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The organic matter was preferentially consumed by the oxidants providing little residual for pyrite oxidation. With the exception of the sandstone, the addition of the oxidant had little effect on accelerating the oxidation rates. The highly alkaline calcium hypochlorite inhibited pyrite oxidation. The oxidant purging technique therefore, is best used to treat clean sandstones and rocks that are relatively free of organic matter.

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*** FOREWORD

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cm	centimeter	m	meter
ft	foot	mg	milligram
g	gram	ml	milliliter
kg	kilogram	uS	microSiemens
l	liter		(micromhos per centimeter)
%	per cent		

ACCELERATING PYRITE OXIDATION USING CHEMICAL OXIDANTS

By F. T. Caruccio,[1], G. Geidel,[2], and W. S. Bradham,[3]

*** ABSTRACT

Acid mine drainage occurs when the balance of acid production exceeds alkalinity. One possible remediation strategy is to selectively remove pyrite from the hydrogeochemistry impacting the drainage quality through accelerated pyrite oxidation using chemical oxidants. The feasibility of this approach was evaluated using high sulfur/low sulfur organic-rich shales, underclays, and refuse and a clean sandstone through column and tub leaching tests using calcium hypochlorite and hydrogen peroxide as the oxidizing agents.

The organic matter was preferentially consumed by the oxidants providing little residual for pyrite oxidation. With the exception of the sandstone, the addition of the oxidant had little effect on accelerating the oxidation rates. The highly alkaline calcium hypochlorite inhibited pyrite oxidation. The oxidant purging technique therefore, is best used to treat clean sandstones and rocks that are

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relatively free of organic matter.

*** INTRODUCTION

Acid mine drainage is commonly associated with mines sited in alkaline deficient/pyrite enriched strata. During the mining process, the natural structure of the strata is destroyed and, in short time periods, unweathered rock surfaces are exposed to accelerated weathering reactions. However, the pre-mining geology through which water had moved (i.e., fractures, joints and pores), evolved over geologic time periods and through the millennia acid producing minerals (hereafter collectively called pyrite) were oxidized, and the dilute levels of acidity leached from the area. Under these conditions, calcium-magnesium carbonate minerals (hereafter collectively referred to as calcareous material) are commonly mobilized from the soil and overlying rock, and deposited as thin calcite-filled veins along the joints and fractures of the underlying bedrock. In this scenario and through time (from a geologic perspective), a non-acid hydrogeochemistry is established in rock through the process whereby the existing fracture porosity is depleted of pyrite and coated with calcareous material, that by whole rock analysis may be pyrite enriched and calcareous matter deficient. In essence, though the alkaline producing calcareous material may comprise only a small percentage of the overburden (the overburden analyses may test out as acid producing), the bulk ground water movement occurs along the calcareous-lined fractures which geochemically produce non-acid seeps.

In the situation presented, the disturbance of land and the concomitant exposure of pyrite creates an acid producing system. Whereas under pre-mining conditions the natural ground water flow was in prolonged contact with pyrite deficient/calcareous enriched material, the land disturbance increased the porosity of the overburden, exposing unweathered pyrite and, at the same time, reducing the water contact with the alkaline material. Under the post-mining conditions, the chemistry of the drainage more closely reflects the composition of the overburden, because the ground water flow, which previously selectively flowed along pyrite depleted zones, is now in contact with a more representative portion of the overburden material.

In itself, the chemistry of the overburden does not control mine drainage quality. Rather, the accessibility and exposure of the acid/alkaline producing materials to water contact is a more appropriate consideration. In the pristine setting, minor amounts of calcareous material deposited along joints and fractures affect the majority of the flow and significantly impact the quality of ground water. In the post mining phase, however, the same amount of calcareous material is now hydrologically dispersed and diluted through the backfill, affects a small percentage of the total flow, and contributes little chemical impact to the seep quality.

The quality of a seep emerging from an abandoned mine is often a blend of many water flow paths and of two or three ground water regimes. Depending on the infiltration capacity of the mine surface and the intensity and duration of a precipitation event, water is (1) charged to a deep, well established and integrated water table recharging a large reservoir that sustains the base flow of the seep, (2) diverted along the reclaimed mine surface as runoff, or may (3) partially penetrate to a shallow horizon and move laterally as interflow to emerge as a transient "wet weather seep" or temporarily contribute to the major seep. Various combinations of these water movements are possible. The deep ground water reservoir sustains seeps through base flow, experiencing recharge a few times during the spring thaw, and "lagging" behind the precipitation event, whereas the other two flow components affect (by quantity and quality) the seep within a narrower time frame.

Under natural conditions ground water movement is slow, chemical impacts on seep quality are gradual, and long-term monitoring programs are required to adequately evaluate a particular treatment. Could not the processes, whereby the effect of a treatment that normally would take years to develop, be accelerated and observed and evaluated within several months? Going one step beyond, could we not also, in the process, accelerate the pyrite oxidation to mimic and recreate the geochemical conditions that existed before the land disturbance and which took eons to develop? If this were possible, then minor amounts of alkalinity would be required to maintain non-acid conditions, as existed in the past, and serve to remediate acid drainage problems.

In addition, should the opportunity be present, the surface of the reclaimed mine could be engineered so that surface water runoff could be made to "leak" into the backfill along designated and preferred recharge channels. These recharge channels could be treated with limestone, to enhance the alkaline load entering the ground water regime of the backfill, or selectively treated with an oxidant to reduce the acid potential of the flow path, or combinations of both. This recharge strategy assumes that the backfill contains zones or channels of higher hydraulic conductivities along which preferential flow would occur and which can be intercepted at the ground surface.

That the alkaline load could be manipulated through the surface reconstruction of alkaline trenches is best demonstrated through a study by Caruccio, Geidel, and Williams (1)[4] in which recharge pits, lined with limestone, were shown to affect the quality of the acidic seeps through reductions in acidity and iron/manganese concentrations. An update of the study, as well as the conceptual base upon

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[4]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

which the recharge enhancement strategy was developed, are covered in a paper by Caruccio and Geidel (2).

Accordingly, should the treatment and enhanced oxidation of acid producing zones prove feasible in reducing the amount of acidity produced, a mechanism for the field application is already in place and could be treated with an appropriate oxidant. In addition, to reductions in acidity that one could expect, the possibility also exists that the preferred flow paths treated with an oxidant would continually become clogged with iron hydroxides and gypsum thereby altering the flow path. This may serve either to remove acid zones from water contact or continually expose new avenues of reactive pyrite requiring additional oxidant.

*** STUDY DESIGN

STRATEGY

The elements of the concept addressed in the introduction may be separated into those related to the geochemical and hydrologic aspects of the system. The geochemical considerations can be evaluated under laboratory conditions through a feasibility study.

Alkalinity and acidity reaction rates are not parallel. Bicarbonate alkalinity generated from limestone is limited by a solubility product which is partially dependent on dissolved carbon dioxide and under atmospheric conditions is around 65 mg/l (as $CaCO_3$). In contrast, pyrite oxidation proceeds continuously through time and the accumulation of soluble, acid producing salts, for all intents and purposes, is unlimited. These salts have the capability of producing orders of magnitude more acid than the alkalinity available from limestone. To offset these disproportionate chemistries, recharge trenches can be implemented to manipulate the hydrology of the backfill, to shift the alkaline and acid loads, as well as serving as conduits for an oxidant and alkalinity; the two chemical components may not be applied simultaneously. An oxidant can be applied first, generating copious amounts of acid that will be treated conventionally at the discharge. The oxidant, entrained along engineered recharge points at the recharge trenches to the discharge points at the seeps, should oxidize all pyrite intercepted by the established ground water flow paths. Having done so, the acid potential of these flow lines (established by the recharge trenches) should be greatly reduced. Subsequently, the recharge pits can be packed with limestone to complete the installations. The alkalinity available from the limestone should now be in a dominant concentration to positively impact the mine drainage quality.

The purpose of this study was to evaluate the efficacy of oxidant treatment, ascertain potential dangers prior to field applications and to develop guidelines for the field application of added pyrite oxidation agents.

This study proceeded in two stages. First, a laboratory evaluation of available oxidants was completed to determine the most suitable, safe, effective, and economical ones to use. This stage included testing of acid producing materials, coupled with appropriate oxidants, using laboratory bench tests and column leaching tests.

In the second stage of the study, the results of the preliminary tests were used to upgrade the trials and increase the scale of the experiment through the use of a second set of columns and large plastic tubs packed with acid producing material.

PURPOSE

The formulation of the accelerated oxidation treatment contained several issues that were to be addressed. These concerns were with:

1. the identification of the best oxidant, optimum dosages, and economy of use;
2. levels of acidity produced;
3. potential deleterious effects of the oxidant (i.e., carry-over into the environment and exothermic reactions);
4. design criteria to determine dosages, rates of application and methods of injection or introduction,
5. and an evaluation of the efficacy of this treatment.

<u>Bench and Column Tests</u>

The first consideration was an evaluation of the available oxidants and was studied through laboratory bench tests. Following an evaluation of the oxidants, the remaining considerations were addressed through advanced leaching tests using the data and results of the batch tests, coupled with the formulation of column leaching tests. Large, 20 cm (8 inch) diameter, 1 m (3 feet) long, plastic columns were packed separately with several samples of materials. The column tests provided the flow dimensions of the test and the leaching efficiency (the degree of interaction between the oxidant and the overburden).

For these tests the materials leached were organic rich shales and underclays. Duplicate columns were used to establish controls and to assess the effect of a particular oxidant on acid production. The acid loads derived from the controls were compared to the experimental columns to evaluate the effectiveness of treatments and the resulting increase in acidity.

The experiment described above was repeated using acid producing sandstones which are known to produce acid but remain physically intact, in addition to acid producing shales (organic rich) that physically decompose upon weathering. This was done, in part, to evaluate the effect of the oxidant on the shale's physical decomposition, as well as provide an assessment of organic matter interaction.

Large Tub Weathering Tests

The laboratory bench tests evaluated the effectiveness and dosage rates of the oxidant to be used for a particular rock type, while the column tests provided kinetic data regarding variations in acid loads (between treated and control tests). The next scale of the study addressed the manner in which flow paths become established in the spoil material. To establish meaningful flow-through times, that begin to approximate small sections of a backfill, scaled-up leaching tests using tubs were completed. For this part of the study three acid producing rock types were collected from coal mines in Pennsylvania and West Virginia and shipped to our laboratory at the University of South Carolina. Representative samples were collected from each rock type and splits were subjected to whole rock chemical analysis, reflected light microscopy, and column leaching tests to determine the acid potential. Each rock type was crushed to pass 0.6 - 1.25 cm (1/4 - 1/2 inch), split into two parts, and packed into two tubs 81 cm x 50.5 cm x 45 cm (32 inches x 20 inches x 18 inches) (total of six tubs). The tubs were inclined (about 10% slope) and drain holes were drilled through the bottom of the downhill side. At the upper half of the surface of the tub, four funnels were embedded to develop channelized flow when the leachant was added to the sample packed tub. Leachates generated by deionized water addition were analyzed for pH, specific conductance, acidity/alkalinity, and sulfate. Once weathering trends were established, one tub in each of the three sets was leached with an oxidant; the other tub in each of the three sets continued to be leached with water to serve as a control. The results of the small-scale column weathering tests were compared to the tub tests to determine the efficacy of treatment.

*** LITERATURE SEARCH FOR OPTIMUM OXIDANT

The initial focus of this phase of the study was to identify and evaluate a variety of oxidants suitable for the field application of pyrite oxidation enhancement. The oxidant should ideally, at the least, be aggressive, self-destructing and not leave a residue deleterious to the environment, safe to handle, inexpensive, and easily entrained by water. As a first step, a computer literature search was completed using the resources listed in table 1.

The following provided the most comprehensive discussions of oxidants in general:

1. "Bromine Compounds," Vol. 4*
2. "Chloramines and Bromamines," Vol. 5*
3. "Hydrogen Peroxide," Vol. 13*
4. "Iodine and Iodine Compounds," Vol. 13*
5. "Peroxides and Peroxy Compounds, Inorganic," Vol. 17*;

* Each of these chapters is in <u>Encyclopedia of Chemical Technology</u>, 3rd. Ed., John Wiley Publisher.

TABLE 1. - Resources and key words used in the literature search for oxidizing agents potentially useful in this study

Resources:
- Main Card Catalog
  - key words:
    - oxidants
    - oxidation
    - oxidizing agents
    - peroxides
- Bibliography and Index of Geology, volumes 51, 50
  - key words:
    - oxidants
    - oxidation
    - oxidizing agents
    - pyrite
    - iron
- Encyclopedia of Chemical Technology
  - key words:
    - hydrogen peroxide
    - peroxides
    - chlorine compounds
    - bromine compounds
    - fluorine compounds
    - iodine compounds
    - oxidants
    - oxidation
    - oxidizing agents
    - pyrite
    - iron compounds
    - sulfur compounds
    - bleaching agents
- Metals Abstracts
  - key words:
    - pyrite
    - pyrite, oxidation
    - oxidants
    - oxidizing agents
    - oxidations
    - oxidation rules

Materials Information (Metals Park, Ohio)
Hydrometallurgy (Canadian Institute of Metallurgy)

From this literature search about 40 oxidizing agents were identified as potentially useful in our study. These agents are listed in table 2. Halogen-based oxidants, other than Cl (i.e., F, Br, etc.) were not considered because of the possible environmental hazards. Through the "Green Book" of the 1987 edition of OPD Chemical Buyers Directory (Schnell Publishing Company, N.Y., N.Y.) companies handling these products were contacted and the "Material Safety Data Sheet" was solicited, as well as a sample of the compound.

The safety data are summarized in table 2 and, coupled with the cost and potential hazardous or deleterious effects of the agent, the list was further screened to exclude the chemicals listed in table 3, from use in this study.

TABLE 2. - Characteristics of potentially useful oxidizing agents

OXIDIZING AGENT	FORMULA	USES	HAZARDS/COMMENTS
*1 Hydrogen Peroxide	H_2O_2	Bleach: textiles, wood, paper; cosmetics, medicinal waste water treatment,	decomposition generates heat and oxygen and is promoted by catalytic impurities, rate increases 2.2 times for each 10 °C rise in temperature
*2 Sodium Peroxide[1]	Na_2O_2	bleach: wood, pulp, textiles	corrosive to metals, strongly alkaline, avoid oxidizables, acids, and transition metal ions
3 Potassium Peroxide	K_2O_2		
4 Magnesium Peroxide	MgO_2		use stainless, glass, plastics, no great hazards
5 Calcium Peroxide	CaO_2	pharmaceuticals, baking	use stainless or glass, avoid transition metals, [$CaSO_4$ ppt?]
*6 Sodium Peroxyborate Tetrahydrate[1] (sodium perborate) (sodium perborate tetrahydrate) (sodium metaborate peroxyhydrate)	$NaBO_3.4H_2O$ ($NaBO_2.H_2O_2.3H_2O$)	laundry dry bleach and detergent	pH 10.1, use stainless, avoid H_2O, oxidizables, acids, transition metals
*7 Sodium Peroxyborate Monohydrate[1]	$NaBO_3.H_2O$	denture cleaners	pH 10.2, use stainless, avoid H_2O, oxidizables, acids, transition metals
*8 Sodium Carbonate Peroxyhydrate[1] (sodium carbonate sesqui (peroxyhydrate)) (sodium carbonate peroxide) (sodium percarbonate)	$2NaCO_3.3H_2O_2$	laundry dry bleach and detergent	pH 10.5, use stainless, teflon, or some plastics, avoid H_2O, oxidizables, acids, transition metals
*9 Oxone Peroxymonosulfate (oxone monopersulfate) (potassium peroxymonosulfate)	$2KHSO_5.KHSO_4.K_2SO_4$	laundry dry bleach	use stainless, porcelain, glass, or some plastics
10 Diammonium Peroxydisulfate (ammonium peroxydisulfate) (ammonium persulfide)	$(NH_4)_2S_2O_8$	metal cleaning and maturing agent for flour	use stainless, glass, teflon, or some plastics, avoid halides, reducing agents, transition metals, and strong bases
11 Dipotassium Peroxydisulfate (potassium peroxydisulfate) (potassium persulfate)	$K_2S_2O_8$	hair bleaching	use stainless, glass, teflon, or some plastics
12 Disodium Peroxydisulfate (sodium peroxydisulfate) (sodium persulfate)	$Na_2S_2O_8$	motel cleaning and cosmetics	use stainless, glass, teflon, or some plastics

TABLE 2. - Characteristics of potentially useful oxidizing agents--Continued

OXIDIZING AGENT	FORMULA	USES	HAZARDS/COMMENTS
13 Iodine Pentoxide	I205		
14 Iodic Acid	HI03		
15 Sodium Iodate	NaI03	baking	
16 Potassium Iodate	KI03		
17 Potassium Acid Iodate	KH(I03)2	alkalimetric standard	
18 Perodic Acid	H5I06		
*19 Calcium Hypochlorite	Ca(OCl)2	bleaching powder and swimming pools	use carbon steel, PVC, or rubber
*20 Sodium Hypochlorite[1]	NaOCl	liquid bleach	
21 Lithium Hypochlorite	LiOCl	swimming pools	
*22 Sodium Hypochlorite - Trisodium Phosphate Complex[1]	(Na3PO4.11H20)4.NaOCl	automatic dishwasher detergent	
23 Dibasic Magnesium Hypochlorite	Mg(OCl)2.2Mg(OH)2		
24 Sodium Chlorate	NaCl03	paper industry, oxidizing Uranium ore	explosion with combustibles, generally dangerous
25 Potassium Chlorate	KC103	match industry	explosion with combustibles, generally dangerous

* Acceptable for use in this study
[1] Not used because of clay dispersion potential

TABLE 3. - Oxidizing agents deemed inappropriate for this study and reasons for exclusion

Agent	Reason
Potassium Peroxide	Expensive
Magnesium Peroxide	Expensive, insoluble
Calcium Peroxide	Moderately expensive, insoluble
Diammonium Perohydisulfate	Expensive
Dipotassium Perohydisulfate	Expensive
Disodium Perohydisulfate	Expensive
Iodine Pentoxide	Expensive
Sodium Iodate	Expensive
Potassium Iodate	Expensive
Potassium Acid Iodate	Not commercially available
Perodic Acid	Expensive
Lithium Hypochlorite	Expensive
Sodium Chlorate (chlorite)	Dangerous
Potassium Chlorate	Dangerous
Lithium Peroxide	Expensive
Strontium Peroxide	Expensive
Barium Peroxide	Expensive
Bromates	Hazardous
Hypo Bromates	Low stability
Chlorates	Hazardous
Dichromates	Pollutant
Permanganates	Pollutant
Chlorine Gas	Difficult to handle
Sodium Perborate	Boron Toxicity

The oxidizing agents potentially useful in this study are identified in table 2 by asterisks.

*** LABORATORY RESULTS

EVALUATION OF OXIDANTS/BENCH TESTS

Preliminary Screening

Based on the literature search, a variety of oxidants that were potentially useful in the study were identified. The list was further screened to exclude those oxidants that were too expensive, dangerous, or not commercially available. The oxidants selected to be used in the preliminary bench tests included:

Oxone (peroxymonosulfate)

Sodium Percarbonate

Sodium Perborate

Hydrogen Peroxide

Calcium Hypochlorite

Sodium Hypochlorite-trisodium phospate complex (chlorinated-TSP)

The bench tests were designed to test the effectiveness of the oxidants and the levels (dosages) required to bring about complete pyrite oxidation. As an initial determination to assess the efficacy of the oxidation, twenty-four 5.00 gram samples of acid-producing tailings were treated with varying dosages of the oxidants listed above. Tailings samples were used in this initial survey because of their homogeneity in composition and surface area, and lack of organic material, thereby reducing the number of variables. The tailings were collected from a copper mine located in central Arizona. The samples had negative NPs (-8.2 to -9.5) and pyritic sulfur contents that varied from 4.57% to 4.92%. X-diffraction data showed pyrite to be the dominant sulfide with a paucity of sulfate. The 5.00 gram samples were placed in beakers and covered with 60 ml of 1%, 3%, 5%, and 10% solutions (by weight) of each of the oxidants (oxone, sodium percarbonate, sodium perborate, hydrogen peroxide, chlorinated TSP, and calcium hypochlorite); except for the hydrogen peroxide solutions which were 1%, 5%, 10%, and 15% (by volume). All solutions were prepared with reagent grade oxidants and deionized water.

The tailings samples were treated with the oxidant solutions and allowed to oxidize for about 17 days. Each solution had a control to which no tailings were added and which remained undisturbed for a 25 day period. In turn, each sample had a control in which 5.0 g of tailings was kept immersed in 60 ml of deionized water that was continuously stirred with a magnetic stirring bar and tightly covered with parafilm to minimize evaporation, yet permitting air to come in contact with the sample. Every three or four days the controls and treated solutions were analyzed for pH and specific conductance. The data collected from this preliminary bench test are presented in table 4 and plotted on figures in Appendix A.

The tailings sample was in fact acid producing, given the pH drop of the control solution to pH 2.5 (fig. A-1) and the continual rise in specific conductance through time (fig. A-1). Reviewing the data presented in the remaining figures, it is noted that, in general, the chlorine based oxidants accelerated the oxidation kinetics better than the oxygen based ones. Further, in some cases the initial pH was greater than 10 and was partly reduced by the acidity generated by the oxidation of the tailings.

TABLE 4. - pH and specific conductance data for 60 ml of varying concentrations of six oxidants in contact with 5 g of acid producing sample

OXIDANT	INITIAL pH	FINAL pH	INITIAL S.C.	FINAL S.C.
Oxone 1%	1.75	1.80	12,500	15,750
Oxone 1% c	2.05	2.00	8,500	9,600
Oxone 3%	1.45	1.50	20,000	23,500
Oxone 3% c	1.85	1.75	15,500	17,000
Oxone 5%	1.35	1.25	23,000	27,000
Oxone 5% c	1.80	1.65	19,000	20,000
Oxone 10%	1.30	1.00	25,500	29,500
Oxone 10% c	1.70	1.55	23,000	25,000
Pcarb 1%	10.20	9.50	9,200	13,000
Pcarb 1% c	10.50	9.70	7,400	8,200
Pcarb 3%	10.35	10.00	15,250	19,500
Pcarb 3% c	10.50	9.95	11,700	15,000
Pcarb 5%	10.50	10.20	18,500	22,500
Pcarb 5% c	10.50	10.00	14,000	19,500
Pcarb 10%	10.75	10.40	22,000	25,000
Pcarb 10% c	10.45	10.40	17,500	22,800
Pbor 1%	9.30	8.65	6,000	8,300
Pbor 1% c	10.10	9.30	2,000	4,500
Pbor 3%	9.75	9.75	6,900	13,000
Pbor 3% c	10.10	9.70	3,500	9,400
Pbor 5%	9.80	10.05	7,000	15,750
Pbor 5% c	10.10	9.80	4,000	11,600
Pbor 10%	10.20	10.90	11,000	19,000
Pbor 10% c	10.15	9.85	5,500	12,200
H-Per 1%	2.65	2.60	4,200	4,900
H-Per 1% c	5.15	5.20	3.5	5.8
H-Per 5%	2.60	2.55	4,400	5,000
H-Per 5% c	4.90	6.20	4.5	9.5
H-Per 10%	2.50	2.55	4,000	5,000
H-Per 10% c	4.40	6.35	9.0	11.6
H-Per 15%	2.05	2.25	5,700	6,600
H-Per 15% c	4.00	6.65	22.0	18.0
Cl-TSP 1%	10.50	7.70	7,100	10,500
Cl-TSP 1% c	11.70	9.20	7,000	6,400
Cl-TSP 3%	11.35	9.65	11,600	16,000
Cl-TSP 3% c	11.80	9.55	11,400	12,800
Cl-TSP 5%	11.70	10.20	15,000	20,000
Cl-TSP 5% c	11.80	9.65	14,500	16,500
Cl-TSP 10%	11.70	11.00	18,000	22,500
Cl-TSP 10% c	11.90	11.05	17,500	19,750
Ca-Hyp 1%	1.90	1.80	12,400	15,000
Ca-Hyp 1% c	11.30	7.35	8,100	9,000
Ca-Hyp 3%	1.65	1.70	18,700	21,500
Ca-Hyp 3% c	11.50	7.10	14,500	17,000
Ca-Hyp 5%	1.50	1.50	21,500	25,000
Ca-Hyp 5% c	11.50	7.00	15,000	20,500
Ca-Hyp 10%	2.20	1.45	24,000	28,000
Ca-Hyp 10% c	11.55	6.70	19,000	24,500

c = control   Pcarb = Sodium percarbonate   Pbor = Sodium perborate
H-per = Hydrogen peroxide   Ca-Hyp = Calcium Hypochlorite

The hydrogen peroxide rapidly decomposed and following an initial stage of activity quickly stabilized and did not affect the sample further (figs. A-8 and A-9). The oxone was shown to produce acidity in itself with initial pH values in the range of 1.7 to 1.3 (table 4). Although the bench tests using oxone provided evidence of pyrite oxidation, through enhanced levels of conductance, it appeared that the oxidant in itself contributed a substantial amount of acidity and on this basis was deleted from further testing.

The sodium percarbonate and the sodium perborate bench tests were essentially similar and showed that increasing strengths of oxidant increased the rate of oxidation - as evidenced by the attendant increases in conductance. The bench tests showed that both of these oxidants were capable of oxidizing the pyrite present in the sample. However, the bench test also showed that the sodium component of these two oxidants effectively deflocculated the clays - producing murky leachates. Some concern was expressed in that the oxidant may enhance suspension of the clays in sludge ponds and create a turbidity problem.

The most promising oxidant appeared to be calcium hypochlorite. It not only reduced the pH below the pH of the sample control, but continued to react with the sample through time (figs. A-12 and A-13). Further, it appears that the optimum dosage is about 0.5% as reflected by the absence of further reactivity with increasing concentrations (with the exception of the 5% solution, the increase in specific conductance for all samples is around 4000 uS). Finally, calcium based oxidants are favored over sodium ones (including chlorinated-TSP) to minimize clay dispersion in the sludge ponds.

Optimum Dosage and Contact Time

Chemical Bench Tests

Based on the preliminary screening of suitable oxidants, calcium hypochlorite was chosen as the optimum oxidant based on cost, clay dispersion potential, and safety considerations relative to the others.

This study was designed to affect chemical changes in coal mine backfills and, although the preliminary tests used metallic sulfide tailings (to control the particle size, sample composition, and lack of organic matter), the advanced experiments utilized coal related strata. For this purpose an acid producing shale and an underclay from two active coal mines in Clearfield County, Pennsylvania were used for this study. Through the cooperation of Swistock Associates Coal Company, approximately 550 kg (1500 pounds) of acid producing underclay between the top "B" (Lower Kitanning) and bottom "B" seam at the Eagle Eye site (designated as Eagle Eye Sample), and approximately 545 kg (1200 pounds) of shale roof material of the "C" coal (designated as Smeal Sample) were collected. Both sets of rock suites were transported to Columbia, South Carolina for processing in preparation for the experiments.

Prior to the leaching tests, however, optimum dosages of the calcium hypochlorite were determined through tests designed to measure the amount of oxidant required to completely oxidize the available pyrite in a given sample. Three size fractions of a shale and underclay were titrated with the oxidant. The three size fractions used in the study consisted of 1) a split of the sample pulverized to pass 125 microns, 2) a split crushed to pass 0.6 cm (1/4 inch) and 3) a split of the sample crushed to pass 0.6 to 1.2 cm (1/4 to 1/2 inch). The strength of the solution used in these tests was 0.5%, the value of which was determined from previous tests to be the optimum concentration to completely oxidize the pyrite contained within the samples.

The samples were analyzed for neutralization potential (NP) using the procedure outlined in Sobek (3) and for pyritic sulfur content using the procedure outlined by Burns (4). In addition to the whole rock analyses (table 5), the sample splits were examined by X-ray diffraction, X-ray fluorescence and reflected light microscopy. The results of the X-ray analyses are presented in Appendix B. Both the Eagle Eye and the Smeal samples are comprised of potassium-alumina-silicate clays. The reflected light studies showed framboidal pyrite occurring as pockets randomly distributed within the Eagle Eye samples and fine-grained pyrite to be widely disseminated within the Smeal samples.

TABLE 5. - Whole rock analysis of the samples used in the column leaching tests

Sample	Pyritic Sulfur (%)	NP (mg $CaCO_3$/gm)
Smeal 1	5.37	6.5
Smeal 2	5.50	7.2
Smeal 3	5.44	5.9
Smeal 4	5.38	6.8
Eagle Eye 1	1.93	1.3
Eagle Eye 2	1.63	0.8
Eagle Eye 3	1.87	1.2
Eagle Eye 4	1.81	0.9

The results of these bench tests are presented in figures 1-3 and show the approximate amount of oxidant needed for each sample for the various size fractions; i.e., the volume (in mls) of calcium hypochlorite 0.5% solution required to oxidize the pyrite in a given weight (gm) of sample.

Reflected Light Microscopy Study

As part of the pilot oxidation tests, samples of the raw and oxidized samples were examined using reflected light microscopy to discern the distribution of pyrite and the degree of oxidation completed at various time intervals. For the Eagle Eye underclay samples, averaging 1.8% sulfur and containing framboidal pyrite within pockets, a large portion of the pyrite was leached clean after one week. However, for the Smeal shale samples, averaging 5.3% sulfur and containing fine-grained pyrite disseminated throughout the sample, only the pyrite exposed on the rock surface was oxidized. A large portion of the pyrite within the rock matrix appeared to be unaffected by the oxidant after one week. Conceivably, some of the pyrite was removed. However, an assessment of the efficiency of the oxidant was obscured by the large residuals of pyrite remaining within the sample.

