WATER QUALITY ASSESSMENT IN TANGKULAP AND DERAMAKOT FOREST RESERVE 2022

by

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INTRODUCTION

A water quality assessment was carried out by the Deramakot FMU staff to assess the quality of 3 rivers in Deramakot FR, namely Sg. Tebelion, Sg. Mannan and Sg. Kun-kun rivers. The samples were analysed by Chemsains Konsultant Sdn. This report provides the results and discussion of water quality as part of the environmental monitoring component for the Tangkulap and Deramakot Sustainable Forest Management Project areas.

LOCATION OF STUDY AREA

A total of 3 sampling points represent the project watershed and its sub-catchment areas which predominantly drain through the project site. These sampling points are labelled WSP1 to WSP3 (Table 1, Figure 1). All the headwaters of these rivers derived from within Deramakot itself. The chemical analyses and water quality classes for all parameters tested for the sampling points in the project area are listed in Table 2. The location of the water sampling point taken is provided in Table 1, while the water quality classes for all selected parameters and chemical analysis tested for the water samples in this project area are listed in Table 2.

Table 1. The Location of Water Quality Sampling Point in Tangkulap and Deramakot FR

Sampling Point	Location	GPS location		Date of Sampling	Surrounding Condition
		Latitude	Longitude		
WSP1	Sg. Tebelion	N 05° 21' 51.16"	E 177° 32' 01.11"	08 December 2022	Secondary forest
WSP2	Sg. Mannan (Basecamp)	N 05° 22' 01.99"	E 177° 25' 29.87"		Secondary forest
WSP3	Sg. Kun-kun	N 05° 29' 22.53"	E 177°11' 35.14"		Secondary forest

