# REPORT ON THE ASSESSMENT OF WATER QUALITY IN NORTHERN GUNUNG RARA (NGR) FOREST RESERVE 2017

*by*

*Noor Azmizah Binti Andaman, Reuben Nilus & Jabanus Miun*

## INTRODUCTION

An environmental baseline sampling was carried out by Hydrology Unit of Forest Research Centre to characterize the water quality of 4 rivers, which drained thru the Northern Gunung Rara (NGR) Sustainable Forest Management project area. These rivers are Sg.Lanap, Sg. Kasuyan, Sg. Kuamut and Sg. Imbok. This assessment is part of the study component required for the Forest Management Plan for NGR project area.

## LOCATION OF STUDY AREA

A total of 4 sampling points represent the project watershed and its sub-catchment areas which predominantly drain through the project site (Figure 1). These sampling points are labelled W1 to W4 (Table 1). The chemical analyses and water quality classes for all parameters tested for the sampling points in the project area are listed in Table 2.

**Table 1.** The location of water quality sampling points in NGR FR (see Map, Figure 1).

| **Sampling Point** | **Location** | **GPS location** | | **Date of Sampling** | **Surrounding Condition** |
|---|---|---|---|---|---|
| | | Latitude | Longitude | | |
| W1 | Sg. Lanap | 04°59’28. 7” | 117°08’07.1” | 20/10/2017 | Secondary forest |
| W2 | Sg. Kasuyan | 04°55’19.3” | 117°11’18.0” | 20/10/2017 | Secondary forest |
| W3 | Sg. Kuamut | 04°53’45.8” | 117°14’24.3” | 20/10/2017 | Secondary forest |
| W4 | Sg. Imbok | 04°51’04.9” | 117°22’18.7” | 20/10/2017 | Secondary forest |

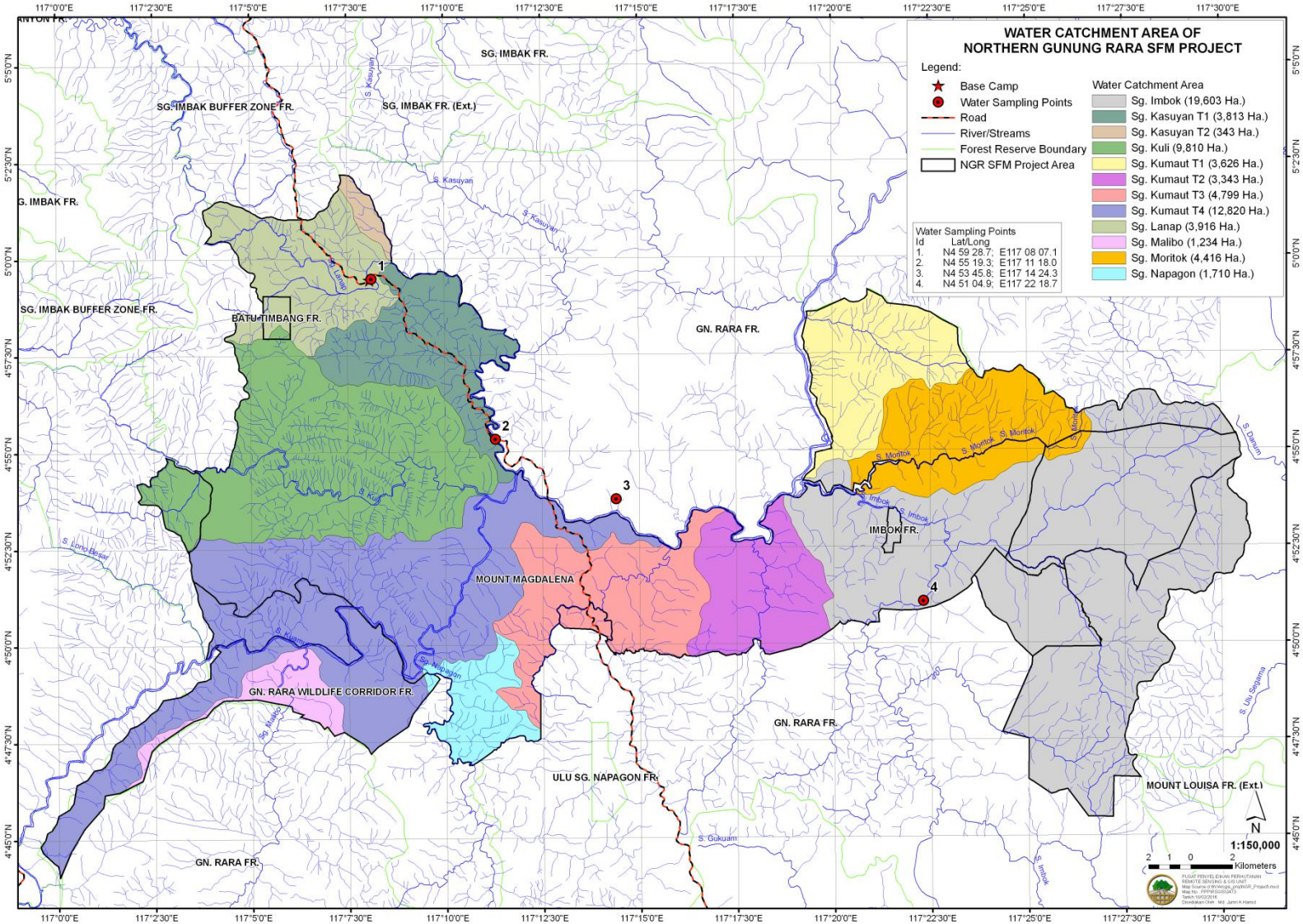


Figure 1. The location of water sampling points to assess river water quality in Northern Gunung Rara Forest Reserve

## RESULTS

### Water Quality

The chemical analyses and water quality classes for all parameters tested for four sampling points in the project area are listed in Table 2.