Essentially, the bench tests demonstrated the need for long contact times between the sample and the oxidant, on the order of one or two weeks, to affect significant degrees of pyrite oxidation.

COLUMN TESTS - HIGH SULFUR, LOW SULFUR/ORGANIC SHALES: CALCIUM HYPOCHLORITE OXIDANT

The two rock types used in this phase of the study were 1) shale roof above the "C" coal at the Smeal mine and 2) the underclay collected from the bottom of the "Top B" coal at the Eagle Eye mine; both mines are located in Clearfield County, Pennsylvania. The samples were crushed and sieved to generate two suites of 0.6 cm - 1.25 cm (1/4 - 1/2 inch) size fraction which, in turn, were riffled into four 12 kg (26 pounds) subsets for each rock type. Four splits from each suite were packed into eight columns 20 cm diameter by 1 m (8 inch diameter by 3 ft), to provide duplicates of each test, leaching two columns each of Eagle Eye and Smeal with deionized water and calcium hypochlorite (a total of eight columns). Four glass funnels were installed through a plastic top cap, the tips of which were embedded into the top 1.5 cm (3 inches) of the packed columns. This was done to enhance the formation of channelized flow and to create flow paths through the columns that would be oxidized clean of reactive pyrite.

To establish a baseline of acid production against which the oxidized samples were to be compared, a weekly leaching schedule using deionized water was instituted for the eight columns. Once a week, 300 ml of deionized water was slowly added, through the funnels, to the four columns packed with the Eagle Eye samples and to the four columns packed with the Smeal samples. The leachate collected the following day was analyzed for pH, specific conductance, acidity, alkalinity and temperature. The remaining leachate was retained and stored in Whirl-paks[5] for timely analyses (i.e., sulfate).

The leaching with deionized water was continued for nine weeks. At this time, the analytical data were loaded onto a Lotus 123 spreadsheet and plots of pH, specific conductance, daily acidity, cumulative acidity, sulfate loads, and cumulative sulfate versus time were generated. The data matrices are presented in Appendix C and the plots

[5] Reference to specific brands, equipment, or trade names in this report is made to facilitate understanding and does not imply endorsement by the Bureau of Mines.

are presented in figures 4 through 10.

The weathering trends for the first 58 days, during which time the samples were leached with deionized water, showed the replicate columns of each material to be similar with respect to their chemical weathering attributes. Having demonstrated the similarities within each rock type, the accelerated oxidation phase of the experiment was started on the 58th day of the leaching cycles.

Beginning on the 58th day, randomly selected columns were leached with a 0.5% solution of calcium hypochlorite oxidant. The Smeal columns #1 and #3, and the Eagle Eye columns #1 and #2 were chosen to receive the oxidant; the remaining four columns were leached according to the same schedule with deionized water and retained as controls.

The bench test data, coupled with the reflected light microscopy results, demonstrated the need for long contact times for adequate oxidation to occur; consequently, every day, the columns were leached with 300 ml of 0.5% calcium hypochlorite oxidant (as were the controls with 300 ml of deionized water). Although the samples were leached daily (including weekends), the leachate was collected and analyzed every third day (for the same parameters as prior to the introduction of the oxidant). This leaching schedule remained in effect for 184 days (acidities were terminated after 160 days of leaching).

The temperature of the sides of the columns remained at the ambient temperature throughout the entire period of the experiment allaying our concern regarding high temperature production due to the exothermic oxidation reactions.

One aspect of the study was to assess the amount of oxidizer required to completely remove the pyrite present in the rock samples. Toward this objective, the results of the bench test were used to extrapolate the volume of oxidant to be used to oxidize the pyrite contained in a given weight of sample. The results are presented in table 6 and show that the amount of oxidant added to each column, within the time frame of the results presented below, was almost twice that required.

TABLE 6. - Amount of oxidant required to deplete available pyrite

Column	Weight (kg)	Pyrite (g)*	Oxidant Equiv.(g)	Oxidant Vol. @ 0.5% (l) Required	Actual
EE-1	14.3	275	57.2	11.44	16.2
EE-2	12.72	207	50.8	10.16	16.2
S-1	13.53	726	40.6	8.12	16.2
S-3	13.2	718	39.6	7.92	16.2

*"available pyrite" based on titratable acidity of 0.6 to. 1.25 cm (1/4 to 1/2 inch fraction).

Both the Smeal and Eagle Eye samples showed increased pH values for the oxidized samples relative to the controls (fig. 4). Inasmuch as the oxidant had an initial pH of 10.4, this is to be expected. The spikes in values for figures 4 to 10 is an artifact of alternating sample collection and analysis between three and four day periods.

Reviewing the specific conductance trends (fig. 5), two different responses occur for both the Eagle Eye and Smeal samples. The specific conductance of the 0.5% calcium hypochlorite solution, as extrapolated from table 4, is about 4500 uS. For the control columns of the Eagle Eye (columns 3 and 4), specific conductance generated by the sample leached with deionized water was around 6000 uS, whereas the leachates from the Smeal controls (columns 2 and 4) averaged around 1,500 uS (fig. 5); reflecting the variability of pyrite available for oxidation in both samples. For the Smeal columns, the specific conductance of the controls (around 1500 uS) shows a net decline from day 58 to day 120; reflecting a dilution effect by the increased frequency of leaching with deionized water. For both the Smeal and Eagle Eye controls, an increase in specific conductance is evident from 120 days to the conclusion of the experiment. For the Smeal columns treated with the oxidant, the specific conductance of leachates is around 6000 uS; the increase is due to the summation of the ionic strengths of sulfide oxidation products plus the oxidant. The effect of the oxidant is expressed in figures 6 and 7 wherein the net daily and cumulative acidity versus time plots are presented. The samples treated with the oxidant produced less acid than the controls; in as much as the oxidant solution contained alkalinity on the order of 2,400 mg/l this was to be expected.

The specific conductance for the leachates collected from the Eagle Eye columns treated with the oxidant is approximately 500 uS higher than the Eagle Eye controls. One possible explanation is the oxidant consuming the organic matter present in the Eagle Eye underclay. This is further reflected in figure 7 wherein the cumulative acidity versus time plots are higher for the controls than for the columns treated with the oxidant. In addition, the titration curves (figs. 1-3) showed a greater amount of oxidant was required to achieve the endpoints, especially for the fine and coarse size fractions.

Sulfate concentrations more readily reflect the extent of pyrite oxidation. Plotting individual sulfate loads versus time (figs. 8-10) and comparing the oxidized and control columns for both the Smeal and Eagle Eye samples, there is a discernible difference in the trends of sulfate production. In the case of the Smeal columns, containing a shale with finely disseminated pyrite, cumulative sulfate production for the four columns, prior to the addition of the oxidant, is about the same (fig. 10). Following treatment, after approximately 60 days, the treated and control cumulative sulfate versus time plots separated into two distinct trends. Interestingly, less sulfate was produced from the samples treated with the oxidant compared to the controls, suggesting the addition of calcium hypochlorite to suppress the pyrite oxidation reaction. Alternatively, the addition of calcium ion in the oxidant may have precipitated gypsum; however, the sulfate concentrations were well below the solubility limits of gypsum.

Pyrite oxidation suppression was more readily discernible in the tests using the Eagle Eye samples. For both the oxidized and control columns cumulative sulfate versus time are similar for the first 60 days or so, at which time a marked difference in trends developed between the controls and the oxidant samples. The control samples exhibited higher cumulative sulfate loads. The oxidized Eagle Eye samples, on the other hand, produced significantly lower sulfate loads; again suggesting a suppression of pyrite oxidation by the oxidant addition (fig. 10, upper plot).

For the Smeal columns, the sulfate versus time trends for the first three leachings reflected an early release of sulfate due to the initial weathering products and subsequently, the gradual release of sulfate due to the limited exposure of the pyrite (fig. 8). On the other hand, the Eagle Eye columns, although containing about one-third less pyrite, produced more sulfate because of the surface availability of reactive framboidal pyrite.

Plots of sulfate versus acidity for the Smeal and Eagle

Eye samples, for the control and oxidized columns, showed the similarities in sulfate versus acidity trends (within each rock suite) reflecting the inefficacy of the calcium hypochlorite to accelerate pyrite oxidation (figs. 11 and 12). For example, the sulfate/acidity ratio for the control and oxidized columns of the Smeal samples was about 1.6:1 (fig.11), whereas for the control and oxidized columns of the Eagle Eye samples the ratio was about 0.8:1 (fig. 12). These differences can be attributed, in part, to the samples NP. However, at the time of the oxidant addition, the samples were leached at least nine times, during which time the small amounts of NP present should have been leached from the samples and not play a significant part in the experiment.

COLUMN TESTS - ORGANIC SHALES AND SANDSTONE: USING HYDROGEN PEROXIDE

<u>Introduction</u>

The results of the column tests, utilizing high sulfur - low sulfur organic shales, showed the organic matter to interfere with oxidant - pyrite interactions. Further, the calcium hypochlorite oxidant chosen in the tests described above was highly alkaline and not only interfered with the pyrite oxidation reactions but, in addition, confused the leachate chemistry. To circumvent these complications, an additional study was designed to assess the enhancement of pyrite oxidation by hydrogen peroxide. This oxidant reacts to produce water and free oxygen with no acid or alkaline residual.

The Eagle Eye sample which was shown to be acid producing, as well as having a high organic matter content, was included in this phase of testing. Two other sample suites were used. A non-organic, neutralizer-deficient, acid producing sandstone was collected from a coal mine in Preston County, West Virginia and was designated in this report as "Preston County # 3" sample.

The third sample collected was acid producing refuse from a coal mine in Greenbrier County, West Virginia and was designated as "Leckie Smokeless" sample. The samples were crushed, sized to pass 0.6 - 1.25 cm (1/4 - 1/2 inch) screens and riffled into two 20 kg (45 pounds) portions; one to be used in the column leaching tests, essentially repeating the tests described above, and the other half was designated for use in tub tests. The whole rock analyses are presented in table 7.

TABLE 7. - Whole rock analysis of samples used in tests with hydrogen peroxide

Sample ID	Rock Type	N.P.	Pyritic Sulfur
Eagle Eye	Underclay	-2.1	2.1%
Preston County # 3	Clean Sandstone	-0.2	0.3%
Leckie Smokeless	Refuse	-5.4	2.3%

The configuration of the columns was identical to that used in the column tests described above. Each rock suite designated for the column tests was riffled into four components (approximately 10 - 12 kg) and packed into four separate columns; creating four columns each for the Eagle Eye, Preston County # 3, and Leckie Smokeless samples for a total of twelve columns. And, as with the previous test, the columns, with the embedded funnels, were initially leached with deionized water. The leaching with deionized water continued for approximately 70 days, after which two of each of the four columns containing each rock type were leached with 300 mls of 10% hydrogen peroxide and continued on a weekly basis for 158 days. As with previous tests, pH, specific conductance, acidity, and sulfate data were loaded onto electronic spreadsheets to generate parameter trends through time plots. These data are presented in figures 13 through 21 and Appendix D. On these plots, specific conductance is expressed as umhos/cm/kg and is equivalent to uS/kg which have normalized to factor out variations in sample weight. All acidity values expressed are net acidities.

Results

Eagle Eye Columns:

The pH of the leachates produced by the Eagle Eye samples declined from initial values of 3.5 - 5.0 to 1.5 - 2.0 with no differences between the control and oxidant columns (fig. 13). Specific conductance values increased from an initial 50 umhos/cm/kg (uS/cm/kg) to a maximum of around 1300 uS/cm/kg at 84 days and subsequently began a slight decline; again, there were no differences between the control and oxidant columns (fig. 13).

Cumulative acidity (net) values reached 8500 mg/kg - 10,000 mg/kg at the termination of the experiment at 154 days. There were no differences between the rate of acid production for the control and oxidant columns (fig 14). Sulfate values reached a maximum of 600 mg/kg at approximately 80 days and began to decline. Cumulative sulfate values were around 8000 mg/kg at the termination of the experiment. As above, no differences existed between the rates of sulfate production for the control and oxidant columns (fig. 15).

Preston County Columns:

The pH of the leachates produced by the Preston County # 3 sandstone declined from an initial 6 - 8 to 2.3 - 2.5. Specific conductance values reached a maximum of about 450 uS/cm/kg at 84 days and began to decline. The oxidant column samples displayed a slight increase in conductivity at 70 days when the oxidant was introduced, but were soon equalled by the control column samples (fig. 16).

Cumulative acidity for the control and oxidant columns reached values of 620 mg/kg to 700 mg/kg, respectively (fig. 17). Sulfate values for the control columns showed a slight increase at 70 days, and cumulative sulfate reached 800 - 900 mg/kg at the termination of the experiment; demonstrating little difference between the rates of sulfate production for the control and oxidant columns (fig. 18).

Leckie Smokeless Columns:

The pH of leachates produced by the Leckie Smokeless refuse remained in the 1.5 - 2.0 range throughout the test period. Specific conductance values reached a maximum of 1450 uS/kg at 84 days and remained relatively constant. For these parameters there were no differences between the control and the oxidant columns (fig. 19).

Cumulative acidities for the Leckie Smokeless columns reached 13,000 - 14,000 mg/kg at the termination of the experiment. Again, there were no differences between the rates of acid production for the control and oxidant columns (fig. 20). Sulfate production was at a maximum at 7 days, with declining levels thereafter. Cumulative sulfates reached 1100 - 1200 mg/kg at 154 days. No differences existed between rates of sulfate production for the control and the oxidant columns (fig. 21).

Based on the data presented above and comparing pH, specific conductance, cumulative acidity, sulfate, and cumulative sulfate values (normalized to accommodate variations in weight) for the control and the oxidant columns, it is concluded that the amounts and concentrations of hydrogen peroxide used in these tests did not significantly affect the oxidation of pyrite. The levels of peroxide used in these tests were scaled down concentrations to coincide with cost effective field application rates. And at the rates and concentrations used in the study, unreacted hydrogen peroxide continually appeared in the leachate collected from the columns. As evidenced by a profusion of "bubbles and sudsing" on the leachate surface, it was apparent that a significant, albeit unknown, oxidation potential of the peroxide was lost during the transfer of water within the columns.

*** LARGE TUB TESTS - ORGANIC SHALES AND SANDSTONES: USING HYDROGEN PEROXIDE

INTRODUCTION

The purpose for coupling the large tub tests with column tests was to evaluate the ability of a large mass of rock to accommodate channelized flow through a portion of the rock pile, thereby preferentially establishing zones or flow channels which could be selectively purged of the acid potential by the oxidant. This was necessary because the entire volume of rock contained in the columns would become inundated by the oxidant even though the oxidant solution was introduced into the funnels that were installed to establish channelized flow. Capillary forces caused the oxidant solution to move laterally, until contacting the column sides and creating saturated flow. In so doing, the entire rock sample became wetted and plug flow was established within the columns. However, the larger masses of rock samples contained in the tubs encouraged channelized flow, more appropriately reflecting anticipated field conditions.

The leaching tubs were constructed of gray PVC plastic measuring 81 cm by 50.8 by 45 cm (32 inches by 20 inches by 18 inches) and were inclined to facilitate drainage through an outlet at one end. The samples were contained by the tubs and covered with a translucent 4 mil polyethylene sheet. At the higher end of the tub, four holes were punched into the upper half of the plastic sheet and plastic funnels were inserted through the holes and about 1.2 cm (3 inches) into the sample surface. This was done to reduce the effect of lateral capillary flow within the rock samples and to create channelized flow conditions. Due to the opaque nature of the tubs, the development of channelized flow could not be readily confirmed, but it is reasonable to assume that the fluid additions were confined to discrete zones within the tubs.

Because the large volumes of rock yielded proportionately fewer particles in the 0.6 by 1.25 cm (1/4 by 1/2 inch) size fraction when crushed, the amount of sample available for the tub tests limited the number of tubs for each sample to two. As a result, one control and one treated tub were available for the study. As in the column tests, the leachates were collected, analyzed, and the results plotted against time to derive trends. These plots are presented in figures 22 through 30. On all of these plots umhos/cm/kg is equivalent to uS/cm/kg and have been normalized to factor out variations in sample weight. Acidities presented in the plots represent net acidities.

RESULTS

Eagle Eye Tubs:

The pH of the leachates produced by the Eagle Eye underclay declined from around 3 to slightly below 2. At the introduction of the oxidant, specific conductance of the oxidant tub leachate showed a slight increase at 63 days. Values for the control tub, however, soon equaled those for the oxidant tub (fig. 22).

Cumulative acidity values reached 950 mg/kg at 98 days, the date of the termination of the experiment. No differences were noted between the control and the oxidant tubs (fig 23). Sulfate values for the oxidant tub reached a maximum of 135 mg/kg at 77 days, while the control tub reached that amount at 84 days. Cumulative sulfate reached 850 mg/kg at 98 days. Similarly, no differences existed between the control and the oxidant columns (fig. 24).

Preston County Tubs:

The pH of the leachates produced by the Preston County Sandstone declined from values of 3.5 - 4.0 to 2.4. At the introduction of the oxidant at 63 days, the oxidant tub showed a sharp decrease in pH (fig. 25). Specific conductance values remained below 10 uS/cm/kg until the introduction of the oxidant. At 63 days, the oxidant tub showed a sharp increase in conductance. Conductances from that tub reached a maximum of 55 uS/cm/kg at 84 days. At 98 days, the end of the leaching experiment, the control tub leachate had reached 40 uS/cm/kg (fig. 25).

Cumulative acidity remained low until the introduction of the oxidant. At that point, the oxidant tub displayed a sharp increase in acid production. Cumulative acidity values for the oxidant and control tubs at 98 days were 58 mg/kg and 12 mg/kg, respectively (fig. 26). Sulfate loads for both tubs remained below 1.5 mg/kg until the introduction of the oxidant. At that time the sulfate load of the oxidant tub increased to 11 mg/kg. Two weeks later, the sulfate load reached a maximum of 12 mg/kg and began to decline. The control tub showed increasing sulfate loads reaching 6.5 mg/kg at 98 days. Cumulative sulfate data mimicked cumulative acidity data in that the level remained below 5 mg/kg until 63 days, at which time the rate of sulfate production of the oxidant tub increased dramatically, reaching 66 mg/kg at 98 days. The cumulative sulfate from the control tub reached 26 mg/kg at 98 days (fig 27). The convergence of the sulfate versus time plots may reflect the depletion of available pyrite exposed on the rock surface; which occurred earlier in the treated samples (because of the enhanced oxidation) than in the controls.

Leckie Smokeless Tubs:

The plots of the values obtained from the Leckie Smokeless tubs (LEK-T-1 and LEK-T-2) showed significant variation in leachate quality from the two tubs from the onset of the experiment. The pH of the leachates declined slightly from an initial 2.2 to around 1.7. Specific conductance values for leachates from both tubs reached maxima of 420 uS/cm/kg and 460 uS/cm/kg at 28 days. There were no differences between the tubs that could be attributed to the introduction of the oxidant (fig. 28).

Cumulative acidity plots of the leachates showed variation between the tubs. Tub LEK-T-1 reached 4750 mg/kg at 98 days, and LEK-T-2 reached 3500 mg/kg (fig. 29). Because the divergence occurred from the beginning of the experiment, the differences cannot be attributed to the action of the oxidant. Sulfate loads also exhibited this variation. The sulfate load for LEK-T-1 reached a maximum of 400 mg/kg at 28 days and LEK-T-2 sulfate loads reached a maximum of 310 mg/kg at 70 days. Cumulative sulfate mimicked cumulative acidity LEK-T-1 reaching 4500 mg/kg and LEK-T-2 reaching 3100 mg/kg at 98 days (fig. 30). Again, for the reasons described above, these differences could not be attributed to the effect of the oxidant.

*** CONCLUSIONS

For the column tests, using high and low sulfur organic rich rocks and calcium hypochlorite as the oxidant, the results showed that at the levels and concentrations of the oxidant used, little if any enhancement of pyrite oxidation took place. It appears that the organic matter content of the samples used in those preliminary tests was preferentially consumed by the oxidant with a minimal residual available for pyrite oxidation. During the derivation of the titration curves, organic-free pyrite containing samples were used and the effect or interference by the organic matter was not noted.

Using calcium hypochlorite, which in a preliminary literature scan was designated as most desirable for use in this experiment, confused the results of the tests through major additions of alkalinity (measured as 2400 mg/l as $CaCO_3$), increases in specific conductance due to the ionic strength of the oxidant, and possible interferences with pyrite oxidation reactions by the high pH (10.4) of the calcium hypochlorite solution.

Accordingly, to circumvent the interferences in leachate chemistry introduced by calcium hypochlorite, a second phase of the study using an organic-free sandstone (Preston County # 3), in addition to an acid producing underclay (Eagle Eye) and refuse (Leckie Smokeless) and hydrogen peroxide as the oxidant was completed. For this phase of the experiment the samples were tested in tubs, as well as columns.

For the second phase of the experiment, in which hydrogen peroxide was used, the Eagle Eye and Leckie Smokeless column data showed no changes in reactivity attributable to the oxidant. There are two plausible explanations for this behavior. First, the design of the column leaching experiment permitted water and oxygen to diffuse into the entire length of the column and allowed pyrite oxidation reactions to occur at a maximum rate. The addition of the oxidant did not significantly accelerate the reactions. Secondly, the oxidant preferentially reacted with the organic matter contained in the samples leaving little residual oxidant for the oxidation of the pyrite.

The Preston County column data hint at a slight effect due to the oxidant. The addition of the oxidant caused small increases in reactivity. However, as the reactions were most probably occurring near a maximum rate, the contribution of the oxidant to oxidation enhancement was slight. In addition, the subtle differences in acid and sulfate production do not support the conclusion that the oxidant affected pyrite oxidation rates.

The tub data, however, show that acid production for each sample was limited compared to the equivalent column. Channelized flow was, in part, responsible for this as the leachant introduced to the tubs was afforded limited lateral migration (as opposed to the columns in which complete saturation occurred). In addition, the tubs were leached with a smaller volume of water (600 ml per 40 kg of rocks) relative to the amount used in leaching the columns (300 ml per 12 kg of rocks), thereby limiting the mobilization of weathering products.

Because of the divergent trends from the beginning of the experiments, the differences between the two Leckie Smokeless tubs were attributable to sample heterogeneities contained in the tubs. The Leckie Smokeless refuse samples, because of their friable nature could not be sieved to a common size fraction. This resulted in irregularities in particle size that complicated flow patterns within the tubs and contributed to the differences in leachate quality. Additionally, because the rates of acid and sulfate production remained the same in the oxidant tub before and after the addition of the oxidant, it was apparent that the oxidant did not enhance the rate of pyrite oxidation. The reasons are the same as given above for the columns.

Plots of cumulative acidity and sulfate for the Eagle Eye tubs reveal no major differences in rates of pyrite oxidation between the oxidant and control tubs. However, the plot of sulfate load indicates that the oxidant tub reached its maximum load one week earlier than the control tub.

The Preston County tub data better exhibit this property and suggests one possible set of conditions under which acid production potential of a sample may be purged by the introduction of an oxidant. The Preston County oxidant tub reached a maximum sulfate load at 77 days after which time the loads began to decline. Sulfate loads from the control tub had not reached maximum loads at the termination of the experiment. However, the Preston County oxidant tub displayed markedly higher acid and sulfate production than the control; responding to the introduction of the hydrogen peroxide.

These observations seem to indicate that in the case of the columns and most of the tubs the acid production reactions were occurring at the maximum rate prior to the addition of the oxidant. Thus the oxidant did nothing to increase the reaction rates of the pyrite. In addition, the presence of organic material may have resulted in the preferential oxidation of the carbonaceous material relative to pyrite.

In the Preston County samples, prior to treatment, the acidity reactions required a longer period of time to attain their maximum reaction rates; due to a lower pyrite content and possibly fewer nutrients available for bacterial growth. Accordingly, the oxidant is more likely to enhance the reaction rates.

The oxidant was added to the Preston County tubs well before the rate of acid production reached a maximum. For this reason, the oxidant was able to increase the rate of pyrite oxidation over the prevailing modest rate, as evidenced by a sharp rise in acidity and sulfate production.

Because the oxidant does not significantly affect the kinetics of pyrite oxidation under conditions at which maximum oxidation rates are taking place its use is limited to unoxidized material or in cases where acid production is occurring at modest rate. Further, because the oxidant preferentially oxidizes organic matter relative to pyrite, its use is not effective in organic-rich rocks. The oxidant purging technique therefore, is best used to treat clean sandstones and rocks that are relatively free of organic matter. This further assumes that all of the oxidant applied to the site will be used to enhance pyrite oxidation. In view of the relatively slow kinetics of pyrite oxidation observed to take place during this study, extended periods of contact time between the oxidant and the sulfide must be afforded to optimize the application of this treatment.

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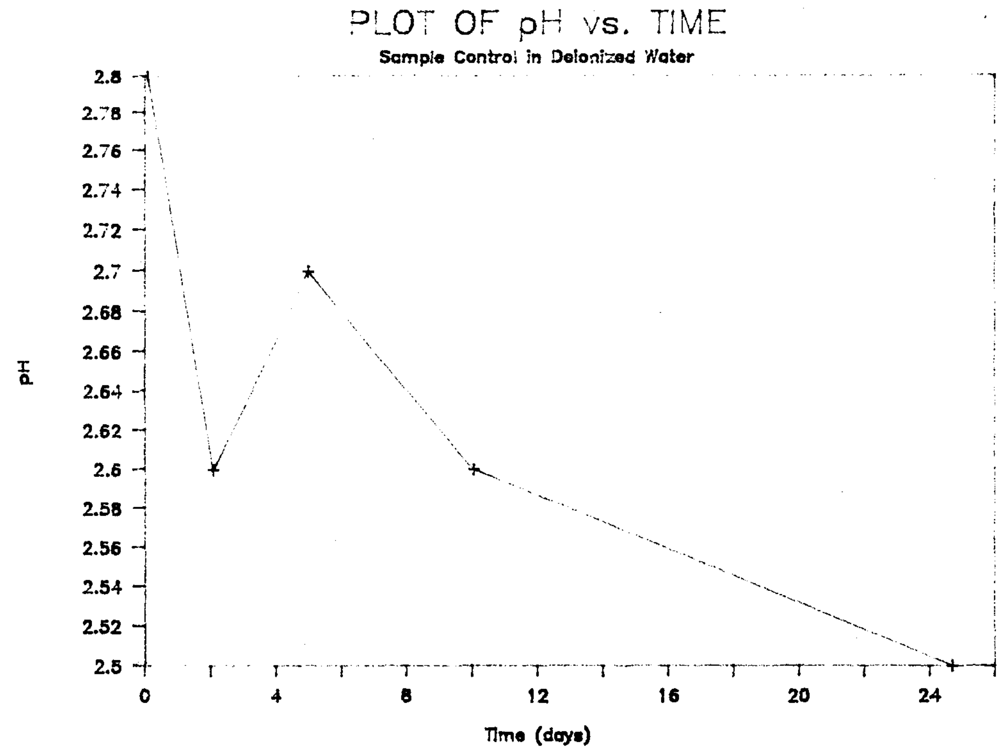
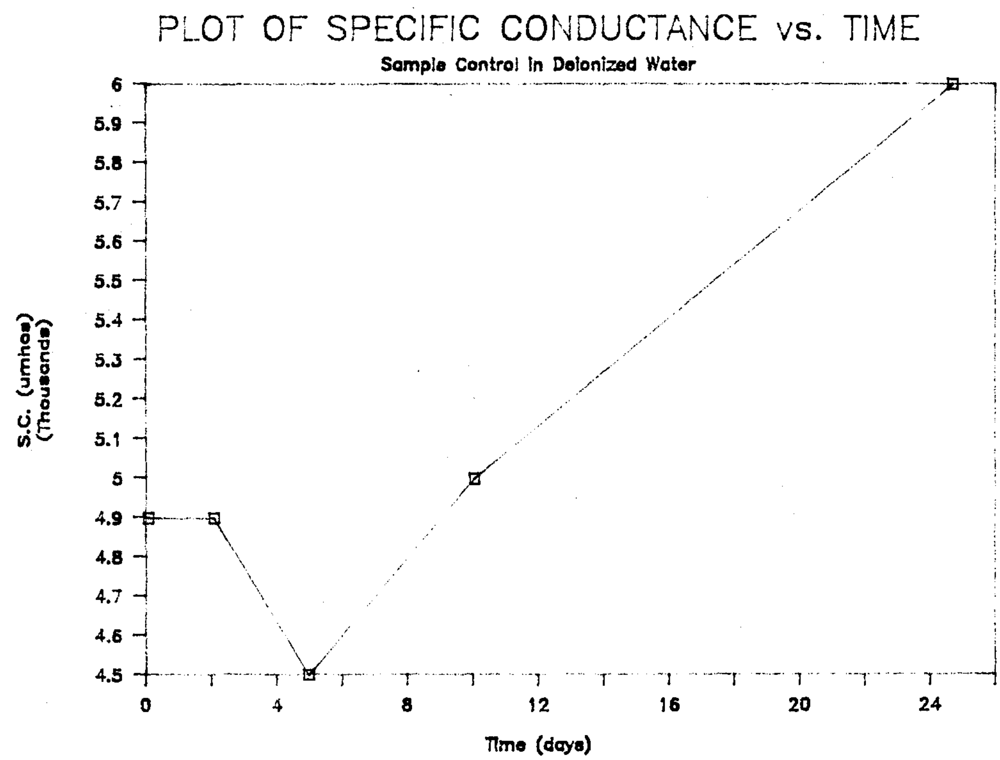
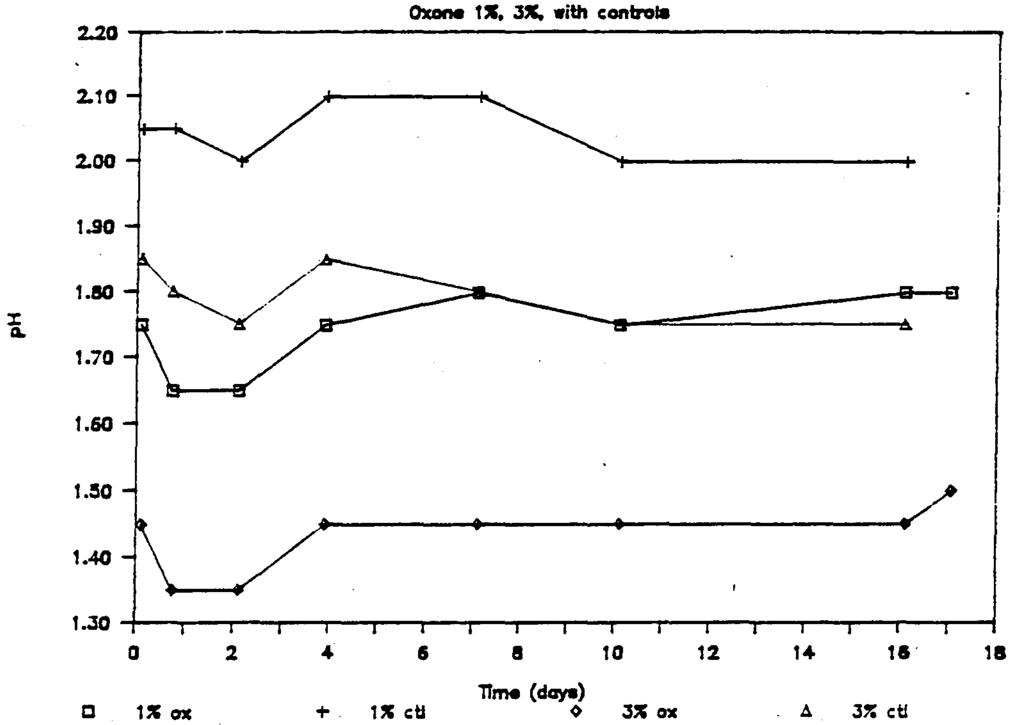
*** APPENDIX A.--PLOTS OF S.C. AND pH VS. TIME FOR PRELIMINARY TESTS


