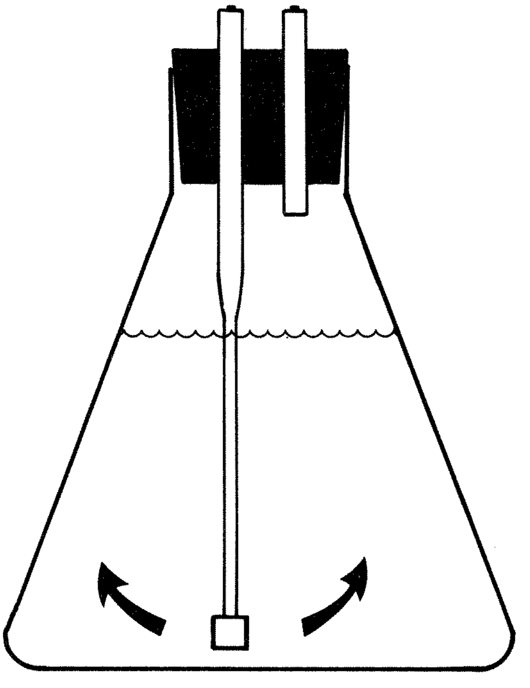
1728

RAPPORT 3/85
O-84022

Treatment of leachate in aerated lagoons

Lab–scale study



Norsk institutt for vannforskning NIVA

NIVA - REPORT

Norwegian Institute for Water Research NIVA

Report No.:
0-84022
Sub-No.:
Serial No.: 1728
Limited distribution:

Main Office
P.O.Box 333 Blindern
N-0314 Oslo 3
Norway
Phone (47 2)23 52 80

Regional Office, Sørlandet
Grooseveien 36
N-4890 Grimstad,
Norway
Phone (47 41)43 033

Regional Office, Østlandet
Rute 866
N-2312 Ottestad
Norway
Phone (47 65)76 752

Regional Office, Vestlandet
Breiviken 2
N-5035 Bergen - Sandviken
Norway
Phone (47 5)25 53 20

Report Title:

Treatment of leachate in aerated lagoons.
Lab-scale study. VA- 3/85

Date: June 1985

0-84022

Author(s):

Peter O. Nelson
Ragnar Storhaug

Topic group:

Geographical area:

Number of pages (incl. app.) 59

Contractor: NTNFs Program for VAR-teknikk

Contractors ref. (or NTNF - No)

Abstract:

In this study aerated lagoons were simulated in 5 litre Erlenmeyer flasks. The experiments showed that phosphorus nutrient supplementation is required for efficient treatment of leachate from a young sanitary landfill. Excellent treatment efficiency can be achieved at low temperatures (0-4 °C) provided that solids retention time is maintained near 40 days and phophorus supplementation is practised.

4 keywords, Norwegian	4 keywords, English
1. Sigevann	1. Leachate
2. Biologisk rensing	2. Biological treatment
3. Luftet lagune	3. Aerated lagoon
4. VA-3/85	4.

Project leader

Ragnar Storhaug (signature)

Ragnar Storhaug

For the Administration

Oddvar Lindholm (signature)

ISBN 82-577-0917-4

Norsk institutt for vannforskning NIVA

0-84022

TREATMENT OF LEACHATE IN AERATED LAGOONS
Lab-scale study

Oslo, Juni 1985
Saksbehandler: Ragnar Storhaug
Medarbeidere : Peter O. Nelson
Marit Villø
Harry Efraimsen

FORORD

Prosjektet er finansiert av NTNFs Utvalg for VAR-forskning og av NIVAs interne forskningsmidler. Dr. Peter O. Nelson fra Oregon State University, Corvallis har hatt ansvaret for den faglige planlegging og gjennomføring av prosjektet. I perioden da prosjektet ble gjennomført var han stipendiat på NIVA.

Laborant Marit Villø har stått for den daglige driften av forsøksanlegget, samt prøvetaking og analysering. Forskningsassistent Harry Efraimsen har utført mikroskopiering og karakterisering av slam. Prosjektet ble gjennomført i NIVAs forsøkslaboratorium.

Ragnar Storhaug

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SUMMARY

This laboratory study was formulated to systematically evaluate the aerated lagoon process to gain better understanding of the limiting factors affecting treatment in full-scale systems. The dual effect of low temperature and nutrient limitation was the most important factor that was studied. Fill-and-draw laboratory reactors were operated to achieve the research objectives.

Experiment I was an investigation of nutrient limitation at three different solid retention times (SRT) 5, 10 and 40 days, and a nominal temperature of 20^{o}C. The experiment showed that a microbial biomass could develop under limited nutrient conditions (COD/N/P = 577/12.1/1). However, this biomass was very disperse. At a higher nutrient supplementation level (COD/N/P = 238/5/1) the microbial biomass was aggregated into discrete flocs. The COD removal was generally less than 90 % at SRT = 5 days, increasing to about 95 % at SRT = 10 days and greater than 98 % at SRT = 40 days.

In Experiment II a commercially available fertilizer and a tertiary wastewater sludge, were investigated for their suitability as sources of phosphorus nutrient for the biological treatment process. No decrease in performance was observed by using the alternative phosphorus compounds.

In Experiment III reactors were operated at 10^{o}C and 5^{o}C and at 5, 10 and 40 days SRT. Under the nutrient limiting conditions only the highest SRT value (40 days) gave adequate removal at low temperature.

In all experiments, iron, calium, cadmium, copper, manganese, lead and zinc were highly removed in all reactors that performed adequately (high COD removal).

Nitrogen in the raw leachate was present almost entirely in the ammoniacal form. Nitrification was negligible in all reactors as effluent nitrite and nitrate concentrations never exceeded 1.0 mg/l. Removal of nitrogen in the reactors was nearly entirely attributable to biological uptake.

The three experiments show that phosphorous nutrient supplementation is required for efficient treatment (high COD and BOD removal) but at significantly lower degree than theoretical stoichiometric concentrations for bacterial growth. Excellent treatment efficiency can be achieved at very low temperatures (0-4^{o}C) provided solids retention time is maintained near 40 days and phosphorus supplementation is practiced.

1. INTRODUCTION

Sanitary landfill leachates represent a potentially serious source of groundwater and surface water contamination because of their typically high organic strength and high concentrations of heavy metals. Since disposal, the use of lined or sealed disposal sites with collection and treatment of the leachate is the most direct means of environmental protection.

The treatability of sanitary landfill leachates by aerobic biological methods has been well documented in the literature (e.g., Cook and Foree, 1974; Johansen, 1975; Chain and DeWalle, 1976; Uloth and Mavinic, 1977). These studies and others have demonstrated that, although their characteristics are highly variable, leachates are generally quite susceptible to treatment by activated sludge and aerated lagoon methods. Problems that have been encountered include nutrient deficiency and heavy metals inhibition. Temperature limitations on aerobic biotreatability have also been investigated (e.g., Zapf-Gilje and Mavinic, 1981; Robinson and Maris, 1983). These studies have found that acceptable removal of organic oxygen-demanding materials can be achieved at temperature ranges from 5-10 ^{o}C provided biological solids retention time (SRT) is sufficiently high or that the corresponding organic loading expressed as food-to-microorganism (F/M) ratio is sufficiently low.

This study investigated the concurrent effects of nutrient and temperature limitation on the aerobic biotreatability of municipal landfill leachate. Particular emphasis was placed on understanding chemical interactions and transformations of nutrients and metals during treatment. This information, when combined with treatment performance results, should enable a more rational and comprehensive design approach to leachate treatment systems.

2. EXPERIMENTAL METHODS AND MATERIALS

2.1. Experimental Design

This laboratory study was formulated to systematically evaluate the aerated lagoon treatment process and to gain better understanding of the limiting factors affecting treatment in full-scale systems. Three experiments were designed to meet the objectives to the research. Experiment I investigated nutrient limitation (COD/N/P ratio) effects on leachate treatability as a function of solids retention time. Experiment II investigated the utility of two alternative phosphorus compounds as nutrient sources, one a commercial monocalcium phosphate fertilizer, and the other a tertiary wastewater treatment aluminum phosphate sludge. Experiment III investigated the effect of temperature limitation on treatability as a function of solids retention time.

2.2. Laboratory Experiments

Fill-and-draw laboratory reactors were operated under a range of experimental conditions to achieve the research objectives. Table 1 summarizes the operating conditions for all reactors. The reactors were identical 5-l erlenmeyer flasks with a 3-l operating volumes. Aeration and mixing were provided with diffused air added through diffuser stones. Figure 1 is a schematic of a typical experimental reactor.

Experiment I reactors (12 total) were operated at four different nutrient conditions ranging from that of the raw leachate (both N and P deficient) to a stoichiometrically balanced condition (N and P at same ratio as for bacterial cells). Each nutrient condition was investigated at three solids retention times. The nominal temperature was 20 C.

Experiment II reactors (2 total) were operated under identical conditions to those of reactor I.B.2 except that the chemical form of the added phosphorus nutrient was changed. A commercially available monocalcium phosphate fertilizer and an aluminum phosphate tertiary wastewater treatment sludge were separately investigated for their suitability as replacement for soluble orthophosphorus.

Table 1. Reactor Experimental Conditions.

Reactor I.D.	Volume (l)	SRT (days)	Temp. (C)	COD/N/P Ratio (mg/mg/mg)	F/M Ratio (gCOD/gVSS-d)
I.A.1	3	5	20	19000/400/.1	3.80
I.A.2	3	5	20	577/12.2/1	0.80
I.A.3	3	5	20	238/5/1	1.08
I.A.4	3	5	20	100/5/1	1.40
I.B.1	3	10	20	19000/400/.1	2.09
I.B.2	3	10	20	577/12.2/1	0.44
I.B.3	3	10	20	238/5/1	0.47
I.B.4	3	10	20	100/5/1	1.41
I.C.1	3	40	20	19000/400/1	0.14
I.C.2	3	40	20	577/12.2/1	0.11
I.C.3	3	40	20	288/5/1	0.11
I.C.4	3	40	20	100/5/1	0.14
II.B.1	3	10	20	577/12.2/1	0.41
II.B.2	3	10	20	577/12.2/1	0.42
III.A.1	3	5	4	577/12.2/1	1.18
III.A.2	3	5	10	577/12.2/1	1.96
III.B.1	3	10	4	577/12.2/1	0.80
III.B.2	3	10	10	577/12.2/1	0.61
III.C.1	3	40	4	577/12.2/1	0.11
III.C.2	3	40	10	577/12.2/1	0.12

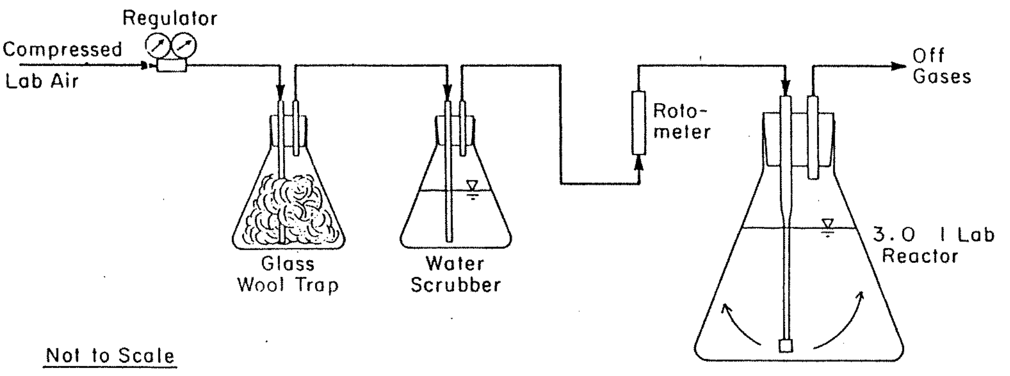


Figure 1. Experimental reactor schematic.

Experiment III reactors (6 total) were operated at nominal temperatures of 10 and 4 ^{o}C but otherwise identical conditions to those of reactors I.A.2, I.B.2, and I.C.2. Thus, the same nutrient condition was investigated at three solids retention times and at two lower temperatures.

2.3. Fill-and-Draw Operation

Fill-and-draw operation of the reactors consisted of feeding and wasting the required volume one time per day. A typical daily feeding and sampling schedule was as follows:

1. Measure reactor DO, pH, and temperature in situ.
2. Bring reactor up to volume with tap water to compensate for evaporative losses.
3. Waste required volume of mixed liquor (reactor volume/SRT).
4. Add same volume of leachate feed solution to reactor.
5. Add required nutrient solutions of phosphorus and nitrogen (volume negligible).
6. Process waste mixed liquor for appropriate analyses.

Fill-and-draw operation results in a cyclic hydraulic and organic loading regime in the reactors. At the beginning of each cycle, the reactor is heavily loaded and dissolved oxygen levels decrease to below 1 mg/l. After several hours the substrate is substantially consumed and DO levels recover to within 1-2 mg/l of saturation. All measurements of chemical parameters reported in this study were made at the end of the operating cycle but prior to substrate and nutrient addition for the next cycle.

2.4. Experimental Materials

Leachate used in the laboratory study was collected in large volume in January, 1984, at the municipal landfill site at Dal Skog, Norway (ca. 60 km north of Oslo) and stored frozen until use. The landfill site was placed in operation in October, 1981, and receives approximately 50,000 m^3 of solid wastes annually. The received solid waste volume is comprised of about 60 % household wastes, 30 % office and commercial wastes, and 10 % building and construction materials. Solid wastes are covered daily with excavated fill material and compacted with a 23 tonnes compactor. Average annual precipitation is 750 mm, and leachate production from the ca. 1.9 hectare site averages ca. 15 m^3/day.

The chemical pomposition of the leachate used in the laboratory study is summarized in Table 2. Leachates from selected other studies are included for comparative purposes. The Dal Skog leachate is characteristic of a young landfill site, being of high organic strength (COD, BOD) but intermediate in nitrogen concentration (ammoniacal and organic forms) and extremely low in phosphorus concentration. Calculated ratios of major parameters were as follows: COD/N/P = 19000/-400/0.1, COD/BOD_7 = 1.67, and COD/TOC = 3.4. Volatile acids (VA) comprised about 30 % of the COD and TOC. From the alkalinity titration to pH = 4.5, the measured VA concentration, and initial pH value, the VA-alkalinity is calculated to be 1630 mg/l and the carbonate alkalinity 2000 mg/l. Metals concentrations are typical, although the toxic heavy metals determined (Cd, Cr, Cu, Pb, and Zn) were somewhat lower than for the other leachates cited.

Table 2. Landfill leachate characteristics.

Parameter	This Study (Dal Skog)	Ref.1 (range)	Ref.2	Ref.3
Age,yr	3	.33-16	--	2
pH	6	3.7-8.5	5.02	5.95
Alk,meq/l	69	0-420	153	--
Cond,uS/cm	7500	2810-16800	--	--
TS,mg/l	--	0-59200	26600	--
TSS,mg/l	450	10-700	--	204
VSS,mg/l	300	---	--	112
COD,mg/l	19000	40-89520	48000	5028
BOD5,mg/l	11400*	81-33360	36000	3035
TOC,mg/l	5590	256-28000	15390	1663
VA,mg/l as C	1830	---	--	1123
TKN,mg/l	400	---	1100	152
NH4-N,mg/l	380	0-1106	--	76
NO2-N,mg/l	.1	0.2-10.3	--	<.02
NO3-N,mg/l	.075	(NO2+NO3)	--	<.5
TOT-P,mg/l	<.1	0-130	11	--
PO4-P,mg/l	<.1	6.5-85	--	.42
Fe,mg/l	482	0-2820	960	102
Ca,mg/l	1865	60-7200	1394	348
Cd,mg/l	.003	.03-17	0.39	.11
Cr,mg/l	.12	--	1.9	.14
Cu,mg/l	.004	0-9.9	--	.08
Mg,mg/l	210	17-15600	310	37
Mn,mg/l	195	.09-125	41	22.8
Pb,mg/l	.003	<.1-2.0	1.44	.11
Zn,mg/l	22.6	0-370	223	17.6

*MEASURED AS BOD7

Ref.1: Chian and DeWalle (1976)
Ref.2: Uloth and Mavinic (1977)
Ref.3: Robinson and Maris (1983)

In Experiment II, the monocalcium phosphate fertilizer, $CaHPO_4$, was added in dry form based on the manufacturer's listed phosphorus content of 21 % P by weight. The aluminum phosphate tertiary wastewater treatment sludge, $AlPO_4$, had a measured dry solids phosphorus content of 5.1 %.

2.5. Analytical Methods

All values of chemical parameters for experimental reactors reported in this study are for filtered effluents (Whatman GF/C glass fiber filters). Raw leachate values are for unfiltered samples. In general, all measurements were made in accordance with accepted procedures (A.P.H.A., 1980). Prior to filtration, reactor mixed liquors were centrifuged at 4000 rpm (mean rotor diameter approx. 14 cm). In situ dissolved oxygen and pH were measured electrometrically, conductivity with a measuring bridge and cell, and temperature with a mercury thermometer accurate to 0.1 ^{o}C. All other parameters were analyzed in the chemical laboratory at the Norwegian Institute for Water Research, Oslo, Norway.

3. RESULTS

All results for experimental reactors are reported for steady-state operating conditions. Steady-state was assumed when 9-l of leachate feed solution had passed through each 3-l reactor after initial seeding and monitoring parameters (pH, COD, and TSS) were approximately constant. Tables of results summarize mean values of all parameters. The complete set of experimental data for the 20 experimental reactors is contained in Appendix A, Tables A-1 through A-20.

