internal report 360

Water quality in Magela Creek upstream and downstream of Ranger: A summary of findings for the 1999-2000 Wet season

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1 Introduction

The implementation of the new Commonwealth Environmental Requirements (ERs) for Ranger Uranium Mine in January 2000 provided for a change in the 'philosophy of compliance' by which the mining company meets environmental objectives to minimise and prevent impact from occurring outside the mine lease. A major part of this change focusses on water quality, particularly in Magela Creek on exit from the mine lease, and the need to be able to discern an unusual change or trend which might provide early warning of a potential problem or verify an impact.

To support the interpretation of the ERs, specifically ER 3.3, a study (Klessa 2000a) was completed to describe the baseline chemistry of Magela Creek upstream of Ranger. The results of this study provide the capability by which significant deviations in key water quality parameters at GS 8210009 (009) can be recognised and assessed. A companion paper, currently in draft (Klessa 2000b) defines key variables (ie water quality parameters), quantifies triggers of change in water quality at 009, determines a level of response to triggers of change and provides for control regimes to help monitor and manage water quality.

The purpose of this paper is twofold; firstly, it provides an interpretative template under the Commonwealth ERs for monitoring data at 009, and, secondly, it updates baseline data for the interpretation of water quality data at 009 during the 2000–01 wet season.

2 Methods

2.1.1 Sources of data

Data contained in Klessa (2000a) were augmented where appropriate by monitoring data from the Ranger water quality database and from the NT DME check monitoring[1] program (Table 2.1).

Table 2.1 Details of new data used

Data source	Site	Time span
Ranger	GS 8210009	1/11/99–2/8/00
	GS 821 0028	29/10/99–26/7/00
NT DME	GS 8210009	4/7/99–5/7/00
	GS 821 0028	6/12/99

2.2 Data analysis

Unfiltered data were used as the starting point to reanalysing frequency distributions for upstream data. Also, the same assumptions and procedures covering data handling and filtering as detailed in Klessa (2000a) were followed in establishing the distributional frequency of baseline data for the period 1979–2000 and whether it conformed with normality. Only the dissolved concentrations of species were analysed. pH and EC data measured *in situ* were excluded because of the possibility of analytical differences with equivalent laboratory samples which form the majority of the database.

[1] The author acknowledges the assistance received from ERA and the NT DME in the provision of monitoring data.

3 Results

3.1 General

Descriptive statistics of water quality parameters upstream and downstream of Ranger are summarised in Tables 1 and 2 respectively with the shaded rows depicting key variables. Generally, the inclusion of 1999–00 data for upstream led to minor adjustments to medians and means for the whole (1979–2000) dataset. Notably, however, the median and mean concentration of upstream U for 1999–00 was much lower compared to running values suggesting that either a higher level of analytical quality control had been achieved by Ranger or that a larger proportion of high flow events had been sampled. The establishment of a ^{226}Ra baseline remained hampered by the small number of analytical determinations.

At GS 009, the concentration of key variables were generally lower compared to historical values. The incidence of lower uranium concentrations, which matched a similar fall upstream, probably reflects improved analytical quality control. A near to historic minimum pH of 4.6 occurred at first flush in early November.

3.2.1 Triggers and trends

Variations in the concentrations of the key variables pH, EC, turbidity, Mn and U at 009 are shown in Figs 1–5. Excluding U, the triggers are standard deviations from the mean for normally distributed baseline data as described by Klessa (2000 a,b) and the key is shown in Fig 1. Triggers for U are derived from the 80th and 90th percentiles of baseline data (Klessa 2000 a,b) and from an ecotoxicological limit. The latter has been set at 5 µg/L (R van Dam, pers comm) using local toxicity data and methodology described in the final draft ANZECC water quality guidelines. The triggers are summarised in Table 3.

3.2.1 pH

The large majority (90%) of results remained within the range $5.52<pH<6.84$ which are the boundaries for the action levels. There were four incursions into the action level representing 6% of samples and there were three occasions (4%) when limits were exceeded (Table 4).

On two occasions (6/3/00 and 19/4/00), high pH values (pH 7.0, 7.2) were measured by NT DME check monitoring. These compared to equivalent pH values of 6.1 and 6.4 (ie typical for 009) monitored by Ranger which had EC values around half of the NT DME samples. Consequently, exceedence of the high pH action and limit triggers is doubtful and have been disregarded.

All the remaining unusual pH readings were associated with acidity and flush events characterised by very low EC readings (<5–10 µS/cm) suggesting a large component of rain-fed surface runoff to flow in Magela Creek. Furthermore, the absence of abnormally high concentrations of contaminants (refer to Figs 2–5) strongly suggests there is no evidence to imply that mine-related factors caused the acidity. Hence these 'events' which gave rise to low pH values at 009 are not considered to breach the Commonwealth ERs.

3.2.2 EC

With the exception of two samples (3/11/99 and 29/2/00) which triggered the action level, all the remaining samples were <33 µS/cm of which most (92% of total) were less than the focus level of 23 µS/cm (Fig 2).