PLOT OF pH vs. TIME
Sample Control in Deionized Water
pH
2.8
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
2.62
2.6
2.58
2.56
2.54
2.52
2.5
0
4
8
12
16
20
24
Time (days)


PLOT OF SPECIFIC CONDUCTANCE vs. TIME
Sample Control in Deionized Water
S.C. (umhos)
(Thousands)
6
5.9
5.8
5.7
5.6
5.5
5.4
5.3
5.2
5.1
5
4.9
4.8
4.7
4.6
4.5
0
4
8
12
16
20
24
Time (days)

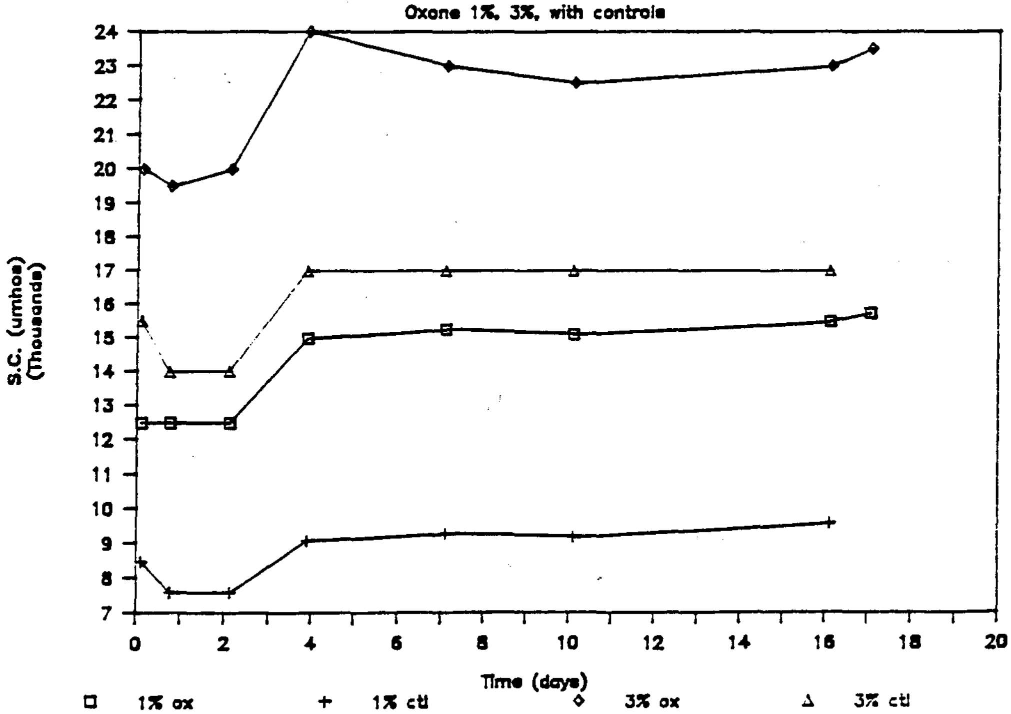
PLOT OF pH vs. TIME

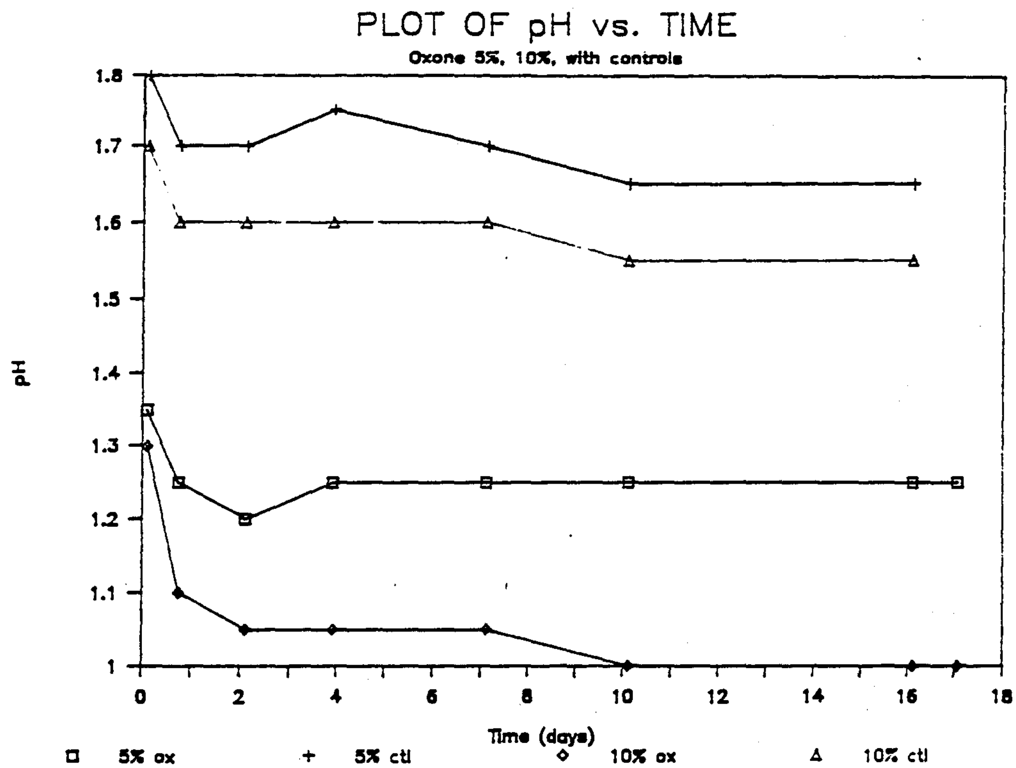
Oxone 1%, 3%, with controls

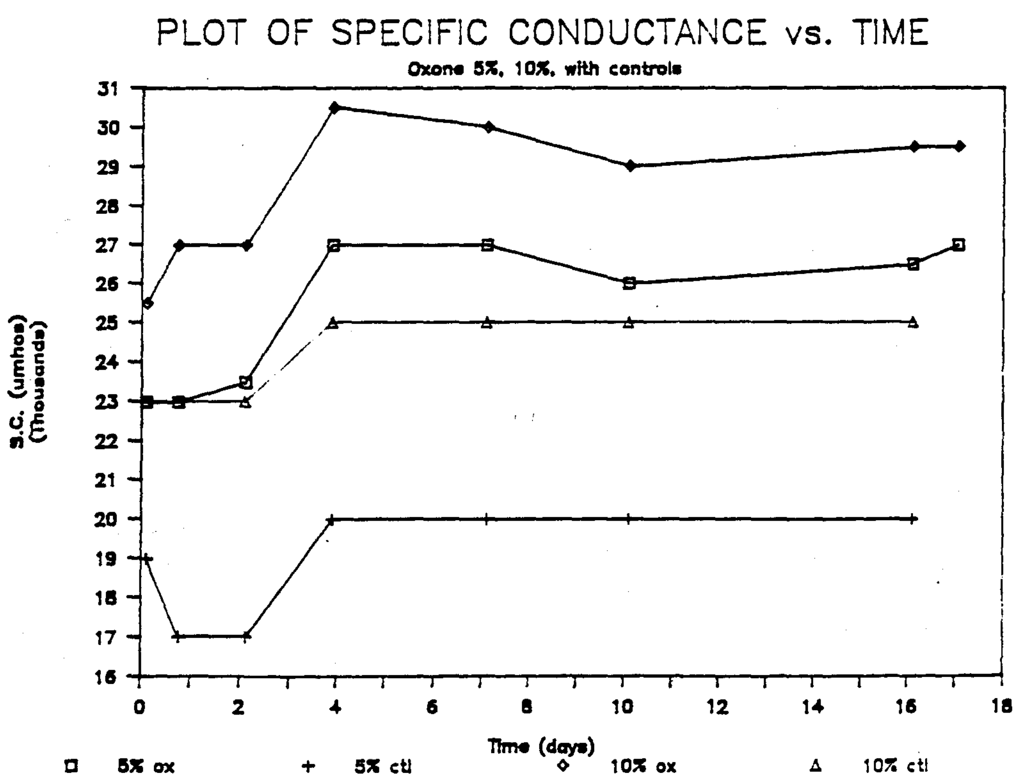


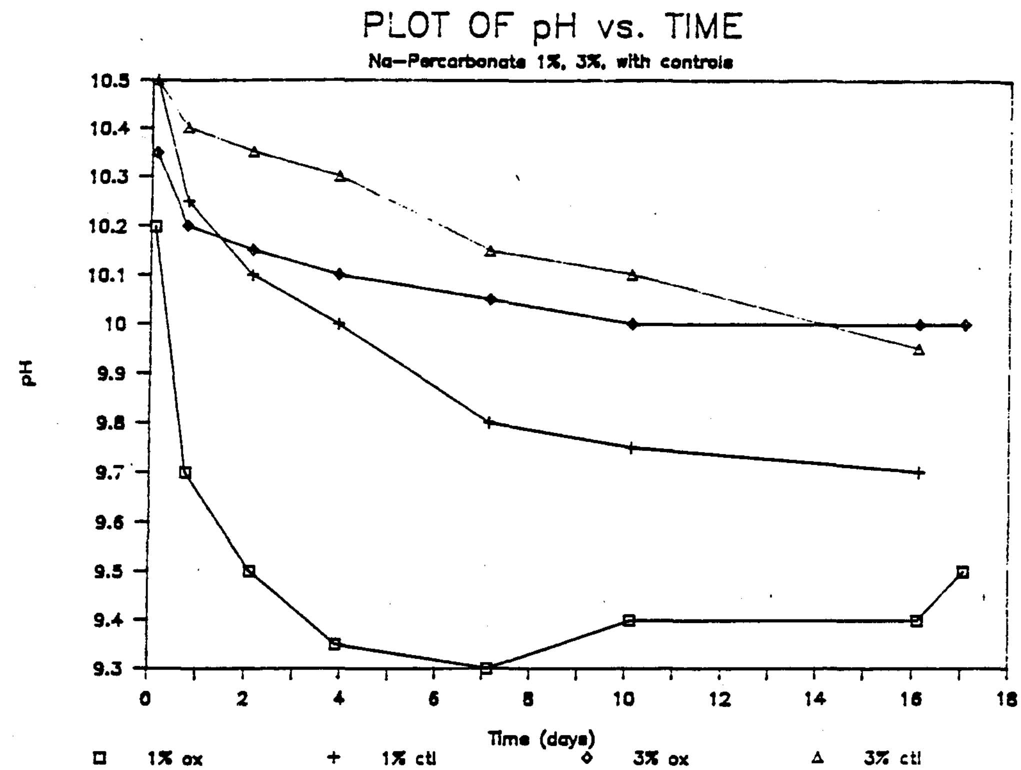
PLOT OF SPECIFIC CONDUCTANCE vs. TIME

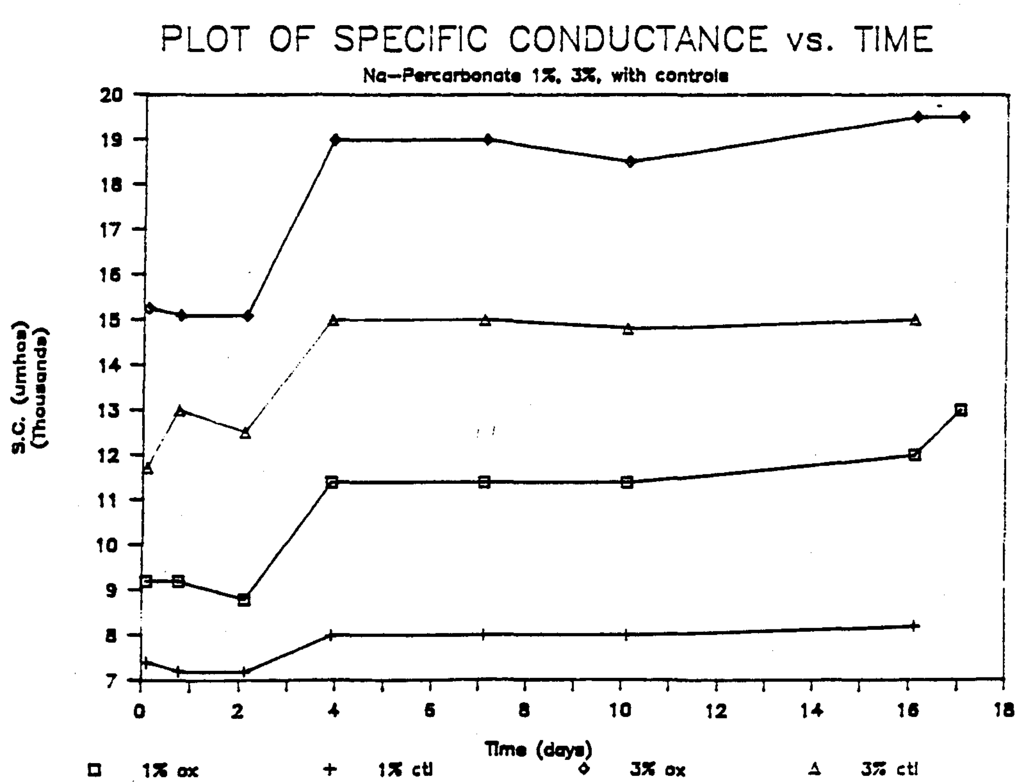
Oxone 1%, 3%, with controls

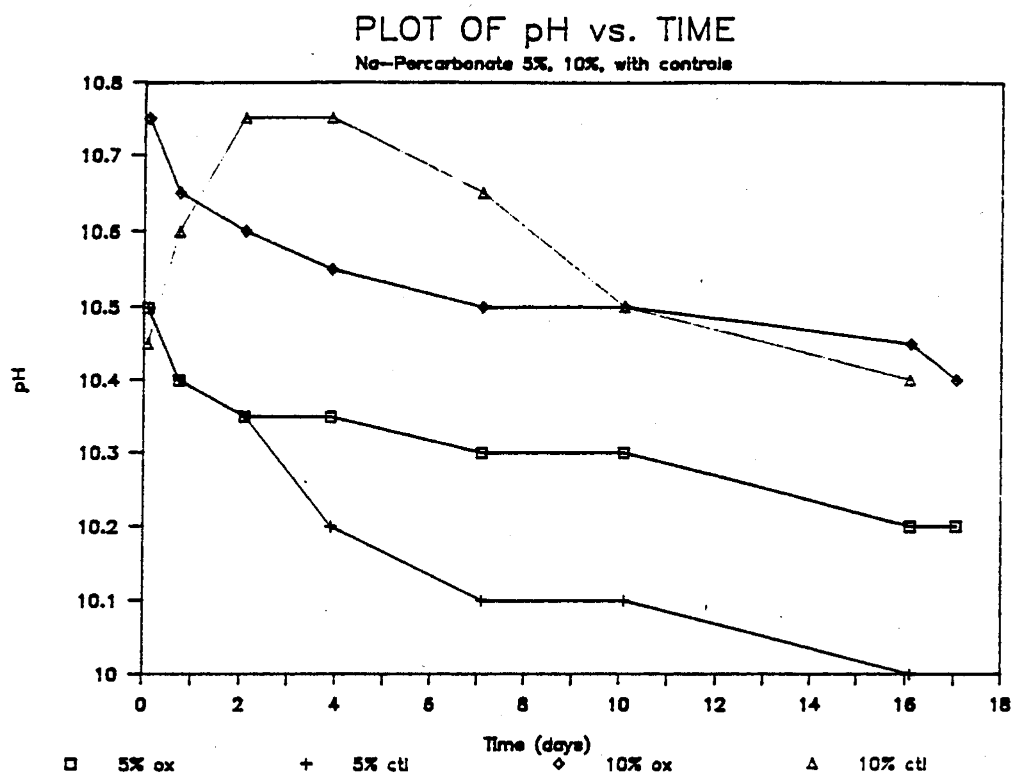


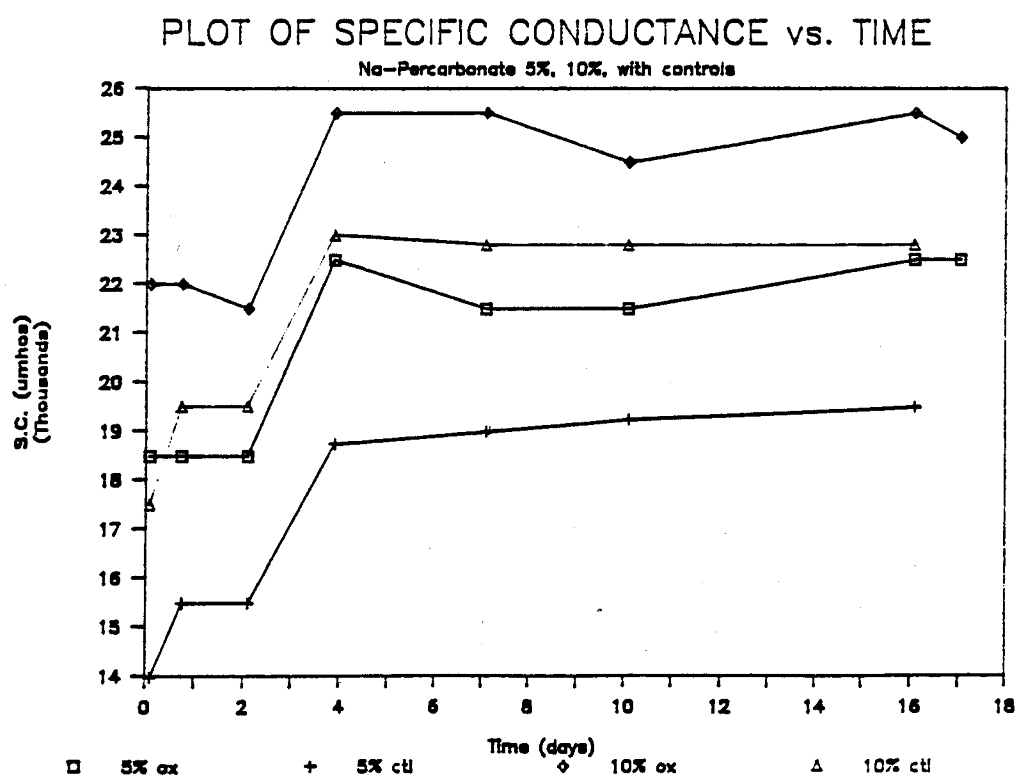

PLOT OF pH vs. TIME
Oxone 5%, 10%, with controls
pH
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0
2
4
6
8
10
12
14
16
18
Time (days)
5% ox
5% ctl
10% ox
10% ctl

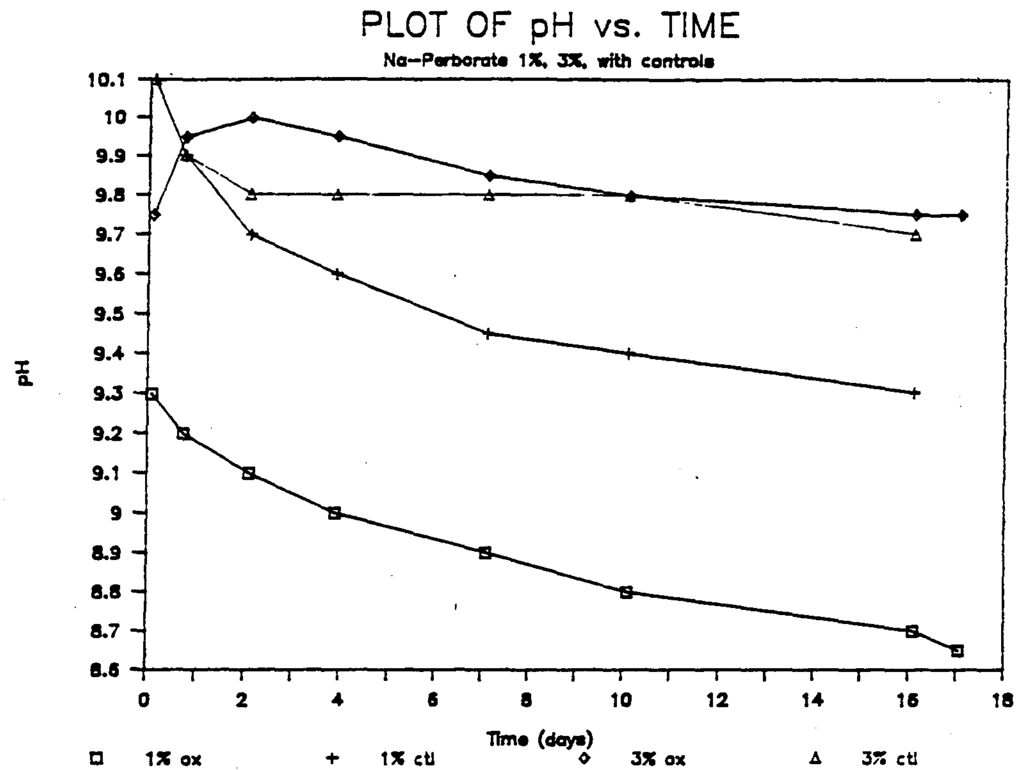

PLOT OF SPECIFIC CONDUCTANCE vs. TIME
Oxone 5%, 10%, with controls
S.C. (umhos)
(Thousands)
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
0
2
4
6
8
10
12
14
16
18
Time (days)
5% ox
5% ctl
10% ox
10% ctl

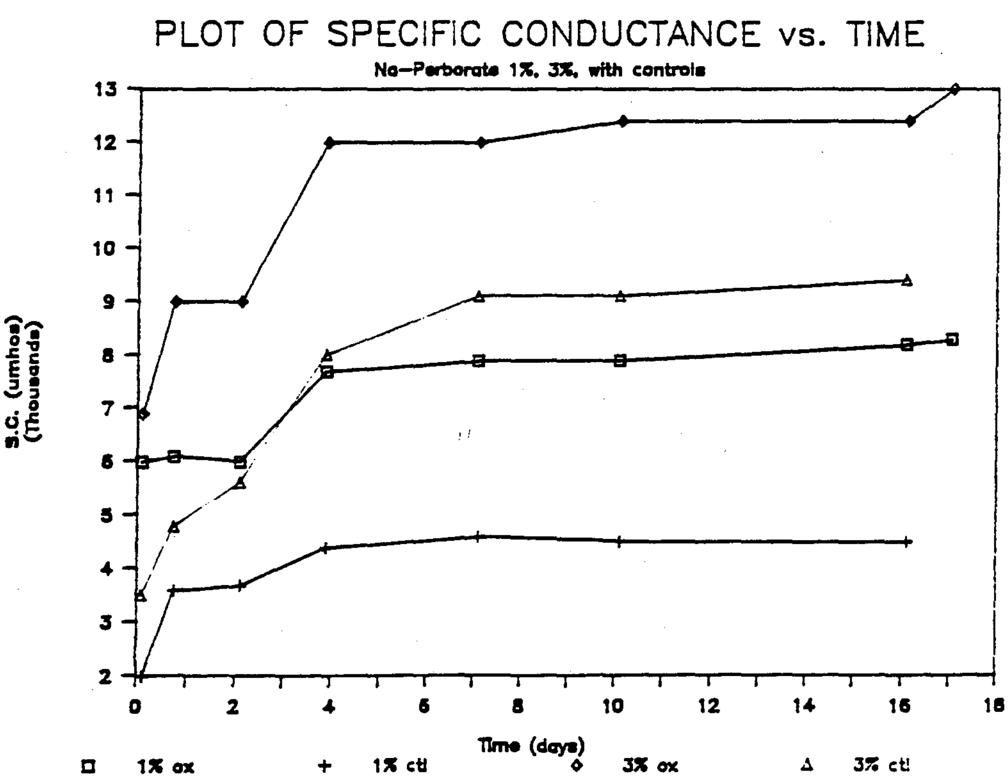

PLOT OF pH vs. TIME
Na-Percarbonate 1%, 3%, with controls
pH
Time (days)
1% ox
1% ctl
3% ox
3% ctl

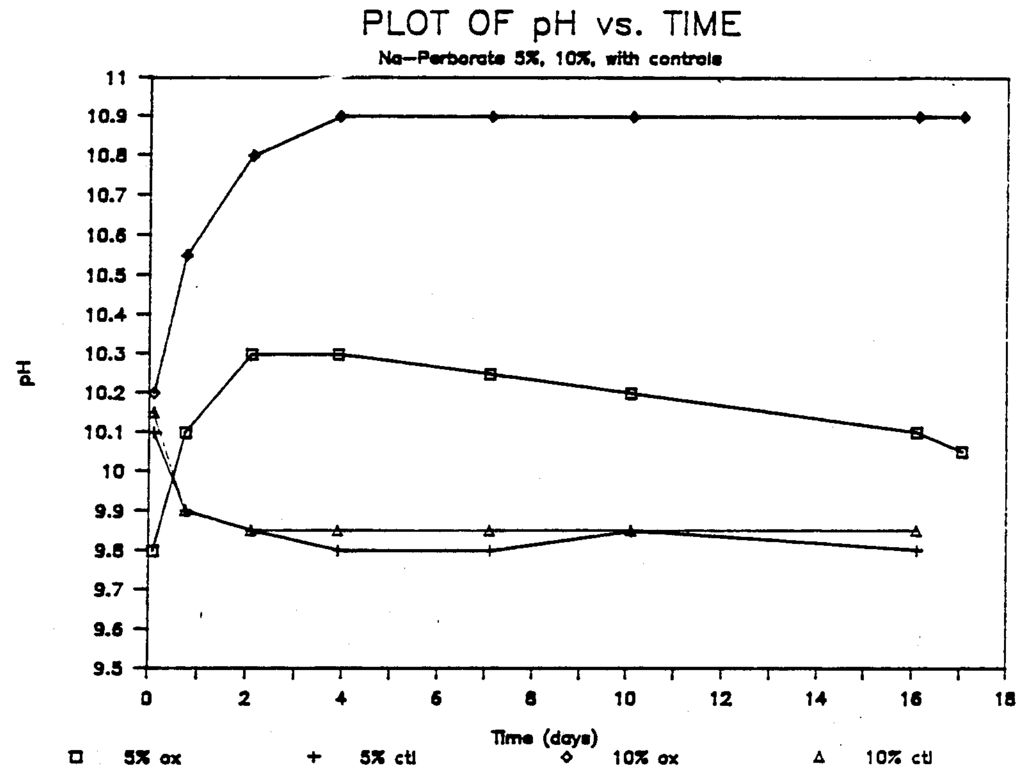

PLOT OF SPECIFIC CONDUCTANCE vs. TIME
Na-Percarbonate 1%, 3%, with controls
S.C. (umhos)
(Thousands)
Time (days)
1% ox
1% ctl
3% ox
3% ctl

