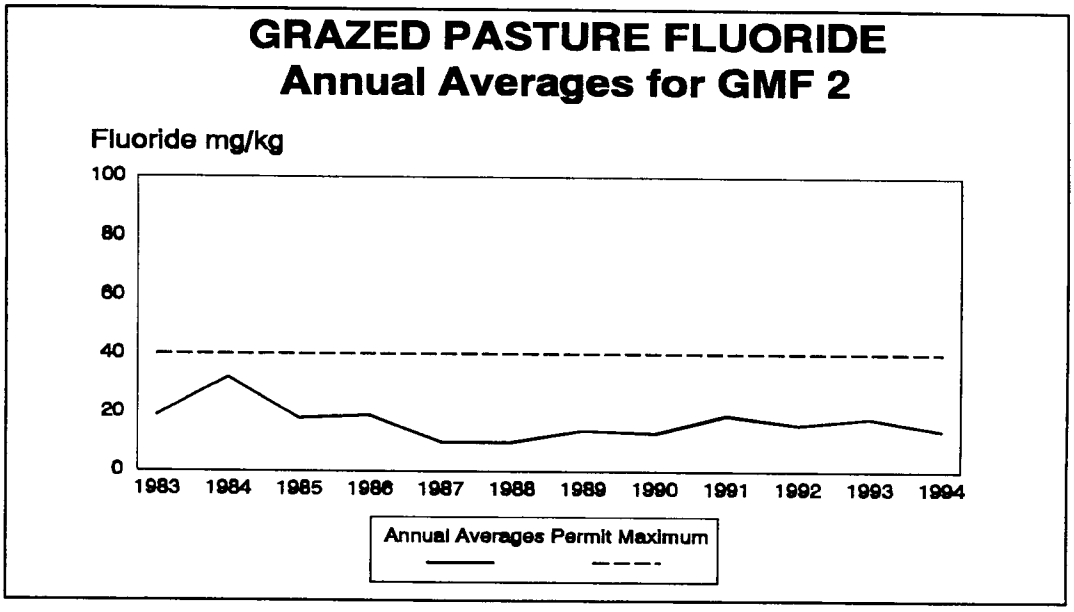
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1993 and 1994.



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.

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.

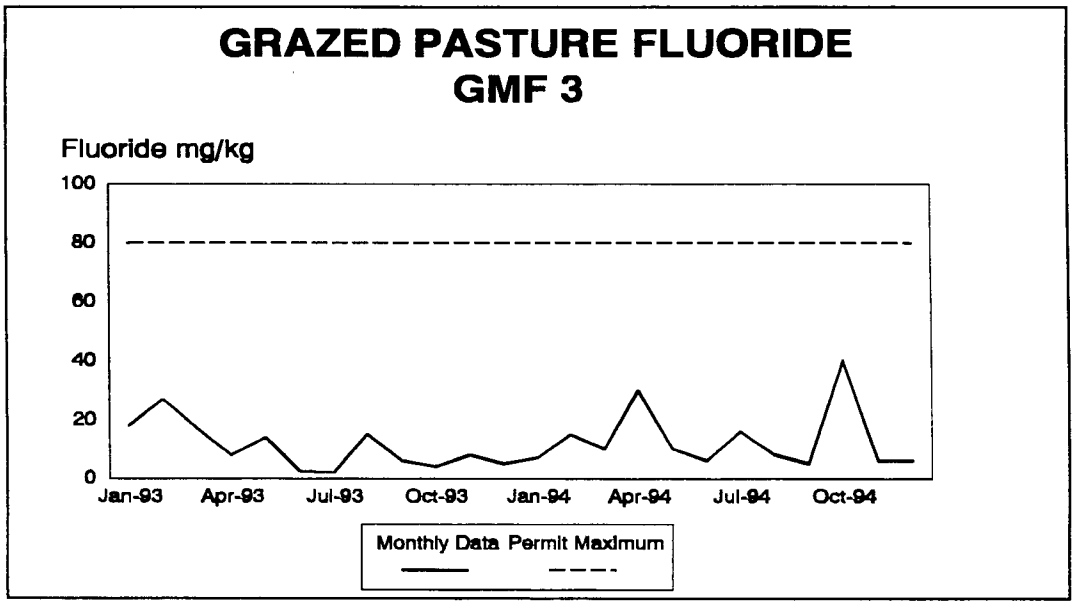
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1994.

	Units	Permit	1994 maximum
Monthly sample	mg/kg	80	40
Two monthly average	mg/kg	60	23
Twelve monthly average	mg/kg	40	13

The annual average for 1994 was 13 mg/kg.

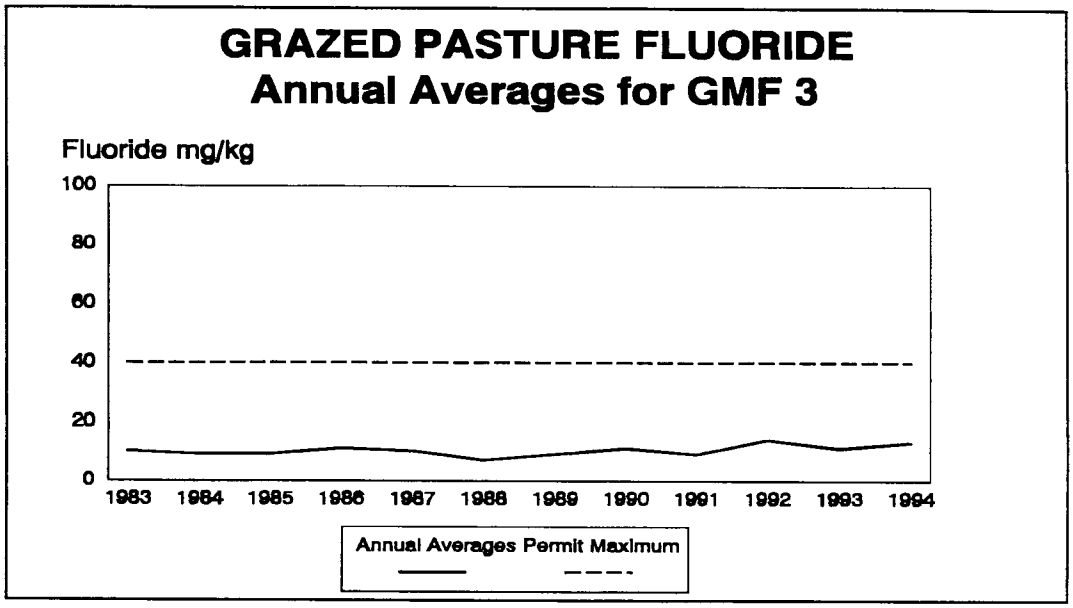
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1993 and 1994.



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.

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.

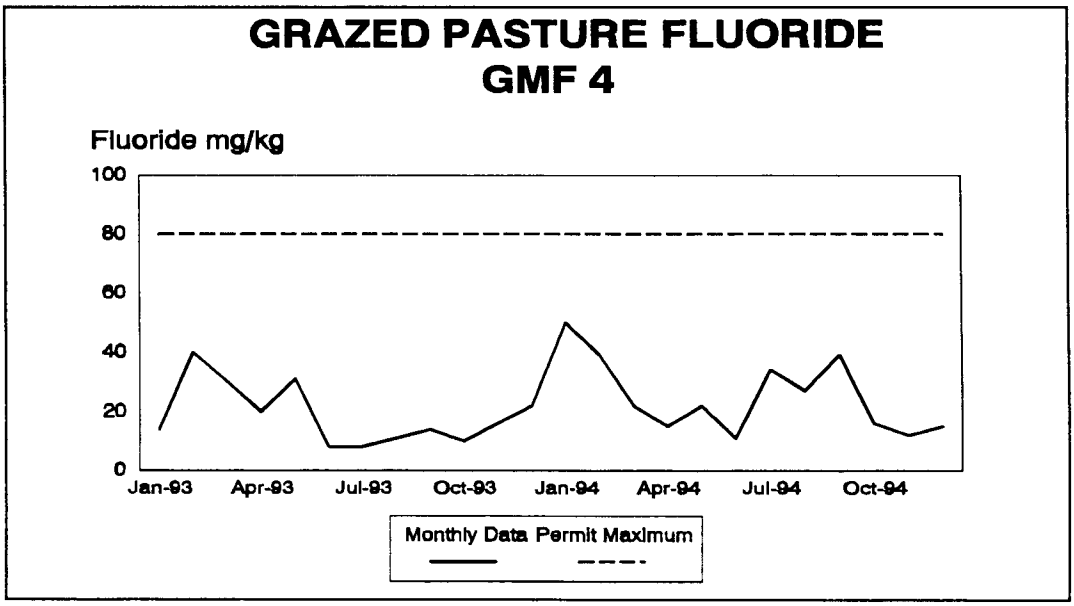
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1994.

	Units	Permit	1994 maximum
Monthly sample	mg/kg	80	50
Two monthly average	mg/kg	60	45
Twelve monthly average	mg/kg	40	27

The annual average for 1994 was 25 mg/kg.

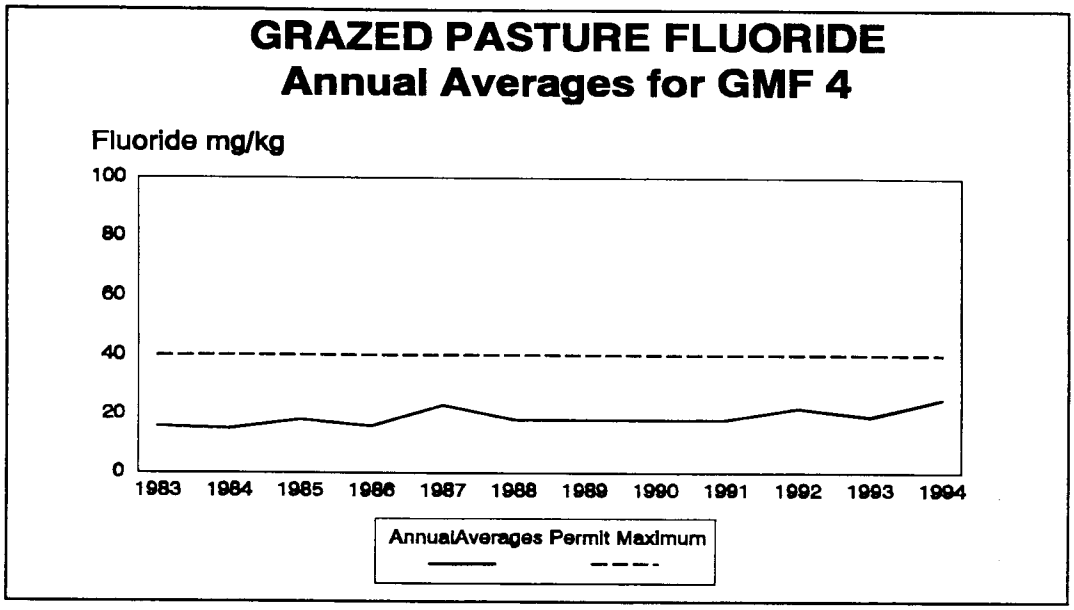
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1993 and 1994.



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

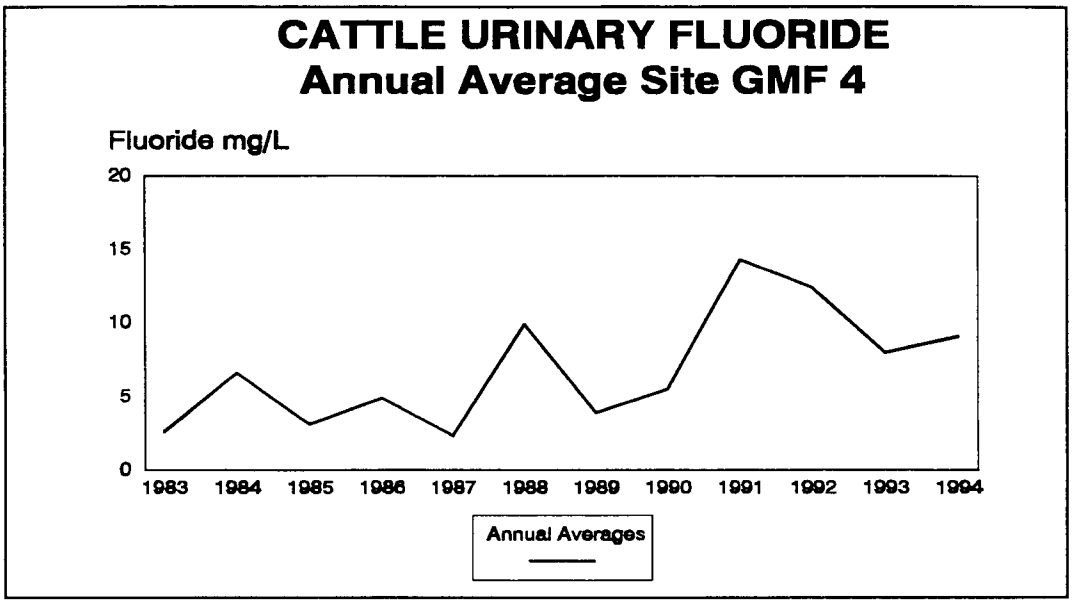
The following table summarises the results of cattle urinary fluoride monitoring during 1994.

	Units	Permit	Result
Average fluoride concentration	mg/L	10	9.1
Maximum fluoride concentration	mg/L	-	9.9
Minimum fluoride concentration	mg/L	-	8.6
No. of samples		-	3

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 1994.

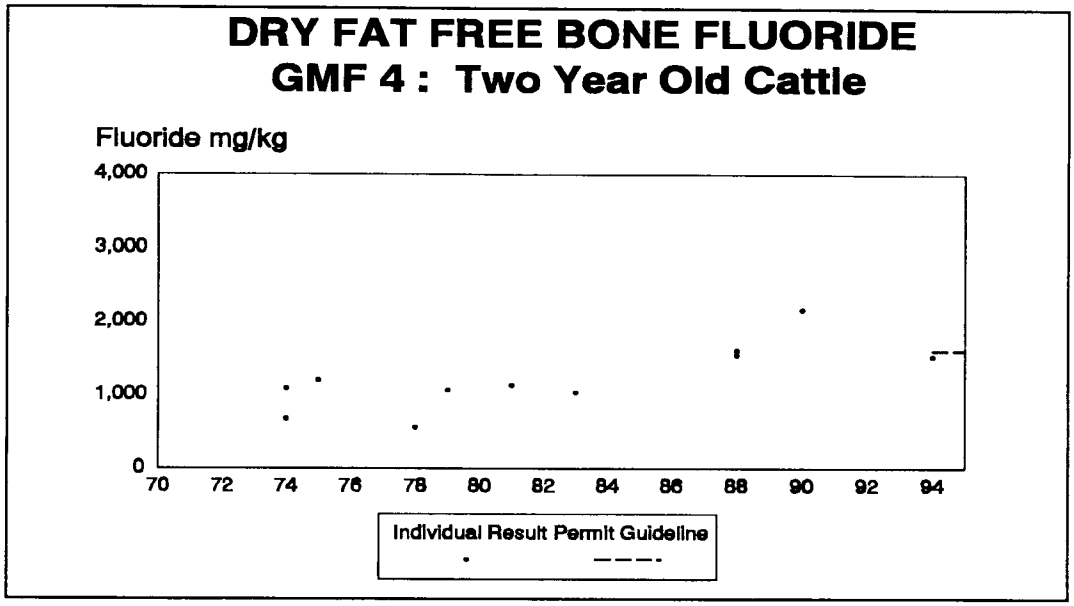
Identification	Age	Units	Permit	Fluoride
Hereford cross	6	mg/kg	2794	2175
Simmental	4	mg/kg	2379	1650
18	4	mg/kg	2379	1250
NZAS 70	2	mg/kg	1605	1525

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

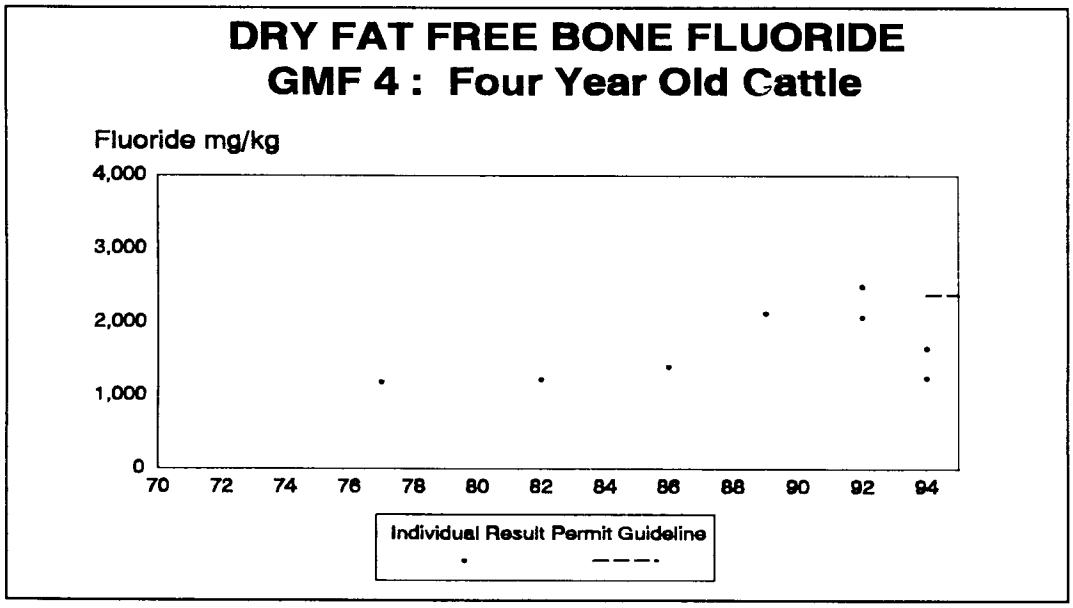
3.6.4 Grazing Monitor Farm No. 4, continued

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.



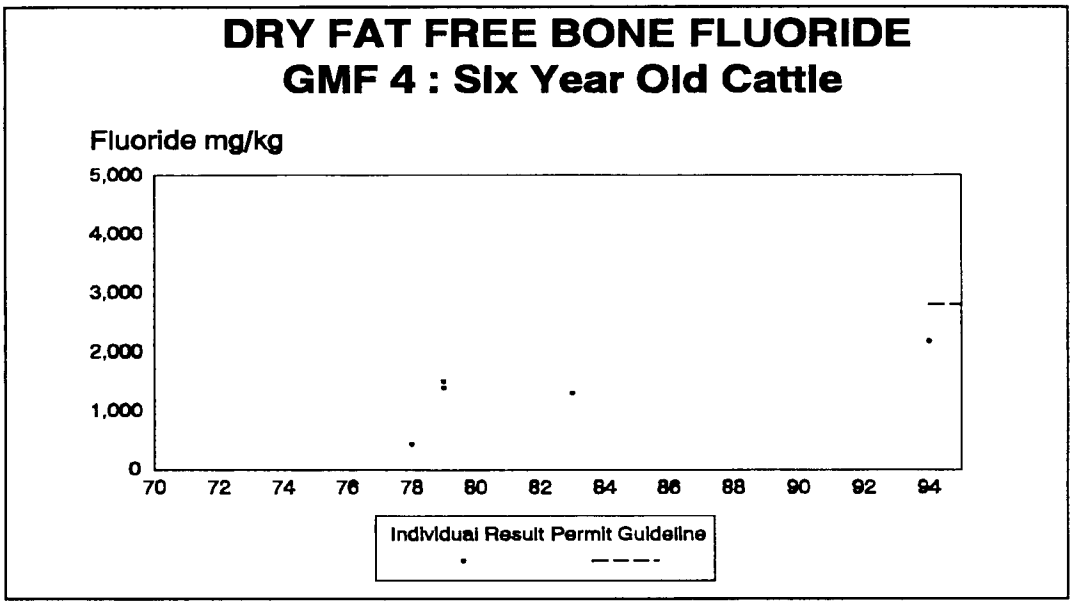
The following graph shows the bone fluoride concentration of individual biopsies collected from four year old cattle since the project began.