Table 1 Summary of median, range and mean values at GS 8210028 (unfiltered data)

	n			Median			Minimum			Maximum			Mean		
Analyte	**1979–99**	**1979–00**	**1999-00**	**1979–99**	**1979–00**	**1999-00**	**1979–99**	**1979–00**	**1999-00**	**1979–99**	**1979–00**	**1999-00**	**1979–99**	**1979–00**	**1999-00**
pH	366	410	44	6.20	6.20	6.12	4.20	4.20	5.17	7.00	7.00	6.83	6.16	6.16	6.12
EC	493	538	45	16	16	11	5	5	5	75	75	47	18	17	12
Turbidity	356	396	40	5.0	4.9	2.0	0.5	0.5	0.5	82.0	82.0	21.1	7.4	7.0	3.4
Ca	214	237	23	0.52	0.51	0.36	0.05	0.05	0.18	6.00	6.00	0.71	0.65	0.62	0.39
Cl	125	138	13	2.1	2.0	1.9	0.8	0.8	1.0	24.0	24.0	3.2	2.8	2.7	2.0
Cu	105	117	12	0.60	0.80	1.00	0.10	0.10	0.18	3.49	3.49	1.0	0.84	0.84	0.88
K	149	169	20	0.22	0.22	0.24	0.05	0.05	0.05	1.80	1.80	0.67	0.30	0.29	0.24
Mg	266	312	46	0.64	0.62	0.54	0.05	0.05	0.05	8.10	8.10	0.99	0.72	0.70	0.57
Mn	224	263	39	5.6	5.3	4.9	0.5	0.50	0.50	180.0	180.0	41.5	10.3	9.6	5.9
Na	150	171	21	1.30	1.30	1.18	0.05	0.05	0.82	5.50	5.50	1.53	1.40	1.37	1.17
NH_4	75	89	13	0.01	0.01	0.025	0.01	0.01	0.025	0.18	0.18	0.025	0.022	0.023	0.025
NO_3	122	135	13	0.03	0.025	0.011	0.002	0.002	0.011	0.43	0.84	0.84	0.049	0.054	0.094
Pb	122	132	10	0.50	0.50	0.27	0.01	0.01	0.02	22.0	22.0	0.50	0.98	0.92	0.26
^{226}Ra	101	105	4	3.0	6.4	15.0	0.6	0.6	10.0	43.2	43.2	31.0	9.8	10.1	17.8
SO_4	232	271	39	0.27	0.27	0.27	0.03	0.03	0.15	9.30	9.30	3.55	0.62	0.59	0.45
U	260	316	56	0.10	0.10	0.05	0.013	0.013	0.039	24.95	24.95	0.22	0.62	0.52	0.06
Zn	93	112	19	2.5	2.0	1.0	0.5	0.5	1.0	81.0	140.7	140.7	9.4	9.7	11.1

Units for electrical conductivity (EC) are µS/cm; for turbidity are NTU; for Ca, Cl, K, Na, NH_4, NO_3 and SO_4 are mg/L; for Cu, Mn, Pb and U are µg/L; and for ^{226}Ra are mBq/L

Table 2 Summary of median, range and mean values at GS 8210009 (unfiltered data)

	n			Median			Minimum			Maximum			Mean		
Analyte	1979–99	1979–00	1999-00	1979–99	1979–00	1999-00	1979–99	1979–00	1999-00	1979–99	1979–00	1999-00	1979–99	1979–00	1999-00
pH	597	653	56	6.10	6.10	6.16	4.50	4.50	4.60	7.70	7.70	7.21	6.13	6.12	6.11
EC	694	749	55	18	18	14	7	4	4	231	231	36	20	20	15
Turbidity	612	654	42	4.0	4.0	2.4	0.5	0.5	0.5	89.0	89.0	9.6	6.0	5.8	2.9
Ca	417	450	33	0.45	0.45	0.44	0.05	0.05	0.16	2.40	2.40	0.75	0.48	0.48	0.42
Cl	271	295	24	2.4	2.4	2.0	0.9	0.9	1.1	31.0	31.0	8.7	3.0	3.0	2.3
Cu	211	224	13	0.70	0.73	1.0	0.10	0.10	0.15	12.00	12.00	1.00	0.85	0.88	0.79
K	309	340	31	0.26	0.25	0.16	0.05	0.05	0.05	1.70	1.70	0.36	0.31	0.30	0.16
Mg	545	595	50	0.80	0.80	0.85	0.05	0.05	0.31	5.30	5.30	1.99	0.98	0.97	0.80
Mn	489	539	50	6.7	6.6	5.6	0.4	0.4	0.5	98.0	98.0	32.2	9.2	8.9	6.5
Na	300	331	31	1.40	1.40	1.2	0.05	0.05	0.82	6.9	6.9	1.6	1.4	1.4	1.2
NH_4	142	156	14	0.010	0.010	0.025	0.010	0.010	0.025	0.61	0.61	0.025	0.028	0.027	0.025
NO_3	267	291	24	0.025	0.025	0.011	0.001	0.001	0.011	1.360	1.360	0.279	0.054	0.052	0.073
Pb	179	191	12	0.40	0.21	0.05	0.005	0.005	0.04	6.90	6.90	0.21	0.49	0.46	0.07
^{226}Ra	237	243	6	2.7	2.8	14.5	0.8	0.5	1.5	63.0	63.0	43.0	7.1	7.4	16.0
SO_4	509	557	47	0.79	0.74	0.62	0.05	0.05	0.12	18.58	18.58	2.70	1.68	1.62	0.80
U	564	631	51	0.13	0.10	0.05	0.002	0.002	0.002	15.01	15.01	1.20	0.26	0.24	0.11
Zn	211	230	19	2.6	2.4	1.0	0.5	0.2	0.2	410.0	410.0	8.3	10.6	7.8	1.3

Units for electrical conductivity (EC) are µS/cm; for turbidity are NTU; for Ca, Cl, K, Na, NH_4, NO_3 and SO_4 are mg/L; for Cu, Mn, Pb and U are µg/L; and for ^{226}Ra are mBq/L