**Table 2.** The results of chemical analyses and water quality classes for all parameter tested for sampling location W1-W4 in NGR project area . Note: 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), fecal coliform (MPN/100mL), total coliform (MPN/100mL), and oil & grease (mg/l).

| Sampling Location | Dissolved Oxygen, DO (mg/l) | Biological Oxygen Demand (BOD5 in mg/l) | Chemical Oxygen Demand (COD in mg/l) | Suspended Solid (SS in mg/l) | pH Value | Ammoniacal-Nitrogen (as N3-N in mg/l) | Oil & Grease (mg/l) | Total Coliform Count (MPN/100mL) | Fecal Coliform Count (MPN/100mL) |
|---|---|---|---|---|---|---|---|---|---|
| **$W_1$** | 3.9 | 1 | 10 | 5 | 7.24 | 0.39 | 1.5 | 330 | 330 |
| **$W_2$** | 3.47 | 1 | 10 | 5 | 7.21 | 0.14 | 1.5 | 330 | 330 |
| **$W_3$** | 1.8 | 1 | 10 | 31 | 7.1 | 0.07 | 1.5 | 16000 | 2800 |
| **$W_4$** | 5.7 | 1 | 10 | 24 | 7.33 | 0.09 | 1.5 | 2400 | 1300 |
| Minimum | 1.8 | 1 | 10 | 5 | 7.1 | 0.07 | 1.5 | 330 | 330 |
| Maximum | 5.7 | 1 | 10 | 31 | 7.33 | 0.39 | 1.5 | 16000 | 2800 |
| Mean | 3.73 | 1.00 | 10.00 | 16.83 | 7.22 | 0.19 | 1.50 | 5898.33 | 1315.00 |
| **NWQSM*** | **W1 & W2: Class III W3:Class IV W4: Class II** | **Class I** | **Class I** | **Class I** | **Class I** | **W1: Class IIB W2- W4: Class I** | **NA** | **W1, W2, W4: Class I W3: Class IIB** | **W1 & W2: Class IIA W3 & W4: Class IIB** |

* National Water Quality Standards for Malaysia

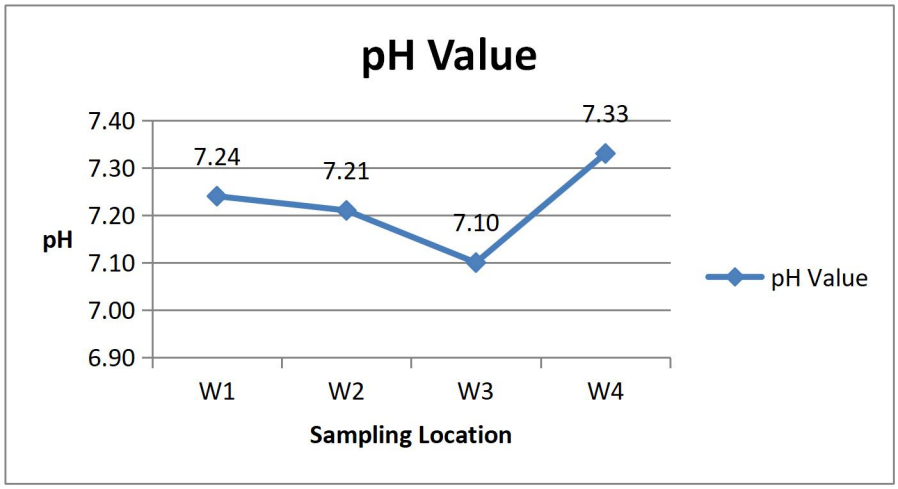


*Figure 2. pH Value*

a) The narrow concentration of hydrogen ions between pH 6 to 9 indicates the typical suitability range for the existence of most biological life. The pH range from 7.10 to 7.33 shows that it is in acceptable limit (Figure 2). Based on the NWQSM, the pH level for all sampling point is classified within the Class I waters quality range (Table 2).