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 during 1994. The scores are related to the year during which the tooth was formed.

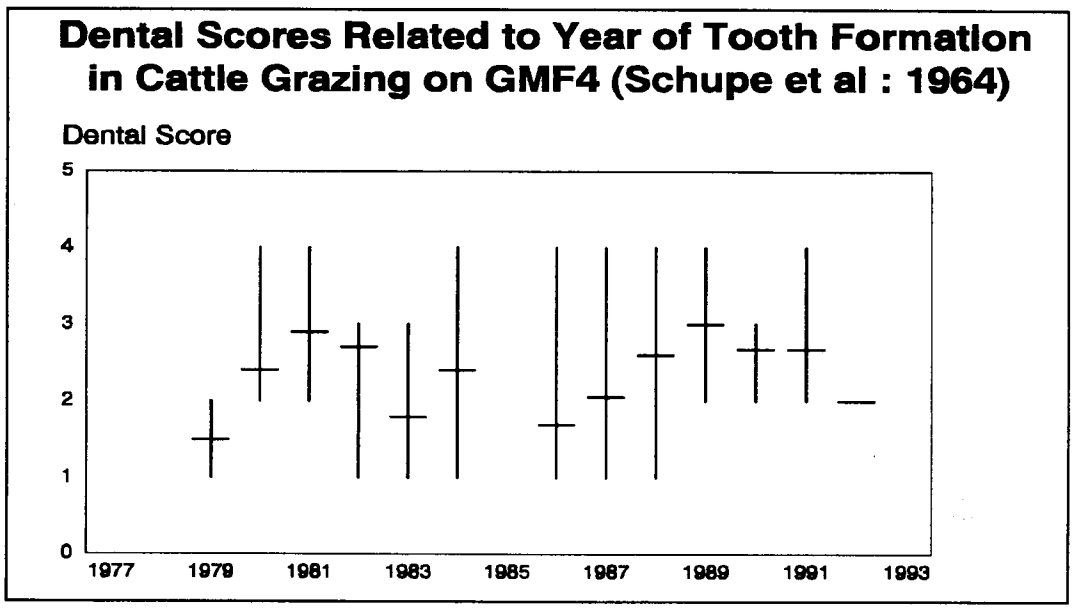
	1990	1991	1992
Average tooth score	2.7	2.7	2
Maximum tooth score	3	4	2
Minimum tooth score	2	2	2
No. of cattle inspected	3	2	1

Note: the tooth scoring system follows the method of Suttie.

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

The results of the monitoring on this farm were all within the permit standards and guidelines during 1994. The results are within the range experienced on this farm over the previous five years.

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.

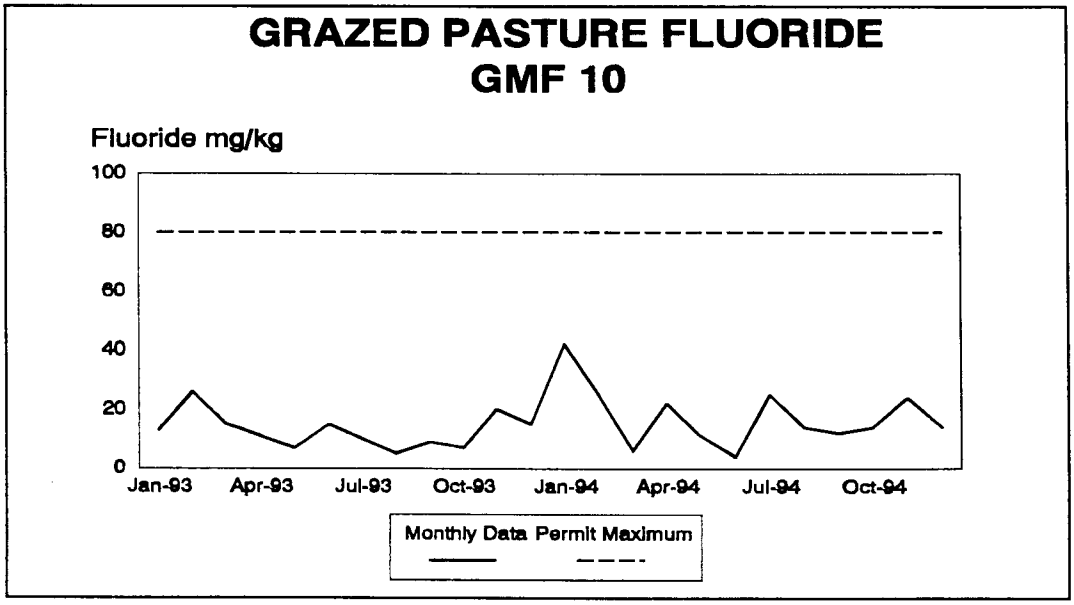
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1994.

	Units	Permit	1994 maximum
Monthly sample	mg/kg	80	42
Two monthly average	mg/kg	60	34
Twelve monthly average	mg/kg	40	18

The annual average for 1994 was 18 mg/kg.

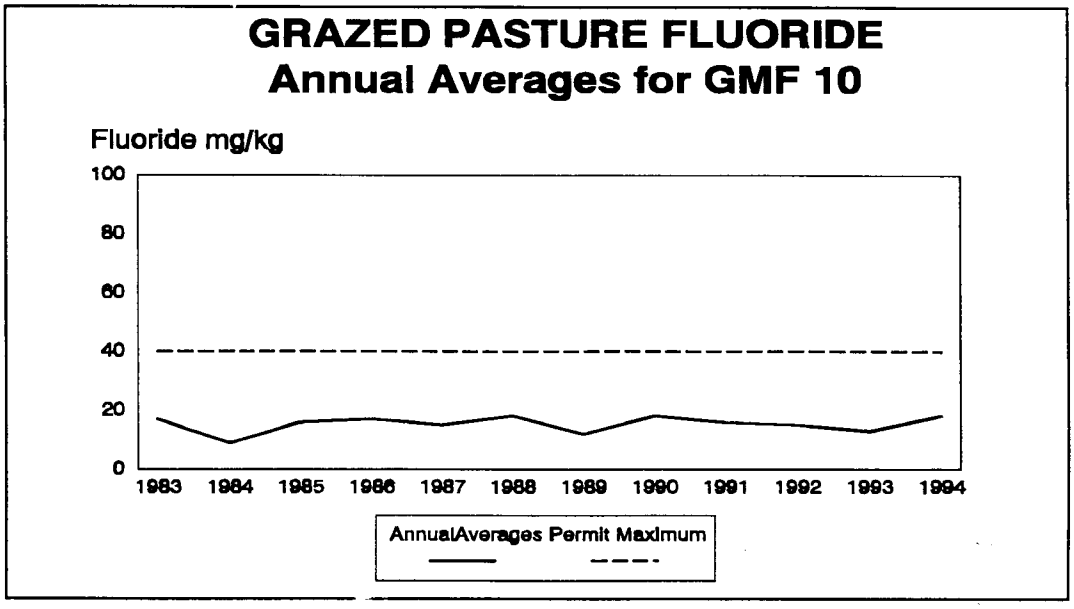
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1993 and 1994.



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.

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.

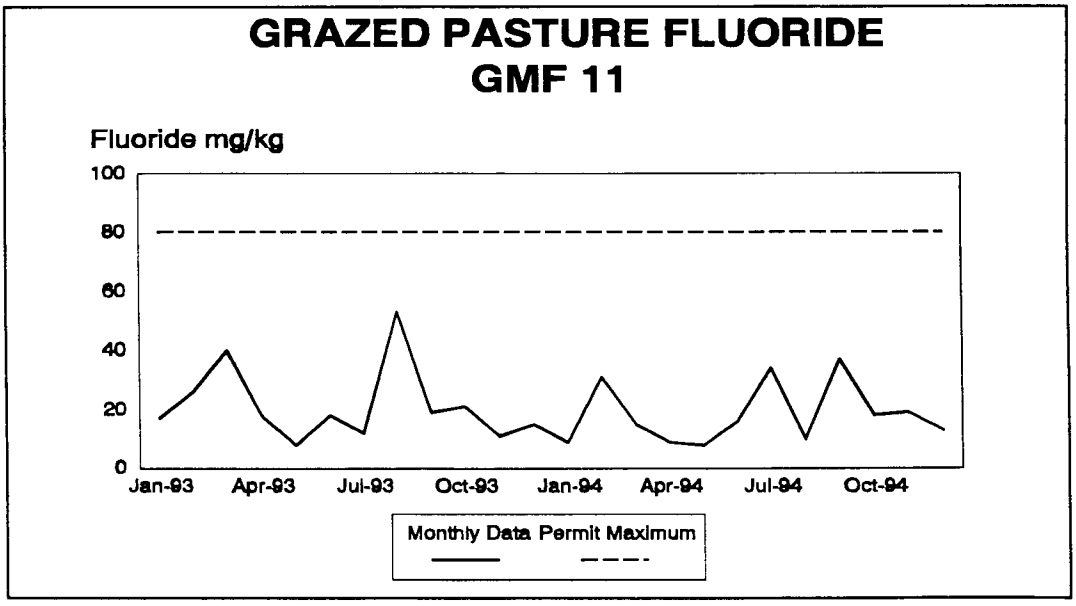
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1994.

	Units	Permit	1994 maximum
Monthly sample	mg/kg	80	37
Two monthly average	mg/kg	60	28
Twelve monthly average	mg/kg	40	21

The annual average for 1994 was 18 mg/kg.

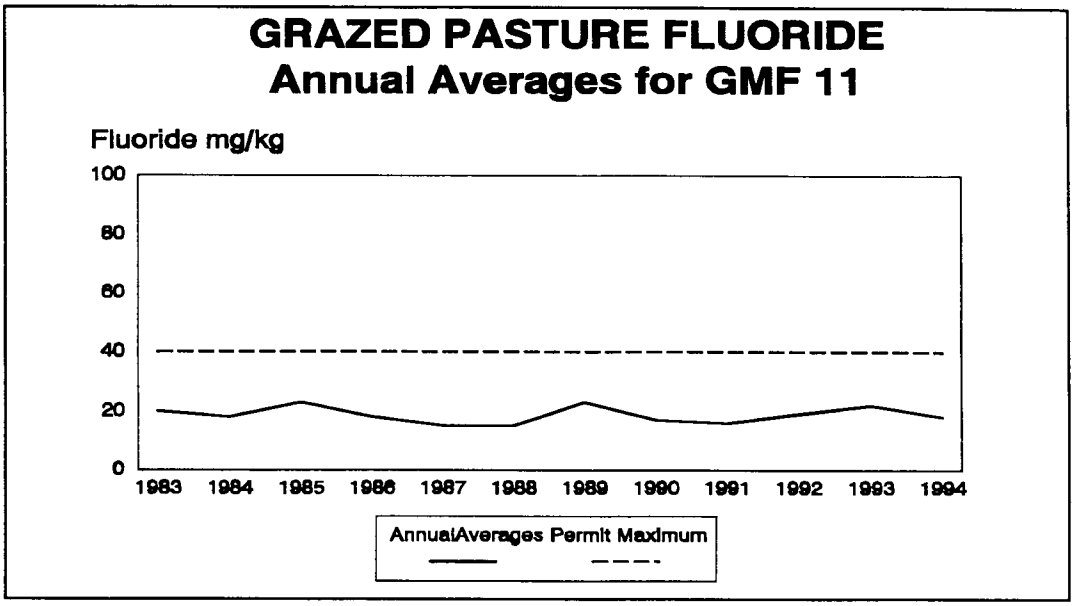
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1993 and 1994.



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.

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.

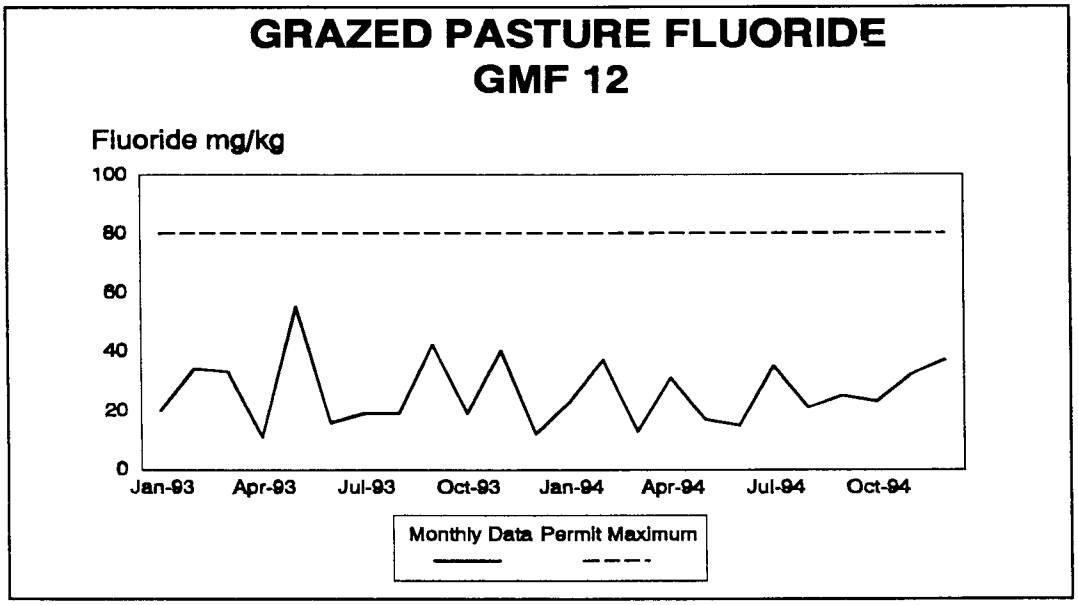
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1994.

	Units	Permit	1994 maximum
Monthly sample	mg/kg	80	37
Two monthly average	mg/kg	60	35
Twelve monthly average	mg/kg	40	27

The annual average for 1994 was 26 mg/kg.

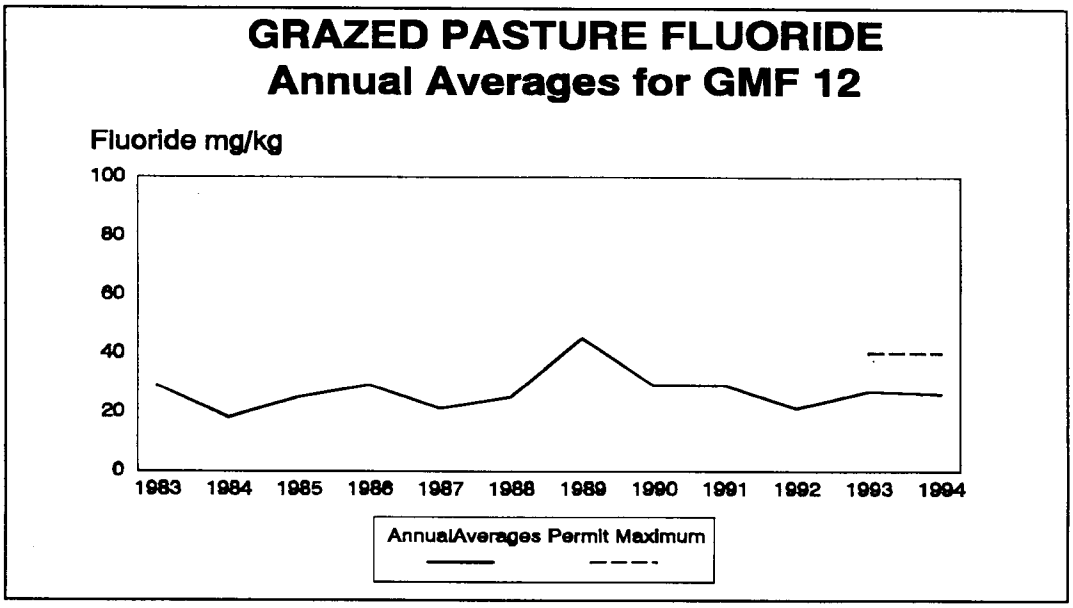
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1993 and 1994.



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.

3.6.8 Grazing Monitor Farm No. 14

The following information is contained in this section:

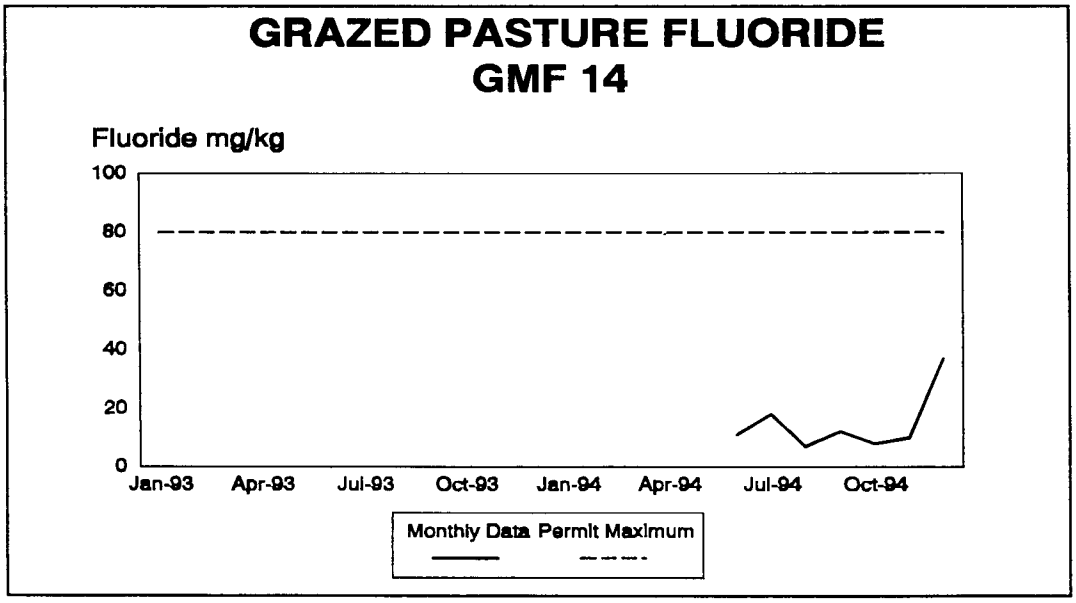
- fluoride in grazed pasture,
- cattle urinary fluoride, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1994.

	Units	Permit	1994 maximum
Monthly sample	mg/kg	80	37
Two monthly average	mg/kg	60	24
Twelve monthly average	mg/kg	40	-

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



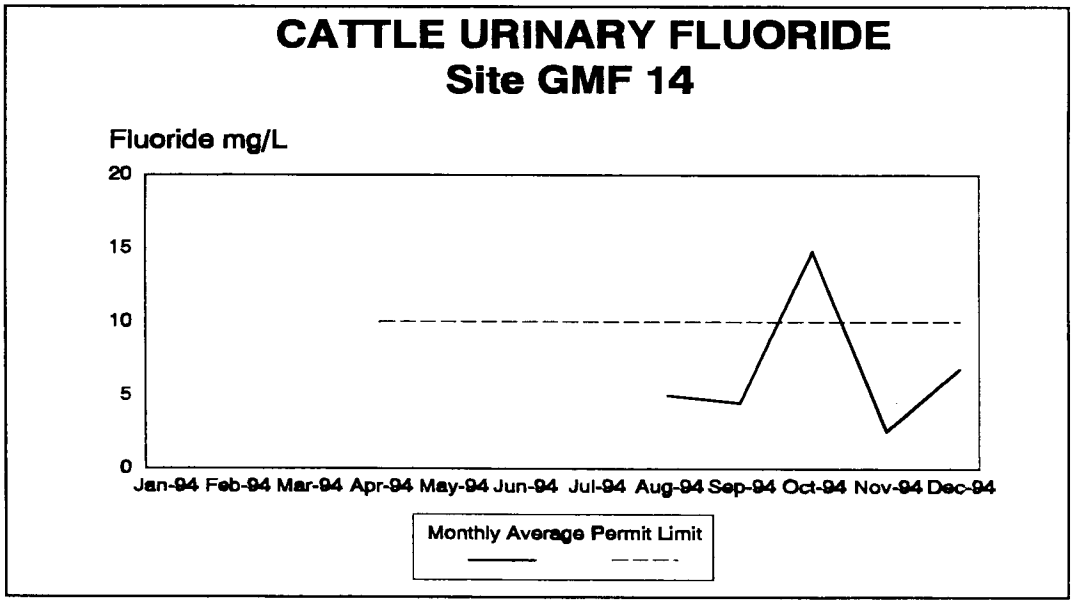
3.6.8 **Grazing Monitor Farm No. 14**, continued

Cattle urinary fluoride

The following table summarises the results of cattle urinary fluoride monitoring during 1994.

