“Trigger” values for New Zealand rivers

NIWA Client Report: MfE002/22
May 2000

“Trigger” values for New Zealand rivers

R J Davies-Colley

Prepared for

Ministry for the Environment

Information contained within this report should not be used without the prior consent of the client

NIWA Client Report: MfE002/22
May 2000

National Institute of Water & Atmospheric Research Ltd
PO Box 11-115, Hamilton
New Zealand
Tel: 07 856 7026
Fax: 07 856 0151

CONTENTS

"TRIGGER" VALUES FOR NEW ZEALAND RIVERS 1

INTRODUCTION.. 1

DESCRIPTION OF THE APPROACH.. 1

COMMENTS ON THE NEW ZEALAND DATA... 2

COMPARISON WITH SE AUSTRALIAN VALUES 3

REFERENCES.. 4

Reviewed by: *Approved for release by:*

G Bryers A B Cooper

Document formatting approved by: P. Bradley or K. MacLeod, NIWA

……………………………………………………………………………

Executive Summary

Trigger values for ecosystem protection are needed in the new ANZECC guidelines that are currently being drafted. If median water quality at monitoring sites exceeds these trigger values, then it is intended to "trigger" a management response. Ministry for Environment has asked NIWA to estimate such trigger values for New Zealand rivers using percentiles taken from the National Rivers Water Quality Network (NRWQN) datasets. Of the 77 sites in the NRWQN, 32 are considered baseline or pseudo-baseline (minimally or lightly impacted) and 11 of these sites are lake-fed or affected by alpine headwaters. The remaining 21 sites were used for estimation of trigger values (as 80 or 20 percentiles) after being further categorised into 3 lowland sites (elevation at monitoring site < 150 m) and 18 upland sites. Variables for which trigger values were estimated were: total phosphorus, dissolved reactive phosphorus, nitrogen, oxidised nitrogen (nitrate + nitrite-N), ammoniacal nitrogen (ammonia + ammonium-N), dissolved oxygen as % saturation, pH, black disc visibility, turbidity, and temperature. In order to obtain a meaningful trigger value for temperature, data for February alone (high insolation, low flow) were used. The percentiles obtained for pH and especially for %DO, may require professional judgement in order to derive trigger values because these variables are subject to diurnal fluctuation. The percentiles are presented and discussed with reference to trigger values for SE Australian rivers.

INTRODUCTION

Trigger values for ecosystem protection are needed for the new ANZECC guidelines that are currently being drafted. These trigger values indicate marginal water quality for supporting ecosystem health (Hart et al. 1999). Running medians of water quality data measured in monitoring programmes may be compared with these trigger values. If the median value of a water quality variable for a particular site exceeds the trigger value, then it is intended to "trigger" a response on the part of water managers, which might be to initiate special sampling or carry out an investigation of reasons for the degraded water quality.

Several ways of specifying trigger values are envisaged by Hart et al. (1999), but in most cases, and for most water quality "issues" (and therefore variables), the use of statistics from datasets for "reference" sites with minor or minimal impact is recommended. The 80 percentile has been (arbitrarily) chosen where high concentrations or values indicate degraded water quality, and the 20 percentile where a low benchmark is appropriate.

The Ministry for Environment (MfE, Mr Bob Zuur) has asked NIWA to estimate trigger values for New Zealand rivers using percentiles calculated for the National Rivers Water Quality Network (NRWQN) dataset. The NRWQN involves sampling of 77 river sites on 49 different rivers at monthly intervals for a variety of water quality variables (Smith & McBride 1990). This report describes the approach taken for site selection and categorisation, presents the relevant percentiles for selected sites in the NRWQN, and gives a brief commentary on the percentiles, including a comparison with SE Australian trigger values.

DESCRIPTION OF THE APPROACH

Ten years of data from the NRWQN have been used to calculate percentiles in order to estimate "trigger" values for the new edition of the ANZECC guidelines. Both 80 and 20 percentiles were calculated: the upper percentiles provide an estimation of the trigger value for most variables, but *lower* percentiles are needed for some variables (e.g. visual clarity) and both for others (dissolved oxygen, pH).