Table 3 Trigger values and limits at GS 009 for 1999–2000

Key variable	Focus level	Action level	Limit
pH	5.85, 6.51	5.52, 6.84	5.19, 7.17
EC (µS/cm)	23	33	47
Turbidity (NTU)	12	28	66
U (µg/L)	0.30	1.90	5.00
Mn (µg/L)	11	21	47
Mg (mg/L)		Use EC triggers	
SO_4		Use EC triggers	

Table 4 Abnormal pH values at GS 009 during 1999–2000

Trigger	Range	Date
Action	6.84<pH<7.71	10/4/00†
Action	5.19<pH<5.52	17/11/99, 23/11/99, 24/11/99, 3/3/00
Limit	<5.19	11/11/99, 29/12/99, 15/3/00
Limit	>7.17	6/3/00†

† NT DME samples

3.2.3 Turbidity

All turbidity measurements were below the focus level of 12 NTU (Fig 3).

3.2.4 Manganese

Three out of a total of thirty-five samples triggered the focus level and one sample triggered the action level on 3/11/99 (Fig 4). The latter occurred in early season and is attributable to first flush. There was no evidence of a downstream mining effect on the variation in Mn concentration.

3.2.5 Uranium

One sample out of fifty-six triggered the focus level. This corresponded to a U concentration of 1.2 µg/L monitored by the NT DME on 5/1/00 but an ERA sample taken the same day was reported as <0.1 µg/L (Fig 5). There was no evidence of a mining effect on the variation in U concentration at 009.

3.3 Adjustment to baseline

The inclusion of 1999–00 data resulted in minor changes to distributions. These are summarised in Table 5 for normally distributed data and shown graphically in Fig 6–12. Non-normally distributed water quality parameters are given in Figs 13–22.

Table 5 Mean and standard deviation of normally distributed baseline parameters (1979–2000)

	pH	EC (µS/cm)	Turb (NTU)	Mg (mg/L)†	Ca (mg/L)†	Na (mg/L)	Mn (µg/L)†
n	423	537	392	280	226	157	241
Mean	6.17	1.1836	0.6552	-0.2062	-0.2964	1.29	0.7514
SD	0.33	0.1503	0.3661	0.3661	0.2196	0.33	0.2727

