



**WATER QUALITY MONITORING:
THE PANHAMNDLE**

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OUTLINE

- INTRODUCTION
- METHODOLOGY
 - SITES/ CHAMPIONS
 - PARAMETERS
- RESULTS
- FOLLOW UP
- CONCLUSIONS AND FUTURE ACTIVITIES

INTRODUCTION

- BOKAVANGO: AIM
 - To build local capacity for sustainable management of the Okavango Delta
- HOORC: STRATEGIC GOAL, MONITORING
 - To establish a set of data, measurements and parameters that will give indications about changes in the physical and man-made environment, in particular, those potentially harmful to humans or the environment

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INTRODUCTION

- Water is the backbone of the Okavango Delta hence its quality needs to be monitored as:
 - Peace in Angola
 - Agricultural and other activities in the Delta
 - Settlements, camps, lodges, fishing, houseboats

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INTRODUCTION

AIMS AND OBJECTIVES

The water quality monitoring is intended to determine the current status and trends in the quality of the Okavango delta water based on:

- Location (panhandle, upper Delta, lower Delta)
- Season rainy season, dry flood season
- Long term (over many years)

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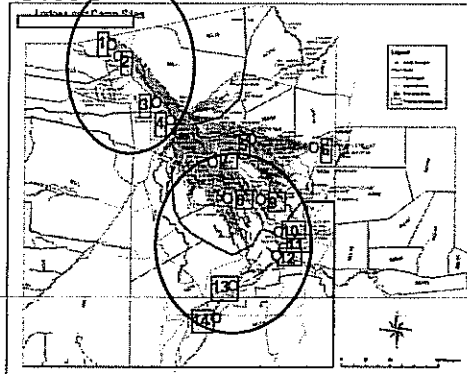
INTRODUCTION

- The information collected will include:
 - Identification of baseline conditions in the water-course system.
 - Detection of any signs of deterioration in water quality (short and long term)
 - Correlation of water quality with salvinia and macroinvertebrates
 - Derive a water quality standards for the Okavango Delta based on the water quality monitoring data
 - Determine appropriateness and effectiveness of control strategies and management actions for pollution control
 - Control measures that should be implemented to improve or prevent deterioration of water quality

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METHODOLOGY

- Sites

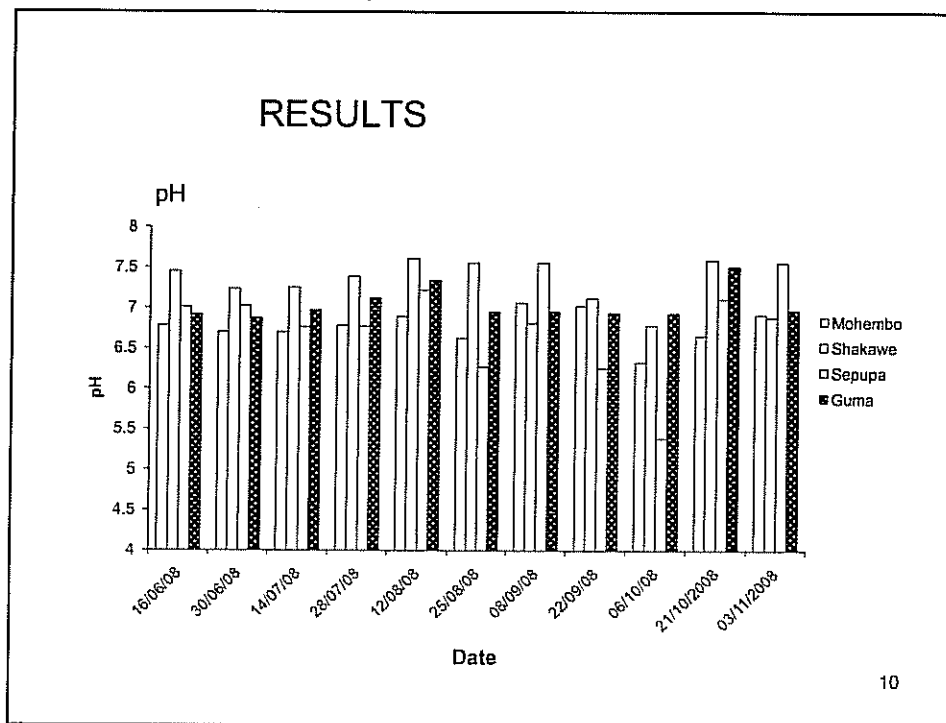
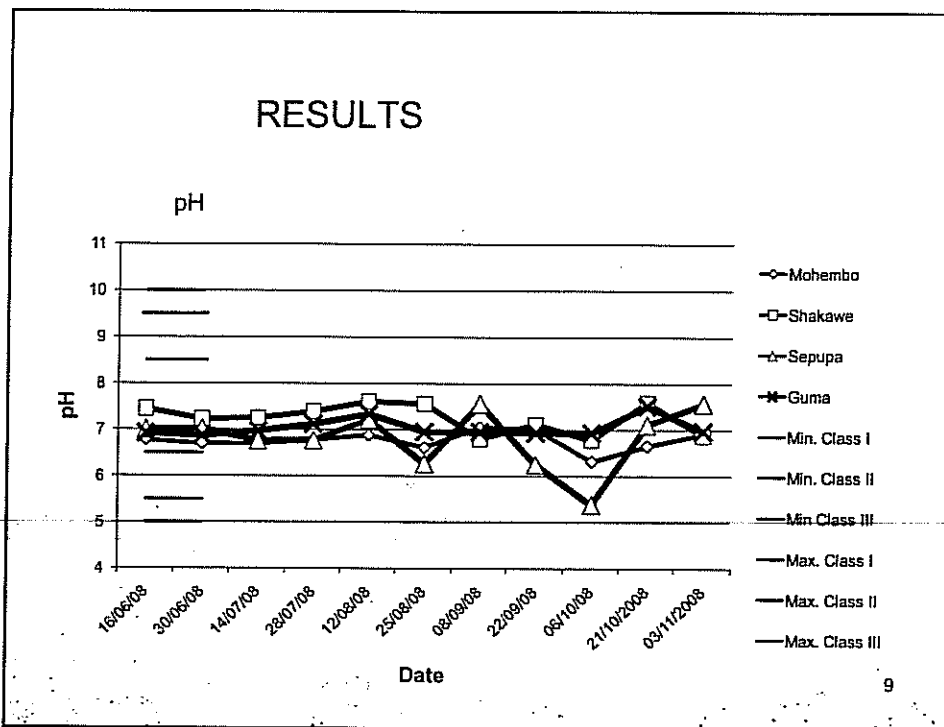


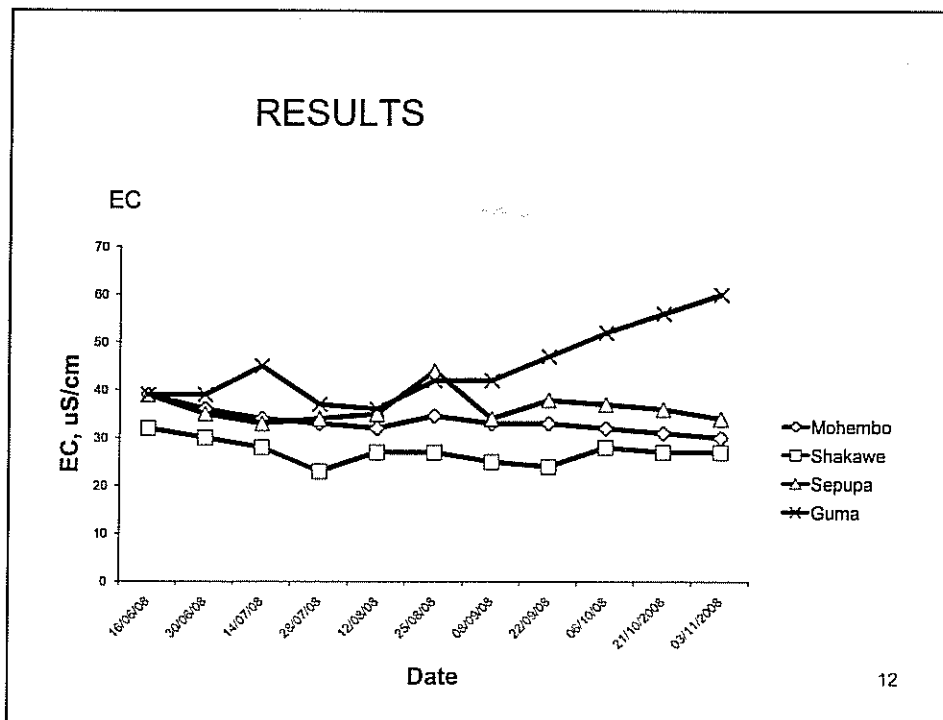
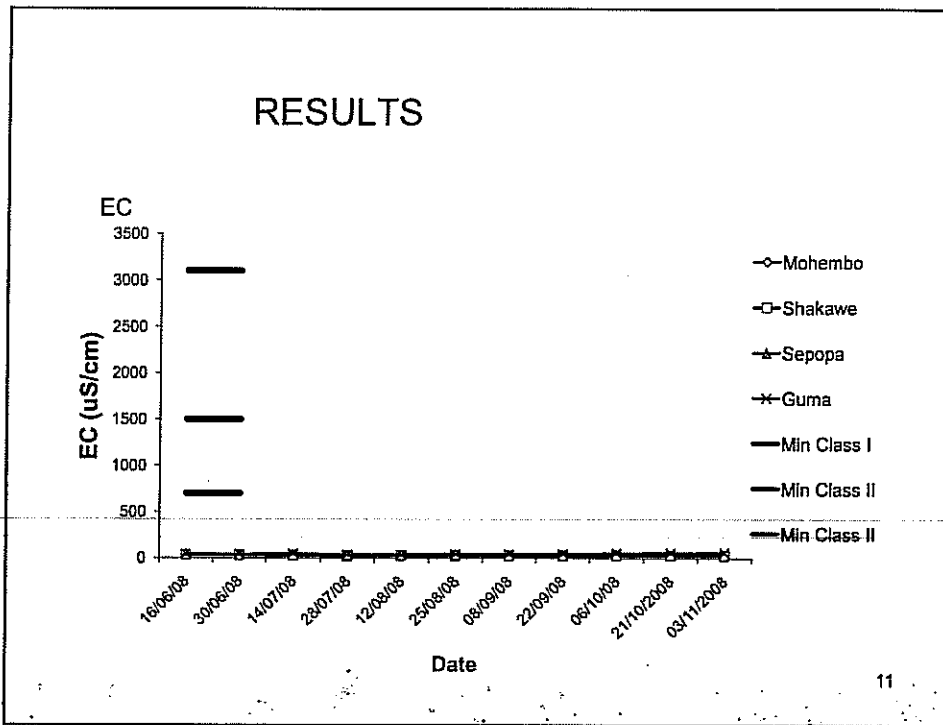
Site	Name
1	Mohembo/DWA
2	Shakawe/ Drotsk's
3	Sepupa/NWDC
4	Guma/Guma R. Lodge
5	Xakanaka/Moremi safaris
6	Khwai/Khwai R. Lodg
7	Eagle Island
8	Nxaraga/HOORC
9	Sandibe
10	Boro/B. fence-HOORC
11	Maun1/HOORC
12	Maun2/HOORC
13	Toteng/HOORC
14	Lake Ngami/HOORC

