

**DEVON AREA
INTERNAL REPORT**



**ENVIRONMENT
AGENCY**

**INVESTIGATION INTO THE
CHEMICALS PRESENT AND
ENTERING STOVER LAKE,
STOVER COUNTRY PARK**

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ENVIRONMENT AGENCY

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Executive Summary:

Stover Lake is a SSSI at Stover Country Park, Stover, Devon. English Nature and the Stover Country Park wardens have been concerned about a decline in the ecological diversity of the main lake and concerns were raised this may be due to eutrophication of the water body.

The lake is fed via streams which have been or have the potential to become polluted from a ranges of sources. These include the Heathfield industrial estate, the A38 dual carriageway, a hydraulically overloaded sewer line, metallic seepage's from a plantation area and potential enrichment from domestic misconnections. Smaller satellite ponds around the periphery of the lake which are groundwater fed have a desirable ecological status.

Investigations were carried out to identify the chemicals present in the water column and in sediment at 4 sites, the inflow, outflow, main lake and a control satellite pond. Samples were collected and analysed using quantitative and investigative qualitative analyses to produce an inventory of substances present. A range of Environmental Quality Standards were adopted and applied to the results and the data set from the lake compared with that from satellite pond control.

The lake was found to be marginally eutrophic with a high zinc concentration present in the sediment. The zinc was at a concentration where some detrimental effects on the biota of the lake would be expected. How these effects would be expressed in the biota / ecology of the lake is unclear. Loading calculations indicated zinc to be the only substance to be accumulated in the lake to any degree. There was no evidence of exotic pollutants in either aqueous or sediment samples at any of the sites other than those naturally associated with freshwater environments.

A portable water quality monitor was installed in the centre of the lake to record dissolved oxygen % saturation, pH, temperature and conductivity. Data gathering was at 15-minute intervals and covered the period early July to early November 2002. Data from his deployment did not indicate the algal activity normally associated with a eutrophic water body. Dissolved oxygen saturation was generally poor and pH levels generally stable. This lack of eutrophic signature combined with presence of a nutrient enriched water body would suggest something to be inhibiting phytoplankton action.

Whilst it is evident that nutrient enrichment and metal seepage to the feeder streams have been having an impact on the lake and potentially its eco-diversity, no evidence of recent exotic pollution incidents were apparent. However, there remains the potential for Stover Lake to be polluted by a major incident from Heathfield industrial estate, hydraulic failure of nearby sewerage and spills on the A38 dual carriageway.

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INVESTIGATION INTO CHEMICALS PRESENT & ENTERING STOVER LAKE, STOVER COUNTRY PARK:

1 INTRODUCTION:

Stover Lake is a Site of Special Scientific Interest (SSSI) and forms part of the Stover Country Park that is situated approximately 2 miles north of Newton Abbot at NGR SX 8340 7510 (see Figure 1).

It has been noted by the Country Park and English Nature that the ecology of the main lake, notably its aquatic flora, has been in decline whilst some satellite ponds appear to be stable. Eutrophication of the lake has been suggested by English Nature as a possible cause.

The main inputs to the lake have the potential to be contaminated by several polluting sources:

Heathfield Industrial / Residential Estate.

Pollution incidents to the lake feeder stream have previously been reported. There is also the potential for residential misconnections to enter the stream.

A38 Road / Drum Bridges.

Road run-off can occur to ditches / drains and enter lake feeder streams.

Liverton Brook / 'Great Plantation' area.

Crude sewage from a hydraulically overloaded sewer line can enter the stream.
Metaliferous seepage / ochre fungus from the coniferous plantation area observed entering the stream at Drum Bridges.

In addition, agricultural run-off and septic tank discharges may potentially enter the feeder streams further up the catchment.

2 OBJECTIVE

The aim of this investigation is to report the chemical composition of water entering, residing and leaving the lake and to compare it with that of a 'good' satellite pond. Sediments will also be analysed to determine a chemical inventory of substances held at these 4 sites.

Continuous water quality monitoring will record data to determine the extent of diurnal variations of parameters as pH and dissolved oxygen. Temporal signatures of these determinands can be useful in illustrating effects of eutrophication if present.

Hydrometric surveying on the day of the chemical sampling will also enable the chemical load to the lake to be calculated.

3 METHOD

3.1 Chemical / Sediment Sampling

Water / sediment samples were collected from 4 sites in the Stover Country Park on 19/02/02 (see Figure 1). Sites were:

Centre of the Lake (site 1) NGR SX 83472 75069

Main input to the Lake (site 2) NGR SX 83188 75256

Satellite (good) Pond (site 3) NGR SX 83484 75198

Output of the Lake (site 4) NGR SX 83756 75204 (sluice gate area sampled as no flow over weir)

Aqueous samples were taken at approximately 5cm from the water surface and sediment collected by grab from the top 5cm of substrate. Each sample was analysed quantitatively for a number of substances. Investigative screening techniques such as Gas Chromatography Mass Spectroscopy (GCMS, solvent extraction at neutral, basic and acidic pH's) and Inductive Coupled Plasma- Mass Spectroscopy (ICP-MS, Acid digestion at 80°C) were also carried out on water & sediments to identify substances not specifically analysed for. Whilst these screening techniques are basically qualitative, they do give an indication of levels of substances present i.e. are also semi-quantitative.

3.2 Continuous Water Quality Monitoring

Two YSI 6920 water quality monitors were used for this investigation. Whilst one was deployed at site 1, 'Centre of the Lake' the other would be cleaned and calibrated ready to replace the first. The monitors were usually validated / replaced and downloaded on a bi-weekly basis. The monitors were programmed to record the parameters dissolved oxygen % saturation, temperature, pH and conductivity at 15 minute intervals.

The dissolved oxygen probe is a rapid pulse Clark-Type polarographic unit which is much less dependent on flow across the membrane than more traditional electrochemical probes. The older types of probe would give very inaccurate results in a still-water environment such as a lake. The new probe is quoted by YSI as giving up to a 3% lower reading in still waters than the true result. This error is reduced further if sampling interval is in the order of 15 minutes (as is the case with this study) or removed completely with minimal flow.

The water quality monitors were deployed horizontally so the probes were approximately 40 cm below the water surface. The total depth of the lake at site 1 is approximately 110 cm. Validation was carried out using freshly calibrated (previous day) hand-held YSI 556 water quality monitors.

3.3 Extra water quality monitor (handheld) data

Spot readings were also occasionally taken (using the handheld YSI 556) at four further sites for additional data (sites 3, 8, 9 & 10 see Figure 1).

3.4 Hydrometry

The Water Resources Team took hydrometric measurements of the inputs and outputs of the lake (see Figure 1). Sites measured were:

Output of the Lake (site 4) NGR SX 8376 7520

Inflow to the Lake (site 5) NGR SX 8299 7529

Outflow by STW (site 6) NGR SX 8347 7476

4 ENVIRONMENTAL QUALITY STANDARDS (EQS's)

EQS's can be applied to water & sediment results and are generally dependent on any designation / use criteria for the water body. Examples of EQS's would include the Protection of Freshwater Life, River Ecosystem (RE) use classification, and Protection of Surface Water Abstraction to mention but a few.

The RE use class of the Liverton Brook is RE 1. The EQS's applicable to this use will be applied to the input and output of the lake and adopted for the main lake and satellite pond. In addition, the EQS's for the Protection of Freshwater Life covers still and flowing waters (Ref.1). The standards for this and a range of other uses will be adopted for Stover Lake itself. This will help with interpretation of the data and give a degree of understanding as to the environmental impact of the substances at the concentrations identified.

The EQS's were obtained using the Equals ver 3.0, a computer database of environmental standards provided by the National Centre for Environmental Toxicology and are presented in Table 1. (Please note, the units given in Table 1 are those given in the database and the standards may be expressed as annual averages, Maximum Allowable Concentrations (MAC) and percentiles).

There are no Environment Agency / UK EQS's for sediments. In their absence, standards derived elsewhere can be used as a guideline. Consensus-based Sediment Quality Guidelines (SQG's) (based on the older numeric SQG's) have been developed in North America. Whilst the previously numeric based guidelines had been developed using a variety of approaches, each with their own advantages and limitations, the consensus based SQG's were concluded to provide a reliable basis for sediment quality assessment in freshwater ecosystems (Ref. 2) and will be adopted for this study.