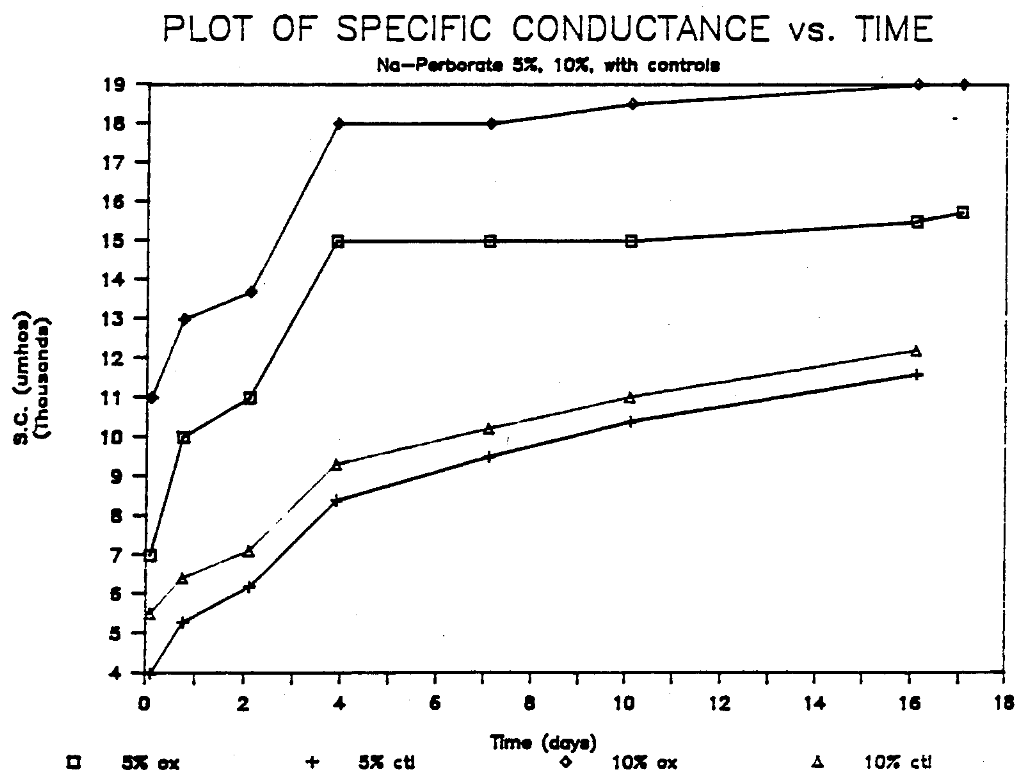

PLOT OF pH vs. TIME
Na-Percarbonate 5%, 10%, with controls
pH
Time (days)
5% ox
5% ctl
10% ox
10% ctl

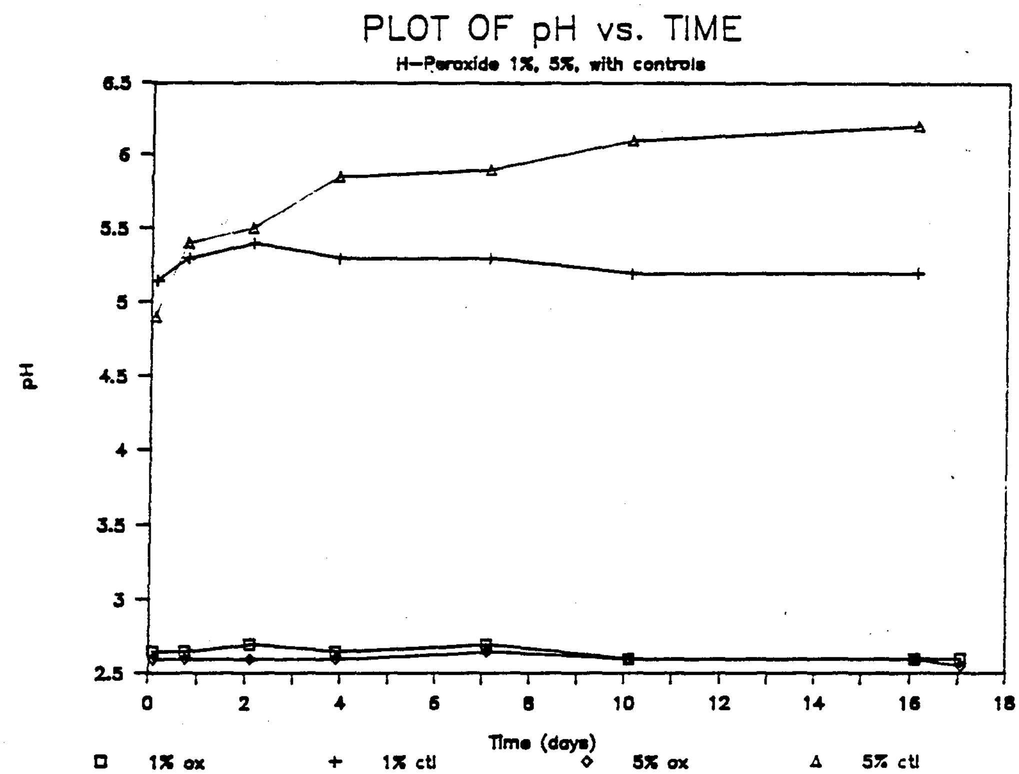

PLOT OF SPECIFIC CONDUCTANCE vs. TIME
Na-Percarbonate 5%, 10%, with controls
S.C. (umhos)
(Thousands)
Time (days)
5% ox
5% ctl
10% ox
10% ctl

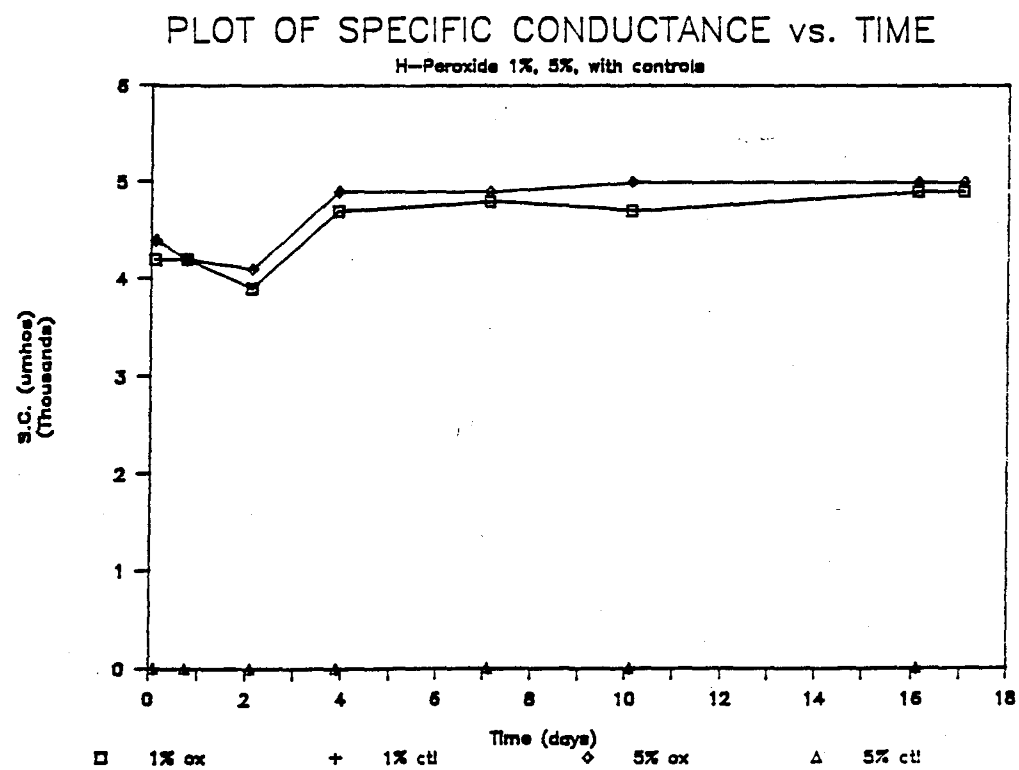

PLOT OF pH vs. TIME
Na-Perborate 1%, 3%, with controls
pH
Time (days)
1% ox
1% ctl
3% ox
3% ctl


PLOT OF SPECIFIC CONDUCTANCE vs. TIME
Na-Perborate 1%, 3%, with controls
S.C. (umhos)
(Thousands)
Time (days)
1% ox
1% ctl
3% ox
3% ctl

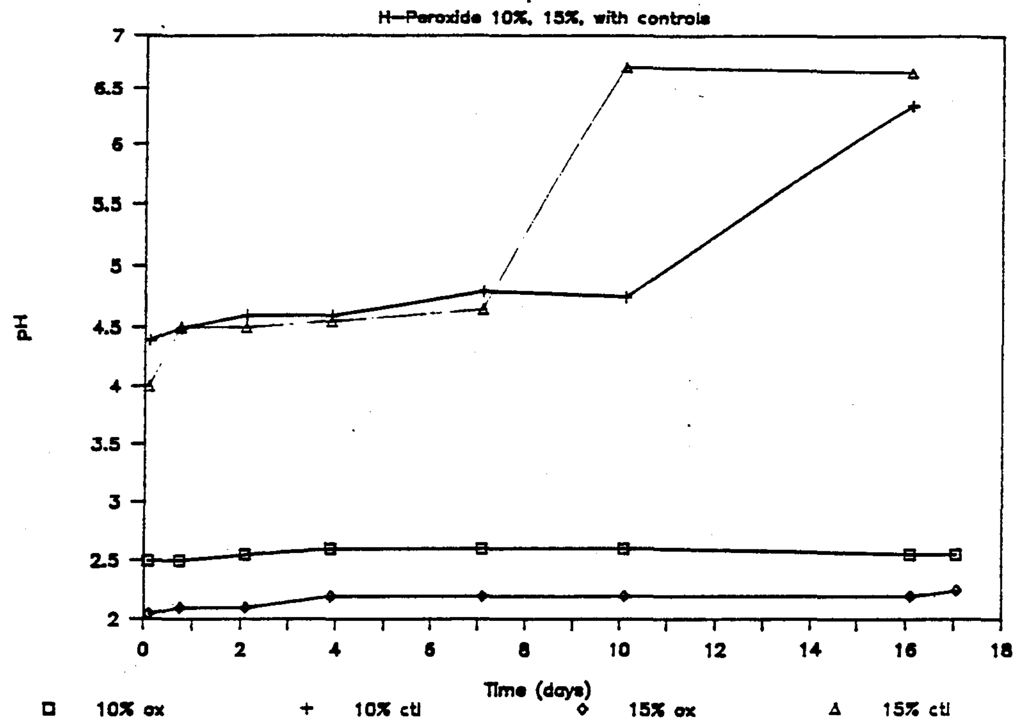

PLOT OF pH vs. TIME
Na–Perborate 5%, 10%, with controls
pH
Time (days)
5% ox
5% ctl
10% ox
10% ctl


PLOT OF SPECIFIC CONDUCTANCE vs. TIME
Na–Perborate 5%, 10%, with controls
S.C. (umhos)
(Thousands)
Time (days)
5% ox
5% ctl
10% ox
10% ctl

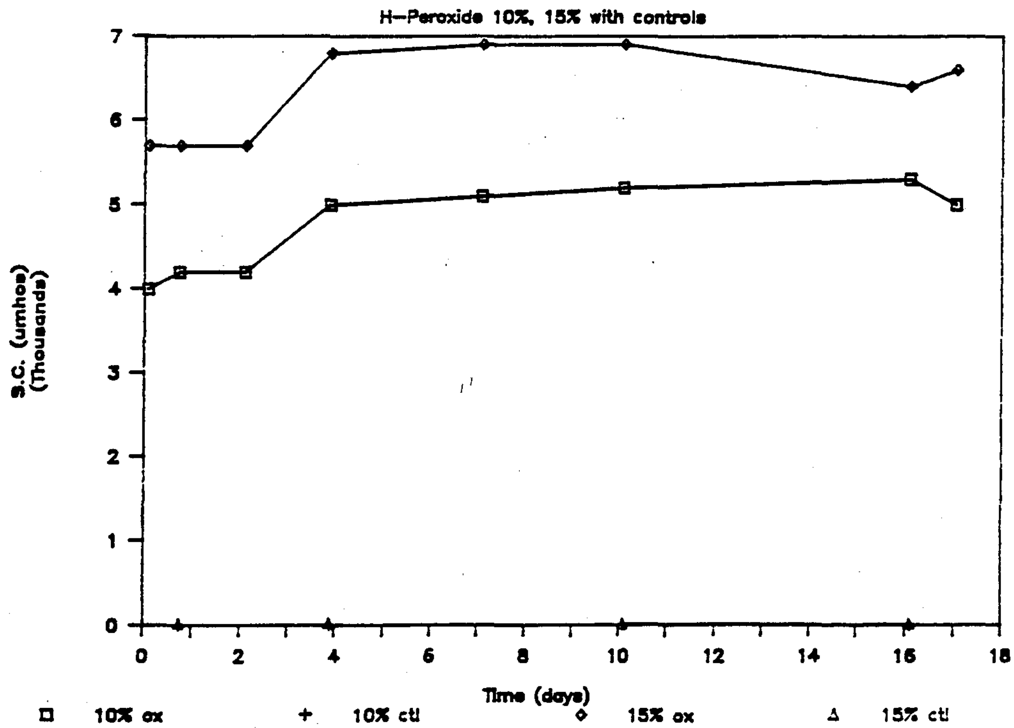

PLOT OF pH vs. TIME
H—Peroxide 1%, 5%, with controls
pH
Time (days)
1% ox
1% ctl
5% ox
5% ctl

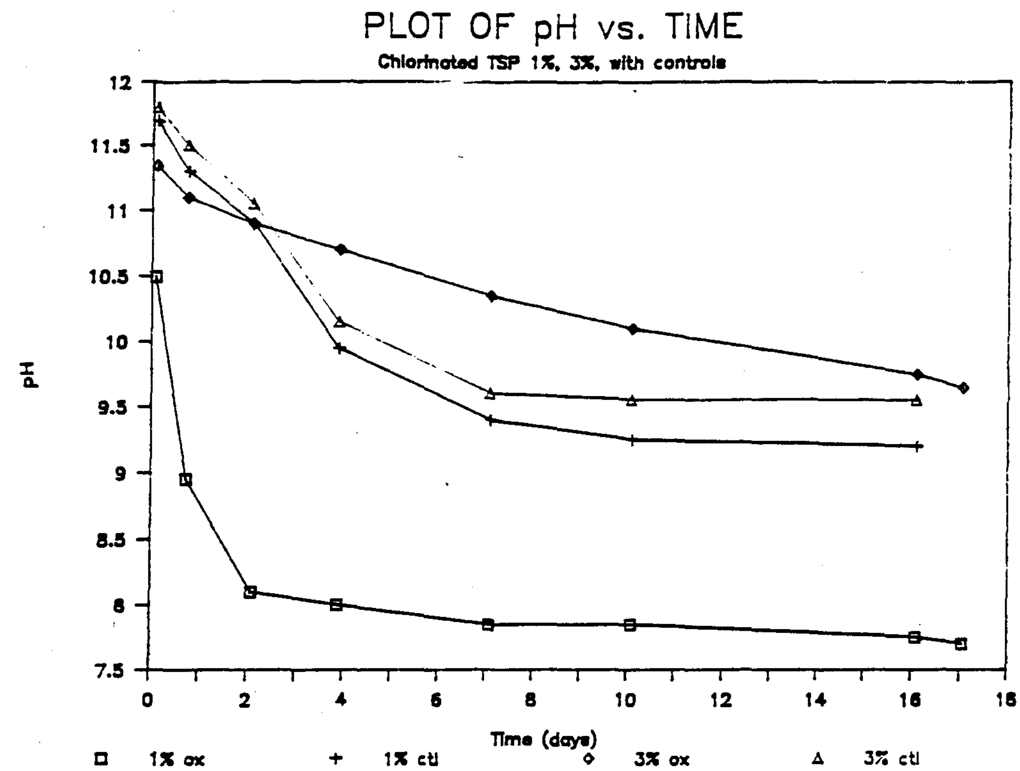

PLOT OF SPECIFIC CONDUCTANCE vs. TIME
H—Peroxide 1%, 5%, with controls
S.C. (umhos)
(Thousands)
Time (days)
1% ox
1% ctl
5% ox
5% ctl

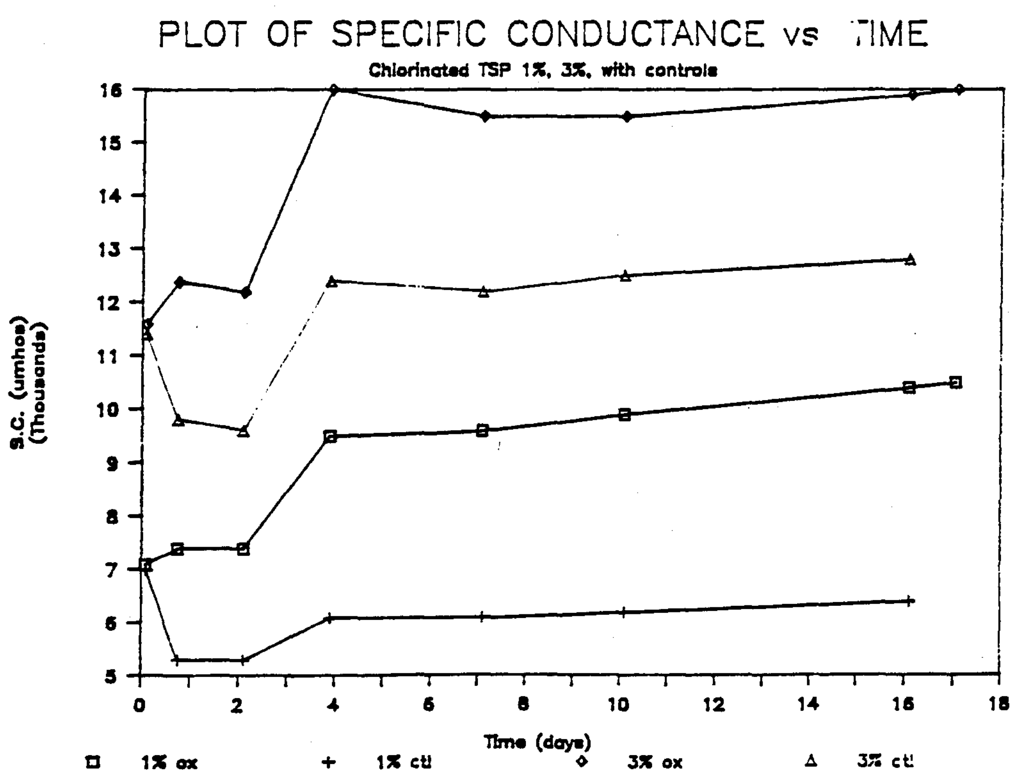
PLOT OF pH vs. TIME

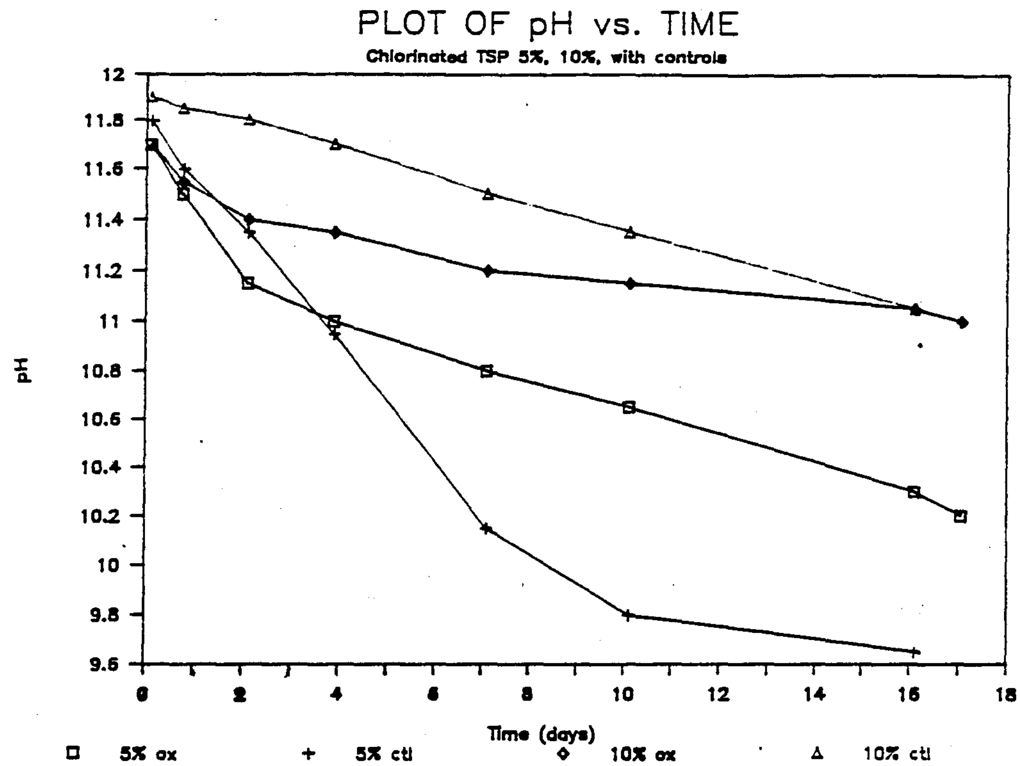


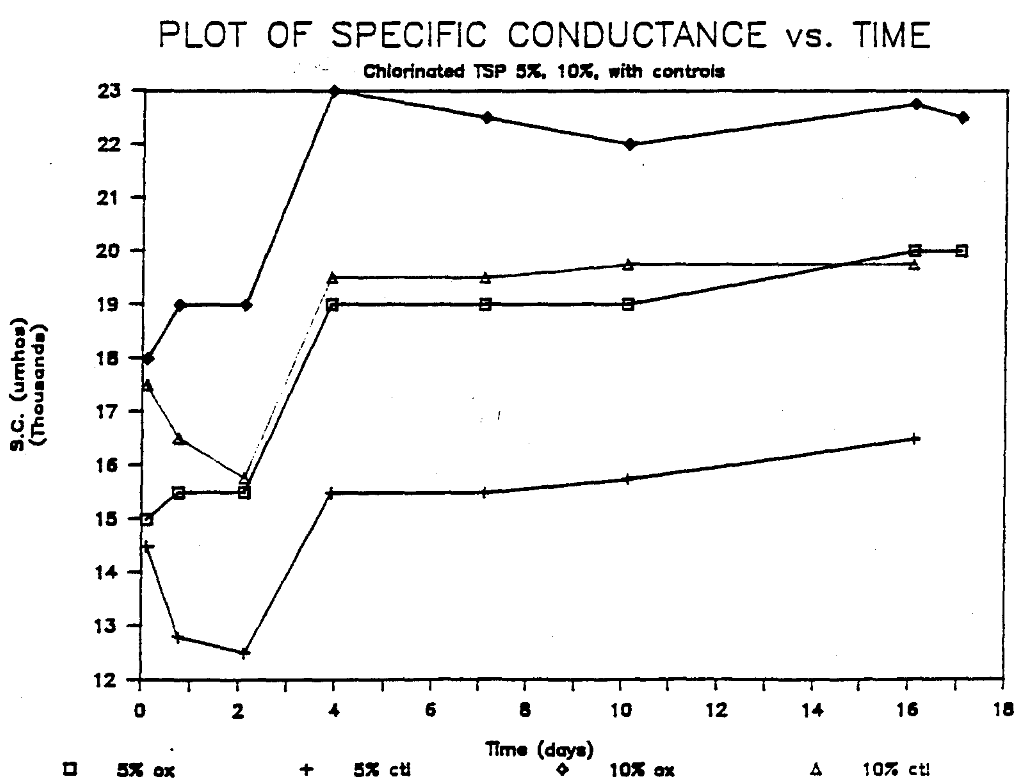
PLOT OF SPECIFIC CONDUCTANCE vs. TIME

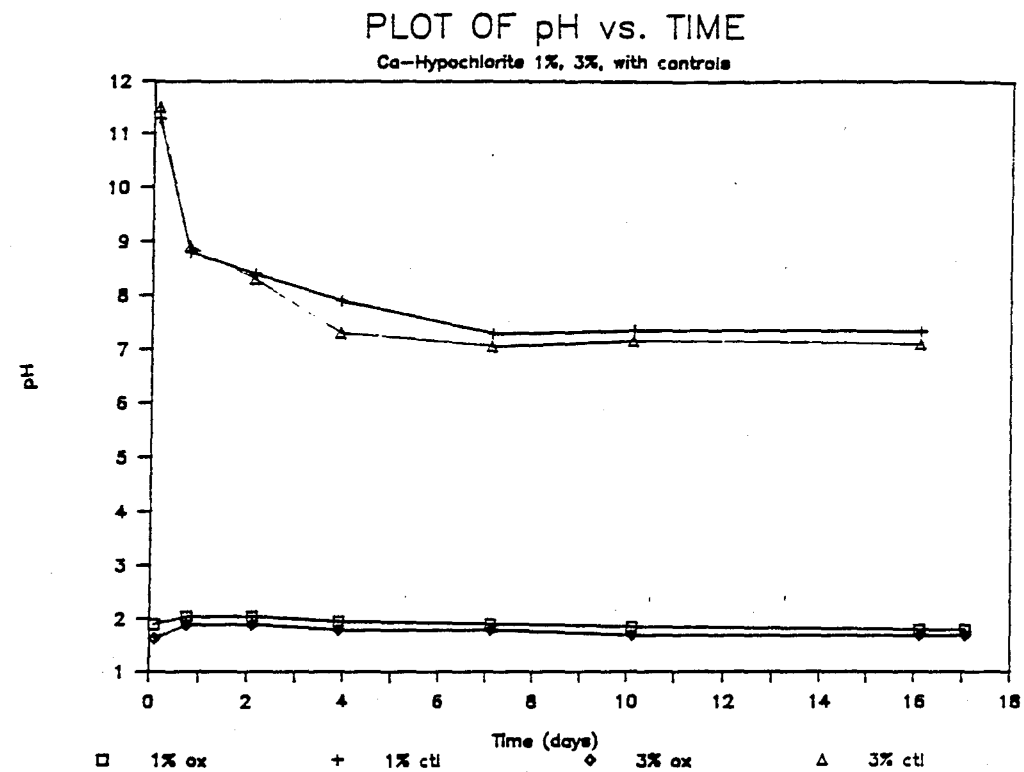


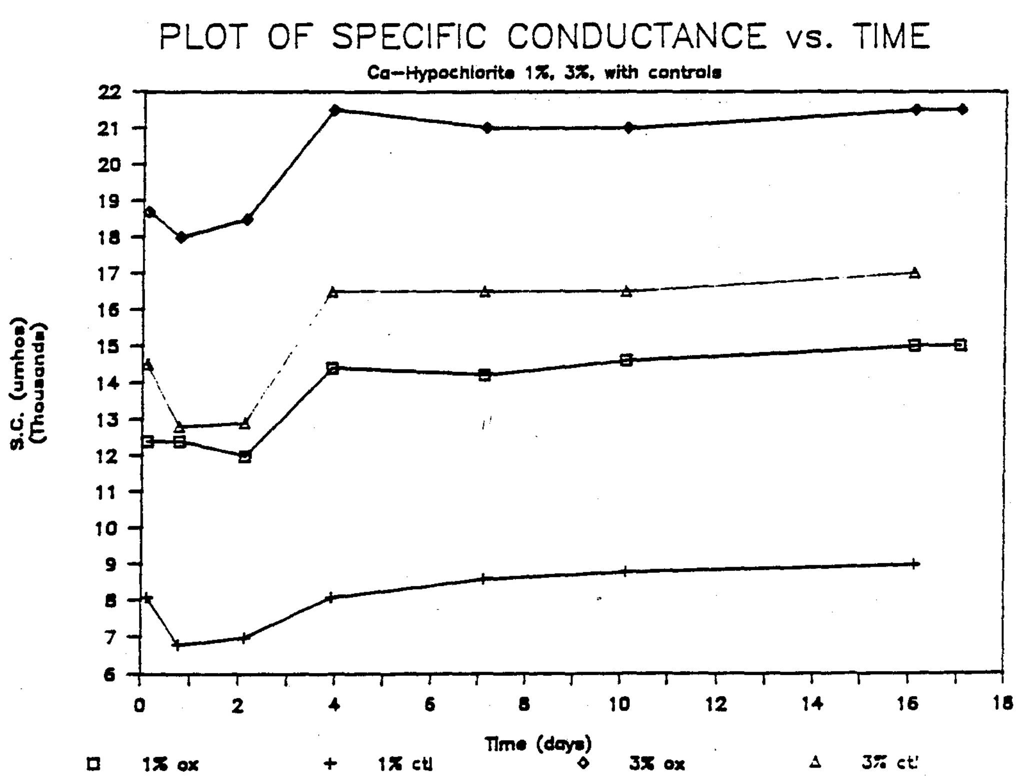

PLOT OF pH vs. TIME
Chlorinated TSP 1%, 3%, with controls
pH
Time (days)
1% ox
1% ctl
3% ox
3% ctl