	Units	Permit	Result
Average fluoride concentration	mg/L	10	6.7
Maximum fluoride concentration	mg/L		19.3
Minimum fluoride concentration	mg/L		2.0
No. of samples			22

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



3.6.8 **Grazing Monitor Farm No. 14**, continued

Comments

The fluoride in grazed pasture was within the permit standards.

The cattle urinary fluoride concentration exceeded the permit guideline in October. Fluoride in grazed pasture during October was 8 mg/kg which should not have produced a high urinary fluoride concentration. There are no other monitoring sites near GMF14 to suggest a reason for the elevated urinary fluoride concentration.

This farm was incorporated into the monitoring program in May '94. For this reason no annual averages have been calculated.

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.

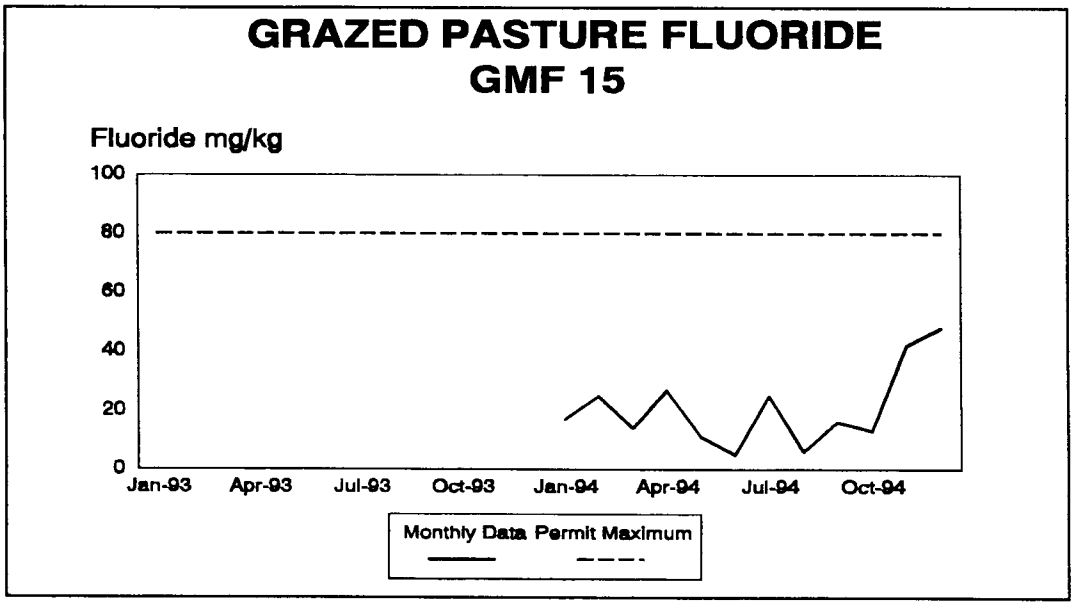
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1994.

	Units	Permit	1994 maximum
Monthly sample	mg/kg	80	48
Two monthly average	mg/kg	60	45
Twelve monthly average	mg/kg	40	21

The annual average for 1994 was 21 mg/kg.

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



3.6.9 **Grazing Monitor Farm No. 15**, continued

Comments

The fluoride in grazed pasture was within the permit standards.

This farm was incorporated into the monitoring program in January '94. For this reason no information for previous years can be presented.

3.6.10 Grazing Monitor Farm No. 16

The following information is contained in this section:

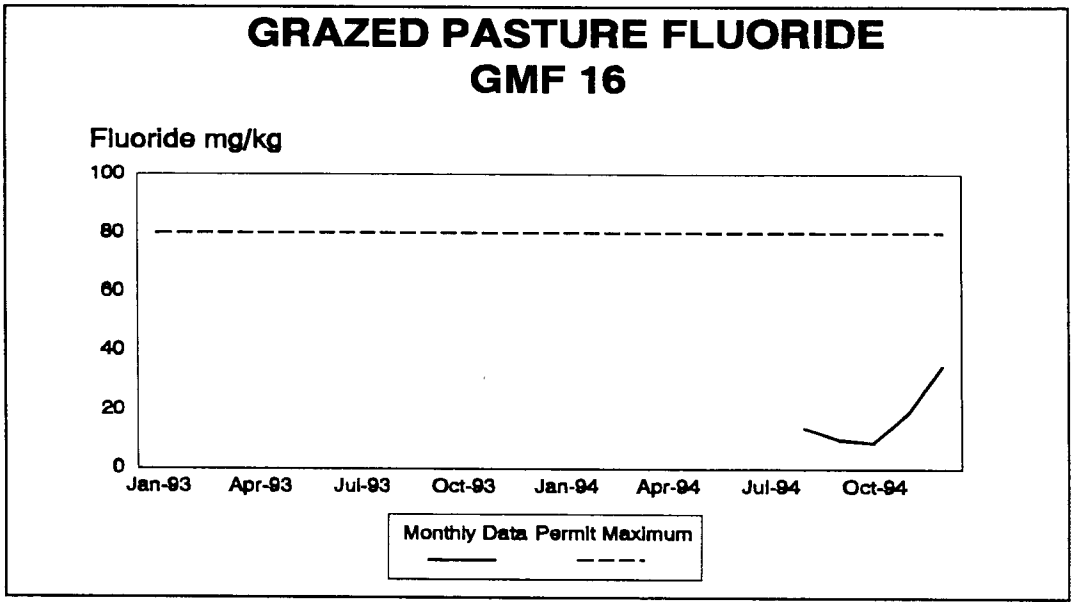
- fluoride in grazed pasture,
- cattle urinary fluoride, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1994.

	Units	Permit	1994 maximum
Monthly sample	mg/kg	80	35
Two monthly average	mg/kg	60	27
Twelve monthly average	mg/kg	40	-

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



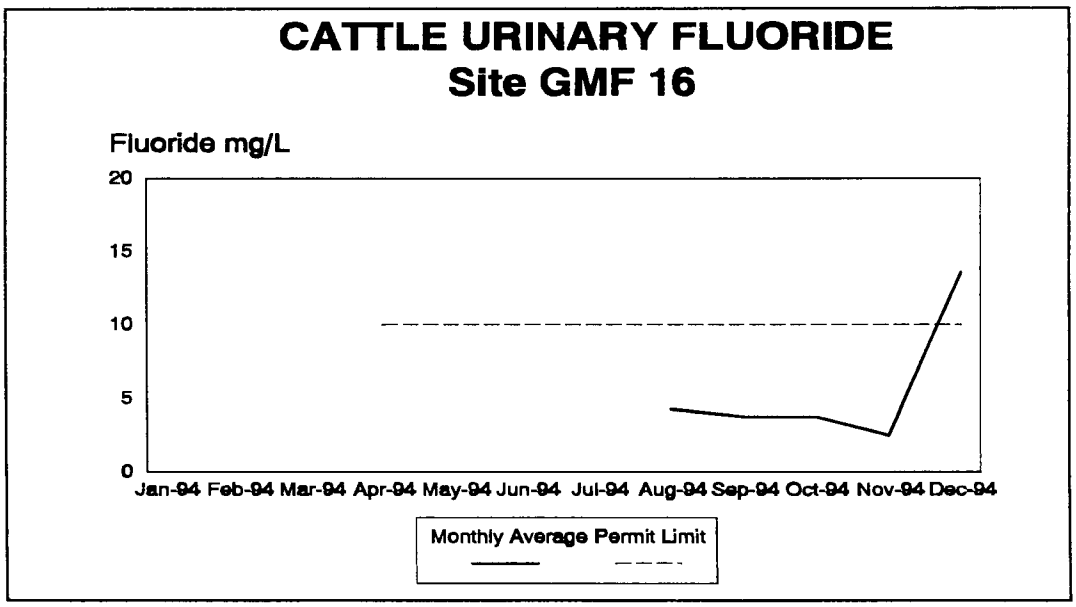
3.6.10 Grazing Monitor Farm No. 16, continued

Cattle urinary fluoride

The following table summarises the results of cattle urinary fluoride monitoring during 1994.

	Units	Permit	Result
Average fluoride concentration	mg/L	10	5.6
Maximum fluoride concentration	mg/L	-	16.8
Minimum fluoride concentration	mg/L	-	2.0
No. of samples		-	20

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



3.6.10 **Grazing Monitor Farm No. 16**, continued

Comments

The fluoride in grazed pasture was within the permit standards.

The cattle urinary fluoride concentration exceeded the permit guideline in December. The fluoride in grazed pasture during December was 35 mg/kg which was the highest for the year. The high results were most likely caused by strong westerly winds transporting smelter sourced fluoride material to the farm.

This farm was incorporated into the monitoring program in August '94. For this reason no annual averages have been calculated.

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 on page 3.33.

3.7.1 Tiwai Experimental Farm No.1

The following information is contained in this section:

- fluoride in grazed pasture,
- sheep urinary fluoride,
- sheep dental effects, and
- comments in the monitoring.

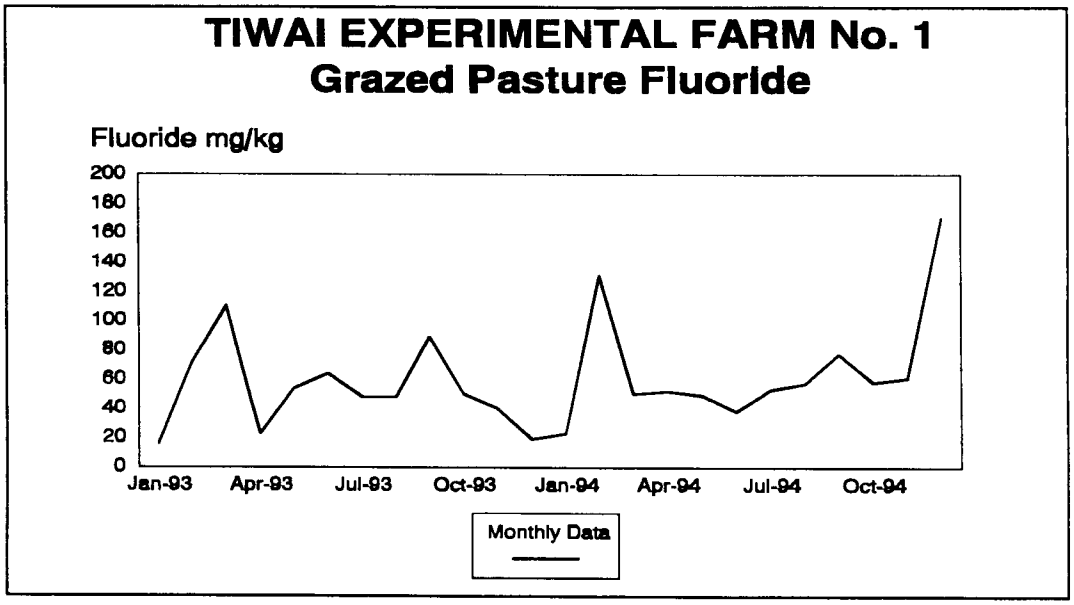
Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1994.

	Units	1994 maximum
Monthly sample	mg/kg	170
Two monthly average	mg/kg	116
Twelve monthly average	mg/kg	68

The annual average for 1994 was 68 mg/kg.

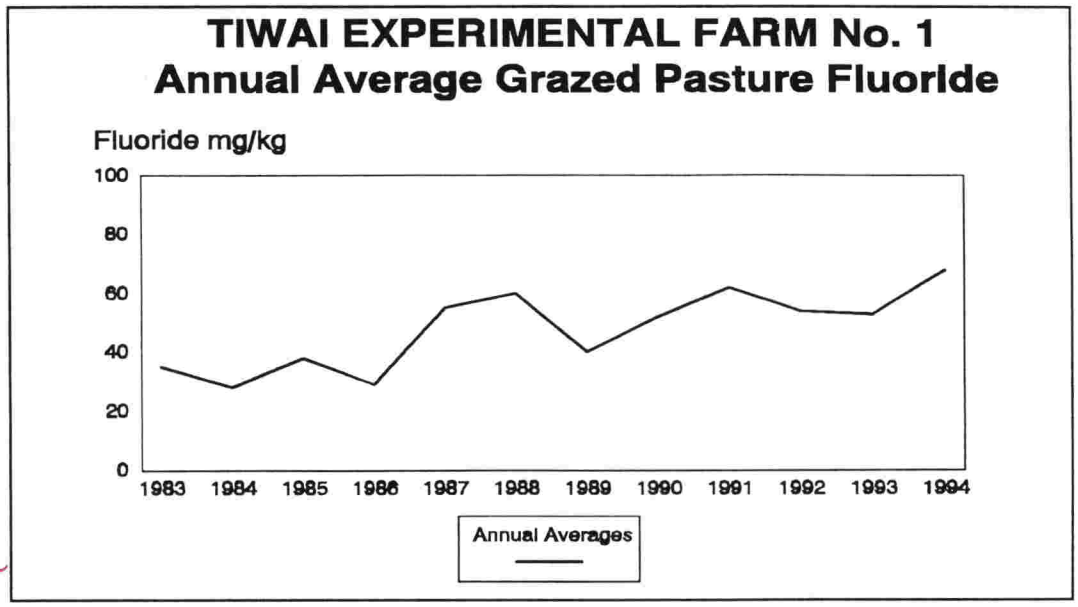
The following graph shows the results of monthly monitoring of grazed pasture.



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.



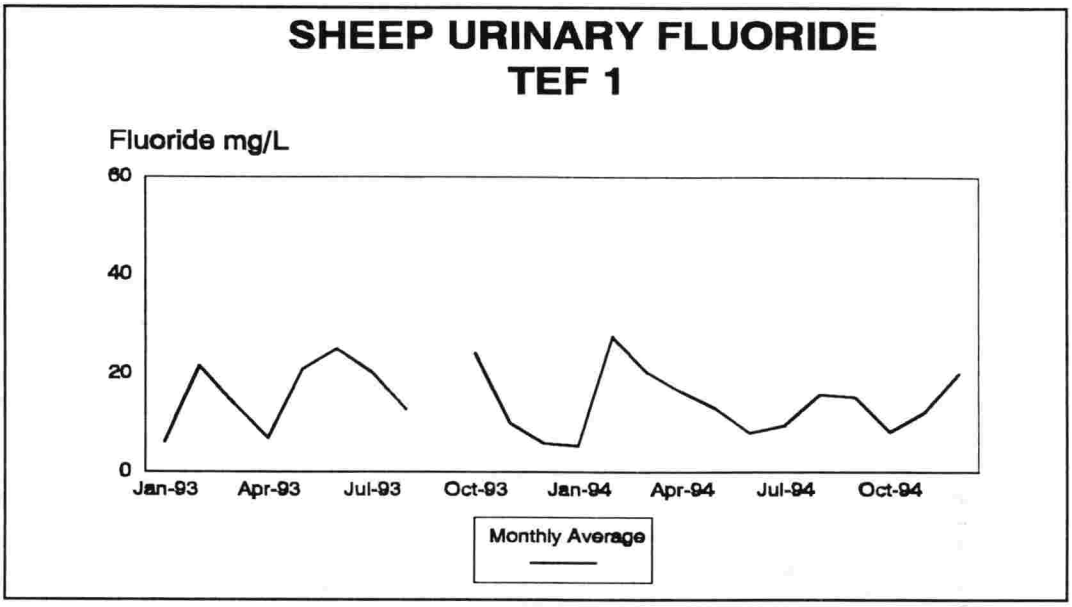
Sheep urinary fluoride

The following table summarises the results of sheep urinary fluoride monitoring during 1994.

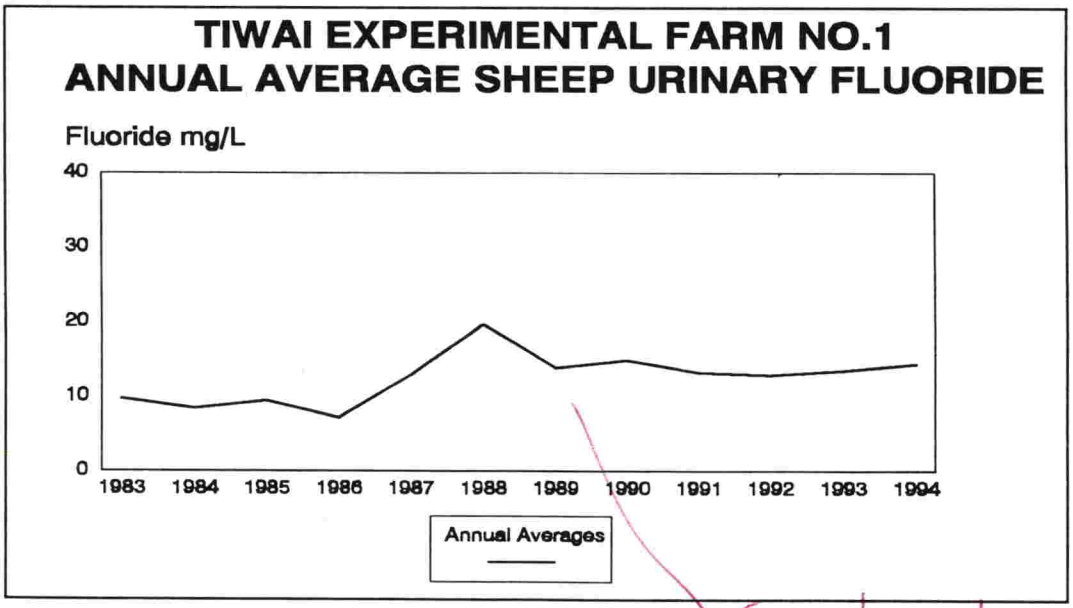
	Units	Result
Average fluoride concentration	mg/kg	14
Maximum fluoride concentration	mg/kg	43
Minimum fluoride concentration	mg/kg	3.3
No. of samples		139

Sheep urinary fluoride, continued

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



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



Some change Lvl.

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.

	1991	1992	1993	1994
Average tooth score	3.2	2.8	3.0	2.7
Maximium tooth score	4	3	3	3
Minimum tooth score	2	2	3	2
No. of sheep inspected	9	9	8	7

Note: the tooth scoring system follows the method of Suttie.

Comments

The results of monitoring on this farm were generally within the range of results experienced on this farm over the past five years.

The elevated annual average grazed pasture fluoride concentration for 1994 was a result of two very high monthly results. The high results were recorded in February and December. The December result appears to the predominance of westerly winds during the month. The February result is unexplained.

No jaw bone samples were collected during 1994 because culling was delayed awaiting the outcome of a review of the Tiwai Experimental Farm Project management.