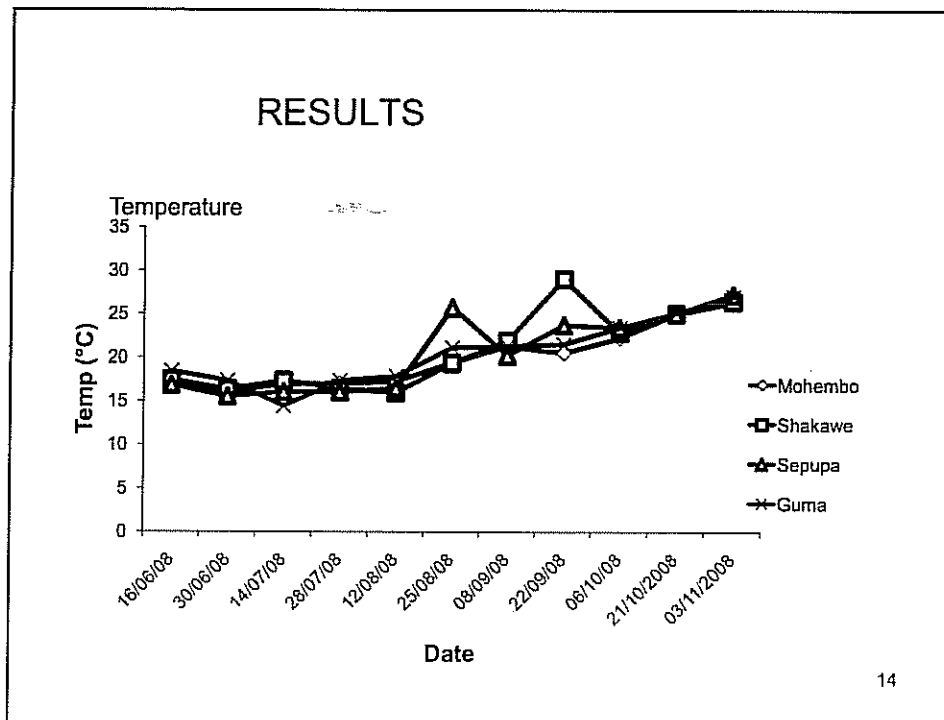
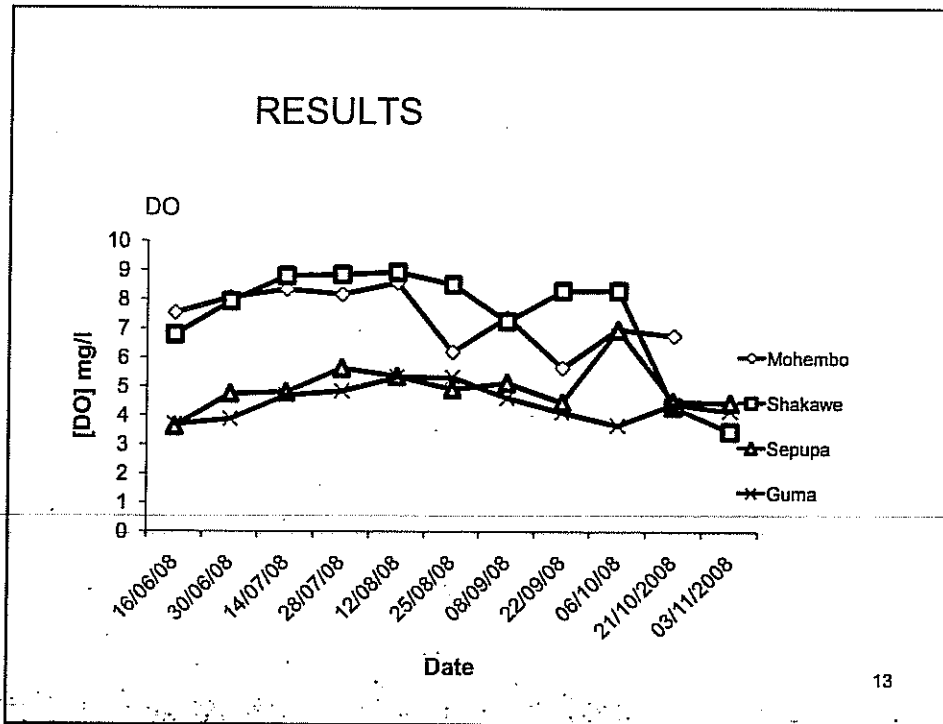
METHODOLOGY

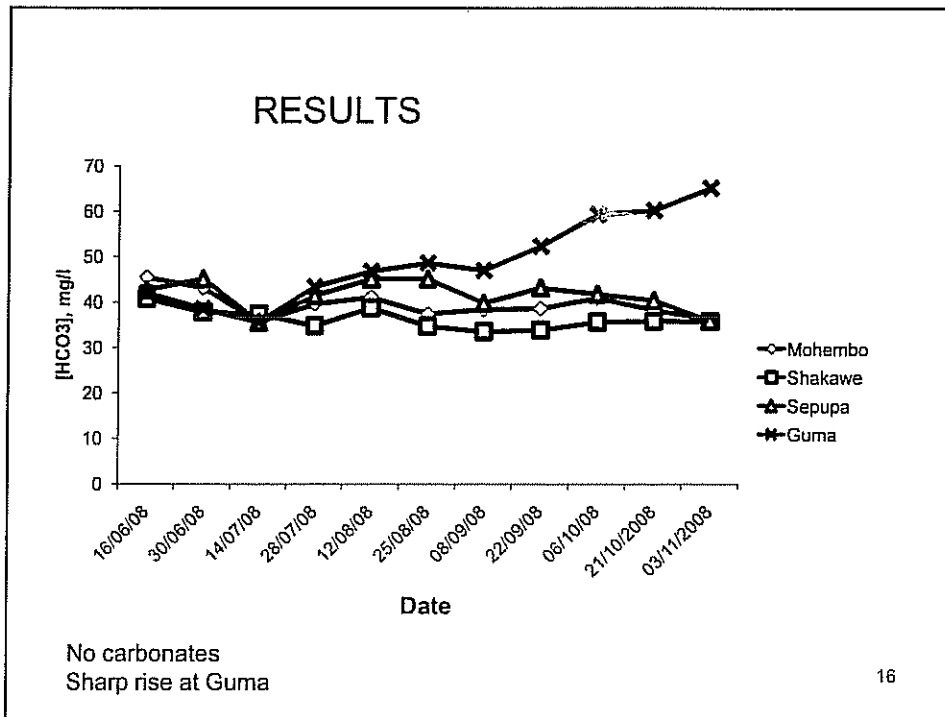
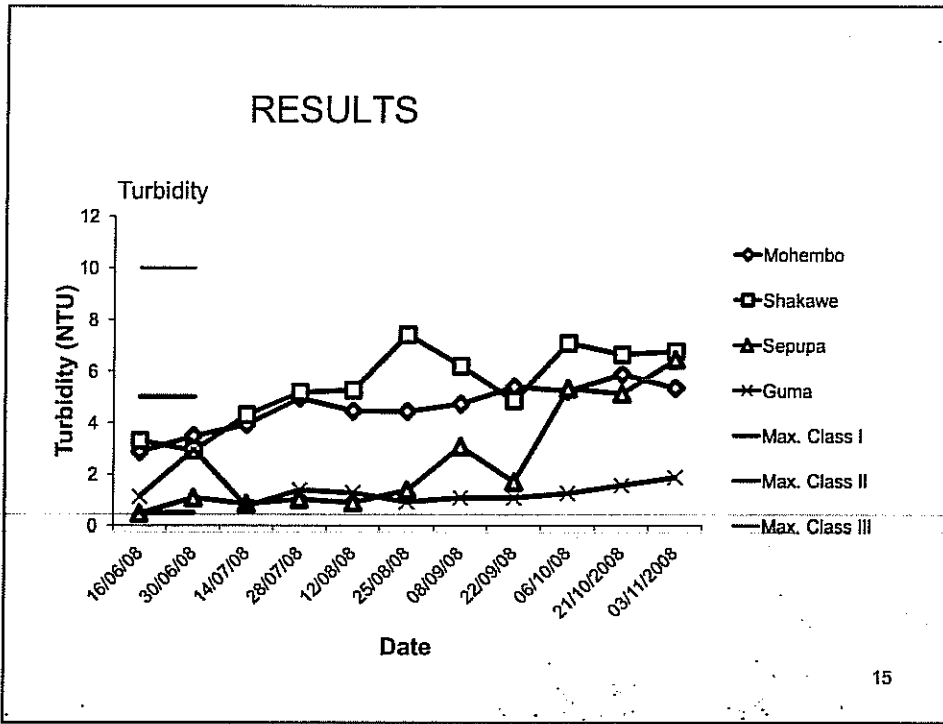
- Parameters

