Appendix A

I. Chlorophyll *a*

Reagents:

1) Distilled water
2) Aqueous acetone solution:
   Carefully measure 100 mL of water into the 1 L graduated cylinder. Transfer the contenet to a 1 L flask or storage bottle. Measure 900 mL of acetone into the graduated cylinder and transfer it to the flask or bottle containing the water (90 % acetone: 10 % distilled water). Mix, label and store the liquid.

Procedure:

1) The samples were filtered as soon as possible after collection as chlorophyll pigments react with light and oxygen.
2) A known volume of sample water was vacuum filtered through a glass fibre filter. When the analysis cannot proceed immediately, samples can be stored in this state at -20 ^{o}C for approximately 3 to 4 weeks if wrapped in aluminium foil to keep the light out.
3) The filter was broken up to facilitate extraction before placing it into a 15 mL centrifuge tube. A 90 % ethanol solution was added and the mixture was shaken thoroughly. The tube should be wrapped in foil to keep out any light and refrigerated at 4 ^{o}C for at least 2 hours but not longer than 24 hours. The tube was shaken three times during this period.
4) After it had been left to stand, the contents of the tube was centrifuged for 10 minutes at which point a clear solution remained. This time can be as short as 5 minutes depending on the speed of the centrifuge.

5) The optical density of the supernatant should ideally be less than 0.05 abs at 750 nm for a 1 cm cuvette.
6) In subdued light the supernatant was poured into a 1 cm cuvette and measured immediately. The concentration of the solution must be determined spectrophotometrically using a multiwavelenght spectrophotometer. The instrument was zeroed on a 90 % ethanol solution and the sample was measured at wavelengths 750, 664, 647 and 630 nm.

Calculation:

The amount of chlorophyll *a* was calculated by inserting the 750 nm corrected absorbances into the equation:

Chlorophyll *a* = 11.85 (Abs 664)-1.54 (Abs 647)-(Abs 630)

The amount of chlorophyll *a* pigment in the water sample was determined using the following equation:

$$\text{Chlorophyll } a\ (\mu g/L) = \frac{(\text{Chl a}) \times V\ (mL)}{v(L) \times \text{cell length (cm)}}$$

Where; V = volume of sample filtered in litres
v = volume of extract solvent in mL

II. Total Suspened Solid (TSS): gravimetric method

Reagents:

Distilled water or de-ionized water.

Procedure:

Filter preparation

1) Pre-wash glass fiber filter disks in Gooch crucibles. With vacuum operating wash the disks with three 20 mL portions of distilled water.
2) When all water has been vacuumed through the filter disks, place the Gooch crucible in a 103-105 $^{\circ}$C oven to dry. Then, place the crucibles into a desiccator to cool.
3) Cool the filters thoroughly in a desiccator before use.
4) Weigh the Gooch crucible and filter (at room temperature) on an analytical balance.
5) Record the weight of the crucible and filter.

Sample analysis

1) Place prepared crucible and filter on the vacuum manifold or side-arm Erlenmeyer flask with vacuum gasket. Wet the filter with distilled water in order to seat the filter against the crucible. Turn on the vacuum. If there is a hole in the filter, it may hear an abnormal hissing or whistling. Use a different weighed crucible and filter.
2) A well-mixed sample is filtered in a glass fiber filter. The volume of water sample used was at least 250 mL.

3) Rinse the filter with three successive 10 mL portions of distilled water. If the sample takes excessive time to filter (longer than 10 minuits), begin again with a different weighed crucible and filter using a smaller volume of sample for filtering.

4) Allow the vacuum to continue until no traces of moisture are present. If solids are present on the side of the funnel, rinse the sides gently with distilled water.

5) Place the crucible in the oven to dry for at least 1-2 hours at 103-105 $^{\circ}$C.

6) Transfer the dried crucible to a desiccator to cool. When the crucible has cooled sufficiently it should not feel warm to the touch on the inside of your forearm.

7) Weigh the dried and cooled crucible on an analytical balance. Record the weight. If the sample is not going to be used for regulatory purposes, it may be acceptable to use this weight as the final dry weight.

8) Return the crucible to the drying oven for another thirty minutes. Cool, reweigh and record its weight. Repeat this procedure until the change in the weight of the residue remains within 4 % or less than 0.5 mg from one weighing to the next (this is referred to as constant weight). Record the final weight and calculate the total suspended solids.

Calculation:

$$\text{mg total suspended solids/L} = \frac{(A-B) \times 1{,}000}{\text{sample volume, mL}}$$

where: A = weight of filter + dried residue, mg, and

B = weight of filter, mg.

III. Dissolved Oxygen (DO): Winkler method

Reagents:

1) Manganous sulfate reagent

Dissolve 36.5 g manganous sulfate monohydrate ($MnSO_4 . H_2O$) in 100 mL distilled water.

2) Alkaline iodide solution

Dissolve 50 g sodium hydroxide (NaOH) in 50 mL distilled water. Add to 30 g potassium iodide (KI) and dissolved in 45 mL distilled water. This reagent should not show a color with starch solution when diluted and acidified.