3.1. Nutrient Limitation Study

Experiment I was an investigation of nutrient limitations at three different SRT's and a nominal temperature of 20 ^{o}C. Results are summarized in Table 3. Because of the severe phosphorus deficiency in the raw leachate (COD/N/P = 19000/400/0.1, NP1), reactors I.A.1 at a 5-day SRT and I.B.1 at a 10-day SRT could not maintain a viable microbial culture and failed (washout). At a 40-day SRT, reactor I.C.1 performed reasonably well under these conditions of severe nutrient limitation.

With the lowest levels of phosphorus supplementation, a microbial population was established and sustained at the lower SRT's despite still being severely P-limited (COD/N/P = 577/12.2/1, NP2). The microbial biomass was highly dispersed and non-flocculant under these conditions. At a higher nutrient supplementation level (COD/N/P = 238/5/1, NP3), the microbial biomass was aggregated substantially into discrete flocs. At the highest nutrient supplementation level, corresponding to the theoretical stoichiometric bacterial nutrient ratio (COD/N/P = 100/5/1, NP4), flocculation of microbial biomass was masked by a massive precipitate that formed, believed to be calcium hydroxyapatite or another phosphorus solid phase (see Discussion section). Performance on these reactors appeared to be adversely affected by the presence of the precipitate, which inhibited complete mixing of the microbial biomass. Interference in sampling and measurement of some parameters, particularly suspended solids, also resulted.

Table 3. Experiment I Summary: Raw Leachate and Treated Effluents, Mean Parameter Values.

REACTOR	SRT (day)	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	IONSTR (M)
LEACHATE	---	6	---	---	.75	57.97	450	300	19000	11400	400	380	97	75	.1	.1	0.12
I.A.1	5	5.7	21	8.2	.95	68.91	1600	1000	14800	9940	340	250	23	140	.17	.1	0.15
I.A.2	5	8.5	21.2	5.9	.5	23.56	7570	4750	2080	855	48	2.1	119	175	1.43	1	0.08
I.A.3	5	8.6	21	6.5	.54	22.87	6170	3530	2550	760	62	9.7	98	164	3.1	1.53	0.09
I.A.4	5	8.4	21.5	5.2	.85	34.8	4620	2710	4090	1620	343	118	177	641	22	8.03	0.14
I.B.1	10	6.2	20.6	8.1	.93	63.02	1630	910	12600	11160	262	241	15	62	.2	.1	0.15
I.B.2	10	8.7	20.4	6.9	.54	20.69	7075	4300	1340	535	24	10	26	70	.3	.1	0.09
I.B.3	10	8.8	20.1	7.4	.55	22.42	7410	4080	940	240	11	1	8	17	.3	.1	0.09
I.B.4	10	8.3	20.5	6.9	.74	7.02	2890	1350	670	95	104	91	5	50	.73	.25	0.12
I.C.1	40	8.8	20.8	8.1	.44	11.24	5960	3280	970	375	40	25	26	126	.1	.1	0.07
I.C.2	40	9	20.6	7.6	.47	6.21	7415	4330	440	25	15	.21	7	13	.1	.1	0.08
I.C.3	40	9	20.6	7.4	.45	5.78	6840	4465	370	45	8	.11	3	35	.15	.1	0.07
I.C.4	40	8.7	20.9	7.3	.56	3.55	6395	3515	380	40	24	2.63	62	189	.25	.1	0.09

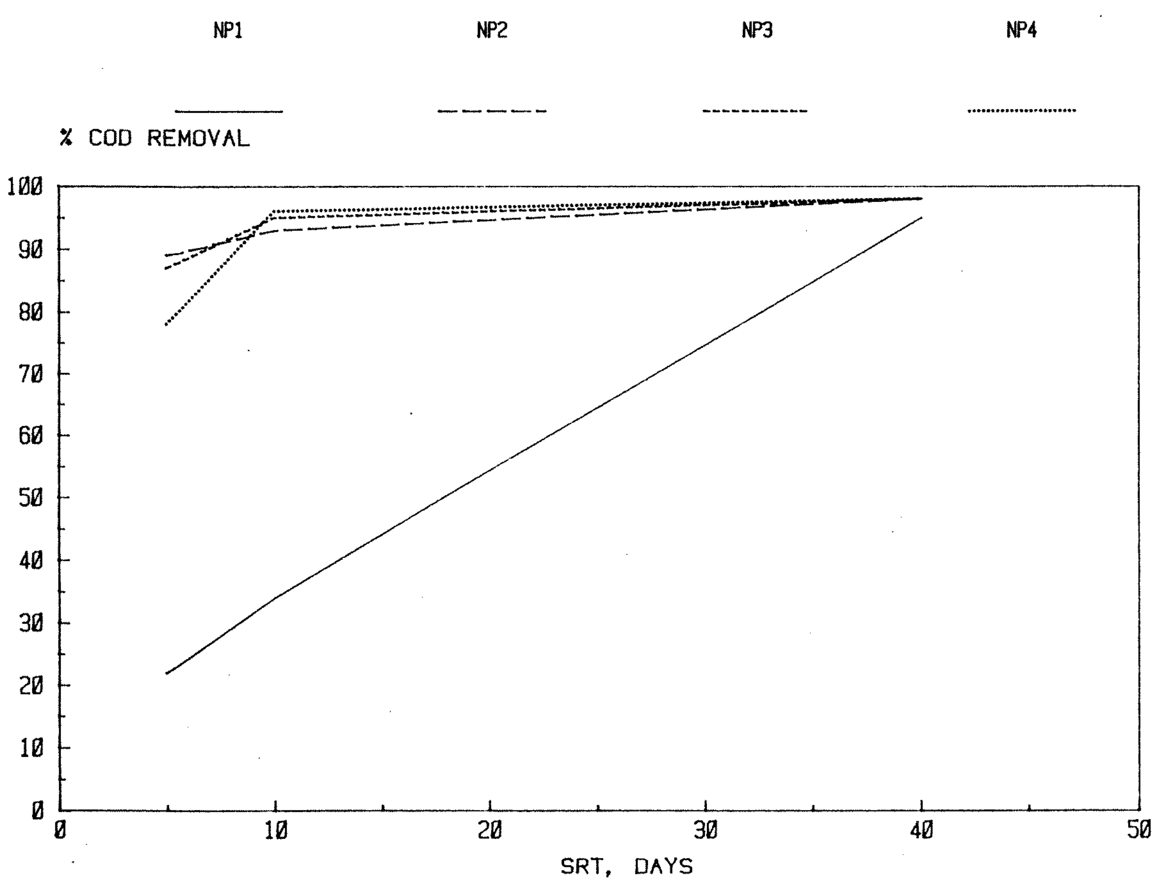


Figure 2. COD Removal vs. SRT for Varying Nutrient Supplementation Levels.

Figure 2 shows COD removal as a function of SRT for the four nutrient levels investigated. Nutrient level SP1 has unacceptable performance at the two lower SRT values (Reactors I.A.1 and I.B.1). At 40 days SRT, COD removal is 95 % confirming that a heterotrophic microbial population was well established under these severely nutrient limited conditions (Reactor I.C.1). At the three higher nutrient addition levels, COD removal efficiency was generally less than 90 % at SRT = 5 days, increasing to about 95 % at SRT = 10 days and greater than 98 % at SRT = 40 days. There was only marginal improvement in COD removal with increased nutrient addition at these two SRT's.

Nitrogen was present almost entirely in the ammoniacal form (NH_3 and NH_4^+) in both the raw leachate and reactor effluents. Virtually no nitrification occurred as indicated by the low effluent concentrations of oxidized nitrogen forms (NO_2^-) and NO_3^-). Both TKN and NH_4-N effluent concentrations decreased with increasing SRT at constant nutrient supplementation level, and with increased phosphorus addition at constant SRT up to nutrient level NP_3. At nutrient level NP_4, nitrogen was also supplemented with ammonium chloride.

Phosphorus was efficiently incorporated into the microbial biomass in all but the highest loaded reactors (SRT = 5 days) at the two highest nutrient addition levels (NP3 and NP4). Effluent total and orthophosphorus concentrations in these reactors indicated that some excess phosphorus was present, although the maximum ortho-P value was only 4 % of added phosphorus (8 mg/l). In the lower loaded reactors (10 and 40 day SRT's), maximum effluent phosphorus concentrations at the highest nutrient addition level were less than 1 % of added phosphorus (0.75 mg/l total-P and 0.25 mg/l ortho-P).

3.2. Phosphorus Compound Study

In Experiment II, two alternative phosphorus compounds, a commercially available fertilizer and a tertiary wastewater treatment sludge, were investigated for their suitability as sources of phosphorus nutrient for the biological treatment process. Based on the results of Experiment I, experimental reactor conditions of SRT = 10 days and NP2 nutrient addition level were selected. These conditions represented limiting satisfactory performance for P added as orthophosphorus (biologically available form). Thus, reduced performance should be evident if phosphorus is not totally available from the alternative compounds due to solubility or other limitations.

Experiment II reactor performance results are summarized in Table 4 including reactors II.B.1 (P from fertilizer) and II.B.2 (P from tertiary sludge) along with reactor I.B.2 of experiment I (P from orthophosphorus) for comparative purposes. All effluent parameters, including COD, BOD, and nitrogen and phosphorus forms are equivalent or lower for experiment II reactors than for control reactor I.B.2. Thus, no decrease in performance was observed by using of the alternative phosphorus compounds.

Table 4. Experiment II Summary: Raw Leachate and Treated Effluents, Mean Parameter Values.

REACTOR	SRT (day)	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	IONSTR (M)
LEACHATE	---	6	---	---	.75	57.97	450	300	19000	11400	400	380	97	75	.1	.1	0.12
I.B.2	10	8.7	20.4	6.9	.54	20.69	7075	4300	1340	535	24	10	26	70	.3	.1	0.09
II.B.1	10	8.8	18.2	7.7	.47	16.81	9635	4665	705	63	10	.73	14	56	.25	.1	0.08
II.B.2	10	8.9	18.3	7.3	.48	18.28	8990	4500	740	8	10	.1	14	16	.2	.1	0.08

3.3. Temperature Limitation

Experiment III reactors were operated at 10 ^{o}C and 5 ^{o}C and at 5, 10, and 40 days SRT to investigate effects of decreasing temperature on performance. By similar reasoning as for experiment II, nutrient addition level NP2 was selected to represent a limiting condition that should more readily exhibit reactor performance under imposed stress conditions. Results of experiment III are summarized in Table 5. Also repeated in the table are results from corresponding Experiment I reactors at 20 ^{o}C for comparative purposes.

Table 5. Experiment III Summary: Raw Leachate and Treated Effluents, Mean Parameter Values.

REACTOR	SRT (day)	pH	TEMP (C)	DC (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	IONSTR (M)
LEACHATE	---	6	---	---	.75	57.97	450	300	19000	11400	400	380	97	75	.1	.1	0.12
I.A.2	5	8.5	21.2	5.9	.5	23.56	7570	4750	2080	395	48	2.1	119	175	1.43	1	0.08
III.A.1	5	8.2	4.5	8.4	.78	47.2	6030	3220	10500	6900	114	69	54	155	.5	.7	0.12
III.A.2	5	8.4	11.5	8.3	.68	37	3700	1940	8050	5390	103	98	37	68	.5	.3	0.11
I.B.2	10	8.7	20.4	6.9	.54	20.69	7075	4300	1340	535	24	10	26	70	.3	.1	0.09
III.B.1	10	8.3	4.5	9.7	.7	52.02	5415	2370	11850	7100	145	120	27	28	.35	.2	0.11
III.B.2	10	8.6	10.1	8.9	.44	23.8	5610	3140	3900	825	15	11	155	190	2.9	2.85	0.07
I.C.2	40	9	20.6	7.6	.47	6.21	7415	4330	440	25	15	.21	7	13	.1	.1	0.08
III.C.1	40	8.6	2.9	11.7	.43	18.26	9005	4275	455	25	10	.1	13	19	.2	.1	0.07
III.C.2	40	8.8	9.7	10.2	.43	18.34	8215	4015	305	5	10	.1	41	8	.2	.1	0.07

Effects of lower temperatures on reactor performance are clearly evidenced from experiment III results. Figure 3 shows COD removal as a function of temperature for the data in Table 5. Under the nutrient limiting conditions of this experiment, only the highest SRT value (40 days) gave adequate removal at low temperatures. Effluent concentrations of nutrients, particularly ammoniacal nitrogen, were also elevated in the low temperature, low SRT reactors.

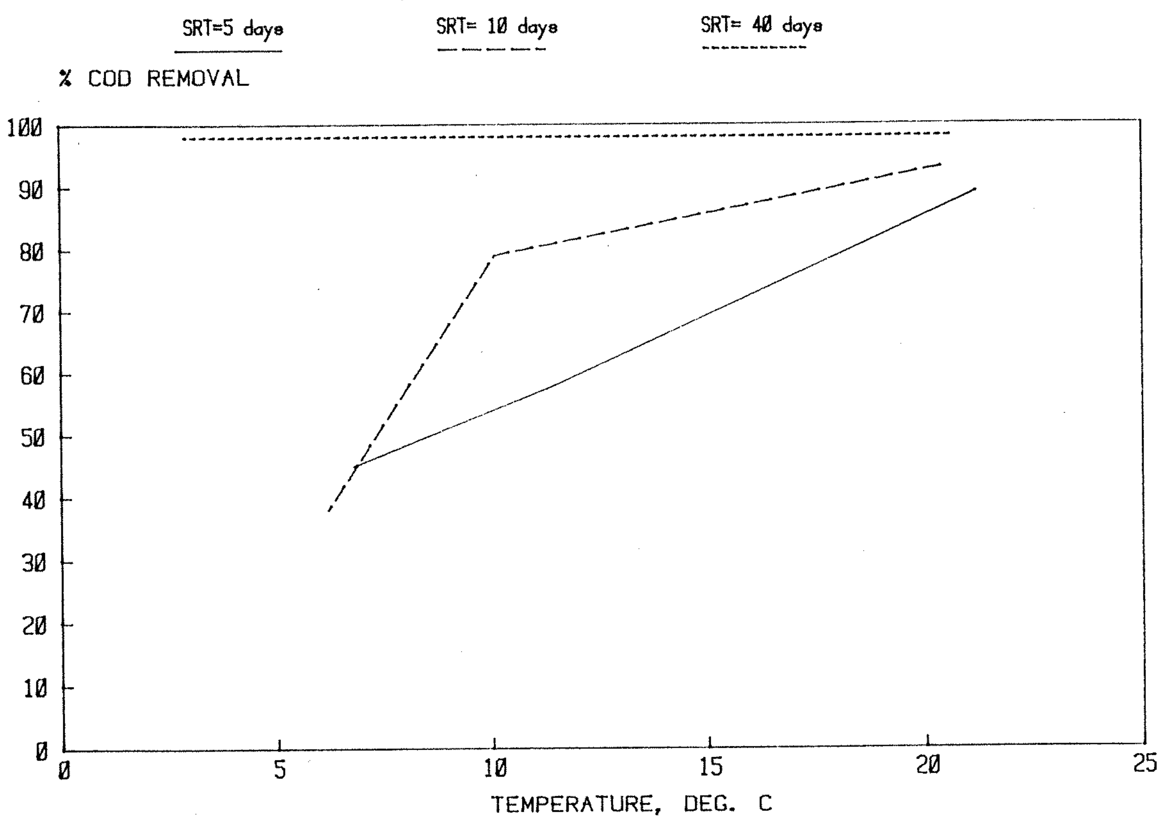


Figure 3. COD Removal vs. Temperature for Varying SRT's.

3.4. Metals Removal

The subterrainean conditions induced by leachate formation in landfills are highly conducive to metals dissolution. These conditions include anaerobiosis, low pH (5-6 range), and high concentrations of organic ligands, principally low molecular weight fatty acids (up to several thousand mg/l). Table 6 summarizes concentrations of the nine metals measured (Fe, Ca, Cd, Cr, Cu, Mg, Mn, Pb, and Zn) in the raw leachate and in the effluents of all experimental reactors.

Table 6. Raw Leachate and Reactor Effluent Metals Concentration.