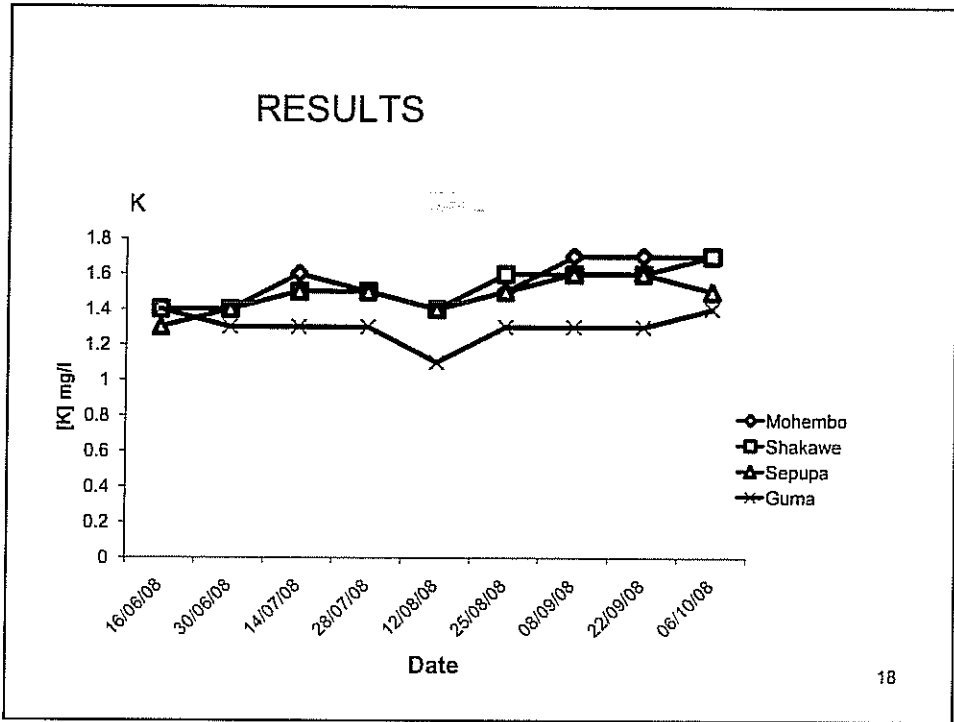
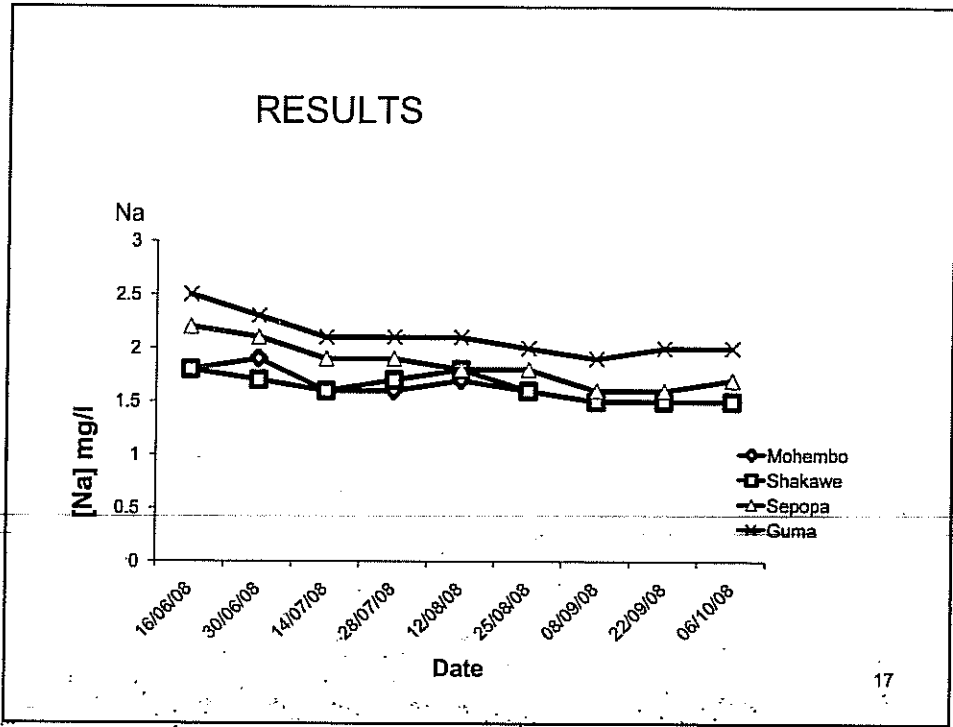
Parameter	Parameter	Parameter	Parameter	Parameter	Parameter
pH	Na	TN	CO3	Al	Cd
EC	K	Cl	HCO3	Fe	Pb
DO	Ca	NO3	DOC	Mn	Ni
T	Mg	SO4	TSS	As	Co
Turbidity	TP	PO4	TDS	Se	TP
SiO2	NH3				

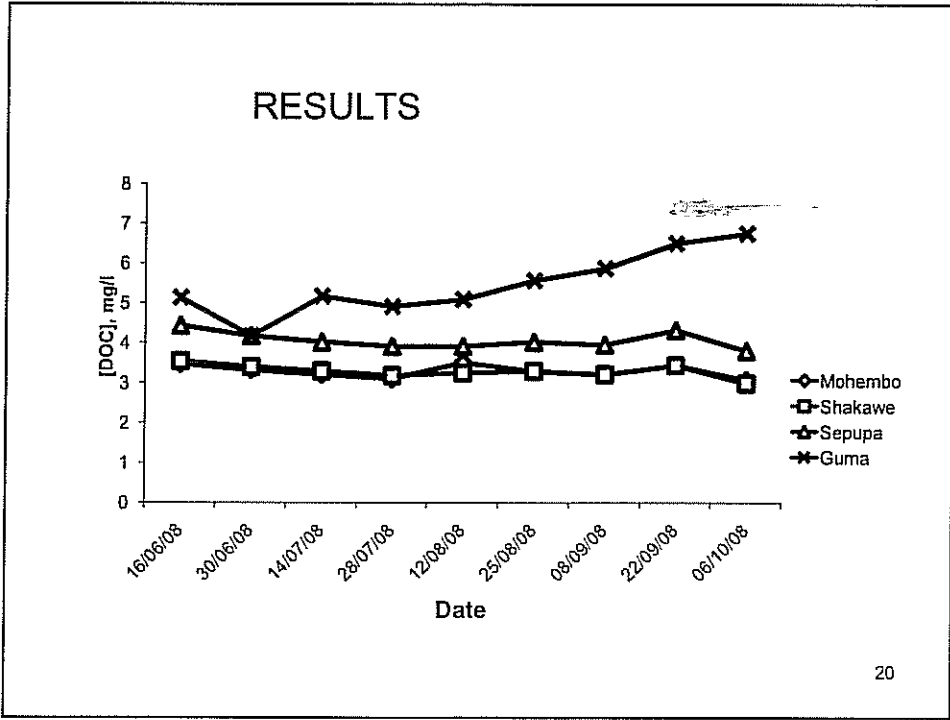
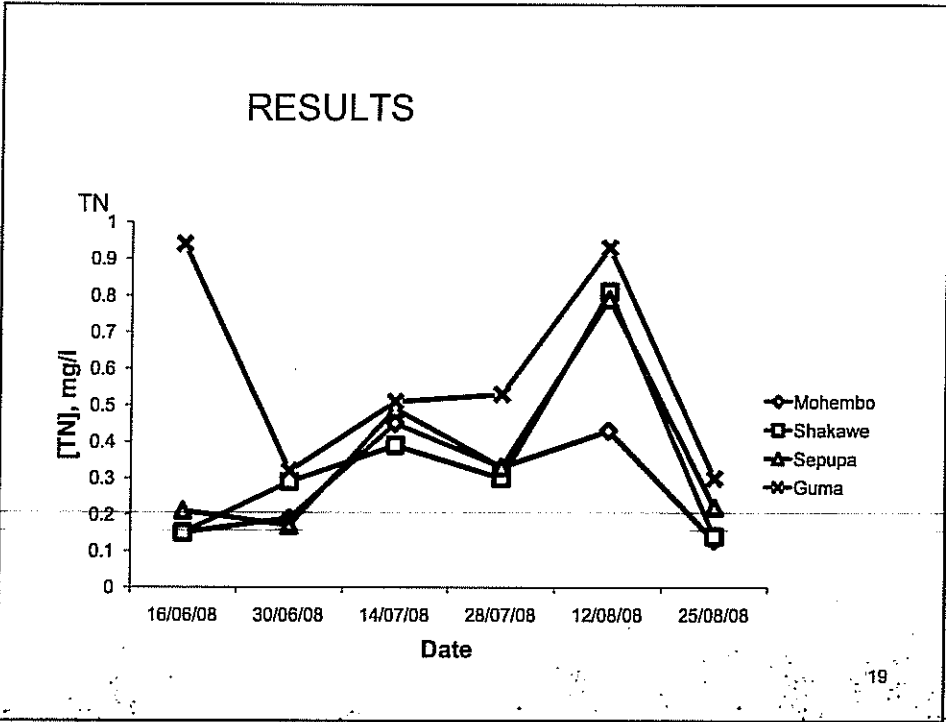




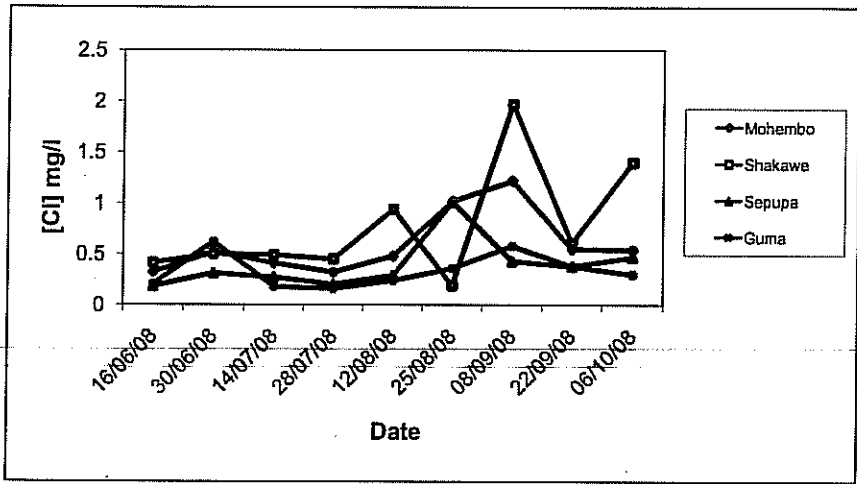






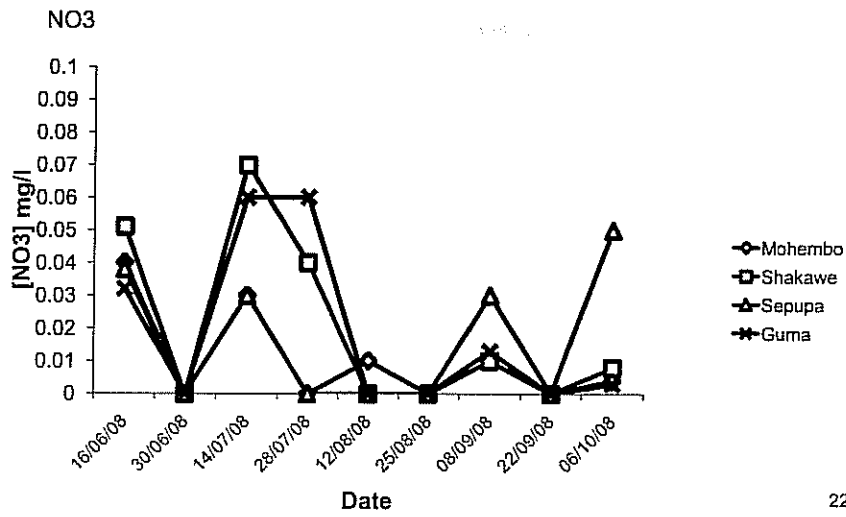


RESULTS



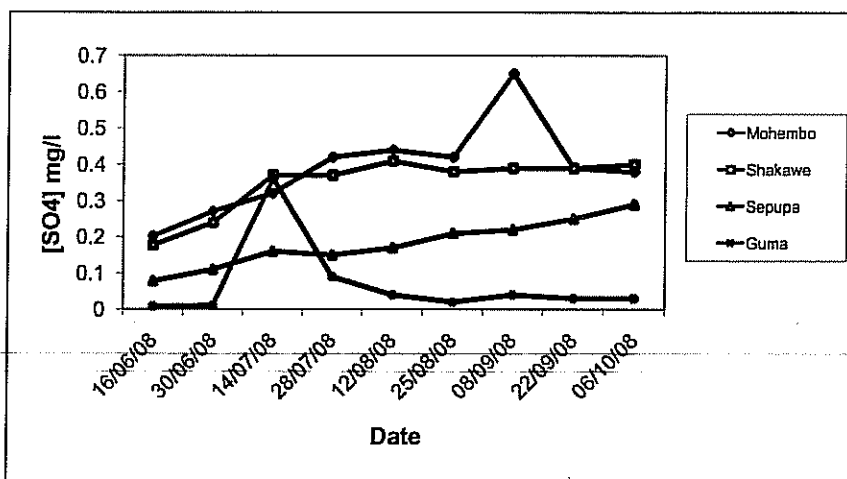
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RESULTS