†Denotes $\log_{10}$ values

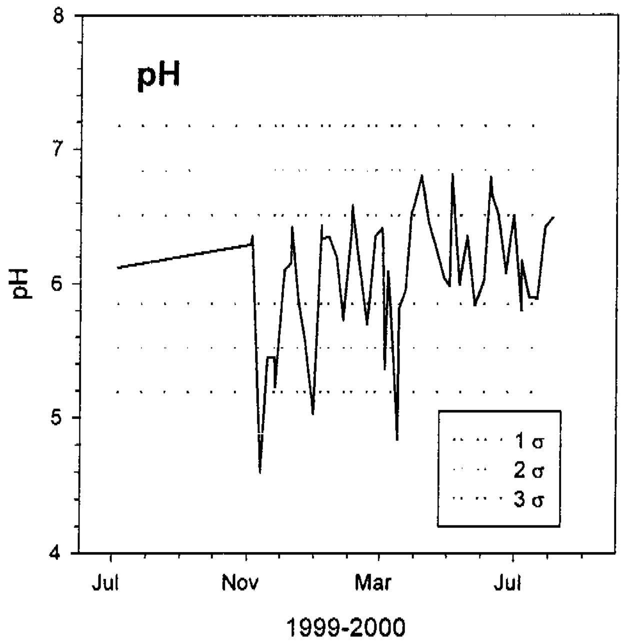

Fig 1 pH at GS 009 during 1999–2000

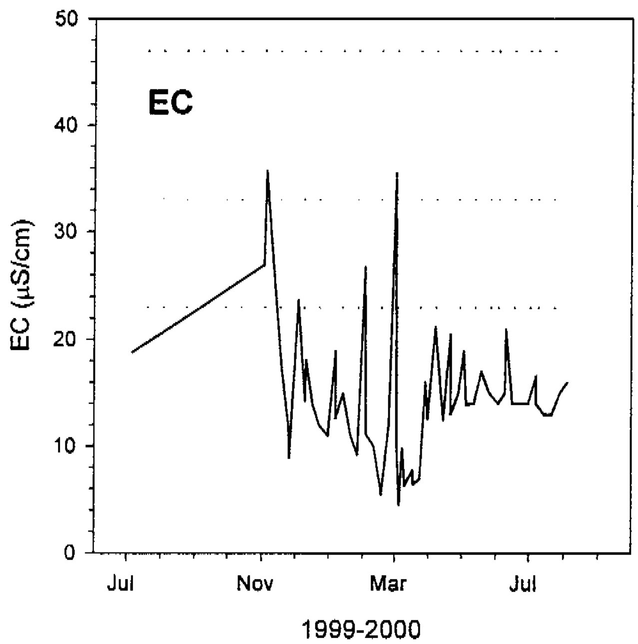

Fig 2 EC at GS 009 during 1999–2000

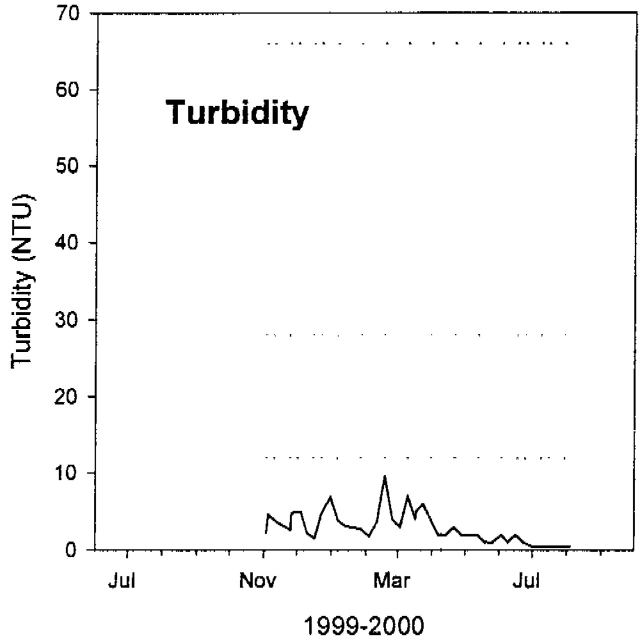

Fig 3 Turbidity at GS 009 during 1999–2000

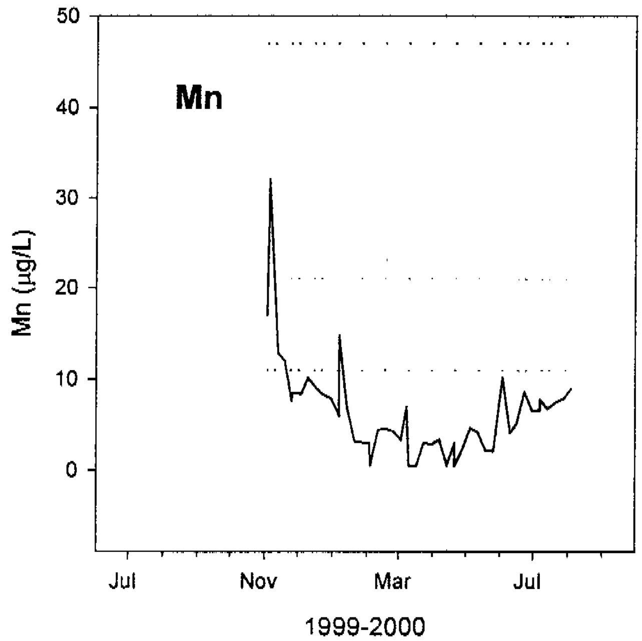

Fig 4 Soluble Mn at GS 009 during 1999–2000

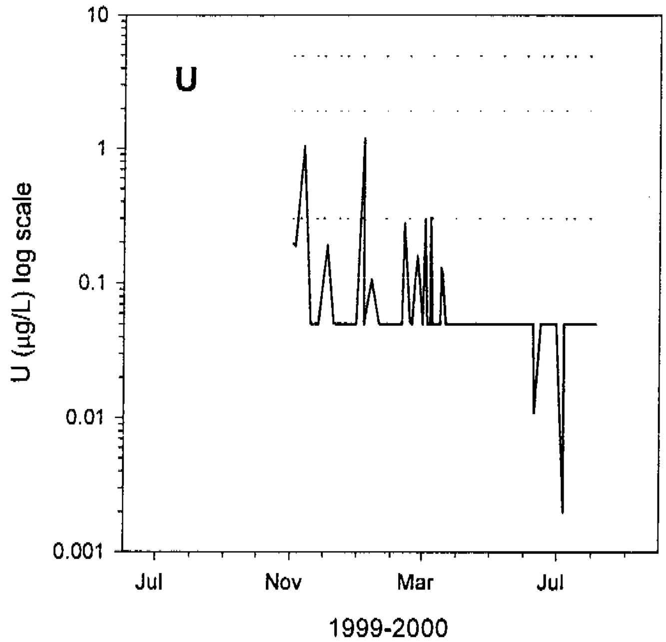

Fig 5 Soluble U at GS 009 during 1999–2000

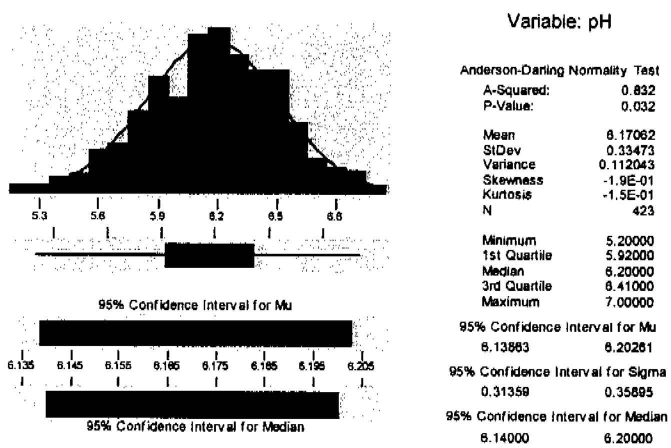

Fig 6 Frequency distribution of pH baseline values

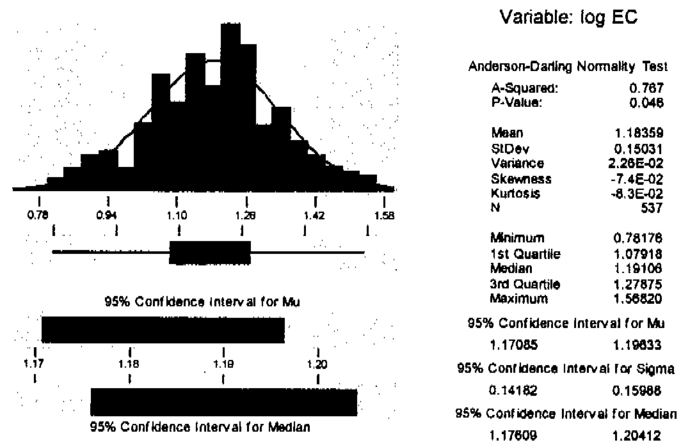