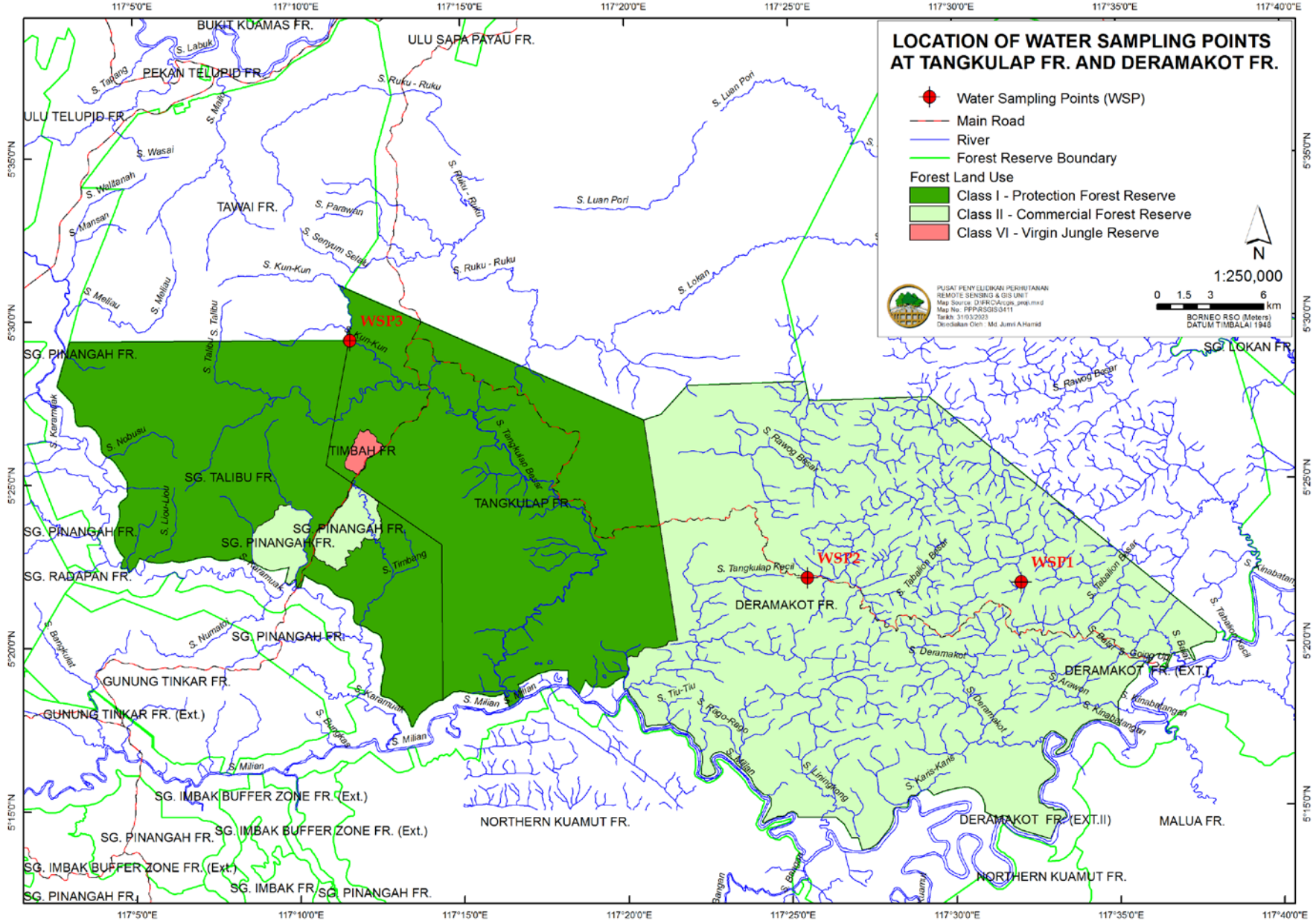

Figure 1 The location of 3 water sampling points WSP1 – WSP3 to assess river water quality in Tangkulap and Deramakot Forest Reserve, Sabah.

RESULT

Water Quality

The chemical analysis and water quality classes for all parameters tested for the sampling points in the project area are listed in the table below.

Table 2. The results of chemical analyses and water quality classes for all parameter tested for sampling location WSP1, WSP2, and WSP3 in Tangkulap and Deramakot SFM Project areas, Sabah. Note: Biological Oxygen Demand (BOD in mg/l), Chemical Oxygen Demand (COD in mg/l), Ammoniacal Nitrogen (AN in mg/l), Suspended Solids (SS in mg/l), Dissolved Oxygen (DO in mg/l), faecal coliform (MPN/100mL), total coliform (MPN/100mL), and oil & grease (mg/l).

	Sampling Location	**Dissolved Oxygen, DO (mg/l)**	**Biological Oxygen Demand**	**Chemical Oxygen Demand**	**Suspended Solid**	**pH Value**	**Ammoniacal-Nitrogen (as N3-N in mg/l)**	**Oil & Grease (mg/l)**	**Total Coliform Count (MPN/100mL)**	**Fecal Coliform Count (MPN/100mL)**
Sg. Tebelion	**WSP_1**	4.8	2	10	10	7	0.06	1.5	9200	330
Sg. Mannan	**WSP_2**	4.6	2	23.2	10	6.8	0.06	1.5	790	490
Sg. Kun-kun	**WSP_3**	5.2	2	14.9	5	7.3	0.05	1.5	1100	230
Minimum		4.6	2	10	5	6.8	0.05	1.5	790	230
Maximum		5.4	2	23.2	10	7.3	0.06	1.5	9200	330
Mean		4.87	2.00	16.03	8.33	7.03	0.06	1.50	3696.67	350.00
NWQSM*		W1 & W2 : Class III W3 : Class II	Class II	Class I	Class I	Class I	Class I	NA	W1 : Class IIB W2 & W3 : Class I	Class II

DISSCUSION

Dissolved Oxygen (DO)
DO is an essential indicator in supporting aquatic life. It measures the amount of oxygen (O_2) that is dissolved in the water (Table 2). The DO levels for sampling points WSP1 and WSP2 are registered as Class III and WSP3 sampling points in Class II under the National Water Quality Standards for Malaysia.

Biological Oxygen Demand (BOD)
This parameter is a measure to indicate the presence of organic waste in the river. All sampling points registered BOD levels within Class II under Malaysia's National Water Quality Standards (Table 2).

Chemical Oxygen Demand (COD)
This parameter is an indicator of organics in the water and is usually used in association with BOD. All sampling points are classified under Class I (Table 2) of Malaysia's National Water Quality Standards.