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RESULTS



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RESULTS

• OBSERVATIONS

- Low EC, increasing downstream, Except for Shakawe
- pH between 5 and 8, Shakawe higher than adjacent sites, Sepupa gave lowest value
- Shakawe and Mohembo have higher DO values than Sepupa and Guma
- Temperature increases from winter to summer
- Turbidity higher for Mohembo and Shakawe compared to Sepupa and Guma. Highest for Shakawe

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RESULTS

- **OBSERVATIONS**
 - Sharp increase in bicarbonate, lowest for Shakawe
 - Guma highest Na concentration, slight decrease from winter to summer.
 - Slight increase in K concentration from winter to summer, lowest concentration at Guma
 - Low TN concentration, highest at Guma
 - Low anion concentration (Cl, SO₄, NO₃), variable trends

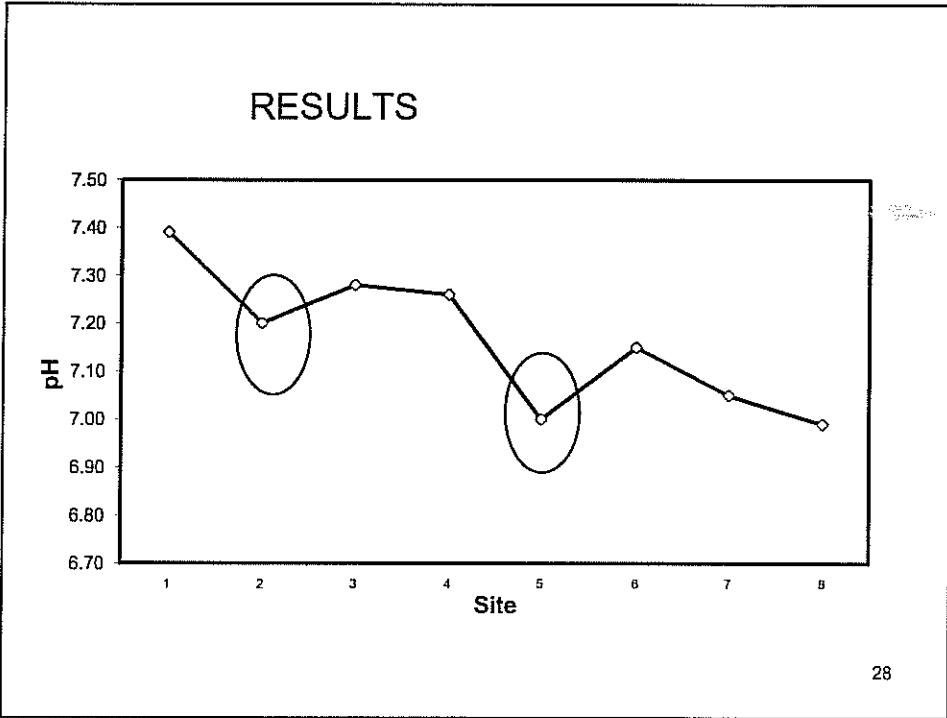
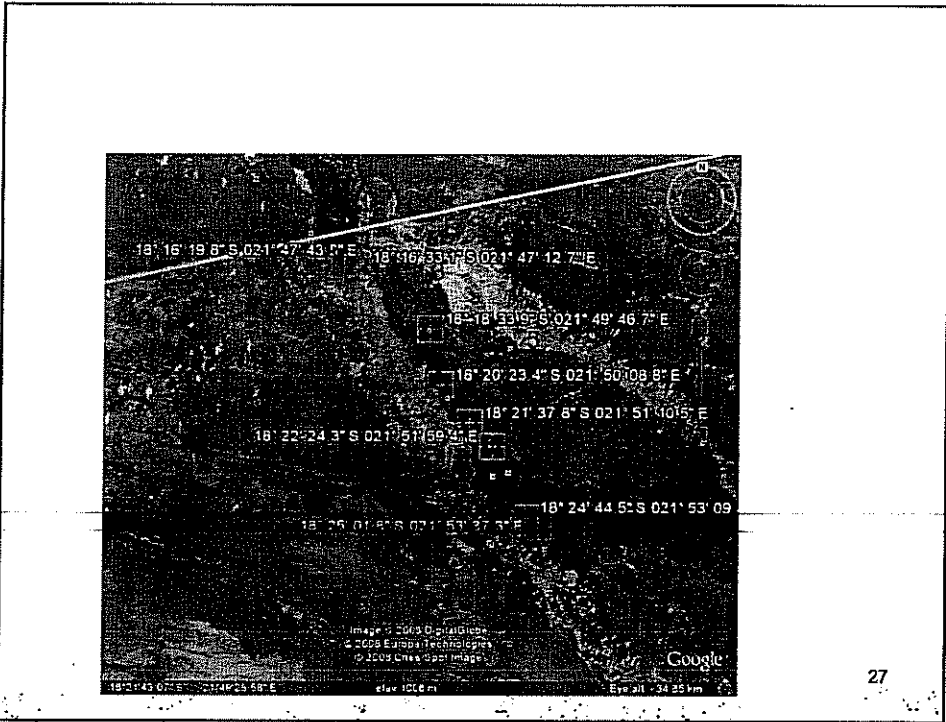
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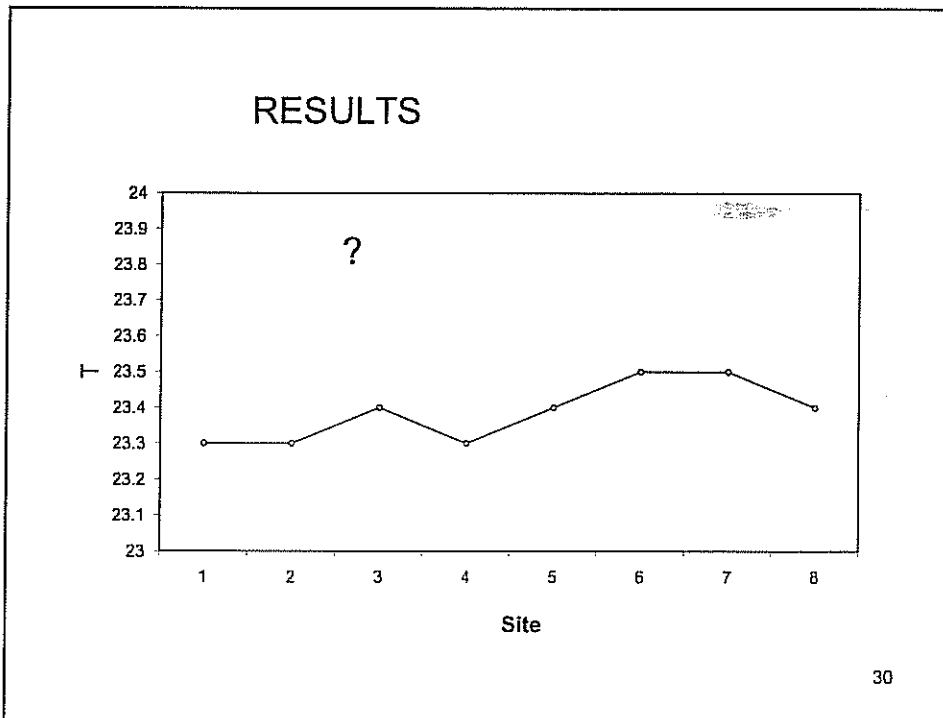
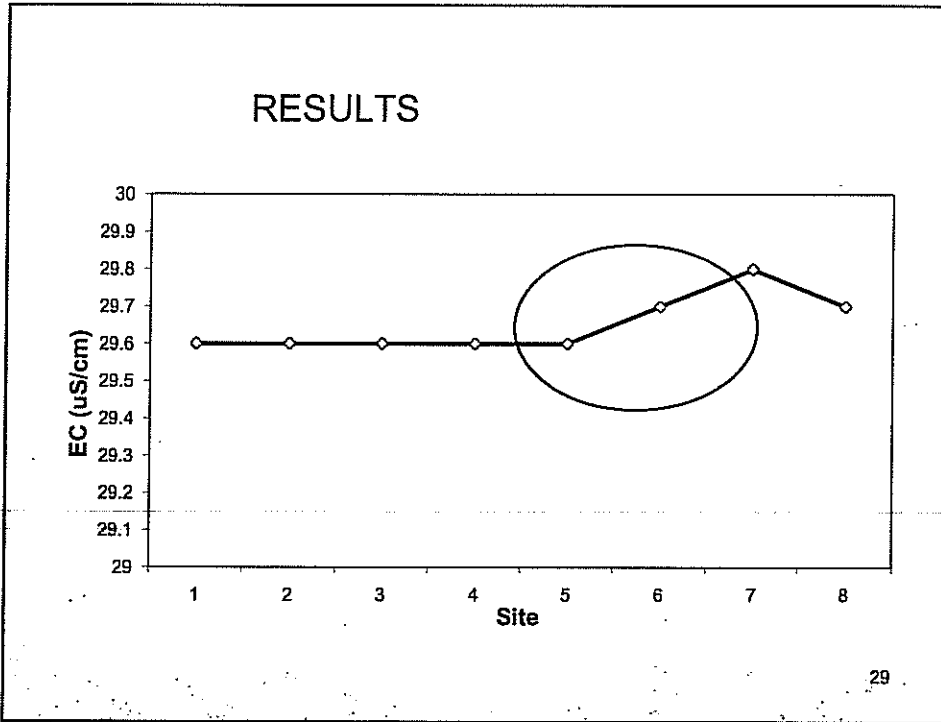
WAY FORWARD?