Fig 7 Frequency distribution of (log) EC (µS/cm) baseline values

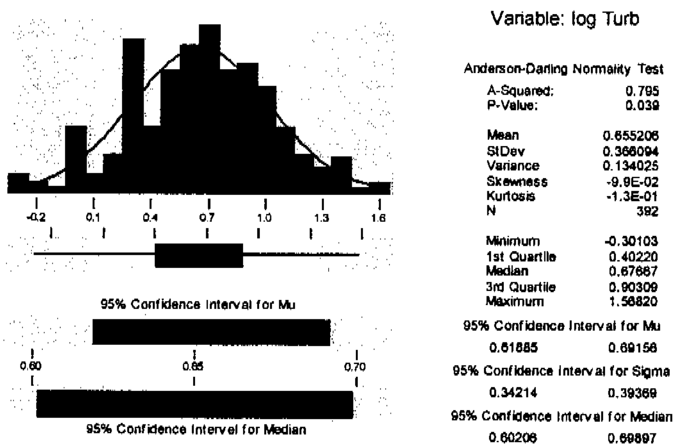

Fig 8 Frequency distribution of (log) turbidity (NTU) baseline values

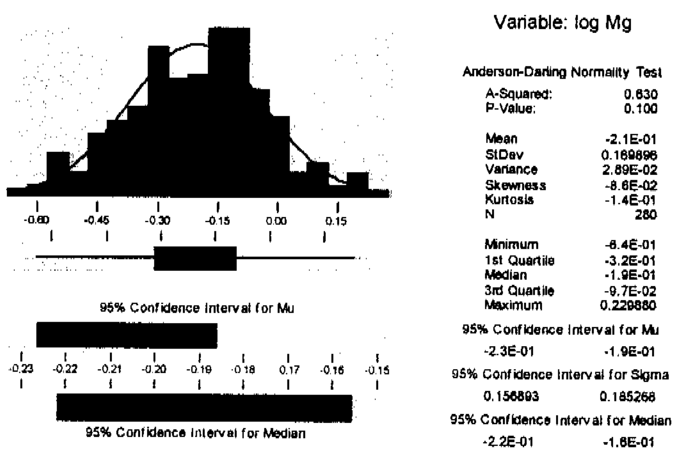

Fig 9 Frequency distribution of (log) magnesium (mg/L) baseline values

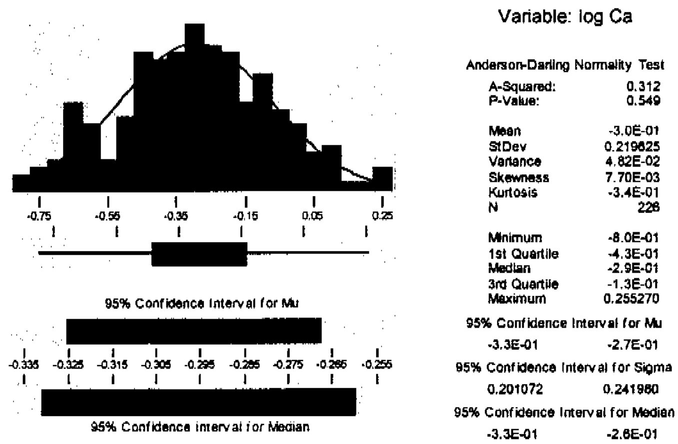

Fig 10 Frequency distribution of (log) calcium (mg/L) baseline values

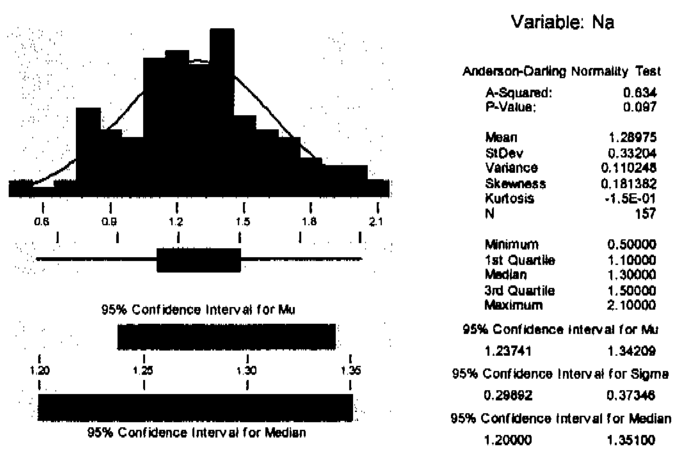

Fig 11 Frequency distribution of sodium (mg/L) baseline values

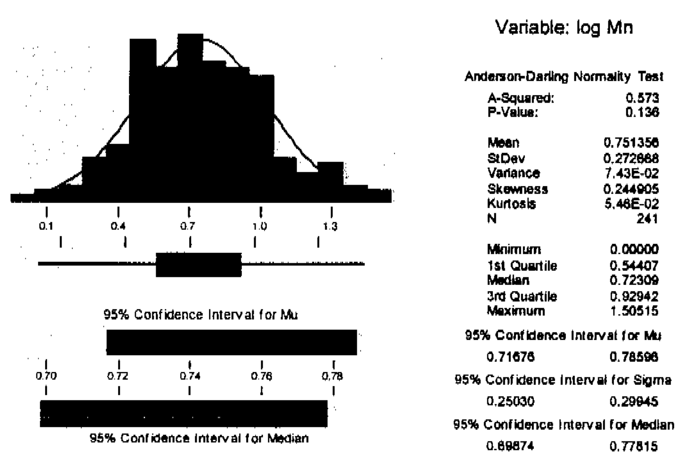

Fig 12 Frequency distribution of dissolved (log) manganese (µg/L) baseline values