An internal review of the management of the Tiwai Experimental Farm project has initiated the following changes:

- lambs grazing on TEF2 to remain on TEF2,
- lambs born on TEF1 will remain on TEF1 and not be transferred to TEF2 for grazing.

The internal review highlighted other stock management concerns which will be addressed at a formal review. The review is to be held in late March. Assistance will be provided by the Ministry of Agriculture and Fisheries and the smelter's veterinary consultant.

3.7.2 Tiwai Experimental Farm No.2

The following information is contained in this section:

- fluoride in grazed pasture,
- sheep urinary fluoride, and
- comments in the monitoring.

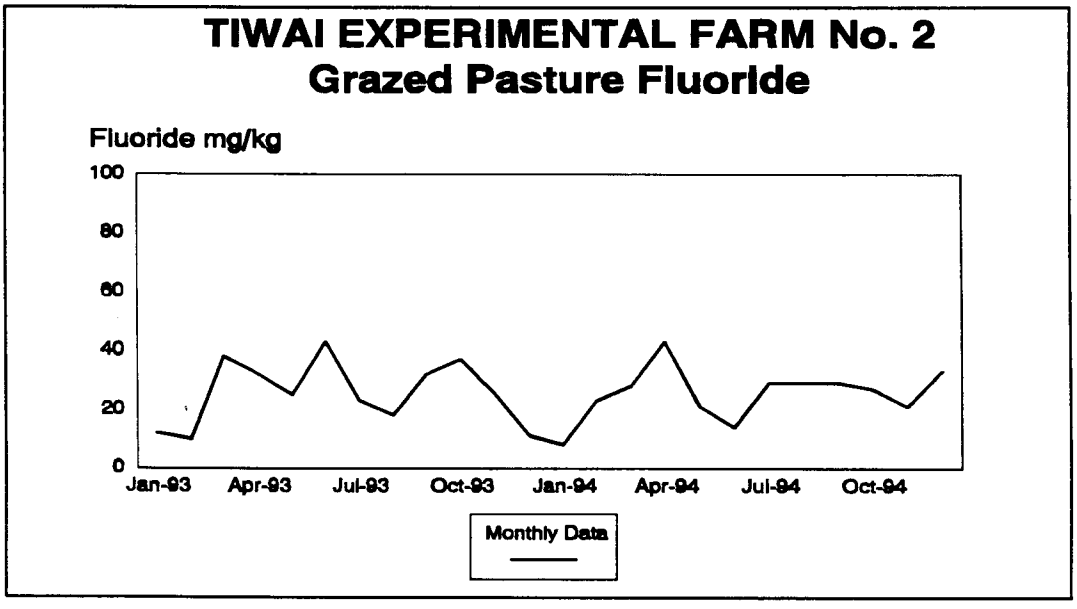
Fluoride in grazed pasture

The following table summarises the maximum grazed pasture monitoring results for 1994.

	Units	1994 maximum
Monthly sample	mg/kg	43
Two monthly average	mg/kg	36
Twelve monthly average	mg/kg	26

The annual average for 1994 was 25 mg/kg.

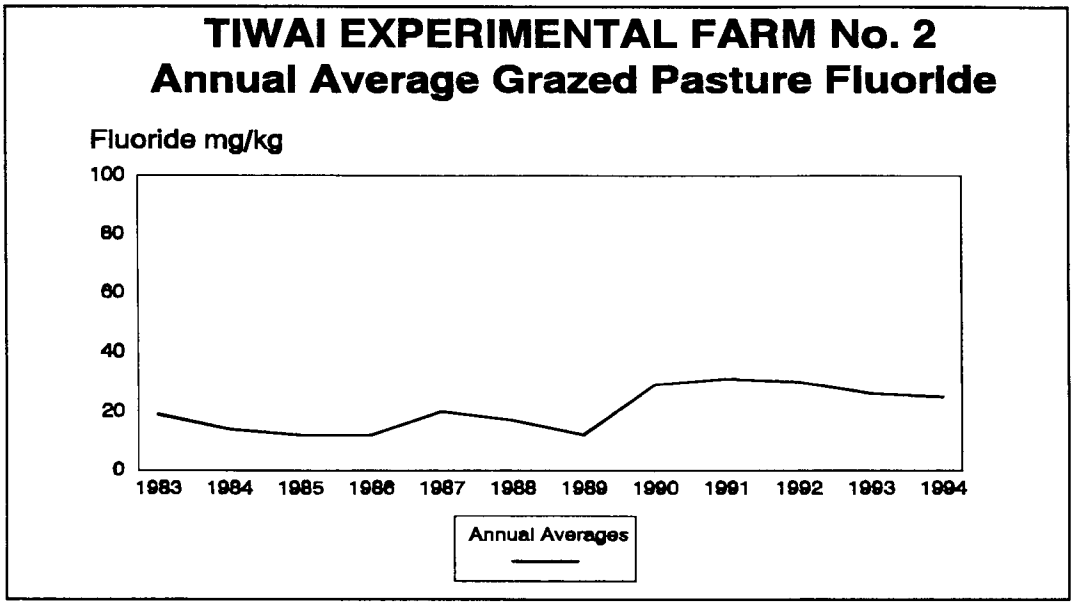
The following graph shows the results of monthly monitoring of grazed pasture.



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

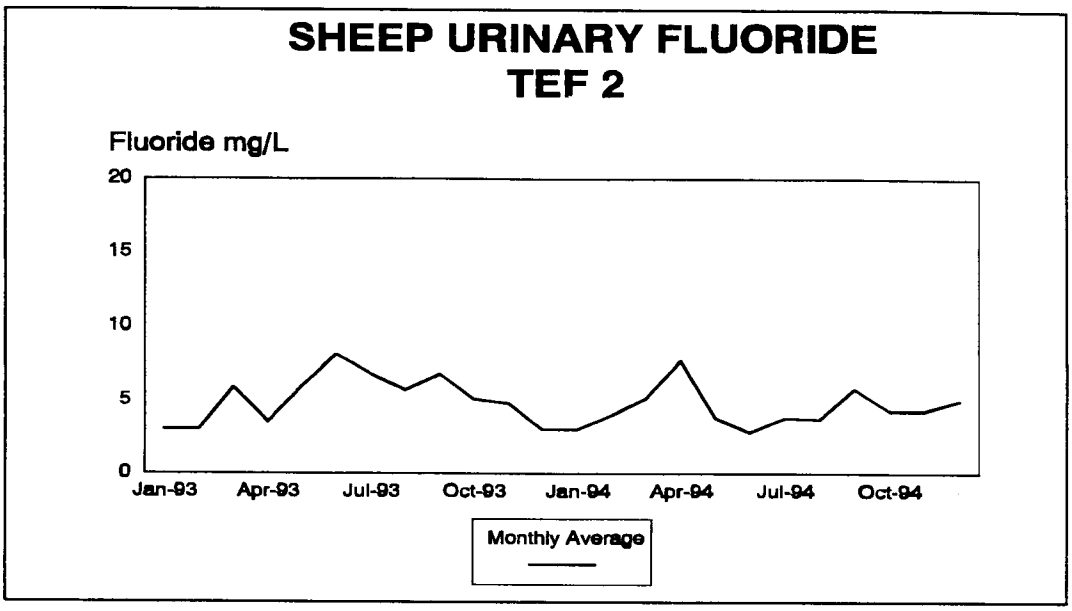
The following table shows the results of sheep urinary fluoride monitoring during 1994.

	Units	Result
Average fluoride concentration	mg/kg	4.5
Maximum fluoride concentration	mg/kg	18.6
Minimum fluoride concentration	mg/kg	1.6
No. of samples		91

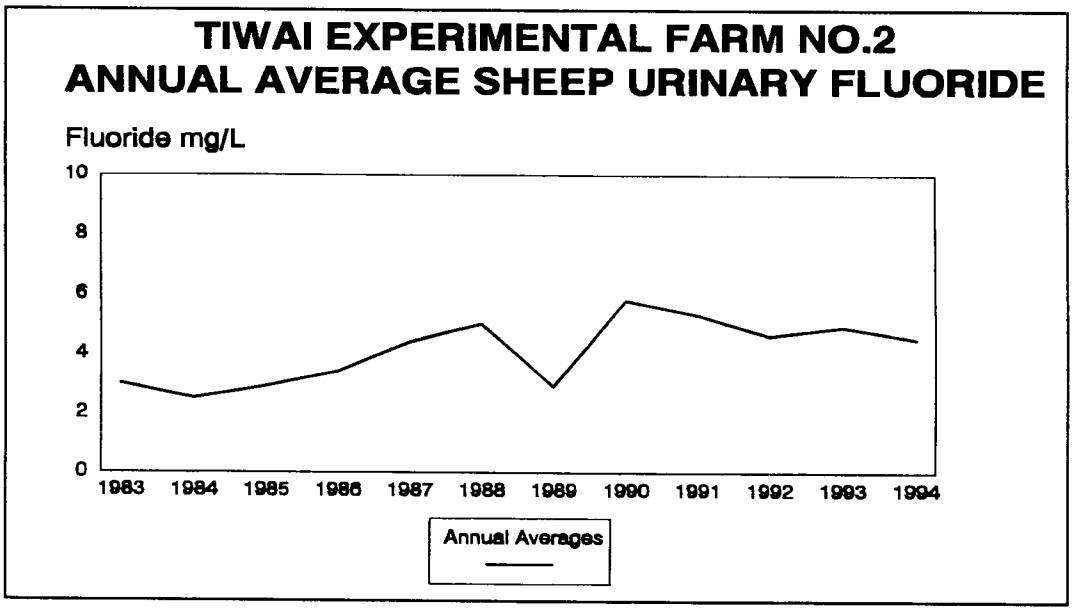
3.7.2 Tiwai Experimental Farm No.2, continued

Sheep urinary fluoride, continued

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



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



3.7.2 **Tiwai Experimental Farm No.2**, continued

Comments

The results of monitoring on this farm were within the range of results experienced on this farm over the past five years.

No jaw bone samples were collected during 1994. See TEF1 on page 3.68.

A review of the management of the Tiwai Experimental Farm Project has resulted in change to the manner in which the farms are managed. The changes are discussed in TEF1 on page 3.68.

3.8 Pasture Fluoride Analysis Methods

Investigations into pasture fluoride analysis methods are continuing. During 1994 the performance of the following methods were compared in the NZAS laboratory:

- AOAC Method 26,
- AOAC Method 26 modified, and
- ASTM Method 3269.

Comments on the work to date are:

- AOAC Method 26 consistently gave the lowest results,
- the results for AOAC Method 26 modified and ASTM Method 3269 appeared comparable except for samples containing higher levels of silica, and
- AOAC Method 26 modified appeared to have less variability than ASTM 3269 when analysing samples with about 10 mg F/kg.

AOAC Method 26 modified became the NZAS laboratory's current best practice for the analysis of routine grazed pasture samples.

The NZAS laboratory participated in an ANAQUAL and an industry organised collaborative survey. A statistical analysis of the laboratory's performance has yet to be completed. This will allow further comparison of AOAC Method 26 modified and methods based on ASTM Method 3269. The NZAS laboratory completed the analysis for both collaborative surveys using AOAC Method 26 modified.

During 1995 the following work will be undertaken:

- a series of quality control samples containing about 50 mg/kg of total fluoride will be prepared, and
- further comparisons between AOAC Method 26 modified and ASTM Method 3269 will be made.

AOAC Method 26 modified analysis will be performed by the NZAS laboratory and ASTM Method 3269 analysis will be performed by an independent laboratory.

Chapter 4

Discharges to Water and their Effects

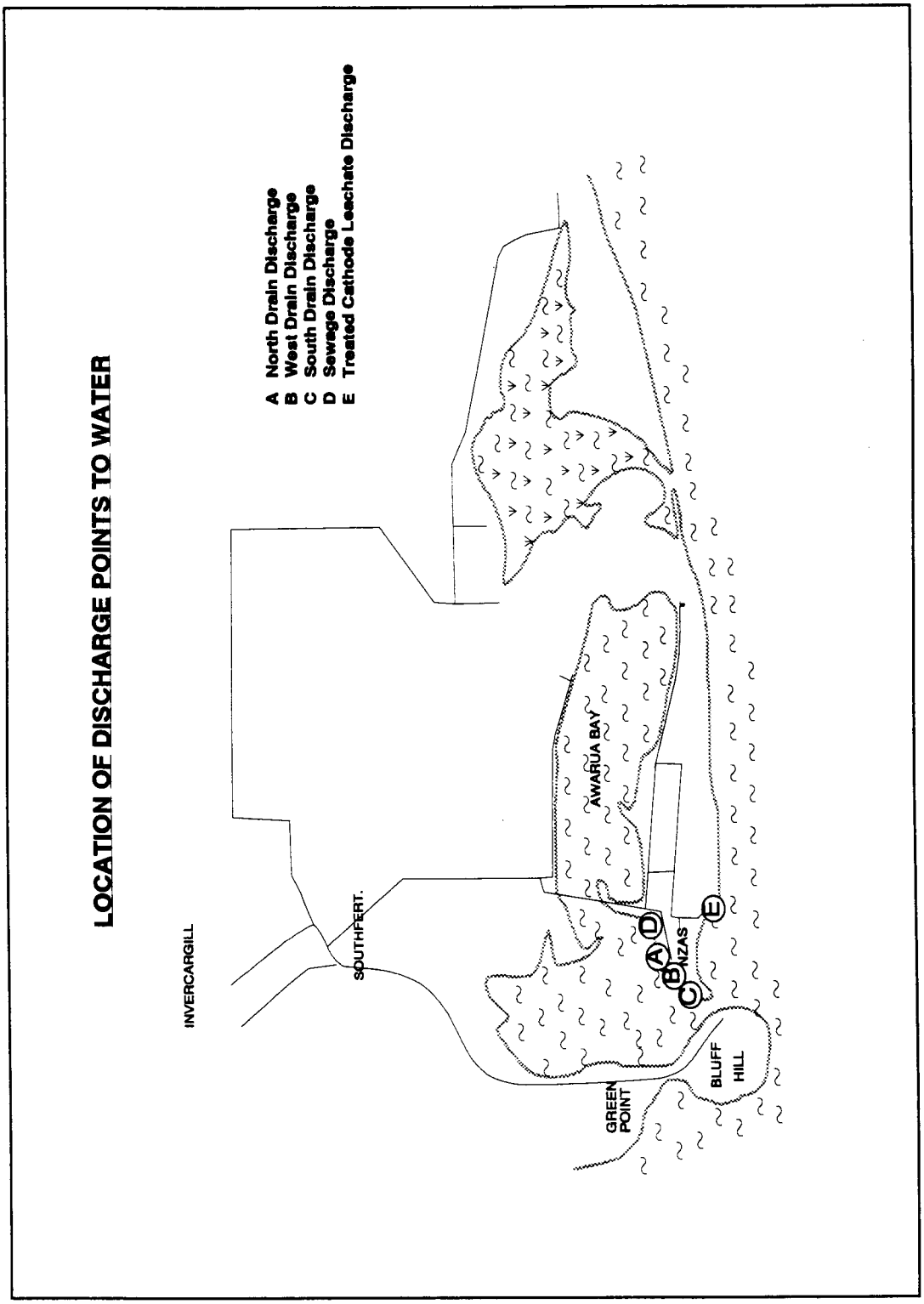
Introduction

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.

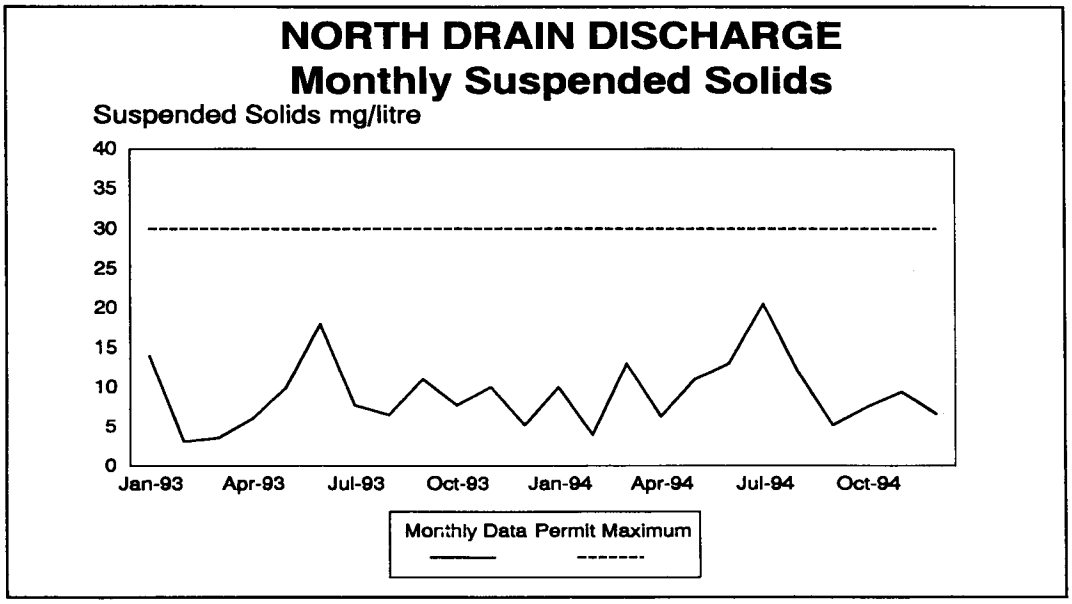

LOCATION OF DISCHARGE POINTS TO WATER
A North Drain Discharge
B West Drain Discharge
C South Drain Discharge
D Sewage Discharge
E Treated Cathode Leachate Discharge
INVERCARGILL
SOUTHPERT.
AWARUA BAY
NZAS
BLUFF HILL
GREEN POINT

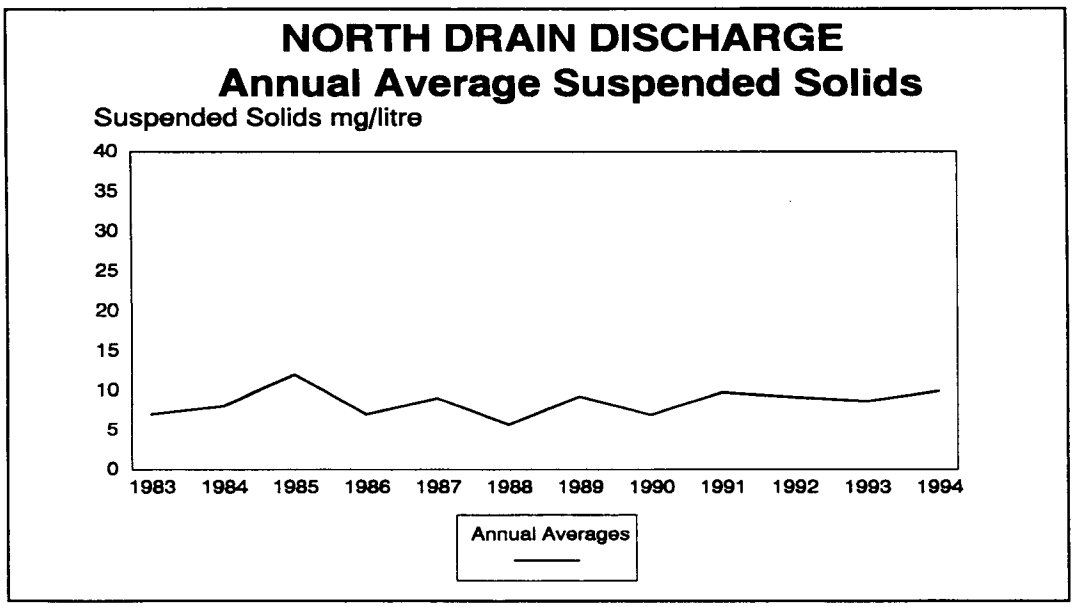
4.1 North Drain Discharges

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.