REACTOR	SRT (day)	pH	TEMP (C)	FE (mg/l)	CA (mg/l)	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
LEACHATE	---	6	---	482	1132	.003	.12	.004	168	171	.0025	22.6
I.A.1	5	5.7	21	62.2	1865	.003	.13	.33	207	109	.29	24.75
I.A.2	5	8.5	21.2	6.2	21.4	.001	.03	.04	177	3.2	.007	.26
I.A.3	5	8.6	21	23	13.7	.001	.04	.04	169	3.1	.01	.48
I.A.4	5	8.4	21.5	29	140	.001	.04	.04	172	2.9	.011	.82
I.B.1	10	6.2	20.6	19.6	1615	.004	.1	.24	181	193	.11	19.1
I.B.2	10	8.7	20.4	2.04	17	.001	.02	.2	154	3	.01	.13
I.B.3	10	8.8	20.1	.47	5	.001	.02	.03	139	1	.005	.05
I.B.4	10	8.3	20.5	1.5	84	.001	.02	.04	158	4	.01	.07
I.C.1	40	8.8	20.8	30.5	7.9	.0004	.02	.14	110	4.6	.002	.77
I.C.2	40	9	20.6	3.9	4.2	.0004	.01	.12	115	.82	.0015	.14
I.C.3	40	9	20.6	.2	4.2	.0004	.01	.06	109	.32	.0016	.05
I.C.4	40	8.7	20.9	.1	110	.0004	.013	.07	117	1.98	.003	.06
II.B.1	10	8.8	18.2	.95	11	.001	.02	.12	104	1.65	.002	.09
II.B.2	10	8.9	18.3	1.39	7.1	.0004	.024	.11	138	.84	.003	.08
III.A.1	5	8.2	4.5	45.1	433	.0005	.06	.06	185	4.73	.005	1
III.A.2	5	8.4	11.5	12.1	619	.0005	.06	.05	166	10.4	.003	.4
III.B.1	10	8.3	4.5	1.56	1120	.0005	.04	.12	205	41.6	.0048	.2
III.B.2	10	8.6	10.1	44	24	.0006	.07	.07	174	5.27	.0045	.68
III.C.1	40	8.6	2.9	.73	11.1	.0002	.022	.1	131	1.47	.002	.07
III.C.2	40	8.8	9.7	.24	7.4	.0003	.02	.1	128	1.07	.0018	.06

Iron, calcium, cadmium, copper, manganese, lead, and zinc were highly removed in all reactors that performed adequately (high COD removal). Percent removals for iron, calcium, manganese, and zinc were in the range 95-100 while for cadmium, copper, and lead, concentrations were too low to accurately calculate percent removal. Chromium had intermediate removal (80-92 %) in adequately performing reactors, while maximum magnesium removal was about 35 %.

3.5. Settling

Measurement of the effects of nutrient addition levels and temperature on sludge settling properties was not a main objective of this study because of the widely different hydrodynamic conditions of the experimetnal reactors compared to full-scale units. Qualitative observations of mixed liquor settling characteristics indicated that flocculation and settling velocity increased as SRT increased. Reactors with 5-day SRT's had extremely dispersed mixed liquors with virtually no settling under all conditions, while 10-day SRT reactors showed an increasing tendency to flocculate, especially at the higher nutrient levels. Reactors with 40-day SRT's flocculated and settled very well under all experimental conditions, but turbidity in the clarified effluent was less at higher temperatures and at the higher nutrient levels.

4. DISCUSSION

4.1. Dual Nutrient-Temperature Limitation

Nutrient limitation in landfill leachate treatability studies has been reported by many previous investigators (e.g., Chian and DeWalle, 1976; Uloth and Mavinic, 1977; Robinson and Maris, 1983; see also Table 1). Typically, phosphorus is severely limited to the point that influent concentrations are nearly negligible relative to stoichiometric requirements for bacterial cell growth. Nitrogen concentrations are variable but also often are insufficient for balanced biological growth.

In most previous biotreatability studies of landfill leachates, when nutrients deficiencies occurred, nutrients were supplemented to approximately stoichiometric requirements, although Cook and Foree (1974) reported good performance in aerobic stabilization of an unsupplemented leachate with a COD/N/P ratio of 1200/21/1. In the current study, it was found that good to excellent BOD and COD removal could be achieved under conditions of severe nutrient limitation. For the raw leachate (COD/N/P=19000/400/1) and 20 ^{o}C temperature, reactors at 5 and 10 day SRT's failed, but the 40-day SRT reactor performed well with 95 % COD removal. With the lowest level of phosphorus supplementation (COD/N/P=577/12.1/1), 98 % COD and 99 % BOD removal were attained at SRT=40 days and T=20 ^{o}C. Performance decreased at SRT's of 10 and 5 days. At the two highest levels of nutrient addition (COD/N/P= 238/5/1 and 100/5/1), both 40-day and 10-day SRT reactor COD and BOD performances were excellent (95-98 % COD and 97-99 % BOD removal), while the 5-day SRT reactors had reduced removal efficiencies.

Effects of reduced temperatures on aerobic biological treatability of landfill leachates have been studied by Zapf-Gilje and Mavinic (1981), and Robinson and Maris (1983). These investigations have demonstrated that good performance can be attained down to temperatures of 9 and 5 ^{o}C, respectively. SRT's greater than 10 days were required for satisfactory performance. In a full scale plant, Stegmann and Ehrig (1980) reported good BOD removal at a temperature of 0.5 ^{o}C but SRT's were very long (order of 100 days).

In this study, reduced temperature effects were superimposed on nutrient limited conditions. This "dual-stressed" system was intended to determine operation and performance criteria during the winter season. As such, it represented an extension of present treatability information for leachates in colder climates. Under combined stress conditions (COD/N/P=577/12.2/1 and T-10 and 4 ^{o}C), SRT's of 5 and 10 days did not give adequate COD and BOD removal, while performance at 40-day SRT remained excellent. Temperature control in the reduced temperature experiment was poor. For the 40-day SRT reactor, temperature ranged from 0.5 to 5 ^{o}C with a mean value of 2.9 ^{o}C. It thus appears that 40 days is an adequate detention time for aerated lagoons in cold climates to achieve good removal of biodegradable organics even with severe nutrient limitation.

4.2. Nitrogen Fate and Distribution

Nitrogen in the raw leachate was present almost entirely in the ammoniacal form. Removal in the reactors appeared to be entirely attributable to biological uptake. A nitrogen mass balance (using an assumed volatile solids cellular nitrogen content of 12.4 %) indicated no volatilization of ammoniacal nitrogen despite the high reactor pH values. In the adequately performing reactors, influent nitrogen was virtually totally utilized (less than 1 mg/l in reactor effluent). Effluent soluble nitrogen was determined to be mostly in organic forms. Poorly performing reactors had high effluent ammoniacal nitrogen concentrations. Similar results have been reported by Cook and Foree (1974) and Robinson and Maris (1983).

Nitrification was negligible in all reactors, as effluent nitrite and nitrate concentrations never exceeded 1.0 mg/l. Since effluent nitrogen in reactors that were performing well (high COD and BOD removal) was mostly in organic forms, it is evident that excess ammoniacal nitrogen beyond biological requirements never existed to provide substrate for nitrifying organisms to establish. Growth rate limitations and pH and temperature inhibition in the poorly performing reactors (low COD and BOD removal) would be expected to adversely affect nitrifying organisms as it did the heterotrophic organisms. Robinson and Maris (1983) reported no nitrification at SRT's below 20 days and only erratic nitrification at a SRT of 20 days which they attributed mainly to low pH caused by the nitrification reaction. Keenan et al. (1984) found apparent nitrification (effluent nitrite and nitrate concentrations were not reported) in a full scale plant at F/M ratios between 0.12 and 0.32 kg COD/day. Pretreatment by lime precipitation, ammonia stripping, and pH adjustment with strong acids were also practised, so conditions varied considerably from those of direct biological treatment processes.

4.3. Phosphorus Fate and Distribution

Although phosphorus was clearly limiting to biological treatment based on its concentration in the raw leachate, good to excellent organics removal was possible using phosphorus supplementation significantly less than that theoretically required to satisfy the stoichiometry of bacterial cells. It is apparent that fungi or other organisms with significantly lower phosphorus and nitrogen requirements than heterotrophic organisms were able to adapt to the limiting nutrient conditons.

The adverse effects of phosphorus limitation decreased as the reactor organic loading decreased, or sludge age increased. Thus, it was possible to obtain high COD and BOD removal at 40-days SRT at leachate phosphorus concentrations that were limiting to 10- and 5-day SRT reactors. This suggests that organisms that are able to adapt to the severely nutrient-limiting environment have lower specific growth rates than the heterotrophs of nutrient-balanced systems. Cook and Foree (1974) also obtained excellent COD removal in a nutrient deficient aerobic treatment unit at an SRT of 10 days. A 5-day SRT unit failed under the same conditions. Microscopic examinations revealed an apparently larger fungi population in nutrient-deficient than in nutrient supplemented units.

Because of the importance of phosphorus as a nutrient, thermodynamic calculations were performed to determine whether precipitation of any phosphorus solid phases was likely, thus limiting phosphorus availability for biological growth. Calcium hydroxyapatite was predicted to be the controlling phosphorus solid phase under the experimental conditions of the reactors and served as the basis for these calculations. Table 7 summarizes thermodynamic data used for calcium complexation and precipitation calculations.

Table 7. Formation Constants for Calcium Complexes at I = 0 M, T = 25 ^{o}C*.

Ligand	Formation K Stoichiometry	Log K
OH^-	ML.H/M	-12.7
CO_3^{--}	ML/M.L	3.0
	ML(s)/M.L	8.34
HCO_3^-	ML/M.L	1.3
PO_4^{---}	ML/M.L	6.46
	M_5OHL_3(s).H/M_5.L_3	41.6
HPO_4^{--}	ML/M.L	2.74
$H_2PO_4^-$	ML/M.L	1.4

* Smith and Martell (1975).

Results of precipitation calculations were expressed in terms of stability indices for calcium hyroxyapatite and calcite (calcium carbonate), where the stability index is defined as the logarithm (base 10) of the molar ion product for the dissociation reaction divided by the solubility product constant for the dissociation reaction corrected to an ionic strength of 0.1 mole/l. Positive and negative values of the stability index indicate an oversaturated and an undersaturated solution, respectively, while a zero value indicates equilibrium with the respective solid phase. As summarized in Table 8, calcium hydroxyapatite appears to be oversaturated or in equilibrium with most reactor solutions. However, measured soluble orthophosphate concentrations used in these calculations were usually at or below the detection limit of 0.1 mg/l. Thus, some reactor solutions may be more nearly equilibrated rather than oversaturated with hydroxyapatite. Other less stable phosphorus solid phases (see Table 7) may initially precipitate with a subsequent slow transformation to the more stable hydroxyapatite (Nancollas et al, 1980).

Table 8. Stability Indices for Calcium Hydroxyapatite and Calcite at $I = 0.1$ M and $T = 25\ ^{o}C$.

Reactor	Stability Index $Ca_5OH(PO_4)_3(s)$	$CaCO_3(s)$
I.A.1	-4.3	-5.0
I.A.2	0.9	-1.4
I.A.3	3.8	-1.4
I.A.4	9.9	-0.8
I.B.1	-1.5	-4.1
I.B.2	1.2	-1.1
I.B.3	-1.0	-1.4
I.B.4	4.1	-1.2
I.C.1	0.0	-1.2
I.C.2	-0.6	-1.1
I.C.3	-0.6	-1.1
I.C.4	4.8	-0.3
II.B.1	0.7	-1.1
II.B.2	0.2	-1.1
III.A.1	7.9	-0.7
III.A.2	7.9	-0.1
III.B.1	7.8	-0.1
III.B.2	5.9	-1.1
III.C.1	-0.1	-1.4
III.C.2	-0.1	-1.2

Calcite appears to be undersaturated in all reactor solutions. However, evidence from influent and effluent calcium concentrations, the alkalinity balance (see below), and the very low phosphorus concentrations (stoichiometrically insufficient to precipitate calcium) all suggest that calcium was precipitated from solution as a corbonate solid phase.

4.4. Metals Fates

Metals removal from aerobic biological treatment of sanitary landfill leachates has generally been reported to be highly efficient (e.g., Uloth and Mavinic, 1977; Zapf-Gilje and Mavinic, 1981; Robinson and Maris, 1983) and was confirmed in this study. The high removal efficiency has been attributed to the combined effects of high TSS concentrations, high pH values, and precipitation of some solid phases. Nelson et al. (1981) have shown that adsorption of heavy metals by activated sludge solids is highly favored at pH values above 8 and that the overall distribution of the metals between solution and solid phases results from competition between organic and inorganic ligands and surface functional groups of the solids.

In leachate treatment systems, additional solid phases are present that contribute to the adsorptive removal of metals. Greatest in concentration and probable effect are the hydroxide and oxide precipitates formed by oxidation of reduced iron Fe(II) and manganese Mn (II), introduced in the raw leachate. These two metals have extremely low solubilities in their higher oxidation states, Fe (III) and Mn (IV), and thus are nearly quantitatively precipitated when subjected to aeration in the experimental reactors (see discussion below). Several investigators have demonstrated the very high adsorptive capacity of ferric hydroxide and manganese oxide solid phases for metals in wastewater treatment processes (e.g., Benjamin et al., 1982) and in natural water sediments, (e.g., Davies-Colley et al., 1984).

Precipitation of solid phases may have other significant influences on the biological treatability of landfill leachates. Beneficial effects include the removal of heavy metals and the general reduction in inorganic salts (total dissolved solids) content. Possible deleterious effects are precipitation of phosphate needed as a nutrient and alkalinity reduction and pH decrease from both carbonate precipitation and oxidation-precipitation of iron and manganese.

Among the most likely precipitating solid phases are the hydroxide or oxide, carbonate, and phosphate forms of nearly all metals present. Thermodynamic calculations were made to determine whether these phases were likely to control the solubility of major and trace metals in the experimental reactors. Solubility determinations were based on calculation of stability indices for the respective solid phases of the metals considered and included corrections for solution ionic strength. Complexing ligands considered were hydroxide, carbonate, bicarbonate orthophosphate, monobasic phosphate, dibasic phosphate, ammonia, and acetate. Table 9 summarizes results of these calculations for the experimental reactors considered as a group. Including in the table are the solid phases considered, the thermodynamically controlling solid phase (that which would form should precipitation occur), and whether a precipitate was predicted to form (stability index > 0). For some metals, there was considerable variation among reactors and important ligands, especially organic compounds, may have been omitted. Thus the results expressed in Table 9 should be considered advisory and needing verification for specific reactor conditions.

The results expressed in Table 9 suggest that the major metals Ca, Fe, and Mn are solubility controlled, while Mg does not form a precipitate. Most minor heavy metals appear to be undersaturated with respect to suspected solid phases. The major removal mechanism for trace metals is probably sorption on the slurry solids (microbial cellular matter and precipitated major metal phases).

For nearly all metals, comparison of leachate influent concentrations and reactor effluent concentrations indicates that poorer removal was achieved in the more poorly performing reactors (those with lower COD removal). This could be caused by both lower pH and by the higher solution concentrations of complexing organic and inorganic ligands, as evidenced by the higher conductivity and COD values. A complete analysis of solution phase ligands was beyond the scope of this study.

Table 9. Metals Solubility Controls.

Metal	Solid Phases Considered	Controlling Solid Phase	Equilibrium Condition
Fe	$Fe(OH)_3$ $FePO_4$	$Fe(OH)_3$	Oversaturated
Ca	$CaCO_3$ $CaHPO_4$ $CaH(PO_4)_3$ $Ca_5OH(PO_4)_3$	$Ca_5OH(PO_4)_3$	Oversaturated
Cd	$Cd(OH)_2$ $CdCO_3$	$CdCO_3$	Undersaturated
Cr	$Cr(OH)_3$	$Cr(OH)_3$	Undersaturated
Cu	$Cu(OH)_2$ $CuCO_3$	$Cu(OH)_2$	Saturated
Mg	$Mg(OH)_2$ $MgCO_3$	$Mg(OH)_2$	Undersaturated
Mn	MnO_2	MnO_2	Oversaturated
Pb	PbO $PbCO_3$	PbO	Undersaturated
Zn	$Zn(OH)_2$ $ZnCO_3$	$ZnCO_3$	Undersaturated

4.5. Alkalinity Balance

The initial pH in most landfill leachates is between 4 and 6 because of volatile acids generation during fermentation of organic matter and supersaturated CO_2 content. This has led some investigators to neutralize leachates prior to treatment despite high measured alkalinities. To more fully understand alkalinity transformations during aerobic biological treatment of landfill leachates, an approximate alkalinity balance was performed.

The alkalinity balance included the following components: influent (raw leachate, all soluble), filtered effluent, volatile acid oxidation, carbonate precipitation, ammonium-nitrogen oxidation, iron oxidation, and manganese oxidation. Alkalinity in particulate forms in the effluent was not included separately as it would presumably be predominantly precipitated carbonates. Table 10 summarizes the alkalinity balance equation and reaction stoichiometry used in calculating alkalinity changes from each term in the equation.

Table 10. Alkalinity Balance Equations.

<u>Overall Balance Equation:</u>

(alk), leachate = (alk), effluent + (alk), $CaCO_3$ ppt'n + (alk), NH_4 oxidation + (alk), Fe and Mn oxidation + (alk), vol.acids oxidation.

<u>Volatile Acids (acetate) Oxidation and Cell Growth:</u>

$$3\ CO_2 + 2\ NH_4^+ + 5\ CH_3COO^- = 2\ C_5H_7O_2N + 3\ H_2O + 3\ HCO_3^-$$

<u>Calcite precipitation:</u>

$$Ca^{++} + HCO_3^- = CaCO_3(s) + H^+$$

<u>Iron Oxidation:</u>

$$4\ Fe^{++} + O_2 + 10\ H_2O = 4\ Fe\ (OH)_3\ (s) + 8\ H^+$$

<u>Manganese Oxidation:</u>

$$2\ Mn^{++} + O_2 + 2\ H_2O = 2\ MnO_2(s) + 4\ H^+$$

<u>Ammonium Ion Oxidation:</u>

$$NH_4^+ + 2\ O_2 = NO_3^- + H_2O + 2\ H^+$$

Predominant alkalinity forms in the raw leachate are volatile acid salts and bicarbonate. From the alkalinity titration (initial pH 6.0 to pH 4.5) and direct measurement of volatile acids concentrations, relative contributions from each of these two forms were estimated to be 30.7 meq/l volatile acids alkalinity and 39.9 meq/l carbonate system alkalinity. The theoretical equivalence point pH for the combined weak acid system is 3.7. In reactors that performed adequately, effluent alkalinity was comprised mainly of carbonate system components since volatile acids were metabolized in the treatment process.