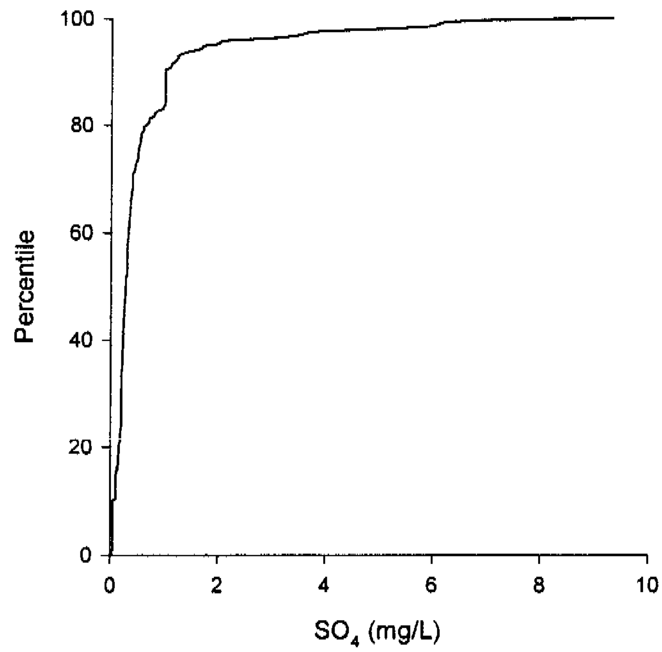

Fig 13 Percentile values for baseline sulphate

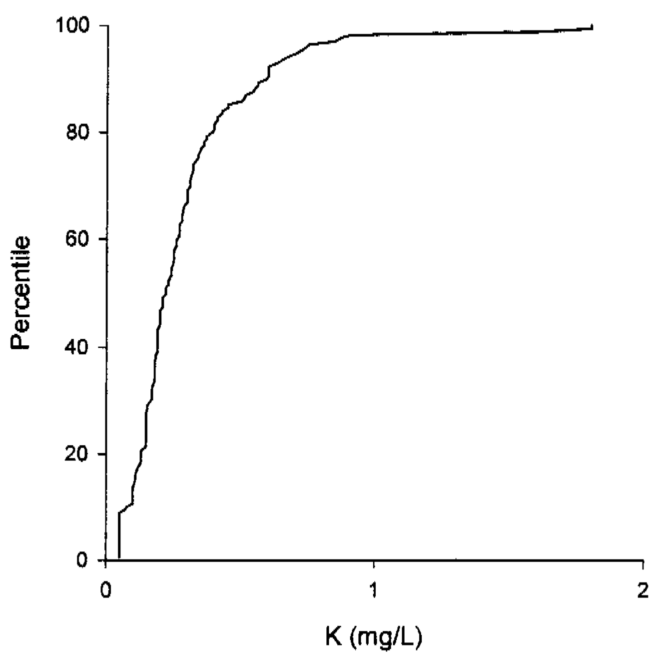

Fig 14 Percentile values for baseline potassium

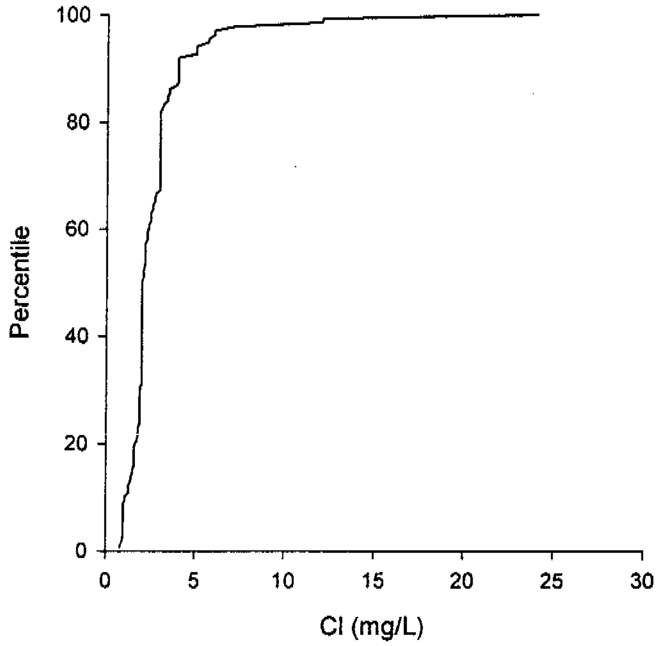

Fig 15 Percentile values for baseline chloride

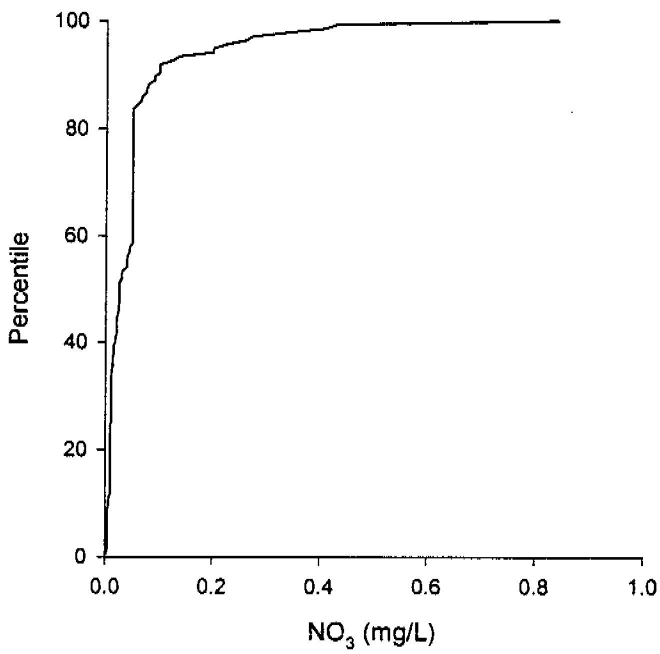

Fig 16 Percentile values for baseline nitrate

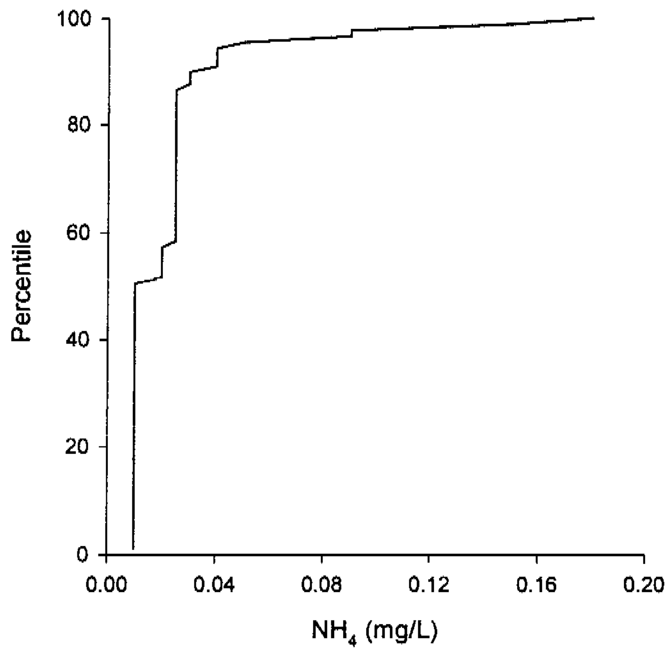

Fig 17 Percentile values for baseline ammonium

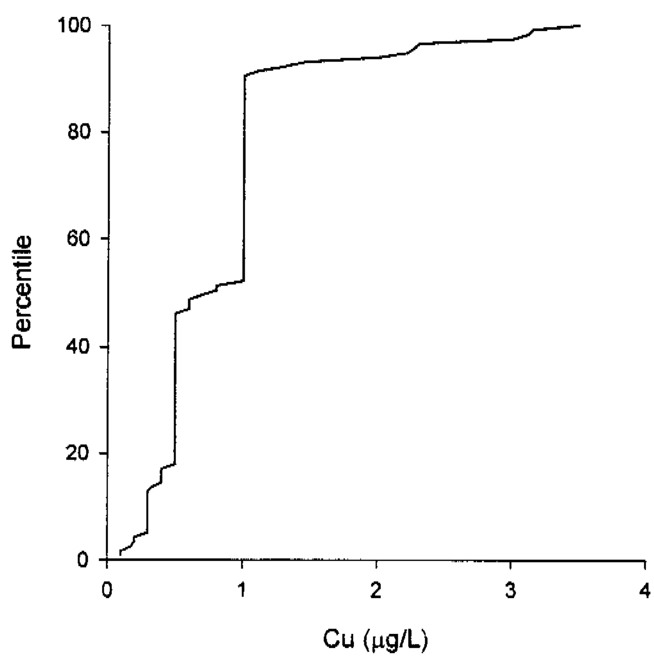

Fig 18 Percentile values for baseline dissolved copper

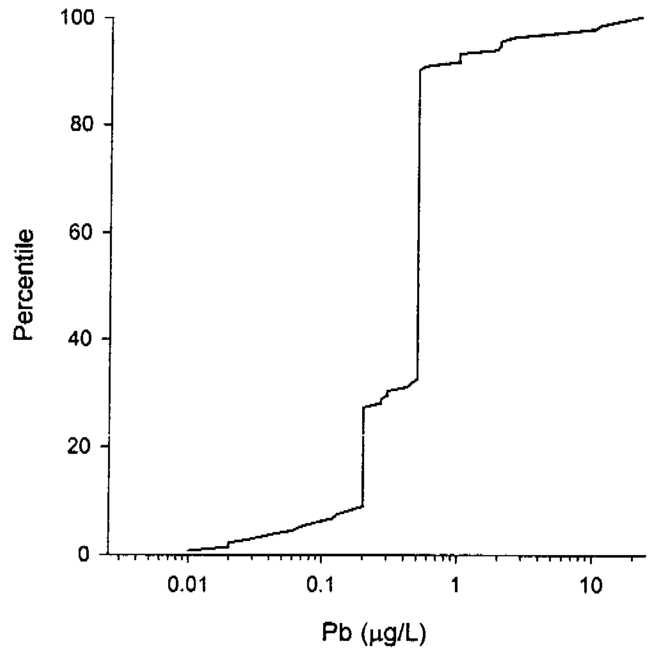

Fig 19 Percentile values for baseline dissolved lead

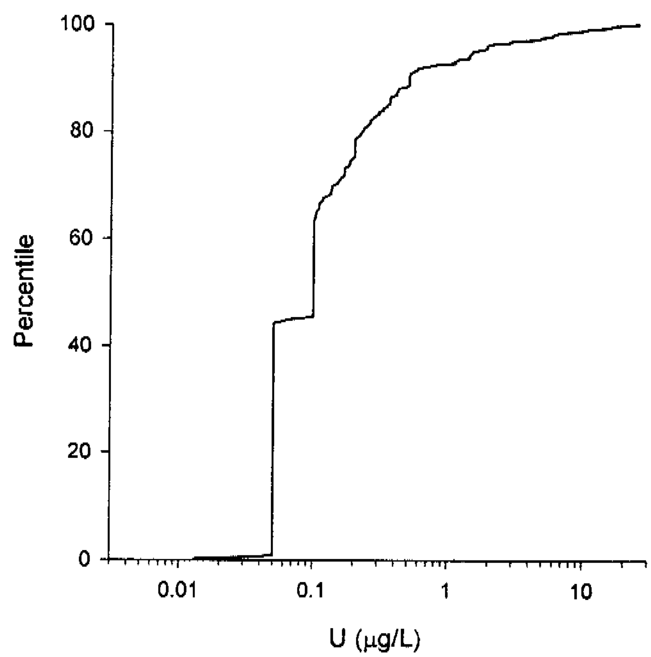

Fig 20 Percentile values for baseline dissolved uranium

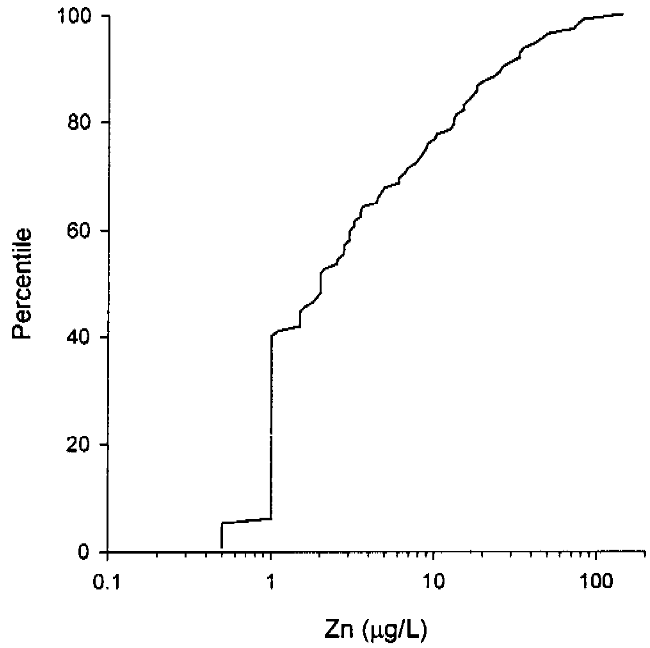

Fig 21 Percentile values for baseline dissolved zinc