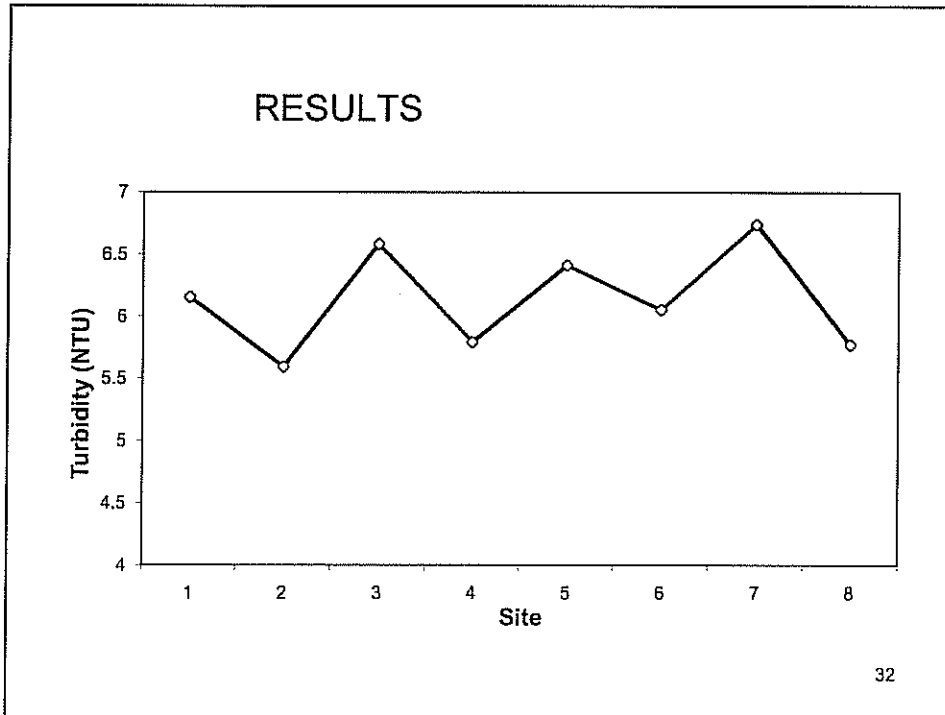
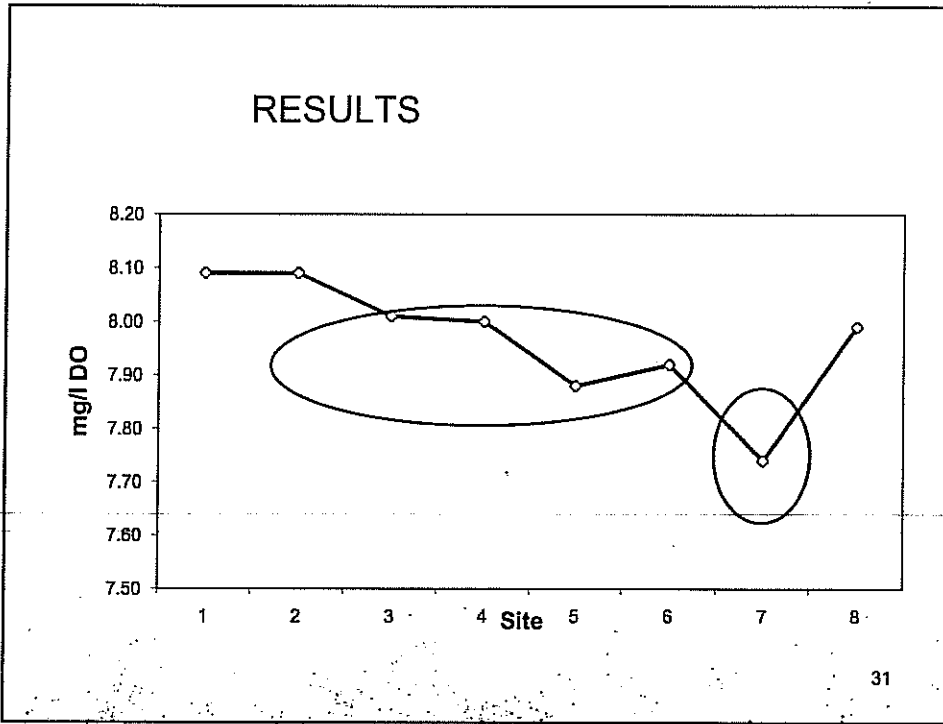
- Site at Shakawe seems to give anomalous results, so investigate further

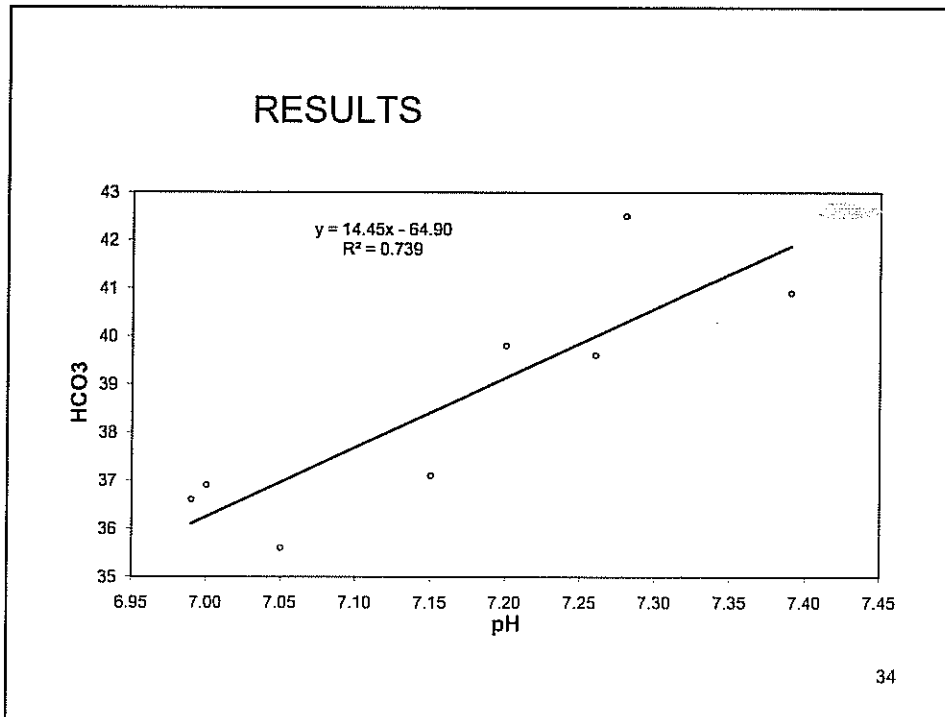
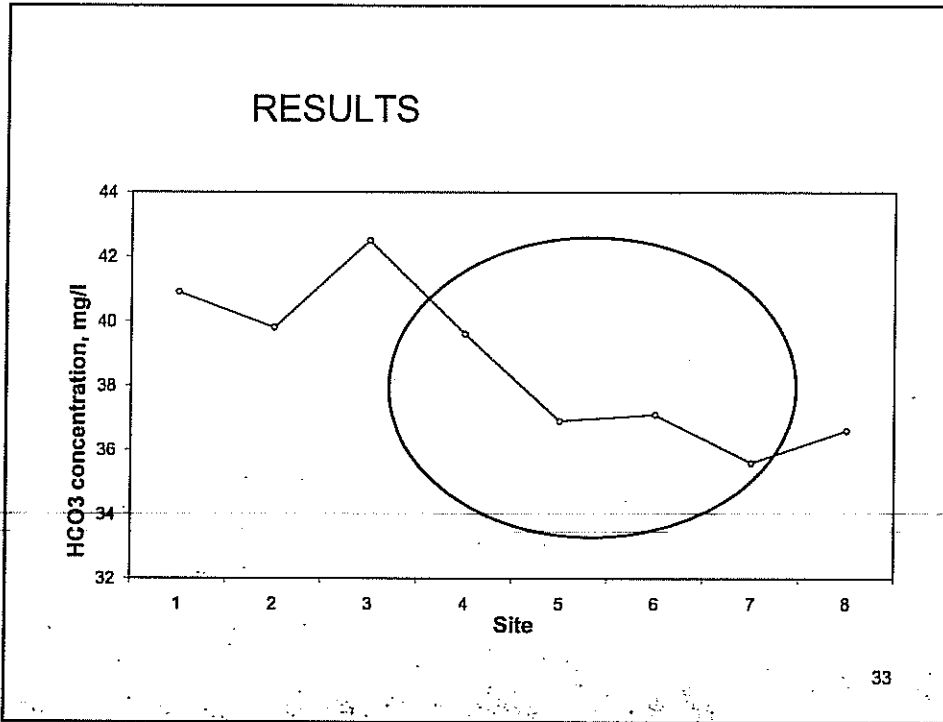
Site Number	Description
1	DWA, Mohembo
2	Upstream of ferry, Mohembo
3	Downstream of ferry, Mohembo
4	Midway between ferry and Shakawe
5	Upstream of Shakawe
6	Downstream of Shakawe
7	Just upstream of Drotsk's
8	1 km downstream of Drotsk's