3) 0.5 N Standard thiosulfate solution

Dissolve 145 g sodium thiosulphate ($Na_2S_2O_3 . 5 H_2O$) and 0.1 sodium carbonate (Na_2CO_3) in 1 L distilled water.

4) Starch indicator solution (0.1-0.2 % solution)

Dissolve 1 g laboratory-grade soluble starch in 150-200 distilled water. Gradually add 20 % NaOH and carefully stir it until it becomes transparent. To see the pH paper change, the concentrated sulfuric acid (conc. HCl) needs to be dropped until it turn to acid. Finally, add 1 mL glacial acetic acid.

5) 0.1 N Iodate solution

- Incubate potassium iodate reagent grade (KIO_3) at 105 $^{\circ}C$ for an hour.

Leave it at the room temperature to cool down.

- Dissolve 0.3567 KIO_3 in distilled water and diluted to 100 mL.

6) Conc. Sulfuric acid (H_2SO_4)

Procedure:

1) Add to the sample collected in a 300 mL bottle, first 1 mL manganous sulphate solution, and then 1 mL alkaline iodide solution. If pipets are dipped into ample, rinse them before returning to reagent bottles. Alternatively, hold pipet tips just above liquid surface when adding reagents. Stopper carefully to exclude air bubbles and mix by inverting bottle a few times. When precipitates have settled sufficiently (to approximately half the bottle volume) to leave clear supernate above the manganous hydroxide floc, add 1 mL conc H_2SO_4. Restopper and mix by inverting several times until dissolution is complete.
2) Add 50 mL water sample in Erlenmeyer flask. Titrate with 0.01 N Na-thiosulphate to a pale straw color. Add a few drops of starch solution and continue titration to the first disappearance of blue color. If the end point is overrun, back-titrate with 0.01 N Na-thiosulphate added dropwise, or by adding a measured volume of treated sample. Repeat titration until the value is constant within 0.05 mL.

Blank:

Add to the distilled water in BOD bottle. Add 1 mL conc. H_2SO_4. Followed by, 1 mL alkaline iodide solution and 1 mL manganous sulphate solution, respectively. Mix them thoroughly. If the color appears, titration is needed to find out the blank value.

Standardization:

Add 5 mL 0.01 N KIO_3 in Erlenmeyer flask. Add 50 mL blank solution and mix thoroughly. Titrate with the 0.01 N sodium thiosulphate, adding starch toward the end of titration, when a pale straw color is reached. Repeat this procedure until a constant value is less than 0.05 mL.

IV. Biochemical Oxygen Demand (BOD_5): Winkler method

Reagents:

See in DO

Procedure:

1) Collect sample with BOD bottle
2) Measure DO_1 (see in DO)
3) Collect sample with BOD (dark) bottle and keep them in BOD incubator (20 $^{\circ}C$) for 5 days. Measure DO_5 by using the same method.

Calculation:

BOD_5 (mg/L) = $DO_1 - DO_5$

V. Dissolved phosphorus: ascorbic acid method

Reagents:

1) Ammonium molybdate solution:

   Dissolve 15 g ammonium paramolybdate in 500 mL de-ionized water.

2) Sulfuric acid:

   Dilute 70 mL. conc. H_2SO_4 to 450 mL with de-ionized water. Leave it at the room temperature to cool down.

3) Ascorbic acid solution:

   Dissolve 27 g L-ascorbic acid in 500 mL deionized water. This solution is not stable; prepare daily.

4) Potassium antimonyl-tartrate solution:

Dissolve 0.34 g potassium antimonyl tartrate [K(SbO) C_4 H_4O_6 . ½ H_2O] in 250 mL deionized water. This solution can be warmed when its use.

5) Composit reagent:

Mix the above reagents in the following proportions for 500 mL of the combined reagent: 100 mL ammonium molybdate solution, 250 mL sulfuric acid, 100 mL ascorbic acid and 50 mL potassium antimonyl tartrate solution. Mix after addition of each reagent. Let all reagents reach room temperature before mixing them in the order given. If turbidity forms in the combined reagent, shake and let it stand for a few minutes until turbidity disappears before proceeding. The reagent is stable for 4 hours. (1 mL standard phosphate solution = 50 μg PO_4^{3-}-P).

Procedure:

1) Pipet 100 mL sample into a clean, dry test tube or 125 mL erlenmeyer flask.
2) Add 0.05 mL (1 drop) phenolphthalein indicator. If a red color develops add 5N H_2SO_4 solution dropwise to just discharge the color.
3) Add 10 ± 0.5 mL composite reagent and mix thoroughly.
4) After at least 10 minutes but less than 2 hours, measure absorbance of each sample at 880 nm, using reagent blank as the reference solution.
5) Prepare individual calibration curves from a series of six standards within the phosphate ranges such as 50, 100 and 500 μg PO_4^{3-}-P/L.
6) Use a deionized water blank with the combined reagent to make photomethic readings for the calibration curve. Plot absorbance and phosphate concentration to check whether it yields a straight line passing through the origin. Test at least on phosphate standard with each set of samples.