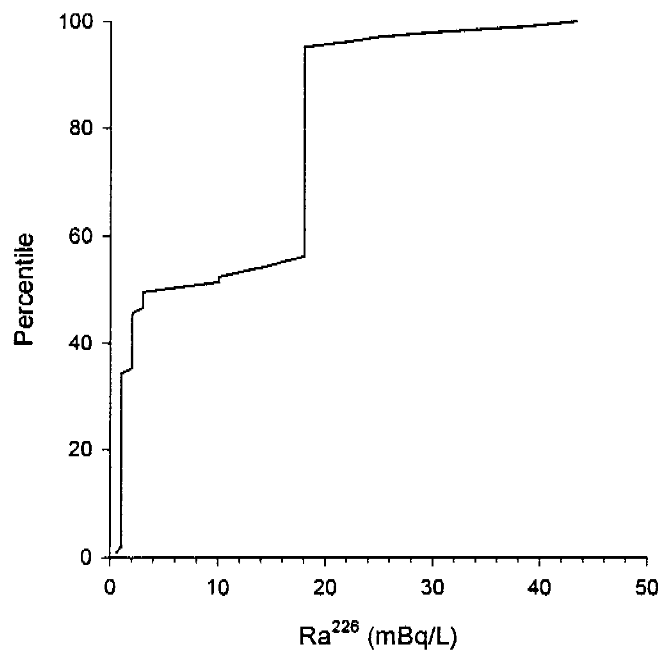

Fig 22 Percentile values for baseline dissolved radium-226

Trigger values and limits at 009 for the 2000–01 season are listed in Table 6.

Table 6 Trigger values and limits at GS 009 for 2000–01

Key variable	Focus level	Action level	Limit
pH	5.84, 6.50	5.51, 6.83	5.18, 7.16
EC (µS/cm)	22	30	43
Turbidity (NTU)	10.5	24	57
U (µg/L)	0.30	1.90	5.00
Mn (µg/L)	11	19	37
Mg (mg/L)		Use EC triggers	
SO_4 (mg/L)		Use EC triggers	

Compared to the 1999–00 triggers and limits (Table 3), values have generally decreased slightly with the largest change shown for the Mn liomit which has fallen from 47 to 37 µg/L. Further annual reviews of the baseline will take place using the accrued monitoring data each year for upstream.

4 Conclusions

Monitoring data collected by ERA and from check monitoring by the statutory authority has indicated that mining activities did not breach water quality objectives in Magela Creek at 009 during the 1999–00 wet season as determined by Commonwealth Environmental Requirements. The continued provision of chemistry data for Magela Creek upstream of Ranger has allowed further tuning of trigger values. Compared to the 1979–1999 period most water quality parameters showed a decrease in median or mean concentrations over the 1999-2000 season.

5 References

Klessa DA 2000a. *The chemistry of Magela Creek: A baseline for assessing change downstream of Ranger*. Supervising Scientist Report 151, Supervising Scientist, Darwin.

Klessa DA 2000b. Assessment of change in water quality downstream of Ranger. Draft, unpublished paper.