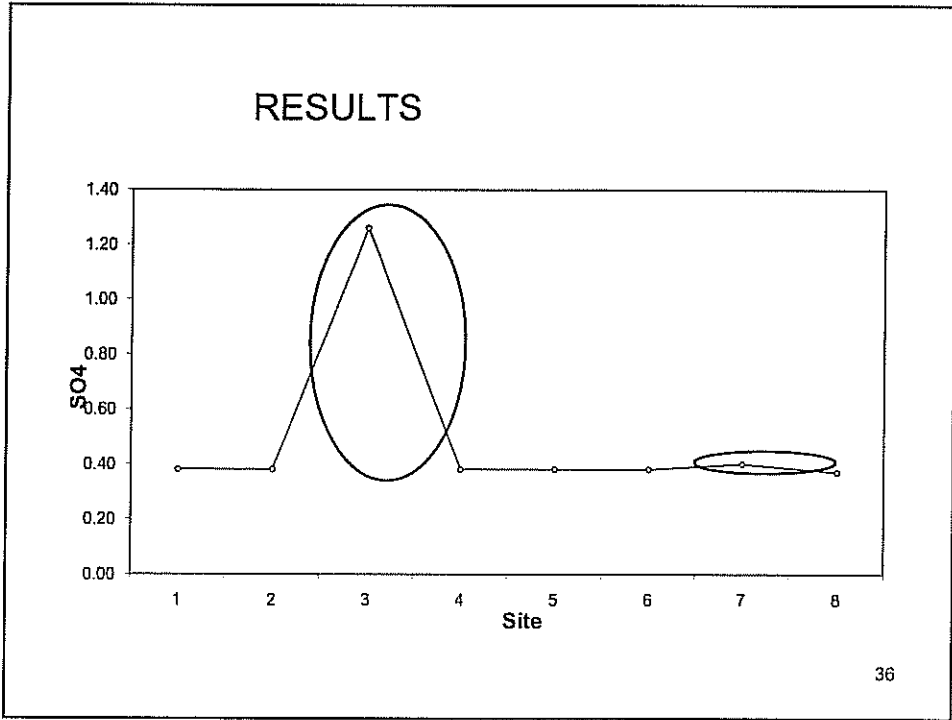
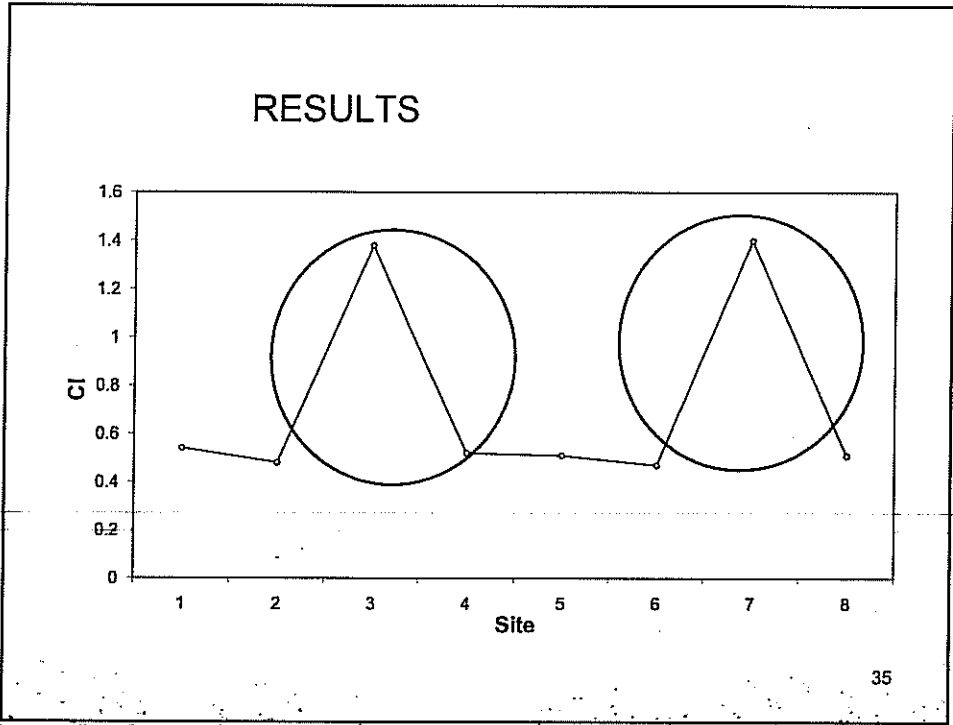
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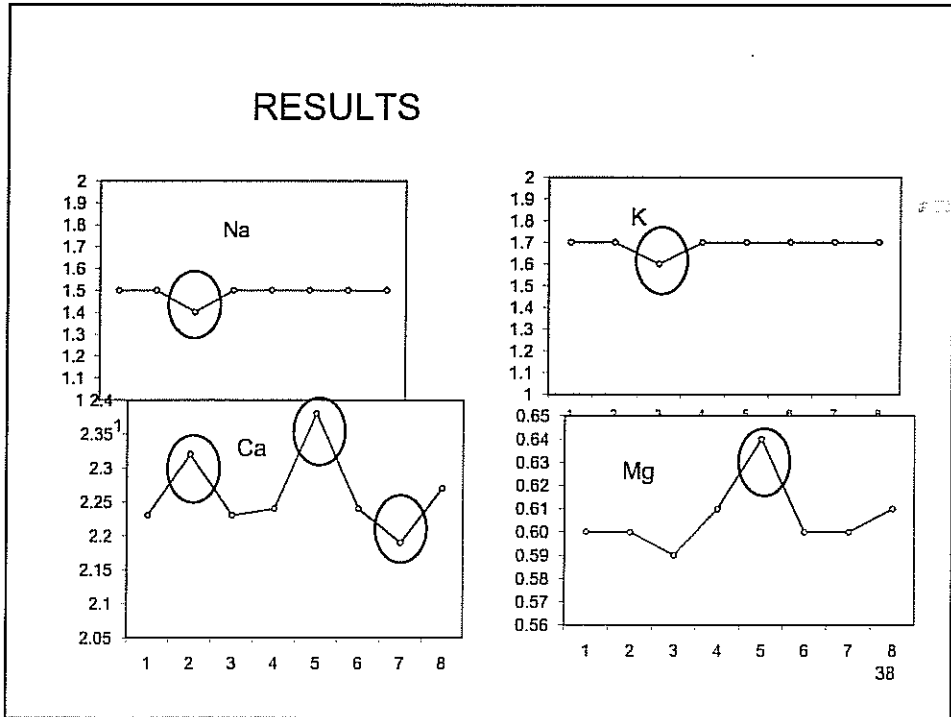
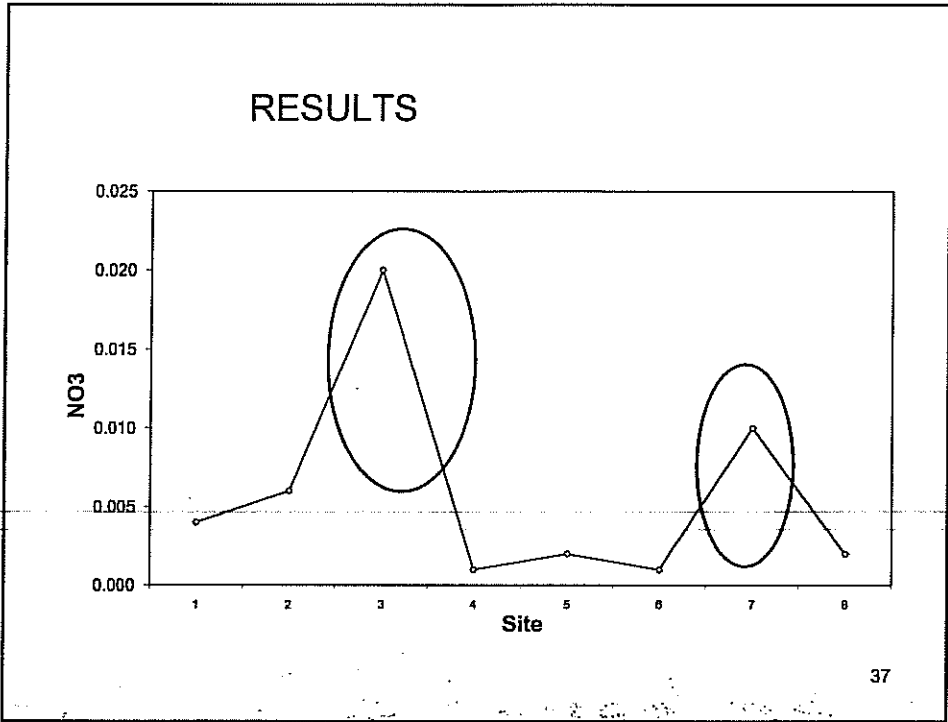


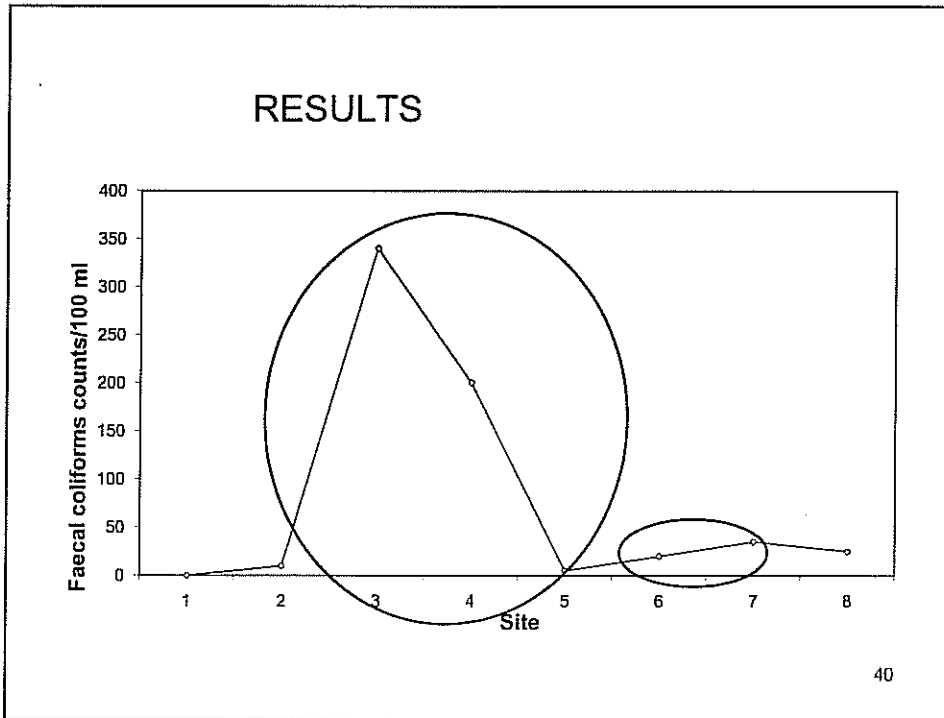
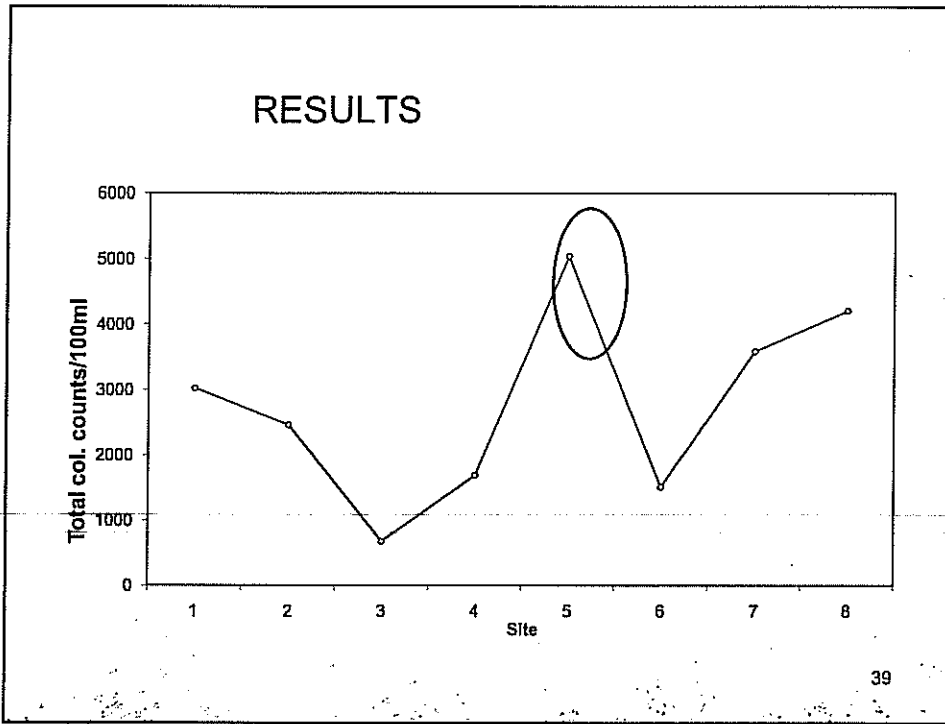