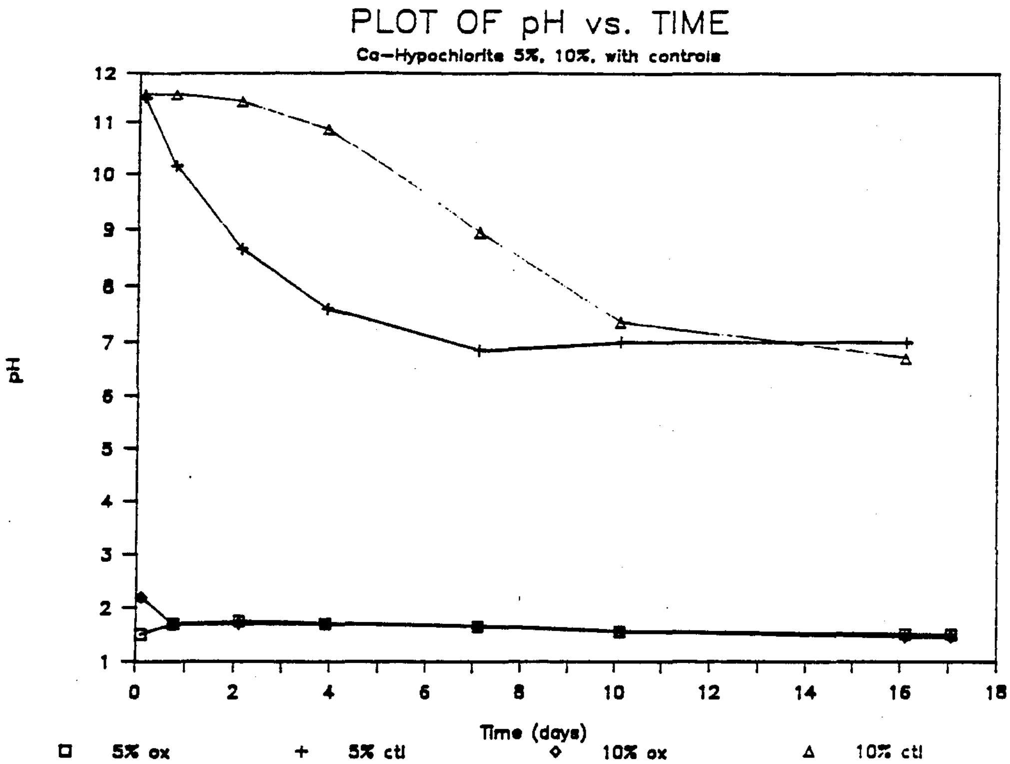

PLOT OF SPECIFIC CONDUCTANCE vs TIME
Chlorinated TSP 1%, 3%, with controls
S.C. (umhos)
(Thousands)
Time (days)
1% ox
1% ctl
3% ox
3% ctl

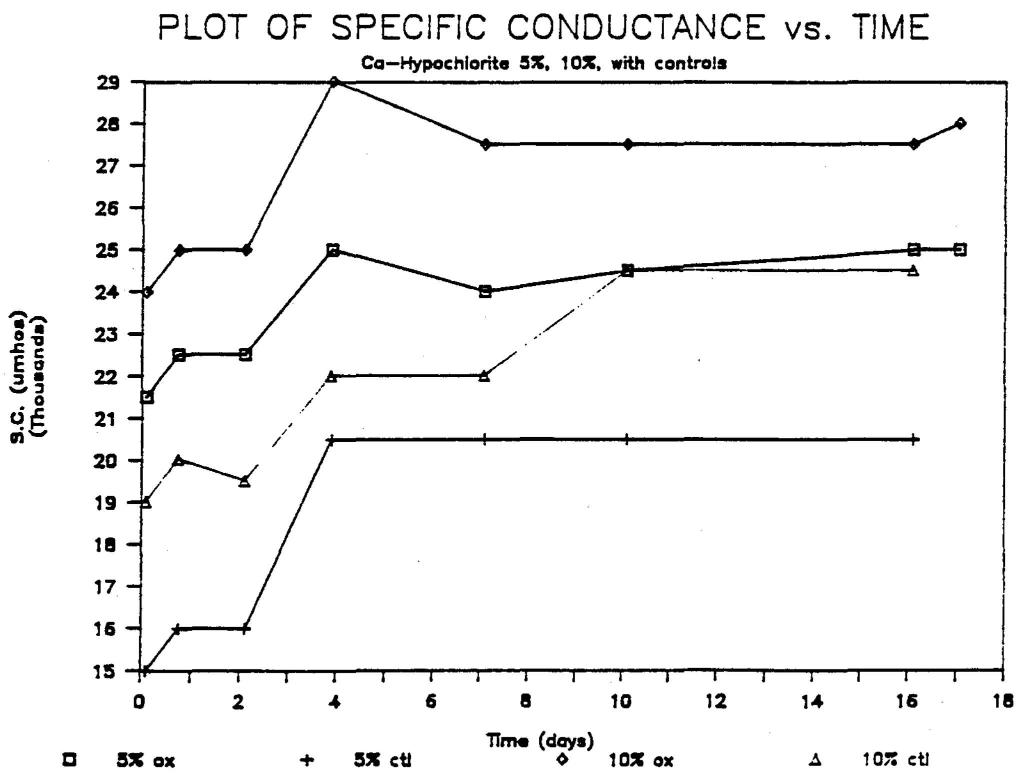

PLOT OF pH vs. TIME
Chlorinated TSP 5%, 10%, with controls
pH
12
11.8
11.6
11.4
11.2
11
10.8
10.6
10.4
10.2
10
9.8
9.6
0
2
4
6
8
10
12
14
16
18
Time (days)
5% ox
5% ctl
10% ox
10% ctl


PLOT OF SPECIFIC CONDUCTANCE vs. TIME
Chlorinated TSP 5%, 10%, with controls
S.C. (umhos)
(Thousands)
23
22
21
20
19
18
17
16
15
14
13
12
0
2
4
6
8
10
12
14
16
18
Time (days)
5% ox
5% ctl
10% ox
10% ctl


PLOT OF pH vs. TIME
Ca—Hypochlorite 1%, 3%, with controls
pH
Time (days)
1% ox
1% ctl
3% ox
3% ctl


PLOT OF SPECIFIC CONDUCTANCE vs. TIME
Ca—Hypochlorite 1%, 3%, with controls
S.C. (umhos)
(Thousands)
Time (days)
1% ox
1% ctl
3% ox
3% ctl


PLOT OF pH vs. TIME
Ca—Hypochlorite 5%, 10%, with controls
pH
12
11
10
9
8
7
6
5
4
3
2
1
0
2
4
6
8
10
12
14
16
18
Time (days)
5% ox
5% ctl
10% ox
10% ctl

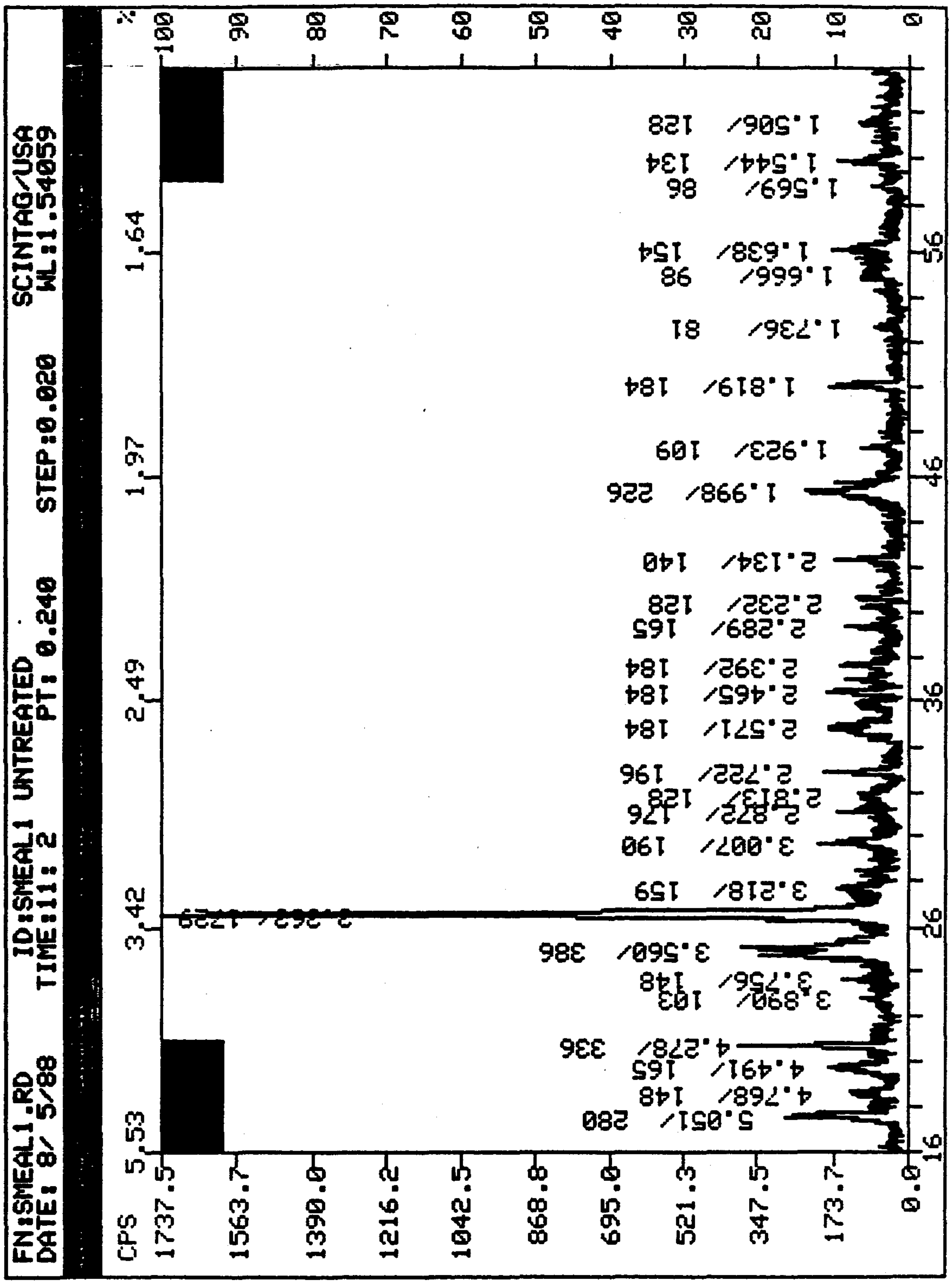

PLOT OF SPECIFIC CONDUCTANCE vs. TIME
Ca—Hypochlorite 5%, 10%, with controls
S.C. (umhos)
(Thousands)
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
0
2
4
6
8
10
12
14
16
18
Time (days)
5% ox
5% ctl
10% ox
10% ctl

*** APPENDIX B.--XRF AND XRD DATA OF EAGLE EYE AND SMEAL SAMPLES

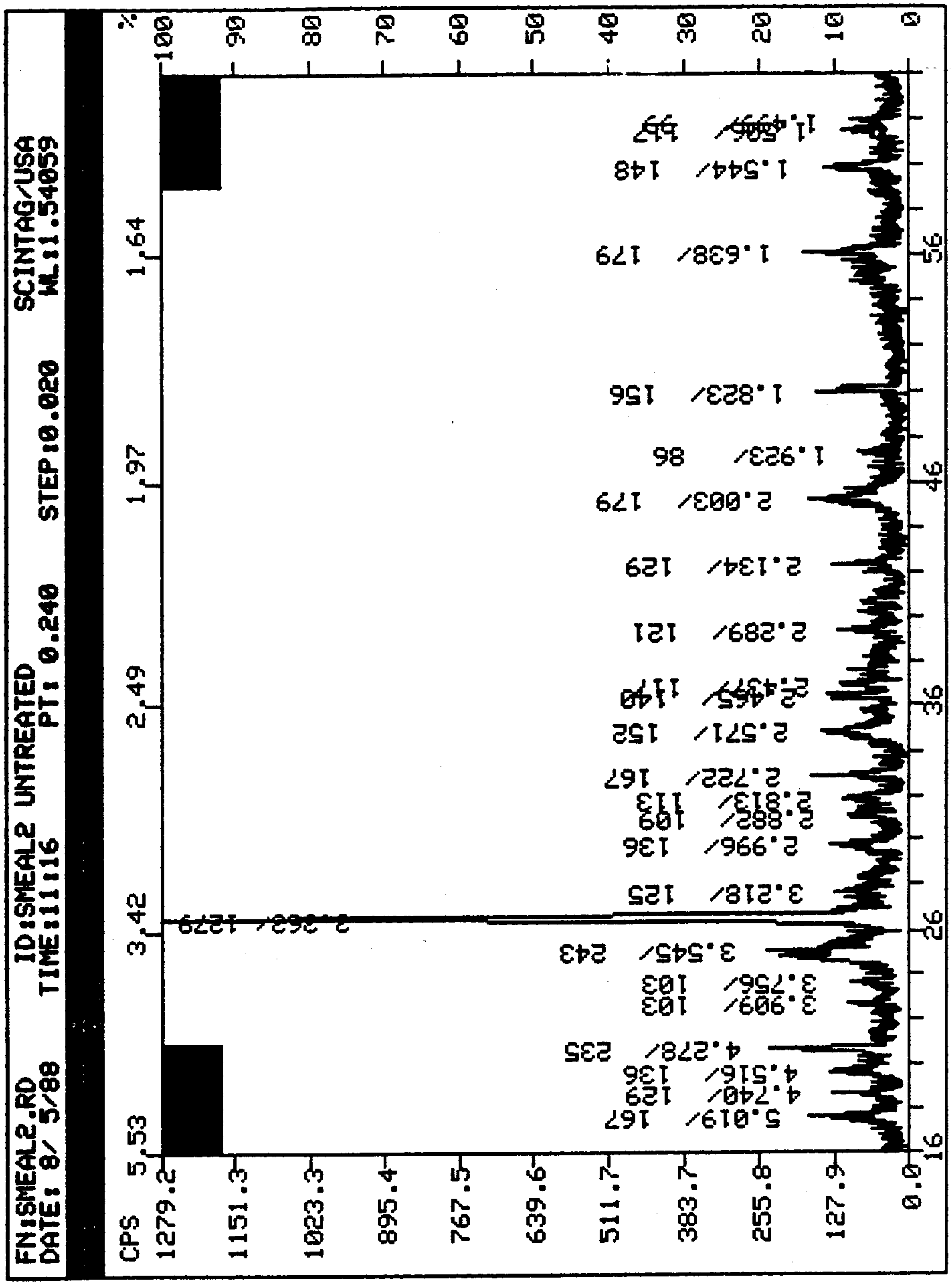
	EAGLE EYE		SMEAL	
Mineral	Mean	Std. Deviation	Mean	Std. Deviation
SiO2 (wt.%)	61.03	0.29	53.71	3.05
TiO2 "	1.69	0.04	0.96	0.02
Al2O3 "	28.12	0.34	21.96	1.30
Fe2O3 "	3.54	0.09	9.96	0.22
MnO "	0.02	0.00	0.15	0.00
MgO "	0.71	0.02	2.04	0.13
CaO "	0.26	0.08	1.12	0.62
Na2O "	0.12	0.01	0.27	0.02
K2O "	2.44	0.07	3.85	0.15
Trace Elements				
Nb (ppm)	29.63	1.87	24.25	0.97
Zr "	273.00	6.63	148.63	4.53
Y "	34.38	3.16	33.38	3.43
Sr "	2404.00	135.58	216.50	2.96
Rb "	178.50	7.97	215.13	2.32
Ni "	71.63	1.93	66.88	2.09
Cr "	110.50	1.41	85.63	2.00
V "	225.38	3.84	209.38	4.61
Sc "	23.00	1.41	16.50	1.22
Ba "	387.75	13.52	564.25	75.95
Zn "	156.38	3.20	136.50	7.11
Cu "	125.75	6.40	88.13	7.01
La "	130.13	7.46	114.25	12.68

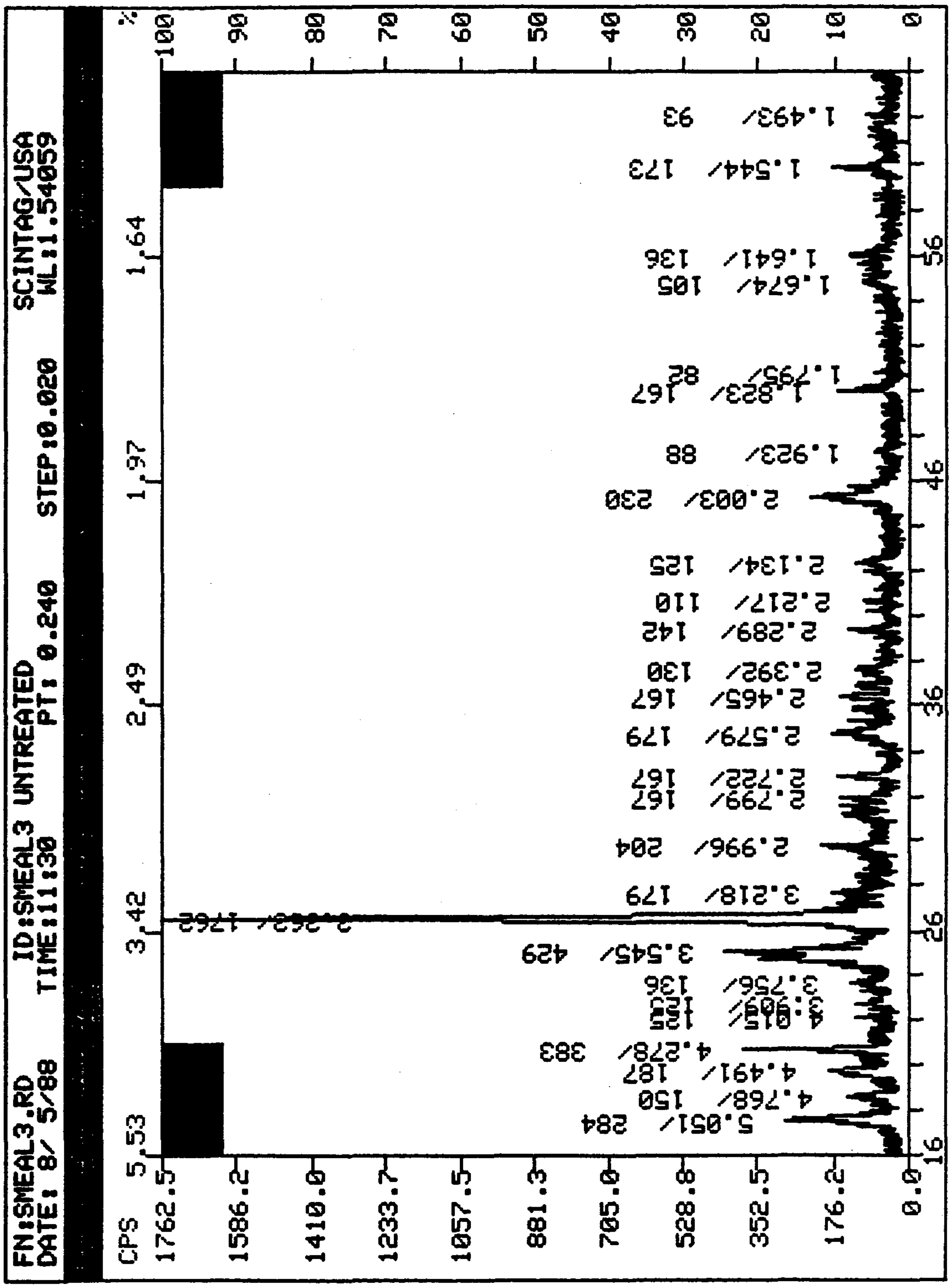
	S-1a	S-1b	S-2a	S-2b	S-3a	S-3b	S-4a	S-4b
SiO2 (wt.%)	56.6	56.3	54.9	57.1	51.3	53.7	52.3	47.5
TiO2 "	0.98	0.98	0.98	0.99	0.93	0.95	0.95	0.93
Al2O3 "	23.12	23.09	22.67	23.36	20.84	22.02	21.25	19.36
Fe2O3 "	9.84	9.74	9.92	9.71	10.16	9.9	9.96	10.43
MnO "	0.15	0.15	0.15	0.15	0.15	0.15	0.14	0.14
MgO "	2.15	2.14	2.13	2.2	1.94	2.03	1.9	1.8
CaO "	0.51	0.58	0.77	0.43	1.74	1.13	1.52	2.26
Na2O "	0.28	0.28	0.27	0.27	0.29	0.3	0.28	0.22
K2O "	4.01	3.98	3.91	4.00	3.74	3.84	3.78	3.54
Nb (ppm)	23	24	26	24	25	25	23	24
Zr "	147	150	146	144	147	144	153	158
Y "	31	36	31	30-	38	31	31	39
Sr "	214	222	219	212	215	215	218	217
Rb "	214	211	214	215	218	215	215	219
Ni "	64	66	65	66	67	71	69	67
Cr "	84	85	89	85	87	83	84	88
V "	213	213	212	216	203	209	206	203
Sc "	15	18	18	16	15	16	16	18
Ba "	642	633	602	639	505	557	524	412
Zn "	129	132	149	143	131	128	141	139
Cu "	89	82	85	79	101	84	88	97
La "	97	106	127	109	99	133	117	126

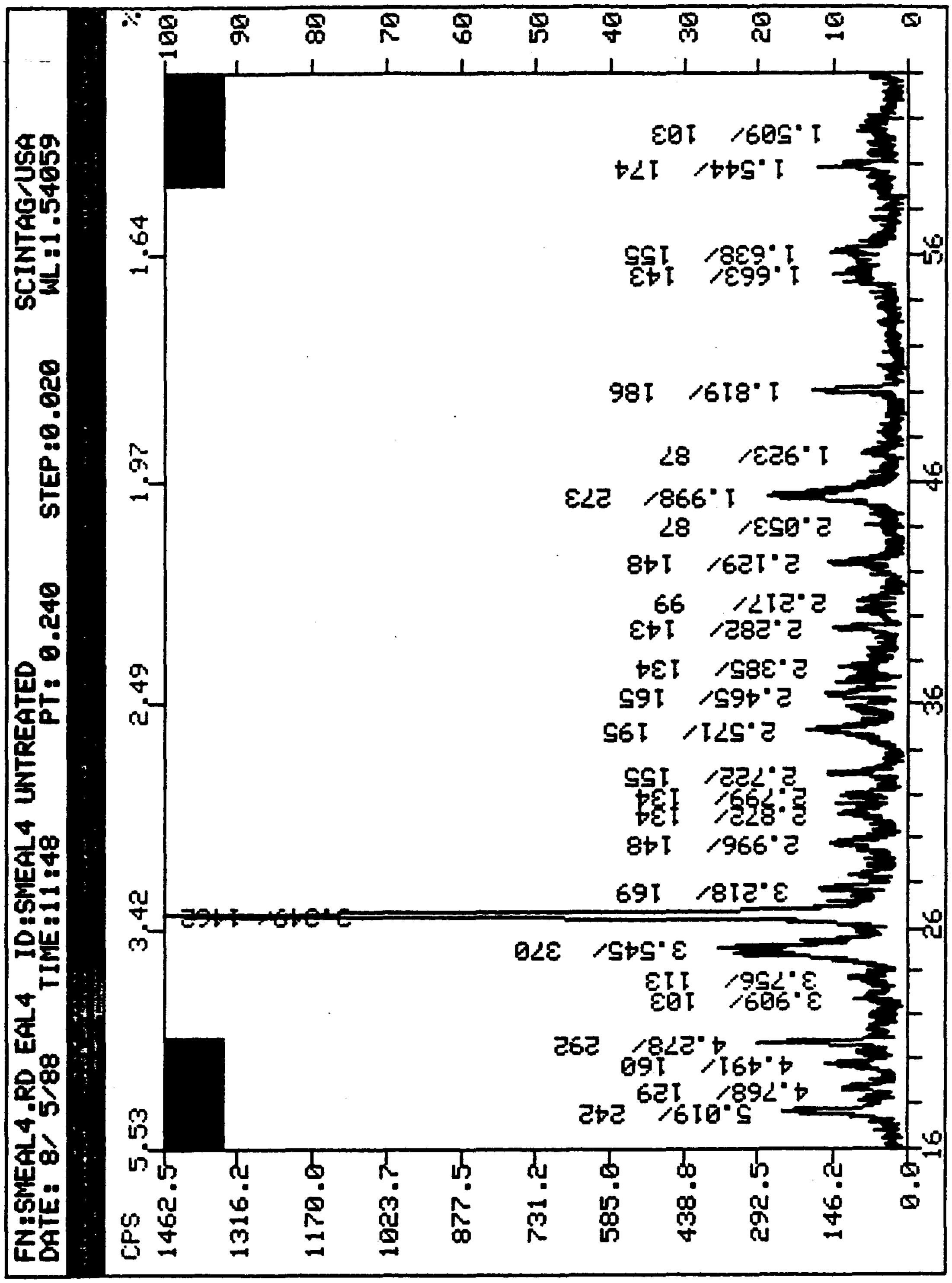
	EE-1a	EE-1b	EE-2a	EE-2b	EE-3a	EE-3b	EE-4a	EE-4b
SiO2 (wt.%)	61.5	60.9	61.3	61.1	60.8	61.2	60.9	60.5
TiO2 "	1.76	1.75	1.66	1.65	1.69	1.7	1.65	1.65
Al2O3 "	28.74	28.61	28.06	27.96	27.74	27.9	28.16	27.81
Fe2O3 "	3.44	3.48	3.47	3.44	3.59	3.56	3.65	3.68
MnO "	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
MgO "	0.69	0.68	0.71	0.72	0.71	0.69	0.71	0.73
CaO "	0.19	0.3	0.14	0.26	0.37	0.18	0.27	0.38
Na2O "	0.13	0.11	0.11	0.1	0.14	0.12	0.11	0.1
K2O "	2.31	2.31	2.47	2.47	2.48	2.49	2.5	2.48
Nb (ppm)	32	32	26	29	31	29	29	29
Zr "	282	283	269	270	276	274	267	263
Y "	34	33	32	32	32	36	42	34
Sr "	2459	2470	2591	2591	2330	2322	2228	2241
Rb "	164	166	182	186	182	182	181	185
Ni "	74	74	70	69	71	70	71	74
Cr "	112	113	110	108	111	110	110	110
V "	220	223	229	231	225	230	222	223
Sc "	22	25	21	24	23	24	21	24
Ba "	386	360	410	398	387	388	393	380
Zn "	154	156	152	159	158	152	159	161
Cu "	126	140	123	123	130	122	117	125
La "	131	135	135	134	116	135	136	119