Reaction stoichiometry in Table 10 reveals that alkalinity is influenced in the following ways. Oxidation of acetate (volatile acid salts) to form bacterial cells results in a net loss of one equivalent of alkalinity per mole oxidized. Calcium carbonate precipitation reduces alkalinity by two equivalents per mole $CaCO_3$(s) formed. Ammonium nitrogen (NH_4^+) oxidation to nitrate consumes two equivalents of alkalinity per mole of nitrogen oxidized. Iron and manganese oxidation to their respective oxides (hydroxides) result in two equivalents of alkalinity consumed per mole of Fe(II) or Mn(II) oxidized.

Results of the alkalinity balance are shown in Table 11. Although significant discrepancies occur in some reactors, most alkalinity balances can be accounted for within 5-10 % of initial (influent) values. This suggests that the alkalinity balance equation includes terms for the predominant alkalinity transformations that occurred in the reactors.

Alkalinity balance results support the assumption that initially low pH values in landfill leachates are caused by the presence of volatile acids and perhaps CO_2 is stripped to attain atmospheric equilibrium and the volatile acids are assimilated as substrate. Thus there appears to be no necessity to neutralize landfill leachates by addition of base chemicals prior to aerated biological treatment processes. As evidenced in this study, adequately performing reactors maintained pH values well in excess of 8 with no base chemical addition.

Table 11. Reactor Alkalinity Balance

Reactor no.	Alkalinity Balance Error, meq/l	Alkalinity Balance Error, %
I.A.1	0.36	0.4
I.A.2	-6.34	7.0
I.A.3	-4.86	5.4
I.A.4	-12.93	14.3
I.B.1	1.17	1.3
I.B.2	-4.26	4.7
I.B.3	-6.65	7.4
I.B.4	10.28	11.4
I.C.1	5.82	6.5
I.C.2	9.30	10.3
I.C.3	9.52	10.6
I.C.4	13.93	15.4
II.B.1	-1.05	1.2
II.B.2	-2.59	2.9
III.A.1	25.87	28.7
III.A.2	30.32	33.6
III.B.1	-4.43	4.9
III.B.2	-3.77	4.2
III.C.1	-2.70	3.1
III.C.2	-2.99	3.3

5. CONCLUSIONS

For aerated lagoon treatment of sanitary landfill leachate subjected to temperature and nutrient limiting conditions, the conclusions of this research are:

1. Phosphorus nutrient supplementation is required for efficient treatment (COD and BOD removal) but at significantly lower degree than theoretical stoichiometric concentrations for bacterial growth. Decreased supplementation is required as solids retention time is increased from 5 to 40 days.

2. Excellent treatment efficiency can be achieved at very low temperatures (between 0 and 4 ^{o}C) provided solids retention time is maintained near 40 days and phosphorus supplementation is practiced.

3. Phosphorus may be solubility limited by formation of calcium hydroxyapatite or another solid phase. Only at the highest phosphorus supplementation levels (approaching stoichiometric requirements for bacterial growth) was a precipitate observed in the reactors.

4. Most major and trace metals are removed at greater than 90 % efficiency from the aqueous phase. Removal of the major metal cations, Ca, Fe, and Mn, appears to occur by sorption to the slurry solids (microbial solids and precipitated metal phases).

5. Raw leachate alkalinity is divided roughly evenly between that of volatile acids and the carbonate system. Consideration of alkalinity transformations during leachate treatment and influent and effluent values indicates that pretreatment to neutralize acids and raise the pH is unnecessary.

6. Understanding chemical reactions of nutrients and heavy metals in leachate treatment systems can contribute to better design and to better control of effluent quality.

6. REFERENCES

1. American Public Health Association, et al., 1980. Standard Methods for the Examination of Water and Wastewater, 15th Ed., Washington, D.C.

2. Benjamin, M.M., Hayes, K.F., and Leckie, J.O., 1982. Removal of toxic metals from power-generation waste streams by adsorption and coprecipitation, J. Water Pollution Control Federation, vol, 54, 1472-1481.

3. Chian, E.S.K., DeWalle, F.B., 1976. Sanitary landfill leachates and their treatment, J. Environmental Engineering Division, A.S.C.E., vol. 102, 411-431.

4. Cook, E.N., and Foree, E.G., 1974. Aerobic biostabilization of sanitary landfill leachate, J. Water Pollution Control Federation, vol. 46. 380-392.

5. Davies-Colley, R.J., Nelson, P.O., and Williamson, K.J., 1984. Cadmium and copper uptake by estuarine sedimentary phases, Environmental Science and Technology, vol. 18, 491-499.

6. Johansen, O.J., 1975. Treatment of leachates from sanitary landfills, NIVA Report No. 0-26/74, Norwegian Institute for Water Research, Oslo, Norway.

7. Keenan, J.D., Steiner, R.L., and Fungaroli, A.A., 1984. Landfill leachate treatment, J. Water Pollution Control Federation, vol. 56, 27-33.

8. Nancollas, G.H., Amjad, Z., and Koutsoukos, P., 1979. Calcium phosphates- speciation, solubility and kinetic considerations, in Chemical Modelling in Aqueous Systems, E.A. Jenne, Ed., A.C.S. Symposium Series 93, Washington, D.C., 475-497.

9. Nelson, P.O., Chung, A.K., and Hudson, M.C., 1981. Factors affecting the fate of heavy metals in the activated sludge process, J. Water Pollution Control Federation, vol. 53. 1323-1333.

10. Robinson, H.D. and Maris, P.J., 1983. The treatment of leachates from domestic wastes in landfills-1; aerobic biological treatment of a medium-strength leachate, Water Research, vol. 17, 1537-1548.

11. Stegmann, R. and Ehrig, H.-J., 1980. Operation and design of biological leachate treatment plants, Progress in Water Technology, vol. 12, 919-947.

12. Uloth, V.C., and Mavinic, D.S., 1977. Aerobic bio-treatment of a high-strength leachate, J. Environmental Engineering Division, A.S.C.E., vol. 103, 647-661.

13. Zapf-Gilje, R., and Mavinic, D.S., 1981. Temperature effects on biostabilization of leachate, J. Environmental Engineering Division, A.S.C.E., vol. 107, 653-663.

APPENDIX A: Experimental data

Table A1: Reactor I.A.1

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
28/2	6	22	7.1	.77	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/2	ND	ND	ND	ND	ND	ND	ND	13000	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/3	5.8	23	7.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3	5.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3	5.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND	15500	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3	5.6	20.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/3	5.6	ND	8.6	ND	ND	1390	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/3	5.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/3	5.8	19.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/3	5.7	ND	10.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15/3	ND	19.9	ND	.94	ND	1860	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	75.64	ND	ND	12000	ND	ND	ND	ND	ND	ND	ND	ND	ND
19/3	5.6	17.1	9.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20/3	5.6	20.8	7.8	ND	ND	1500	990	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21/3	5.6	ND	ND	ND	ND	ND	ND	ND	ND	350	270	23	227	.3	.1	ND	ND
22/3	5.6	ND	ND	ND	ND	ND	ND	16500	12210	ND	ND	ND	ND	ND	ND	ND	ND
23/3	5.6	22.4	7.3	ND	ND	ND	ND	ND	ND	346	264	ND	ND	.1	.1	59.7	2100
26/3	5.5	22.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/3	5.6	21.5	7.5	1.05	62.18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/3	5.6	21.4	ND	1.02	ND	1840	1130	17000	7665	ND	ND	ND	ND	ND	ND	ND	ND
29/3	5.6	ND	ND	ND	ND	1420	870	ND	ND	ND	ND	ND	ND	ND	ND	64.7	1630
30/3	5.6	ND	ND	ND	ND	ND	ND	ND	ND	330	218	ND	57	.1	.1	ND	ND
2/4	8.7	(RESEEDED WITH SLUDGE FROM DAL SKOG)															
3/4	8		6.2														
4/4	7.7																
5/4	7.7																
6/4	7.6																
9/4	5.8																
10/4	5.8		8.8														
11/4	5.7																
12/4	5.7																
13/4	5.4																
MEAN	5.66	20.95	8.23	0.95	68.91	1602	997	14800	9938	342	251	23	142	0.17	0.10	62.20	1865
STD.DEV	0.13	1.66	1.26	0.13	9.52	230	130	2197	3214	11	28	ND	ND	0.12	0.00	3.54	332

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
28/2	ND	ND	ND	ND	ND	ND	ND
29/2	ND	ND	ND	ND	ND	ND	ND
1/3	ND	ND	ND	ND	ND	ND	ND
5/3	ND	ND	ND	ND	ND	ND	ND
6/3	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND
8/3	ND	ND	ND	ND	ND	ND	ND
9/3	ND	ND	ND	ND	ND	ND	ND
12/3	ND	ND	ND	ND	ND	ND	ND
13/3	ND	ND	ND	ND	ND	ND	ND
14/3	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	ND	ND
19/3	ND	ND	ND	ND	ND	ND	ND
20/3	ND	ND	ND	ND	ND	ND	ND
21/3	ND	ND	ND	ND	ND	ND	ND
22/3	ND	ND	ND	ND	ND	ND	ND
23/3	.0033	.13	.26	196	2.23	.11	24.9
26/3	ND	ND	ND	ND	ND	ND	ND
27/3	ND	ND	ND	ND	ND	ND	ND
28/3	ND	ND	ND	ND	ND	ND	ND
29/3	.0034	.13	.39	218	216	.47	24.6
30/3	ND	ND	ND	ND	ND	ND	ND
2/4							
3/4							
4/4							
5/4							
6/4							
9/4							
10/4							
11/4							
12/4							
13/4							
MEAN	.00335	0.13	0.33	207	109	0.29	24.75
STD.DEV	0.00	0.00	0.09	16	151	0.25	0.21

Table A2: Reactor I.A.2

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
28/2	8.2	22	5.7	.41	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/3	8.6	23	6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3	7.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND	1900	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3	8.2	21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/3	8.5	ND	6.3	ND	ND	7380	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/3	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/3	7.8	20.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/3	8.3	ND	7.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15/3	ND	20.7	ND	.53	ND	6455	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	27.3	ND	ND	1900	ND	ND	ND	ND	ND	ND	ND	ND	ND
19/3	8.5	17.1	5.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20/3	8.4	21.2	4.5	ND	ND	10320	6570	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21/3	8.5	ND	ND	ND	ND	ND	ND	ND	ND	72	1.6	119	285	2.3	2	ND	ND
22/3	8.8	ND	ND	ND	ND	ND	ND	2400	690	ND	ND	ND	ND	ND	ND	ND	ND
23/3	8.6	ND	5.7	ND	ND	ND	ND	ND	ND	44	.58	ND	ND	1.4	.8	7.18	15.2
26/3	9	22.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/3	8.6	21.9	6.3	.54	19.81	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/3	8.7	21.5	ND	.52	ND	7370	4400	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/3	ND	ND	ND	ND	ND	6310	3290	2250	1100	ND	ND	ND	ND	ND	ND	5.27	27.6
30/3	8.7	ND	ND	ND	ND	ND	ND	1950	ND	27	4.15	ND	60	.6	.2	ND	ND
2/4	8.8	21.7															
3/4	8.6		4.4														
4/4	8.6																
5/4	8.8																
6/4	8.8																
9/4	8.8																
10/4	8.7	18.6	7.6														
11/4	8.8																
12/4	8.7																
13/4	7.8																
MEAN	8.47	21.16	5.86	0.50	23.56	7567	4753	2080	895	48	2.11	119	173	1.43	1.00	6.23	21.40
STD.DEV	0.32	1.64	0.81	0.06	5.30	1618	1668	231	290	23	1.84	ND	159	0.85	0.92	1.35	8.77

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
28/2	ND	ND	ND	ND	ND	ND	ND
1/3	ND	ND	ND	ND	ND	ND	ND
5/3	ND	ND	ND	ND	ND	ND	ND
6/3	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND
8/3	ND	ND	ND	ND	ND	ND	ND
9/3	ND	ND	ND	ND	ND	ND	ND
12/3	ND	ND	ND	ND	ND	ND	ND
13/3	ND	ND	ND	ND	ND	ND	ND
14/3	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	ND	ND
19/3	ND	ND	ND	ND	ND	ND	ND
20/3	ND	ND	ND	ND	ND	ND	ND
21/3	ND	ND	ND	ND	ND	ND	ND
22/3	ND	ND	ND	ND	ND	ND	ND
23/3	.0006	.031	.04	183	2.62	.0068	.29
26/3	ND	ND	ND	ND	ND	ND	ND
27/3	ND	ND	ND	ND	ND	ND	ND
28/3	ND	ND	ND	ND	ND	ND	ND
29/3	.0006	.031	.04	170	3.76	.0072	.22
30/3	ND	ND	ND	ND	ND	ND	ND
2/4							
3/4							
4/4							
5/4							
6/4							
9/4							
10/4							
11/4							
12/4							
13/4							
MEAN	.0006	0.03	0.04	177	3.19	.007	0.26
STD.DEV	0	0	0	9	0.81	0.00	0.05

Table A3: Reactor I.A.3

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
28/2	8.5	22	4.9	.53	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/3	8.4	23.5	4.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3	8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND	2950	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3	8.6	20.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/3	8.8	ND	7.7	ND	ND	5935	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/3	8.9	20.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/3	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/3	8.7	ND	9.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15/3	ND	19.8	ND	.57	ND	6185	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	27.63	ND	ND	3200	ND	ND	ND	ND	ND	ND	ND	ND	ND
19/3	8.7	16.9	7.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20/3	8.5	21.1	6.6	ND	ND	9820	6260	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21/3	8.5	ND	ND	ND	ND	ND	ND	ND	ND	96	16.8	98	250	5.9	2.8	ND	ND
22/3	8.9	ND	ND	ND	ND	ND	ND	2400	910	ND	ND	ND	ND	ND	ND	ND	ND
23/3	8.7	22.5	6	ND	ND	ND	ND	ND	ND	ND	11.6	ND	ND	1.1	.3	10.8	6.7
26/3	9	22.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/3	8.5	21.5	6	.53	18.11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/3	8.7	21.5	ND	.52	ND	5620	3040	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/3	8.5	ND	ND	ND	ND	3270	1280	2000	610	ND	ND	ND	ND	ND	ND	35.6	20.7
30/3	8.3	ND	ND	ND	ND	ND	ND	2200	ND	27	.58	ND	77	2.3	1.5	ND	ND
2/4	8.6	22.4															
3/4	8.6		5.7														
4/4	8.6																
5/4	8.8																
6/4	8.7																
9/4	8.7																
10/4	8.8	18.5	7.5														
11/4	8.8																
12/4	8.8																
13/4	8.5																
27/4	8.7																
MEAN	8.60	21.05	6.53	0.54	22.87	6166	3527	2550	760	62	9.66	98	164	3.10	1.53	23	13.70
STD.DEV	0.23	1.75	1.60	0.02	6.73	2350	2525	507	212	49	8.28	ND	122	2.50	1.25	18	9.90

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
28/2	ND	ND	ND	ND	ND	ND	ND
1/3	ND	ND	ND	ND	ND	ND	ND
5/3	ND	ND	ND	ND	ND	ND	ND
6/3	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND
8/3	ND	ND	ND	ND	ND	ND	ND
9/3	ND	ND	ND	ND	ND	ND	ND
12/3	ND	ND	ND	ND	ND	ND	ND
13/3	ND	ND	ND	ND	ND	ND	ND
14/3	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	ND	ND
19/3	ND	ND	ND	ND	ND	ND	ND
20/3	ND	ND	ND	ND	ND	ND	ND
21/3	ND	ND	ND	ND	ND	ND	ND
22/3	ND	ND	ND	ND	ND	ND	ND
23/3	.0006	.032	.04	164	1.77	.0072	.28
26/3	ND	ND	ND	ND	ND	ND	ND
27/3	ND	ND	ND	ND	ND	ND	ND
28/3	ND	ND	ND	ND	ND	ND	ND
29/3	.0006	.04	.04	173	4.37	.0078	.67
30/3	ND	ND	ND	ND	ND	ND	ND
2/4							
3/4							
4/4							
5/4							
6/4							
9/4							
10/4							
11/4							
12/4							
13/4							
27/4							
MEAN	.0006	0.04	0.04	169	3.07	0.01	0.48
STD.DEV	0	0.01	0	6	1.84	0.00	0.28

Table A4: Reactor I.A.4

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
28/2	8.8	22	5.4	.66	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/3	8.7	23	5.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3	8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND	4750	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3	7.9	21.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/3	8.5	ND	7.9	ND	ND	6070	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/3	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/3	7.7	20.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/3	7.5	ND	.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15/3	ND	21.4	ND	1.14	ND	3455	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	54.29	ND	ND	5000	ND	ND	ND	ND	ND	ND	ND	ND	ND
19/3	8.7	17.4	8.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20/3	8.5	21.4	6.9	ND	ND	5840	3550	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21/3	8.3	ND	ND	ND	ND	ND	ND	ND	ND	314	138	177	592	23	7.8	ND	ND
22/3	8.6	ND	ND	ND	ND	ND	ND	2900	1280	ND	ND	ND	ND	ND	ND	ND	ND
23/3	8	24	.9	ND	ND	ND	ND	ND	ND	346	207	ND	ND	18	6.5	34	208
26/3	8.5	21.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/3	8.6	21.5	6.3	.81	15.31	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/3	8.6	21.4	ND	.77	ND	4320	2700	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/3	8.4	ND	ND	ND	ND	3430	1880	4400	1950	ND	ND	ND	ND	ND	ND	23.3	71
30/3	8.4	ND	ND	ND	ND	ND	ND	3400	ND	368	10.4	ND	690	26	9.8	ND	ND
2/4	8.5	21.9															
3/4	8.2		5.7														
4/4	8.2																
5/4	8.3																
6/4	8.2																
9/4	8																
10/4	8.3	18.9	7.4														
11/4	8.4																
12/4	8.4																
13/4	7.9																
27/4	8.2																
MEAN	8.35	21.47	5.18	0.85	34.80	4623	2710	4090	1615	343	118	177	641	22	8.03	29	140
STD.DEV	0.36	1.61	2.99	0.21	27.56	1270	835	902	474	27	100	ND	69	4	1.66	8	97