RESULTS

- **OBSERVATIONS**

- EC increases slightly from Shakawe
- pH decreases from upstream of points 2 and 5
- Water temperature is lowest at Mohembo even though Mohembo was sampled last
- DO decreases to point 7 and then recovers
- HCO₃ decreases to point 7 input of acidic substances?
- Maxima for Cl at points 3 and 7

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RESULTS

- **OBSERVATIONS**

- Turbidity fluctuates
- SO₄ maximum at point 3
- NO₃ maximum at points 3, and 7
- Total coliforms maximum at point 6
- Faecal coliform maximum at point 3

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RESULTS

- Something is happening just upstream of points 3 and 7 and needs further investigation

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CONCLUSIONS & FUTURE WORK

- Most of the parameters meet BOBS drinking water standard
- Some concern of possible impact on water quality of activities around Mohembo-Shakawe points 3 and 7-need to check these activities
- Need to get champions to send samples to Maun
- Will include some microbiological sampling

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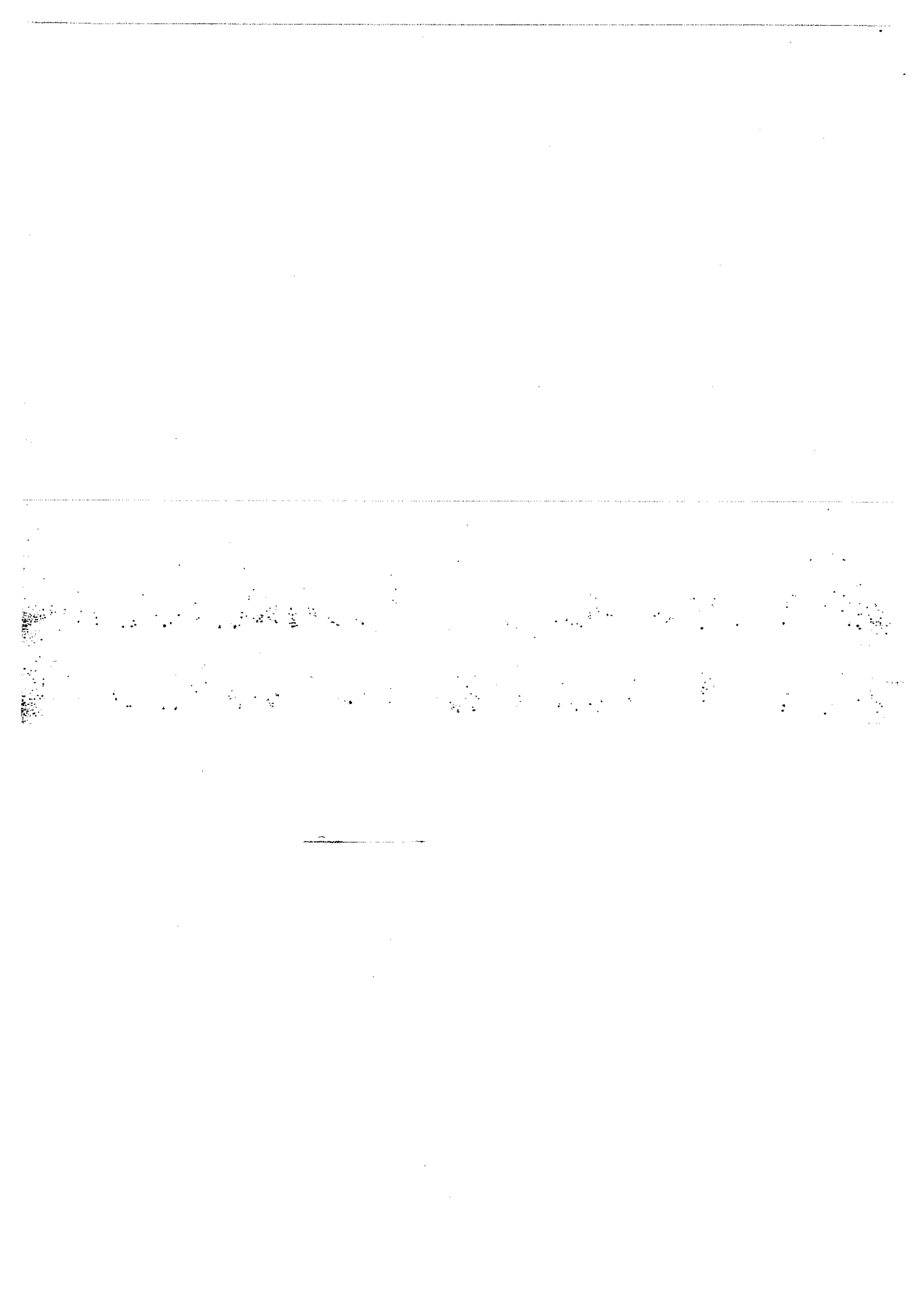
- Monitoring at Toteng. Lake Ngami, Boro/B. fence, Maun and Sandibe started
- To start sampling at Kwhai, Xakanaka, and Eagle Island
- Provide report so far
- Workshop 1 year after commencement of the programme (just after June 2009)

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ACKNOWLEDGEMENTS

- **CHAMPIONS**
 - DWA
 - Drotsk's
 - NWDC
 - Guma River Lodge
 - Sandibe Camp
 - Moremi Safaris
 - Khwai River lodge
 - HOORC field and Laboratory staff
 - BOKAVANGO staff

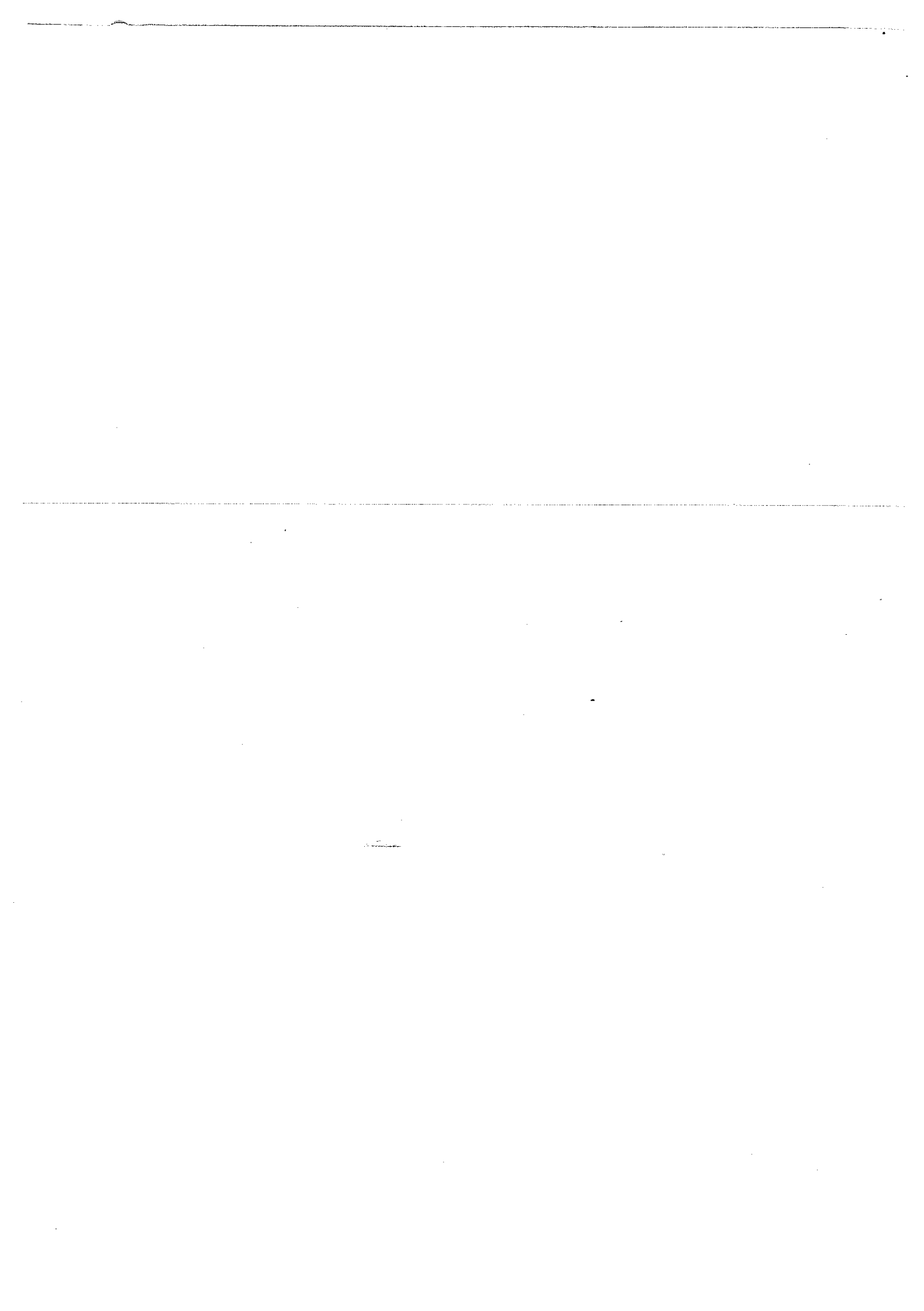
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BOS 32: 2000 Drinking Water Specifications

Table 1- Physical and organoleptic requirements

Determinands	Units	Upper limit and ranges		
		Class I (Ideal)	Class II (Acceptable)	Class III (Max. allowable)
Physical and organoleptic (aesthetic) requirements				
Colour	TCU	15	20	50
Conductivity at 25° C	µS/cm	700	1500	3100
Dissolved Solids	mg/l	450	1000	2000
Odour	n/a	Not objectionable	Not objectionable	Not objectionable
pH value at 25° C	pH	6.5-8.5	5.5-9.5	5.0-10.0
Taste	n/a	Not objectionable	Not objectionable	Not objectionable
Turbidity	NTU	0.5	5	10