Of the 77 river sites in the NRWQN, 32 sites are regarded as "baseline" (essentially un-impacted) or "pseudo-baseline" (lightly impacted) (Smith and McBride 1990). Data from these sites were used for the calculation of percentiles.

Temperature is one variable that is strongly seasonal in its distribution, so data for February visits (late summer) at which time a combination of comparatively low flows and still high insolation gives seasonal temperature maxima, were used to derive percentiles for this variable. Note that February temperatures are typically *higher* than January temperatures in the NRWQN dataset.

The minimally or slightly impacted sites were categorised as "upland" (site elevation > 150 m) and "lowland" (< 150 m) following the approach taken in Australia. Unfortunately, most un-impacted to slightly impacted sites are at relatively high elevation, and only four suitable lowland sites are available in the NRWQN: The Waipapa River (Northland), the Upper Waipa and Ohinemuri Rivers (Waikato Region) and the Haast River (Westland). The last river is alpine in its headwaters, and so the percentiles were re-calculated with Haast data removed.

There are fully 28 upland un-impacted to slightly impacted sites in the NRWQN. However, 10 of these are either lake fed (e.g., Tarawera @ lake outlet, Waikato @ Reids farm) or have alpine headwaters with glaciation (e.g., Waimakariri @ the Gorge, Shotover @ Bowens) or both (Waitaki @ Kurow, Clutha @ Luggate), and so the analysis was repeated with these sites removed, leaving only 18 sites.

Appendices 1 and 2 list the baseline and pseudo-baseline sites, give their elevations and other data, and record notes about their catchment characteristics.

Site categorisation and the estimation of percentiles was done in DataDesk which apparently uses a slightly different algorithm for percentile interpolation from MS EXCEL. Appendix 3 summarises the DataDesk output.

COMMENTS ON THE NEW ZEALAND DATA

Table 1 summarises the percentiles calculated for a range of variables for the different categories of baseline or pseudo-baseline sites. Percentiles for visual clarity (black disc range, m), turbidity, and temperature are included, as well as for the variables (five nutrient measures, dissolved oxygen, pH) covered for various regions of Australia (trigger values for SE Australia, taken from the draft ANZECC guidelines, are given for comparison in Table 1).

The dissolved oxygen (DO) percentiles seem unlikely to be very useful for estimating trigger values, since they are for daytime sampling whereas diurnal minima usually occur near dawn. For a similar reason pH minima may not be very useful. The temperature percentiles for February alone (e.g., 80 percentile temperature for upland sites = 18 ^{o}C, and 21.5 ^{o}C for lowland rivers) are probably more useful as trigger values than year-round values. For all three diurnally (and seasonally) varying variables (temperature, pH and DO), professional judgement might need to be used for deriving trigger values.

Unfortunately, the NRWQN does not include data for chlorophyll *a* in periphyton, although observations of periphyton as % cover are routinely made. Nor are water column chlorophyll *a* analyses made, so no trigger values can be given for Chla in the water or on the bed of New Zealand rivers.

Note that turbidity and visual water clarity are closely, inversely, related, and the 80 percentile for turbidity is broadly consistent with the 20 percentile for visibility and *vice versa*.

COMPARISON WITH SE AUSTRALIAN VALUES

A comparison was made with trigger values for SE Australia (including Tasmania) a region that may be more comparable climatically with New Zealand than the other (tropical and or arid) regions of Australia. This comparison can only be made on "face value", because analytical methods may differ.

Trigger values for SE Australia, for both total phosphorus (TP) and total nitrogen (TN), are similar to the 80 percentiles from the NRWQN, which is "comforting". Percentiles for dissolved reactive phosphorus ("DRP" equivalent to FRP) and ammoniacal-N ("NH4") are also similar to, but somewhat lower than, for SE Australia.

Of the nutrients, the greatest difference between NZ and SE Australia is for oxidised-N ("NO3"). The 80 percentiles for oxidised-N in Table 1 are appreciably higher than for SE Australia, particularly for lowland sites. This raises questions about the designation of these three lowland sites as "baseline" or "pseudo-baseline". Nitrate-N is a good indicator of land use and it seems likely that the Ohinemuri River in particular (designated as "pseudo-baseline") is actually appreciably impacted by agricultural runoff. I notice that the trigger value (190 ppb) for upland rivers in Tasmania, which may be climatically more comparable with NZ, is much higher than for upland SE Australia generally (15 ppb).