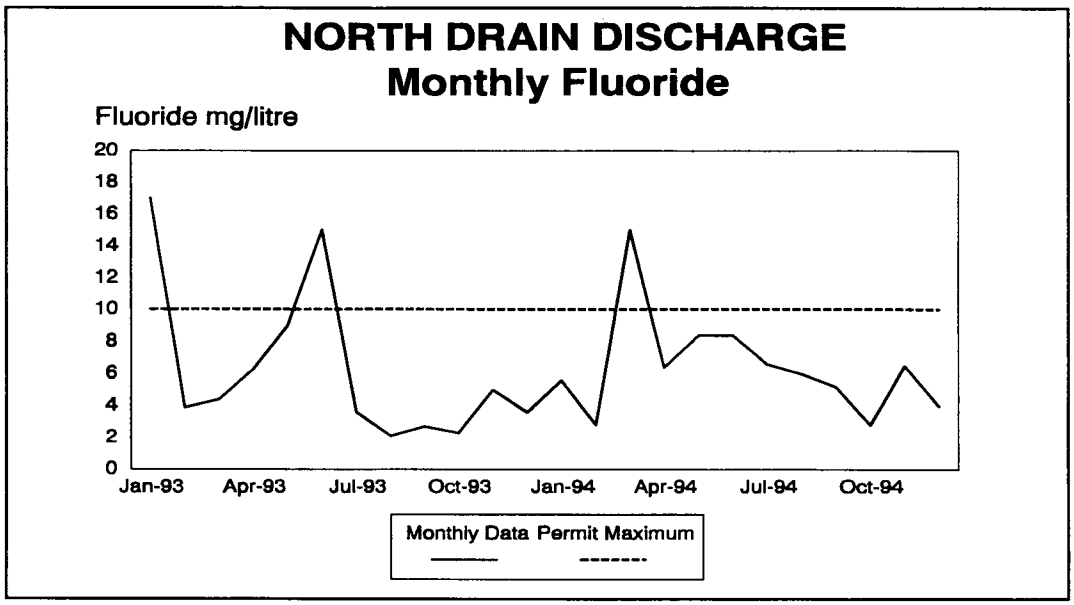
Monitoring Results

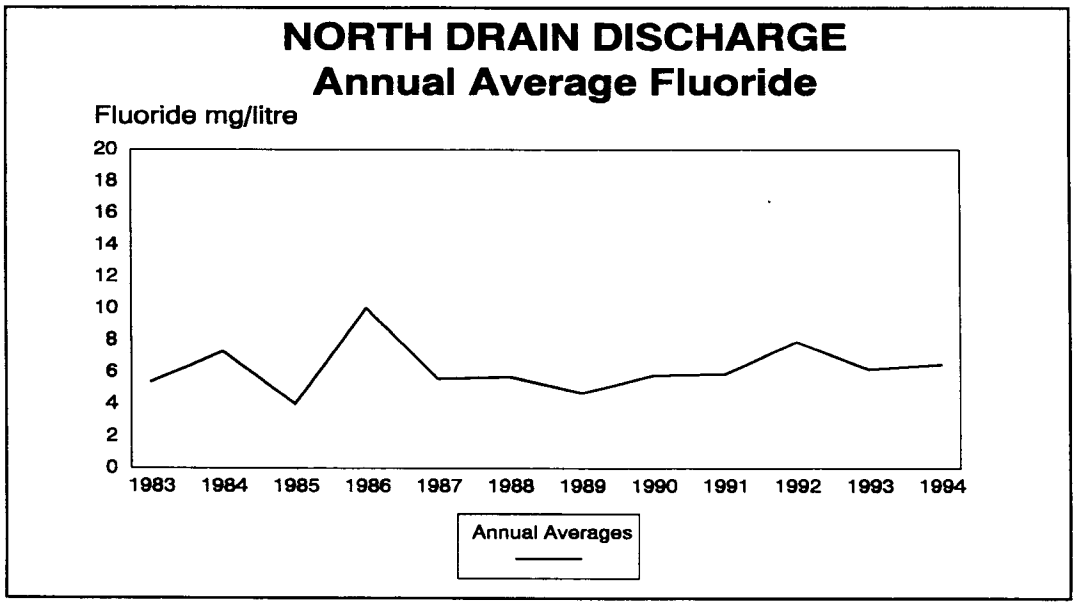




4.1 North Drain Discharges, Continued

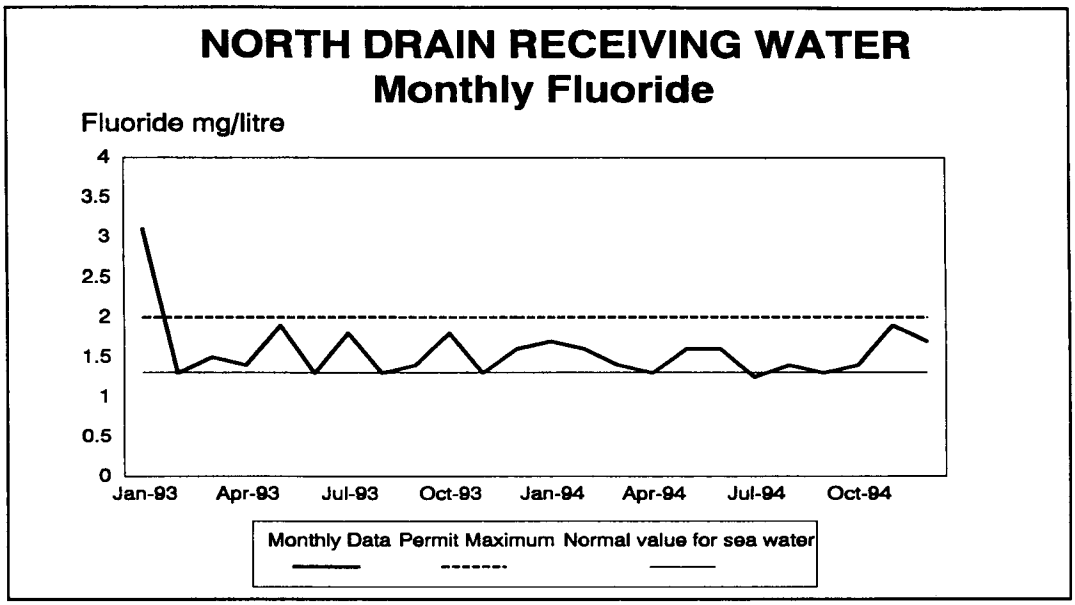
Monitoring Results, continued

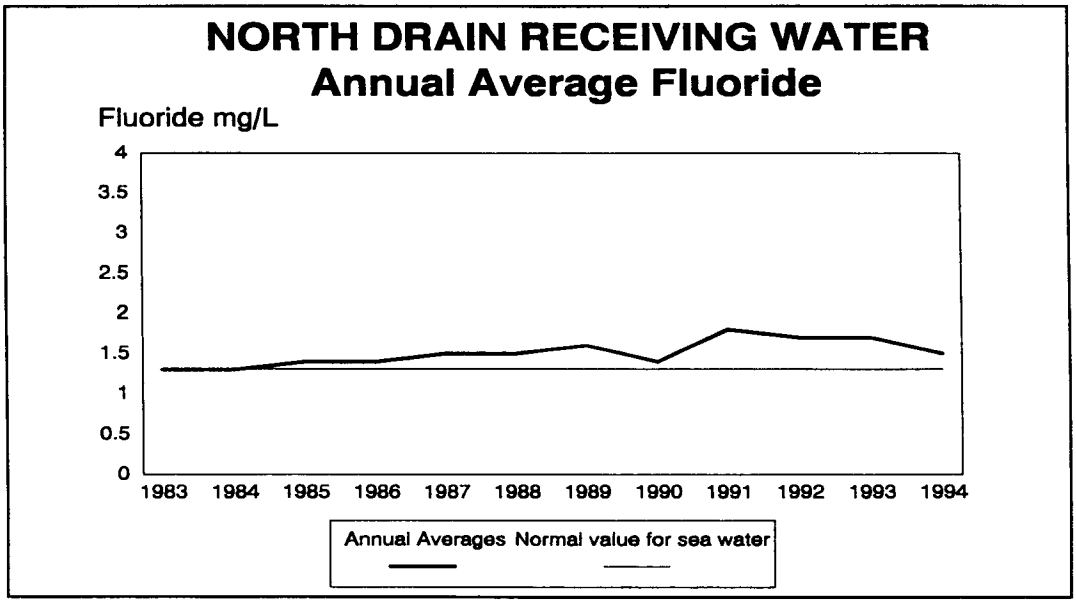




4.1 North Drain Discharges, Continued

Monitoring Results, continued





4.1 North Drain Discharges, Continued

Comments

The North Drain fluoride concentration permit standard was exceeded in March 1994. The main source of fluoride in this drain is the low level discharge through the potroom roof louvres. This was more fully discussed in the 1992 report to the Interdepartmental Committee. Potroom roof louvre discharges have remained within permit standards.

A team of consultants is evaluating several options for dealing with site storm and process water from all three site drains.

Currently the team is considering combining all of the flows and discharging the water either into Foveaux Strait or onto land. The team is also assessing fluoride and PAH treatment options.

The team's work is scheduled to be completed in mid March 1995. Full consultation with interested parties, including the Southland Regional Council, will take place before a decision is reached.

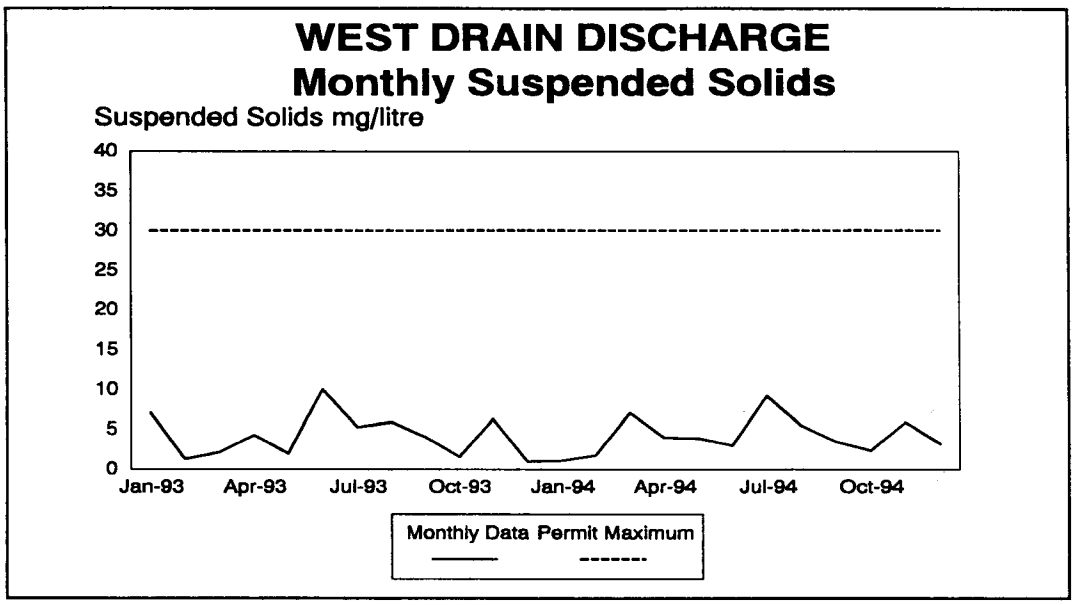
All other North Drain discharges during 1994 were within permit standards.

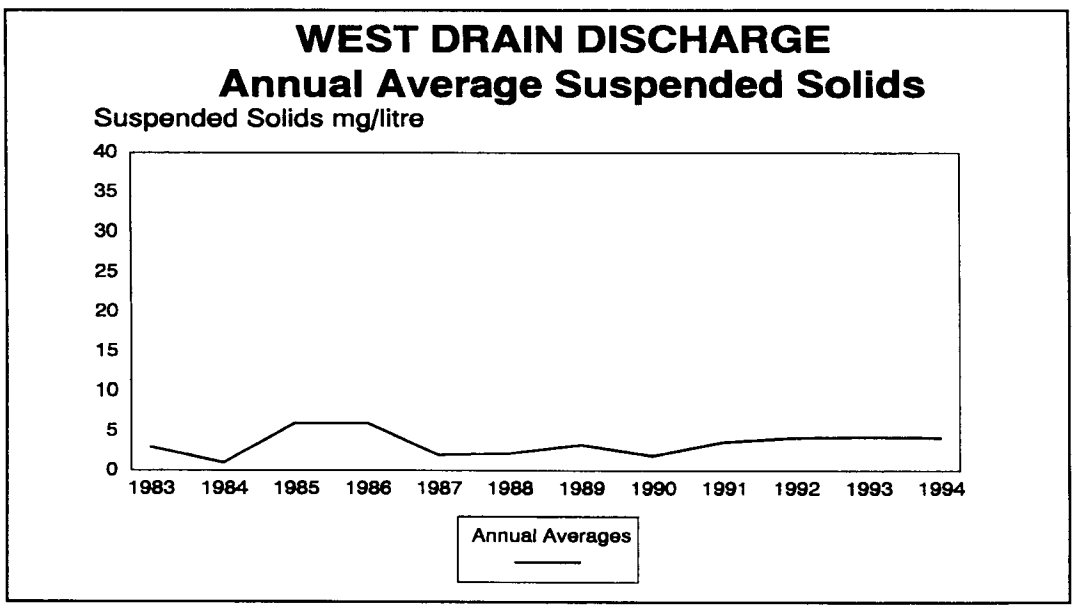
4.2 West Drain Discharges

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.