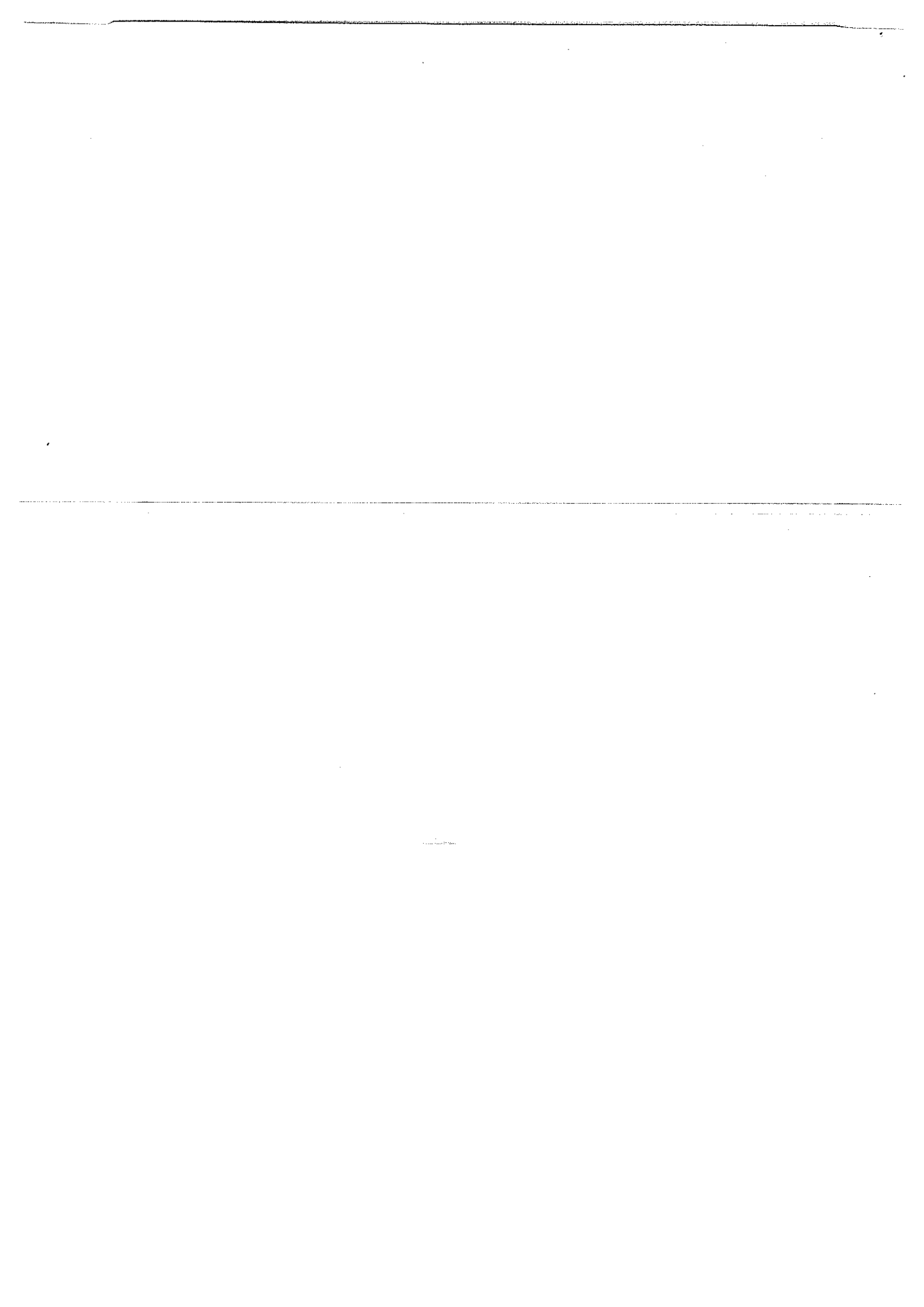
BOS 32: 2000 Drinking Water Specifications

Table 2A - Chemical requirements: Inorganic macro-determinands

Determinands	Upper limit and ranges		
	Class I (Ideal) mg/l	Class II (Acceptable) mg/l	Class III (Max. allowable) mg/l
Chemical requirements: Inorganic- Macro-determinands			
Ammonia as N	0.2	1	2
Calcium as Ca	80	150	200
Chloride as Cl	100	200	600
Chlorine residual	0.3-0.6	0.6-1.0	1
Fluoride as F	0.7	1	1.5
Hardness as CaCO ₃	20	200	500
Magnesium as Mg	30	70	100
Nitrate as NO ₃	45	45	45
Nitrite as NO ₂	3	3	3
Potassium as K	25	50	100
Sodium as Na	100	200	400
Sulfate as SO ₄	200	250	400
Zinc as Zn	3	5	10

Table 2B - Chemical requirements: Inorganic micro - determinands

Determinands	Upper limit and ranges		
	Class I (Ideal) µg/l	Class II (Acceptable) µg/l	Class III (Max. allowable) µg/l
Chemical requirements: Inorganic-Micro-determinands			
Aluminium as Al	100	200	200
Antimony as Sb	5	5	5
Arsenic as As	10	10	10
Cadmium as Cd	3	3	3
Chromium as Cr (total)	50	50	50
Cobalt as Co	250	500	1000
Copper as Cu	1000	1000	1000
Cyanide (free) as CN	70	70	70
Cyanide (recoverable) as CN	70	70	70
Iron as Fe	30	300	2000
Lead as Pb	10	10	10
Manganese as Mn	50	100	500
Mercury as Hg (total)	1	1	1
Nickel as Ni	20	20	20
Selenium as Se	10	10	10



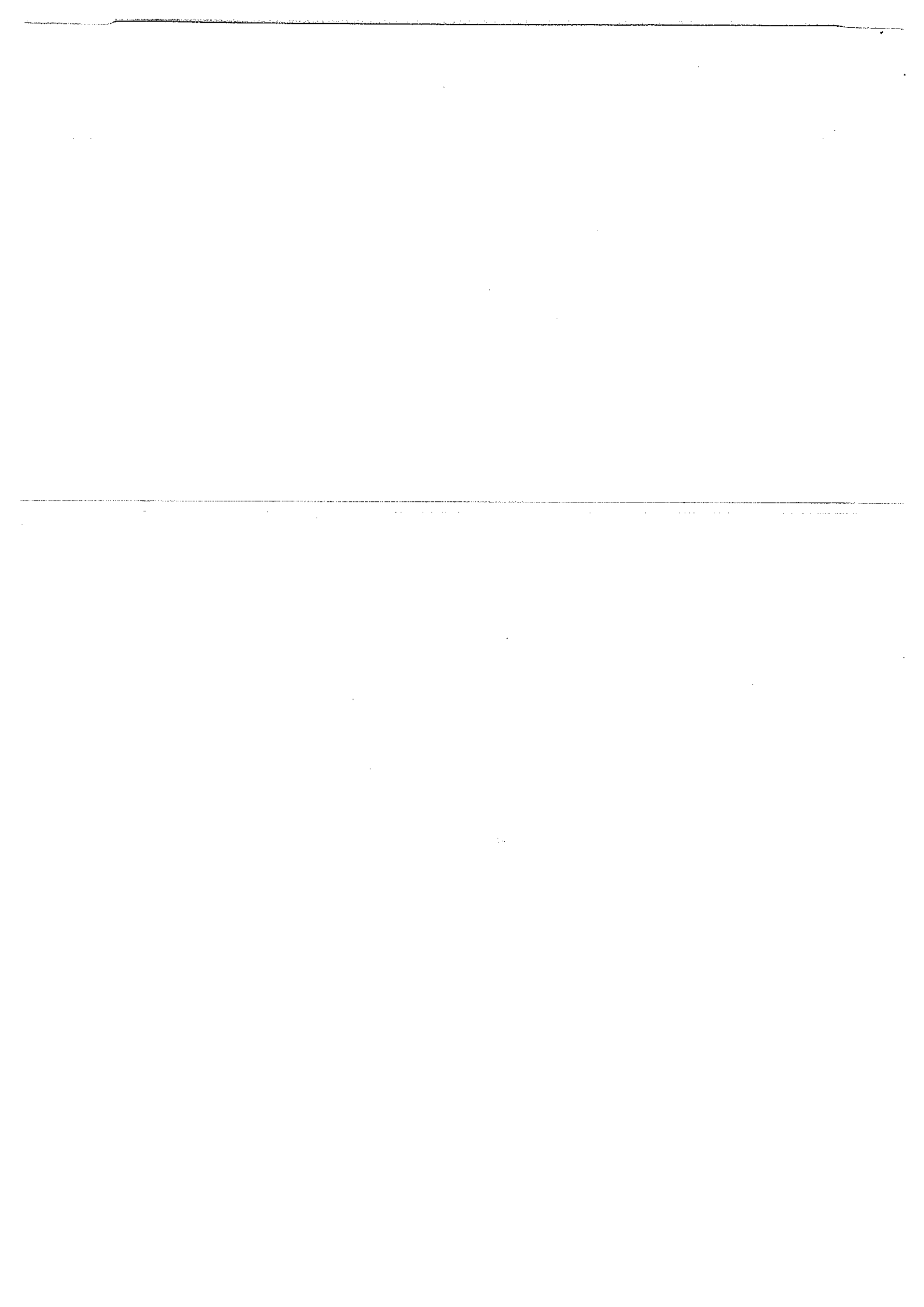
BOS 32: 2000 Drinking Water Specifications

Table 3 - Chemical requirements: Organic determinands

Determinands	Upper limit and ranges		
	Class I (Ideal) µg/l	Class II (Acceptable) µg/l	Class III (Max. allowable) µg/l
Chemical requirements: Organic determinands			
Total organic carbon	8	8	8
Total trihalomethanes	1000	1000	1000
Phenols	10	10	10
Chloroform	30	30	30
Total pesticides	5	5	5?
Pesticide	1	1	1?
Poly-aromatic hydrocarbons	100	100	100
Toluene	700	700	700
Xylene	500	500	500
Ethyl benzene	300	300	300

Malcolm's Note:

? It is not clear what "total pesticides" & "pesticide" mean.



BOS 32: 2000 Drinking Water Specifications

Table 4 - Microbiological requirements

Determinands	Units	Allowable compliance contribution		
		95% min	4% max	1% max
		Upper limits		
Total coliform	Count/ 100 ml	Not detected	10	100
Faecal coliform	Count/ 100 ml	Not detected	1	10
Faecal streptococci	Count/ 100 ml	Not detected	10	100