Calculation:

Obtain a standard curve by plotting absorbance of standards against PO_4^{3-}-P concentration. Compute sample concentrations directly from standard curve. Report as milligrams oxidized PO_4^{3-}-P per liter.

VI. Nitrite-nitrogen: colorimetric method

Reagents:

1) deionized water
2) Sulphanilamide:

   Dissolve 10 g sulfanilamide in a mixture of 100 mL concentrated HCl and 600 mL deionized water. Dilute to 1 L with deionized water. The solution is stable for many months.
3) N-(1-naphthyl)-ethylenediamine dihydrochloride (NED dihydrochloride) solution:

   Dissolve 1 g N-(1-naphthyl)-ethylenediamine dihydrochloride in deionized water and dilute to 1 L. Store in a dark bottle. Replace monthly or as soon as a brown color appears.
4) Stock nitrite solution:

   Dissolve 0.4926 g $NaNO_2$ or 0.6072 g KNO_2 (dried in a desiccator for 24 hours) and dilute to 1 L. Preserve with 2 mL chloroform ($CHCl_3$) and refrigerate. This is stable for approximately 3 months (1 mL = 0.1 mg NO_2^--N).
5) Standard nitrite solution:

   Dilute 5 mL stock nitrite solution to 500 mL with nitrite-free water; 1 mL = 0.001 mg NO_2^--N.

Procedure:

1) To a 50 mL sample in a 125 mL flask, add 2 L sulfanilamide and mix thoroughly. Add 2 mL NED-dihydrochloride solution and mix immediately.
2) Between 10 minutes and 2 hours afterward, measure absorbance at 543 nm.
3) Using the standard NO_2^--N solution, prepare standards in the range 0.01 to 0.5 mg NO_2^--N/L by diluting the following volumes of standard to 100 mL in volumetric flasks: 1, 2, 5, 10, 20, 50 mL.

Calculation:

Obtain a standard curve by plotting absorbance of standards against NO_2^--N concentration. Compute sample concentrations directly from standard curve. Report as milligrams oxidized NO_2^--N per liter.

VII. Nitrate-nitrogen: colorimetric method

Reagents:

1) Deionized water
2) Copper-Cadmium (Cu-Cd) granules:

   Wash 0.5 to 2.0 mm. Cd granules with 6N HCl and rinse with water. Swirl Cd with 2 % $CuSO_4$ solution for 5 minutes or until blue color partially fades. Decant and repeat with fresh $CuSO_4$ until a brown colloided precipitate develops. Wash Cu-Cd copiously with water (at least 10 times) to remove all precipitated Cu.
3) Ammonium chloride-EDTA solution:

   Dissolve 125 g ammonium chloride (NH_4Cl) and 17 g disodium ethylenediamine tetraacetate (EDTA) in 400 mL deionized water. Adjust pH to 8.5 with concentrated NH_4OH and dilute to 500 mL.

4) Dilute ammonium chloride-EDTA solution:

Dilute 25 mL NH_4Cl-EDTA solution to 1 L with deionized water.

5) Concentrated ammonium hydroxide (conc. NH_4OH)

6) 6 N sodium hydroxide (NaOH):

Dissolve 240 g NaOH in deionized water and dilute to 1 L.

7) 6 N hydrochloric acid (HCl):

Dissolve 50 mL HCl in deionized water and dilute to 100 mL.

8) 2% copper sulfate solution:

Dissolve 20 g $CuSO_4 . 5H_2O$ in deionized water and dilute to 1 L.

9) Zinc sulfate solution:

Dissolve 100 g $ZnSO_4 . 7H_2O$ in deionized water and dilute to 1 L.

10) Stock nitrate solution:

Dissolve 0.7218 g KNO_3 (dried in a desiccator for 24 hours) in deionized water and dilute to 100 mL (1 mL = 1 mg NO_3^--N). Add 0.2 mL $CHCl_3$. Store refrigerated; allow reagent to come to room temperature before use.

11) Standard nitrate solution:

Dilute 1 mL stock nitrate solution to 100 mL with deionized water; 1 mL = 0.01 mg NO_3^--N.

Procedure:

1) Preparation of reduction column: Insert a glass wool plug into the bottom of the reduction column and fill it with water. Add sufficient Cu-Cd granules to produce a column 18.5 centrimetres long. Maintain water level above Cu-Cd granules to prevent entrapment of air. Wash column with 200 mL dilute NH_4Cl-EDTA solution. Activate column by passing through it, at 7-10 mL/minute, 100 mL of a solution composed of a 1 mg NO_3^--N/L standard and 75 mL NH_4Cl-EDTA solution.

2) Treatment of sample:

2.1 Turbidity removal: If turbidity or suspended solids are present, remove by filtering through a 0.45 μm pore diameter membrane or glass fiber filter.

2.2 pH adjustment: Adjust pH to between 7 and 9, as necessary, using a pH meter and dilute HCl or NaOH. This insures a pH of 8.5 after adding NH_4Cl-EDTA solution.