The 'Threshold Effect Concentration' (TEC) is used to provide an accurate basis for predicting absence of sediment toxicity. The 'Probable Effect Concentration' (PEC) is used to provide an accurate basis for predicting sediment toxicity (Ref. 2).

No EQS's were identified for nutrients present in sediments.

5 RESULTS

5.1 Chemical samples

The quantitative analyses show few of the determinands at the 4 sites to have exceeded the adopted EQS's. Of the exceeded values, the majority are those which would be applicable to drinking water (see Table 1). Of the sediment analyses, most of the metals were above the adopted TEC's and a lower proportion above the PEC's (see Table 1 and Figure 2).

Leachable nutrient concentrations (the fraction more readily available to biological processes, comm. Laboratory) in the sediment of the Lake (site 1) were generally greater than those present in the sediment of the satellite pond (site 3). However, leachable orthophosphate was below detection limits at all sites and the leachable phosphorus concentration was higher in the satellite pond sediment sample than that taken from the Lake at site 1 (see Figure 3).

Apart from the leachable fraction, total nitrogen, phosphorus and ammonia concentrations present in the sediment were greater in the Lake sample than the good pond (see Figure 3).

Nutrient-based determinands in the aqueous samples were also generally at higher concentrations in the Lake sample than that from the satellite pond (see Figure 4).

Metal concentrations in the aqueous samples were variable (See Figure 5).

The results from the qualitative / semi-quantitative analyses for organic compounds at the four sites did not give any cause for concern. The scans highlighted substances associated with the natural decomposition of organic matter and were at low concentrations (comm. Laboratory). One aqueous sample (site 4, see Table 1) did contain a trace of diesel (very low concentration) which can be associated with heavy machinery being used in the area at the time.

Similarly, qualitative / semi-quantitative scans for exotic metals highlighted only those normally associated with the natural geology and were at expected levels (comm. Laboratory).

The chlorophyll-a content of the lake sample was less than that in the satellite pond (2.8 mg/l and 3.1 mg/l respectively, see Table 1)

5.2 Substances exceeding adopted EQS's

See Table 1

Site 1 Centre of the Lake.

Aqueous samples

Total phosphorus (0.087 mg/l) would marginally place the lake in a eutrophic category (guideline). Total aluminium (0.226 mg/l), total iron (1.26 mg/l), turbidity and colour would exceed the standard for drinking water.

Sediment samples

Copper, zinc, cadmium, lead, arsenic and nickel would exceed the TEC EQS's. Zinc, arsenic and nickel would exceed the PEC EQS's

Site 2 Input to the Lake.

Aqueous samples

Dissolved Oxygen (79.7%) would exceed the RE 1 EQS, Nitrite (0.0338 m/l) would exceed the 'Protection of FW life' EQS, total iron (0.568 mg/l) and turbidity would exceed the standard for drinking water.

Sediment samples

Copper, zinc, cadmium, lead, arsenic and nickel would exceed the TEC EQS's. Zinc and lead would exceed the PEC EQS's

Site 3 Satellite Pond.**Aqueous samples**

Dissolved Oxygen (76.6%) would exceed the RE 1 EQS. Dissolved copper (0.0064 mg/l) would exceed standard for the protection of aquatic life (due to very low hardness of the water). COD (37 mg/l) would exceed the standard for water abstraction intended for drinking, total aluminium (0.725 mg/l), total iron (0.961), total hardness (17.3 mg/l), alkalinity, turbidity and colour would exceed the standard for drinking water.

Sediment samples

Copper, zinc, lead, arsenic and nickel would exceed the TEC EQS's. Arsenic would exceed the PEC EQS's.

Site 4 Output of the Lake.**Aqueous samples**

Dissolved Oxygen (68.2%) would exceed the RE 1 EQS. Total iron (1.55 mg/l), turbidity and colour would exceed the standard for drinking water.

Sediment samples

Copper, zinc, cadmium, lead, arsenic and nickel would exceed the TEC EQS's.

5.3 Continuous Water Quality Monitor

Data recorded by the continuous water quality monitors are presented in Figure 6. Basic statistics from the recorded data covering the period 3rd July 2002 to 9th November 2002, are presented below in Table 2.

Table 2. Continuous Water Quality Monitor Statistics.

Parameter	Minimum	Maximum	Average	Standard Deviation
Dissolved Oxygen % sat	1.2	105.5	46.5	17.60
Temperature °C	7.87	22.65	16.1	3.36
pH	6.93	7.41	7.12	0.08
Conductivity mS/cm	0.197	0.330	0.293	0.02

Diurnal variations were recorded in the data (see Figure 6). Validation readings taken using a hand-held water quality monitor were in general agreement with the data sets recorded (see Figure 6).

5.4 Extra water quality monitor (handheld) data

Data collected from site 1, 3, 8, 9 and 10 are presented in Table 3 below.

Table 3. Water quality data collected via handheld YSI 556.

Date	Time	Site	Site Description	Temp Deg C	DO % sat	pH	Cond uS/cm
16/07/2002	14:21	1	Lake	18.23	60.1	6.98	280
03/07/2002	14:59	1	Lake	17.3	50.5	7.25	267
01/08/2002	13:28	1	Lake	19.46	42.7	7.06	318
16/08/2002	08:25	1	Lake	17.94	20.7	7.14	307
16/08/2002	08:33	9	Lilly area in Lake	17.38	20.9	7.1	308
16/08/2002	08:37	8	Reed area side of Lake	17.36	42.9	7.16	308
16/08/2002	08:47	10	Feeder stream footbridge	15.22	39.3	7.3	395
16/08/2002	08:55	3	Satellite pond	16.68	54.1	5.89	122
29/08/2002	08:28	1	Lake	18.3	75.3	7.22	302
29/08/2002	08:40	8	Reed area side of Lake	17.95	69	7.13	283
11/09/2002	09:09	1	Lake	14.92	34.7	7.12	305
11/09/2002	09:21	8	Reed area side of Lake	15.44	115	7.58	306
09/10/2002	13:55	1	Lake	12.88	58.5	7.19	303
09/10/2002	14:02	9	Lilly area in Lake	13	61.1	7.15	303
09/10/2002	14:11	8	Reed area side of Lake	13.15	99.1	7.36	305
09/10/2002	14:19	10	Feeder stream footbridge	11.76	49.6	7.22	356
09/10/2002	14:29	3	Satellite pond	13.23	98.2	7.24	124
21/11/2002	12:05	1	Lake	9.56	59.7	7.26	249
21/11/2002	12:14	8	Reed area side of Lake	10.51	70.1	7.1	225
21/11/2002	12:26	10	Feeder stream footbridge	10.52	79.5	7.15	224
21/11/2002	12:32	3	Satellite pond	9.75	83	5.67	106

Note:

11 September 2002 .

High dissolved oxygen saturation at the side of the lake by the reeds (site 8, 115 DO % sat.) was most likely caused by large quantities of filamentous algae (identified as *Spirogyra* sp.) present on the substrate. This contrasts with the low dissolved oxygen concentration in the middle of the lake (site 1, 34.7 DO % sat.). Dense 'clouds' of *Daphnia* sp. were also observed at site 8.

5.5 Hydrometry

The hydrometry measurements were taken on the same date as the collection of the chemical samples (see Table 4 below and APPENDIX I).

Table 4. Hydrometry sites and results

Site	Flow cumecs
Inflow to the Lake (site 5 inc small drain)	0.022068
Outflow by STW (site 6)	0.022859
Output of the Lake (site 4)	0.019154
Total outflow	0.042013

The flow data was used to determine the load of the chemicals entering and leaving the lake (see Table 1).

6 DISCUSSION

The primary aim of this study has been to list the chemicals entering, leaving and residing in Stover Lake. This hopefully can provide an understanding of what maybe causing or contributing to the general decrease in the eco-diversity observed in the lake. The satellite pond (site 3) was included in the sampling as a basis for comparison, the diversity and ecology of this pond regarded as desirable by Stover Country Park.

6.1 Chemical Inventory

The results from the aqueous samples collected from the lake (site 1) did not exceed any EQS's for the Protection of Freshwater Life. Indeed, the only EQS's identified as being exceeded were those used for drinking water (total aluminum, total iron, colour and turbidity see Table 1). As a comparison, the sample taken from the satellite pond contained over three times the concentration of total aluminum than that recorded in the lake sample. Likely source for the aluminum would be the clay substrate rather than anthropogenic action and at this stage is of little concern.