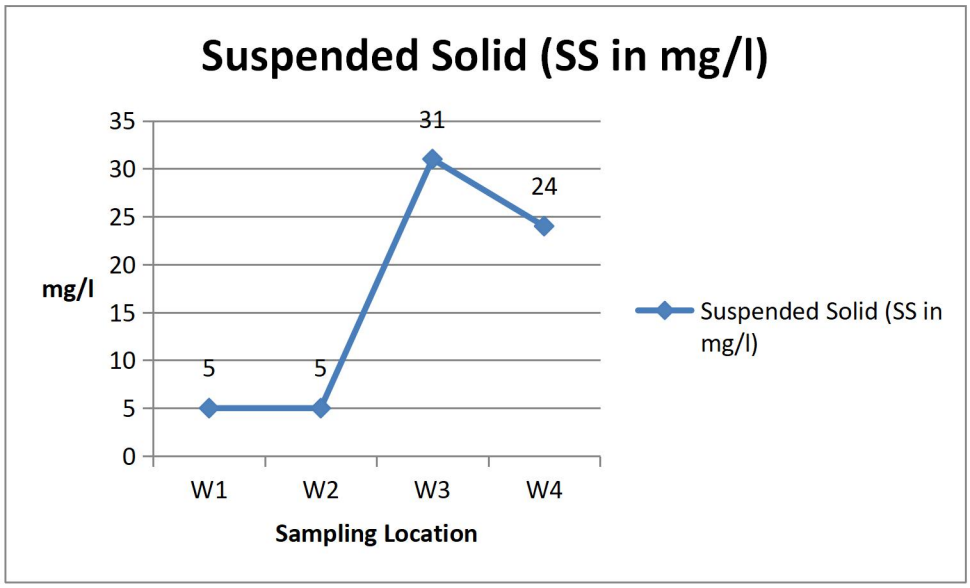


*Figure 3. Total Suspended Solid*

b) TSS is an indicator of the amount of land disturbance within the catchment area and relates to the erosion that took place nearby sampling area or upstream. The TSS range from 5 to 31 mg/l (Figure 3). All sampling points registered TSS levels under Class I waters of the National Water Quality Standards for Malaysia (Table 2).

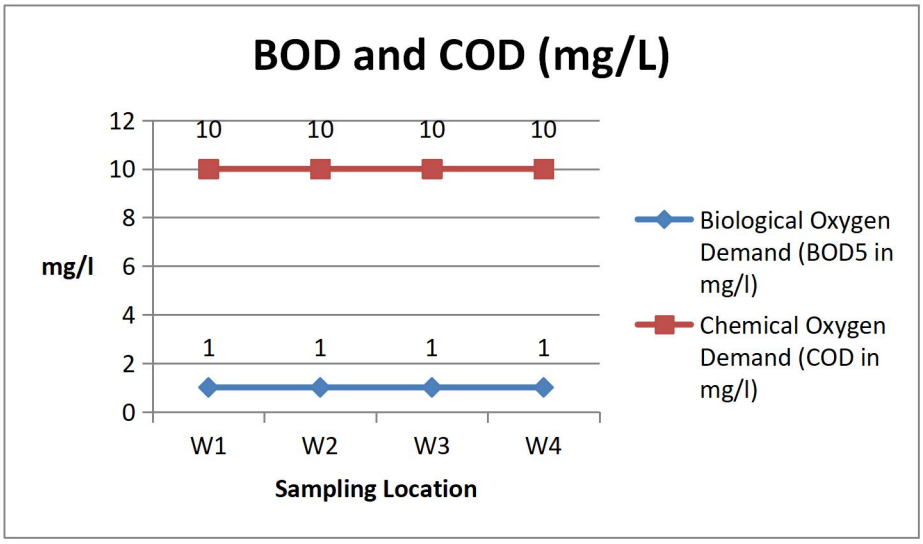


*Figure 4. Biological Oxygen Demand (BOD) & Chemical Oxygen Demand (COD)*

**c)** This parameter is a measure to indicate the presence of organic waste in the river and usually correlates with COD. All sampling points registered BOD and COD levels within Class I under the National Water Quality Standards for Malaysia (Table 2).

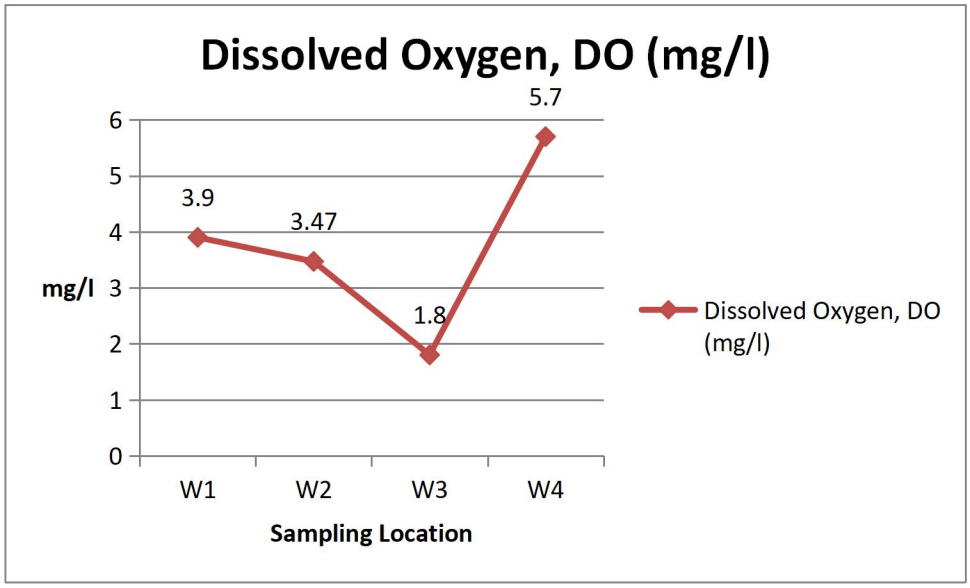


*Figure 5. Dissolved Oxygen (DO)*

**d)** 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 range from 1.80 to 5.70 mg/l. The DO for sampling point W1 and W2 are in Class III. For sampling point W4 are in Class IIB. As for sampling point W3 registered the lower DO and falls under Class IV of NWQMS.