The 20 and 80 percentile values for % saturation DO are very close, suggesting a very "tight" distribution of the data around 100% saturation. The 80 percentile pH for upland NZ rivers is 8.00 pH units, appreciably above that (7.5) for SE Australia. Other trigger values for pH and DO are well within SE Australian values. As noted above, the DO and pH percentiles may not be very useful as trigger values because of diurnal and seasonal variation.

The 80 percentiles for turbidity in NZ are low compared to the wide range given for SE Australia. No comparative visibility data are available for SE Australia.

ACKNOWLEDGEMENTS

Thanks to Mark O'Donohue, Monash University, Victoria, for explaining the concepts behind trigger values, and to Bob Zuur, Ministry for Environment, for providing liason. Graham Bryers provided data from the NRWQN and carried out preliminary site sorting and data processing. Graham and Bryce Cooper reviewed the report.

REFERENCES

Hart, B.T.; Maher, B.; Lawrence, I. (1999). New generation water quality guidelines for ecosystem protection. *Freshwater biology 41*: 347-359.

Smith, D.G.; McBride, G.B. (1990). New Zealand's National Water Quality Monitoring Network- design and first year's operation. *Water resources bulletin 26*: 767-775.

Table 1. Trigger values for New Zealand rivers

Data from the National Rivers Water Quality Network (NRWQN). Percentiles compiled 18/5/2000 by R. J. Davies-Colley
Baseline or Pseudo-baseline Sites, JANUARY 1989 TO DECEMBER 1998 (10 YEARS)

	TP	**DRP**	**TN**	**NO3**	**NH4**	**DO%**	**pH**	**Clar**	**Turb**	**Temp**	**Temp**
	ppb P	ppb P	ppb N	ppb N	ppb N	%	units	m	FTU	Deg C	*Feb. only* Deg C
Upland sites, elevation > 150 m (= 28 SITES)											
NO. OBSERVATIONS	3388	3394	3032	3396	3047	3365	3360	3382	3399	3400	278
80th PERCENTILE	24	6.0	230	108	9	103.7	8.01		5.00	14.4	18.1
20th PERCENTILE						99.1	7.42	0.65			
Upland sites, elevation > 150 m, glacial and lake-fed sites removed (= 18 SITES)											
NO. OBSERVATIONS	2194	2199	1960	2200	1973	2176	2179	2188	2202	2202	179
80th PERCENTILE	26	9.0	295	167	10	102.8	8.00		4.10	13.9	17.9
20th PERCENTILE						98.9	7.3	0.8			
SE Australia (upland)	***20***	***15***	***250***	***15***	***13***	***110***	***7.5***		***2 to 25***		
						90	***6.5***				
Lowland sites, elevation < 150 m (= 4 SITES)											
NO. OBSERVATIONS	473	473	422	474	426	474	470	473	473	474	38
80th PERCENTILE	28	9.0	555	391	15	103.1	7.77		4.89	16.9	20.3
20th PERCENTILE						97.4	7.2	0.75			
Lowland sites, elevation < 150 m, Haast River (alpine headwaters) removed (= 3 SITES)											
NO. OBSERVATIONS	353	353	315	354	318	354	351	353	353	354	30
80th PERCENTILE	33	10.0	614	444	21	105	7.87		5.58	16.1	21.5
20th PERCENTILE						98	7.15	0.56			
SE Australia (lowland)	***50***	***20***	***500***	***40***	***20***	***110***	***8***		***6 to 50***		
						85	***6.5***				

APPENDIX 1.