6.2 Nutrients

The total phosphorus concentration in the aqueous samples from the lake would marginally classify it into the eutrophic category and the satellite pond as mesotrophic (result site 1, 0.087 mg/l, site 3, 0.023 mg/l, see Table 3). However, it must be emphasized that this is only on the basis of one data set and that the guideline standard is quoted as annual geometric mean. Activities such as burrowing (in sediment) and metabolism / uptake by biota and temperature rise may well vary this concentration.

Interestingly, under aerobic conditions, aluminum and iron will bind the phosphorus preventing release to biota. When conditions become anoxic, phosphorus is re-released to the water column and becomes available to biological processes (Ref. 1). At the time of the sample collection, the water in the lake was aerobic (84% sat, see Table 1). The classification was based on this single sample. However, during the period of the water quality monitor deployment, anoxic conditions were recorded near the surface of the lake (see Table 1) and it is very likely the occurrence / duration of such anoxic conditions were

far greater at depth nearer the substrate. It is fair to assume that under such conditions, phosphate concentrations in the water column available to biota use would be elevated.

The input to the lake (running water) would be categorized as mesotrophic (result site 2, 0.055 mg/l orthophosphate). This standard is for Soluble Reactive Phosphorus (SRP, or orthophosphate as an equivalent) and uses an annual average as the basis of the categorization (see Table 3).

Table 3. Interim standards for phosphorus in standing and running waters.

Trophic Category	Standing Fresh Waters (ug TP/l annual geometric mean)	Running Fresh Waters (ug/l SRP, annual mean)
Oligotrophic	8	20
Mesotrophic	25	60
Meso-eutrophic	-	100
Eutrophic	85	200

Ref. 3

As would be expected, the nutrient concentrations in both aqueous and sediment samples from the lake were generally higher than those from the satellite pond. This would be expected considering the potentially nutrient rich inputs. However, high densities of phytoplankton were not observed in the centre of the lake despite it's elevated nutrient status even during the summer months. Indeed, the continuous water quality monitor installed at site 1 did not record data normally associated with a eutrophic water body throughout the deployment period.

The chlorophyll-a concentration in the sample taken from site 1 was similar to that recorded in the satellite pond site 3 (2.8 ug/l and 3.1 ug/l respectively). Ideally, more samples temporally separated to include all seasons would be required to draw any conclusions as it is likely the algae present would have been fairly dormant at the date of the sample. Macrophyte population during the summer months within the body of the main lake was dominated by *Nymphaea* sp.

6.3 Continuous monitoring data

Data from the monitor deployed at site 1 indicated the water quality to be quite poor at times. Although the pH and conductivity remained fairly stable and within EQS's, the dissolved oxygen saturation was consistently below the adopted EQS of 80% (average 46.5% saturation).

Typically, with a eutrophic water body, oxygen saturation and pH levels would show large characteristic diurnal variations. These 'swings' are usually so great as to result in changes of several pH units and oxygen depletion to super-saturation in a 24-hour period.

Diurnal variations were present in the recorded dissolved oxygen and pH data, but were not as extreme as would be expected in a eutrophic environment. Indeed, although oxygen depletion was readily recorded, saturation levels rarely rose above 80 %.

Incidentally, whilst there was little evidence of effects from photosynthesis (phytoplankton) or observation of zooplankton at the centre of the lake (site 1), algae and

large colonies of *Daphnia* sp. were observed at the lake margins (pers.com.). On this occasion (11 September 2002, see Table 3), the dissolved oxygen levels in water overlaying sheets of *Spirogyra* sp. present on the substrate were super-saturated (hand-held monitor 115 DO% saturation) as would be expected with a nutrient enriched water body. By comparison, the saturation recorded in the centre of the lake was 34.7%. This may suggest that something could be inhibiting phytoplankton in the main body of the lake.

The lake is also very shallow (110 cm at site 1). When sampled, the substrate was dark, finely divided with a characteristic 'rotten egg' smell, usually associated with anoxic conditions. This may be a contributing factor to the low dissolved oxygen levels recorded at the site.

When the data are compared against that for rainfall (Chudleigh station number 361850 NGR SX 866 793, see Figure 6), the dilution effect of the rainfall is shown by the decrease in conductivity. Besides the dissolved oxygen and pH diurnal variations being flattened slightly (see Figure 1), generally no further effects were recorded.

6.4 Exotics Scan

The qualitative / semi-quantitative scans (GCMS & ICPMS) did not indicate any exotic pollutants in either the water column or the sediments at any of the sites. Whilst this is encouraging considering the potential inputs from the Heathfield industrial estate, the sediment samples were collected from the top 5 cm of substrate.

The temporal span that this depth of sediment equates to is not known; it may be that older and deeper sediments may or may not contain indications of historic pollution incidents.

Substances identified (hydrocarbons see Table 1) were at very low levels (ug/g) and are considered to be the by-products of various natural metabolism processes. A trace of diesel at the outflow (site 4) was identified but can be linked to the use of heavy machinery in the area on the day of sampling. The metal scans again resulted in those one would normally associate with natural geology and at the appropriate levels (comm. Laboratory).

6.5 Metals in Water column

With exception to the aluminium and iron (discussed previously), no other metals in the aqueous samples exceeded adopted EQS's in the lake sample.

The copper concentration in the satellite pond however, did exceed the adopted EQS for copper (Protection of Freshwater life) due to the very low total hardness of the sample. Again, since the ecology of this pond is good, this result is not regarded as too detrimental.

No particular pattern was discernible between the lake and satellite pond samples. For example, whilst, sodium, potassium, magnesium, iron and calcium were at higher concentration in the lake sample, cadmium, zinc, copper, aluminium and chromium were higher in the satellite pond.

Interestingly, zinc concentrations were highest in aqueous samples from the feeder stream but yet the satellite pond samples were higher than the lake. Metaliferous seepage is known to occur from the plantation area north-west of the Drum Bridges roundabout. It is possible that zinc present in the input becomes locked into the sediment rather than

remaining in suspension. This could explain why the zinc concentration in the aqueous lake sample is lower than the input but is elevated in the lake sediment sample.

6.6 *Metals in the sediment*

The metal concentrations recorded in the sediments were in excess of the TEC and PEC limits. It must be stressed that these standards are not absolute and likely to be site specific. Also, it is noted that the concentrations at which biological effects are recorded may indeed change depending on the total chemistry of the sediment. For these reasons, TEC and PEC standards will be used as guidelines.

Samples of the lake sediment exceeded the PEC standard for zinc, arsenic and nickel. The arsenic concentration in the lake was comparable to that in the satellite pond (lake 46.2 mg/kg, satellite pond 43 mg/kg, PEC 33 mg/kg). As such, this indicates the arsenic concentration isn't having a too detrimental effect. Nickel levels in the lake were just above the PEC (49.9 mg/l, PEC 48 mg/kg) but the zinc concentrations exceeded the PEC by approximately 19%; concentrations in the satellite pond were low by comparison (lake 545 mg/kg, good pond 141 mg/kg, PEC 459 mg/kg).

Although zinc is a necessary trace element for biological processes, high concentrations are known to be toxic to both animal and plant life. That the concentration in the sediment is 19% greater than the PEC EQS, a standard above which the effects are probable, some toxic effects are likely to be observable in the lake environment.

How any detrimental effect would be expressed is unclear. Again, caution must be used with these EQS's. That the arsenic concentrations in both lake and satellite pond are above the PEC levels (with ecodiversity in the satellite pond expressed as good), this only highlights how 'guideline' these standards are.

6.7 *Hydrology and Chemical loading to the lake*

In an attempt to quantify loading to the lake, flow data were recorded from the streams entering and leaving the lake. These results indicated that there was approximately twice the volume of water leaving than entering the lake at any one time. However, it has been suggested that there may be many small feeder ditches on the lakes periphery and that groundwater may form a significant input to the lake.

Using the flow data and chemical analysis results, an indication of the loading to the lake was made (Table 1). These calculations obviously took no account of the 'unseen' inputs to the lake and assumed the chemical composition of the two outflows to be the same. The difference between the loads has suggested that only zinc, both dissolved and total, was being retained in the lake environment. This would explain why there was a high concentration of zinc in the sediment in the centre of the lake. These calculations were only performed on the aqueous results, the sediments being prone to scouring under spate / high flow conditions at the inflow / outflow sites.