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
28/2	ND	ND	ND	ND	ND	ND	ND
1/3	ND	ND	ND	ND	ND	ND	ND
5/3	ND	ND	ND	ND	ND	ND	ND
6/3	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND
8/3	ND	ND	ND	ND	ND	ND	ND
9/3	ND	ND	ND	ND	ND	ND	ND
12/3	ND	ND	ND	ND	ND	ND	ND
13/3	ND	ND	ND	ND	ND	ND	ND
14/3	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	ND	ND
19/3	ND	ND	ND	ND	ND	ND	ND
20/3	ND	ND	ND	ND	ND	ND	ND
21/3	ND	ND	ND	ND	ND	ND	ND
22/3	ND	ND	ND	ND	ND	ND	ND
23/3	.0008	.0415	.03	185	4.11	.0108	1.02
26/3	ND	ND	ND	ND	ND	ND	ND
27/3	ND	ND	ND	ND	ND	ND	ND
28/3	ND	ND	ND	ND	ND	ND	ND
29/3	.0006	.036	.04	158	1.67	.011	.61
30/3	ND	ND	ND	ND	ND	ND	ND
2/4							
3/4							
4/4							
5/4							
6/4							
9/4							
10/4							
11/4							
12/4							
13/4							
27/4							
MEAN	.0007	0.04	0.04	172	2.89	.0109	0.82
STD.DEV	0.00	0	0.01	19	1.73	0.00	0.29

Table A5: Reactor I.B.1

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
28/2	8.4	22	6.4	.59	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/3	8.3	23	6.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3	8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3	8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND	7700	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3	7.8	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/3	7.6	ND	8.9	ND	ND	2705	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/3	6.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/3	6.1	19.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/3	5.8	ND	9.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15/3	ND	19.7	ND	.89	63.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	1570	ND	12000	ND	ND	ND	ND	ND	ND	ND	ND	ND
19/3	5.9	17	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20/3	5.8	20.7	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21/3	5.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
22/3	5.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/3	5.7	22.1	7.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26/3	5.8	22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/3	5.8	21.5	7.6	1.13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/3	5.8	21	ND	1.11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/3	5.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/3	5.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/4	5.7	20.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/4	5.7	ND	7.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/4	5.6	ND	ND	ND	ND	1510	965	14000	11160	ND	ND	ND	ND	ND	ND	ND	ND
5/4	5.8	ND	ND	ND	ND	ND	ND	13500	ND	262	230	15	62	.3	.1	ND	ND
6/4	5.7	ND	ND	ND	ND	1180	ND	14500	ND	267	ND	ND	ND	.1	ND	27.3	1620
9/4	5.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/4	5.7	18.9	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/4	5.7	ND	ND	ND	ND	1320	860	13500	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/4	5.7	ND	ND	ND	ND	ND	ND	ND	ND	267	252	ND	ND	.2	.1	11.9	1610
13/4	5.7	ND	ND	ND	ND	1495	ND	13000	ND	251	ND	ND	ND	.2	ND	ND	ND
MEAN	6.24	20.61	8.12	0.93	63.02	1630	913	12600	11160	262	241	15	62	0.20	0.10	19.60	1615
STD.DEV	0.94	1.63	1.07	0.25	ND	546	74	2299	ND	8	16	ND	ND	0.08	0.00	10.89	7

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
28/2	ND	ND	ND	ND	ND	ND	ND
1/3	ND	ND	ND	ND	ND	ND	ND
5/3	ND	ND	ND	ND	ND	ND	ND
6/3	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND
8/3	ND	ND	ND	ND	ND	ND	ND
9/3	ND	ND	ND	ND	ND	ND	ND
12/3	ND	ND	ND	ND	ND	ND	ND
13/3	ND	ND	ND	ND	ND	ND	ND
14/3	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	ND	ND
19/3	ND	ND	ND	ND	ND	ND	ND
20/3	ND	ND	ND	ND	ND	ND	ND
21/3	ND	ND	ND	ND	ND	ND	ND
22/3	ND	ND	ND	ND	ND	ND	ND
23/3	ND	ND	ND	ND	ND	ND	ND
26/3	ND	ND	ND	ND	ND	ND	ND
27/3	ND	ND	ND	ND	ND	ND	ND
28/3	ND	ND	ND	ND	ND	ND	ND
29/3	ND	ND	ND	ND	ND	ND	ND
30/3	ND	ND	ND	ND	ND	ND	ND
2/4	ND	ND	ND	ND	ND	ND	ND
3/4	ND	ND	ND	ND	ND	ND	ND
4/4	ND	ND	ND	ND	ND	ND	ND
5/4	ND	ND	ND	ND	ND	ND	ND
6/4	.0032	.1	.17	184	186	.14	19.2
9/4	ND	ND	ND	ND	ND	ND	ND
10/4	ND	ND	ND	ND	ND	ND	ND
11/4	ND	ND	ND	ND	ND	ND	ND
12/4	.0043	.09	.3	178	199	.08	18.9
13/4	ND	ND	ND	ND	ND	ND	ND
MEAN	.00375	0.10	0.24	181	193	0.11	19.05
STD.DEV	7.8E-4	0.01	0.09	4	9	0.04	0.21

Table A6: Reactor I.B.2

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
28/2	8.9	21.5	5.8	.45	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/3	8.8	23	6.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND	2050	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3	8.5	20.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/3	8.8	ND	8	ND	ND	4710	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/3	8.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/3	8.6	18.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/3	8.7	ND	9.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15/3	ND	19.3	ND	.54	20.69	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	7300	ND	1900	ND	ND	ND	ND	ND	ND	ND	ND	ND
19/3	8.4	16.4	7.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20/3	8.6	20.4	5.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21/3	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
22/3	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/3	8.8	21.9	6.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26/3	8.7	21.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/3	8.6	21	6.1	.58	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/3	8.7	20.7	ND	.57	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/3	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/3	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/4	8.7	20.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/4	8.7	ND	5.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/4	8.5	ND	ND	ND	ND	8750	4260	1200	535	ND	ND	ND	ND	ND	ND	ND	ND
5/4	8.9	ND	ND	ND	ND	ND	ND	1100	ND	27.2	9.4	26	70	.4	.1	ND	ND
6/4	8.8	ND	ND	ND	ND	4830	ND	950	ND	21.7	ND	ND	ND	.3	ND	2.5	15.9
9/4	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/4	8.8	18.9	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/4	8.8	ND	ND	ND	ND	9420	4340	1050	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/4	8.7	ND	ND	ND	ND	ND	ND	ND	ND	22.7	10	ND	ND	.2	.1	1.57	18.8
13/4	8.7	ND	ND	ND	ND	7440	ND	1150	ND	25.6	ND	ND	ND	.3	ND	ND	ND
MEAN	8.69	20.38	6.95	0.54	20.69	7075	4300	1343	535	24	10	26	70	0.30	0.10	2.04	17
STD.DEV	0.15	1.70	1.49	0.06	ND	1956	57	441	ND	3	0	ND	ND	0.08	0.00	0.66	2

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
28/2	ND	ND	ND	ND	ND	ND	ND
1/3	ND	ND	ND	ND	ND	ND	ND
5/3	ND	ND	ND	ND	ND	ND	ND
6/3	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND
8/3	ND	ND	ND	ND	ND	ND	ND
9/3	ND	ND	ND	ND	ND	ND	ND
12/3	ND	ND	ND	ND	ND	ND	ND
13/3	ND	ND	ND	ND	ND	ND	ND
14/3	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	ND	ND
19/3	ND	ND	ND	ND	ND	ND	ND
20/3	ND	ND	ND	ND	ND	ND	ND
21/3	ND	ND	ND	ND	ND	ND	ND
22/3	ND	ND	ND	ND	ND	ND	ND
23/3	ND	ND	ND	ND	ND	ND	ND
26/3	ND	ND	ND	ND	ND	ND	ND
27/3	ND	ND	ND	ND	ND	ND	ND
28/3	ND	ND	ND	ND	ND	ND	ND
29/3	ND	ND	ND	ND	ND	ND	ND
30/3	ND	ND	ND	ND	ND	ND	ND
2/4	ND	ND	ND	ND	ND	ND	ND
3/4	ND	ND	ND	ND	ND	ND	ND
4/4	ND	ND	ND	ND	ND	ND	ND
5/4	ND	ND	ND	ND	ND	ND	ND
6/4	.0008	.023	.365	164	2.63	.0075	.13
9/4	ND	ND	ND	ND	ND	ND	ND
10/4	ND	ND	ND	ND	ND	ND	ND
11/4	ND	ND	ND	ND	ND	ND	ND
12/4	.0006	.0225	.035	143	2.52	.0062	.13
13/4	ND	ND	ND	ND	ND	ND	ND
MEAN	.0007	0.02	0.20	154	3	0.01	0.13
STD.DEV	1.4E-4	0.00	0.23	15	0	0.00	0.00

Table A7: Reactor I.B.3

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
28/2	9	21.5	6.2	.49	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/3	8.9	22.5	6.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND	1350	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3	8.8	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/3	8.8	ND	6.1	ND	ND	5060	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/3	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/3	8.3	19.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/3	8.6	ND	9.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15/3	ND	19.2	ND	.51	19.43	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	8520	ND	1300	ND	ND	ND	ND	ND	ND	ND	ND	ND
19/3	8.8	16.2	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20/3	8.8	20.2	7.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21/3	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
22/3	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/3	8.9	21.7	6.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26/3	8.8	21.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/3	8.8	21	7.4	.56	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/3	8.9	20.6	ND	.55	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/3	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/3	8.8	ND	ND	ND	ND	ND	ND	750	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/4	8.9	20.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/4	8.8	ND	6.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/4	8.6	ND	ND	ND	ND	10400	5070	900	240	ND	ND	ND	ND	ND	ND	ND	ND
5/4	8.9	ND	ND	ND	ND	ND	ND	850	ND	12.7	1.2	8	17	.4	.1	ND	ND
6/4	8.9	ND	ND	ND	ND	6510	ND	800	ND	10.4	ND	ND	ND	.2	ND	.21	5.3
9/4	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/4	8.9	17.4	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/4	8.9	ND	ND	ND	ND	6540	3090	800	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/4	8.9	ND	ND	ND	ND	ND	ND	ND	ND	10.1	.19	ND	ND	.2	.1	.73	5
13/4	8.9	ND	ND	ND	ND	7410	ND	750	ND	10.4	ND	ND	ND	.4	ND	ND	ND
30/4		23		.64	25.4												
MEAN	8.79	20.14	7.43	0.55	22.42	7407	4080	938	240	11	1	8	17	0.30	0.10	0.47	5
STD.DEV	0.16	1.78	1.17	0.03	ND	1858	1400	245	ND	1	1	ND	ND	0.12	0.00	0.37	0

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
28/2	ND	ND	ND	ND	ND	ND	ND
1/3	ND	ND	ND	ND	ND	ND	ND
5/3	ND	ND	ND	ND	ND	ND	ND
6/3	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND
8/3	ND	ND	ND	ND	ND	ND	ND
9/3	ND	ND	ND	ND	ND	ND	ND
12/3	ND	ND	ND	ND	ND	ND	ND
13/3	ND	ND	ND	ND	ND	ND	ND
14/3	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	ND	ND
19/3	ND	ND	ND	ND	ND	ND	ND
20/3	ND	ND	ND	ND	ND	ND	ND
21/3	ND	ND	ND	ND	ND	ND	ND
22/3	ND	ND	ND	ND	ND	ND	ND
23/3	ND	ND	ND	ND	ND	ND	ND
26/3	ND	ND	ND	ND	ND	ND	ND
27/3	ND	ND	ND	ND	ND	ND	ND
28/3	ND	ND	ND	ND	ND	ND	ND
29/3	ND	ND	ND	ND	ND	ND	ND
30/3	ND	ND	ND	ND	ND	ND	ND
2/4	ND	ND	ND	ND	ND	ND	ND
3/4	ND	ND	ND	ND	ND	ND	ND
4/4	ND	ND	ND	ND	ND	ND	ND
5/4	ND	ND	ND	ND	ND	ND	ND
6/4	.0006	.0215	.05	147	1.12	.0048	.05
9/4	ND	ND	ND	ND	ND	ND	ND
10/4	ND	ND	ND	ND	ND	ND	ND
11/4	ND	ND	ND	ND	ND	ND	ND
12/4	.0005	.02	.017	131	.99	.005	.05
13/4	ND	ND	ND	ND	ND	ND	ND
30/4							
MEAN	.00055	0.02	0.03	139	1	0.00	0.05
STD.DEV	7.1E-5	0.00	0.02	11	0	0.00	0.00

Table A8: Reactor I.B.4

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
28/2	8.7	21.5	5.8	.63	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/3	8.7	22.5	6.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND	800	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3	8.5	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/3	8.5	ND	8.2	ND	ND	3450	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/3	8.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/3	8.2	19.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/3	8.1	ND	9.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15/3	ND	19.5	ND	.7	7.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	3310	ND	600	ND	ND	ND	ND	ND	ND	ND	ND	ND
19/3	8.3	16.8	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20/3	8.2	20.9	6.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21/3	8.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
22/3	8.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/3	8.3	22.3	6.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26/3	8.2	21.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/3	8	21	6.8	.81	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/3	8.1	20.5	ND	.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/3	8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/3	8	ND	ND	ND	ND	ND	ND	600	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/4	8.1	21.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/4	8.2	ND	3.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/4	8	ND	ND	ND	ND	3800	1820	650	95	ND	ND	ND	ND	ND	ND	ND	ND
5/4	8.3	ND	ND	ND	ND	ND	ND	600	ND	94.7	71	5	50	.7	.2	ND	ND
6/4	8.3	ND	ND	ND	ND	3180	ND	650	ND	112	ND	ND	ND	.8	ND	1.82	79
9/4	8.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/4	8.3	18.3	7.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/4	8.4	ND	ND	ND	ND	2140	880	800	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/4	8.4	ND	ND	ND	ND	ND	ND	ND	ND	104.8	90.8	ND	ND	.7	.3	1.18	88
13/4	8.3	ND	ND	ND	ND	1450	ND	650	ND	106	ND	ND	ND	.7	ND	ND	ND
MEAN	8.27	20.48	6.87	0.74	7.02	2888	1350	669	95	104	81	5	50	0.73	0.25	1.50	84
STD.DEV	0.20	1.65	1.65	0.09	ND	899	665	84	ND	7	14	ND	ND	0.05	0.07	0.45	6

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
28/2	ND	ND	ND	ND	ND	ND	ND
1/3	ND	ND	ND	ND	ND	ND	ND
5/3	ND	ND	ND	ND	ND	ND	ND
6/3	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND
8/3	ND	ND	ND	ND	ND	ND	ND
9/3	ND	ND	ND	ND	ND	ND	ND
12/3	ND	ND	ND	ND	ND	ND	ND
13/3	ND	ND	ND	ND	ND	ND	ND
14/3	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	ND	ND
19/3	ND	ND	ND	ND	ND	ND	ND
20/3	ND	ND	ND	ND	ND	ND	ND
21/3	ND	ND	ND	ND	ND	ND	ND
22/3	ND	ND	ND	ND	ND	ND	ND
23/3	ND	ND	ND	ND	ND	ND	ND
26/3	ND	ND	ND	ND	ND	ND	ND
27/3	ND	ND	ND	ND	ND	ND	ND
28/3	ND	ND	ND	ND	ND	ND	ND
29/3	ND	ND	ND	ND	ND	ND	ND
30/3	ND	ND	ND	ND	ND	ND	ND
2/4	ND	ND	ND	ND	ND	ND	ND
3/4	ND	ND	ND	ND	ND	ND	ND
4/4	ND	ND	ND	ND	ND	ND	ND
5/4	ND	ND	ND	ND	ND	ND	ND
6/4	.001	.022	.033	170	5.07	.009	.07
9/4	ND	ND	ND	ND	ND	ND	ND
10/4	ND	ND	ND	ND	ND	ND	ND
11/4	ND	ND	ND	ND	ND	ND	ND
12/4	.0008	.02	.048	145	3.35	.008	.06
13/4	ND	ND	ND	ND	ND	ND	ND
MEAN	.0009	0.02	0.04	158	4	0.01	0.07
STD.DEV	1.4E-4	0.00	0.01	18	1	0.00	0.01

Table A9: Reactor I.C.1

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
28/2	9.1	22	6.8	.42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/2	ND	ND	ND	ND	ND	ND	ND	640	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/3	9	23	7.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND	630	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3	8.9	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/3	9	ND	8.9	ND	ND	3960	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/3	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/3	8.8	19.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/3	8.7	ND	10.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15/3	ND	20.3	ND	.44	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	13.38	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
19/3	8.8	17.5	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20/3	8.8	21.4	8.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21/3	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
22/3	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/3	8.9	ND	7.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26/3	9	22.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/3	8.8	22.7	7.2	.41	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/3	8.9	21.5	ND	.45	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/3	8.8	21.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/3	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/4	8.9	21.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/4	8.8	ND	7.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/4	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/4	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/4	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/4	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/4	8.9	18.7	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/4	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/4	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/4	8.8	ND	ND	ND	ND	6190	ND	860	ND	ND	ND	ND	ND	ND	ND	ND	ND
25/4	8.8	21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/4	8.6	ND	7.1	.48	18.91	6870	ND	1950	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/4	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/5	9.1	19.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/5	9	20.5	8.3	.39	1.424	6710	3320	ND	ND	ND	ND	ND	ND	ND	ND	30.5	7.9
4/5	8.9	ND	ND	ND	ND	ND	ND	1250	550	ND	ND	ND	ND	.1	.1	ND	ND
7/5	8.5	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/5	8.6	ND	ND	ND	ND	6090	3240	ND	ND	ND	24.8	26	126	ND	ND	ND	ND
9/5	8.5	ND	8.7	ND	ND	ND	ND	ND	ND	40	ND	ND	ND	ND	ND	ND	ND
10/5	8.5	21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	.1	.1	ND	ND
11/5	9.1	20.5	ND	.49	ND	ND	ND	500	200	ND	ND	ND	ND	ND	ND	ND	ND
MEAN	8.83	20.81	8.12	0.44	11.24	5964	3280	972	375	40	25	26	126	0.10	0.10	30.50	7.90
STD.DEV	0.16	1.41	0.91	0.04	8.94	1168	57	547	247	ND	ND	ND	ND	0.00	0.00	ND	ND

Table A9 cont.