Appendix. 1. NRWQN baseline or pseudobaseline site data

Region	Site Code	Place	Map Series	MapID	x	y	Tideda #	Catch. Area km2	Highest Catch. Elev m	Site Elev m
Whangarei	WH1	Waipapa @ Forest Ranger	NZMS260	P05	734	584	47804	122	237	30
Hamilton	HM1	Waipa @ Otewa	NZMS260	S16	156	234	43481	304	413	80
Hamilton	HM6	Ohinemuri @ Karangahake	NZMS260	T13	506	172	9213	305	248	10
Rotorua	*RO1*	*Tarawera @ Lake outlet*	*NZMS260*	*V16*	*169*	*297*	*15341*	*414*	*455*	*320*
Rotorua	RO4	Whirinaki @ Galatea	NZMS260	V17	368	953	15410	509	528	205
Rotorua	*RO6*	*Waikato @ Reids Farm*	*NZMS260*	*U18*	*778*	*763*	*1143444*	*3305*	*655*	*349*
Turangi	TU2	Tongariro @ Turangi	NZMS260	T19	537	417	1043459	786	1005	363
Wanganui	WA2	Manganui @ SH3	NZMS260	Q20	189	130	39508	19	725	320
Wanganui	WA5	Rangitikei @ Mangaweka	NZMS260	T22	504	512	32702	2689	864	518
Wanganui	WA7	Manawatu @ Weber Rd	NZMS260	U23	747	26	32503	716	371	152
Gisborne	GS2	Waikohu @ No. 1 Br.	NZMS260	X17	83	997	19734	30.5	722	457
Havelock Nth	HV1	Makaroro @ Burnt Br.	NZMS260	U22	928	489	23218	121	863	329
Havelock Nth	HV4	Ngaruroro @ Kuripapango	NZMS260	U20	969	974	23104	384	1108	488
Havelock Nth	HV6	Mohaka @ Glenfalls	NZMS260	V20	240	188	21803	1040	820	320
Wellington	WN2	Hutt @ Kaitoke	NZMS260	S26	942	150	29808	87	576	200
Wellington	WN5	Ruramahanga @ SH2	NZMS260	S25	299	461	29254	78	829	268
Nelson	NN2	Motueka @ Gorge	NZMS260	N28	28	526	57008	166	1049	376
Nelson	NN3	Wairau @ Dip Flat	NZMS260	N29	36	234	60114	521	1422	655
Nelson	*NN5*	*Buller @ Longford*	*NZMS260*	*M29*	*590*	*378*	*93202*	*1404*	*888*	*183*
Greymouth	GY3	Grey @ Waipuna	NZMS260	K31	100	718	91404	642	774	171
Greymouth	*GY4*	*Haast @ Roaring Billy*	*NZMS260*	*G37*	*129*	*895*	*86802*	*1027*	*1009*	*53*
Christchurch	*CH1*	*Hurunui @ Mandamus*	*NZMS260*	*M33*	*725*	*240*	*65104*	*1060*	*976*	*442*
Christchurch	*CH3*	*Waimakariri @ Gorge*	*NZMS260*	*L35*	*331*	*605*	*66402*	*2387*	*1034*	*244*
Tekapo	TK3	Opuha @ Skipton Br.	NZMS260	J38	482	790	69614	458	1020	238
Tekapo	*TK4*	*Waitaki @ Kurow*	*NZMS260*	*I40*	*80*	*88*	*71104*	*9741*	*1047*	*250*
Alexandra	*AX1*	*Clutha @ Luggate Br.*	*NZMS1*	*S12*	*4 78*	*85*	*75241*	*4453*	*973*	*305*
Alexandra	*AX2*	*Kawarau @ Chards*	*NZMS260*	*F41*	*844*	*698*	*75262*	*4302*	*1043*	*305*
Alexandra	*AX3*	*Shotover @ Bowens Peak*	*NZMS260*	*F41*	*722*	*710*	*75276*	*1079*	*1200*	*320*
Dunedin	DN2	Sutton @ SH87	NZMS260	H43	832	84	74338	151	672	220
Dunedin	DN6	Mataura @ Parawa	NZMS260	E43	635	73	77505	787	787	259
Dunedin	DN7	Oreti @ Lumsden	NZMS260	E44	541	892	78607	1139	694	220
Dunedin	*DN10*	*Monowai below Gates*	*NZMS260*	*C44*	*853*	*751*	*79712*	*258*	*701*	*213*

Notes - Sites in italics have alpine headwaters or are lake-fed

APPENDIX 2.