Total Suspended Solid
TSS indicates the amount of land disturbance within the catchment area and relates to the erosion that occurred near the sampling area or upstream. All sampling points are registered under Class I of the NWQSM.

pH Value
Based on the National Water Quality Standards for Malaysia, all sampling points' pH levels are classified within the Class I water quality range (Table 2). The narrow concentration of hydrogen ions between pH 6 to 9 indicates the typical suitability range for the existence of most biological life.

Ammoniacal- Nitrogen (as N_3-N)
This parameter is an indicator of pollution from excessive usage of ammonia-rich fertilisers. It is used to measure the health of the water in natural bodies such as rivers or lakes or manmade water reservoirs. All sampling points registered levels of AN as Class I under the National Water Quality Standards for Malaysia (Table 2).

Oil and Grease
This parameter aims to test whether indiscriminate oil or oily waste has been dumped into the water systems. All samples showed levels of oil and grease below measurable ranges (<1.5 mg/l) and reflected near-natural reference levels (Table 2).

Total Coliform Count (TCC)
The term total coliform count (TCC) refers to a numerical count that generally includes both faecal and non-faecal coliforms. The observation is used to highlight bacterial contamination of the waters. Sampling points WSP1 show elevated levels as Class III. The sampling points WSP2 and WSP3 registered TCC levels under Class I, of the National Water Quality Standards for Malaysia.

Faecal Coliform Count (FCC)
The term refers to a subset numerical count of total coliform, primarily comprising faecal coliforms bacteria, that originates from the guts of warm-blooded animals and humans. The observation is used as an indicator of faecal matters. All sampling points registered FCC levels within Class I under Malaysia's National Water Quality Standards.

Synthesis of assessment

Generally, the tests for water quality sampling from the various local rivers are characterised as clean (Table 3). The pH for all rivers generally complied with the standards set for water under Class I of the NQWSM. The pHs for all sampling points are within an acceptable limit.

All rivers indicated no trace of oil and grease and harmful levels of ammonium nitrate (an indicator of extremely used fertiliser). There is no indication of excessive usage of ammonia-rich fertilisers, shown by the Ammoniacal-Nitrogen (N3-N) result, which complied with the standards under Class I of the National Water Quality Standards for Malaysia. For total suspended solid, all sampling points generally complied with the standards set for water under Class I of the National Water Quality Standards for Malaysia, indicating that the impact of soil erosion is minimal. No indications of organic pollution in all sampling points, as the BOD for all sampling points are under Class II of NQWSM. For DO amounts, sampling points WSP1 and WSP2 show elevated levels for DO with Class III of NQWSM. Other sampling points show Class II of NQWSM. DO are essential for the aquatic life within the river water. A low DO level would threaten the aquatic community.

Based on the total and faecal coliform counts, all sampling points' bacterial contamination levels are low and show no sewerage problem. All sampling points generally complied with the standards set for water under Class I and Class II of the National Water Quality Standards for Malaysia.

Water Quality Index (WQI)

Based on the river water quality index, all sampling points fall within the Clean water quality status. It is recommended that the management team maintain or install signage at all sampling points to prevent people from dumping waste into the watercourse. Furthermore, the management should periodically brief departmental and contract workers on this matter and protect the water quality in all the rivers. The management may also need to conduct periodic inspections and monitoring of existing sewage and septic tanks in all office and living quarters within the FMU to prevent deterioration of the waste treatment system.

The results of water quality index for WSP1 to WSP3 sampling points are listed in Table 3.

Table 3. The water quality index (WQI) for WSP1 to WSP3 sampling points in Tangkulap and Deramakot Project Area. (Note: DO % saturation values were calculated based on dissolved oxygen saturation factor of 8.26 mgL^{-1} at temperature 25° C).

Attributes	Sampling Point		
	WSP1	WSP2	WSP3
DO%	58.09	55.67	62.93
BOD	2	2	2
COD	10	23.2	14.9
SS	10	10	5
pH	7	6.8	7.3
NH3-NL	0.06	0.06	0.05
SIDO	61.63	58.07	68.56
SIBOD	91.94	91.94	91.94
SICOD	85.8	70.628617	79.283
SIAN	94.2	94.2	95.25
SISS	91.63	91.63	94.51
SIpH	99.35	98.98	98.12
WQI	85.47	82.21	86.42
CLASS	II	II	II
WQ STATUS	C	C	C