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
28/2	ND	ND	ND	ND	ND	ND	ND
29/2	ND	ND	ND	ND	ND	ND	ND
1/3	ND	ND	ND	ND	ND	ND	ND
5/3	ND	ND	ND	ND	ND	ND	ND
6/3	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND
8/3	ND	ND	ND	ND	ND	ND	ND
9/3	ND	ND	ND	ND	ND	ND	ND
12/3	ND	ND	ND	ND	ND	ND	ND
13/3	ND	ND	ND	ND	ND	ND	ND
14/3	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	ND	ND
19/3	ND	ND	ND	ND	ND	ND	ND
20/3	ND	ND	ND	ND	ND	ND	ND
21/3	ND	ND	ND	ND	ND	ND	ND
22/3	ND	ND	ND	ND	ND	ND	ND
23/3	ND	ND	ND	ND	ND	ND	ND
26/3	ND	ND	ND	ND	ND	ND	ND
27/3	ND	ND	ND	ND	ND	ND	ND
28/3	ND	ND	ND	ND	ND	ND	ND
29/3	ND	ND	ND	ND	ND	ND	ND
30/3	ND	ND	ND	ND	ND	ND	ND
2/4	ND	ND	ND	ND	ND	ND	ND
3/4	ND	ND	ND	ND	ND	ND	ND
4/4	ND	ND	ND	ND	ND	ND	ND
5/4	ND	ND	ND	ND	ND	ND	ND
6/4	ND	ND	ND	ND	ND	ND	ND
9/4	ND	ND	ND	ND	ND	ND	ND
10/4	ND	ND	ND	ND	ND	ND	ND
11/4	ND	ND	ND	ND	ND	ND	ND
12/4	ND	ND	ND	ND	ND	ND	ND
13/4	ND	ND	ND	ND	ND	ND	ND
25/4	ND	ND	ND	ND	ND	ND	ND
27/4	ND	ND	ND	ND	ND	ND	ND
30/4	ND	ND	ND	ND	ND	ND	ND
2/5	ND	ND	ND	ND	ND	ND	ND
3/5	.0004	.0185	.14	110	4.57	.0019	.77
4/5	ND	ND	ND	ND	ND	ND	ND
7/5	ND	ND	ND	ND	ND	ND	ND
8/5	ND	ND	ND	ND	ND	ND	ND
9/5	ND	ND	ND	ND	ND	ND	ND
10/5	ND	ND	ND	ND	ND	ND	ND
11/5	ND	ND	ND	ND	ND	ND	ND
MEAN	.0004	0.02	0.14	110	4.57	.0019	0.77
STD.DEV	ND	ND	ND	ND	ND	ND	ND

Table A10: Reactor I.C.2

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
28/2	9.1	22	6.8	.45	ND	ND	ND	680	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/3	9	23	7.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND	570	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3	8.9	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/3	9	ND	8.5	ND	ND	3540	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/3	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/3	8.8	19.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/3	8.7	ND	10.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15/3	ND	20	ND	.43	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	15.18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
19/3	8.8	17.5	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20/3	8.8	21.2	8.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21/3	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
22/3	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/3	8.9	22.6	7.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26/3	9	22.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/3	8.8	21.5	7.3	.46	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/3	8.9	21.3	ND	.46	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/3	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/3	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/4	8.9	21.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/4	8.9	ND	7.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/4	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/4	9.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/4	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/4	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/4	9	18.4	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/4	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/4	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/4	9	ND	ND	ND	ND	7320	ND	350	ND	ND	ND	ND	ND	ND	ND	ND	ND
25/4	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/4	9.1	20.5	1	.47	1.78	8025	ND	350	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/4	9.2	19.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/5	9.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/5	9.1	20.5	8	.47	1.68	10120	4565	ND	ND	ND	ND	ND	ND	ND	ND	3.94	4.15
4/5	9.2	ND	ND	ND	ND	ND	ND	330	30	ND	ND	ND	ND	.1	.1	ND	ND
7/5	9	19.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/5	9.1	ND	ND	ND	ND	8070	4090	ND	ND	ND	.21	7	13	ND	ND	ND	ND
9/5	8.9	ND	8.4	ND	ND	ND	ND	ND	ND	15	ND	ND	ND	ND	ND	ND	ND
10/5	9.2	20.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	.1	.1	ND	ND
11/5	9.2	20	ND	.53	ND	ND	ND	380	19	ND	ND	ND	ND	ND	ND	ND	ND
MEAN	8.96	20.59	7.58	0.47	6.21	7415	4328	443	25	15	.21	7	13	0.10	0.10	3.94	4.15
STD.DEV	0.20	1.44	2.16	0.03	7.77	2405	336	146	ND	ND	ND	ND	ND	0.00	0.00	ND	ND

Table A10 cont.

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
28/2	ND	ND	ND	ND	ND	ND	ND
29/2	ND	ND	ND	ND	ND	ND	ND
1/3	ND	ND	ND	ND	ND	ND	ND
5/3	ND	ND	ND	ND	ND	ND	ND
6/3	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND
8/3	ND	ND	ND	ND	ND	ND	ND
9/3	ND	ND	ND	ND	ND	ND	ND
12/3	ND	ND	ND	ND	ND	ND	ND
13/3	ND	ND	ND	ND	ND	ND	ND
14/3	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	ND	ND
19/3	ND	ND	ND	ND	ND	ND	ND
20/3	ND	ND	ND	ND	ND	ND	ND
21/3	ND	ND	ND	ND	ND	ND	ND
22/3	ND	ND	ND	ND	ND	ND	ND
23/3	ND	ND	ND	ND	ND	ND	ND
26/3	ND	ND	ND	ND	ND	ND	ND
27/3	ND	ND	ND	ND	ND	ND	ND
28/3	ND	ND	ND	ND	ND	ND	ND
29/3	ND	ND	ND	ND	ND	ND	ND
30/3	ND	ND	ND	ND	ND	ND	ND
2/4	ND	ND	ND	ND	ND	ND	ND
3/4	ND	ND	ND	ND	ND	ND	ND
4/4	ND	ND	ND	ND	ND	ND	ND
5/4	ND	ND	ND	ND	ND	ND	ND
6/4	ND	ND	ND	ND	ND	ND	ND
9/4	ND	ND	ND	ND	ND	ND	ND
10/4	ND	ND	ND	ND	ND	ND	ND
11/4	ND	ND	ND	ND	ND	ND	ND
12/4	ND	ND	ND	ND	ND	ND	ND
13/4	ND	ND	ND	ND	ND	ND	ND
25/4	ND	ND	ND	ND	ND	ND	ND
27/4	ND	ND	ND	ND	ND	ND	ND
30/4	ND	ND	ND	ND	ND	ND	ND
2/5	ND	ND	ND	ND	ND	ND	ND
3/5	.0004	.0135	.12	115	.82	.0015	.14
4/5	ND	ND	ND	ND	ND	ND	ND
7/5	ND	ND	ND	ND	ND	ND	ND
8/5	ND	ND	ND	ND	ND	ND	ND
9/5	ND	ND	ND	ND	ND	ND	ND
10/5	ND	ND	ND	ND	ND	ND	ND
11/5	ND	ND	ND	ND	ND	ND	ND
MEAN	.0004	0.01	0.12	115	0.82	.0015	0.14
STD.DEV	ND	ND	ND	ND	ND	ND	ND

Table A11: Reactor I.C.3

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
28/2	9.1	21.5	6.8	.43	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/2	ND	ND	ND	ND	ND	ND	ND	640	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/3	9	23	7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND	510	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3	9	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/3	9	ND	8.3	ND	ND	2910	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/3	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/3	8.9	19.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/3	8.8	ND	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15/3	ND	20	ND	.42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	13.97	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
19/3	8.9	17	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20/3	8.9	21.3	7.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21/3	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
22/3	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/3	9	22.7	6.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26/3	9	22.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/3	8.9	21.5	7.3	.46	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/3	8.9	21.2	ND	.45	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/3	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/3	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/4	9	20.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/4	8.9	ND	7.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/4	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/4	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/4	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/4	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/4	9	18.6	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/4	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/4	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/4	9	ND	ND	ND	ND	6365	ND	260	ND	ND	ND	ND	ND	ND	ND	ND	ND
25/4	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/4	9.1	20.5	.6	.45	1.7	7285	ND	260	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/4	9.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/5	9	19.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/5	9.1	20.5	7.9	.44	1.66	8340	4160	ND	ND	ND	ND	ND	ND	ND	ND	.22	4.2
4/5	9.2	ND	ND	ND	ND	ND	ND	260	50	ND	ND	ND	ND	.1	.1	ND	ND
7/5	9	19.5	ND	ND.	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/5	9	ND	ND	ND	ND	9300	4770	ND	ND	ND	.11	3	35	ND	ND	ND	ND
9/5	8.9	ND	8.2	ND	ND	ND	ND	ND	ND	8	ND.	ND	ND	ND	ND	ND	ND
10/5	9.1	20.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	.2	.1	ND	ND
11/5	9.2	20	ND	.49	ND	ND	ND	310	35	ND	ND	ND	ND	ND	ND	ND	ND
MEAN	8.95	20.55	7.35	0.45	5.78	6840	4465	373	43	8	0.11	3	35	0.15	0.10	0.22	4.20
STD.DEV	0.14	1.48	2.22	0.02	7.10	2458	431	163	11	ND	ND	ND	ND	0.07	0.00	ND	ND

Table A11 cont.

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
28/2	ND	ND	ND	ND	ND	ND	ND
29/2	ND	ND	ND	ND	ND	ND	ND
1/3	ND	ND	ND	ND	ND	ND	ND
5/3	ND	ND	ND	ND	ND	ND	ND
6/3	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND
8/3	ND	ND	ND	ND	ND	ND	ND
9/3	ND	ND	ND	ND	ND	ND	ND
12/3	ND	ND	ND	ND	ND	ND	ND
13/3	ND	ND	ND	ND	ND	ND	ND
14/3	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	ND	ND
19/3	ND	ND	ND	ND	ND	ND	ND
20/3	ND	ND	ND	ND	ND	ND	ND
21/3	ND	ND	ND	ND	ND	ND	ND
22/3	ND	ND	ND	ND	ND	ND	ND
23/3	ND	ND	ND	ND	ND	ND	ND
26/3	ND	ND	ND	ND	ND	ND	ND
27/3	ND	ND	ND	ND	ND	ND	ND
28/3	ND	ND	ND	ND	ND	ND	ND
29/3	ND	ND	ND	ND	ND	ND	ND
30/3	ND	ND	ND	ND	ND	ND	ND
2/4	ND	ND	ND	ND	ND	ND	ND
3/4	ND	ND	ND	ND	ND	ND	ND
4/4	ND	ND	ND	ND	ND	ND	ND
5/4	ND	ND	ND	ND	ND	ND	ND
6/4	ND	ND	ND	ND	ND	ND	ND
9/4	ND	ND	ND	ND	ND	ND	ND
10/4	ND	ND	ND	ND	ND	ND	ND
11/4	ND	ND	ND	ND	ND	ND	ND
12/4	ND	ND	ND	ND	ND	ND	ND
13/4	ND	ND	ND	ND	ND	ND	ND
25/4	ND	ND	ND	ND	ND	ND	ND
27/4	ND	ND	ND	ND	ND	ND	ND
30/4	ND	ND	ND	ND	ND	ND	ND
2/5	ND	ND	ND	ND	ND	ND	ND
3/5	.0004	.0125	.06	109	.32	.0016	.05
4/5	ND	ND	ND	ND	ND	ND	ND
7/5	ND	ND	ND	ND	ND	ND	ND
8/5	ND	ND	ND	ND	ND	ND	ND
9/5	ND	ND	ND	ND	ND	ND	ND
10/5	ND	ND	ND	ND	ND.	ND	ND
11/5	ND	ND	ND	ND	ND	ND	ND
MEAN	.0004	0.01	0.06	109	0.32	.0016	0.05
STD.DEV	ND	ND	ND	ND	ND	ND	ND

Table A12: Reactor I.C.4

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
28/2	9.1	21.5	7	.45	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/2	ND	ND	ND	ND	ND	ND	ND	640	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/3	9	23	7.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/3	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND	440	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3	8.7	20.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/3	8.8	ND	8.5	ND	ND	2460	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/3	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/3	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/3	8.9	ND	10.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	.48	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	9.42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
19/3	8.7	17.9	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20/3	8.7	21	8.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21/3	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
22/3	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/3	8.8	22.5	7.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26/3	8.7	22.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/3	8.6	21.5	7.2	.54	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/3	8.7	21.2	ND	.54	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/3	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/3	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/4	8.6	20.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/4	8.6	ND	7.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/4	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/4	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/4	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/4	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/4	8.7	18.7	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/4	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/4	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/4	8.6	ND	ND	ND	ND	7350	ND	270	ND	ND	ND	ND	ND	ND	ND	ND	ND
25/4	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/4	8.6	20.5	.3	.62	.57	6920	ND	260	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/4	8.6	19.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/5	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/5	8.5	20.5	6.5	.62	.656	6830	3015	ND	ND	ND	ND	ND	ND	ND	ND	.1	110
4/5	8.5	ND	ND	ND	ND	ND	ND	280	50	ND	ND	ND	ND	.3	.1	ND	ND
7/5	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/5	8.4	ND	ND	ND	ND	8415	4015	ND	ND	ND	2.63	62	189	ND	ND	ND	ND
9/5	8.4	ND	7.8	ND	ND	ND	ND	ND	ND	24	ND	ND	ND	ND	ND	ND	ND
10/5	8.6	21.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	.2	.1	ND	ND
11/5	8.8	20.5	ND	.67	ND	ND	ND	380	24	ND	ND	ND	ND	ND	ND	ND	ND
MEAN	8.66	20.88	7.33	0.56	3.55	6395	3515	378	37	24	2.63	62	189	0.25	0.10	0.10	110
STD.DEV	0.16	1.38	2.32	0.08	5.08	2288	707	147	18	ND	ND	ND	ND	0.07	0.00	ND	ND

Table A12 cont.