Appendix 2. NRWQN site description

Site Code	**Type**	**Brief Description & Reasons for Inclusion**
WH1	Baseline	Largely native bush and small amount exotic.
HM1	Baseline	Catchment largely native bush; unlikely to change. Little pasture.
HM6	Baseline*	*Pseudobaseline. Major tributary of the Waihou River. Contains or will contain discharges from several large gold mining operations. Some pa
RO1	*Baseline*	*Catchment includes several Rotorua lakes; mainly bush but some pasture/exotics. Some natural geothermal inputs.*
RO4	Baseline	With major forestry. Major tributary of Rangitikei. Useful paired with RO3 - geology upstream very different (RO3 -Taupo pumice, flat; RO4 - U
RO6	*Baseline**	**Psuedobaseline for Waikato region. Major recreation river. Downstream 0f Lake Taupo (area 623 km2). See TU2 and Waikato region.*
TU2	Baseline	For Waikato system although some catchment development for pasture/exotics. Major international trout fishery. See RO6 and Waikato egion
WA2	Baseline	With small amount of pasture development. Representative of radial streams from Mt Taranaki. Local trout fishing.
WA5	Baseline*	*Pseudo baseline. Largely undeveloped bush/tussock catchment; some pasture. Nationally important for recreation (rafting, fishing).
WA7	Baseline*	*Pseudo baseline. Some upstream pasture development.
GS2	Baseline	Baseline for Waipaoa and, because of similar geology to Motu River catchment, can also be used as Motu baseline.
HV1	Baseline	Baseline for Tukituki (HV2). Some pasture development but mainly bush.
HV4	Baseline	Bush/tussock.
HV6	Baseline*	*Pseudo baseline. Mainly bush catchment but some pasture and exotic development.
WN2	Baseline	Bush catchment
WN5	Baseline	Bush catchment with a small amount of exotics and pasture.
NN2	Baseline	Native bush catchment.
NN3	Baseline	Native bush catchment.
NN5	*Baseline**	**Pseudo baseline. Beech forest catchment; some pasture development. (Impact site is GY1).*
GY3	Baseline	Beech forest catchment. Some minor upstream development for holiday homes.
GY4	*Baseline*	*Largest alpine-fed Westland river; representative in terms of catchment geology and lack of development.*
CH1	*Baseline*	*Typical high alpine catchment, tussock, beech.*
CH3	*Baseline*	*A major (and representative) braided river of the Canterbury Plains. Major fishery and recreation value. Alpine fed.*
TK3	Baseline*	Pseudo baseline, for Opihi system. Some development.
TK4	*Baseline*	*For river at end of hydroelectric lakes system. Main river in region. Little upstream development.*
AX1	*Baseline*	*Takes L. Wanaka and L. Hawea waters. Some catchment devpt. Starting point of the country's major river upstream of hydro electric develop*
AX2	*Baseline**	**Pseudo baseline; Little catchment development. Major tourist vlues (and pressures) being downstream of Queenstown and L. Wakatipu. The*
AX3	*Baseline**	**Pseudo baseline; little catchmentdevelopment. Major tributary of Kawarau R. Subject to tourist pressure, past and current alluvial gold minin*
DN2	Baseline	Tussock catchment typical of region. Largely undeveloped. Typical input to taieri.
DN6	Baseline	Tussock with beech forst patches. Small amount of pasture development.
DN7	Baseline*	*Pseudo baseline. Improved pasture on plains. Extensively grazed tussock elsewhere. Regional fishery.
DN10	*Baseline*	*(Baseline (although from man-enhance lake) for Waiau system. Wholly beech forest. National Park status.*

Notes - Sites in italics have alpine headwaters or are lake-fed

Appendix 3
DataDesk summaries of percentiles for baseline or pseudo-baseline NRWQN sites

1. Lowland sites (< 150 m elevation)

a. Four baseline lowland sites: WH1 (Waipapa), HM1 (Waipa @ Otewa), HM6 (Ohinemuri), GY4 (Haast).