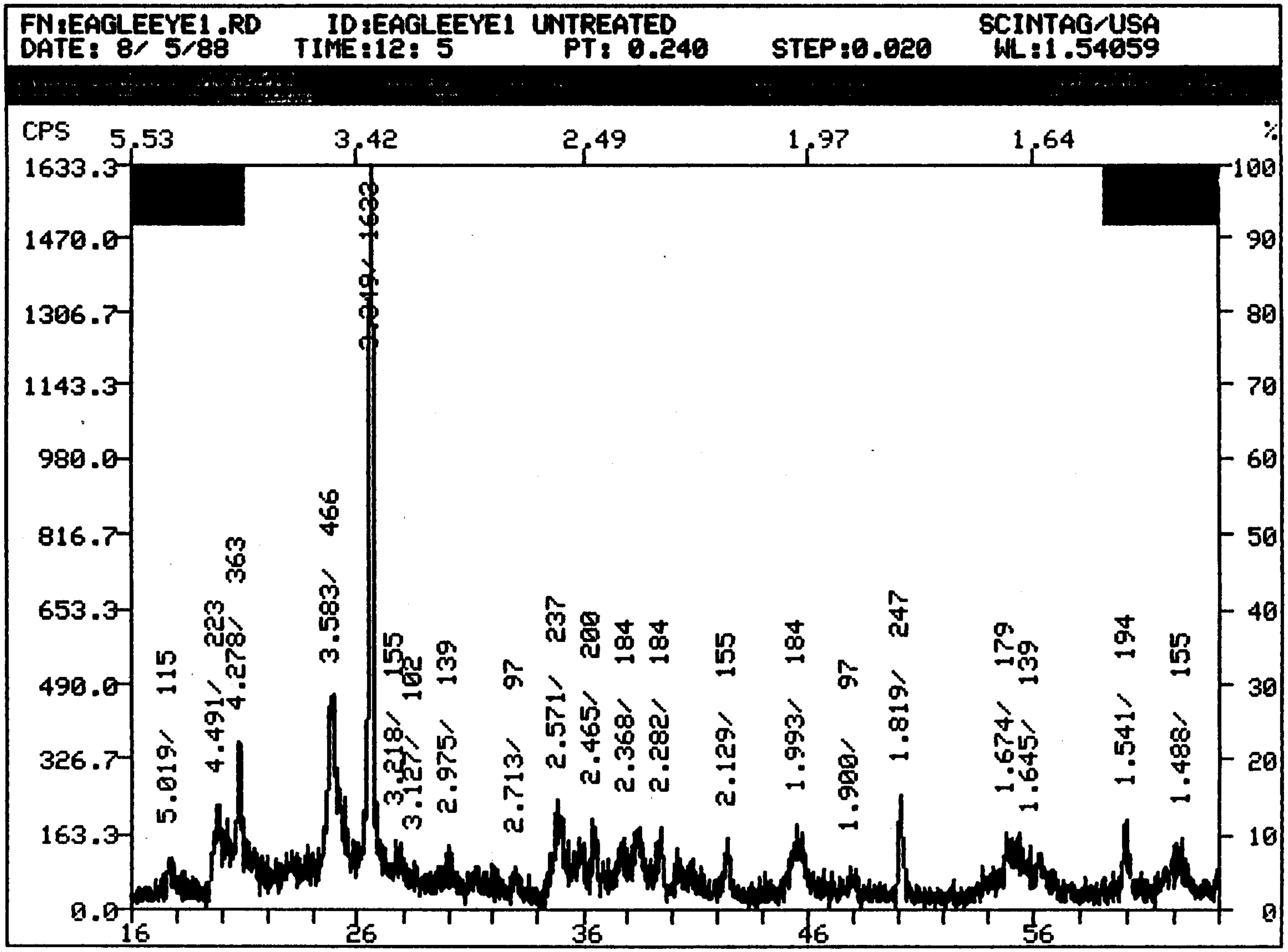


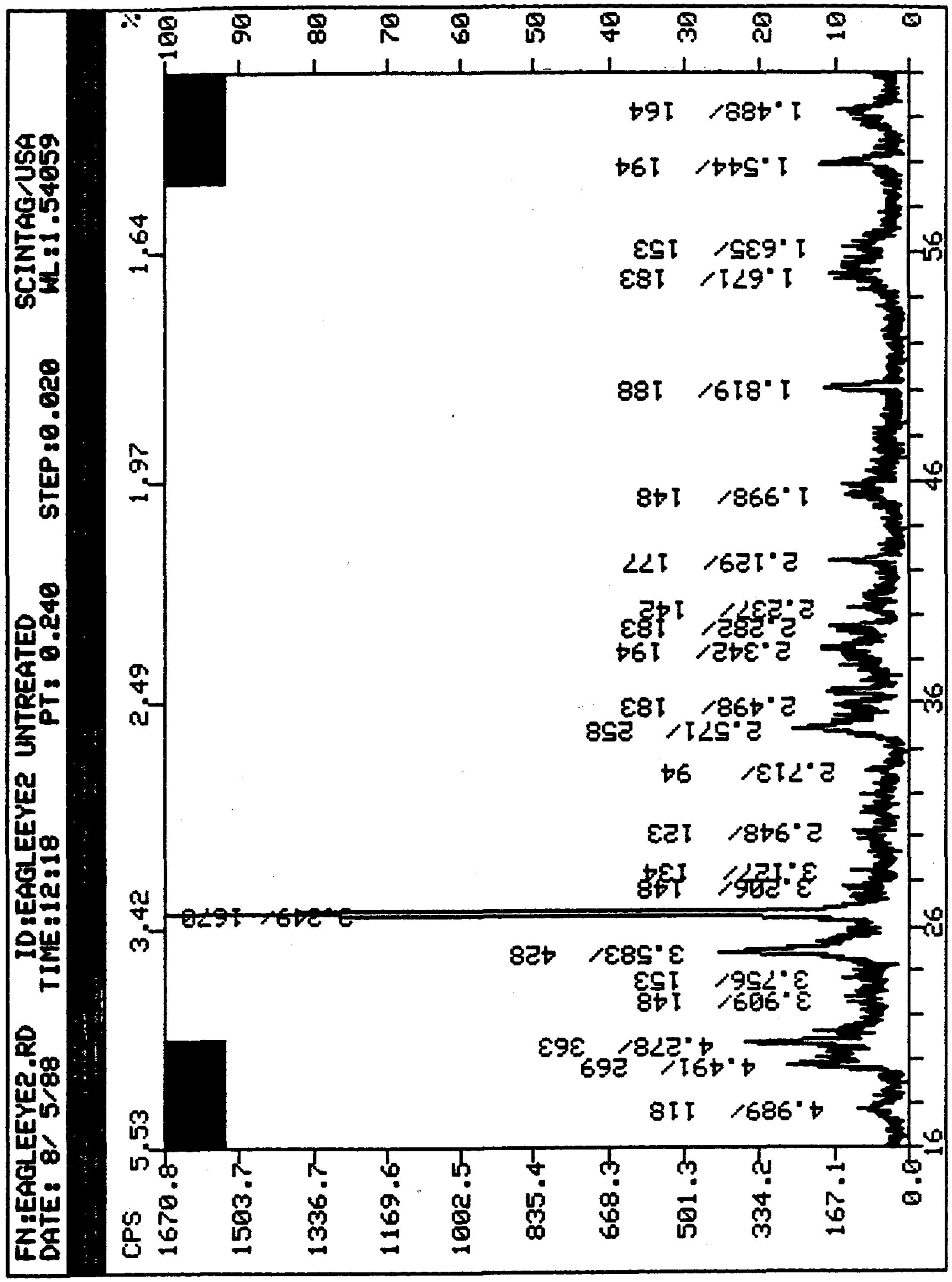
FN:SMEAL1.RD
DATE: 8/ 5/88
ID:SMEAL1 UNTREATED
TIME:11: 2
PT: 0.240
STEP:0.020
SCINTAG/USA
WL:1.54059
CPS
1737.5
1563.7
1390.0
1216.2
1042.5
868.8
695.0
521.3
347.5
173.7
0.0
%
100
90
80
70
60
50
40
30
20
10
0
5.53
3.42
2.49
1.97
1.64
16
26
36
46
56
5.051/ 280
4.768/ 148
4.491/ 165
4.278/ 336
3.890/ 103
3.756/ 148
3.560/ 386
3.218/ 159
3.007/ 190
2.722/ 196
2.571/ 184
2.465/ 184
2.392/ 184
2.289/ 165
2.232/ 128
2.134/ 140
1.998/ 226
1.923/ 109
1.819/ 184
1.736/ 81
1.666/ 98
1.638/ 154
1.569/ 86
1.544/ 134
1.506/ 128

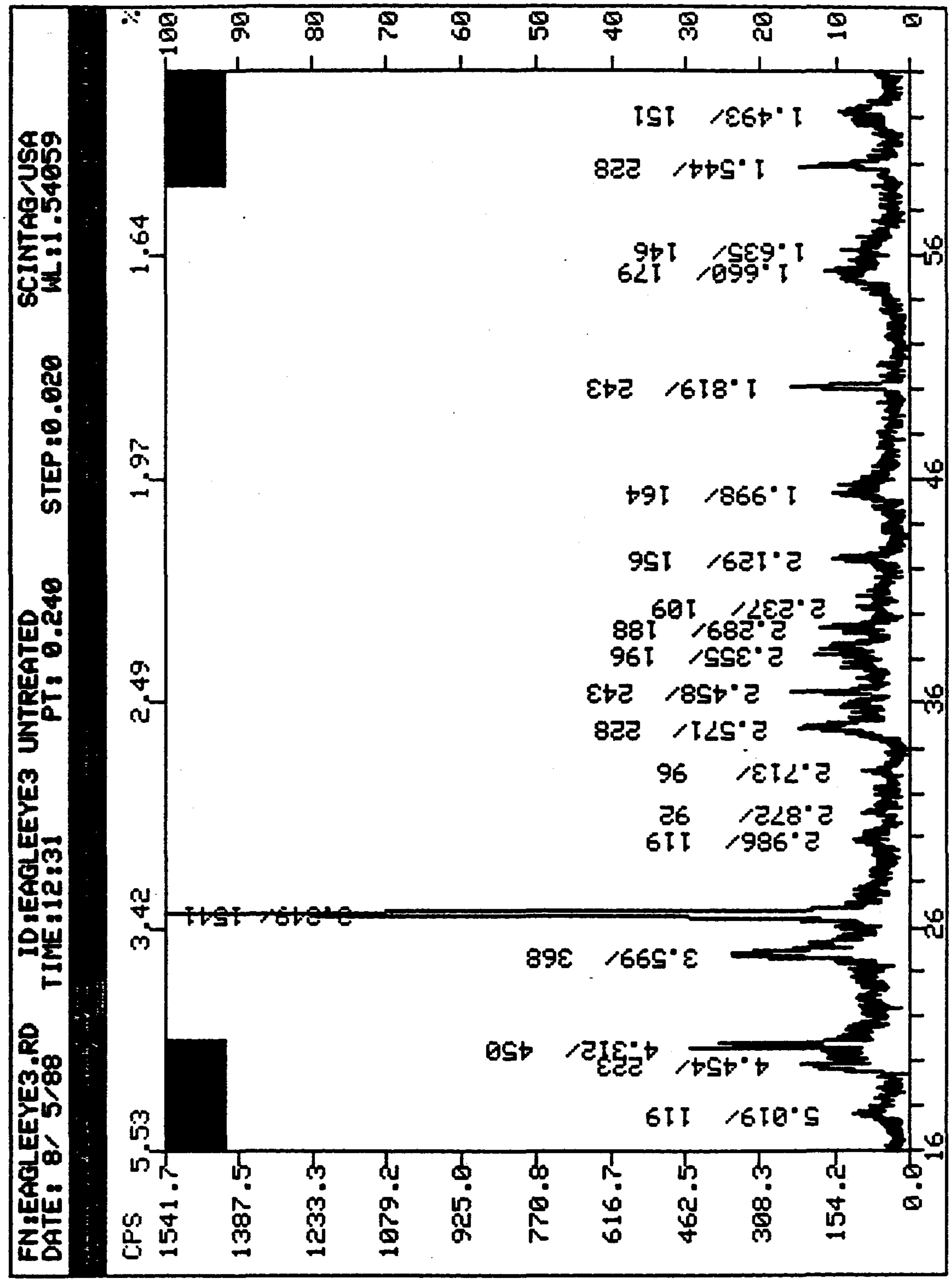

FN:SMEAL2.RD
DATE: 8/ 5/88
ID:SMEAL2 UNTREATED
TIME:11:16
PT: 0.240
STEP:0.020
SCINTAG/USA
WL:1.54059
CPS
%
3.363/ 1279
3.545/ 243
4.278/ 235
3.218/ 125
2.996/ 136
2.722/ 167
2.571/ 152
2.289/ 121
2.134/ 129
2.003/ 179
1.923/ 86
1.823/ 156
1.638/ 179
1.544/ 148
5.019/ 167
4.740/ 129
4.516/ 136
3.909/ 103
3.756/ 103


FN:SMEAL3.RD
DATE: 8/ 5/88
ID:SMEAL3 UNTREATED
TIME:11:30
PT: 0.240
STEP:0.020
SCINTAG/USA
WL:1.54059
CPS
%
5.051/ 284
4.768/ 150
4.491/ 187
4.278/ 383
4.015/ 125
3.909/ 125
3.756/ 136
3.545/ 429
3.362/ 1762
3.218/ 179
2.996/ 204
2.799/ 167
2.722/ 167
2.579/ 179
2.465/ 167
2.392/ 130
2.289/ 142
2.217/ 110
2.134/ 125
2.003/ 230
1.923/ 88
1.823/ 167
1.795/ 82
1.674/ 105
1.641/ 136
1.544/ 173
1.493/ 93


FN:SMEAL4.RD EAL4 ID:SMEAL4 UNTREATED SCINTAG/USA
DATE: 8/ 5/88 TIME:11:48 PT: 0.240 STEP:0.020 WL:1.54059
CPS
%


FN:EAGLEEYE1.RD
ID:EAGLEEYE1 UNTREATED
SCINTAG/USA
DATE: 8/ 5/88
TIME:12: 5
PT: 0.240
STEP:0.020
WL:1.54059
CPS
%
5.53
3.42
2.49
1.97
1.64
1633.3
1470.0
1306.7
1143.3
980.0
816.7
653.3
490.0
326.7
163.3
0.0
100
90
80
70
60
50
40
30
20
10
0
16
26
36
46
56
5.019/ 115
4.491/ 223
4.278/ 363
3.583/ 466
3.349/ 1633
3.218/ 155
3.127/ 102
2.975/ 139
2.713/ 97
2.571/ 237
2.465/ 200
2.368/ 184
2.282/ 184
2.129/ 155
1.993/ 184
1.900/ 97
1.819/ 247
1.674/ 179
1.645/ 139
1.541/ 194
1.488/ 155


FN:EAGLEEYE2.RD ID:EAGLEEYE2 UNTREATED SCINTAG/USA
DATE: 8/ 5/88 TIME:12:18 PT: 0.240 STEP:0.020 WL:1.54059
CPS
%
3.249/ 1670
3.583/ 428
4.278/ 363
4.491/ 269
2.571/ 258
4.989/ 118
3.909/ 148
3.756/ 153
3.206/ 148
3.127/ 134
2.948/ 123
2.713/ 94
2.498/ 183
2.342/ 194
2.282/ 183
2.237/ 142
2.129/ 177
1.998/ 148
1.819/ 188
1.671/ 183
1.635/ 153
1.544/ 194
1.488/ 164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770.8
616.7
462.5
308.3
154.2
0.0
%
100
90
80
70
60
50
40
30
20
10
0
5.53
3.42
2.49
1.97
1.64
16
26
36
46
56
5.019/ 119
4.454/ 223
4.312/ 450
3.599/ 368
3.019/ 1541
2.986/ 119
2.872/ 92
2.713/ 96
2.571/ 228
2.458/ 243
2.355/ 196
2.289/ 188
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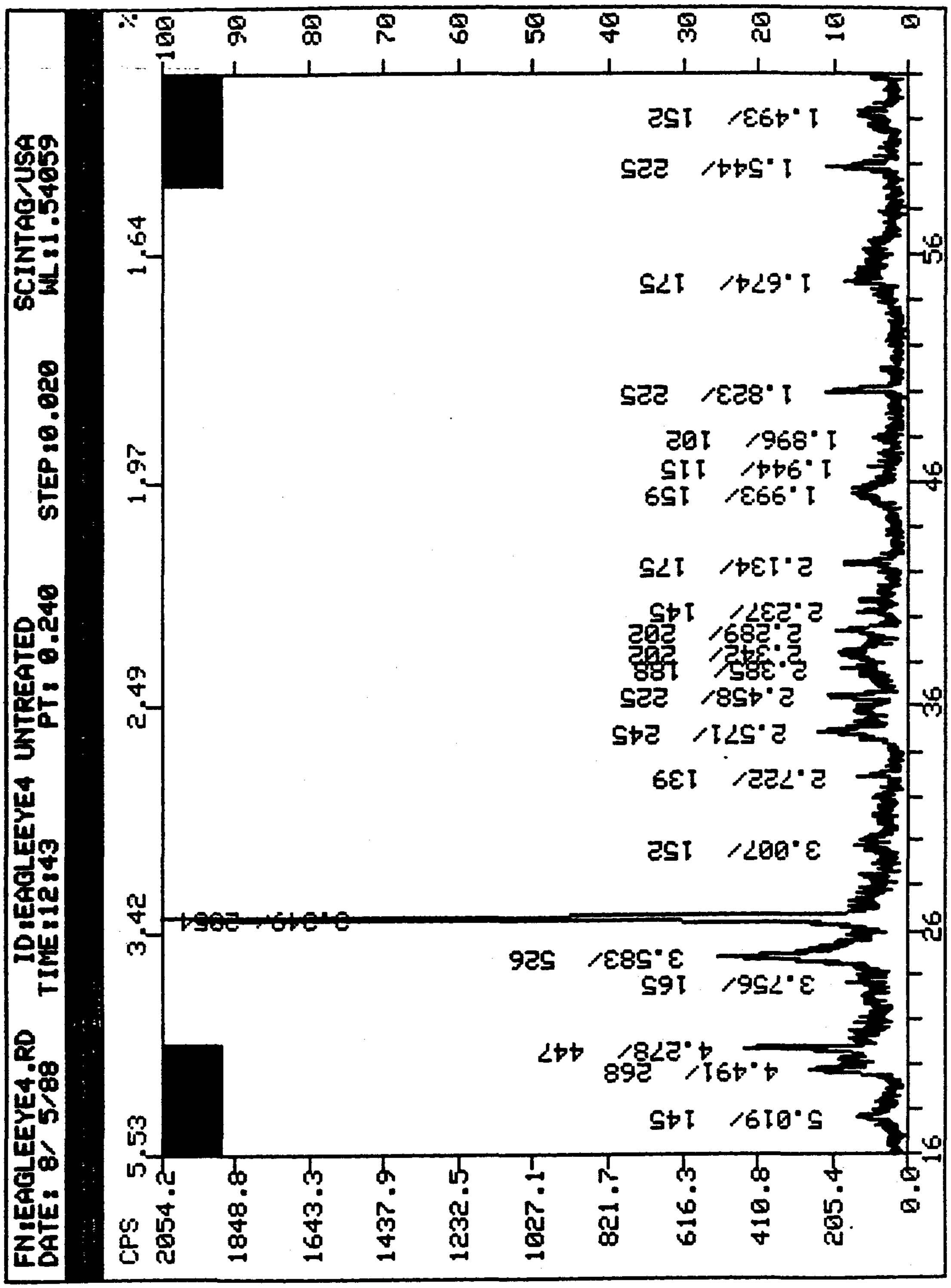
1.493/ 151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1232.5
1027.1
821.7
616.3
410.8
205.4
0.0
%
100
90
80
70
60
50
40
30
20
10
0
5.53
3.42
2.49
1.97
1.64
16
26
36
46
56
5.019/ 145
4.491/ 268
4.278/ 447
3.756/ 165
3.583/ 526
3.007/ 152
2.722/ 139
2.571/ 245
2.458/ 225
2.385/ 188
2.342/ 202
2.289/ 202
2.237/ 145
2.134/ 175
1.993/ 159
1.944/ 115
1.896/ 102
1.823/ 225
1.674/ 175
1.544/ 225
1.493/ 152

*** APPENDIX C.--DATA MATRIX FOR EAGLE EYE AND SMEAL COLUMN SAMPLES USING CALCIUM HYPOCHLORITE

LEACHING COLUMN EAGLE EYE-1
14300 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
24-Aug-88	0	4.50	220.0	1050.0	3.13	0.00	3.1	3.1	12.85	12.85
30-Aug-88	6	3.40	173.0	4400.0	16.51	0.00	16.5	19.6	35.81	48.66
06-Sep-88	13	3.15	169.0	3800.0	13.96	0.00	14.0	33.6	26.59	75.25
13-Sep-88	20	2.70	217.0	3950.0	15.14	0.00	15.1	48.7	32.63	107.87
20-Sep-88	27	2.50	172.0	4500.0	16.42	0.00	16.4	65.2	38.49	146.36
27-Sep-88	34	2.40	270.0	5300.0	52.87	0.00	52.9	118.0	65.14	211.50
04-Oct-88	41	2.50	250.0	7600.0	114.95	0.00	114.9	233.0	136.36	347.87
13-Oct-88	50	2.00	246.0	11000.0	338.03	0.00	338.0	571.0	289.01	636.87
21-Oct-88	58	1.95	265.0	12500.0	430.86	0.00	430.9	1001.9	383.60	1020.47
26-Oct-88	63	2.00	230.0	12100.0	321.68	0.00	321.7	1323.6	315.24	1335.72
28-Oct-88	65	2.15	300.0	11000.0	199.30	0.00	199.3	1522.9	144.13	1479.84
31-Oct-88	68	2.00	858.0	9900.0	390.00	0.00	390.0	1912.9	287.10	1766.94
02-Nov-88	70	2.20	285.0	7800.0	67.26	0.00	67.3	1980.1	53.06	1820.01
04-Nov-88	72	2.30	291.0	7500.0	55.96	0.00	56.0	2036.1	47.90	1867.91
07-Nov-88	75	2.75	560.0	7400.0	97.90	0.00	97.9	2134.0	79.15	1947.07
09-Nov-88	77	3.00	310.0	6500.0	46.07	0.00	46.1	2180.0	36.22	1983.29
11-Nov-88	79	2.40	276.0	6700.0	36.19	0.00	36.2	2216.2	32.65	2015.94
14-Nov-88	82	2.45	790.0	6800.0	82.87	0.00	82.9	2299.1	85.05	2100.99
16-Nov-88	84	2.55	275.0	6300.0	26.44	0.00	26.4	2325.5	28.27	2129.26
21-Nov-88	89	2.80	490.0	6100.0	34.27	0.00	34.3	2359.8	45.89	2175.14
23-Nov-88	91	2.80	267.0	6500.0	14.94	0.00	14.9	2374.8	23.98	2199.12
28-Nov-88	96	3.10	1083.0	6200.0	49.23	0.00	49.2	2424.0	92.02	2291.14
01-Dec-88	99	2.65	290.0	6350.0	18.25	0.00	18.3	2442.2	23.93	2315.08
03-Dec-88	101	2.90	556.0	5850.0	27.22	0.00	27.2	2469.5	45.63	2360.71
06-Dec-88	104	3.00	218.0	6000.0	9.91	0.00	9.9	2479.4	17.94	2378.65
13-Dec-88	111	3.25	214.0	5300.0	8.23	0.00	8.2	2487.6	16.88	2395.53
17-Dec-88	115	3.10	815.0	5400.0	31.35	0.00	31.3	2518.9	39.72	2435.25
29-Dec-88	127	2.90	213.0	5600.0	8.94	0.00	8.9	2527.9	16.80	2452.05
04-Jan-89	133	3.05	212.0	5700.0	9.64	0.00	9.6	2537.5	13.26	2465.30
11-Jan-89	140	3.05	220.0	6150.0	11.54	0.00	11.5	2549.1	13.35	2478.66
18-Jan-89	147	2.85	194.0	6000.0	10.17	0.00	10.2	2559.2	12.66	2491.32
25-Jan-89	154	2.90	198.0	6000.0	8.65	0.00	8.7	2567.9	13.93	2505.25
02-Feb-89	162	2.80	197.0	7000.0	12.05	0.00	12.1	2579.9	13.86	2519.11
08-Feb-89	168	2.75	220.0	6600.0		0.00			15.68	2534.80
17-Feb-89	177	2.90	234.0	6700.0		0.00			17.56	2552.35
23-Feb-89	183	2.90	204.0	6050.0		0.00			15.31	2567.66
02-Mar-89	190	2.90	219.0	6100.0		0.00			16.43	2584.09

LEACHING COLUMN EAGLE EYE-2
12720 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
24-Aug-88	0	3.60	265.0	1500.0	9.41	0.00	9.4	9.4	22.92	22.92
30-Aug-88	6	3.40	171.0	4250.0	16.23	0.00	16.2	25.6	43.02	65.94
06-Sep-88	13	3.05	170.0	3800.0	15.79	0.00	15.8	41.4	28.07	94.00
13-Sep-88	20	2.65	215.0	4000.0	16.86	0.00	16.9	58.3	33.81	127.81
20-Sep-88	27	2.50	165.0	5000.0	25.54	0.00	25.5	83.8	46.05	173.86
27-Sep-88	34	2.20	283.0	9000.0	206.35	0.00	206.4	290.2	240.28	414.14
04-Oct-88	41	2.35	271.0	10500.0	379.23	0.00	379.2	669.4	373.90	788.04
13-Oct-88	50	1.85	242.0	14000.0	606.90	0.00	606.9	1276.3	494.65	1282.70
21-Oct-88	58	1.85	260.0	14500.0	602.99	0.00	603.0	1879.3	547.80	1830.50
26-Oct-88	63	2.00	227.0	13000.0	437.22	0.00	437.2	2316.5	460.42	2290.92
28-Oct-88	65	2.05	300.0	12000.0	288.92	0.00	288.9	2605.4	270.28	2561.20
31-Oct-88	68	2.00	845.0	10500.0	465.02	0.00	465.0	3070.5	421.01	2982.21
02-Nov-88	70	2.15	290.0	8800.0	91.19	0.00	91.2	3161.7	72.24	3054.45
04-Nov-88	72	2.20	291.0	8100.0	74.35	0.00	74.4	3236.0	59.92	3114.37
07-Nov-88	75	2.70	510.0	8200.0	125.29	0.00	125.3	3361.3	99.99	3214.35
09-Nov-88	77	2.90	271.0	7200.0	53.26	0.00	53.3	3414.6	40.91	3255.26
11-Nov-88	79	2.85	245.0	7300.0	40.93	0.00	40.9	3455.5	34.49	3289.75
14-Nov-88	82	2.40	815.0	7200.0	128.14	0.00	128.1	3583.6	93.23	3382.98
16-Nov-88	84	2.60	274.0	6200.0	29.62	0.00	29.6	3613.2	31.66	3414.64
21-Nov-88	89	2.40	495.0	6950.0	56.43	0.00	56.4	3669.7	55.20	3469.84
23-Nov-88	91	2.50	269.0	7200.0	27.49	0.00	27.5	3697.2	28.91	3498.75
28-Nov-88	96	2.85	1090.0	6700.0	81.41	0.00	81.4	3778.6	110.04	3608.79
01-Dec-88	99	2.60	281.0	6500.0	20.99	0.00	21.0	3799.6	26.36	3635.15
03-Dec-88	101	2.75	555.0	6200.0	37.09	0.00	37.1	3836.7	50.61	3685.76
06-Dec-88	104	2.90	223.0	6150.0	14.90	0.00	14.9	3851.6	21.12	3706.88
13-Dec-88	111	2.95	215.0	5550.0	12.68	0.00	12.7	3864.2	20.54	3727.42
17-Dec-88	115	2.95	835.0	5500.0	49.23	0.00	49.2	3913.5	45.74	3773.16
29-Dec-88	127	2.50	217.0	6200.0	15.35	0.00	15.4	3928.8	22.06	3795.22
04-Jan-89	133	2.90	220.0	6100.0	14.70	0.00	14.7	3943.5	16.71	3811.93
11-Jan-89	140	2.85	233.0	6350.0	16.03	0.00	16.0	3959.5	18.43	3830.36
18-Jan-89	147	2.90	206.0	5850.0	12.15	0.00	12.1	3971.7	16.51	3846.87
25-Jan-89	154	2.55	198.0	7400.0	23.35	0.00	23.3	3995.0	16.49	3863.36
02-Feb-89	162	2.60	197.0	7500.0	21.30	0.00	21.3	4016.3	16.41	3879.77
08-Feb-89	168	2.65	227.0	6800.0		0.00			18.91	3898.68
17-Feb-89	177	2.85	243.0	6750.0		0.00			20.24	3918.92
23-Feb-89	183	2.95	210.0	6000.0		0.00			17.49	3936.41
02-Mar-89	190	2.90	215.0	6300.0		0.00			18.59	3955.00

LEACHING COLUMN EAGLE EYE-3
12670 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
24-Aug-88	0	4.55	190.0	950.0	2.83	0.00	2.8	2.8	10.80	10.80
30-Aug-88	6	3.45	176.0	4250.0	37.19	0.00	37.2	40.0	43.06	53.86
06-Sep-88	13	3.30	178.0	3750.0	17.33	0.00	17.3	57.4	26.69	80.55
13-Sep-88	20	2.70	192.0	3800.0	14.64	0.00	14.6	72.0	32.58	113.13
20-Sep-88	27	2.50	180.0	4450.0	22.00	0.00	22.0	94.0	46.17	159.31
27-Sep-88	34	2.30	267.0	6550.0	111.16	0.00	111.2	205.2	139.08	298.39
04-Oct-88	41	2.40	258.0	8500.0	203.63	0.00	203.6	408.8	219.92	518.31
13-Oct-88	50	1.95	250.0	11200.0	421.27	0.00	421.3	830.1	369.97	888.28
21-Oct-88	58	1.90	260.0	13000.0	497.63	0.00	497.6	1327.7	459.67	1347.95
26-Oct-88	63	2.00	227.0	11500.0	501.66	0.00	501.7	1829.3	392.37	1740.32
28-Oct-88	65	2.10	300.0	8650.0	266.38	0.00	266.4	2095.7	251.39	1991.70
31-Oct-88	68	2.00	866.0	7350.0	563.89	0.00	563.9	2659.6	498.68	2490.39
02-Nov-88	70	2.15	278.0	6100.0	120.68	0.00	120.7	2780.3	126.61	2617.00
04-Nov-88	72	2.10	278.0	5850.0	120.68	0.00	120.7	2901.0	101.94	2718.94
07-Nov-88	75	2.70	660.0	5600.0	273.48	0.00	273.5	3174.5	225.66	2944.60
09-Nov-88	77	2.70	291.0	5300.0	120.58	0.00	120.6	3295.0	118.65	3063.26
11-Nov-88	79	2.40	260.0	5550.0	105.17	0.00	105.2	3400.2	95.34	3158.60
14-Nov-88	82	2.25	790.0	5400.0	327.35	0.00	327.3	3727.6	304.78	3463.37
16-Nov-88	84	2.10	268.0	5100.0	105.76	0.00	105.8	3833.3	97.51	3560.88
21-Nov-88	89	2.10	497.0	5450.0	210.84	0.00	210.8	4044.2	182.25	3743.13
23-Nov-88	91	2.10	278.0	5700.0	112.45	0.00	112.5	4156.6	100.08	3843.21
28-Nov-88	96	2.35	1088.0	5550.0	440.09	0.00	440.1	4596.7	391.66	4234.87
01-Dec-88	99	2.20	287.0	4900.0	130.25	0.00	130.2	4726.9	87.23	4322.10
03-Dec-88	101	2.25	542.0	4900.0	240.63	0.00	240.6	4967.6	171.50	4493.60
06-Dec-88	104	2.40	220.0	5100.0	99.84	0.00	99.8	5067.4	75.98	4569.58
13-Dec-88	111	2.25	211.0	4900.0	93.68	0.00	93.7	5161.1	77.96	4647.54
17-Dec-88	115	2.25	825.0	4650.0	374.41	0.00	374.4	5535.5	265.34	4912.88
29-Dec-88	127	2.10	187.0	6050.0	130.99	0.00	131.0	5666.5	115.11	5027.99
04-Jan-89	133	2.20	192.0	8400.0	259.51	0.00	259.5	5926.0	212.19	5240.17
11-Jan-89	140	2.00	221.0	9600.0	370.66	0.00	370.7	6296.7	285.99	5526.16
18-Jan-89	147	1.95	270.0	10000.0	468.82	0.00	468.8	6765.5	377.74	5903.91
25-Jan-89	154	1.90	178.0	10000.0	372.30	0.00	372.3	7137.8	286.46	6190.37
02-Feb-89	162	2.10	178.0	11000.0	358.25	0.00	358.2	7496.0	245.08	6435.45
08-Feb-89	168	2.05	201.0	10500.0					322.71	6758.16
17-Feb-89	177	2.20	212.0	10000.0					318.28	7076.45
23-Feb-89	183	2.20	182.0	10000.0					265.66	7342.11
02-Mar-89	190	2.10	182.0	10000.0					250.49	7592.60