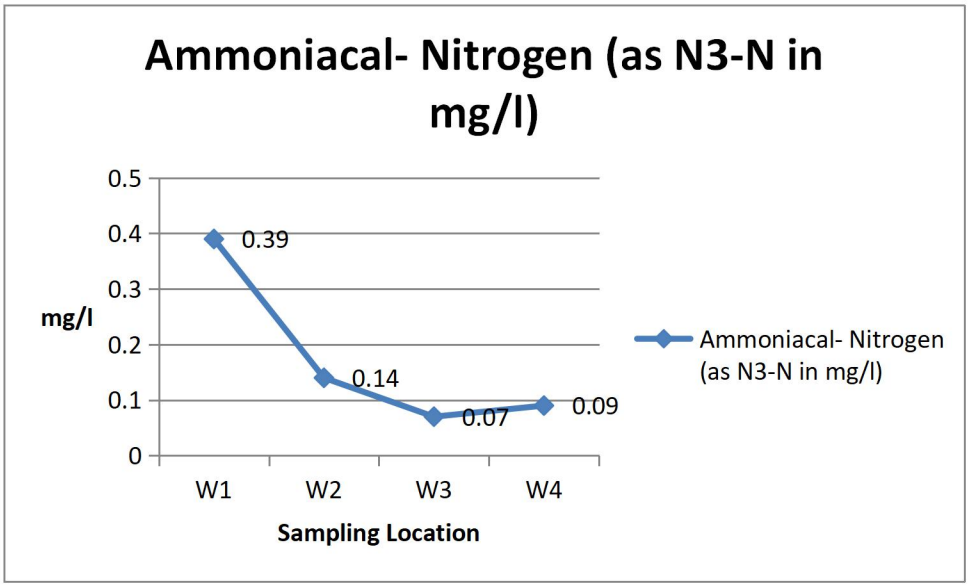


***Figure 5. Ammoniacal- Nitrogen (as $N_3$-N)***

e) This parameter is an indicator of pollution from excessive usage of ammonia rich fertilizers and often used as a measure of the health of water in natural bodies such as rivers or lakes, or in manmade water reservoirs. Three sampling point registered AN levels in acceptable limits (Figure 5) and under Class I of the NWQSM (Table 2). While sampling point W1 registered AN level as Class IIB of NWQSM.

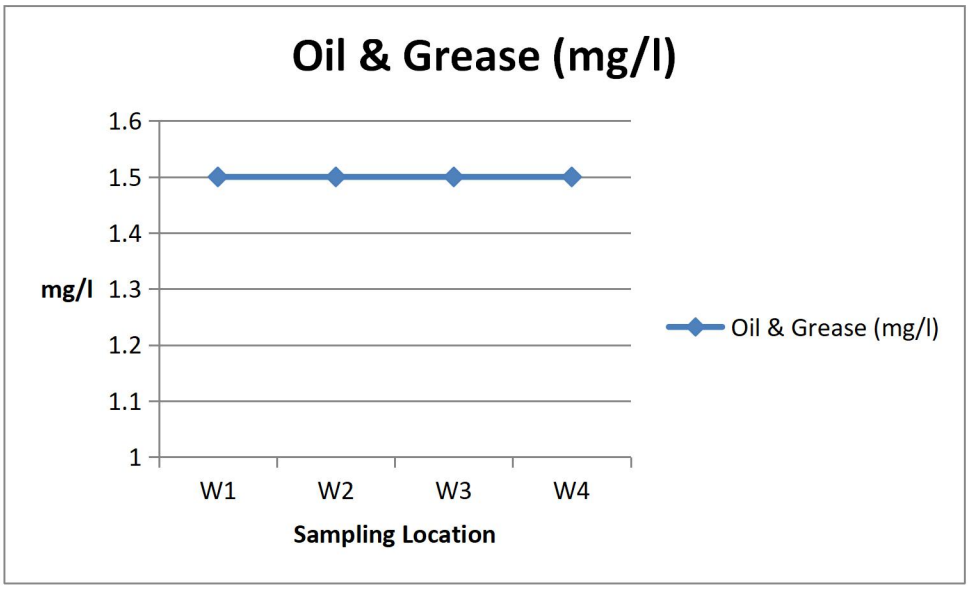


***Figure 6. Oil and Grease***

f) This parameter is aim to test whether there has been indiscriminate dumping of oil or oily waste into the water systems. All sampled showed levels of oil and grease below measurable ranges (<1.5 mg/l) and reflect near natural reference level (Table 2).