Summaries
No Selector
Percentile 20

Variable	Count	Mean	Median	Lower ith %tile	Upper ith %tile
TP	473	32.3087	15	7	28
DRP	473	6.12262	5	2	9
TN	422	318.749	212.5	70	555
NO3	474	199.586	78.5	22	390.7
NH4	426	13.5845	7	4	15
DO%	474	100.349	99	97.4	103.1
pH	470	7.55787	7.56	7.2	7.775
Clar	473	2.15696	1.9	0.75	3.119
Turb	473	8.04655	1.8	0.991	4.89
Temp	474	12.8091	12.5	9	16.9
BOD5	473	0.45803	0.4	0.2	0.65

b. Three baseline lowland sites (Haast removed being alpine affected)

Summaries
cases selected according to Select NOT Haast
Percentile 20

Variable	Count	Mean	Median	Lower ith %tile	Upper ith %tile
TP	353	39.6941	18	8	33
DRP	353	6.65609	6	1.4	10
TN	315	390.251	325	74	614
NO3	354	258.895	195	36	444.1
NH4	318	16.5031	8	4	21
DO%	354	101.448	99.7	98	104.94
pH	351	7.55564	7.53	7.15	7.87
Clar	353	2.12649	1.8	0.561	2.998
Turb	353	9.81598	1.8	0.991	5.58
Temp	354	12.2342	11.5	8.4	16.14
BOD5	353	0.49957	0.4	0.2	0.7

c. Temp summary is not very useful because of seasonality, so we select just February data

Summary of Temp
cases selected according to Select Feb
474 total cases of which 436 are missing
Percentile 20

Count 38
Mean 17.8842
Median 18.75
Lower ith %tile 14.67
Upper ith %tile 20.28

Summary of Temp
cases selected according to Feb, NOT Haast

474 total cases of which 444 are missing
Percentile 20

Count	30
Mean	19.4633
Median	19.25
Lower ith %tile	17.75
Upper ith %tile	21.45

2. Upland sites (> 150 m elevation)

d. 28 Upland baseline sites

Summaries
No Selector
Percentile 20

Variable	Count	Mean	Median	Lower ith %tile	Upper ith %tile
TP	3388	28.9153	9	4	24
DRP	3394	4.26827	2.7	1	6
TN	3032	159.67	91.5	54.9	230
NO3	3396	76.6623	31	9	108
NH4	3047	6.32622	5	3	9
DO%	3365	101.415	101	99.1	103.7
pH	3360	7.71887	7.73	7.42	8.01
Clar	3382	3.12273	2.4	0.65	5.2
Turb	3399	8.7449	1.2	0.5	5
Temp	3400	10.6379	10.35	6.95	14.4
BOD5	3390	0.35792	0.3	0.1	0.5

e. 18 Upland baseline sites (alpine and/or lake-fed sites removed)

Summaries
cases selected according to Select NOT glacial, lake
Percentile 20

Variable	Count	Mean	Median	Lower ith %tile	Upper ith %tile
TP	2194	28.737	11	5	26
DRP	2199	5.96016	4	2	9
TN	1960	205.702	140	63	295
NO3	2200	106.626	49.5	15	167
NH4	1973	6.99088	6	3	10
DO%	2176	100.945	100.7	98.87	102.8
pH	2179	7.65826	7.62	7.3	8
Clar	2188	3.03631	2.385	0.8	4.718
Turb	2202	8.43552	1.3	0.55	4.1
Temp	2202	10.1807	9.75	6.6	13.9
BOD5	2197	0.40318	0.3	0.15	0.6

f. Temp summary is not very useful because of seasonality, so we select just February data

Summary of Temp
cases selected according to Select Feb
3404 total cases of which 3126 are missing
Percentile 20

Count 278
Mean 15.9004
Median 16
Lower ith %tile 13.6
Upper ith %tile 18.09

Summary of Temp
cases selected according to Feb, NOT glacial, lake
3404 total cases of which 3226 are missing
Percentile 20

Count 178
Mean 15.4309
Median 15.5
Lower ith %tile 13.2
Upper ith %tile 17.9