REFERENCES

Department Of Environment Malaysia (DOE), 2020. Malaysia Environmental Quality Report 2020. https://enviro2.doe.gov.my/ekmc/digital-content/laporan-kualiti-alam-sekeliling-environmental-quality-report-2020/

http://www.wepa-db.net/policies/law/malaysia/eq_surface.htm

APPENDIX I

METHODOLOGY

Sampling Method and Parameters Tested for Chemical Analyses

The grab sampling technique was used to collect water samples. All samples were preserved accordingly and sent to Chemsain Konsultant Sdn. Bhd (an accredited laboratory), company number 130904-U for analysis within 24 hours. Parameters tested are according to the DOE Water Quality Index (WQI) with additional other physical and microbiological analyses of the waters. The parameters tested were concentration of hydrogen ion (pH), Biological Oxygen Demand (BOD in mg/l), Chemical Oxygen Demand (COD in mg/l), Ammoniacal Nitrogen (AN in mg/l), Suspended Solid (SS in mg/l), Dissolved Oxygen (DO in mg/l), faecal coliform (MPN/100mL), total coliform (MPN/100mL), and oil & grease (mg/l). The results for all parameters were tested by Chemsain Konsultant Sdn. Bhd are listed in Appendix II.

Water Quality Index For Sg Kawag, Sg. Bole, Sg. Segama, Sg. Danum, Sg. Malua and Sg. Segama Ulu

Water Quality Index (WQI) is used to determine the water quality status and to classify the rivers based on WQI and the Interim National Water Quality Standards for Malaysia (INWQSM). It also provides a convenient means of summarizing water quality data for sampled river water. The existing WQI equations are proposed by the Department of Environment Malaysia. DOE river water monitoring programme was practised in Malaysia since the year 1978. Water quality data were used to determine the water quality status whether in the clean, slightly polluted or polluted category and to classify the rivers in Class I, II, III, IV or V based on Water Quality Index (WQI) and National Water Quality Standards for Malaysia (NWQS).

The results of the water quality sampling receive from Chemsain Konsultant Sdn. Bhd (an accredited laboratory) for sampling points namely W1 and W6 was calculated using the Water Quality Index (WQI) to determine the status and classify the rivers. The formulas used in the calculation of WQI are:

$$\mathbf{WQI = 0.22SIDO+0.19SIBOD+0.16SICOD+0.16SISS+0.15SIAN+0.12SI\ pH} \quad (1)$$

where, WQI = Water quality index; SIDO = Sub-index of DO; SIBOD = Sub-index of BOD; SICOD = Sub-index of COD; SIAN = Sub-index of AN; SISS = Sub-index of TSS; SIpH = Sub-index of pH.

Sub-index for DO (in % saturation):

$SIDO = 0$ for $DO < 8$ (2a)

	= 100 for	DO > 92	(2b)
	$= -0.395 + 0.030DO^2 - 0.00020DO^3$	for 8 < DO < 92	(2c)

Sub-index for BOD:

SIBOD	= 100.4 – 4.23BOD	for BOD < 5	(3a)
	$= 108e^{-0.055BOD} - 0.1BOD$	for BOD > 5	(3b)

Sub-index for COD:

SICOD	= -1.33COD + 99.1	for COD < 20	(4a)
	$= 103e^{-0.0157COD} - 0.04COD$	for COD > 20	(4b)

Sub-index for AN:

SIAN	= 100.5 – 105AN	for AN < 0.3	(5a)
	$= 94e^{-0.573AN} - 5 \mid AN - 2 \mid$	for 0.3 < AN < 4	(5b)
	= 0	for AN > 4	(5c)

Sub-index for SS:

SISS	$= 97.5e^{-0.00676SS} + 0.05SS$	for SS < 100	(6a)
	$= 71e^{-0.0016SS} - 0.015SS$	for 100 < SS < 1000	(6b)
	= 0	for SS > 1000	(6c)

Sub-index for pH:

SIpH	$= 17.2 - 17.2pH + 5.02pH^2$	for pH < 5.5	(7a)
	$= -242 + 95.5pH - 6.67pH^2$	for 5.5 < pH < 7	(7b)
	$= -181 + 82.4pH - 6.05pH^2$	for 7 < pH < 8.75	(7c)
	$= 536 - 77.0pH + 2.76pH^2$	for pH > 8.75	(7d)