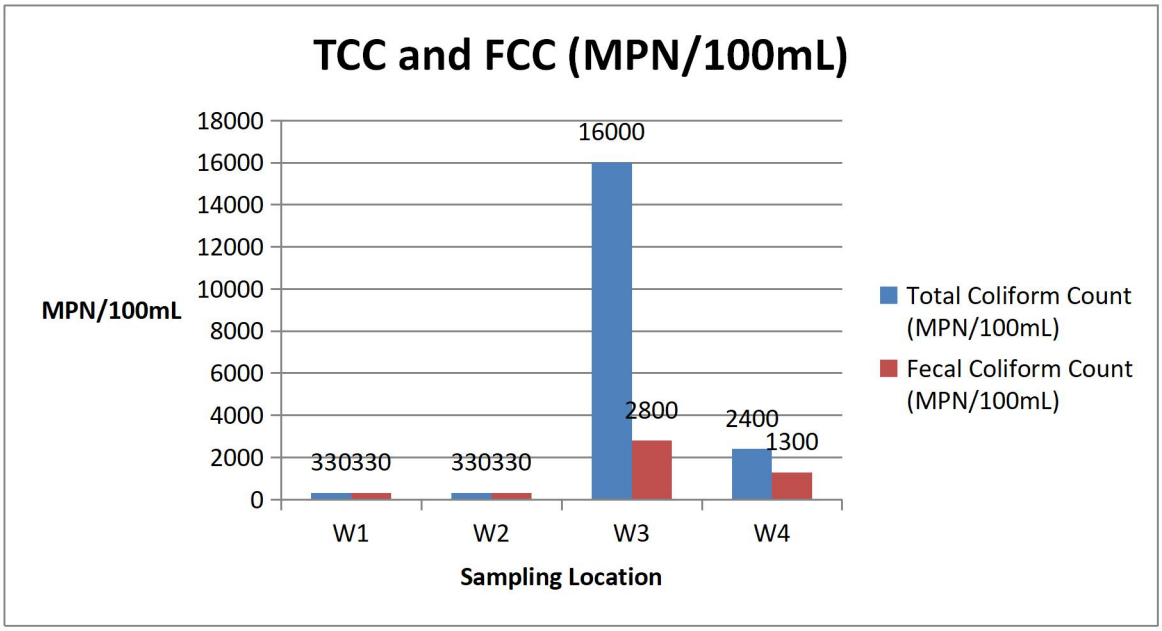


***Figure 7. Total Coliform Count (TCC)***

g) The term total coliform count (TCC) refers to a numerical count that generally includes both fecal and non-fecal coliforms, and the observation is used to highlight bacterial contamination of the waters. Sampling points W1, W2 and W4 registered TCC levels within Class I under the Interim National Water Quality Standards for Malaysia (Table 2). Whereas, the TCC levels for sampling point W3 is registered as Class IIB under the National Water Quality Standards for Malaysia. While the term Fecal Coliform Count refers to a subset numerical count of total coliform, primarily comprising fecal coliforms bacteria that originates from the guts of warm-blooded animals and humans. The observation is used as an indicator of fecal matters. Two sampling point's registered FCC levels within Class IIA, sampling point W1 and W2, while two (2) other sampling points W and W4, within Class IIB of NWQSM (Table 2). Both the TCC and FCC level shows it is in acceptable limit (Figure 6).

**Synthesis of assessment**

In general, the tests for water quality sampled from the various local rivers are characterised as clean water and indicated as Class I and Class II (Table 3). The pH for all rivers generally complied with the standards set for water under Class I of the NWQSM. The acceptable limit for river water pH is 6 to 9, thus the pH for all sampling points are in an acceptable limit. All rivers indicated no trace of oil and grease. There is no indication of excessive usage and harmful level of ammonium nitrate (indicator of extreme used of fertilizer), shown by Ammoniacal-Nitrogen (as $N_3$-N) result, in three (3) sampling point (W2, W3 & W4) which complied with the standards under Class I. Only W1 sampling point show results Under Class IIA. When present in levels above 0.1 mg/l N, sewage or industrial contamination may be indicated (Anonymous 2001). This needs further investigation as the result is the same as of year 2015 analysis.

For total suspended solid all sampling points generally complied with the standards set for water under Class I and Class IIA of the National Water Quality Standards for Malaysia, indicating impact of soil erosion is at the minimal level.

No indications of organic pollution in all sampling point as the BOD for all sampling point are under Class I of NQWSM. The amounts of COD in all sampling points are under Class I of NWQSM.

For DO parameter only sampling points W4 are in Class IIA. Sampling point W1 and W2 are under Class III, while W3 has the lower DO under Class IV of NQWSM. Further monitoring is required as previous readings indicate good DO level. DO are essential for the aquatic life within the river water. A low DO level would threaten the aquatic community whereas only DO level below 2 mg/l is considered harmful for aquatic life.

Based on the total coliform counts (TCC) only sampling point W3, has elevated TCC level of Class IIA, while sampling point W1, W2 and W4 are in Class I of Class IIB of NQWMS. For fecal coliform count (FCC), the bacterial contamination levels in W1& W2 sampling points are under Class IIA of NQWMS. W3 and W4 sampling point shows FCC under Class IIB. For sampling point W1 and W2, the total FCC is equivalent to total TCC indicating that the source of microbes are comprising fecal coliforms bacteria, that originates from the guts of warm-blooded animals and humans. This could indicate that people or mammals species has been using the previous point as waste dumping area. Further investigation to clarify this issue is needed. Although the TCC and FCC level are showing elevated level in W3 and W4, this would indicate the source of microbes or coliform bacteria could have originated from the soil, plants and other sources on the surface waters.

**Water Quality Index (WQI)**

The results of water quality index for W1 to W4 sampling points are listed in Table 3.