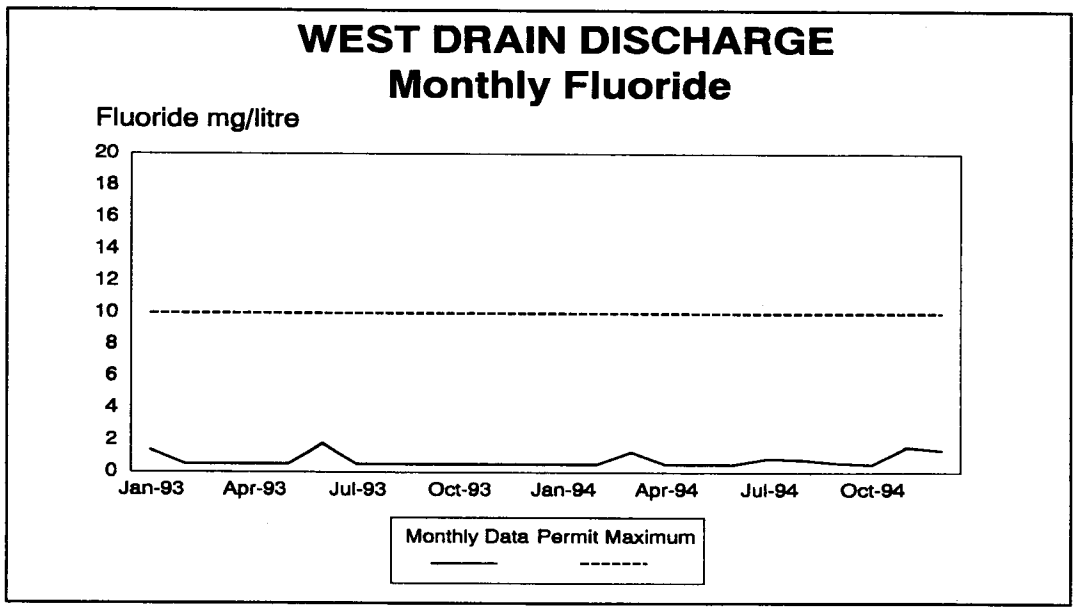
Monitoring Results

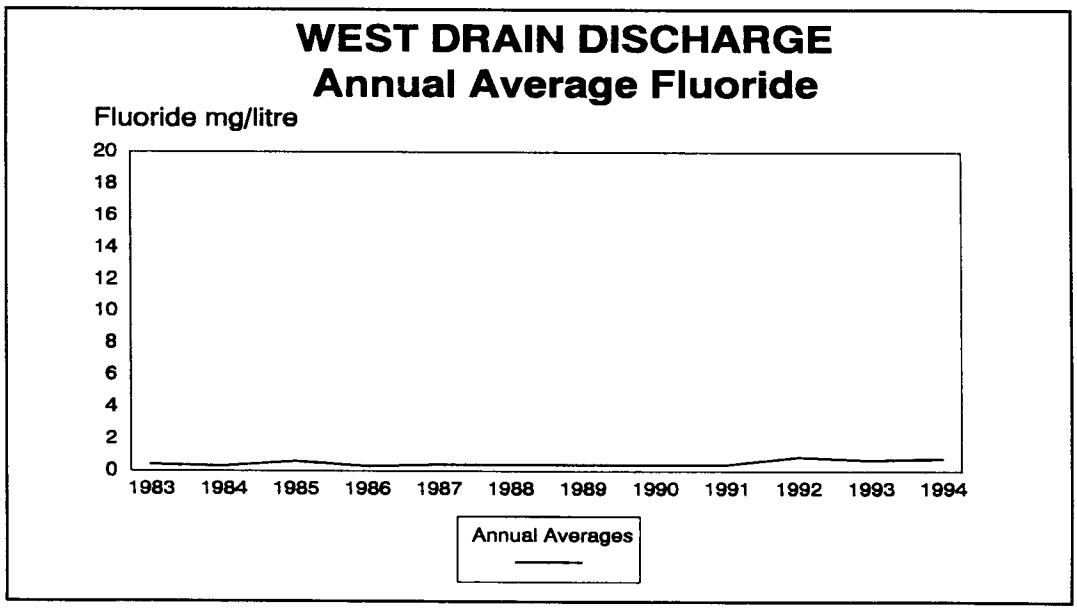




4.2 West Drain Discharges, Continued

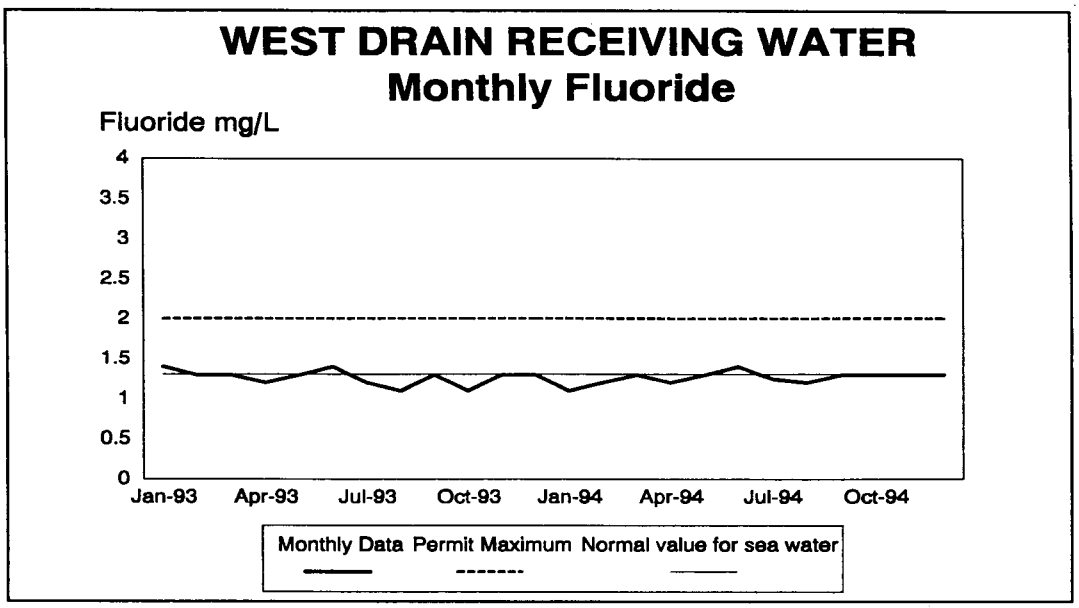
Monitoring Results, continued

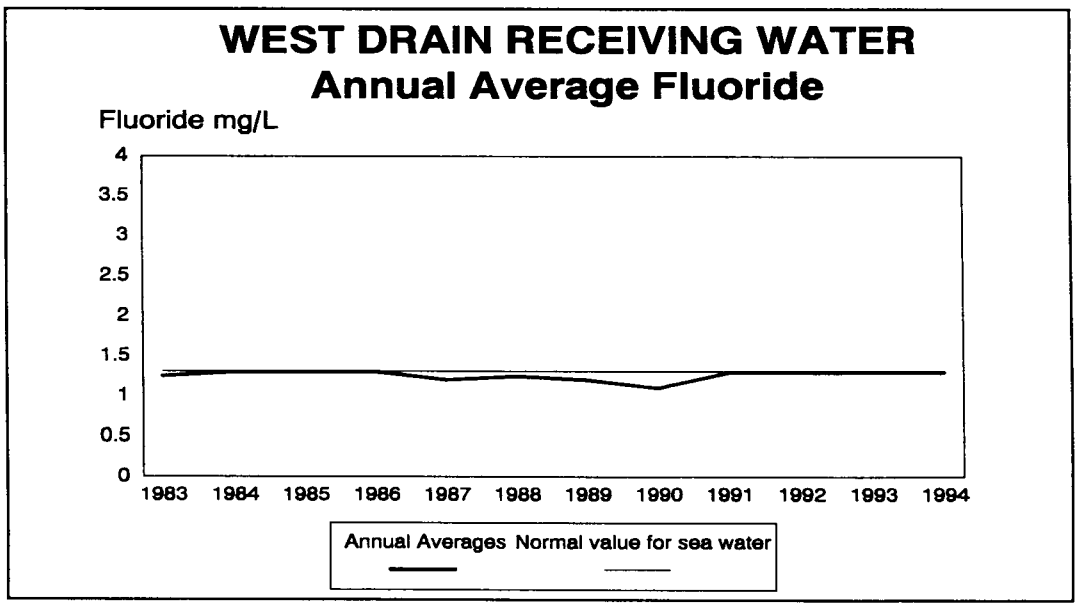




4.2 West Drain Discharges, Continued

Monitoring Results, continued





Comments

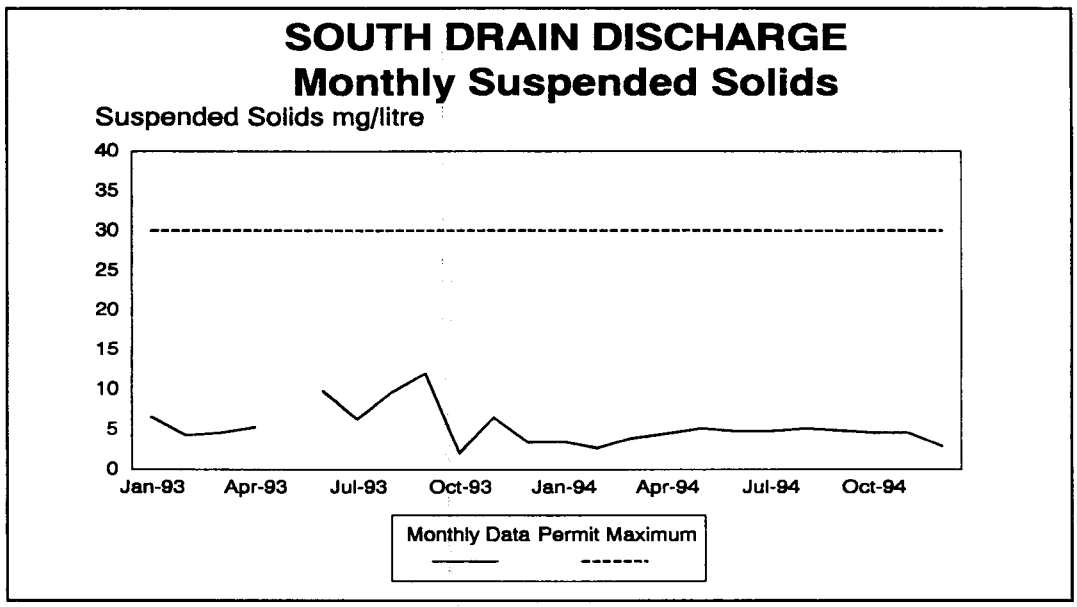
Discharges from the West Drain during 1994 were stable and within permit standards.

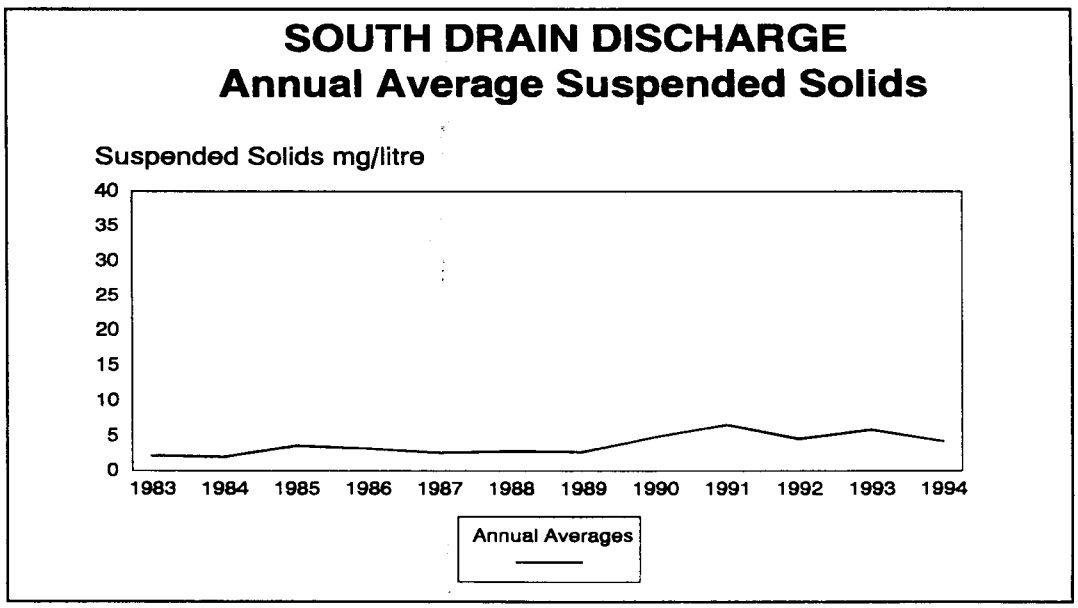
4.3 South Drain Discharges

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.

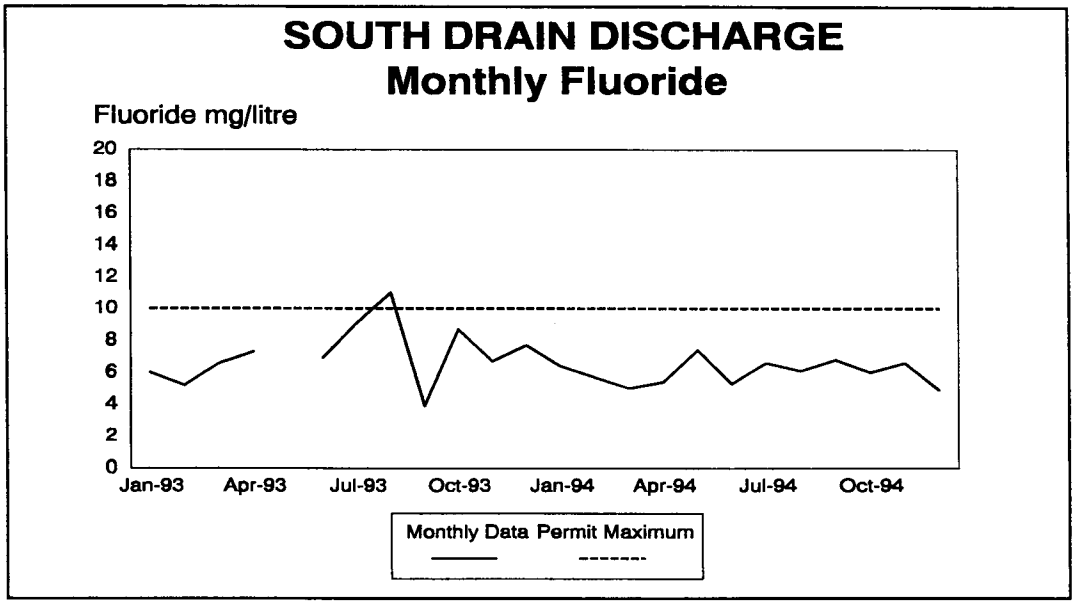
Monitoring Results

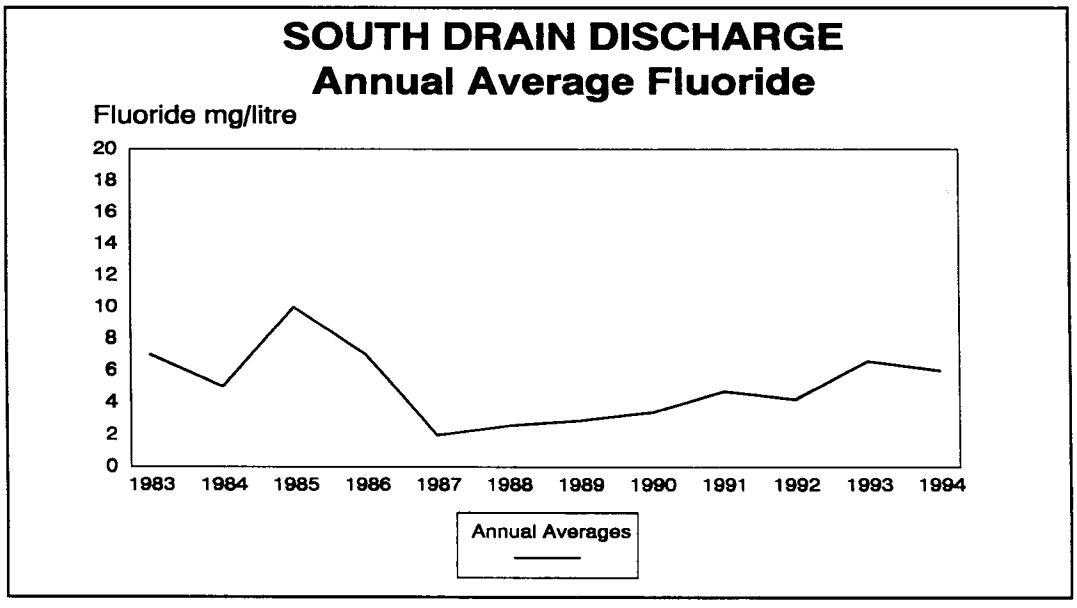




4.3 South Drain Discharges, Continued

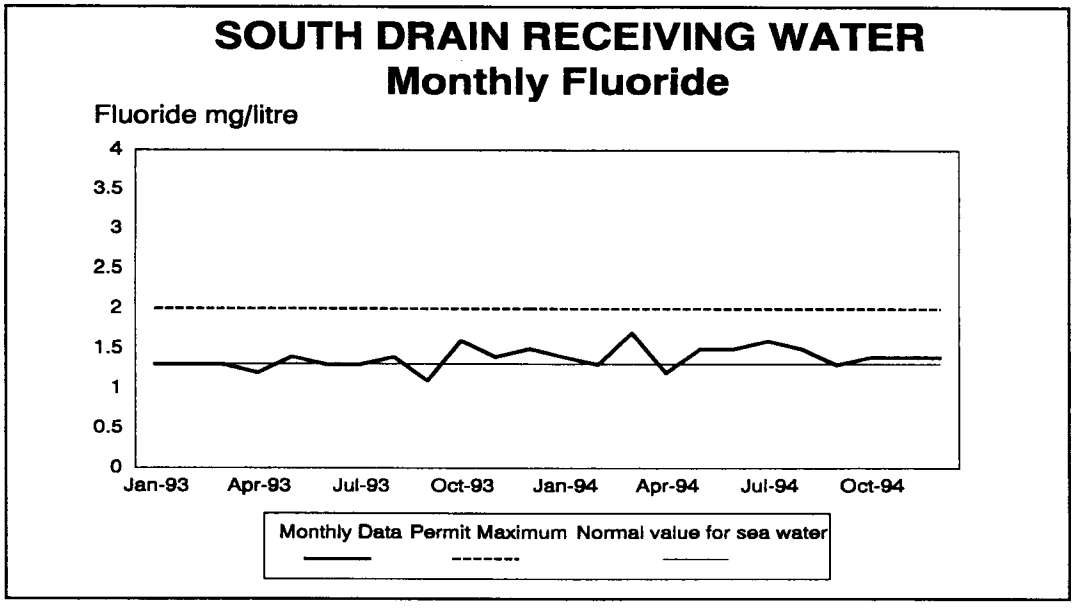
Monitoring Results, continued

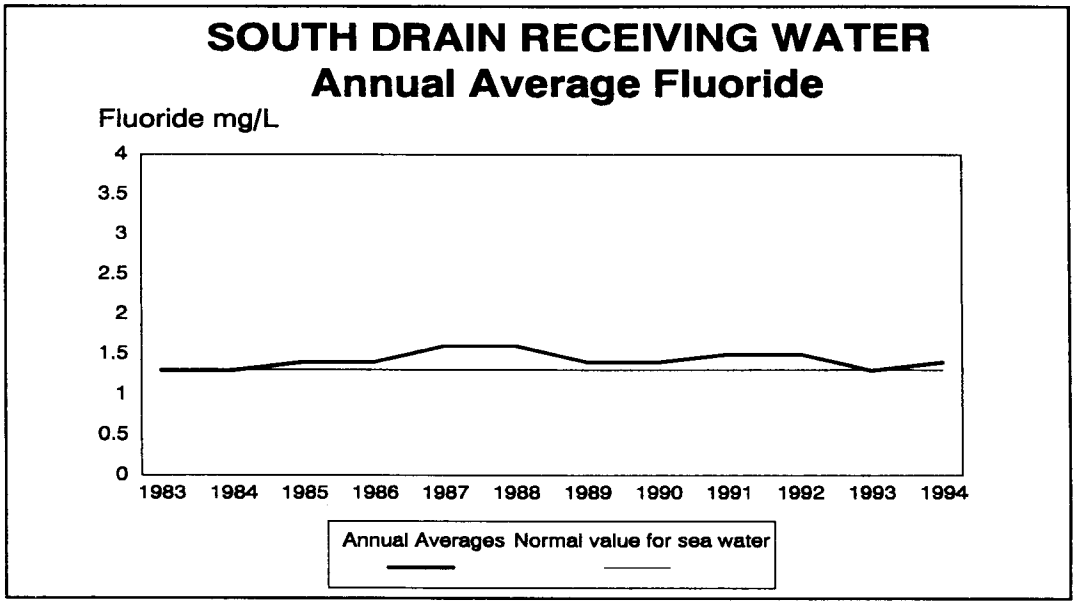




4.3 South Drain Discharges, Continued

Monitoring Results, continued





Comments

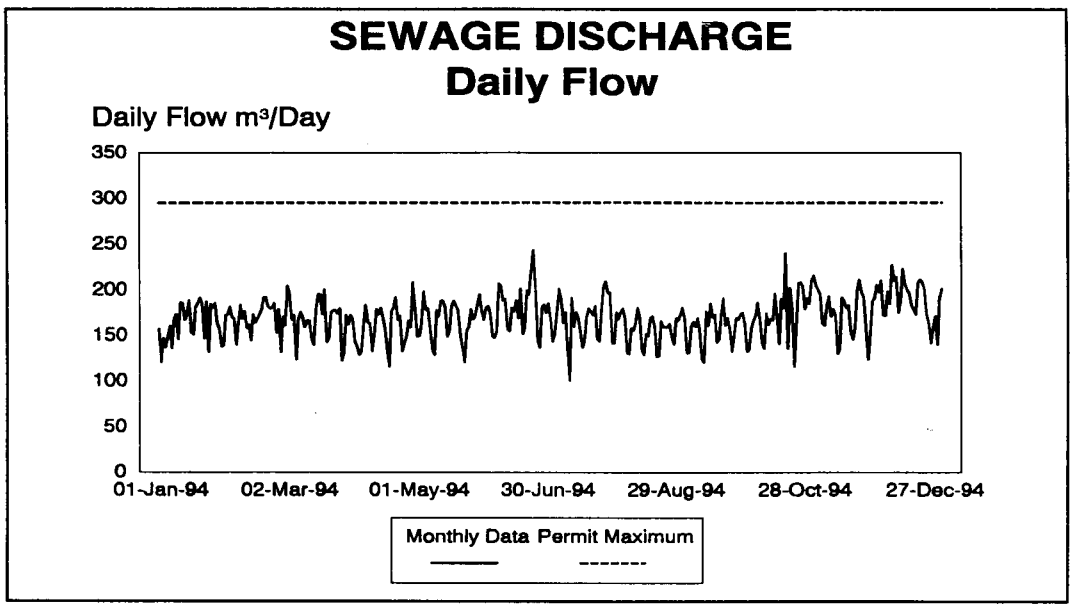
Discharges from the South Drain during 1994 were stable and within permit standards.

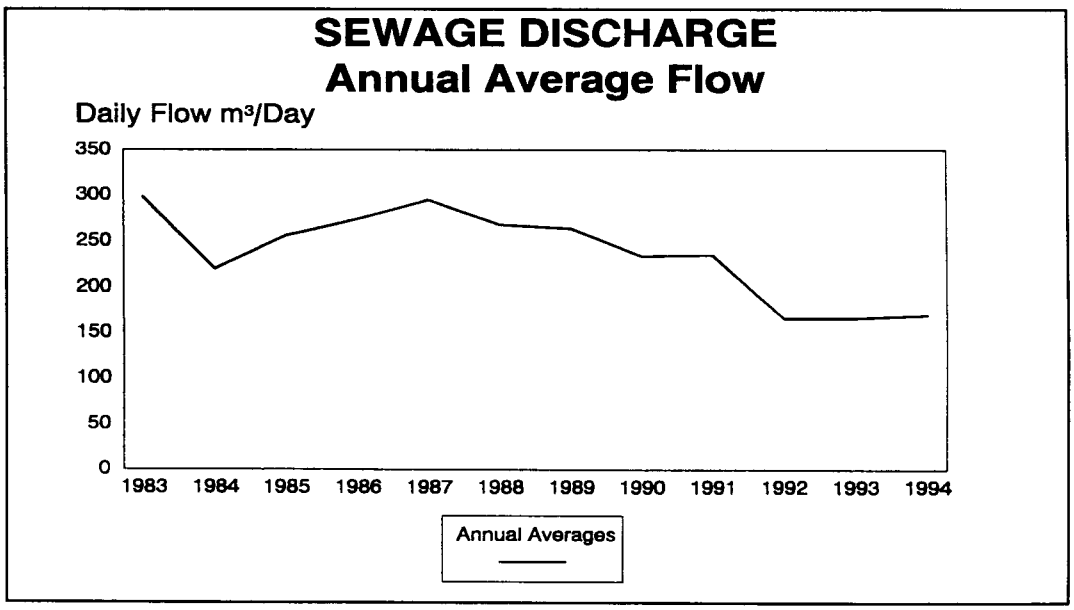
4.4 Treated Sewage Discharges

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.