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

PARAMETER	UNIT	CLASS				
		I	IIA/IIB	III#	IV	V
A l	mg/l	NATURAL LEVEL OR ABSENT	-	(0.06)	0.5	LEVEL ABOVE IV
As	mg/l		0.05	0.4 (0.05)	0.1	
Ba	mg/l		1	-	-	
Cd	mg/l		0.01	0.01* (0.001)	0.01	
Cr (VI)	mg/l		0.05	1.4 (0.05)	0.1	
Cr (III)	mg/l		-	2.5	-	
Cu	mg/l		0.02	-	0.2	
Hardness	mg/l		250	-	-	
Ca	mg/l		-	-	-	
Mg	mg/l		-	-	-	
Na	mg/l		-	-	3 SAR	
K	mg/l		-	-	-	
Fe	mg/l		1	1	1 (Leaf) 5 (Others)	
Pb	mg/l		0.05	0.02* (0.01)	5	
Mn	mg/l		0.1	0.1	0.2	
Hg	mg/l		0.001	0.004 (0.0001)	0.002	
NI	mg/l		0.05	0.9*	0.2	
Se	mg/l		0.01	0.25 (0.04)	0.02	
Ag	mg/l		0.05	0.0002	-	
Sn	mg/l		-	0.004	-	
U	mg/l		-	-	-	
Zn	mg/l		5	0.4*	2	
B	mg/l		1	(3.4)	0.8	
Cl	mg/l		200	-	80	
Cl_2	mg/l		-	(0.02)	-	
CN	mg/l		0.02	0.06 (0.02)	-	
F	mg/l		1.5	10	1	
NO_2	mg/l		0.4	0.4 (0.03)	-	
NO_3	mg/l		7	-	5	
P	mg/l		0.2	0.1	-	
Silica	mg/l		50	-	-	
SO_4	mg/l		250	-	-	
S	mg/l		0.05	(0.001)	-	
CO_2	mg/l		-	-	-	
Gross-α	Bq/l		0.1	-	-	
Gross-β	Bq/l		1	-	-	
Ra-226	Bq/l		< 0.1	-	-	
Sr-90	Bq/l		< 1	-	-	
CCE	mg/l		500	-	-	-
MBAS/BAS	mg/l		500	5000 (200)	-	-
O & G (Mineral)	mg/l		40; N	N	-	-
O & G (Emulsified Edible)	mg/l		7000; N	N	-	-
PCB	mg/l		0.1	6 (0.05)	-	-
Phenol	mg/l		10	-	-	-
Aldrin/Dieldrin	mg/l		0.02	0.2 (0.01)	-	-
BHC	mg/l		2	9 (0.1)	-	-
Chlordane	mg/l		0.08	2 (0.02)	-	-
t-DDT	mg/l		0.1	(1)	-	-
Endosulfan	mg/l		10	-	-	-
Heptachlor/Epoxide	mg/l		0.05	0.9 (0.06)	-	-
Lindane	mg/l		2	3 (0.4)	-	-
2,4-D	mg/l		70	450	-	-
2,4,5-T	mg/l		10	160	-	-
2,4,5-TP	mg/l		4	850	-	-
Paraquat	mg/l		10	1800	-	-

Notes :
* = At hardness 50 mg/l CaCO
# = Maximum (unbracketed) and 24-hour average (bracketed) concentrations
N = Free from visible film sheen, discolouration and deposits

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Electrical Conductivity*	µS/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	%	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2°C	-	Normal + 2°C	-	-
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform**	count/100 ml	10	100	400	5000 (20000)[a]	5000 (20000)[a]	-
Total Coliform	count/100 ml	100	5000	5000	50000	50000	> 50000

Notes :

N : No visible floatable materials or debris, no objectional odour or no objectional taste

* : Related parameters, only one recommended for use

** : Geometric mean

a : Maximum not to be exceeded

WATER CLASSES AND USES

CLASS	USES
Class I	Conservation of natural environment. Water Supply I – Practically no treatment necessary. Fishery I – Very sensitive aquatic species.
Class IIA	Water Supply II – Conventional treatment required. Fishery II – Sensitive aquatic species.
Class IIB	Recreational use with body contact.
Class III	Water Supply III – Extensive treatment required. Fishery III – Common, of economic value and tolerant species; livestock drinking.
Class IV	Irrigation
Class V	None of the above.