**Table 3.** The water quality index (WQI) for W1 to W4 sampling points in NGR FR. (Note: DO % saturation values were calculated based on dissolved oxygen saturation factor of 8.26 $mgL^{-1}$ at temperature 25° C).

| Sampling Location | DO% | BOD | COD | SS | pH | NH3-NL | SIDO | SI BOD | SI COD | SI AN | SI SS | pH SI | WQI | CLASS | WQ STATUS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $W_1$ | 47.20 | 1 | 10 | 5 | 7.24 | 0.39 | 45 | 96 | 86 | 67 | 95 | 98 | 79 | II | SP |
| $W_2$ | 41.99 | 1 | 10 | 5 | 7.21 | 0.14 | 38 | 96 | 86 | 86 | 95 | 99 | 80 | II | SP |
| $W_3$ | 21.78 | 1 | 10 | 31 | 7.1 | 0.07 | 12 | 96 | 86 | 93 | 81 | 99 | 73 | III | SP |
| $W_4$ | 68.98 | 1 | 10 | 24 | 7.33 | 0.09 | 77 | 96 | 86 | 91 | 84 | 98 | 88 | II | C |
| AVERAGE | 44.99 | 1.00 | 10.00 | 16.25 | 7.22 | 0.17 | 42.11 | 96.17 | 85.80 | 82.39 | 88.17 | 98.55 | 79.56 | II | SP |

Note: C = CLEAN SP = SLIGHTLY POLLUTED

Based on the river water quality index, sampling point W1 and W2 river water quality falls within Class II, while W3 sampling point falls within Class III, and all falls within slightly polluted river. Only W4 sampling point is within Class II under Clean river. Nonetheless, water that categorized as Class II required conventional treatment such as boiling before it can be used for domestic consumption.

It is recommended that the management team to periodically check for sampling point W1 as the ammoniacal nitrogen reading is slightly higher than the reading from year before. The management team also need to carry out periodic inspection and monitoring at all the sampling points to prevent deterioration of the water quality. The management team also needs to install signage at all the sampling point to prevent visitors or passerby traversing the road from dumping waste into the watercourse. The management also may need to carry out periodic inspection and monitoring on existing sewage and septic tanks in all office and living quarters within the project area to prevent deterioration of the waste treatment system.

## REFERENCES

Department Of Environment Malaysia (DOE), 2011. Malaysia Environmental Quality Report 2011. http://www.doe.gov.my/webportal/en/penerbitan-jas/

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

## APPENDIX I

## METHODOLOGY

### A. Sampling Method and Parameters Tested for Chemical Analyses

Grab sampling technique were used to collect water samples at proposed location as indicated in Map 1. All samples were preserved accordingly and sent to Chemsain Konsultant Sdn. Bhd (an accredited laboratory) for analysis within 24 hours. Parameters measured were according to the DOE Water Quality Index (WQI) with additional physical and microbiological analysis of the samples. 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), fecal coliform (FCC MPN/100mL), total coliform (TCC MPN/100mL), and oil & grease (mg/l).

### B. Data Analysis

Water Quality Index (WQI) was proposed by the Department of Environment Malaysia and can be used to determine the water quality status and classify the rivers based on the National Water Quality Standards for Malaysia (NWQSM). This water monitoring programme was practised in Malaysia since 1978. The NWQSM provides a convenient means of summarizing water quality data for sampled river water by classifying them into various categories, such as Class I, II, III, IV or V based on Water Quality Index (WQI) and National Water Quality Standards for Malaysia (NWQSM). Subsequently, the water quality status can be grouped into broad classes such as clean, slightly polluted or polluted.

The formulas used in the calculation of WQI is as follows:

**$WQI = 0.22SIDO+0.19SIBOD+0.16SICOD+0.16SISS+0.15SIAN+0.12SI\ pH$ (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)

## APPENDIX II

**PHOTO.1. Sampling points W1**, Sg. Lanap, sampling was done on a clear weather.

**PHOTO.2. Sampling points W1**, Sg. Lanap river.

**PHOTO.3. Sampling point W2,** Sg. Kasuyan river.

**PHOTO.4. Sampling point W2,** Sg. Kasuyan river.

**PHOTO.5. Sampling point W2,** Sg. Kuamut river.

**PHOTO.6. Sampling point W3,** Sg. Kuamut river.

**PHOTO.7. Sampling points W4**, Sg. Imbok river.

# APPENDIX III WATER QUALITY RESULTS


**CHEMSAIN KONSULTANT SDN BHD** *(130904-U)*
Lots 2 & 7, Lorong Suria, Off Lorong Buah Duku 1, Taman Perindustrian Suria,
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**Tel:** +60-88-389671 / 381278 **Fax:** +60-88-381280
**Email:** laboratory.kk@chemsain.com


MS ISO/IEC 17025 TESTING SAMM No. 238

## TEST REPORT

* NOT FOR ADVERTISEMENT PURPOSES *

| | | | | |
|---|---|---|---|---|
| Customer | : | Jabatan Perhutanan Sabah<br>PPP Sepilok, PS 1407,<br>90715 Sandakan, Sabah. | Lab No.<br>Type (No.) of Sample<br>Date Received<br>Date of Report | : CK/CL405/3651/17<br>: River Water (4)<br>: 19th October 2017<br>: 15th November 2017 |
| Attn | : | Ms. Noor Azmizah Bt. Andaman | Service Order | : - |