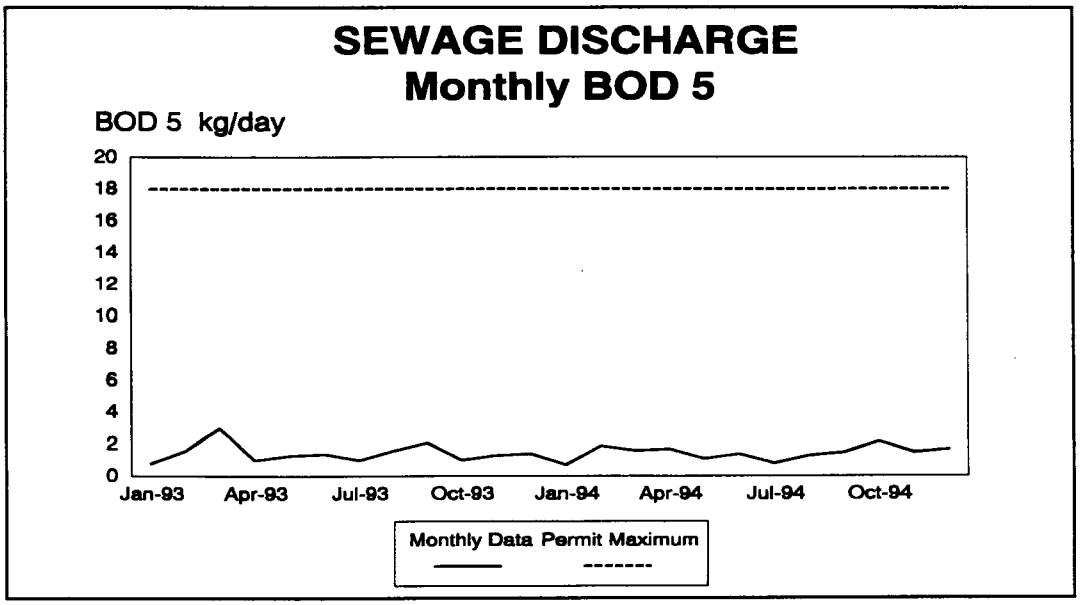
Monitoring Results

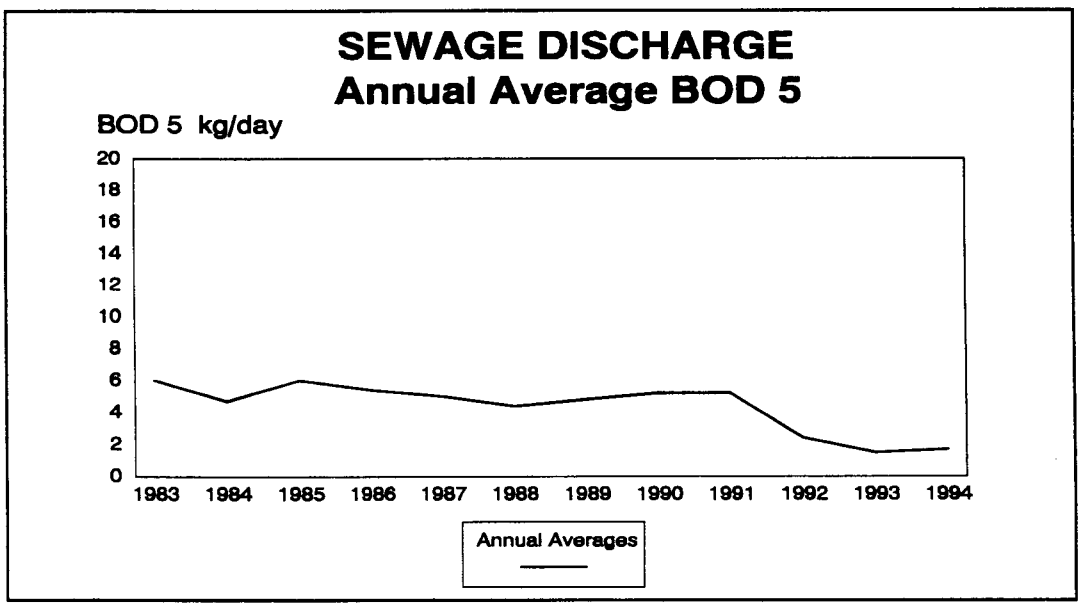




4.4 Treated Sewage Discharges, Continued

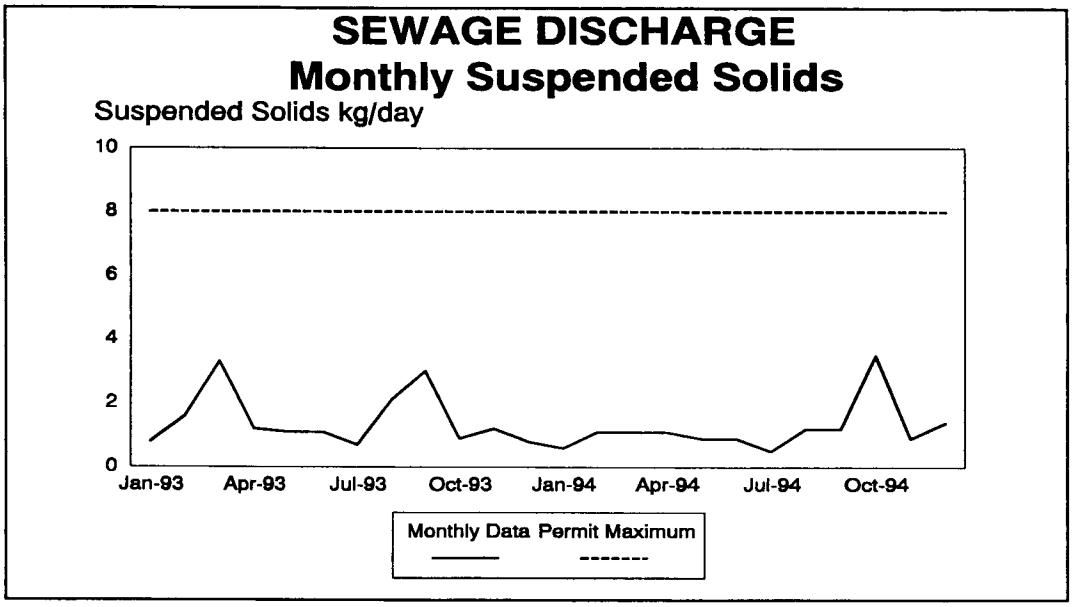
Monitoring Results, continued

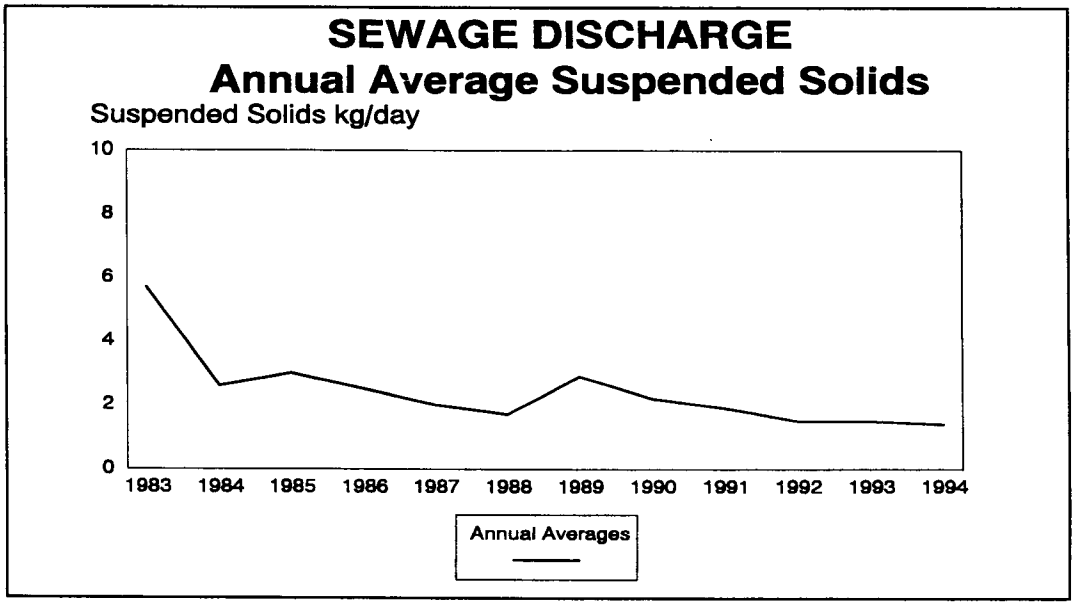




4.4 Treated Sewage Discharges, Continued

Monitoring Results, continued





4.4 Treated Sewage Discharges, Continued

Comments

The reduction in volume and improvements in the quality of the effluent achieved in 1992 were sustained in 1993 and 1994.

Discharges of treated sewage into Awarua Bay during 1994 were stable and within permit standards.

Land disposal of treated sewage effluent

The smelter has employed a consultant to investigate the feasibility of land disposal of treated sewage effluent from the sewage plant. The land disposal of the effluent is an alternative to the existing discharge of the effluent to Awarua Bay.

The consultant's investigation is to include:

- chemical analysis of the effluent,
  - heavy metals,
  - nutrients,
- bacteriological analysis of the effluent,
- infiltration measurement at five different sites,
- surface and subsurface soil testing at five sites,
- irrigation modelling at four sites, and,
- groundwater modelling.

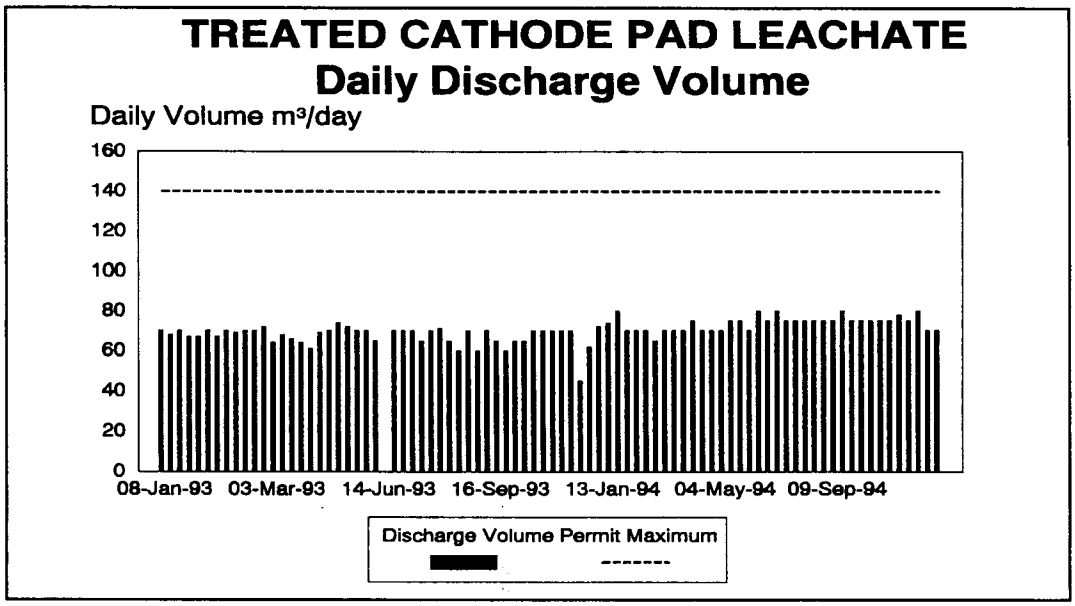
4.5 Treated Cathode Leachate Discharges

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



Comment

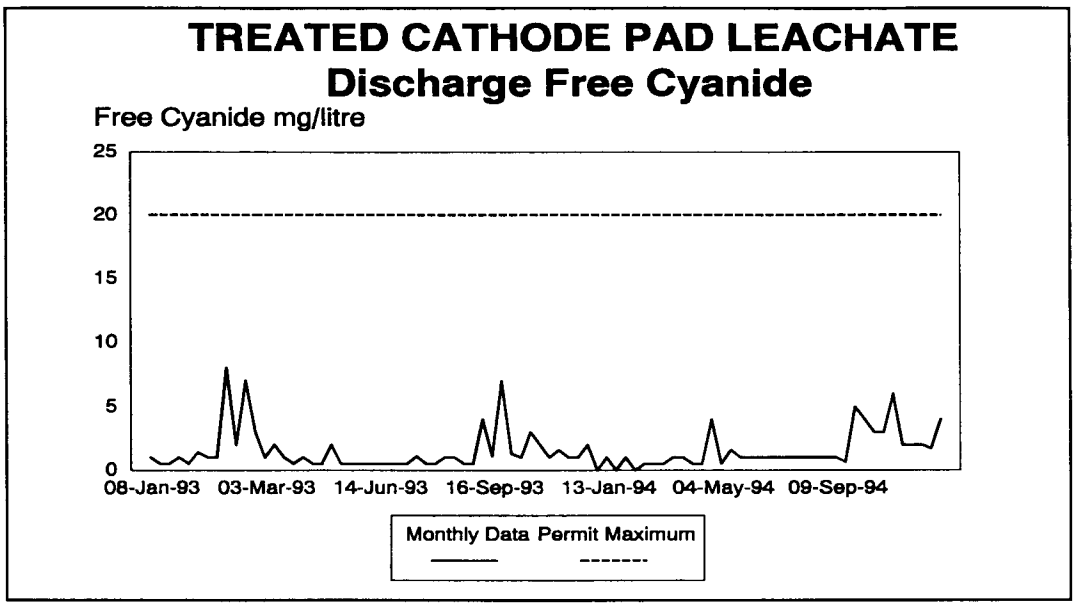
The daily discharge limit of 140 m^3/day was not exceeded during 1994.

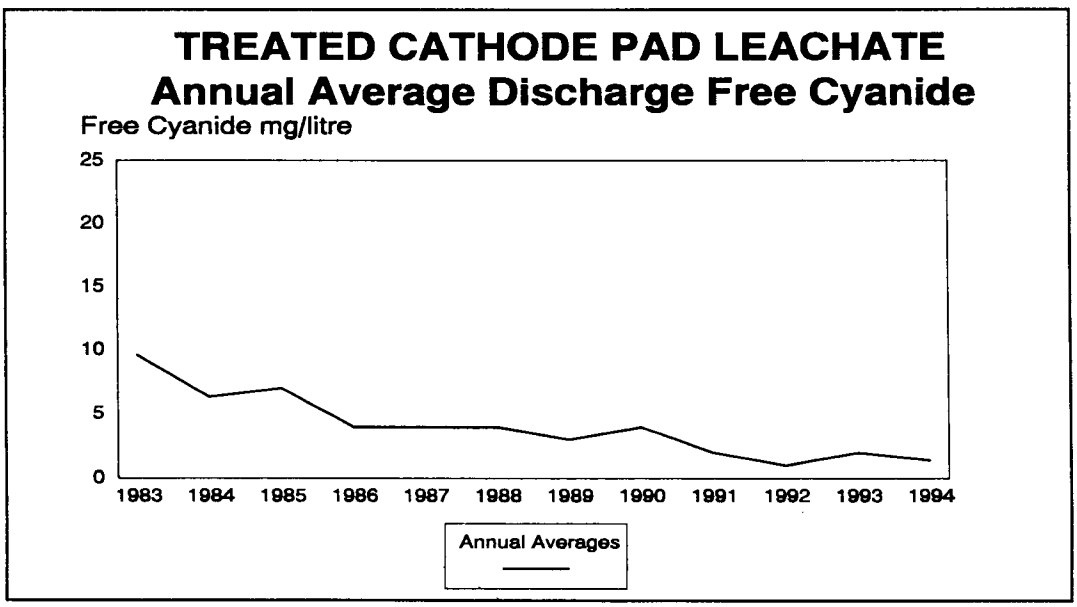
The number of discharges, and consequently the volume of treated leachate discharged, has been decreasing since the cathode pad was covered in 1992. There were 127 discharges in 1991 compared with the 38 discharges in 1994. The bulk of the discharge is effluent generated by cell shell and cathode bar washing.

As the concentration of contaminants has not increased, and the volume discharged has decreased, the mass of contaminants discharged to the environment has decreased since 1992.

4.5.1 Discharge Free Cyanide

Monitoring Results





4.5.1 **Discharge Free Cyanide**, continued

Comments

The treatment of cathode pad leachate continues to produce an effluent with a very low concentration of free cyanide.

Discharges into Foveaux Strait during 1994 were within the permit standards.

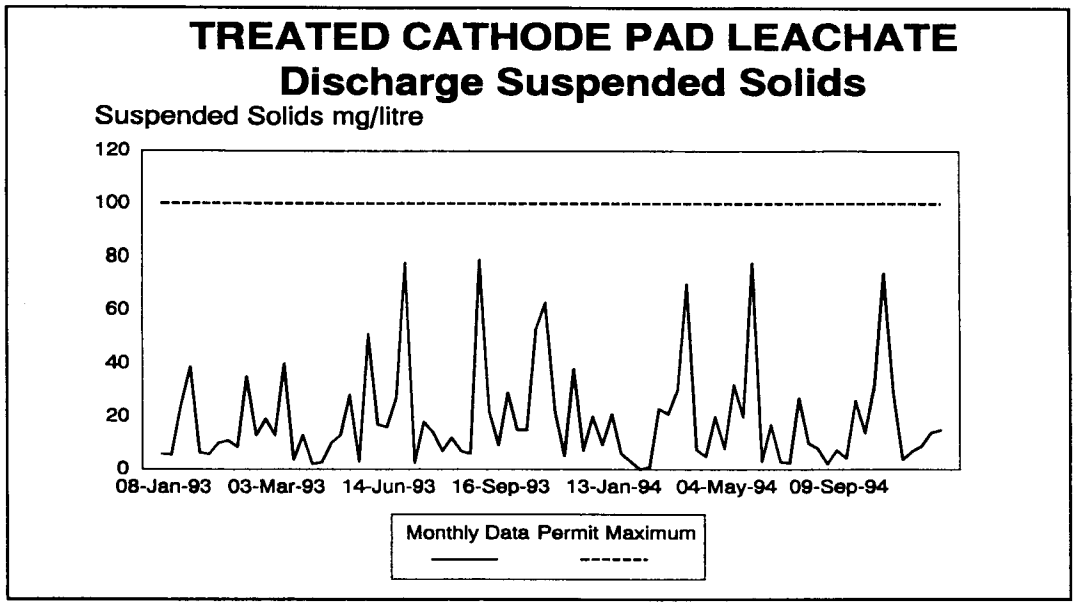
The annual average for 1994 was consistent with the previous three years.

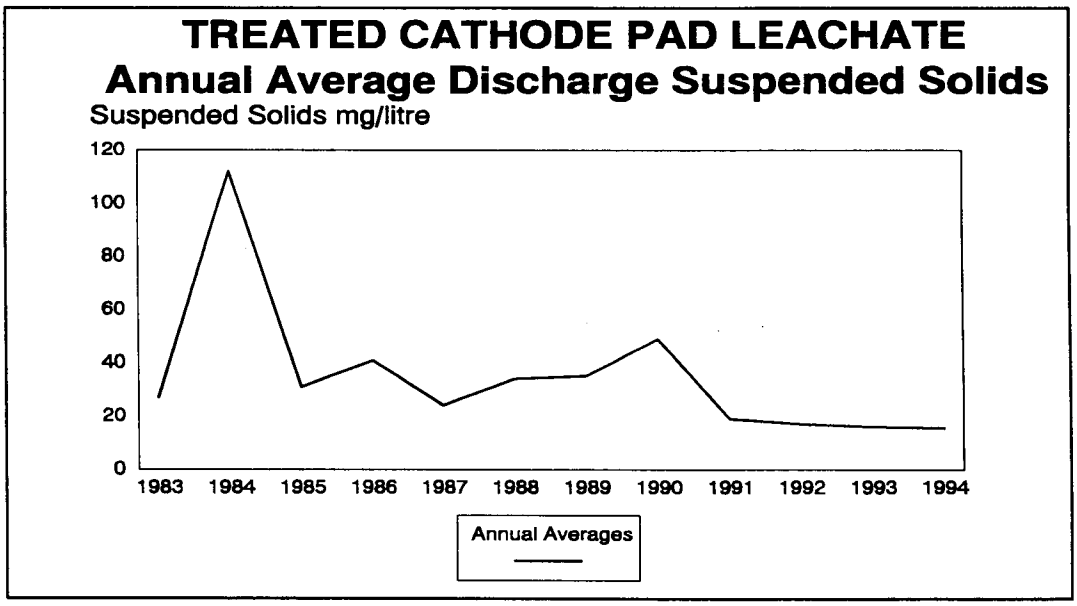
Work undertaken in 1994 to refine the treatment process has resulted in a process change. The quantity of chlorine-producing reagent added to treat the cyanide is calculated based on the free cyanide initially measured in the leachate. Previously this analysis was a field titration performed at the treatment plant. In effluent with low levels of free cyanide this method tends to over-estimate the free cyanide concentration. This meant that excessive quantities of the chlorine-producing reagent were added. This method of analysis has been replaced by the laboratory distillation method which is considered to be more accurate.