2.3 Sample reduction: To 25 mL sample or a portion diluted to 25 mL, add 75 mL NH_4Cl-EDTA solution and mix. Pour mixed sample into column and collect at a rate of 7 to 10 mL/minute. Discard first 25 mL. Collect the rest in original sample flask. There is no need to wash columns between samples, but if columns are not to be reused for several hours or longer, pour 50 mL dilute NH_4Cl-EDTA solution on to the top and let it pass through the system. Store Cu-Cd column in this solution and never allow it to dry.

2.4 Color development and measurement: As soon as possible, and not within 15 minutes after reduction, add 2 mL sulfanilamide reagent to 50 mL sample. Let the reagent react for 2 to 8 minutes. Add 2 mL NED-dihydrochloride solution and mix immediately. After 10 minutes up to 2 hours, measure the absorbance at 543 nm against a deionized water-reagent blank.

2.5 Standards: Using the standard NO_3^--N solution, prepare standards in the range 0.05 to 1.0 mg NO_3^--N/L by diluting the following volumes of standard to 100 mL in volumetric flasks: 0.5, 1.0, 2.0, 5.0 and 10.0 mL. Carry out reduction of standards exactly as described above for other samples.

Calculation:

Obtain a standard curve by plotting absorbance of standards against NO_3^--N concentration. Compute sample concentrations directly from standard curve. Report as milligrams oxidized NO_3^--N per liter.

VIII. Ammonia-nitrogen: phenate method

Reagents:

1) Sodium hypochlorite solution:

   Add 10 mL of bleach solution containing 5 % sodium hypochlorite (NaOCl) to 40 mL deionized water. Adjust pH to 6.5-7.0 with 1:1 (HCl : H_2O). Reagent is stable up to 1 week.

2) Manganoussulfate solution:

   Dissolve 50 mg 0.0003 M manganous sulfate ($MnSO_4 . H_2O$) in 100 mL deionized water.

3) Phenate solution:

   Dissolve 2.5 g sodiumhydroxide (NaOH) and 10 g phenol (C_6H_5OH) in 100 mL deionized water. Reagent is stable up to 1 week.

4) Ammonia standard solution:

   Dissolve 0.3819 g ammonium chloride (anhydrous NH_4Cl; oven dried at 80 $^\circ$C) in deionized water and diluted to 1 L (1 mL = 1 mg NH_3-N)

Procedure:

1) To a 10 mL sample in a 50 mL beaker, add 1 drop (0.05 mL) $MnSO_4$ solution. Place on a magnetic stirrer and add 0.5 mL hypochlorous acid reagent.

2) Immediately add, a drop at a time, 0.6 mL phenate reagent. Stir vigorously during addition of reagents. Color formation is complete in 10 minutes and is stable for at least 24 hours.
3) Measure absorbance of each sample at 630 nm, using reagent blank as the reference solution
4) Use standard ammonia solution and water blank to prepare the calibration curve in the appropriate ammonia concentration range. Working standards in concentrations of 0.01, 0.03, 0.05 and 0.10 mg NH_3-N/L.

Calculation:

Obtain a standard curve by plotting absorbance of standards against NH_3-N concentration. Compute sample concentrations directly from standard curve. Report as milligrams oxidized NH_3-N per liter.

Appendix B

Table 1. Summarized the means and range of variation of the environmental variables and Chlorophyll *a* at the arsenic contaminated waters from July 2004 to June 2005 : As=Total Arsenic, Water=Water temperature, Light= Light intensity, Cond=Conductivity DO=Dissolved oxygen demand, TSS=Total suspended solids, BOD_5=Biochemical oxygen demand, Am=Ammonia-nitrogen, Ni=Nitrate- nitrogen, Phos=Dissolved phosphorus, Chl *a*=Chlorophyll *a*, ND.=Non detection vulue.

		Location 1		Location 2		Location 3		Location 4		Location 5		Location 6	
	Units	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
As	(μg/L)	69.31±5.66	31.21-98.96	17.92±4.30	10.80-64.94	39.06±3.31	19.00-57.46	0.92±0.35	0.3-4.69	84.41±13.95	36.88-167.85	8.68±1.51	4.76-24.55
Cond	(μS/cm)	70.17±8.73	0-134.10	29.61±2.94	21.17-50.50	65.13±7.30	46.73-114.50	56.71±5.58	38.10±89.33	140.28±16.08	84.50-214.40	183.10±18.99	119.13-275.80
pH		6.37±0.23	5.19-7.60	6.00±0.32	4.32-7.88	6.24±0.33	4.43-8.28	6.10±0.24	4.79-8.05	6.66±0.26	5.21-8.10	6.67±0.28	5.33-8.02
DO	(mg/L)	4.56±0.42	2.02-6.67	5.97±0.33	3.67-7.56	5.17±0.32	3.20-6.91	6.13±0.20	4.98-7.38	5.68±0.33	4.03-7.30	5.70±0.30	4.50-7.86
TSS	(mg/L)	6.6±0.89	3.7-12.4	7.1±0.74	4.4-13.3	10.4±1.72	3.8-22.1	2.9±0.19	1.5-3.9	75.4±30.01	11.0-296.5	9.5±1.17	4.4-20.5
BOD_5	(mg/L)	2.18±0.24	0.9-3.36	1.80±0.26	0.63-3.48	2.32±0.25	0.7-3.39	2.06±0.27	0.2-3.39	1.77±0.32	0.4-3.61	2.07±0.34	0.63-5.18
Am	(mg/L)	0.03±0.01	ND.-0.08	0.01±0.01	ND.-0.06	0.02±0.01	ND.-0.06	0.01±0.01	ND.-0.05	0.02±0.01	ND.-0.08	0.02±0.01	ND.-0.09
Ni	(mg/L)	0.08±0.02	0.01-0.23	0.04±0.01	0.01±0.07	0.05±0.01	0.01-0.12	0.04±0.01	0.01-0.08	0.06±0.02	0.01-0.20	0.06±0.02	0.01-0.24
Phos	(mg/L)	0.04±0.002	0.03-0.06	0.02±0.002	0.01-0.03	0.03±0.003	0.02-0.05	0.01±0.0	0.01	0.04±0.008	0.01-0.10	0.01±0.001	0.01-0.02
Chl *a*	(μg/L)	21.9±5.29	3.7-58.7	10.8±1.06	5.0-17.0	28.3±5.28	3.0-71.0	4.4±0.57	2.0-8.0	5.4±0.90	1.0-11.3	23.3±2.46	11.3-39.0