6.8 Sources of pollution

The analyses have shown there to be undesirably high concentrations of nutrients and metals (particularly zinc) in the Stover Lake at site 1. Although no exotic organic compounds were identified in the qualitative / semi-quantitative scans, the potential for pollution incidents of this nature are a reality.

Potential sources for this pollution include:

Nutrients & Organic matter

Crude foul discharges from Liverton – Heathfield Industrial / residential sewerage network (mis-connections, hydraulic overload discharges to watercourse).

Wild fowl on Stover Lake itself.

Potential agricultural run-off and septic tank discharges in rural stretches of the feeder streams.

Metals

'Great Plantation' woodland seepage's, run-off / spills from Heathfield Industrial Estate & the A38 road.

Exotics (metals, organic compounds) and fuels

Run-off / spills from Heathfield Industrial Estate & A38 road and to lesser degree Liverton – Heathfield Industrial sewerage network.

6.9 National Centre for Ecotoxicology and Hazardous Substances (NCEHS)

Please note that this report was circulated to the NCEHS.

7 CONCLUSIONS

1. The data indicate that Stover Lake is mildly eutrophic. However, excessive diurnal variations in dissolved oxygen concentration and pH level were not recorded.
2. Sources of nutrient enrichment are likely to be crude foul discharges to the feeder stream via overloaded sewerage, mis-connections etc from Liverton – Heathfield Industrial / Residential estate and wild fowl on Stover Lake itself.
3. Dissolved oxygen concentrations in the centre of the lake were consistently low during the period of investigation.
4. The zinc concentration in the sediment at the centre of the lake is above the Probable Effect Concentration EQS. How this would be expressed in the eco-diversity of the lake is unclear.
5. The zinc concentration in the sediment from the satellite pond is much less than that from the lake, being marginally above the Threshold Effect Concentration EQS.
6. The evidence suggests that the source of the zinc in the lake sediment to be upstream of the feeder stream input site (site 2) and is likely to be metaliferous seepage's from the plantation area and to a lesser degree runoff from Heathfield Industrial estate.

7. No evidence of any recent 'exotic' pollution incidents could be identified in either aqueous or sediment samples taken from the centre of the lake.
8. There remains the potential for Stover Lake to be polluted by a major incident from Heathfield Industrial Estate, hydraulic failure of nearby sewerage or spill on the A38 road.

8 REFERENCES

1. Comments from National Centre for Ecotoxicology and Hazardous Substances (NCEHS). Environment Agency, Evenlode House, Wallingford.
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Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39, 20-31
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Figure 1. Map of Stover Lake showing data collection points.

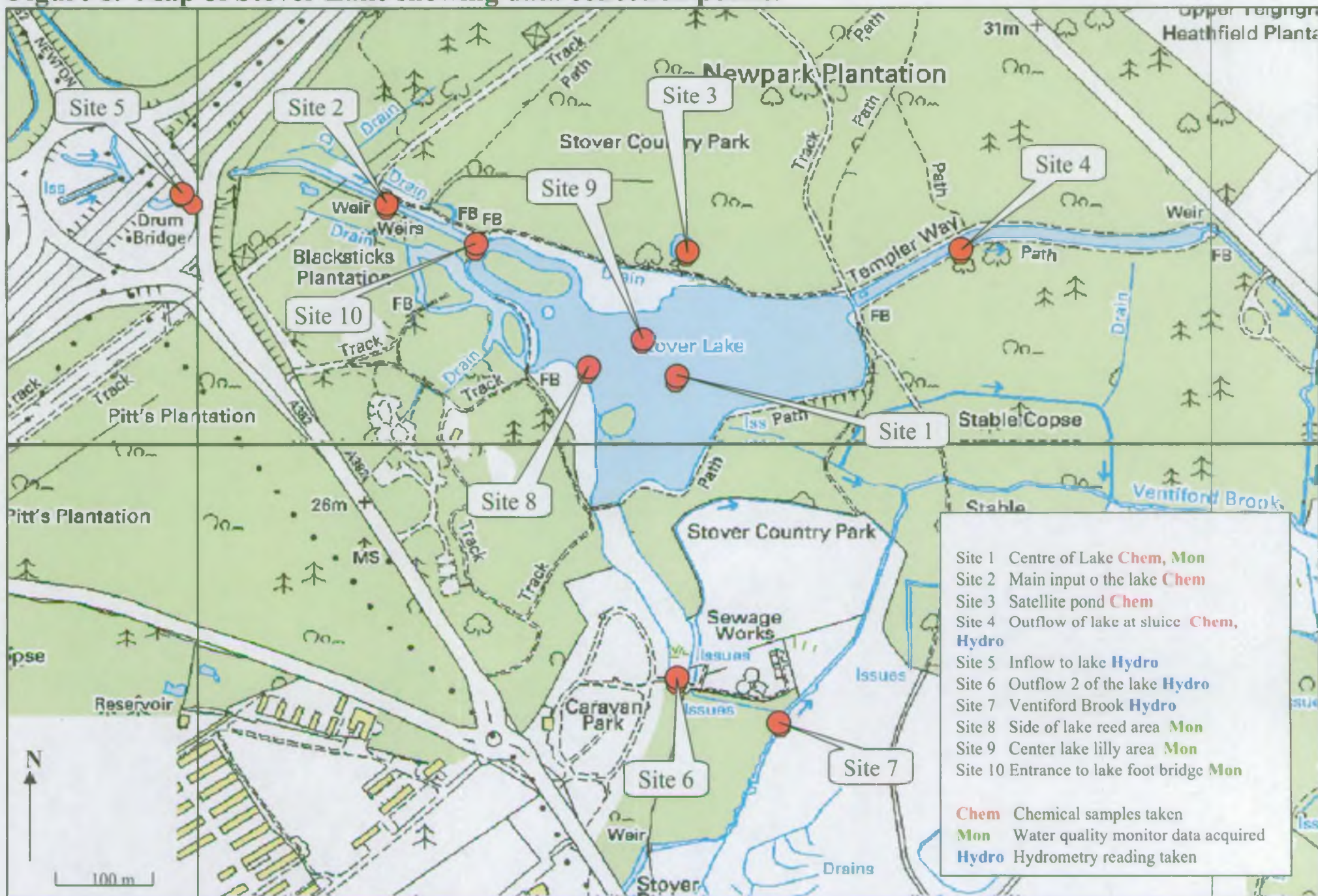


Table 1. Stover Lake Investigation: 19 February 2002: Note Please read in conjunction with notes overleaf.