DOE WATER QUALITY CLASSIFICATION BASED ON WATER QUALITY INDEX

SUB INDEX & WATER QUALITY INDEX	INDEX RANGE		
	CLEAN	SLIGHTLY POLLUTED	POLLUTED
Biochemical Oxygen Demand (BOD)	91 - 100	80 - 90	0 - 79
Ammoniacal Nitrogen (NH_3-N)	92 - 100	71 - 91	0 - 70
Suspended Solids (SS)	76 - 100	70 - 75	0 - 69
Water Quality Index (WQI)	81 - 100	60 - 80	0 - 59

DOE WATER QUALITY INDEX CLASSIFICATION

PARAMETER	UNIT	CLASS				
		I	II	III	IV	V
Ammoniacal Nitrogen	mg/l	< 0.1	0.1 – 0.3	0.3 – 0.9	0.9 – 2.7	> 2.7
Biochemical Oxygen Demand	mg/l	< 1	1 – 3	3 – 6	6 – 12	> 12
Chemical Oxygen Demand	mg/l	< 10	10 – 25	25 – 50	50 – 100	> 100
Dissolved Oxygen	mg/l	> 7	5 – 7	3 – 5	1 – 3	< 1
pH	-	> 7.0	6.0 – 7.0	5.0 – 6.0	< 5.0	> 5.0
Total Suspended Solid	mg/l	< 25	25 – 50	50 – 150	150 – 300	> 300
Water Quality Index (WQI)		> 92.7	76.5 – 92.7	51.9 – 76.5	31.0 – 51.9	< 31.0

WQI FORMULA AND CALCULATION

FORMULA

WQI = (0.22 * SIDO) + (0.19 * SIBOD) + (0.16 * SICOD) + (0.15 * SIAN) + (0.16 * SISS) + (0.12 * SIpH)
where;

SIDO = Subindex DO (% saturation)
SIBOD = Subindex BOD
SICOD = Subindex COD
SIAN = Subindex NH_3-N
SISS = Subindex SS
SIpH = Subindex pH
$0 \leq WQI \leq 100$

Best Fit Equations for the Estimation of Various Subindex Values

Subindex for DO (in % saturation)

SIDO = 0	for $x \leq 8$
SIDO = 100	for $x \geq 92$
$SIDO = -0.395 + 0.030x^2 - 0.00020x^3$	for $8 < x < 92$

Subindex for BOD

SIBOD = 100.4 - 4.23x	for $x \leq 5$
SIBOD = 108 * exp(-0.055x) - 0.1x	for $x > 5$

Subindex for COD

SICOD = -1.33x + 99.1 for $x \leq 20$
SICOD = 103 * exp(-0.0157x) - 0.04x for $x > 20$

Subindex for NH_3-N

SIAN = 100.5 - 105x for $x \leq 0.3$
SIAN = 94 * exp(-0.573x) - 5 * | x – 2 | for $0.3 < x < 4$
SIAN = 0 for $x \geq 4$

Subindex for SS

SISS = 97.5 * exp(-0.00676x) + 0.05x for $x \leq 100$
SISS = 71 * exp(-0.0016x) - 0.015x for $100 < x < 1000$
SISS = 0 for $x \geq 1000$

Subindex for pH

SIpH = 17.2 - 17.2x + 5.02x^2 for $x < 5.5$
SIpH = -242 + 95.5x - 6.67x^2 for $5.5 \leq x < 7$
SIpH = -181 + 82.4x - 6.05x^2 for $7 \leq x < 8.75$
SIpH = 536 - 77.0x + 2.76x^2 for $x \geq 8.75$