Appendix C

Monthly changes of environmental variables in arsenic contaminated waters were shown as follows:

I. Total arsenic

Months	Lo1	Lo2	Lo3	Lo4	Lo5	Lo6	Mean	SE
Jul	67.08	11.37	38.92	0.73	75.45	10.71	75.45	0.73
Aug	58.06	12.75	19.00	0.39	95.40	6.89	95.40	0.39
Sep	31.21	13.62	31.21	0.44	60.74	7.65	60.74	0.44
Oct	86.56	14.77	29.34	0.30	39.59	7.83	86.56	0.30
Nov	40.84	16.08	30.54	4.69	39.59	8.63	40.84	4.69
Dec	84.29	11.72	38.89	0.42	36.88	5.86	84.29	0.42
Jan	89.16	15.11	51.29	0.40	50.40	7.09	89.16	0.40
Feb	98.96	14.70	55.74	1.07	63.37	6.71	98.96	1.07
Mar	65.24	13.73	41.76	0.45	73.71	4.76	73.71	0.45
Apr	70.58	15.45	41.75	0.60	167.85	5.87	167.85	0.60
May	66.12	10.80	32.89	0.85	158.78	7.61	158.78	0.85
Jun	73.64	64.94*	57.46	0.67	151.12	24.55*	70.72	2.18
Mean	69.31	13.64	39.06	0.92	84.41	7.24		
SE	5.66	0.54	3.31	0.35	13.95	0.48		

***** These values were not taken into consideration in statistical analysis, probably due to an error during the analysis process.

II. Water temperature

Months	Lo1	Lo2	Lo3	Lo4	Lo5	Lo6	Mean	SE
Jul	29.3	30.2	30.7	32.3	33.2	33.3	31.5	0.68
Aug	29.5	30.7	30.5	31.6	32.1	33.0	31.2	0.51
Sep	29.9	30.3	31.3	33.0	30.7	32.1	31.2	0.48
Oct	29.0	30.9	30.7	30.7	29.6	32.2	30.5	0.46
Nov	28.4	29.7	30.3	30.3	28.8	30.6	29.7	0.37
Dec	27.2	28.4	28.8	28.8	28.2	28.2	28.3	0.25
Jan	29.0	29.2	29.5	30.8	32.3	34.1	30.8	0.83
Feb	28.5	29.7	29.9	30.8	31.2	32.1	30.4	0.51
Mar	29.6	31.0	31.4	31.0	32.2	33.6	31.5	0.55
Apr	31.5	32.3	32.8	33.9	34.7	36.1	33.6	0.68
May	30.1	31.2	30.6	31.8	32.0	33.4	31.5	0.47
Jun	32.2	31.8	32.3	32.3	32.8	34.8	32.7	0.43
Mean	29.5	30.4	30.7	31.4	31.5	32.8		
SE	0.39	0.32	0.32	0.39	0.54	0.59		

III. Light intensity

Months	Lo1	Lo2	Lo3	Lo4	Lo5	Lo6	Mean	SE
Jul	1179.8	2397.7	2472.1	1325.4	1263.6	299.2	1489.6	335.71
Aug	69.9	1564.4	1053.8	876.5	509.3	344.0	736.3	220.29
Sep	2516.6	2502.7	2391.1	2486.1	1733.1	386.7	2002.7	345.58
Oct	729.8	1803.5	2091.0	1061.6	860.6	378.5	1154.1	269.31
Nov	1280.9	1533.2	1071.7	1330.0	1551.1	300.6	1177.9	189.76
Dec	689.9	626.8	197.9	311.4	628.8	346.6	466.9	84.17
Jan	861.2	503.3	823.4	861.9	2241.0	1039.2	1055.0	247.64
Feb	302.1	892.4	548.5	438.3	2091.6	1556.4	971.6	289.51
Mar	668.7	2000.7	1871.8	819.4	2826.7	2295.5	1747.1	344.95
Apr	950.9	1097.6	696.5	897.1	1525.2	1219.8	1064.5	117.45
May	312.8	468.1	788.2	919.0	1279.6	2073.7	973.6	260.35
Jun	1395.1	1885.8	1298.1	1588.3	1495.4	1323.4	1497.7	89.36
Mean	913.1	1439.7	1275.3	1076.2	1500.5	963.6		
SE	186.7	206.3	217.7	164.6	194.1	211.1		