	Site	Site 1 Lake				Site 2 Main input		Site 3 Satellite		Site 4 Outflow		Load from Input	Load from output	Load Input - Load output	Environmental Quality Standard (from Equals V3.0 database, WRc application)					
		19-Feb-02		19-Feb-02		19-Feb-02		19-Feb-02		Surface water, intended for drinking water	River Ecosystem use class				Protection of FW life	Designated Fisheries	Drinking water			
		Date	Time	Date	Time	Date	Time	Date	Time											
	Determinand				Result															
<--9501-->	DO % sat	84		79.7		76.6		68.2		1758.8196	2865.2866	-1106.467	50%	80% (10%ile)	-	-	-	-	>75%	
<--9924-->	DO mg/l calc	10		9.41		9.06		8.18		207.65988	343.66634	-136.00646	-	-	2mg/l (95%ile prop.)	-	>8.0mg/l G	-	-	
<--0061-->	pH	7.37		7.35		6.31		6.9		162.1998	289.8897	-127.6899	5.5 - 9 (G 90 %ile)	6-9 (5% 95%ile)	6 - 9 (95%ile)	-	6-9 (50%ile)	-	5.5-9.5	
<--0062-->	Cond uS	248		352		246		10335.198		7767.936	10335.198	-2567.262	1000 uS/cm (G. 90%ile)	-	-	-	-	-	1500uS/cm	
<--0063-->	Turbidity	15.2		5.7		9.34		19.5		127.77372	831.8574	-704.08368	-	-	-	-	-	-	4.0 mg/l as PtCo (1.95%ile)	
<--0072-->	Colour	28.1		16		54.7		29.3		353.088	1230.9809	-877.8929	100 mg/l PtCo (1.95%ile)	-	-	-	-	-	10 mg/l as PtCo (1.95%ile)	
<--0076-->	Temp oC	7.52		8.04		7.99		7.41		177.42672	311.31633	-133.88961	25.95%ile	-	-	-	-	-	25 MAC	
<--0085-->	BOD ATU mg/l as O2	1.1		1.5		1.4		1.2		33.102	50.4156	-17.3136	<5 mg/l (G 90%ile)	2.5 mg/l (90%ile)	6 mg/l (G. 95%ile)	6 mg/l (G. 95%ile)	-	-	-	
<--0092-->	COD mg/l as O2	18		12		37		20		264.816	840.26	-575.444	30 mg/l (A3 G. 90%ile)	-	-	-	-	-	-	
<--0135-->	Suspended solids 105 mg/l	9.1	<	3		4.9		12.1		66.204	508.3573	-442.1533	25mg/l (A1.G. 90%ile)	-	<= 25 mg/l (G. as)	<=25mg/l (G. as)	-	-	none (G)	
<--0143-->	Solids non-volatile 500 mg/l	<	20	<	20	<	20	<	20	441.36	840.26	-398.9	-	-	-	-	-	-	-	
<--0158-->	Total Hardness mg/l	83.8		105		17.3		84.2		2317.14	3537.4946	-1220.3546	-	-	-	-	-	-	17.3 mg/l as CaCO3 (1%ile)	
<--0111-->	NH3 mg/l as N	0.185		0.154		0.174		0.199		3.398472	8.360587	-4.962115	2mg/l as (NH4 MAC)	0.6 mg/l (90%ile)	-	1 mg/l (95%ile T, as NH4)	-	-	0.5 mg/l (as NH4 MAC)	
<--0114-->	N Kjeldahl mg/l	0.72		0.68		0.75		0.69		15.00624	28.98897	-13.98273	2mg/l as (G. 90%ile)	-	-	-	-	-	1 mg/l MAC	
<--0116-->	N total oxidised mg/l	1.02		1.65	<	0.2		1		36.4122	42.013	-5.6008	-	-	-	-	-	-	-	
<--0117-->	NO3 mg/l	0.996		1.62		0.191		0.972		35.75016	40.836636	-5.086476	75mg/l (MAC)	-	-	-	-	-	50mg/l (MAC)	
<--0118-->	NO2 mg/l	0.0242		0.0338		0.0087		0.0282		0.7458984	1.1847666	-0.4388682	-	-	0.03 mg/l (G. 95%ile, T)	-	-	-	0.1mg/l (MAC)	
<--0119-->	Un ionised NH3 mg/l	0.0007		0.0006	<	0.0001		0.0002		0.0132408	0.0084026	0.0048382	-	-	-	-	0.025 (95%ile, T)	-	-	
<--0729-->	Chlorophyll-a ug/l	2.8	<			3.1		3.5		0	147.0455	-147.0455	-	-	-	-	-	-	-	
<--3683-->	Nitrogen total inorganic mg/l	1.21		1.8		0.374		1.2		39.7224	50.4156	-10.6932	-	-	-	-	-	-	-	
<--0162-->	Alkalinity pH 4.5 mg/l	58		69		10		54		1522.692	2268.702	-746.01	-	-	-	-	-	-	0 mg HCO3- (1.2%ile)	
<--0172-->	Chloride ion as Cl mg/l	37.6		64.8		31.3		38		1430.0064	1596.494	-166.4876	200mg/l (G. 90%ile)	-	250mg/l (prop)	-	-	-	250mg/l	
<--0180-->	Ortho-phosphate mg/l	0.055		0.055	<	0.01		0.068		1.21374	2.856884	-1.643144	0.7 (G. 90%ile)	-	-	-	-	-	-	
<--0182-->	Reactive silicate diss as Si O2 mg/l	5.76		6.31		1.61		5.97		139.24908	250.81761	-111.56853	-	-	-	-	-	-	-	
<--0183-->	Sulphate mg/l as SO4	10		12		12		12		264.816	504.156	-239.34	375mg/l (MAC)	-	400mg/l (prop.as)	-	-	-	250mg/l (MAC)	
<--0192-->	Phosphate mg/l	0.067		0.055	<	0.02		0.074		1.21374	3.108962	-1.895222	0.7mg/l (G 90%ile)	-	-	-	-	-	-	
<--0348-->	Phosphorus as P mg/l	0.087		0.068		0.023		0.103		1.500624	4.327339	-2.826715	*see overleaf	-	0.4 mg/l as PO4 as	130ug/l (G MAC)	-	-	2200ug/MAC	
<--1188-->	Nitrogen Dry weight mg/kg	2100		1900		2000		2000		-	-	-	-	-	-	-	-	-	-	
<--1077-->	Ammonia Dry weight mg/kg as N	56.7		59.3		37.2		48.3		-	-	-	-	-	-	-	-	-	-	
<--0349-->	Phosphorus as P Dry Weight mg/kg	1610		1260	<	500		1140		-	-	-	-	-	-	-	-	-	-	
<--8068-->	Orthophosphate leachable Dry weight mg/kg	<	0.045	<	0.049	<	0.047	<	0.045	-	-	-	-	-	-	-	-	-	-	
<--8069-->	Silicate reactive leachable Dry weight mg/kg	9.88		8.33		2.35		7.53		-	-	-	-	-	-	-	-	-	-	
<--8070-->	Nitrate leachable Dry weight mg/kg	14		2.37		No Result		1.9		-	-	-	-	-	-	-	-	-	-	
<--8071-->	Tot Inorg Nitrogen leachable Dry weight mg/kg	6.52		5.05		3.63		5.74		-	-	-	-	-	-	-	-	-	-	
<--8076-->	Tot oxidised Nitrogen leachable Dry weight mg/kg	2.53		2.51	<	0.15		2.09		-	-	-	-	-	-	-	-	-	-	
<--8077-->	Tot Phosphorus leachable Dry weight mg/kg	0.466		0.547		0.563		0.665		-	-	-	-	-	-	-	-	-	-	
<--8078-->	Ammonia leachable Dry weight mg/l as N	3.99		2.54		3.48		3.65		-	-	-	-	-	-	-	-	-	-	
<--8079-->	Nitrite leachable Dry weight mg/l	1.13		0.14		0.16		0.19		-	-	-	-	-	-	-	-	-	-	
<--0106-->	Cd Diss ug/l	<	0.1	<	0.1	0.12	<	0.1		2.2068	4.2013	-1.9945	-	-	-	-	-	-	-	
<--0108-->	Cd ug/l	<	0.1	<	0.1	0.12	<	0.1		2.2068	4.2013	-1.9945	5ug/l (95%ile)	-	5ug/l (as, T)	-	-	-	5 ug/l MAC	
<--0207-->	Sodium mg/l	19.3		35		15.2		19.5		772.38	819.2535	-46.8735	-	-	170 mg/l (prop. as)	-	-	-	150mg/l (MAC)	
<--0211-->	Potassium mg/l	2.9		3.46		1.7		2.87		76.35528	120.57731	-44.22203	-	-	-	-	-	-	12mg/l (MAC)	
<--0213-->	Copper diss mg/l	<	0.0025	<	0.0025	0.0064	<	0.0025		0.05517	0.1050325	-0.0498625	-	-	6.10.1.6 ug/l as	40.112.22.40ug/l G 95%ile	-	-		
<--0215-->	Copper mg/l	<	0.0025	<	0.0025	0.0063	<	0.0025		0.05517	0.1050325	-0.0498625	50 ug/l 90 %ile	-	-	-	-	-	3000ug/l MAC	
<--0235-->	Magnesium diss mg/l	3.86		4.84		2.26		3.9		106.80912	163.8507	-57.04158	-	-	-	-	-	-	-	
<--0237-->	Magnesium mg/l	3.96		4.93		2.35		4.03		108.79524	169.31239	-60.51715	-	-	-	-	-	-	50 mg/l MAC	
<--0239-->	Calcium diss mg/l	27.2		33.9		3.2		27.3		748.1052	1146.9549	-398.8497	-	-	-	-	-	-	-	
<--0241-->	Calcium mg/l	27.9		34.1		3.8		28.2		752.5188	1184.7666	-432.2478	-	-	-	-	-	-		