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
28/2	ND	ND	ND	ND	ND	ND	ND
29/2	ND	ND	ND	ND	ND	ND	ND
1/3	ND	ND	ND	ND	ND	ND	ND
5/3	ND	ND	ND	ND	ND	ND	ND
6/3	ND	ND	ND	ND	ND	ND	ND
7/3	ND	ND	ND	ND	ND	ND	ND
8/3	ND	ND	ND	ND	ND	ND	ND
9/3	ND	ND	ND	ND	ND	ND	ND
12/3	ND	ND	ND	ND	ND	ND	ND
13/3	ND	ND	ND	ND	ND	ND	ND
14/3	ND	ND	ND	ND	ND	ND	ND
15/3	ND	ND	ND	ND	ND	ND	ND
16/3	ND	ND	ND	ND	ND	ND	ND
19/3	ND	ND	ND	ND	ND	ND	ND
20/3	ND	ND	ND	ND	ND	ND	ND
21/3	ND	ND	ND	ND	ND	ND	ND
22/3	ND	ND	ND	ND	ND	ND	ND
23/3	ND	ND	ND	ND	ND	ND	ND
26/3	ND	ND	ND	ND	ND	ND	ND
27/3	ND	ND	ND	ND	ND	ND	ND
28/3	ND	ND	ND	ND	ND	ND	ND
29/3	ND	ND	ND	ND	ND	ND	ND
30/3	ND	ND	ND	ND	ND	ND	ND
2/4	ND	ND	ND	ND	ND	ND	ND
3/4	ND	ND	ND	ND	ND	ND	ND
4/4	ND	ND	ND	ND	ND	ND	ND
5/4	ND	ND	ND	ND	ND	ND	ND
6/4	ND	ND	ND	ND	ND	ND	ND
9/4	ND	ND	ND	ND	ND	ND	ND
10/4	ND	ND	ND	ND	ND	ND	ND
11/4	ND	ND	ND	ND	ND	ND	ND
12/4	ND	ND	ND	ND	ND	ND	ND
13/4	ND	ND	ND	ND	ND	ND	ND
25/4	ND	ND	ND	ND	ND	ND	ND
27/4	ND	ND	ND	ND	ND	ND	ND
30/4	ND	ND	ND	ND	ND	ND	ND
2/5	ND	ND	ND	ND	ND	ND	ND
3/5	.0004	.0125	.07	117	1.98	.003	.06
4/5	ND	ND	ND	ND	ND	ND	ND
7/5	ND	ND	ND	ND	ND	ND	ND
8/5	ND	ND	ND	ND	ND	ND	ND
9/5	ND	ND	ND	ND	ND	ND	ND
10/5	ND	ND	ND	ND	ND	ND	ND
11/5	ND	ND	ND	ND	ND	ND	ND
MEAN	.0004	.0125	0.07	117	1.98	.003	0.06
STD.DEV	ND	ND	ND	ND	ND	ND	ND

Table A13: Reactor II.B.1

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
2/5	9.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/5	9.2	18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/5	9.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/5	9	ND	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/5	9.2	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/5	9.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
18/5	8.8	20.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/5	8.6	ND	6.7	.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
24/5	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
25/5	8.6	19.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/5	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/5	8.7	17.5	6.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/5	8.8	18.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/6	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/6	8.9	19	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/6	8.8	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/6	8.8	21.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/6	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/6	8.7	14.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/6	8.7	16.3	8.6	.45	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/6	8.7	16.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/6	8.7	16.3	8.1	.45	16.806	9130	4440	870	ND	0-25	ND	ND	ND	.3	.1	ND	ND
15/6	8.8	18.2	ND	ND	ND	10140	4890	540	ND	0-25	.73	14	56	.2	.1	.95	11
MEAN	8.83	18.21	7.66	0.47	16.81	ERROR	ERROR	705	ND	ND	0.73	14	56	0.25	0.10	0.95	11
STD.DEV	0.21	1.98	0.99	0.03	ND	ERROR	ERROR	233	ND	ND	ND	ND	ND	0.07	0.00	ND	ND

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
2/5	ND	ND	ND	ND	ND	ND	ND
7/5	ND	ND	ND	ND	ND	ND	ND
8/5	ND	ND	ND	ND	ND	ND	ND
9/5	ND	ND	ND	ND	ND	ND	ND
10/5	ND	ND	ND	ND	ND	ND	ND
11/5	ND	ND	ND	ND	ND	ND	ND
18/5	ND	ND	ND	ND	ND	ND	ND
23/5	ND	ND	ND	ND	ND	ND	ND
24/5	ND	ND	ND	ND	ND	ND	ND
25/5	ND	ND	ND	ND	ND	ND	ND
28/5	ND	ND	ND	ND	ND	ND	ND
29/5	ND	ND	ND	ND	ND	ND	ND
30/5	ND	ND	ND	ND	ND	ND	ND
1/6	ND	ND	ND	ND	ND	ND	ND
4/6	ND	ND	ND	ND	ND	ND	ND
5/6	ND	ND	ND	ND	ND	ND	ND
6/6	ND	ND	ND	ND	ND	ND	ND
8/6	ND	ND	ND	ND	ND	ND	ND
11/6	ND	ND	ND	ND	ND	ND	ND
12/6	ND	ND	ND	ND	ND	ND	ND
13/6	ND	ND	ND	ND	ND	ND	ND
14/6	ND	ND	ND	ND	ND	ND	ND
15/6	.0007	.02	.12	104	1.65	.0023	.09
MEAN	.0007	0.02	0.12	104	1.65	.0023	0.09
STD.DEV	ND	ND	ND	ND	ND	ND	ND

Table A14: Reactor II.B.2

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
2/5	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/5	9.1	18.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/5	9.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/5	8.9	ND	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/5	9.2	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/5	9.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
18/5	8.7	20.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/5	8.7	ND	7.3	.48	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
24/5	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
25/5	8.9	19.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/5	8.8	18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/5	8.7	18.8	5.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/5	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/6	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/6	9	19	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/6	8.8	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/6	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/6	8.7	21.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/6	8.7	14.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/6	8.7	16.4	7.7	.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/6	8.7	16.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/6	8.8	16.1	8	.46	18.277	8160	4130	920	ND	0-25	ND	ND	ND	.3	.1	ND	ND
15/6	8.8	18.2	ND	ND	ND	9820	4870	560	8	0-25	.1	14	16	.1	.1	1.39	7.1
MEAN	8.85	18.34	7.34	0.48	18.28	8990	4500	740	8	ND	0.10	14	16	0.20	0.10	1.39	7.10
STD.DEV	0.16	2.01	1.27	0.02	ND	1174	523	255	ND	ND	ND	ND	ND	0.14	0.00	ND	ND

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
2/5	ND	ND	ND	ND	ND	ND	ND
7/5	ND	ND	ND	ND	ND	ND	ND
8/5	ND	ND	ND	ND	ND	ND	ND
9/5	ND	ND	ND	ND	ND	ND	ND
10/5	ND	ND	ND	ND	ND	ND	ND
11/5	ND	ND	ND	ND	ND	ND	ND
18/5	ND	ND	ND	ND	ND	ND	ND
23/5	ND	ND	ND	ND	ND	ND	ND
24/5	ND	ND	ND	ND	ND	ND	ND
25/5	ND	ND	ND	ND	ND	ND	ND
28/5	ND	ND	ND	ND	ND	ND	ND
29/5	ND	ND	ND	ND	ND	ND	ND
30/5	ND	ND	ND	ND	ND	ND	ND
1/6	ND	ND	ND	ND	ND	ND	ND
4/6	ND	ND	ND	ND	ND	ND	ND
5/6	ND	ND	ND	ND	ND	ND	ND
6/6	ND	ND	ND	ND	ND	ND	ND
8/6	ND	ND	ND	ND	ND	ND	ND
11/6	ND	ND	ND	ND	ND	ND	ND
12/6	ND	ND	ND	ND	ND	ND	ND
13/6	ND	ND	ND	ND	ND	ND	ND
14/6	ND	ND	ND	ND	ND	ND	ND
15/6	.0004	.024	.11	138	.84	.003	.08
MEAN	.0004	.024	.11	138	0.84	.003	0.08
STD.DEV	ND	ND	ND	ND	ND	ND	ND

Table A15: Reactor III.A.1

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
25/4	8.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26/4	8.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/4	8.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/4	8.5	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/5	8.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/5	8.2	5.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/5	8.1	10	ND	.78	7.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/5	7.9	9.5	8.4	ND	ND	6560	3450	11500	6900	ND	ND	ND	ND	.5	.7	ND	ND
10/5	8.2	ND	ND	ND	ND	5500	2990	ND	ND	114	69.1	54	155	ND	ND	ND	ND
11/5	8.2	ND	ND	ND	ND	ND	ND	9500	ND	ND	ND	ND	ND	ND	ND	45.1	433
MEAN	8.22	6.75	8.40	0.78	7.20	6030	3220	10500	ND	ND	ND	ND	ND	ND	ND	ND	ND
STD.DEV	0.17	3.75	ND	ND	ND	750	325	1414	ND	ND	ND	ND	ND	ND	ND	ND	ND

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
25/4	ND	ND	ND	ND	ND	ND	ND
26/4	ND	ND	ND	ND	ND	ND	ND
27/4	ND	ND	ND	ND	ND	ND	ND
30/4	ND	ND	ND	ND	ND	ND	ND
2/5	ND	ND	ND	ND	ND	ND	ND
7/5	ND	ND	ND	ND	ND	ND	ND
8/5	ND	ND	ND	ND	ND	ND	ND
9/5	ND	ND	ND	ND	ND	ND	ND
10/5	ND	ND	ND	ND	ND	ND	ND
11/5	.0005	.06	.05	166	10.4	.003	.4
MEAN	ND	ND	ND	ND	ND	ND	ND
STD.DEV	ND	ND	ND	ND	ND	ND	ND

Table A16: Reactor III.A.2

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
25/4	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26/4	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/4	8.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/4	8.9	11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/5	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/5	8.1	10.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/5	8.1	ND	ND	.68	3.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/5	8	13	8.3	ND	ND	3870	2060	8600	5390	ND	ND	ND	ND	.5	.3	ND	ND
10/5	8.2	ND	ND	ND	ND	3530	1820	ND	ND	103	98	37	68	ND	ND	ND	ND
11/5	8.2	ND	ND	ND	ND	ND	ND	7500	ND	ND	ND	ND	ND	ND	ND	12.1	619
MEAN	8.38	11.50	8.30	0.68	3.70	3700	1940	8050	ND	ND	ND	ND	ND	ND	ND	ND	ND
STD.DEV	0.32	1.32	ND	ND	ND	240	170	778	ND	ND	ND	ND	ND	ND	ND	ND	ND

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
25/4	ND	ND	ND	ND	ND	ND	ND
26/4	ND	ND	ND	ND	ND	ND	ND
27/4	ND	ND	ND	ND	ND	ND	ND
30/4	ND	ND	ND	ND	ND	ND	ND
2/5	ND	ND	ND	ND	ND	ND	ND
7/5	ND	ND	ND	ND	ND	ND	ND
8/5	ND	ND	ND	ND	ND	ND	ND
9/5	ND	ND	ND	ND	ND	ND	ND
10/5	ND	ND	ND	ND	ND	ND	ND
11/5	.0005	.06	.05	166	10.4	.003	.4
MEAN	ND	ND	ND	ND	ND	ND	ND
STD.DEV	ND	ND	ND	ND	ND	ND	ND

Table A17: Reactor III.B.1

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
25/4	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26/4	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/4	8.6	7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/4	8.8	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/5	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/5	8.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/5	8.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/5	8	9.5	9.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/5	8.3	13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/5	8.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
18/5	8	5	9.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/5	8.1	5	9.9	.64	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
24/5	7.9	4	ND	ND	ND	5170	2370	12400	ND	165	136	ND	ND	.4	.2	ND	ND
25/5	8.1	4	ND	.76	52.021	5660	ND	11300	7100	125	103	27	28	.3	.2	1.56	1120
MEAN	8.34	6.19	9.70	0.70	52.02	5415	2370	11850	7100	145	120	27	28	0.35	0.20	1.56	1120
STD.DEV	0.32	3.54	0.17	0.08	ND	346	ND	778	ND	28	23	ND	ND	0.07	0.00	ND	ND

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
25/4	ND	ND	ND	ND	ND	ND	ND
26/4	ND	ND	ND	ND	ND	ND	ND
27/4	ND	ND	ND	ND	ND	ND	ND
30/4	ND	ND	ND	ND	ND	ND	ND
2/5	ND	ND	ND	ND	ND	ND	ND
7/5	ND	ND	ND	ND	ND	ND	ND
8/5	ND	ND	ND	ND	ND	ND	ND
9/5	ND	ND	ND	ND	ND	ND	ND
10/5	ND	ND	ND	ND	ND	ND	ND
11/5	ND	ND	ND	ND	ND	ND	ND
18/5	ND	ND	ND	ND	ND	ND	ND
23/5	ND	ND	ND	ND	ND	ND	ND
24/5	ND	ND	ND	ND	ND	ND	ND
25/5	.0005	.04	.12	205	41.6	.0048	.2
MEAN	.0005	0.04	0.12	205	41.60	.0048	0.20
STD.DEV	ND	ND	ND	ND	ND	ND	ND

Table A18: Reactor III.B.2

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
25/4	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26/4	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27/4	8.6	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/4	8.8	11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2/5	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/5	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/5	8.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/5	8.5	ND	9.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/5	8.8	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/5	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
18/5	8.6	10	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/5	8.5	9.2	9	.41	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
24/5	8.6	8	ND	ND	ND	5970	3140	4300	ND	25	20.3	ND	ND	2.5	2.5	ND	ND
25/5	8.7	9.7	ND	.46	23.795	7250	ND	3500	ND	5	.7	155	190	3.3	3.2	44	23.5
MEAN	8.65	10.06	8.93	0.44	23.80	6610	3140	3900	ND	15	11	155	190	2.90	2.85	44.00	24
STD.DEV	0.12	1.41	0.21	0.04	ND	905	ND	566	ND	14	14	ND	ND	0.57	0.49	ND	ND

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
25/4	ND	ND	ND	ND	ND	ND	ND
26/4	ND	ND	ND	ND	ND	ND	ND
27/4	ND	ND	ND	ND	ND	ND	ND
30/4	ND	ND	ND	ND	ND	ND	ND
2/5	ND	ND	ND	ND	ND	ND	ND
7/5	ND	ND	ND	ND	ND	ND	ND
8/5	ND	ND	ND	ND	ND	ND	ND
9/5	ND	ND	ND	ND	ND	ND	ND
10/5	ND	ND	ND	ND	ND	ND	ND
11/5	ND	ND	ND	ND	ND	ND	ND
18/5	ND	ND	ND	ND	ND	ND	ND
23/5	ND	ND	ND	ND	ND	ND	ND
24/5	ND	ND	ND	ND	ND	ND	ND
25/5	.0006	.065	.07	174	5.27	.0045	.68
MEAN	.0006	0.07	0.07	174	5.27	.0045	0.68
STD.DEV	ND	ND	ND	ND	ND	ND	ND

Table A19: Reactor III.C.1

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
18/5	8.6	5	9.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/5	8.5	5	10.7	.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
24/5	8.8	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
25/5	8.7	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/5	8.7	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/5	8.7	2	12.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/5	8.7	3.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/6	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/6	8.7	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/6	8.6	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/6	8.7	3.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/6	8.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/6	8.6	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/6	8.7	.5	12.5	.44	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/6	8.5	.5	ND	.43	ND	8360	3950	460	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/6	8.4	1.5	12.8	ND	ND	ND	ND	ND	ND	10	.1	ND	ND	ND	ND	ND	ND
15/6	8.7	3.9	ND	.43	18.264	9650	4600	450	24.7	10	.1	13	19	.2	.1	.73	11.1
MEAN	8.65	2.87	11.66	0.43	18.26	9005	4275	455	25	10	0.10	13	19	0.20	0.10	0.73	11.10
STD.DEV	0.10	1.52	1.33	0.02	ND	912	460	7	ND	0	0.00	ND	ND	ND	ND	ND	ND

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
18/5	ND	ND	ND	ND	ND	ND	ND
23/5	ND	ND	ND	ND	ND	ND	ND
24/5	ND	ND	ND	ND	ND	ND	ND
25/5	ND	ND	ND	ND	ND	ND	ND
28/5	ND	ND	ND	ND	ND	ND	ND
29/5	ND	ND	ND	ND	ND	ND	ND
30/5	ND	ND	ND	ND	ND	ND	ND
1/6	ND	ND	ND	ND	ND	ND	ND
4/6	ND	ND	ND	ND	ND	ND	ND
5/6	ND	ND	ND	ND	ND	ND	ND
6/6	ND	ND	ND	ND	ND	ND	ND
8/6	ND	ND	ND	ND	ND	ND	ND
11/6	ND	ND	ND	ND	ND	ND	ND
12/6	ND	ND	ND	ND	ND	ND	ND
13/6	ND	ND	ND	ND	ND	ND	ND
14/6	ND	ND	ND	ND	ND	ND	ND
15/6	.0002	.022	.1	131	1.47	.002	.07
MEAN	.0002	.022	0.10	131	1.47	.002	0.07
STD.DEV	ND	ND	ND	ND	ND	ND	ND

Table A20: Reactor III.C.2

DATE	pH	TEMP (C)	DO (mg/l)	COND (uS/cm x10^-4)	ALK (meq/l)	TSS (mg/l)	VSS (mg/l)	COD (mg/l)	BOD (mg/l)	TKN (mg/l)	NH4-N (mg/l)	NO2-N (ug/l)	NO3-N (ug/l)	TOT-P (mg/l)	PO4-P (mg/l)	FE (mg/l)	CA (mg/l)
18/5	8.7	10	9.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23/5	8.7	8.9	10.7	.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
24/5	8.7	8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
25/5	8.8	9.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28/5	8.8	10.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29/5	8.8	10	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30/5	8.8	10.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1/6	8.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4/6	9	10.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/6	8.8	11.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/6	8.7	12.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/6	8.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/6	8.8	7.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/6	8.8	8.6	10.4	.44	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13/6	8.7	8.8	ND	.43	ND	7990	3910	280	ND	ND	ND	ND	ND	ND	ND	ND	ND
14/6	8.7	9.3	10.3	ND	ND	ND	ND	ND	ND	10	.1	ND	ND	ND	ND	ND	ND
15/6	8.8	8.9	ND	.43	18.337	8440	4120	330	5	10	.1	41	8	.2	.1	.24	7.4
MEAN	8.78	9.67	10.24	0.43	18.34	8215	4015	305	5	10	0.10	41	8	0.20	0.10	0.24	7.40
STD.DEV	0.08	1.34	0.35	0.02	ND	318	148	35	ND	0	0.00	ND	ND	ND	ND	ND	ND