IV. Conductivity

Months	Lo1	Lo2	Lo3	Lo4	Lo5	Lo6	Mean	SE
Jul	58.17	22.90	56.10	40.60	90.13	129.73	66.27	15.61
Aug	62.17	47.47	53.87	39.37	88.50	132.07	70.57	14.10
Sep	68.07	24.27	47.70	52.63	117.00	135.20	74.14	17.56
Oct	62.00	25.93	50.53	42.30	84.50	133.13	66.40	15.57
Nov	77.40	22.30	46.73	38.10	91.13	123.10	66.46	15.36
Dec	96.20	28.20	87.53	72.73	214.40	224.30	120.56	32.70
Jan	69.23	21.17	47.47	42.37	112.50	119.13	68.64	16.19
Feb	67.43	28.87	60.57	76.37	214.13	260.33	117.95	38.74
Mar	62.60	21.63	50.20	38.50	201.50	259.47	105.65	40.56
Apr	75.07	23.70	52.90	66.03	90.53	144.07	75.38	16.54
May	72.20	38.33	113.40	82.17	194.87	260.87	126.97	34.44
Jun	134.10	50.50	114.50	89.33	184.13	275.80	141.39	32.48
Mean	78.35	30.50	67.34	57.71	141.59	185.15		
SE	6.07	2.94	7.30	5.58	16.08	18.99		

V. pH

Months	Lo1	Lo2	Lo3	Lo4	Lo5	Lo6	Mean	SE
Jul	7.60	7.33	7.36	6.29	8.10	7.51	7.37	0.24
Aug	6.89	7.21	7.23	6.06	7.67	7.04	7.02	0.22
Sep	7.03	6.92	7.11	6.77	6.87	8.02	7.12	0.19
Oct	5.25	4.79	5.21	5.62	5.71	5.85	5.41	0.16
Nov	5.75	5.81	5.06	5.53	5.21	5.33	5.45	0.12
Dec	6.40	5.55	6.34	6.04	6.95	7.03	6.38	0.23
Jan	6.03	5.35	5.68	5.90	6.04	6.62	5.94	0.17
Feb	6.80	6.34	6.71	6.67	7.34	7.53	6.90	0.18
Mar	7.48	7.88	8.28	8.05	7.58	7.88	7.86	0.12
Apr	5.77	4.32	4.43	5.49	6.63	5.76	5.40	0.36
May	5.19	5.06	6.14	4.79	5.60	5.58	5.40	0.20
Jun	6.27	5.42	5.31	6.00	6.23	5.87	5.85	0.17
Mean	6.37	6.00	6.24	6.10	6.66	6.67		
SE	0.23	0.32	0.33	0.24	0.26	0.28		

VI. Dissolved oxygen

Months	Lo1	Lo2	Lo3	Lo4	Lo5	Lo6	Mean	SE
Jul	2.95	3.67	4.46	5.78	6.75	5.69	4.88	0.59
Aug	6.15	6.47	4.60	6.59	6.61	5.85	6.05	0.31
Sep	6.30	7.56	6.91	7.23	7.30	7.86	7.19	0.22
Oct	5.13	6.68	6.52	5.72	4.99	4.64	5.61	0.34
Nov	6.67	6.28	5.62	7.38	6.67	7.19	6.63	0.26
Dec	2.02	6.18	6.15	6.61	7.02	5.97	5.66	0.74
Jan	4.38	7.50	5.83	6.01	4.96	5.35	5.67	0.44
Feb	4.19	6.37	4.60	5.49	4.69	5.01	5.06	0.32
Mar	5.54	4.55	5.77	6.03	4.79	6.11	5.47	0.27
Apr	4.35	5.45	3.20	5.85	4.63	4.50	4.66	0.38
May	3.64	5.88	4.42	4.98	4.03	5.75	4.78	0.37
Jun	3.41	5.00	4.00	5.93	5.77	4.51	4.77	0.40
Mean	4.56	5.97	5.17	6.13	5.68	5.70		
SE	0.42	0.33	0.32	0.20	0.33	0.30		

VII. Total suspended solids

Months	Lo1	Lo2	Lo3	Lo4	Lo5	Lo6	Mean	SE
Jul	10.7	5.7	15.4	3.4	38.1	7.1	13.4	10.7
Aug	12.4	13.3	12.5	3.7	13.9	7.9	10.6	12.4
Sep	10.8	9.6	6.4	2.9	198.0	11.6	39.9	10.8
Oct	6.0	5.4	13.6	2.5	296.5	7.6	55.3	6.0
Nov	4.2	4.8	5.4	3.2	236.3	7.3	43.5	4.2
Dec	4.8	6.1	7.0	2.1	33.1	4.4	9.6	4.8
Jan	3.7	6.6	3.9	1.5	12.9	10.8	6.6	3.7
Feb	5.9	5.9	3.8	3.1	11.0	7.2	6.2	5.9
Mar	7.5	7.6	11.5	2.7	11.0	11.6	8.6	7.5
Apr	4.0	9.6	17.8	3.9	22.4	10.3	11.3	4.0
May	4.3	5.8	22.1	2.7	11.7	20.5	11.2	4.3
Jun	4.5	4.4	5.8	2.6	20.4	8.1	7.6	4.5
Mean	6.6	7.1	10.4	2.9	75.4	9.5		
SE	0.9	0.8	1.7	0.2	30.0	1.2		