Note:
* means multiply with

MALAYSIAN MARINE WATER QUALITY STANDARDS

PARAMETER (µG/L) UNLESS OTHERWISE STATED	CLASSIFICATION					
	CLASS 1	CLASS 2	CLASS 3	INTERIM CLASS E1	INTERIM CLASS E2	INTERIM CLASS E3
	SENSITIVE MARINE HABITATS	FISHERIES (INCLUDING MARICULTURE)	INDUSTRY, COMMERCIAL ACTIVITIES & COASTAL SETTLEMENTS	ESTUARIES		
				COASTAL PLAIN	LAGOON	COMPLEX DISTRIBUTARY NETWORK
Dissolved Oxygen (mg/l)	>6.0	>5.0	>3.0	>5.0	>5.0	>5.0
Suspended Solids (mg/l)	25.0	50.0	100.0	30.0	30.0	30.0
Phosphate	5.0	75.0	670.0	100.0	180.0	180.0
Nitrate	10.0	60.0	700.0	200.0	570.0	430.0
Ammonia	35.0	50.0	320.0	5.0	10.0	10.0
Mercury	0.04	0.04	0.04	0.04	0.04	0.04
Cadmium	0.50	2.00	3.00	1.00	1.00	1.00
Chromium (VI)	0.14	10.00	20.00	10.00	10.00	10.00
Copper	1.30	2.90	8.00	1.00	1.00	1.00
Cyniade	2.00	7.00	14.00	5.00	5.00	5.00
Lead	2.20	8.50	12.00	1.30	2.00	2.00
Zinc	7.00	50.00	100.00	16.00	5.00	5.00
Arsenic (III)	1.00	3.00	3.00	3.00	1.00	1.00
Aluminium	27.0	27.0	55.0	27.0	27.0	27.0
TBT	0.001	0.010	0.050	0.002	0.002	0.002
PAH	100.0	200.0	1000.0	5.0	5.0	5.0
Total Phenol	1.0	10.0	100.0	10.0	10.0	10.0
Oil & Grease (mg/l)	0.01	0.14	5.00	1.00	1.00	1.00
Faecal Coliform (cfu/100ml)	70	70	70	70	70	70
Temperature (°C)	≤ 2 °C increase over maximum ambient					
pH	6.5 - 9.0					
Marine Litter	Free from marine litter					

MALAYSIAN MARINE WATER QUALITY INDEX (MMWQI) FORMULA AND CALCULATION

$MMWQI = qi\,DO^{0.18} \times qi\,FC^{0.19} \times qi\,NH_3^{0.15} \times qi\,NO_3^{0.16} \times qi\,PO_4^{0.17} \times qi\,TSS^{0.15}$

whereby;

qi DO	= Subindex Dissolved Oxygen
qi FC	= Subindex Faecal Coliform
qi NH_3	= Subindex Unionized Ammonia
qi NO_3	= Subindex Nitrate
qi PO_4	= Subindex Phosphate
qi TSS	= Subindex Total Suspended Solids

*Salinity of the marine water quality data shall be higher than 10 ppt

BEST FIT EQUATIONS FOR THE ESTIMATION OF VARIOUS SUBINDEX VALUES

Dissolved Oxygen (DO) in mg/l

qi DO = -85.816 + 55.4768(DO) – 4.142$(DO)^2$

If DO is less than (<) 3 mg/l, or more than (>) 10 mg/l, qiDO= 10

Faecal Coliform (FC) in cfu/100ml

qi FC = 100*$EXP^{(-0.005(Faecal\ Coliform))}$

If FC is more than (>) 500 cfu/100ml, qi FC = 8

Unionized Ammonia (NH_3) in µg/l

qi NH_3 = 100*$EXP^{(-0.0046(Unionized\ Ammonia))}$

If Ammoniacal Nitrogen (NH3-N) is measured, convert the value into unionized ammonia.

Nitrate (NO_3) in µg/l

qi NO3 = 94.8*$EXP^{(-0.00035(Nitrate))}$

Phosphate (PO_4) in µg/l

qi PO4 = 95.2*$EXP^{(-0.002(Phosphate))}$

If PO_4 is more than (>) 900µg/l, qi PO_4 = 10

Total Suspended Solids (TSS) in mg/l

qi TSS = 95.8*$EXP^{(-0.0043(Total\ Suspended\ Solid))}$

If TSS is more than (>) 100 mg/l, qiTSS = 20

UNIONIZED AMMONIA CALCULATION

In order to convert the concentration of total ammoniacal nitrogen into unionized ammonia, calculate (a), (b), (c) and (d). Substitute the results into equation 1.