LEACHING COLUMN EAGLE EYE-4
12690 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
24-Aug-88	0	3.50	270.0	1600.0	8.94	0.00	8.9	8.9	19.57	19.57
30-Aug-88	6	3.40	173.0	3900.0	31.85	0.00	31.8	40.8	40.35	59.93
06-Sep-88	13	3.10	173.0	3350.0	14.31	0.00	14.3	55.1	25.90	85.83
13-Sep-88	20	2.70	193.0	3800.0	15.65	0.00	15.6	70.8	37.26	123.09
20-Sep-88	27	2.55	175.0	4100.0	20.63	0.00	20.6	91.4	40.68	163.77
27-Sep-88	34	2.35	271.0	5600.0	69.41	0.00	69.4	160.8	94.50	258.27
04-Oct-88	41	2.40	259.0	7600.0	158.18	0.00	158.2	319.0	130.62	388.89
13-Oct-88	50	2.00	231.0	11100.0	414.13	0.00	414.1	733.1	352.23	741.13
21-Oct-88	58	1.90	261.0	14000.0	581.03	0.00	581.0	1314.1	518.30	1259.43
26-Oct-88	63	2.00	231.0	12000.0	491.49	0.00	491.5	1805.6	473.29	1732.71
28-Oct-88	65	2.00	300.0	8800.0	336.88	0.00	336.9	2142.5	244.73	1977.44
31-Oct-88	68	2.00	837.0	7800.0	676.06	0.00	676.1	2818.6	551.14	2528.58
02-Nov-88	70	2.15	273.0	6350.0	142.52	0.00	142.5	2961.1	132.07	2660.65
04-Nov-88	72	2.00	271.0	5300.0	146.82	0.00	146.8	3107.9	124.68	2785.33
07-Nov-88	75	2.65	650.0	6000.0	313.73	0.00	313.7	3421.6	285.97	3071.30
09-Nov-88	77	2.70	290.0	5550.0	134.26	0.00	134.3	3555.9	127.59	3198.89
11-Nov-88	79	2.25	260.0	5750.0	115.25	0.00	115.2	3671.1	100.62	3299.51
14-Nov-88	82	2.30	800.0	5650.0	346.73	0.00	346.7	4017.9	299.39	3598.89
16-Nov-88	84	2.10	263.0	5200.0	106.22	0.00	106.2	4124.1	95.54	3694.43
21-Nov-88	89	2.10	490.0	5600.0	226.85	0.00	226.9	4350.9	173.45	3867.88
23-Nov-88	91	2.10	274.0	5850.0	113.36	0.00	113.4	4464.3	109.54	3977.42
28-Nov-88	96	2.35	1094.0	5650.0	474.15	0.00	474.2	4938.5	428.98	4406.40
01-Dec-88	99	2.20	285.0	5300.0	115.10	0.00	115.1	5053.6	103.92	4510.31
03-Dec-88	101	2.30	562.0	5150.0	199.29	0.00	199.3	5252.8	206.93	4717.24
06-Dec-88	104	2.40	218.0	5300.0	85.89	0.00	85.9	5338.7	77.56	4794.80
13-Dec-88	111	2.20	206.0	5200.0	97.40	0.00	97.4	5436.1	84.08	4878.88
17-Dec-88	115	2.15	820.0	4850.0	331.17	0.00	331.2	5767.3	264.48	5143.36
29-Dec-88	127	2.10	180.0	6650.0	152.48	0.00	152.5	5919.8	139.57	5282.94
04-Jan-89	133	2.30	186.0	8950.0	289.48	0.00	289.5	6209.3	248.12	5531.06
11-Jan-89	140	1.95	201.0	10000.0	384.10	0.00	384.1	6593.4	314.47	5845.53
18-Jan-89	147	1.90	268.0	10200.0	538.53	0.00	538.5	7131.9	481.09	6326.62
25-Jan-89	154	1.85	172.0	11000.0	393.07	0.00	393.1	7525.0	300.86	6627.48
02-Feb-89	162	2.10	172.0	12000.0	386.29	0.00	386.3	7911.3	295.49	6922.97
08-Feb-89	168	2.00	198.0	10200.0					317.39	7240.36
17-Feb-89	177	2.15	215.0	10500.0					362.54	7602.89
23-Feb-89	183	2.25	176.0	10000.0					285.79	7888.68
02-Mar-89	190	2.10	175.0	10000.0					262.32	8151.00

LEACHING COLUMN SMEAL-1
13530 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
24-Aug-88	0	3.90	300.0	1900.0	11.97	0.00	12.0	12.0	30.16	30.16
30-Aug-88	6	3.30	143.0	6700.0	32.46	0.00	32.5	44.4	75.04	105.20
06-Sep-88	13	2.90	135.0	4250.0	14.67	0.00	14.7	59.1	31.93	137.12
13-Sep-88	20	2.85	163.0	3900.0	11.51	0.00	11.5	70.6	24.09	161.22
20-Sep-88	27	2.75	177.0	4050.0	12.71	0.00	12.7	83.3	32.05	193.27
27-Sep-88	34	2.75	193.0	4000.0	16.76	0.00	16.8	100.1	42.08	235.35
04-Oct-88	41	3.10	202.0	4100.0	19.41	0.00	19.4	119.5	46.28	281.63
13-Oct-88	50	2.90	158.0	4000.0	16.35	0.00	16.3	135.8	35.03	316.67
21-Oct-88	58	2.90	225.0	4300.0	27.02	0.00	27.0	162.9	48.23	364.89
26-Oct-88	63	3.50	235.0	5500.0	17.37	0.00	17.4	180.2	50.37	415.26
28-Oct-88	65	3.65	295.0	5550.0	32.71	0.00	32.7	212.9	48.03	463.30
31-Oct-88	68	3.20	837.0	6000.0	77.33	0.00	77.3	290.3	132.11	595.40
02-Nov-88	70	3.65	292.0	5750.0	21.58	0.00	21.6	311.9	40.71	636.11
04-Nov-88	72	3.50	293.0	6000.0	24.36	0.00	24.4	336.2	38.21	674.32
07-Nov-88	75	3.45	550.0	6300.0	38.62	0.00	38.6	374.8	71.19	745.51
09-Nov-88	77	4.25	318.0	5400.0	16.45	0.00	16.5	391.3	33.23	778.73
11-Nov-88	79	4.15	273.0	5800.0	15.13	0.00	15.1	406.4	31.51	810.25
14-Nov-88	82	4.05	840.0	5800.0	52.77	0.00	52.8	459.2	86.98	897.23
16-Nov-88	84	3.90	271.0	5600.0	15.02	0.00	15.0	474.2	29.28	926.51
21-Nov-88	89	3.80	475.0	5800.0	27.21	0.00	27.2	501.4	49.42	975.93
23-Nov-88	91	4.05	260.0	6150.0	14.41	0.00	14.4	515.8	27.06	1002.99
28-Nov-88	96	4.25	1045.0	6100.0	57.93	0.00	57.9	573.8	107.71	1110.70
01-Dec-88	99	4.85	286.0	5600.0	14.80	0.00	14.8	588.6	24.62	1135.32
03-Dec-88	101	4.80	536.0	5500.0	27.73	0.00	27.7	616.3	47.59	1182.92
06-Dec-88	104	4.30	210.0	5650.0	11.64	0.00	11.6	627.9	18.86	1201.78
13-Dec-88	111	4.40	210.0	5300.0	12.42	0.00	12.4	640.3	19.44	1221.22
17-Dec-88	115	5.30	830.0	5100.0	42.94	1.10	41.8	682.2	66.52	1287.73
29-Dec-88	127	3.80	186.0	6200.0	11.69	0.00	11.7	693.9	19.85	1307.59
04-Jan-89	133	3.75	195.0	5800.0	15.13	0.00	15.1	709.0	14.31	1321.90
11-Jan-89	140	3.85	205.0	6100.0	15.15	0.00	15.2	724.2	15.44	1337.34
18-Jan-89	147	4.55	170.0	5600.0	12.56	0.00	12.6	736.7	11.97	1349.31
25-Jan-89	154	4.10	176.0	5900.0	14.63	0.00	14.6	751.3	14.60	1363.91
02-Feb-89	162	4.30	198.0	6300.0	14.63	0.00	14.6	766.0	16.04	1379.96
08-Feb-89	168	3.95	200.0	6100.0					16.40	1396.36
17-Feb-89	177	3.65	231.0	5800.0					18.94	1415.30
23-Feb-89	183	4.00	195.0	5700.0					16.56	1431.86
02-Mar-89	190	4.15	202.0	5500.0					16.96	1448.82

LEACHING COLUMN SMEAL-2
13220 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
24-Aug-88	0	4.45	260.0	2300.0	10.74	0.00	10.7	10.7	30.29	30.29
30-Aug-88	6	3.45	165.0	6200.0	33.09	0.00	33.1	43.8	82.38	112.66
06-Sep-88	13	2.90	153.0	4850.0	18.53	0.00	18.5	62.4	46.29	158.96
13-Sep-88	20	2.85	187.0	4200.0	14.11	0.00	14.1	76.5	36.78	195.73
20-Sep-88	27	2.80	195.0	3950.0	13.94	0.00	13.9	90.4	38.35	234.08
27-Sep-88	34	2.75	204.0	4000.0	17.36	0.00	17.4	107.8	43.98	278.06
04-Oct-88	41	3.10	209.0	4000.0	18.97	0.00	19.0	126.7	49.01	327.07
13-Oct-88	50	2.90	189.0	4100.0	18.59	0.00	18.6	145.3	46.46	373.54
21-Oct-88	58	2.95	227.0	3900.0	23.61	0.00	23.6	168.9	46.36	419.90
26-Oct-88	63	2.95	251.0	2800.0	23.73	0.00	23.7	192.7	53.54	473.44
28-Oct-88	65	3.30	300.0	2350.0	28.37	0.00	28.4	221.0	42.33	515.77
31-Oct-88	68	3.00	830.0	2400.0	47.09	0.00	47.1	268.1	117.12	632.90
02-Nov-88	70	3.05	271.0	2000.0	12.81	0.00	12.8	280.9	53.09	685.99
04-Nov-88	72	3.00	274.0	2100.0	15.54	0.00	15.5	296.5	34.29	720.28
07-Nov-88	75	3.10	535.0	2200.0	26.30	0.00	26.3	322.8	75.56	795.84
09-Nov-88	77	3.60	276.0	1850.0	11.48	0.00	11.5	334.3	33.18	829.02
11-Nov-88	79	2.85	265.0	1800.0	11.02	0.00	11.0	345.3	29.92	858.94
14-Nov-88	82	3.45	815.0	1800.0	33.91	0.00	33.9	379.2	85.98	944.91
16-Nov-88	84	3.00	276.0	1800.0	9.39	0.00	9.4	388.6	29.70	974.61
21-Nov-88	89	2.85	520.0	1900.0	23.60	0.00	23.6	412.2	55.52	1030.12
23-Nov-88	91	3.10	272.0	1800.0	10.29	0.00	10.3	422.5	25.47	1055.59
28-Nov-88	96	3.05	972.0	1850.0	44.11	0.00	44.1	466.6	88.94	1144.53
01-Dec-88	99	3.20	286.0	1600.0	10.82	0.00	10.8	477.4	25.49	1170.02
03-Dec-88	101	3.30	557.0	1600.0	21.07	0.00	21.1	498.5	44.32	1214.34
06-Dec-88	104	3.10	242.0	1700.0	10.07	0.00	10.1	508.5	22.14	1236.48
13-Dec-88	111	3.10	239.0	1650.0	11.75	0.00	11.8	520.3	22.58	1259.06
17-Dec-88	115	3.05	810.0	1450.0	30.64	0.00	30.6	550.9	64.08	1323.15
29-Dec-88	127	2.80	230.0	2450.0	20.88	0.00	20.9	571.8	44.56	1367.71
04-Jan-89	133	2.80	226.0	2650.0	24.79	0.00	24.8	596.6	45.84	1413.54
11-Jan-89	140	2.90	230.0	3100.0	30.45	0.00	30.4	627.1	53.96	1467.50
18-Jan-89	147	2.90	211.0	3100.0	37.91	0.00	37.9	665.0	49.50	1517.01
25-Jan-89	154	2.80	215.0	3300.0	40.66	0.00	40.7	705.6	52.65	1569.66
02-Feb-89	162	3.00	216.0	3600.0	38.80	0.00	38.8	744.4	60.45	1630.10
08-Feb-89	168	2.80	226.0	3400.0					58.73	1688.83
17-Feb-89	177	2.80	230.0	4000.0					78.14	1766.98
23-Feb-89	183	2.80	231.0	3200.0					58.88	1825.85
02-Mar-89	190	2.90	229.0	3400.0					56.56	1882.42

LEACHING COLUMN SHEAL-3
13200 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
24-Aug-88	0	4.70	260.0	1500.0	4.34	0.00	4.3	4.3	16.94	16.94
30-Aug-88	6	3.60	165.0	6350.0	36.09	0.00	36.1	40.4	75.00	91.94
06-Sep-88	13	2.95	155.0	5100.0	22.50	0.00	22.5	62.9	49.32	141.26
13-Sep-88	20	2.80	185.0	4050.0	14.42	0.00	14.4	77.4	36.44	177.70
20-Sep-88	27	2.80	200.0	3700.0	13.52	0.00	13.5	90.9	34.85	212.55
27-Sep-88	34	2.75	212.0	3850.0	16.86	0.00	16.9	107.7	43.36	255.91
04-Oct-88	41	3.10	211.0	3950.0	18.78	0.00	18.8	126.5	47.16	303.06
13-Oct-88	50	2.85	182.0	4000.0	20.68	0.00	20.7	147.2	38.95	342.02
21-Oct-88	58	2.90	231.0	3600.0	24.06	0.00	24.1	171.3	42.88	384.89
26-Oct-88	63	4.35	241.0	5000.0	22.82	0.00	22.8	194.1	52.95	437.84
28-Oct-88	65	4.70	300.0	5400.0	28.41	0.00	28.4	222.5	42.40	480.23
31-Oct-88	68	4.25	850.0	5700.0	64.39	0.00	64.4	286.9	115.78	596.02
02-Nov-88	70	4.70	281.0	5500.0	18.63	0.00	18.6	305.5	31.53	627.55
04-Nov-88	72	4.60	281.0	5700.0	21.29	0.00	21.3	326.8	32.53	660.08
07-Nov-88	75	4.60	540.0	6000.0	34.77	0.00	34.8	361.6	60.60	720.67
09-Nov-88	77	5.25	300.0	5400.0	15.91	0.00	15.9	377.5	33.85	754.53
11-Nov-88	79	4.65	279.0	5700.0	14.80	0.00	14.8	392.3	28.02	782.54
14-Nov-88	82	5.20	835.0	5700.0	47.44	0.00	47.4	439.7	86.47	869.01
16-Nov-88	84	4.50	266.0	5700.0	13.10	0.00	13.1	452.8	26.99	896.00
21-Nov-88	89	4.50	485.0	6000.0	25.72	0.00	25.7	478.5	46.27	942.26
23-Nov-88	91	5.95	282.0	6050.0	12.82	0.00	12.8	491.4	26.35	968.61
28-Nov-88	96	6.05	1034.0	6050.0	50.92	2.35	48.6	539.9	56.65	1025.26
01-Dec-88	99	6.40	284.0	5600.0	11.83	0.65	11.2	551.1	23.03	1048.29
03-Dec-88	101	6.55	547.0	5550.0	24.86	3.73	21.1	572.2	26.15	1074.44
06-Dec-88	104	5.10	221.0	5750.0	10.05	0.17	9.9	582.1	11.89	1086.33
13-Dec-88	111	5.15	220.0	5400.0	10.00	0.17	9.8	592.0	12.27	1098.60
17-Dec-88	115	6.40	830.0	5150.0	40.87	5.28	35.6	627.5	39.76	1138.36
29-Dec-88	127	4.00	205.0	6450.0	13.20	0.00	13.2	640.7	23.28	1161.64
04-Jan-89	133	4.10	185.0	6150.0	12.61	0.00	12.6	653.4	13.54	1175.18
11-Jan-89	140	4.15	222.0	6300.0	16.82	0.00	16.8	670.2	17.37	1192.55
18-Jan-89	147	4.20	197.0	6500.0	22.39	0.00	22.4	692.6	15.81	1208.37
25-Jan-89	154	4.00	194.0	6900.0	16.53	0.00	16.5	709.1	16.61	1224.97
02-Feb-89	162	4.20	199.0	7400.0	16.96	0.00	17.0	726.1	18.23	1243.21
08-Feb-89	168	3.95	217.0	6500.0		0.00			21.39	1264.60
17-Feb-89	177	4.00	229.0	6800.0		0.00			20.38	1284.98
23-Feb-89	183	3.90	204.0	6000.0		0.00			20.94	1305.92
02-Mar-89	190	3.60	142.0	7300.0		0.00			21.67	1327.59

LEACHING COLUMN SMEAL-4
13750 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
24-Aug-88	0	4.40	260.0	1950.0	9.73	0.00	9.7	9.7	27.99	27.99
30-Aug-88	6	3.55	155.0	6000.0	26.63	0.00	26.6	36.4	63.69	91.68
06-Sep-88	13	3.05	127.0	4600.0	13.58	0.00	13.6	49.9	29.56	121.23
13-Sep-88	20	2.85	166.0	4000.0	10.65	0.00	10.6	60.6	27.77	149.00
20-Sep-88	27	2.85	175.0	3850.0	10.36	0.00	10.4	71.0	31.18	180.18
27-Sep-88	34	2.85	198.0	3750.0	14.04	0.00	14.0	85.0	38.16	218.34
04-Oct-88	41	3.15	197.0	4100.0	15.76	0.00	15.8	100.8	44.41	262.76
13-Oct-88	50	2.95	177.0	4100.0	19.31	0.00	19.3	120.1	40.55	303.31
21-Oct-88	58	2.95	232.0	4250.0	25.31	0.00	25.3	145.4	52.31	355.61
26-Oct-88	63	3.10	239.0	2900.0	21.73	0.00	21.7	167.1	49.02	404.63
28-Oct-88	65	3.20	300.0	2450.0	21.82	0.00	21.8	188.9	42.91	447.54
31-Oct-88	68	3.05	831.0	2450.0	60.44	0.00	60.4	249.4	120.90	568.44
02-Nov-88	70	3.25	273.0	2100.0	12.41	0.00	12.4	261.8	34.00	602.44
04-Nov-88	72	3.05	282.0	2100.0	15.38	0.00	15.4	277.2	30.39	632.84
07-Nov-88	75	3.40	530.0	2200.0	26.98	0.00	27.0	304.1	69.20	702.04
09-Nov-88	77	3.70	282.0	1850.0	12.31	0.00	12.3	316.4	32.29	734.34
11-Nov-88	79	2.90	266.0	1850.0	10.64	0.00	10.6	327.1	32.85	767.19
14-Nov-88	82	3.60	810.0	1800.0	32.40	0.00	32.4	359.5	83.00	850.19
16-Nov-88	84	3.05	276.0	1650.0	8.03	0.00	8.0	367.5	26.33	876.52
21-Nov-88	89	2.90	520.0	1850.0	20.80	0.00	20.8	388.3	52.98	929.50
23-Nov-88	91	3.15	280.0	1700.0	9.16	0.00	9.2	397.5	20.35	949.85
28-Nov-88	96	3.20	1032.0	1700.0	37.53	0.00	37.5	435.0	79.94	1029.79
01-Dec-88	99	3.20	287.0	1500.0	9.39	0.00	9.4	444.4	22.51	1052.30
03-Dec-88	101	3.20	560.0	1500.0	18.33	0.00	18.3	462.7	38.02	1090.32
06-Dec-88	104	3.00	239.0	1600.0	7.82	0.00	7.8	470.5	19.66	1109.97
13-Dec-88	111	3.15	241.0	1600.0	9.64	0.00	9.6	480.2	20.74	1130.72
17-Dec-88	115	3.15	820.0	1350.0	26.84	0.00	26.8	507.0	60.94	1191.65
29-Dec-88	127	2.90	228.0	2300.0	17.41	0.00	17.4	524.4	34.64	1226.29
04-Jan-89	133	2.80	223.0	2650.0	21.89	0.00	21.9	546.3	41.88	1268.17
11-Jan-89	140	2.90	224.0	3200.0	34.62	0.00	34.6	580.9	48.25	1316.41
18-Jan-89	147	3.00	212.0	3100.0	34.69	0.00	34.7	615.6	45.66	1362.07
25-Jan-89	154	2.85	218.0	3200.0	33.69	0.00	33.7	649.3	43.37	1405.44
02-Feb-89	162	3.15	215.0	3500.0	35.18	0.00	35.2	684.5	50.02	1455.46
08-Feb-89	168	2.90	222.0	3200.0		0.00			50.58	1506.04
17-Feb-89	177	2.90	233.0	3700.0		0.00			65.43	1571.47
23-Feb-89	183	2.90	232.0	3200.0		0.00			53.98	1625.45
02-Mar-89	190	2.95	231.0	3300.0		0.00			54.86	1680.31

***APPENDIX D.--DATA MATRIX FOR SMEAL, PRESTON COUNTY #3, AND LECKIE SMOKELESS COLUMN AND TUB TESTS USING HYDROGEN PEROXIDE

LEACHING COLUMN: EAGLE EYE 5
12460 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Aug-89	0	5.11	66.0	790.0	0.12	0.12	0.01	0.01	2.22	2.22
17-Aug-89	7	3.00	192.0	3400.0	25.15		25.15	25.16	44.66	46.89
24-Aug-89	14	2.70	246.0	5100.0	59.70		59.70	84.86	85.31	132.20
31-Aug-89	21	2.75	257.0	3850.0	71.03		71.03	155.89	105.45	237.65
07-Sep-89	28	2.55	276.0	3650.0	67.14		67.14	223.03	96.90	334.55
14-Sep-89	35	2.25	266.0	5600.0	125.23		125.23	348.26	152.64	487.19
21-Sep-89	42	2.11	260.5	7350.0	220.11		220.11	568.37	254.92	742.11
28-Sep-89	49	2.00	291.0	8800.0	384.94		384.94	953.31	368.44	1110.55
05-Oct-89	56	1.95	256.5	10500.0	463.49		463.49	1416.80	446.30	1556.85
12-Oct-89	63	1.90	249.0	9650.0	515.01		515.01	1931.81	497.16	2054.01
19-Oct-89	70	1.65	156.0	14500.0	436.43		436.43	2368.24	411.77	2465.78
26-Oct-89	77	1.60	264.0	13000.0	843.95		843.95	3212.19	712.48	3178.27
02-Nov-89	84	1.55	265.0	19000.0	798.28		798.28	4010.47	636.70	3814.97
09-Nov-89	91	1.60	256.5	13500.0	576.40		576.40	4586.87	547.91	4362.88
16-Nov-89	98	1.60	265.0	14500.0	541.86		541.86	5128.73	495.44	4858.32
23-Nov-89	105	1.60	263.0	16000.0	550.27		550.27	5679.00	507.28	5365.60
30-Nov-89	112	1.65	228.0	14500.0	411.99		411.99	6090.99	385.75	5751.35
07-Dec-89	119	1.65	250.0	14500.0	447.78		447.78	6538.77	341.53	6092.88
14-Dec-89	126	1.65	248.5	14000.0	475.96		475.96	7014.73	398.36	6491.24
21-Dec-89	133	1.73	264.0	14000.0	466.90		466.90	7481.63	446.66	6937.90
28-Dec-89	140	1.78	287.0	13000.0	411.71		411.71	7893.34	392.08	7329.98
04-Jan-90	147	1.76	257.0	14000.0	388.87		388.87	8282.21	366.32	7696.30
11-Jan-90	154	1.77	272.0	13000.0	390.19		390.19	8672.40	350.86	8047.16

LEACHING COLUMNS: EAGLE EYE 6
12420 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Aug-89	0	4.78	41.0	700.0	0.07	0.05	0.01	0.01	1.22	1.22
17-Aug-89	7	3.90	161.0	2700.0	11.20		11.20	11.21	29.06	30.28
24-Aug-89	14	3.00	251.0	4500.0	46.08		46.08	57.29	76.78	107.06
31-Aug-89	21	2.85	252.0	3700.0	63.47		63.47	120.76	90.98	198.04
07-Sep-89	28	2.75	265.0	3950.0	66.23		66.23	186.99	97.00	295.04
14-Sep-89	35	2.40	265.0	4650.0	82.09		82.09	269.08	101.03	396.07
21-Sep-89	42	2.22	268.0	6010.0	161.25		161.25	430.33	99.49	495.56
28-Sep-89	49	2.06	266.0	8150.0	303.16		303.16	733.49	341.47	837.03
05-Oct-89	56	2.00	262.0	9850.0	416.63		416.63	1150.12	283.81	1120.84
12-Oct-89	63	1.95	256.5	8550.0	473.99		473.99	1624.11	380.70	1501.54
19-Oct-89	70	1.90	307.0	10500.0	678.58		678.58	2302.69	529.51	2031.06
26-Oct-89	77	1.75	246.5	10000.0	680.33		680.33	2983.02	504.23	2535.29
02-Nov-89	84	1.65	262.0	16500.0	706.95		706.95	3689.97	969.37	3504.66
09-Nov-89	91	1.65	264.5	14500.0	745.37		745.37	4435.34	604.77	4109.43
16-Nov-89	98	1.65	270.0	14500.0	699.84		699.84	5135.18	601.11	4710.54
23-Nov-89	105	1.60	288.0	16000.0	760.23		760.23	5895.41	693.15	5403.69
30-Nov-89	112	1.65	226.0	15000.0	517.51		517.51	6412.92	462.37	5866.06
07-Dec-89	119	1.60	251.5	15500.0	599.89		599.89	7012.81	529.67	6395.73
14-Dec-89	126	1.60	247.0	15000.0	619.99		619.99	7632.80	512.76	6908.49
21-Dec-89	133	1.70	295.0	15000.0	680.43		680.43	8313.23	639.02	7547.52
28-Dec-89	140	1.75	252.0	14000.0	447.12		447.12	8760.35	401.89	7949.41
04-Jan-90	147	1.76	270.0	15000.0	463.09		463.09	9223.44	397.63	8347.04
11-Jan-90	154	1.76	310.0	13000.0	513.36		513.36	9736.80	438.12	8785.16

LEACHING COLUMNS: EAGLE EYE 7
12370 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Aug-89	0	4.11	111.0	710.0	1.37	0.00	1.37	1.37	3.93	3.93
17-Aug-89	7	3.10	154.0	2800.0	17.03		17.03	18.40	25.70	29.63
24-Aug-89	14	2.90	258.0	3850.0	40.05		40.05	58.45	63.58	93.21
31-Aug-89	21	2.80	268.0	3450.0	64.10		64.10	122.55	92.70	185.91
07-Sep-89	28	2.75	267.0	3450.0	59.67		59.67	182.22	83.06	268.96
14-Sep-89	35	2.40	270.0	4200.0	76.72		76.72	258.94	93.39	362.35
21-Sep-89	42	2.25	271.5	5200.0	143.87		143.87	402.81	155.42	517.76
28-Sep-89	49	2.09	265.0	7450.0	259.48		259.48	662.29	270.27	788.03
05-Oct-89	56	2.00	277.0	9100.0	386.98		386.98	1049.27	355.69	1143.72
12-Oct-89	63	1.95	251.0	8400.0	438.07		438.07	1487.34	417.14	1560.87
19-Oct-89	70	1.85	312.0	10500.0	650.07		650.07	2137.41	655.02	2215.89
26-Oct-89	77	1.75	251.0	10500.0	703.32		703.32	2840.73	561.90	2777.79
02-Nov-89	84	1.70	266.5	16000.0	709.62		709.62	3550.35	561.01	3338.80
09-Nov-89	91	1.70	259.0	14000.0	711.88		711.88	4262.23	537.49	3876.29
16-Nov-89	98	1.70	268.0	14000.0	684.62		684.62	4946.85	524.19	4400.48
23-Nov-89	105	1.65	284.0	15000.0	671.08		671.08	5617.93	614.79	5015.27
30-Nov-89	112	1.70	230.0	13000.0	459.02		459.02	6076.95	408.70	5423.97
07-Dec-89	119	1.70	252.0	14000.0	563.28		563.28	6640.23	440.28	5864.25
14-Dec-89	126	1.70	251.0	13000.0	523.51		523.51	7163.74	416.07	6280.32
21-Dec-89	133	1.77	296.0	13000.0	580.04		580.04	7743.78	543.64	6823.96
28-Dec-89	140	1.84	266.0	12000.0	463.33		463.33	8207.11	337.17	7161.12
04-Jan-90	147	1.81	274.0	13000.0	455.58		455.58	8662.69	428.71	7589.83
11-Jan-90	154	1.81	305.0	12000.0	501.08		501.08	9163.77	459.09	8048.92