DATE	CD (mg/l)	CR (mg/l)	CU (mg/l)	MG (mg/l)	MN (mg/l)	PB (mg/l)	ZN (mg/l)
18/5	ND	ND	ND	ND	ND	ND	ND
23/5	ND	ND	ND	ND	ND	ND	ND
24/5	ND	ND	ND	ND	ND	ND	ND
25/5	ND	ND	ND	ND	ND	ND	ND
28/5	ND	ND	ND	ND	ND	ND	ND
29/5	ND	ND	ND	ND	ND	ND	ND
30/5	ND	ND	ND	ND	ND	ND	ND
1/6	ND	ND	ND	ND	ND	ND	ND
4/6	ND	ND	ND	ND	ND	ND	ND
5/6	ND	ND	ND	ND	ND	ND	ND
6/6	ND	ND	ND	ND	ND	ND	ND
8/6	ND	ND	ND	ND	ND	ND	ND
11/6	ND	ND	ND	ND	ND	ND	ND
12/6	ND	ND	ND	ND	ND	ND	ND
13/6	ND	ND	ND	ND	ND	ND	ND
14/6	ND	ND	ND	ND	ND	ND	ND
15/6	.0003	.02	.1	128	1.07	.0018	.06
MEAN	.0003	.02	0.10	128	1.07	.0018	0.06
STD.DEV	ND	ND	ND	ND	ND	ND	ND

RAS/LIS
10.6.85
DISK:RAS2
labsig

VA rapporter utgitt av NIVA

1/78 **Tiltak i eksisterende avløpssystem. Delrapport 1.**
C2-31 Kjell Øren. November 1978

1/79 **Kjemisk felling med kalk og sjøvann. Del 2**
C2-34 O-40/71 A Lasse Vråle. Juli 1979

2/79 **Driftsresultater fra norske simultanfellingsanlegg.**
C2-28 Lasse Vråle, Eilen A. Vik. Juli 1979

3/79 **Slamavvanning med filterpresser. Del 1**
O-78102 Bjørn-Erik Haugan. November 1979

4/79 **Slamavvanning med filterpresser. Del 2**
O-78102 Bjørn-Erik Haugan. September 1979

5/79 **Sigevann fra søppelfyllplass.**
C2-26 Torbjørn Damhaug, Arild Eikum,
Ole Jakob Johansen. August 1979

6/79 **Vannforurensning fra veg.**
O-79024 Eivind Lygren, Egil Gjessing,
John Ferguson. Desember 1979

9/79 **Primærfelling med ulike fellingskjemikalier ved Sandvika renseanlegg.**
O-79001 Lasse Vråle. Desember 1979

1/80 **Bakteriologiske forhold i norske og utenlandske råvannskilder**
O-78029 Jens J. Nygård. Februar 1981

2/80 **Treatment of Septic Tank Sludge**
Research Proposal
F-80413 Arild Eikum. Januar 1980

3/80 **Industrifyllplass i Arendal-Grimstadregionen**
Vurdering av vannforurensning og rensetekniske tiltak for alternativene Gloseheia og Lundeheia
O-80016 Torbjørn Damhaug, Hans Holtan. Mars 1980

4/80 **Utprøving av analysemetoder for PAH og kartlegging av PAH-tilførsler til norske vannforekomster**
A3-25 Lasse Berglind. Mars 1980

5/80 **Mobil avvanning av septikslam**
Utprøving av septikbil »HAMSTERN»
O-80019 Bjørn-Erik Haugan. November 1980

6/80 **Tilføringsgrad**
Kontroll og kalibrering av vannmålestasjon ved Monserud kloakkrenseanlegg. Del 1
O-78107 Lasse Vråle. Oktober 1980

7/80 **Tilføringsgrad**
Forurensningstilførsler og beregning av tilføringsgrad for Monserud renseanlegg i 1979. Del 2
O-78107 Lasse Vråle. Oktober 1980

8/80 **Overløp i avløpsnett**
Tilstand i dag og mulige tiltak
C2-32 Eivind Lygren. September 1980

9/80 **Sikring av vannforsyning i Oslo mot forurensninger ved uhell eller sabotasje**
Vurdering av faremomenter. (Sperret)
O-79084 Egil Gjessing, Jens J. Nygård. September 1980

10/80 **Important aspects of water treatment in USA**
XT-25 Eilen Arctander Vik. Juli 1980

11/80 **Myrgrøfting, effekt på vannkvalitet**
Noen observasjoner fra grøftet myrområde i Røyken 1971-79
XK-05 Egil Gjessing. September 1980

12/80 **Driftsundersøkelse av vannbehandlingsanlegg**
F-80417 Torbjørn Damhaug. November 1980

13/80 **Hvirveloverløp**
Avskilling av sedimenterbart materiale og flytestoffer i overløpsvann
O-79090 Eivind Lygren. Desember 1980

14/80 **Use of UV and H_2O_2 in water and wastewater treatment**
Research Proposal
F-80415 Arild Schanke Eikum. Desember 1980

1/81 **Treatment of potable water containing humus by electrolytic addition of aluminium followed by direct filtration**
Research Proposal
F-80415 Eilen Arctander Vik. Januar 1981

2/81 **Water research in developing countries**
A desk survey about planning and ongoing research projects
O-80028 Svein Stene Johansen. Januar 1981

3/81 **VA-teknisk forsøkshall Sentralrenseanlegg Vest SRV**
Notat
Arild Schanke Eikum, Arne Lundar. Februar 1981

4/81 **Alkalization/hardening of drinking water**
Research proposal
G-314 Egil Gjessing. Februar 1981

5/81 **Tiltak mot forurensning fra fiskeoppdrett**
Behandling av vann i resirkuleringsanlegg for fiskeoppdrett
Forskningsprogram 1981-1984
FP-80802 Arild Schanke Eikum, Eivind Lygren. Mai 1981

6/81 **Tiltak i eksisterende avløpssystem. Delrapport 2**
O-80018 Svein Stene Johansen. Mai 1981

7/81 **Kalking av tilløp til lille Asketjern for fjerning av humus**
Innledende forsøk. O-81065 Eilen Arctander Vik. August 1981

8/81 **Tilføringsgrad for oppsamlingsnett**
Status for eksisterende målinger
O-80055 Lasse Vråle. August 1981

9/81 **A Water Pricing Study for Western Province, Zambia. Draft !**
O-81022 Svein Stene Johansen. September 1981

10/81 **Fjerning av humus ved H_2O_2 tilsetning og UV - bestråling**
F-80415 Lasse Berglind. Oktober 1981

11/81 **Treatment of Septic Sludge**
European practice
O-80040 Arild Schanke Eikum. November 1981

12/81 **Silgrainsyre som fellingsmiddel for avløpsvann**
Buhrestua renseanlegg. Nesodden
O-80093 Lasse Vråle. Desember 1981

13/81 **Analyse av vannbehov i husholdninger, næringsvirksomhet institusjoner og til kommunaltekniske formål**
O-78028-01 Svein Stene Johansen, Kim Wedum. Desember 1981

1/82 **Fjerning av nitrogen fra kommunalt avløpsvann ved ammoniakkavdrivning**
F-81427 Torbjørn Damhaug. Mars 1982

2/82 **Rensing av sigevann fra søppelfyllplasser**
OF-80606 Torbjørn Damhaug. Juni 1982

3/82 **Hvirvelkammer og hvirveloverløp**
Regulering av vannføring og rensing av overløpsvann
O-79090 Eivind Lygren, Kim Wedum. Mai 1982

4/82 **Avvanning av septikslam i container**
O-81104 Bjarne Paulsrud. August 1982

5/82 **Kalibrering og justering av vannføringsmålere**
O-82011 Kim Wedum. Mai 1982

6/82 **Vurdering av driftsinstrukser og driftsforhold ved renseanlegg rundt Indre Oslofjord**
O-82004 Arne Lundar, Bjarne Paulsrud. August 1982

7/82 **Styring av kjemikaliedosering ved kjemiske renseanlegg**
Erfaringer med bruk av ledningsevne som styringsparameter
O-82025 Torbjørn Damhaug, Bjarne Paulsrud. August 1982

8/82 **Strålingskjemisk oksydasjon av organisk stoff i vann**
Programforslag. (Sperret)
F-80415 Kim Wedum. September 1982

9/82 **Slamstabilisering under høy temperatur ved bruk av rent oksygen**
F-81430 Bjørn-Erik Haugan. Oktober 1982

10/82 **Tørrværsavsetninger i fellessystemrør**
O-82022 Oddvar Lindholm. November 1982

11/82 **Treatment of septage**
European practice
O-80040 Arild Schanke Eikum. Februar 1983

1/83 **Alkalisering av drikkevann**
Delrapport 1 NIVA/SIFF
F-82441 Eilen A. Vik. Mars 1983

2/83 **Industriavløp på kommunale renseanlegg**
Forbehandling av meieriavløp i luftede utjevningsbasseng
Delrapport 1
O-82017 Torbjørn Damhaug. Februar 1983

3/83 **Samlet optimalisering av avløpsrenseanlegg og avløpsledningsnett**
O-82124 Oddvar Lindholm. Februar 1983

4/83 **Driftskontrollprogram for galvanoindustriens renseanlegg**
O-79049 Eigil Iversen. Mars 1983

6/83 **Optimalisering av galvanotekniske industrirenseanlegg**
O-82119 Eigil Iversen. Mai 1983

7/83 **Utslipp av syre, løst organisk materiale og suspendert stoff fra Hunsfos Fabrikker og Norsk Wallboard juli-oktober 1982**
O-82067 Øivind Tryland. Mars 1983

8/83 **Analyseresultater for avløpsvann fra Mosjøen Aluminiumverk april-oktober 1982**
O-82027 Øivind Tryland. Mars 1983

9/83 **Vannforurensning ved bruk av kalksalpeter som støvdempingsmiddel på grusveger**
O-81050 Eivind Lygren, Reidun Schei. Juni 1983 (Sperret)

10/83 **Funksjonsprøving nr 2 av membran kammerfilterpresser VEAS Mars 1983**
O-82130 Lasse Vråle. Mars 1983

11/83 **Spillvannstap fra oppsamlingsnett**
Delrapport 1
Forurensningsproduksjon fra boligfelt med tett oppsamlingsnett i Sydskogen, Røyken kommune
O-81041 Lasse Vråle. April 1983

12/83 **Spillvannstap fra oppsamlingsnett**
Delrapport 2
Automatisk overvåking av vannforbruk og lekkasje som alternativ metode for beregning av tilføringsgrad.
Resultater fra undersøkelsene ved Sydskogen, Buhrestua og Siggerud.
O-81041 Lasse Vråle. Desember 1984

13/83 **Spillvannstap fra oppsamlingsnett**
Delrapport 3
Spillvannstapets resipient påvirkning i Siggerudgryta, Ski kommune
O-81041 Lasse Vråle. August 1983

14/83 **Spillvannstap fra oppsamlingsnett**
Delrapport 4
Spillvannstapets innvirkning på grunnvannskvalitet.
Buhrestua rensedistrikt, Nesodden kommune.
O-81041 Lasse Vråle. Oktober 1984

15/83 **A feasibility study of fishfarming in Jordan**
O-83026 Eivind Lygren, Torbjørn Damhaug. Juni 1983 (Sperret)

16/83 **Driftsanalyse av Bekkelaget renseanlegg**
O-82005 Bjarne Paulsrud, Kim Wedum. Juni 1983 (Sperret)

17/83 **Water Research in Zambia**
A review of the need for water research
O-83014 Svein Stene Johansen. September 1983

18/83 **Water Research in Kenya**
A review of the need for water research
O-83014 Svein Stene Johansen. September 1983

19/83 **Water research in Tanzania**
A review of the need for water research
O-83014 Svein Stene Johansen, Torbjørn Damhaug. May 1984

20/83 **Mikrobiologisk angrep på gummipakninger til vann- og avløpsrør**
Programforslag
O-83033 Kim Wedum. Juni 1983 (Sperret)

21/83 **Slamdeponering ved norske mangansmelteverk**
Fysisk-kjemisk karakterisering av drensvann og virkninger av drensvann på biologiske forhold i resipienten
0-80058 Øivind Tryland, Harry Efraimsen. April 1983

22/83 **Sandstangen vannverk**
0-83079 Eilen A. Vik. Juni 1983 (Sperret)

23/83 **Erfaringer med mottak av septikslam på kommunale renseanlegg**
0-82037 Bjarne Paulsrud. Juli 1983

24/83 **Miljøgifter i overvann**
0-83063 Oddvar Lindholm. August 1983

25/83 **Arealfordeling av korttidsnedbør**
0-83005, F-83450 Oddvar Lindholm. Oktober 1983

26/83 **Urbanhydrologi i Sverige**
En litteraturstudie
0-83092 Oddvar Lindholm. November 1983

27/83 **Tørrværsavsetninger i fellessystemrør**
Fase II
0-82111 Oddvar Lindholm, November 1983

28/83 **Bruk av rent oksygen for luktreduksjon ved renseanlegg R-2, Lillehammer**
0-82083 Bjarne Paulsrud, Bjørn-Erik Haugan. November 1983

29/83 **Avsluttende funksjonsprøve for membran-filterpresser ved VEAS, oktober-november 1983**
0-83098 Lasse Vråle, Bjarne Paulsrud. November 1983 (Sperret)

30/83 **Emerging European Wastewater Treatment Technology Preliminary Description**
0-83150 Arild Schanke Eikum. Desember 1963 (Sperret)

31/83 **Treforedlingsindustriens avløpsvann**
Mikrobiell nedbrytning av klorert organisk materiale i blekeriavløpsvann
F-81434 Øivind Tryland, Harry Efraimsen. Desember 1983

32/83 **Suspensjoners synkehastighet**
Metode for analyse av finfordelte partiklers synkehastighet i vann
F-81434 Øivind Tryland. Desember 1983

33/83 **Silgrainsyre som fellingsmiddel ved SRV, VEAS Slemmestad**
0-82102 Lasse Vråle, P. Sagberg. Desember 1983. (Sperret)

1/84 **Industriavløp på kommunale renseanlegg**
0-82017 Torbjørn Damhaug. Januar 1984

2/84 **Luftet lagune for rensing av sigevann**
Delrapport 1. Driftserfaringer
0-83027 Ragnar Storhaug. Februar 1984

3/84 **Highway pollution in a Nordic Climate**
0-79024 Eivind Lygren. Mars 1984

4/84 **An evaluation of large-scale algal cultivation systems for fish feed production**
0-84002 Torbjørn Damhaug et al. Februar 1984 (Sperret)

5/84 **Matematisk modell av avløpsrenseanlegg**
0-82124/F-83448 Oddvar Lindholm. Februar 1984

6/84 **Adsorption in Water Treatment**
Fluoride Removal
FP-83828 Eilen A. Vik. Februar 1984

7/84 **Analyse av vannføringsdata**
0-81113 Kim Wedum. Januar 1984

8/84 **Renseeffekt i Heistad renseanlegg med og uten tilkopling av industrielt avløpsvann**
0-83093 Øivind Tryland. April 1984

9/84 **Hygienisering av slam ved bruk av rent oksygen**
F-81430 Bjarne Paulsrud, Bjørn-Erik Haugan, Gunnar Langeland. Juli 1984

10/84 **Slamavvanning med filterpresser ved SRV**
Økonomisk sammenligning av Lasta membran-filterpresser og Rittershaus & Blecher kammerfilterpresser
0-83098 Lasse Vråle, Bjarne Paulsrud. Mai 1984 (Sperret)

11/84 **Separat behandling av slamvann fra avvanning av septikslam**
Biologisk rensing ved bruk av aktivslam
0-83021 Ragnar Storhaug. Juni 1984

12/84 **Industriutslipp til vassdrag**
Avveininger for å beskytte resipienten, eksempel fra en tekstilbedrift
OF-81618 Bjørn-Erik Haugan, Kim Wedum. April 1984 (Sperret)

13/84 **Treforedlingsindustriens avløpsvann**
Virkning av peroksyd og UV-bestråling på klororganisk materiale og farge i celluloseblekeriers avløpsvann
F-81434 Øivind Tryland. Mai 1984

14/84 **Driftsassistanse**
Vannrenseanlegg, ÅSV A/S Fundo Aluminium
0-83141 Eigil Iversen, Torbjørn Damhaug. Juni 1984

15/84 **Ammonium som forurensningsparameter**
0-83035 Kim Wedum. August 1984

16/84 **Driftsoppfølging av Biovac renseanlegg for helårsbolig**
0-82101 Bjarne Paulsrud. September 1984

17/84 **Kalkfelling på små renseanlegg**
0-83067 Ragnar Storhaug. Oktober 1984

18/84 **Hygienisering av slam ved lufttilførsel (Janca-prosessen)**
0-84050 Bjarne Paulsrud, Gunnar Langeland. September 1984

19/84 **Utvikling av lukket mærkonstruksjon.**
Prosessløsning og optimalisering
0-84091 Kjell Maroni, Eivind Lygren, Bjørn Braaten. Oktober 1984. (Sperret)

20/84 **Forurensningsproduksjon fra husholdning**
Halvårlig sommerundersøkelse fra Sydskogen i 1983, Røyken kommune.
F-83451 Lasse Vråle. Oktober 1984

21/84 **Luftet lagune for rensing av sigevann**
0-83027 Ragnar Storhaug. April 1985

22/84 **Avløpsvannmengder tilført påslippene ved SRV i 1983 og 1984**
0-83090 Lasse Vråle. April 1985

VA rapporter utgitt av NIVA

1/85 **Spesifikk forurensningsproduksjon fra husholdning**
Enkel litteraturstudie
0-84131-01 Lasse Vråle. Mars 1985

2/85 **Kritisk analyse av spesifikke forurensningsmålinger**
0-84131-02 Lasse Vråle. Mars 1985