a. Calculation of Ionic Strength (IS)

$$IS = \frac{19.9273 * Salinity}{(1000 - 1.005109 * Salinity)}$$

Salinity in part per thousand (ppt)

b. Calculation of PKa

$$PKa = (0.0901821 + \frac{2729.92}{(Temp + 273.15)} + IS(0.1552 - 0.000314 * Temp)$$

Temperature in °C

c. Calculation of working pH

pHsw = pH – (0.0007 x IS) – 0.131

d. Calculation of mole fraction for unionized ammonia

Mole Fraction =
equation 1:

Ammoniacal nitrogen (NH_3-N) x mole fraction x 17/14

Ammoniacal nitrogen should be measured in µg/l

GROUNDWATER QUALITY STANDARDS FOR CONVENTIONAL RAW WATER TREATMENT (DRINKING WATER)

PARAMETER	STANDARD (mg/L)
Total coliform	5000 MPN/100 ml
E coli	5000 MPN/100 ml
Kekeruhan	1000 NTU
Warna	300 TCU
pH	5.5-9.0
Suhu	Normal ± 2°C
Konduktiviti	1000 µS/cm#
Jumlah Pepejal Terlarut	1500
Klorida	250
Ammonia	1.5
Nitrat	10
Besi	1.0
Fluorida	1.5
Kekerasan	500
Mangan	0.2
COD	10
MBAS	1.0
BOD	6
Nitrit	0.4#
Raksa	0.001
Kadmium	0.003
Arsenik	0.01
Sianida	0.07
Plumbum	0.05
Kromium	0.05
Kuprum	1.0
Zink	3.0
Natrium	200
Sulfat	250
Selenium	0.01
Perak	0.05
Magnesium	150
Minyak	0.3
Racun Perosak (Pesticides)	0.00003-0.03*
Fenol	0.002
Nikel	0.05
Gross alpha	0.1 Bq/l
Gross beta	1.0 Bq/l

*Aldrin/ Dieldrin, DDT, Heptachlor, Methoxychlor, Lindane, Chlordane, Endosulfan, Hexachlorobenzene, 2,4,5–T, 2,4-D, 2,4-DB, Alachlor, Aldicarb, Carbofuran, MCPA, Permethrin

#Diambil dari *Class IIA, National Water Quality Standards*

GROUNDWATER QUALITY INDEX (GWQI) FORMULA AND CALCULATION

To calculate the GWQI, the additive equation is used as follows:

$$GWQI=\sum W_i q_i$$

or

GWQI = 0.13Si(pH) + 0.17Si(Fe) + 0.17Si(*E. coli*)+ 0.04Si(TDS) + 0.09Si(SO_4^{2-}) + 0.22Si(NO_3) + 0.17 Si (Phenol)

The sub-indices of all the parameters used for generating the GWQI are as follows

pH Sub Index

pH	*Si(pH)*	
<3.0	0	Acidic
3 – 4	10	
4 – 5.5	30	
5.5 – 9	100	
9 – 10	30	Alkaline
10 – 11	10	
>11.0	0	

Iron Sub Index

Si (Fe) = (1-$_i$C/5.0) x 100

Si (Fe) = 0, if Ci exceeds 5.0 mg/L; Ci is the concentration of iron determined in the groundwater sample.

Nitrate Sub Index

Si (NO_3^-) = (1 - C_i/100) x 100

Si (NO_3^-) = 0, if C_i exceeds 100 mg/L; C_i is the concentration of nitrate determined in the groundwater sample.

Phenol Sub Index

Si (Phenol) = (1- C_i/0.015) x 100

Si (Phenol) = 0, if Ci exceeds 0.015 mg/L; Ci is the concentration of phenol determined in the groundwater sample.

Total Dissolved Solid Sub Index

Si (TDS) = (1- C_i/3000) x 100

Si (TDS) = 0, if Ci exceeds 3000 mg/L; Ci is the concentration of total dissolved solid determined in the groundwater sample.

Sulfate Sub Index

Si (SO_4^{2-}) = (1- C_i/1000) x 100

Si (SO_4^{2-}) = 0, if Ci exceeds 1000 mg/L; C_i is the concentration of sulfate determined in the groundwater sample.

***E. coli* Sub Index**

Si (E. coli) = (1- C $_i$/5000) x 100

Si (*E. coli*) = 0, if Ci exceeds 5000 MPN/100ml; Ci is the MPN E. coli measured in the groundwater sample.