The leachate is still analysed before it is discharged and during discharge by the distillation method.

4.5.2 Discharge Suspended Solids

Monitoring Results





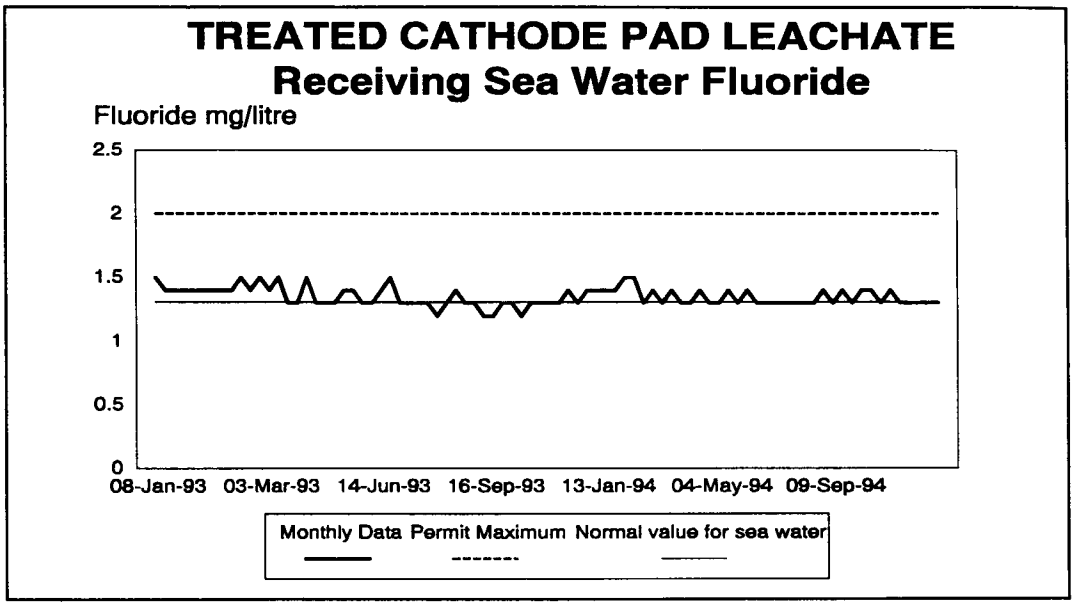
Comments

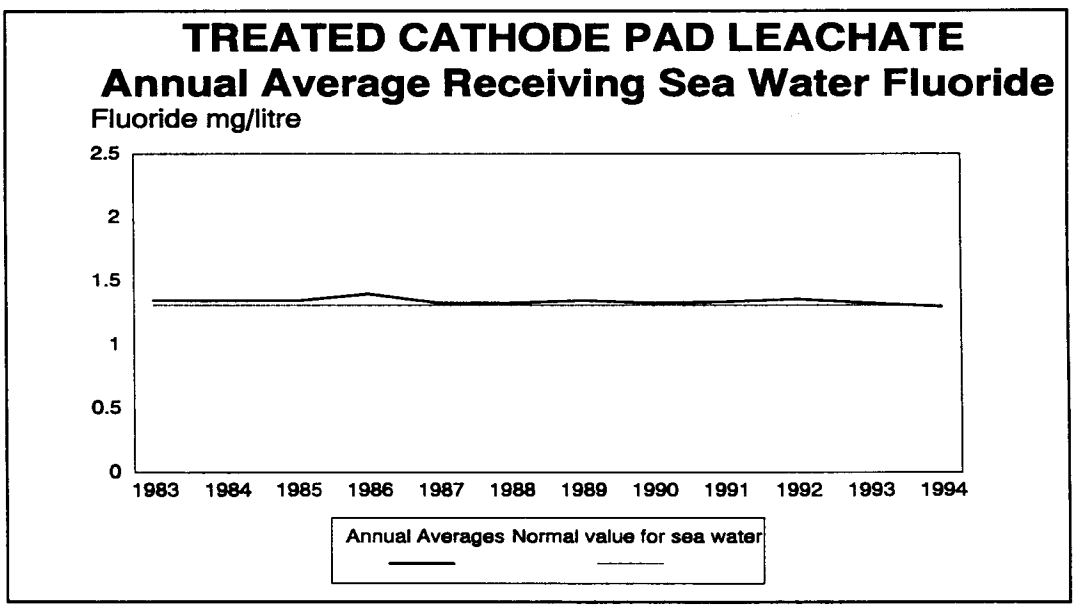
Discharges into Foveaux Strait during 1994 were within the permit standards.

The annual average for 1994 was consistent with the previous three years.

4.5.3 Receiving Seawater Fluoride

Monitoring Results





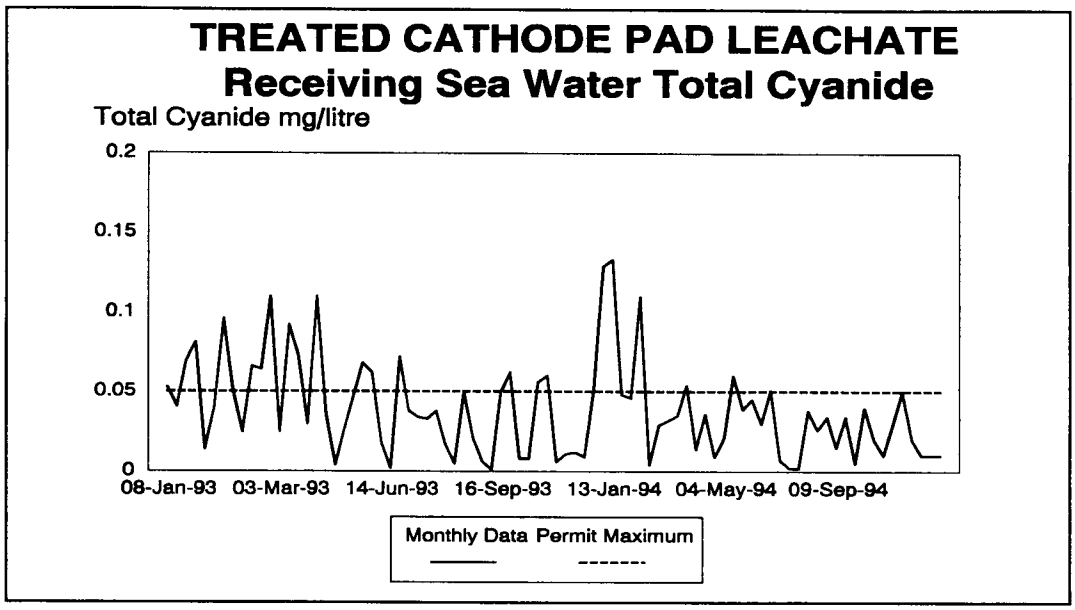
Comments

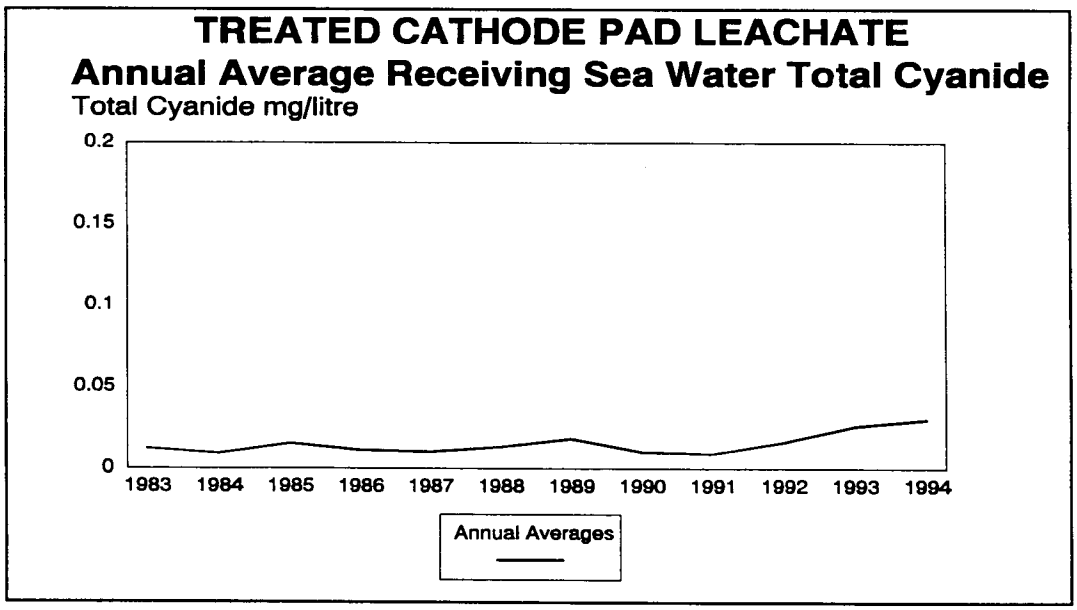
Discharges into Foveaux Strait during 1994 were within the permit standards.

The annual average for 1994 was consistent with the previous ten years.

4.5.4 Receiving Seawater Total Cyanide

Monitoring Results





Comments

Monitoring results indicated the receiving seawater total cyanide concentrations were above the permit condition eight times during 1994. The annual average concentrations have been increasing since 1991.

4.5.4 **Receiving Seawater Total Cyanide**, continued

Comments, continued

The likely causes of the increasing receiving seawater total cyanide concentrations are:

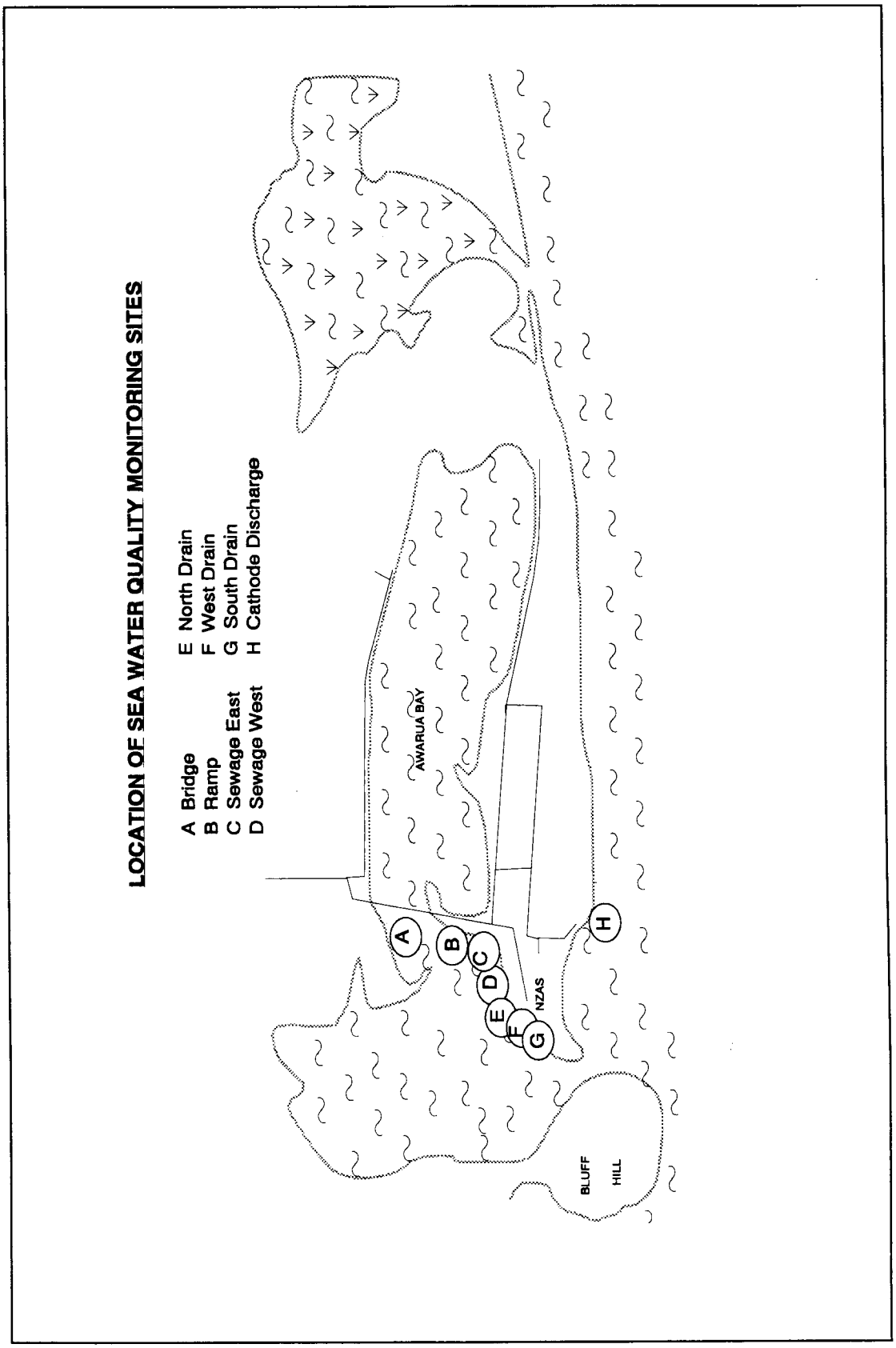
- the release of contaminated groundwater from the sea floor, and
- sampling shortly after low tide when the receiving seawater dilution is at its lowest.

These factors were more fully discussed in the 1993 report to the Interdepartmental Committee.

4.6 Sea Water Quality

Introduction

Several sites around the smelter are monitored for sea water quality. A map of the sites is shown on the following page.


LOCATION OF SEA WATER QUALITY MONITORING SITES
A Bridge
B Ramp
C Sewage East
D Sewage West
E North Drain
F West Drain
G South Drain
H Cathode Discharge
AWARUA BAY
NZAS
BLUFF HILL
A
B
C
D
E
F
G
H

4.6 Sea Water Quality, Continued

Introduction, continued

Two types of monitoring is undertaken:

- chemical analysis at eight sites, and
- bacteriological monitoring at four sites.

Each of the sites was sampled five times during December. The following table shows the average and the range for the chemical analysis results:

	Temperature °C (Range)	pH (Range)
Bridge	14.9 (4.3)	8.23 (0.18)
Ramp	16.2 (3.1)	8.22 (0.17)
Sewage East	14.6 (3.7)	8.22 (0.13)
Sewage West	14.6 (4.0)	8.22 (0.12)
North Drain	14.6 (3.9)	8.20 (0.22)
West Drain	15.1 (4.1)	8.23 (0.16)
South Drain	14.8 (3.9)	8.20 (0.16)
Cathode Discharge	13.4 (2.0)	8.19 (0.15)
Range of Averages	2.8	0.04

Temperature

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

The average temperatures measured at each of the sites were within a range of 2.8°C.

The largest variation (4.3°C) in temperature at a single site was found at the site furthest from the smelter, at the bridge.

4.6 Sea Water Quality, Continued

pH

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

The average pH measured at each of the sites was within a range of 0.04. No pH measured at any time was outside the range 6.7 - 8.5.

Dissolved oxygen

All of the dissolved oxygen values recorded at the eight sites were above the 5 mg/L minimum specified by the Class SB standard.

Faecal coliforms

Samples were collected from four sites on five occasions during December. The median faecal coliform concentration for each of the sites was nil, which is less than the Class SB standard of 200/100 mL. The maximum faecal coliform concentration was 18, determined in a sample collected at the bridge.

Visual inspection

Weekly visual inspections of the receiving seawater outside the mixing zone of all discharge points was initiated during the second half of 1994.

The Class SB standard requires that the natural colour and clarity of the water shall not be changed to a conspicuous extent and requires that discharges must be substantially free from suspended solids, grease and oil.

No conspicuous change in colour or clarity or grease and oil was detected during the water quality sampling rounds. This was also the case during the weekly visual inspections of the drains and sewage outfall which were initiated during the second half of 1994.

Compliance

The Class SB standards were met in the seawater surrounding the smelter during 1994.

Chapter 5

Groundwater

5.1 Spent Cathode Stockpile Leachate

The contamination under the spent cathode stockpile was explained at the Interdepartmental Committee Meeting held in 1994.

Field work during 1994 confirmed that it is possible to selectively extract the groundwater with the highest levels of contamination. Work then focused on identifying the most effective method of capturing the targeted material, that is, the groundwater with a total cyanide concentration greater than 500 mg/L.

Options investigated for extracting the targeted material included:

- the installation of a large diameter shaft with horizontal drains radiating out to capture the targeted material, and
- various arrangements of conventional bores.

The most effective option in terms of capture efficiency, total time to complete the remediation, and minimizing the effect on the environment is a well field of conventional wells over the whole target area at about 25 metre spacings. (This would involve about 20 wells in total.)

In January 1995 NZAS was granted a Land Use consent under the Resource Management Act to install a small number of additional groundwater monitoring wells. These wells were needed to supply some details to aid the design of the extraction well field. Work is now focusing on how groundwater will be treated and discharged.

An investigation into the extent of mixing and dilution achieved by the present discharge outfall diffuser has been carried out. This highlighted that at the maximum allowable discharge rate there is insufficient dilution available to meet the receiving seawater conditions in the present consent. Options available to overcome this include modifications to the diffuser or a reduction in the planned extraction rate.

A bench scale trial of an in-situ bioremediation process using the natural gravel materials was completed with promising results. A scaled up trial using the natural, in-situ gravels and actual affected groundwater instead of a synthetic representation has been designed. Preparations are underway to commence the trial.

5.2 Diesel Leak

As reported in the 1993 report, the diesel recovery plant was restarted in February 1994. The purpose of the restart was to determine if time or changed circumstances had made more free diesel available for recovery. The 1994 recovery operation was shutdown in June 1994. Comments on the recovery are:

- maximum daily recovery was about 110 litres per day, and,
- total volume recovered was about 4300 litres.

The diesel bioremediation plant in the metal storage yard was used in a modified operation during 1994.

The southern gallery was operated intermittently to maximise air exchange. Experience gained during commissioning showed that the most productive bioremediation occurred during commissioning rather than during normal continuous operation. The modified operation is to mimic the commissioning by operating the plant on a two day on, two day off cycle. Nutrients are not being added to the groundwater as sufficient have been added for present requirements.

The northern gallery is being used to inject air into the affected area. The air injection has been operating since the middle of October. Comments on the air injection are:

- soil gas measurements show fresh air is reaching the target area,
- soil gas measurements show respiration of bacteria is occurring,
- the affected area needs to be above the water level before air injection is successful.

An air sparging trial has been underway since the middle of October. This trial is aimed to provide information on the long term operation of air sparging as a bioremediation tool at the smelter. To date there has been no evidence of the formation of ferric hydroxide which would block the airways in the aquifer. Soil gas measurements have shown that the radius of influence of this one sparging point is up to sixty metres.

Future work on the bioremediation of the diesel contamination includes the design of a compressed air network to deliver air to sparging points over the entire affected area.