VIII. Biochemical Oxygen Demand

Months	Lo1	Lo2	Lo3	Lo4	Lo5	Lo6	Mean	SE
Jul	2.62	2.67	2.61	1.97	2.13	3.03	2.51	0.16
Aug	2.78	1.59	2.71	2.11	1.17	2.49	2.14	0.26
Sep	3.36	3.48	2.99	3.17	1.16	1.31	2.58	0.43
Oct	1.19	1.07	2.37	2.62	2.80	1.60	1.94	0.31
Nov	2.78	1.04	2.75	1.45	2.06	2.22	2.05	0.28
Dec	1.22	0.65	1.08	1.61	3.57	1.29	1.57	0.42
Jan	1.90	0.63	0.70	0.84	2.05	2.21	1.39	0.30
Feb	3.13	2.48	1.73	2.22	0.73	0.63	1.82	0.41
Mar	0.90	1.37	2.14	2.97	1.08	2.22	1.78	0.33
Apr	1.53	2.21	2.17	0.20	0.40	1.69	1.37	0.36
May	2.80	2.59	3.84	3.39	3.61	5.18	3.57	0.38
Jun	1.90	1.82	2.80	2.18	0.53	1.02	1.71	0.33
Mean	2.18	1.80	2.32	2.06	1.77	2.07		
SE	0.24	0.26	0.25	0.27	0.32	0.34		

VIX. Nitrate-nitrogen

Months	Lo1	Lo2	Lo3	Lo4	Lo5	Lo6	Mean	SE
Jul	0.03	0.01	0.01	0.01	0.01	0.01	0.02	0.004
Aug	0.06	0.04	0.08	0.06	0.04	0.04	0.05	0.007
Sep	0.08	0.04	0.09	0.08	0.05	0.05	0.06	0.008
Oct	0.04	0.03	0.03	0.03	0.04	0.02	0.03	0.004
Nov	0.01	0.01	0.01	0.01	0.03	0.01	0.01	0.002
Dec	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.005
Jan	0.04	0.01	0.01	0.01	0.01	0.01	0.02	0.005
Feb	0.11	0.07	0.11	0.07	0.14	0.24	0.12	0.026
Mar	0.02	0.01	0.02	0.01	0.03	0.07	0.03	0.009
Apr	0.21	0.06	0.06	0.02	0.20	0.01	0.09	0.036
May	0.10	0.06	0.12	0.06	0.03	0.11	0.08	0.013
Jun	0.23	0.07	0.11	0.06	0.09	0.11	0.11	0.025
Mean	0.08	0.04	0.05	0.04	0.06	0.06		
SE	0.02	0.01	0.01	0.01	0.02	0.02		

X. Ammonia-nitrogen

Months	Lo1	Lo2	Lo3	Lo4	Lo5	Lo6	Mean	SE
Jul	0.07	0.00	0.02	0.00	0.06	0.09	0.04	0.016
Aug	0.05	0.00	0.01	0.00	0.00	0.04	0.02	0.008
Sep	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.002
Oct	0.02	0.01	0.01	0.03	0.04	0.01	0.02	0.005
Nov	0.01	0.00	0.02	0.03	0.03	0.01	0.02	0.003
Dec	0.08	0.06	0.06	0.05	0.08	0.05	0.06	0.006
Jan	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.002
Feb	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.001
Mar	0.00	0.03	0.00	0.01	0.02	0.02	0.01	0.005
Apr	0.03	0.00	0.04	0.00	0.02	0.01	0.02	0.007
May	0.01	0.00	0.05	0.01	0.00	0.00	0.01	0.007
Jun	0.04	0.00	0.04	0.00	0.01	0.02	0.02	0.007
Mean	0.03	0.01	0.02	0.01	0.02	0.02		
SE	0.01	0.01	0.01	0.00	0.01	0.01		