| Lab No.: | 3651-1 | *Test Method* |
|---|---|---|
| Parameter(s) | Sg. Lanap<br>Date: 18/10/17<br>Time: 12.44 pm | |
| pH Value @ 25°C | 7.24 | *APHA 4500H+ B, 2012* |
| Biochemical Oxygen Demand in 5 days @ 20°C, mg/L | <1.00 | *APHA 5210 B & 4500-O G, 2012* |
| Suspended Solids, mg/L | <5.00 | *APHA 2540 D, 2012* |
| Dissolved Oxygen, mg/L | 3.90 | *APHA 4500-O G, 2012* |
| Oil & Grease, mg/L | <1.50 | *APHA 5520 B, 2012* |
| Chemical Oxygen Demand, mg/L | <10.0 | *APHA 5220 C, 2012* |
| Ammoniacal-Nitrogen (as $NH_3$-N), mg/L | 0.39 | *APHA 4500 $NH_3$ F, 2012* |

| Lab No.: | 3651-2 | *Test Method* |
|---|---|---|
| Parameter(s) | Sg. Kasuyan<br>Date: 18/10/17<br>Time: 11.59 am | |
| pH Value @ 25°C | 7.21 | *APHA 4500H+ B, 2012* |
| Biochemical Oxygen Demand in 5 days @ 20°C, mg/L | <1.00 | *APHA 5210 B & 4500-O G, 2012* |
| Suspended Solids, mg/L | <5.00 | *APHA 2540 D, 2012* |
| Dissolved Oxygen, mg/L | 3.47 | *APHA 4500-O G, 2012* |
| Oil & Grease, mg/L | <1.50 | *APHA 5520 B, 2012* |
| Chemical Oxygen Demand, mg/L | <10.0 | *APHA 5220 C, 2012* |
| Ammoniacal-Nitrogen (as $NH_3$-N), mg/L | 0.14 | *APHA 4500 $NH_3$ F, 2012* |

# CHEMSAIN KONSULTANT SDN BHD *(130904-U)*

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MS ISO/IEC 17025
TESTING
SAMM No. 238

## TEST REPORT

* NOT FOR ADVERTISEMENT PURPOSES *

Lab No.: CK/CL405/3651/17

| Lab No.: | 3651-3 | |
|---|---|---|
| Parameter(s) | Sg. Kuamut<br>Date: 18/10/17<br>Time: 10.22 am | *Test Method* |
| pH Value @ 25°C | 7.10 | *APHA 4500H⁺ B, 2012* |
| Biochemical Oxygen Demand in 5 days @ 20°C, mg/L | <1.00 | *APHA 5210 B & 4500-O G, 2012* |
| Suspended Solids, mg/L | 31.0 | *APHA 2540 D, 2012* |
| Dissolved Oxygen, mg/L | 1.80 | *APHA 4500-O G, 2012* |
| Oil & Grease, mg/L | <1.50 | *APHA 5520 B, 2012* |
| Chemical Oxygen Demand, mg/L | <10.0 | *APHA 5220 C, 2012* |
| Ammoniacal-Nitrogen (as $NH_3$-N), mg/L | 0.07 | *APHA 4500 $NH_3$ F, 2012* |

| Lab No.: | 3651-4 | |
|---|---|---|
| Parameter(s) | Sg. Imbok<br>Date: 18/10/17<br>Time: 9.40 am | *Test Method* |
| pH Value @ 25°C | 7.33 | *APHA 4500H⁺ B, 2012* |
| Biochemical Oxygen Demand in 5 days @ 20°C, mg/L | <1.00 | *APHA 5210 B & 4500-O G, 2012* |
| Suspended Solids, mg/L | 24.0 | *APHA 2540 D, 2012* |
| Dissolved Oxygen, mg/L | 5.70 | *APHA 4500-O G, 2012* |
| Oil & Grease, mg/L | <1.50 | *APHA 5520 B, 2012* |
| Chemical Oxygen Demand, mg/L | <10.0 | *APHA 5220 C, 2012* |
| Ammoniacal-Nitrogen (as $NH_3$-N), mg/L | 0.09 | *APHA 4500 $NH_3$ F, 2012* |

Date of commencement of $BOD_5$ analysis: 19th October 2017

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CHEMIST

CHEMSAIN KONSULTANT SDN. BHD. Laboratory Kota Kinabalu (130904-U)

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**Email:** laboratory.kk@chemsain.com


MS ISO/IEC 17025
TESTING
SAMM No. 238

## TEST REPORT

* NOT FOR ADVERTISEMENT PURPOSES *

| | | | | | |
|---|---|---|---|---|---|
| Customer | : | Jabatan Perhutanan Sabah<br>PPP Sepilok, PS1407,<br>90715 Sandakan, Sabah. | Lab No.<br>Type (No.) of Sample<br>Date Received<br>Date of Report | :<br>:<br>:<br>: | CK/ML405/3668/17<br>River Water (4)<br>20th October 2017<br>31st October 2017 |
| Attn | : | Ms. Noor Azmizah Bt Andaman | Service Order | : | - |

| Lab No.: | 3668-1 | 3668-2 | *Test Method* |
|---|---|---|---|
| Parameter | Sg. Lanap (NGR)<br>Date: 18/10/17<br>Time: 12. 44 pm | Sg. Kasuyan (NGR)<br>Date: 18/10/17<br>Time: 11.59 am | |
| Total Coliform Count<br>MPN/100mL, 35±0.5°C/48 h | $3.3 \times 10^2$ | $3.3 \times 10^2$ | *APHA 9221B, 2012* |
| Fecal Coliform Count<br>MPN/100mL, 44.5±0.2°C/24 h | $3.3 \times 10^2$ | $3.3 \times 10^2$ | *APHA 9221E, 2005* |