GCMS and ICP-MS results			
Site 1	Mid lake	Mas spec. Sed: Hydrocarbons at 2 ug/g level, Mas Spec. Aqu: Nothing unusual ICP-MS: Li 0.008 mg/l, Rb 0.006 mg/l, Sr 0.058 mg/l, Ba 0.023 mg/l	Comments: The organic compounds identified in the GCMS scans were very low concentrations and considered to be the natural by-products of biological processes such as rotting vegetation (Lab comment). The trace of diesel / heating oil identified at the outlet (site 4) was likely contamination from a tractor which had crossed upstream a couple of hours previous. The metals Lithium, Rubidium, Stontium and Boron identified in the ICP-MS were in concentrations likely to be regarded as background levels (Lab comment).
Site 2	Main Input	Mas Spec. Sed: Hydrocarbons at 3 ug/g level, Mas Spec. Aqu: Hexadecanol 100ppb ICP-MS: Li 0.011 mg/l, Rb 0.006 mg/l, Sr 0.074 mg/l, Ba 0.026 mg/l	
Site 3	Good pond	Mas Spec. Sed: Hydrocarbons at 1.5 ug/g level, Mas Spec. Aqu: Nothing unusual ICP-MS: Li 0.007 mg/l, Rb 0.006 mg/l, Sr 0.019 mg/l, Ba 0.015 mg/l	
Site 4	Outflow	Mas Spec. Sed: Esential oils 12 ug/g, Hydrocarbon 5ug/g, hexacosanol 1 ug/g level Mas Spec Aqu: Trace of diesel / heating oil ICP-MS: Li 0.009 mg/l, Rb 0.006 mg/l, Sr 0.055 mg/l, Ba 0.023 mg/l	

RE 1 standard adopted
Some standards are based on total hardness of the sample. In this case, 4 EQS's are given relating to the 4 sites respectively.
Where different EQS's are applicable for both Salmonid and Cyprinid, only those for Cyprinind given.
G: Guideline
I: Imperative
aa: Annual Average
MAC: Maximum allowable concentration
Min: Minimum allowable
X%ile: The X percentile
T: Total
D: Dissolved (filtered)
prop : proposed standard
Water abstraction for drinking class A2 adopted

*Trophic category (guideline)	Standing fresh water (ug TP/l annual geo mean)	Running fresh waters (ug SRP annual mean)
Oligotrophic	8	20
Mesotrophic	25	60
Meso-eutrophic	-	100
Eutrophic	85	200
TP: Total Phosphorus		
SRP: Soluable reactive phosphorus (orthophosphate used for this determinand)		
Geo mean: geometric mean		
(Aquatic eutrophication in England & Wales; a management strategy. Environment Agency August 2000)		

** TEC	Threshold Effect Concentration: Used to provide an accurate basis for predicting absence of sediment toxicity
*** PEC	Probable Effect Concentration: Used to provide an accurate basis for predicting sediment toxicity.
Above guidelines & definitions from' Development and evaluation of consensus-based sediment quality guideleines for freshwater ecosytems, 2000, MacDonald D.D, Ingersoll C.G, Berger T.A, Achives of Environmental Contamination and Toxicology 39,20-31 (2000)'.	
(Maybe over or under protective of sediment at a given location depending on site specific conditions)	

Figure 2. Stover Lake sediment analysis: Metals
Dry weight results compared against TEC & PEC EQS's