XI. Dissolved phosphorus

Months	Lo1	Lo2	Lo3	Lo4	Lo5	Lo6	Mean	SE
Jul	0.04	0.01	0.04	0.01	0.04	0.01	0.02	0.006
Aug	0.05	0.01	0.02	0.01	0.05	0.01	0.02	0.008
Sep	0.05	0.03	0.04	0.01	0.04	0.02	0.03	0.005
Oct	0.06	0.03	0.05	0.01	0.08	0.02	0.04	0.010
Nov	0.03	0.01	0.02	0.01	0.01	0.01	0.02	0.003
Dec	0.05	0.02	0.03	0.01	0.02	0.01	0.02	0.006
Jan	0.04	0.01	0.02	0.01	0.01	0.01	0.02	0.005
Feb	0.05	0.01	0.02	0.01	0.01	0.02	0.02	0.006
Mar	0.06	0.02	0.04	0.01	0.03	0.02	0.03	0.008
Apr	0.04	0.01	0.03	0.01	0.02	0.01	0.02	0.005
May	0.05	0.03	0.03	0.01	0.10	0.01	0.04	0.013
Jun	0.03	0.01	0.02	0.01	0.02	0.01	0.02	0.004
Mean	0.04	0.02	0.03	0.01	0.04	0.01		
SE	0.002	0.002	0.003	0.000	0.008	0.001		

XII. Chlorophyll *a*

Months	Lo1	Lo2	Lo3	Lo4	Lo5	Lo6	Mean	SE
Jul	58.7	6.7	71.0	6.7	8.3	23.0	29.1	11.7
Aug	54.0	14.3	33.3	6.7	3.0	19.3	21.8	7.8
Sep	22.3	5.7	3.0	2.0	10.0	12.7	9.3	3.1
Oct	24.0	11.7	37.3	3.7	6.0	24.7	17.9	5.3
Nov	15.7	12.3	26.0	5.0	3.7	17.3	13.3	3.4
Dec	3.7	10.7	31.0	3.0	11.3	11.3	11.8	4.1
Jan	5.0	17.0	19.0	4.3	3.3	24.3	12.2	3.7
Feb	7.3	11.3	9.3	3.3	2.7	18.0	8.7	2.3
Mar	9.3	14.7	42.3	8.0	4.3	39.0	19.6	6.8
Apr	11.3	9.3	34.7	5.7	4.7	36.7	17.1	6.0
May	34.0	5.0	23.7	2.7	1.0	23.7	15.0	5.7
Jun	17.0	10.7	8.3	2.0	6.0	29.3	12.2	4.0
Mean	21.9	10.8	28.3	4.4	5.4	23.3		
SE	5.3	1.1	5.3	0.6	0.9	2.5		

Appendix D

Each measured environmental value (Table 2) is given a standard score that ranges from 0.1 to 1.0 depending on its relationship to the recommended maximum allowable level given a score of 1.0. For each water sample these scores are summed to provide an indication of its quality. Value will range from 0.7 to 7.0 with the latter having the worst quality. According to the work of Peerapornpisal (2004) the values are then classified according to the following Table 3.

Table 2 Standard scores for each environmental variable

DO (mg/L)	Standard score
> 8	0.1
7-8	0.2
6-7	0.3
5-6	0.4
4-5	0.5
3-4	0.6
2-3	0.7
1-2	0.8
0.5-1	0.9
< 0.5	1.0

Table 2 (continued)

BOD (mg/L)	Standard score
< 0.25	0.1
0.25-0.5	0.2
0.5-1	0.3
1-2	0.4
2-4	0.5
4-10	0.6
10-20	0.7
20-40	0.8
40-80	0.9
> 80	1.0

Conductivity (μS/cm)	Standard score
< 10	0.1
10-20	0.2
20-40	0.3
40-70	0.4
70-100	0.5
100-150	0.6
150-230	0.7
230-400	0.8
400-550	0.9
> 550	1.0

Table 2 (continued)

Nitrate-nitrogen (mg/L)	Standard score
< 0.05	0.1
0.05-0.1	0.2
0.1-0.3	0.3
0.3-0.8	0.4
0.8-1.5	0.5
1.5-3.0	0.6
3.0-10.0	0.7
10.0-20.0	0.8
20.0-40.0	0.9
> 40.0	1.0

Ammonia-nitrogen (mg/L)	Standard score
< 0.1	0.1
0.1-0.2	0.2
0.2-0.4	0.3
0.4-0.8	0.4
0.8-1.5	0.5
1.5-3.0	0.6
3.0-5.0	0.7
5.0-10.0	0.8
10.0-20.0	0.9
> 20.0	1.0

Table 2 (continued)

Dissolved phosphorus (mg/L)	Standard score
< 0.05	0.1
0.05-0.2	0.2
0.2-0.4	0.3
0.4-0.8	0.4
0.8-1.5	0.5
1.5-3.0	0.6
3.0-5.0	0.7
5.0-10.0	0.8
10.0-20.0	0.9
> 550	1.0

Dissolved phosphorus (mg/L)	Standard score
< 0.05	0.1
0.05-0.2	0.2
0.2-1.0	0.3
1.0-2.5	0.4
2.5-5.0	0.5
5.0-10.0	0.6
10.0-20.0	0.7
20.0-50.0	0.8
50.0-150.0	0.9
> 150	1.0

Source: Prommana (2006)

Table 3 Score from the assessment of water quality

Scores	Trophic status
0.1-0.9	hyper oligotrophic
1.0-1.8	oligotrophic
1.9-2.7	oligotrophic-mesotrophic
2.8-3.6	mesotrophic
3.7-4.5	mesotrophic-eutrophic
4.6-5.4	eutrophic
> 5.5	hypereutrophic

Source: Prommana (2006)