| Lab No.: | 3668-3 | 3668-4 | *Test Method* |
|---|---|---|---|
| Parameter | Sg. Kuamut (NGR)<br>Date: 18/10/17<br>Time: 11.22 am | Sg. Imbok (NGR)<br>Date: 18/10/17<br>Time: 9.40 am | |
| Total Coliform Count<br>MPN/100mL, 35±0.5°C/48 h | $1.6 \times 10^4$ | $2.4 \times 10^3$ | *APHA 9221B, 2012* |
| Fecal Coliform Count<br>MPN/100mL, 44.5±0.2°C/24 h | $2.8 \times 10^3$ | $1.3 \times 10^3$ | *APHA 9221E, 2005* |

STEPFANIE EVERT[illegible]
M. Sc.
MJMM0369
MICROBIOLOGIST

CHEMSAIN KONSULTANT SDN. BHD. Laboratory Kota Kinabalu (130904-U)

## APPENDIX IV

i. National Water Quality Standards For Malaysia
ii. Water Classes And Uses
iii. DOE Water Quality Classification Based On Water Quality Index
iv. DOE Water Quality Index Classification
v. WQI Formula And Calculation

**Source from:** Department Of Environment Malaysia (DOE), 2011. Malaysia Environmental Quality Report 2011. http://www.doe.gov.my/webportal/en/penerbitan-jas/

**APPENDIX IV (i)**

# ANNEX

## NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

| PARAMETER | UNIT | CLASS | | | | |
|---|---|---|---|---|---|---|
| | | I | IIA/IIB | III# | IV | V |
| Al | mg/l | ↑ | - | (0.06) | 0.5 | ↑ |
| 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 (IV) | 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) | L |
| Pb | mg/l | | 0.05 | 0.02* (0.01) | 5 | E |
| Mn | mg/l | | 0.1 | 0.1 | 0.2 | V |
| Hg | mg/l | N | 0.001 | 0.004 (0.0001) | 0.002 | E |
| Ni | mg/l | A | 0.05 | 0.9* | 0.2 | L |
| Se | mg/l | T | 0.01 | 0.25 (0.04) | 0.02 | S |
| Ag | mg/l | U | 0.05 | 0.0002 | - | |
| Sn | mg/l | R | - | 0.004 | - | A |
| U | mg/l | A | - | - | - | B |
| Zn | mg/l | L | 5 | 0.4* | 2 | O |
| B | mg/l | | 1 | (3.4) | 0.8 | V |
| Cl | mg/l | L | 200 | - | 80 | E |
| $Cl_2$ | mg/l | E | - | (0.02) | - | |
| CN | mg/l | V | 0.02 | 0.06 (0.02) | - | |
| F | mg/l | E | 1.5 | 10 | 1 | |
| $NO_2$ | mg/l | L | 0.4 | 0.4 (0.03) | - | |
| $NO_3$ | mg/l | S | 7 | - | 5 | IV |
| P | mg/l | | 0.2 | 0.1 | - | |
| Silica | mg/l | O | 50 | - | - | |
| $SO_4$ | mg/l | R | 250 | - | - | |
| S | mg/l | | 0.05 | (0.001) | - | |
| $CO_2$ | mg/l | A | - | - | - | |
| Gross-α | Bq/l | B | 0.1 | - | - | |
| Gross-β | Bq/l | S | 1 | - | - | |
| Ra-226 | Bq/l | E | < 0.1 | - | - | |
| Sr-90 | Bq/l | N | < 1 | - | - | ↓ |
| CCE | µg/l | T | 500 | - | - | - |
| MBAS/BAS | µg/l | | 500 | 5000 (200) | - | - |
| O & G (Mineral) | µg/l | | 40; N | N | - | - |
| O & G (Emulsified Edible) | µg/l | | 7000; N | N | - | - |
| PCB | µg/l | | 0.1 | 6 (0.05) | - | - |
| Phenol | µg/l | | 10 | - | - | - |
| Aldrin/Dieldrin | µg/l | | 0.02 | 0.2 (0.01) | - | - |
| BHC | µg/l | | 2 | 9 (0.1) | - | - |
| Chlordane | µg/l | | 0.08 | 2 (0.02) | - | - |
| t-DDT | µg/l | | 0.1 | (1) | - | - |
| Endosulfan | µg/l | | 10 | - | - | - |
| Heptachlor/Epoxide | µg/l | | 0.05 | 0.9 (0.06) | - | - |
| Lindane | µg/l | | 2 | 3 (0.4) | - | - |
| 2,4-D | µg/l | | 70 | 450 | - | - |
| 2,4,5-T | µg/l | | 10 | 160 | - | - |
| 2,4,5-TP | µg/l | | 4 | 850 | - | - |
| Paraquat | µg/l | ↓ | 10 | 1800 | - | - |

Notes :

* = At hardness 50 mg/l $CaCO_3$
\# = Maximum (unbracketed) and 24-hour average (bracketed) concentrations
N = Free from visible film sheen, discolouration and deposits

# APPENDIX IV (i & ii)

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

# APPENDIX IV (iii & iv)

## 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 |

# APPENDIX IV (v)

## 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(-0.0061x) - 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