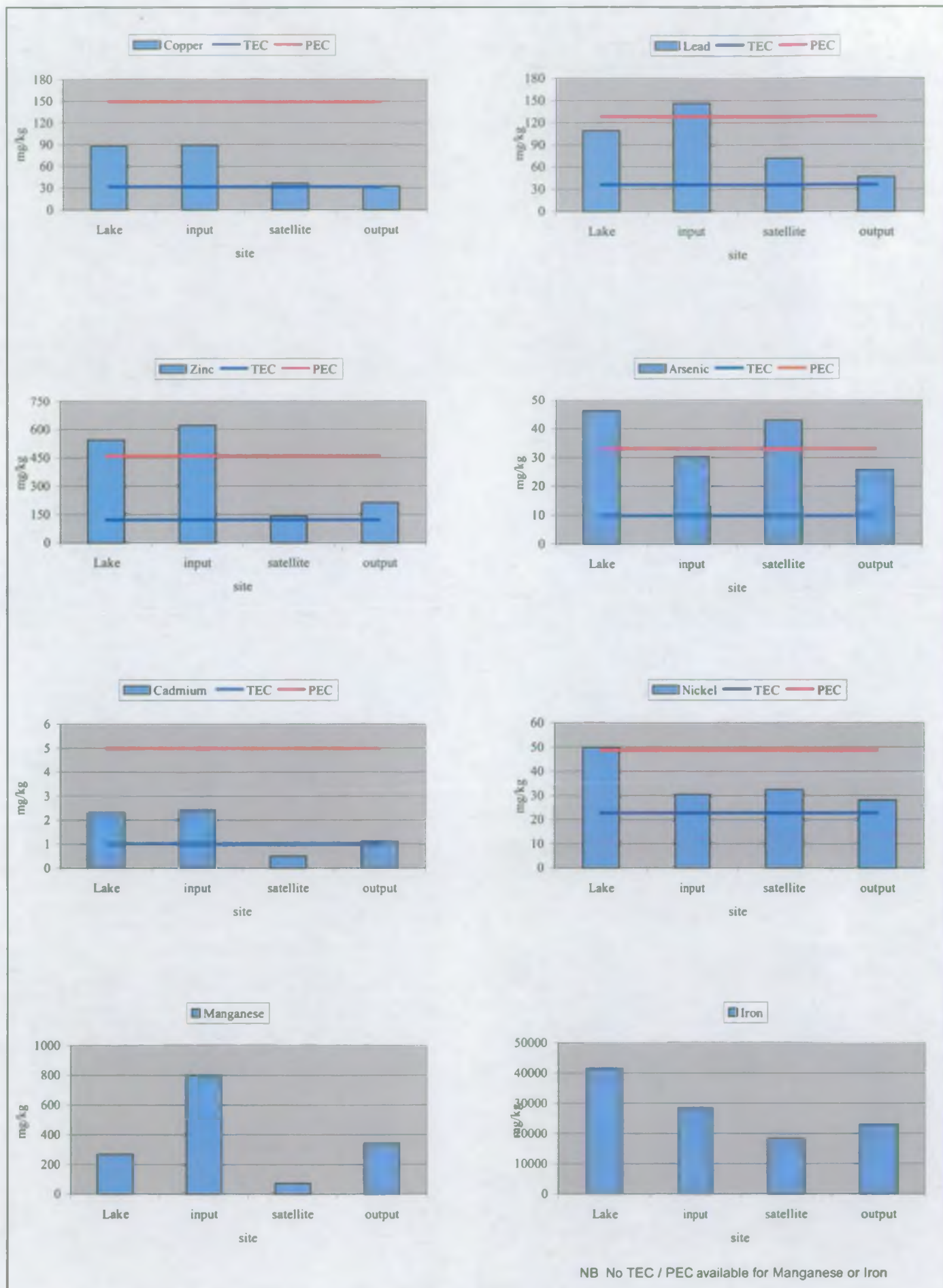


Figure 3. Stover Lake sediment analysis: Leachable and total nutrients

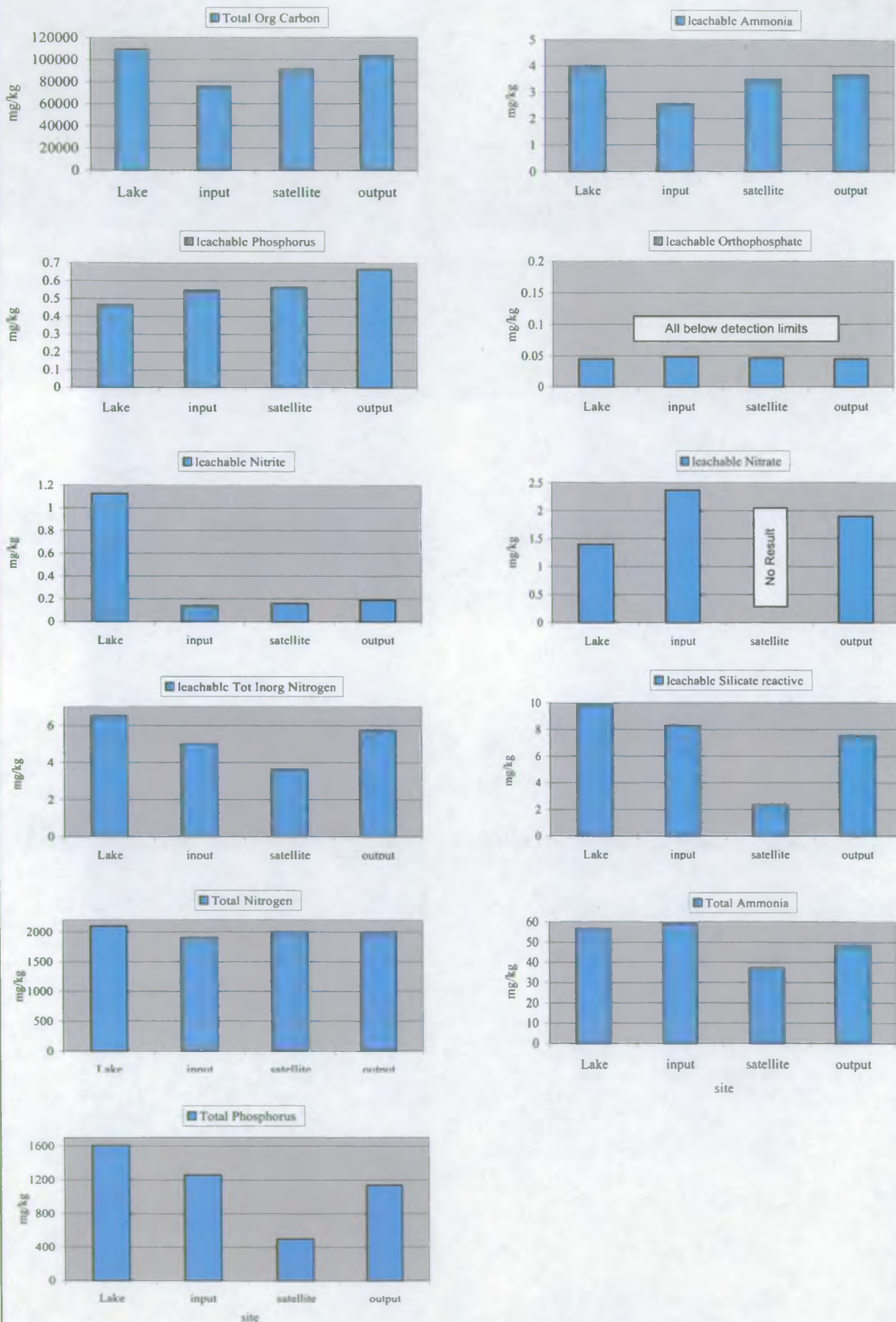


Figure 4. Stover Lake Aqueous analysis: Nutrients

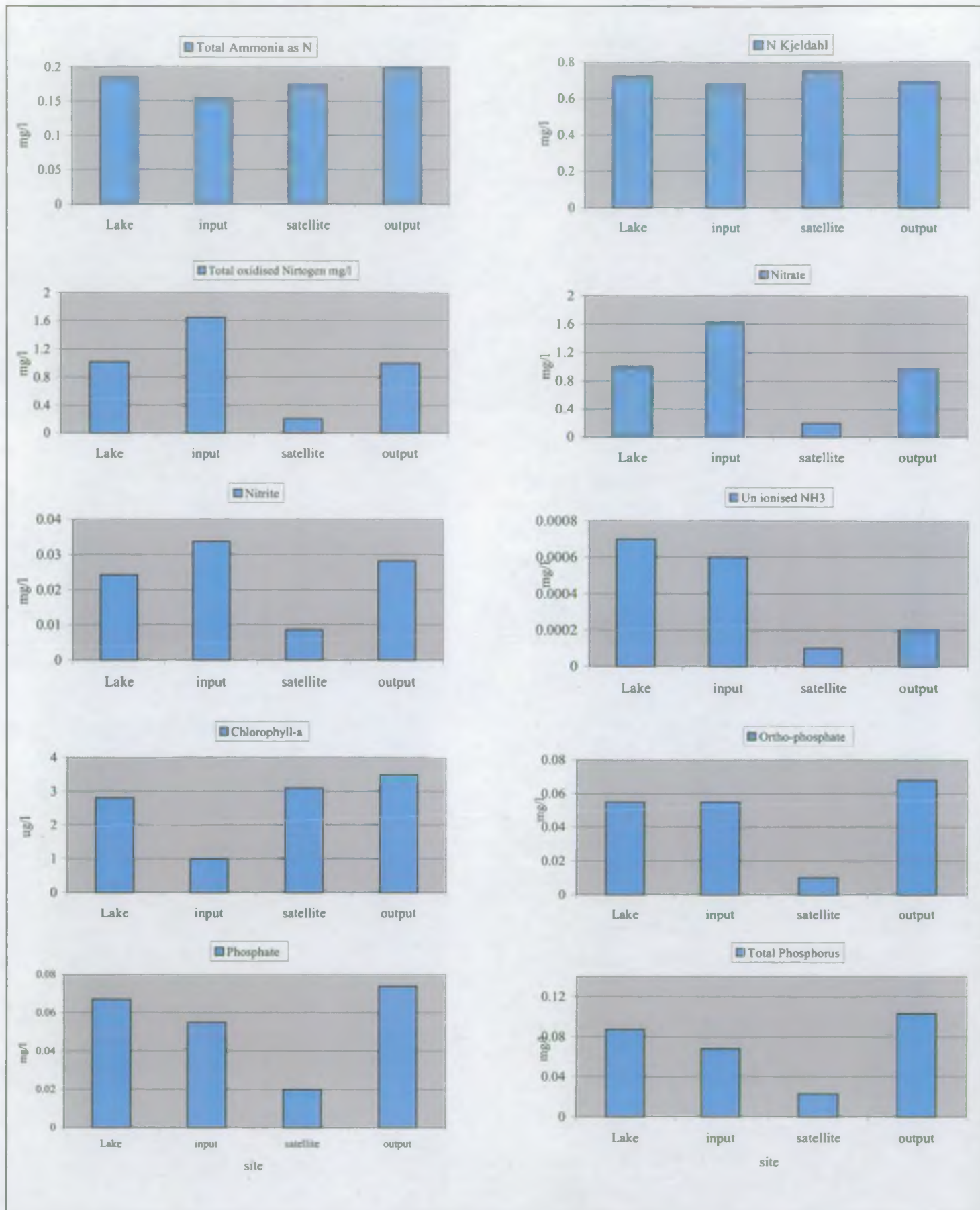
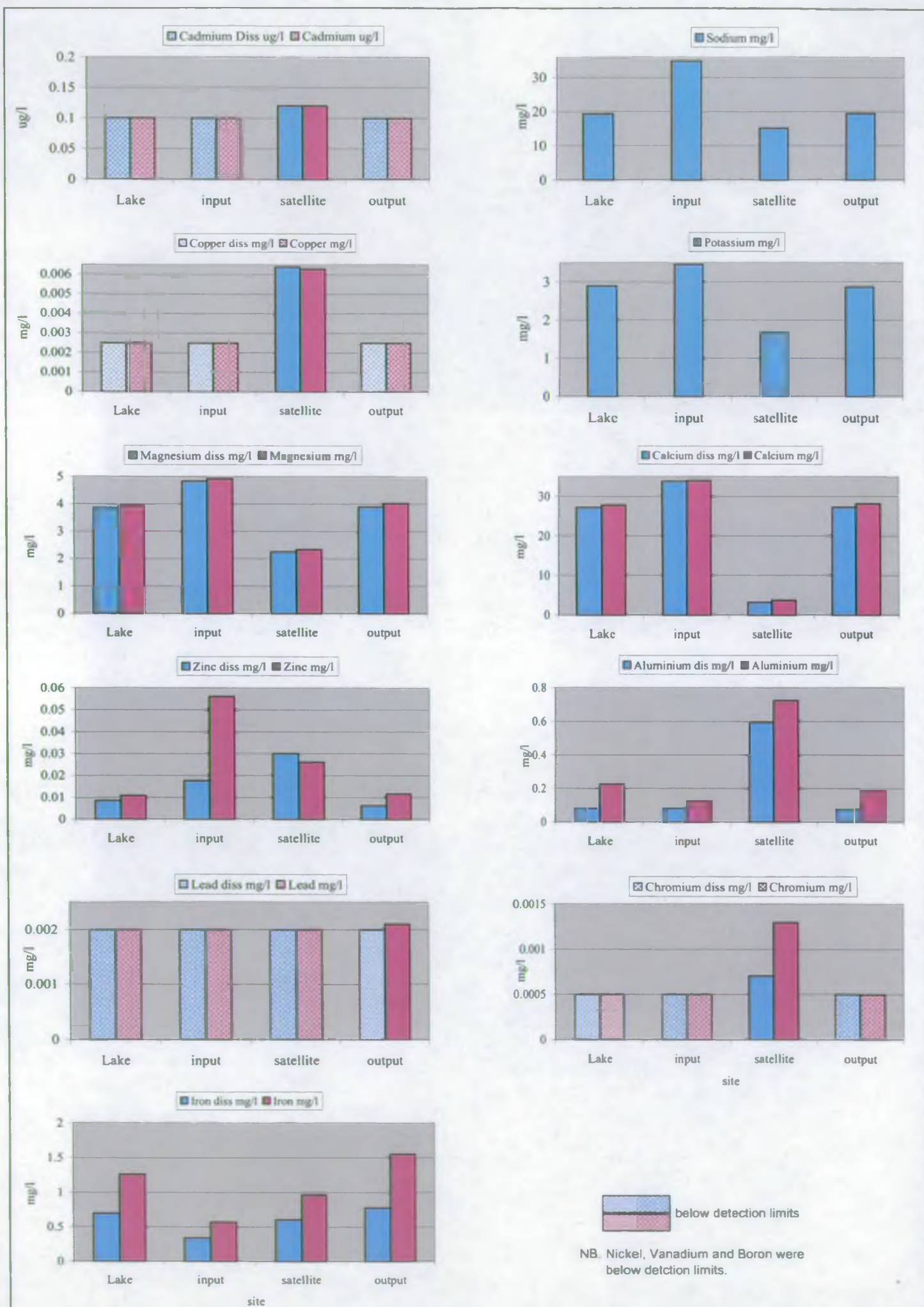
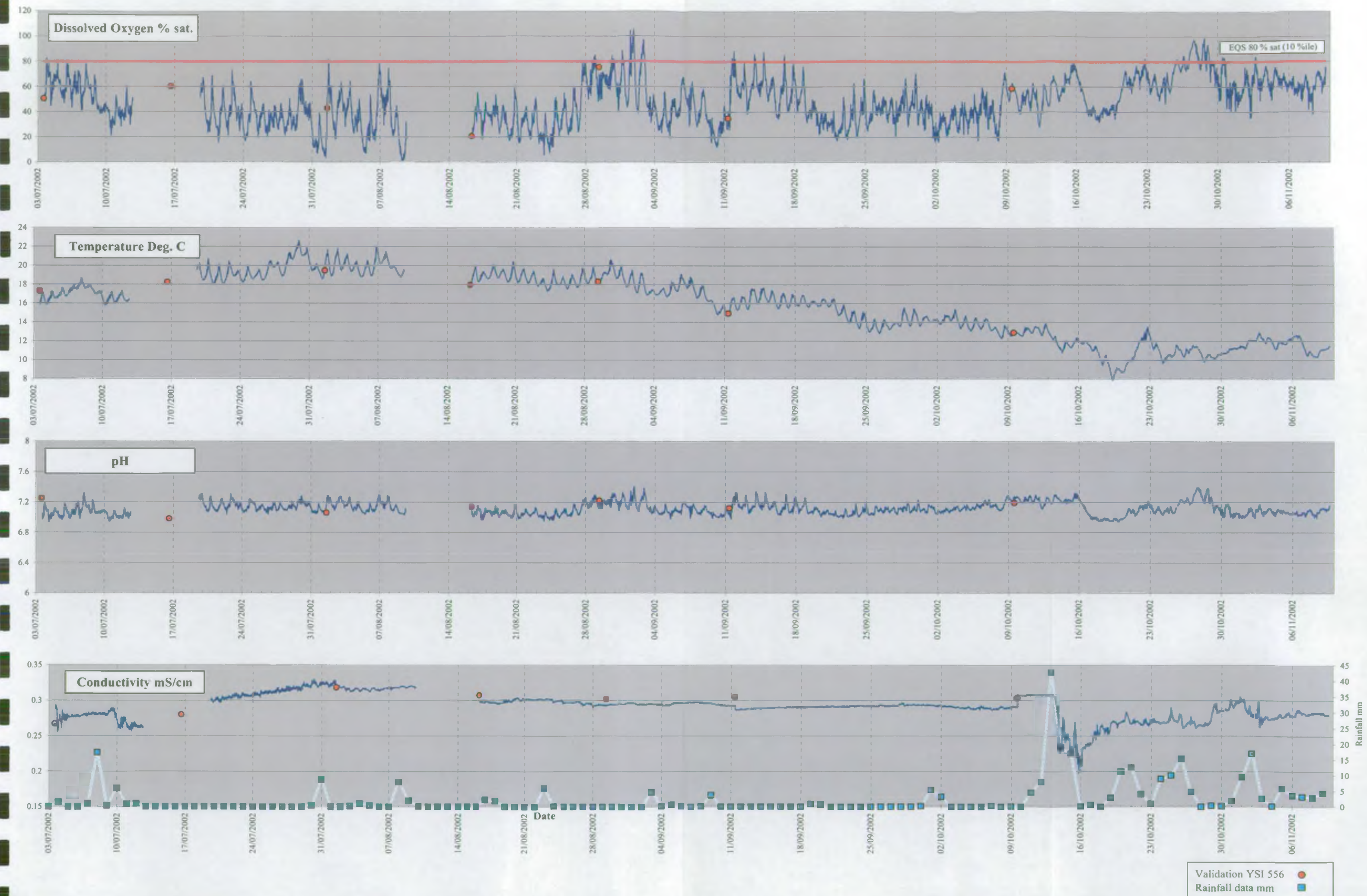


Figure 5. Stover Lake aqueous analysis: Metals



NB. Nickel, Vanadium and Boron were below detection limits.

Figure 6. Stover Lake. Continuous water quality monitoring data collected from the centre of the lake (site 1) for the period 03 July 2002 to 09 November 2002.



APPENDIX I

E.A. South West Region, Devon Area

Secondary Gauging Details

National Grid Reference : SX83757520
Site Location : stover lake **main outflow**
Gauge Zero height : 0.000 Metres

Date : 19/02/2002 Start Finish 19/02/2002
Time : 11:22 11:38
Stage : 0.000 metres 0.000 metres above Gauge Zero

Observer Name : ms Stage Variation : Steady
Meter Code : 1464 Counter Code : G
Gauging Method : Waded with rods Calculation Method : Mean-section
Input Method : Computed

Comments : **sluice open no flow over weir**

Depths : 0.5

Readings/vert. : 1 Fixed no. of : secs : 50

Gauging Results

Area of Flow : 0.044250 sqm Mean Stage : 0.000 metres
Mean Velocity : 0.432848 m/s No. of Panels : 8
Discharge : **0.019154** cumecs

E.A. South West Region, Devon Area

Secondary Gauging Details

National Grid Reference : SX83477476
Site Location : stover lake
Gauge Zero height : 0.000 Metres

outflow no 2

Date : 19/02/2002 Start Finish
Time : 11:50 12:10
Stage : 0.000 metres 0.000 metres above Gauge Zero

Observer Name : ms Stage Variation : Steady
Meter Code : 1464 Counter Code : G
Gauging Method : Waded with rods Calculation Method : Mean-section
Input Method : Computed

Comments : this is by stw

Depths : 0.5

Readings/vert. : 1 Fixed no. of : secs : 50

Gauging Results

Area of Flow : 0.162300 sqm Mean Stage : 0.000 metres
Mean Velocity : 0.140845 m/s No. of Panels : 10
Discharge : 0.022859 cumecs

E.A. South West Region, Devon Area

Secondary Gauging Details

National Grid Reference : SX82977527
Site Location : **stover lake 1** stream
Gauge Zero height : 0.000 Metres

Date : 19/02/2002 Start 19/02/2002 Finish
Time : 12:49 13:02
Stage : 0.000 metres 0.000 metres above Gauge Zero

Observer Name : ms Stage Variation : Steady
Meter Code : 1464 Counter Code : G
Gauging Method : Waded with rods Calculation Method : Mean-section
Input Method : Computed

Comments : **gauged between slip road and a38**

Depths : 0.5

Readings/vert. : 1 Fixed no. of secs : 50

Gauging Results

Area of Flow : 0.111180 sqm Mean Stage : 0.000 metre
Mean Velocity : 0.193989 m/s No. of Panels : 7
Discharge : **0.021568** cumecs

Small Rte Drain below ^{Slip road} Culvert / estimated 0.5 4/5