LEACHING COLUMNS: EAGLE EYE 8
12470 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Aug-89	0	3.74	100.0	600.0	1.35	0.00	1.35	1.35	3.13	3.13
17-Aug-89	7	2.90	195.0	4400.0	38.66		38.66	40.01	65.77	68.90
24-Aug-89	14	2.80	255.0	4600.0	52.51		52.51	92.52	79.32	148.22
31-Aug-89	21	2.75	271.0	3650.0	68.51		68.51	161.03	96.72	244.94
07-Sep-89	28	2.75	271.0	3450.0	62.19		62.19	223.22	82.08	327.03
14-Sep-89	35	2.25	265.0	4800.0	101.95		101.95	325.17	116.27	443.30
21-Sep-89	42	2.13	273.0	6800.0	201.74		201.74	526.91	213.65	656.95
28-Sep-89	49	2.00	281.0	8300.0	325.39		325.39	852.30	323.88	980.83
05-Oct-89	56	1.95	262.0	9700.0	404.58		404.58	1256.88	379.20	1360.03
12-Oct-89	63	1.95	258.0	8600.0	456.74		456.74	1713.62	434.23	1794.26
19-Oct-89	70	1.80	233.5	11000.0	515.90		515.90	2229.52	466.40	2260.66
26-Oct-89	77	1.70	252.0	11000.0	681.11		681.11	2910.63	592.47	2853.14
02-Nov-89	84	1.65	258.0	16500.0	685.44		685.44	3596.07	598.13	3451.27
09-Nov-89	91	1.70	248.0	14000.0	596.63		596.63	4192.70	509.17	3960.43
16-Nov-89	98	1.65	260.0	15000.0	658.86		658.86	4851.56	510.82	4471.25
23-Nov-89	105	1.60	250.0	16000.0	601.84		601.84	5453.40	550.11	5021.36
30-Nov-89	112	1.65	227.5	14500.0	439.58		439.58	5892.98	373.21	5394.57
07-Dec-89	119	1.65	246.0	14500.0	471.43		471.43	6364.41	403.56	5798.13
14-Dec-89	126	1.65	245.0	14500.0	515.34		515.34	6879.75	387.48	6185.61
21-Dec-89	133	1.71	265.0	14500.0	509.92		509.92	7389.67	432.12	6617.73
28-Dec-89	140	1.80	264.0	12500.0	352.49		352.49	7742.16	328.11	6945.84
04-Jan-90	147	1.76	263.0	14000.0	402.79		402.79	8144.95	373.94	7319.77
11-Jan-90	154	1.75	260.0	13000.0	403.31		403.31	8548.26	361.91	7681.69

LEACHING COLUMNS: PRESTON COUNTY #3-1
11540 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Aug-89	0	5.90	38.0	320.0	0.02	0.11	-0.09	-0.09	0.10	0.10
17-Aug-89	7	5.98	200.0	770.0	0.26	0.08	0.18	0.09	5.69	5.79
24-Aug-89	14	4.90	254.0	900.0	1.35	0.05	1.30	1.39	9.42	15.21
31-Aug-89	21	3.65	261.0	765.0	2.45		2.45	3.84	12.23	27.44
07-Sep-89	28	3.40	254.0	900.0	2.53		2.53	6.37	11.35	38.79
14-Sep-89	35	3.10	258.5	1050.0	3.06		3.06	9.43	12.67	51.45
21-Sep-89	42	2.95	273.0	1010.0	4.48		4.48	13.91	15.15	66.61
28-Sep-89	49	2.83	269.5	1045.0	5.72		5.72	19.63	17.30	83.90
05-Oct-89	56	2.70	264.0	1750.0	8.56		8.56	28.19	21.52	105.42
12-Oct-89	63	2.55	253.0	1800.0	13.45		13.45	41.64	29.18	134.61
19-Oct-89	70	2.15	255.0	4800.0	46.71		46.71	88.35	75.26	209.87
26-Oct-89	77	2.25	249.5	3600.0	58.27		58.27	146.62	80.06	289.93
02-Nov-89	84	2.20	255.0	5450.0	58.87		58.87	205.49	80.79	370.72
09-Nov-89	91	2.25	259.0	4500.0	55.48		55.48	260.97	69.08	439.80
16-Nov-89	98	2.25	259.0	4300.0	55.51		55.51	316.48	60.67	500.46
23-Nov-89	105	2.20	228.0	4850.0	52.70		52.70	369.18	67.29	567.76
30-Nov-89	112	2.25	252.0	4200.0	50.84		50.84	420.02	60.39	628.15
07-Dec-89	119	2.30	249.5	3950.0	45.09		45.09	465.11	50.33	678.48
14-Dec-89	126	2.30	249.0	3750.0	43.95		43.95	509.06	50.23	728.71
21-Dec-89	133	2.25	228.0	4200.0	49.13		49.13	558.19	60.81	789.53
28-Dec-89	140	2.33	292.0	3550.0	45.98		45.98	604.17	58.91	848.43
04-Jan-90	147	2.31	263.0	3500.0	42.94		42.94	647.11	43.09	891.52
11-Jan-90	154	2.29	233.0	3500.0	37.09		37.09	684.20	40.56	932.08

LEACHING COLUMNS: PRESTON COUNTY #3-2
11910 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Aug-89	0	6.52	56.0	260.0	0.03	0.16	-0.13	-0.13	0.27	0.27
17-Aug-89	7	5.84	187.0	790.0	0.14	0.03	0.10	-0.03	5.14	5.41
24-Aug-89	14	5.00	257.5	860.0	1.12	0.05	1.07	1.04	8.96	14.37
31-Aug-89	21	4.05	251.0	670.0	1.48		1.48	2.52	10.91	25.28
07-Sep-89	28	3.50	253.5	840.0	1.85		1.85	4.37	11.19	36.47
14-Sep-89	35	3.05	267.0	1100.0	3.16		3.16	7.53	14.29	50.76
21-Sep-89	42	2.84	275.0	1040.0	6.12		6.12	13.65	18.15	68.92
28-Sep-89	49	2.70	272.0	1075.0	9.70		9.70	23.35	25.03	93.95
05-Oct-89	56	2.55	275.0	2200.0	15.07		15.07	38.42	32.30	126.25
12-Oct-89	63	2.50	257.0	2350.0	21.69		21.69	60.11	43.75	170.00
19-Oct-89	70	2.30	246.0	3850.0	40.72		40.72	100.83	63.27	233.27
26-Oct-89	77	2.45	247.0	3350.0	46.75		46.75	147.58	66.09	299.36
02-Nov-89	84	2.20	251.0	5200.0	49.57		49.57	197.15	61.16	360.52
09-Nov-89	91	2.20	248.0	4450.0	47.48		47.48	244.63	57.33	417.84
16-Nov-89	98	2.20	250.0	4500.0	48.36		48.36	292.99	57.79	475.63
23-Nov-89	105	2.15	253.0	5000.0	52.54		52.54	345.53	69.55	545.18
30-Nov-89	112	2.20	249.0	4200.0	41.57		41.57	387.10	52.37	597.55
07-Dec-89	119	2.20	257.0	4350.0	42.39		42.39	429.49	50.04	647.59
14-Dec-89	126	2.20	244.5	4100.0	40.32		40.32	469.81	47.61	695.20
21-Dec-89	133	2.22	247.0	4300.0	42.65		42.65	512.46	54.52	749.72
28-Dec-89	140	2.27	292.0	3500.0	37.52		37.52	549.98	46.21	795.94
04-Jan-90	147	2.26	262.0	3700.0	35.23		35.23	585.21	36.37	832.31
11-Jan-90	154	2.25	263.0	3700.0	36.40		36.40	621.61	43.28	875.59

LEACHING COLUMNS: PRESTON COUNTY #3-3
11930 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Aug-89	0	6.75	36.0	260.0	0.02	0.09	-0.07	-0.07	0.16	0.16
17-Aug-89	7	7.50	179.0	715.0	0.01	0.44	-0.44	-0.51	4.59	4.75
24-Aug-89	14	5.30	266.0	875.0	0.86	0.10	0.75	0.24	9.56	14.31
31-Aug-89	21	3.85	253.0	710.0	1.39		1.39	1.63	11.17	25.48
07-Sep-89	28	3.70	264.5	825.0	1.80		1.80	3.43	10.86	36.34
14-Sep-89	35	3.15	254.0	1100.0	2.69		2.69	6.12	11.74	48.08
21-Sep-89	42	2.95	264.0	1035.0	4.66		4.66	10.78	17.08	65.15
28-Sep-89	49	2.76	265.5	1085.0	8.94		8.94	19.72	26.99	92.14
05-Oct-89	56	2.55	257.5	2550.0	16.20		16.20	35.92	37.68	129.82
12-Oct-89	63	2.45	257.0	2500.0	25.03		25.03	60.95	48.16	177.97
19-Oct-89	70	2.10	258.5	5350.0	78.22		78.22	139.17	103.51	281.48
26-Oct-89	77	2.30	243.5	3800.0	68.01		68.01	207.18	81.26	362.74
02-Nov-89	84	2.20	256.0	5350.0	63.35		63.35	270.53	65.71	428.44
09-Nov-89	91	2.25	214.0	4600.0	51.23		51.23	321.76	59.32	487.76
16-Nov-89	98	2.25	265.0	4600.0	53.87		53.87	375.63	57.13	544.90
23-Nov-89	105	2.25	243.0	4600.0	51.37		51.37	427.00	49.89	594.79
30-Nov-89	112	2.30	262.0	3950.0	46.33		46.33	473.33	52.45	647.24
07-Dec-89	119	2.30	263.0	3800.0	43.30		43.30	516.63	49.95	697.20
14-Dec-89	126	2.30	265.0	3600.0	42.55		42.55	559.18	47.61	744.81
21-Dec-89	133	2.29	237.0	3900.0	42.75		42.75	601.93	49.88	794.70
28-Dec-89	140	2.35	296.0	3550.0	40.34		40.34	642.27	40.29	834.99
04-Jan-90	147	2.36	271.0	3200.0	34.24		34.24	676.51	39.59	874.58
11-Jan-90	154	2.33	241.0	3200.0	33.30		33.30	709.81	35.21	909.79

LEACHING COLUMNS: PRESTON COUNTY #3-4
11780 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Aug-89	0	7.82	12.0	310.0	0.00	0.09	-0.09	-0.09	0.05	0.05
17-Aug-89	7	7.54	195.0	670.0	0.03	0.51	-0.48	-0.57	4.12	4.17
24-Aug-89	14	5.45	268.0	785.0	0.67	0.10	0.57	0.00	8.74	12.92
31-Aug-89	21	4.85	250.0	645.0	1.20	0.05	1.15	1.15	9.83	22.75
07-Sep-89	28	3.85	257.0	715.0	1.44		1.44	2.59	8.38	31.13
14-Sep-89	35	3.30	261.0	890.0	2.07		2.07	4.66	10.62	41.75
21-Sep-89	42	3.23	264.0	1000.0	2.66		2.66	7.32	8.08	49.83
28-Sep-89	49	3.00	264.0	1020.0	3.59		3.59	10.91	13.41	63.25
05-Oct-89	56	2.75	264.0	1550.0	6.17		6.17	17.08	19.28	82.53
12-Oct-89	63	2.60	247.0	1900.0	12.13		12.13	29.21	27.09	109.62
19-Oct-89	70	2.35	247.5	3600.0	30.94		30.94	60.15	42.87	152.49
26-Oct-89	77	2.35	245.0	3250.0	40.76		40.76	100.91	61.00	213.49
02-Nov-89	84	2.20	249.0	5000.0	50.73		50.73	151.64	71.17	284.66
09-Nov-89	91	2.20	247.0	4650.0	54.85		54.85	206.49	80.58	365.24
16-Nov-89	98	2.20	251.0	4700.0	56.84		56.84	263.33	69.21	434.45
23-Nov-89	105	2.15	256.0	5100.0	61.13		61.13	324.46	70.58	505.03
30-Nov-89	112	2.20	249.0	4350.0	47.16		47.16	371.62	40.62	545.65
07-Dec-89	119	2.20	254.0	4300.0	46.01		46.01	417.63	50.41	596.06
14-Dec-89	126	2.20	246.0	4150.0	43.55		43.55	461.18	50.07	646.13
21-Dec-89	133	2.19	242.0	4400.0	49.12		49.12	510.30	50.87	696.99
28-Dec-89	140	2.25	297.0	3700.0	44.61		44.61	554.91	48.53	745.52
04-Jan-90	147	2.26	263.0	3650.0	35.75		35.75	590.66	38.87	784.39
11-Jan-90	154	2.25	255.0	3550.0	35.68		35.68	626.34	36.36	820.75

LEACHING COLUMNS: LECKIE SMOKELESS 1
10670 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Aug-89	0	2.00	198.0	11000.0	630.00		630.00	630.00	556.59	556.59
17-Aug-89	7	1.85	308.0	15000.0	1412.27		1412.27	2042.27	1288.10	1844.69
24-Aug-89	14	1.90	248.0	14000.0	800.42		800.42	2842.69	695.50	2540.19
31-Aug-89	21	1.80	294.0	10500.0	1080.11		1080.11	3922.80	799.45	3339.64
07-Sep-89	28	1.85	273.0	11500.0	858.79		858.79	4781.59	643.38	3983.02
14-Sep-89	35	1.70	276.0	12000.0	759.61		759.61	5541.20	612.43	4595.45
21-Sep-89	42	1.75	277.0	12000.0	696.72		696.72	6237.92	557.40	5152.85
28-Sep-89	49	1.74	275.0	12000.0	642.72		642.72	6880.64	515.49	5668.34
05-Oct-89	56	1.75	264.0	12000.0	575.88		575.88	7456.52	467.59	6135.93
12-Oct-89	63	1.75	258.0	10000.0	583.52		583.52	8040.04	511.99	6647.92
19-Oct-89	70	1.70	224.0	11500.0	532.47		532.47	8572.51	365.88	7013.80
26-Oct-89	77	1.75	229.0	10500.0	579.48		579.48	9151.99	522.79	7536.59
02-Nov-89	84	1.65	247.0	15500.0	575.74		575.74	9727.73	480.02	8016.61
09-Nov-89	91	1.60	242.0	15000.0	599.50		599.50	10327.23	511.98	8528.59
16-Nov-89	98	1.60	239.0	14000.0	603.66		603.66	10930.89	522.09	9050.68
23-Nov-89	105	1.60	250.0	15000.0	551.08		551.08	11481.97	494.46	9545.14
30-Nov-89	112	1.60	210.0	13500.0	342.36		342.36	11824.33	321.32	9866.46
07-Dec-89	119	1.60	225.0	14500.0	423.64		423.64	12247.97	375.27	10241.73
14-Dec-89	126	1.60	212.5	14000.0	299.16		299.16	12547.13	315.28	10557.01
21-Dec-89	133	1.70	239.0	14000.0	438.76		438.76	12985.89	396.60	10953.61
28-Dec-89	140	1.77	265.0	11000.0	328.38		328.38	13314.27	305.58	11259.19
04-Jan-90	147	1.78	294.0	12000.0	350.82		350.82	13665.09	332.88	11592.07
11-Jan-90	154	1.71	267.0	12500.0	373.75		373.75	14038.84	330.46	11922.53

LEACHING COLUMNS: LECKIE SMOKELESS 2
10460 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Aug-89	0	2.00	281.0	11000.0	915.30		915.30	915.30	818.18	818.18
17-Aug-89	7	1.80	322.0	14500.0	1462.24		1462.24	2377.54	1364.68	2182.86
24-Aug-89	14	1.90	234.5	14000.0	803.99		803.99	3181.53	733.23	2916.09
31-Aug-89	21	1.80	278.0	10500.0	996.26		996.26	4177.79	845.27	3761.36
07-Sep-89	28	1.85	266.0	11500.0	890.95		890.95	5068.74	698.21	4459.57
14-Sep-89	35	1.70	282.0	11500.0	753.09		753.09	5821.83	629.00	5088.57
21-Sep-89	42	1.76	278.0	11500.0	618.59		618.59	6440.42	540.35	5628.91
28-Sep-89	49	1.75	270.5	11500.0	620.33		620.33	7060.75	516.07	6144.98
05-Oct-89	56	1.80	267.5	12000.0	582.69		582.69	7643.44	481.58	6626.56
12-Oct-89	63	1.75	236.5	10000.0	528.93		528.93	8172.37	447.77	7074.33
19-Oct-89	70	1.70	247.0	11500.0	575.67		575.67	8748.04	515.51	7589.84
26-Oct-89	77	1.70	230.0	10500.0	621.18		621.18	9369.22	534.41	8124.25
02-Nov-89	84	1.65	250.0	15500.0	606.21		606.21	9975.43	512.81	8637.06
09-Nov-89	91	1.65	242.0	13000.0	516.16		516.16	10491.59	444.35	9081.41
16-Nov-89	98	1.65	253.0	13000.0	509.63		509.63	11001.22	446.40	9527.81
23-Nov-89	105	1.60	252.0	15000.0	554.83		554.83	11556.05	480.78	10008.58
30-Nov-89	112	1.65	213.0	12000.0	339.25		339.25	11895.30	291.83	10300.41
07-Dec-89	119	1.65	225.5	13500.0	411.98		411.98	12307.28	329.03	10629.44
14-Dec-89	126	1.65	217.5	12500.0	373.79		373.79	12681.07	325.00	10954.45
21-Dec-89	133	1.71	242.0	13500.0	549.48		549.48	13230.55	412.63	11367.07
28-Dec-89	140	1.77	278.0	11000.0	227.76		227.76	13458.31	335.54	11702.61
04-Jan-90	147	1.79	250.0	12000.0	321.86		321.86	13780.17	285.73	11988.34
11-Jan-90	154	1.78	268.0	11000.0	363.86		363.86	14144.03	317.19	12305.54

LEACHING COLUMNS: LECKIE SMOKELESS 3

10760 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Aug-89	0	2.00	343.0	11000.0	1066.77	0.00	1066.77	1066.77	972.58	972.58
17-Aug-89	7	1.85	313.0	14000.0	1298.83		1298.83	2365.60	1160.22	2132.80
24-Aug-89	14	1.90	245.0	13500.0	767.90		767.90	3133.50	657.13	2789.93
31-Aug-89	21	1.80	290.5	10000.0	1038.48		1038.48	4171.98	764.18	3554.11
07-Sep-89	28	1.85	273.5	11000.0	840.71		840.71	5012.69	626.05	4180.16
14-Sep-89	35	1.70	280.0	11000.0	646.13		646.13	5658.82	538.92	4719.08
21-Sep-89	42	1.75	277.0	11500.0	574.72		574.72	6233.54	496.98	5216.06
28-Sep-89	49	1.75	274.0	11000.0	532.21		532.21	6765.75	471.22	5687.29
05-Oct-89	56	1.75	270.0	10500.0	510.26		510.26	7276.01	427.46	6114.74
12-Oct-89	63	1.75	248.0	9500.0	522.16		522.16	7798.17	432.16	6546.90
19-Oct-89	70	1.65	208.5	12000.0	510.57		510.57	8308.74	452.41	6999.31
26-Oct-89	77	1.65	208.5	11000.0	581.32		581.32	8890.06	515.24	7514.56
02-Nov-89	84	1.60	246.0	15500.0	540.47		540.47	9430.53	466.57	7981.12
09-Nov-89	91	1.65	205.0	12500.0	323.41		323.41	9753.94	283.78	8264.90
16-Nov-89	98	1.65	215.0	12000.0	337.79		337.79	10091.73	275.59	8540.49
23-Nov-89	105	1.60	260.0	14000.0	479.53		479.53	10571.26	413.20	8953.69
30-Nov-89	112	1.65	211.0	12500.0	307.48		307.48	10878.74	212.55	9166.24
07-Dec-89	119	1.60	205.0	13500.0	336.08		336.08	11214.82	297.90	9464.14
14-Dec-89	126	1.60	205.0	13500.0	337.79		337.79	11552.61	297.90	9762.04
21-Dec-89	133	1.67	200.0	15000.0	391.40		391.40	11944.01	372.94	10134.97
28-Dec-89	140	1.76	251.0	11500.0	325.56		325.56	12269.57	295.88	10430.85
04-Jan-90	147	1.75	213.0	13000.0	310.20		310.20	12579.77	265.70	10696.55
11-Jan-90	154	1.73	234.0	13500.0	372.74		372.74	12952.51	332.01	11028.57

LEACHING COLUMNS: LECKIE SMOKELESS 4

10720 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Aug-89	0	2.00	221.0	12000.0	814.89	0.00	814.89	814.89	702.71	702.71
17-Aug-89	7	1.90	307.0	15000.0	1482.74		1482.74	2297.63	1356.58	2059.29
24-Aug-89	14	1.95	249.0	13500.0	915.75		915.75	3213.38	757.45	2816.74
31-Aug-89	21	1.85	283.0	9500.0	834.35		834.35	4047.73	762.25	3579.00
07-Sep-89	28	1.85	267.0	11000.0	756.67		756.67	4804.40	627.25	4206.25
14-Sep-89	35	1.70	278.0	11000.0	699.64		699.64	5504.04	627.57	4833.82
21-Sep-89	42	1.75	272.0	12000.0	638.77		638.77	6142.81	527.81	5361.63
28-Sep-89	49	1.75	280.0	11500.0	595.52		595.52	6738.33	456.59	5818.23
05-Oct-89	56	1.75	264.0	12000.0	543.02		543.02	7281.35	439.59	6257.82
12-Oct-89	63	1.70	250.0	10500.0	562.79		562.79	7844.14	484.05	6741.86
19-Oct-89	70	1.65	239.0	11500.0	543.52		543.52	8387.66	463.78	7205.64
26-Oct-89	77	1.65	217.0	10500.0	541.49		541.49	8929.15	459.99	7665.63
02-Nov-89	84	1.60	239.5	15000.0	522.65		522.65	9451.80	431.77	8097.40
09-Nov-89	91	1.65	239.0	13500.0	491.99		491.99	9943.79	406.19	8503.59
16-Nov-89	98	1.60	247.0	13000.0	474.18		474.18	10417.97	402.78	8906.37
23-Nov-89	105	1.60	245.0	15000.0	520.74		520.74	10938.71	412.48	9318.85
30-Nov-89	112	1.65	204.0	12500.0	326.36		326.36	11265.07	307.63	9626.48
07-Dec-89	119	1.65	223.0	14000.0	407.72		407.72	11672.79	359.77	9986.25
14-Dec-89	126	1.65	217.5	13000.0	359.73		359.73	12032.52	335.62	10321.87
21-Dec-89	133	1.66	240.0	13500.0	460.46		460.46	12492.98	404.06	10725.93
28-Dec-89	140	1.77	267.0	11000.0	347.61		347.61	12840.59	293.43	11019.36
04-Jan-90	147	1.77	246.0	12000.0	325.89		325.89	13166.48	275.92	11295.28
11-Jan-90	154	1.74	269.0	12000.0	374.79		374.79	13541.27	263.93	11559.21

LEACHING TUBS: EAGLE EYE-T-1

47433.70 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Oct-89	0	2.95	277.0	1450.0	4.55	0.00	4.55	4.55	5.53	5.53
17-Oct-89	7	2.95	186.0	920.0	1.30		1.30	5.85	1.70	7.23
24-Oct-89	14	3.00	138.0	555.0	0.50		0.50	6.35	0.84	8.07
31-Oct-89	21	2.80	203.0	1000.0	1.07		1.07	7.42	1.48	9.55
07-Nov-89	28	2.45	277.0	2300.0	7.15		7.15	14.57	7.11	16.66
14-Nov-89	35	2.20	215.5	4300.0	18.21		18.21	32.78	15.25	31.91
21-Nov-89	42	2.20	356.0	5600.0	42.66		42.66	75.44	32.70	64.61
28-Nov-89	49	2.05	382.0	7050.0	71.82		71.82	147.26	58.91	123.52
05-Dec-89	56	2.00	382.0	7700.0	90.37		90.37	237.63	74.08	197.60
12-Dec-89	63	1.80	402.0	10000.0	128.14		128.14	365.77	119.44	317.04
19-Dec-89	70	1.85	403.0	7950.0	120.09		120.09	485.86	104.43	421.47
26-Dec-89	77	1.94	426.0	9600.0	112.15		112.15	598.01	131.40	552.87
02-Jan-90	84	1.92	409.0	9750.0	116.12		116.12	714.13	100.64	653.52
09-Jan-90	91	1.85	373.0	10000.0	135.43		135.43	849.56	96.01	749.53
16-Jan-90	98	1.90	412.0	9200.0	90.12		90.12	939.68	89.70	839.23

LEACHING TUBS: EAGLE EYE-T-2

48873.00 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Oct-89	0	2.85	147.0	1750.0	2.74	0.00	2.74	2.74	3.49	3.49
17-Oct-89	7	2.90	129.5	1050.0	1.01		1.01	3.75	1.58	5.08
24-Oct-89	14	2.70	137.0	1150.0	0.76		0.76	4.51	1.86	6.94
31-Oct-89	21	2.55	327.5	2550.0	6.33		6.33	10.84	8.65	15.59
07-Nov-89	28	2.40	279.0	3000.0	9.02		9.02	19.86	10.13	25.72
14-Nov-89	35	2.20	232.0	4400.0	16.98		16.98	36.84	14.81	40.53
21-Nov-89	42	2.19	359.0	5600.0	38.87		38.87	75.71	35.95	76.48
28-Nov-89	49	2.05	379.0	7000.0	66.50		66.50	142.21	60.90	137.39
05-Dec-89	56	2.00	373.5	7900.0	86.50		86.50	228.71	77.49	214.88
12-Dec-89	63	1.95	430.0	8050.0	107.90		107.90	336.61	100.33	315.21
19-Dec-89	70	1.95	412.0	7300.0	107.53		107.53	444.14	94.55	409.76
26-Dec-89	77	1.98	418.0	8600.0	102.61		102.61	546.75	97.53	507.28
02-Jan-90	84	1.95	417.0	9700.0	133.70		133.70	680.45	113.36	620.64
09-Jan-90	91	1.89	417.0	10000.0	131.01		131.01	811.46	116.63	737.27
16-Jan-90	98	1.99	412.0	8800.0	104.95		104.95	916.41	95.12	832.40

LEACHING TUBS: PRESTON COUNTY #3-T-1
54294.30 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Oct-89	0	3.40	157.5	245.0	0.11	0.00	0.11	0.11	0.28	0.28
17-Oct-89	7	3.80	139.0	110.0	0.06	0.00	0.06	0.17	0.11	0.39
24-Oct-89	14	3.80	154.0	105.0	0.06		0.06	0.23	0.13	0.52
31-Oct-89	21	3.80	194.5	145.0	0.07		0.07	0.30	0.17	0.68
07-Nov-89	28	3.90	206.0	140.0	0.09		0.09	0.39	0.21	0.89
14-Nov-89	35	3.75	226.0	155.0	0.09		0.09	0.48	0.26	1.15
21-Nov-89	42	3.49	351.0	210.0	0.19		0.19	0.67	0.58	1.74
28-Nov-89	49	3.40	335.0	315.0	0.29		0.29	0.96	0.90	2.63
05-Dec-89	56	3.25	388.0	420.0	0.52		0.52	1.48	1.37	4.00
12-Dec-89	63	2.35	440.5	2400.0	8.14		8.14	9.62	10.93	14.93
19-Dec-89	70	2.50	418.0	2350.0	14.62		14.62	24.24	11.34	26.27
26-Dec-89	77	2.41	439.0	2800.0	8.89		8.89	33.13	12.14	38.41
02-Jan-90	84	2.36	417.0	3000.0	8.68		8.68	41.81	10.57	48.99
09-Jan-90	91	2.34	380.0	2850.0	7.64		7.64	49.45	9.19	58.18
16-Jan-90	98	2.40	424.0	2650.0	8.89		8.89	58.34	7.47	65.66

LEACHING TUBS: PRESTON COUNTY #3-T-2
54503.40 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Oct-89	0	3.40	108.0	265.0	0.08	0.00	0.08	0.08	0.22	0.22
17-Oct-89	7	3.85	119.0	165.0	0.06	0.00	0.06	0.14	0.14	0.36
24-Oct-89	14	3.85	211.5	160.0	0.10		0.10	0.24	0.28	0.64
31-Oct-89	21	3.95	212.0	220.0	0.09		0.09	0.33	0.31	0.95
07-Nov-89	28	4.00	210.0	155.0	0.09		0.09	0.42	0.26	1.21
14-Nov-89	35	3.90	219.0	220.0	0.22		0.22	0.64	0.42	1.63
21-Nov-89	42	3.77	291.0	240.0	0.17		0.17	0.81	0.53	2.15
28-Nov-89	49	3.70	375.0	330.0	0.29		0.29	1.10	1.04	3.20
05-Dec-89	56	3.70	427.0	335.0	0.41		0.41	1.51	1.27	4.47
12-Dec-89	63	3.45	398.0	400.0	0.44		0.44	1.95	1.64	6.11
19-Dec-89	70	3.35	416.0	425.0	0.62		0.62	2.57	2.11	8.22
26-Dec-89	77	3.04	438.0	880.0	0.73		0.73	3.30	3.58	11.80
02-Jan-90	84	2.76	434.0	1300.0	1.50		1.50	4.80	3.75	15.55
09-Jan-90	91	2.60	385.0	2050.0	3.03		3.03	7.83	4.88	20.43
16-Jan-90	98	2.48	431.0	2250.0	4.40		4.40	12.23	6.65	27.08

LEACHING TUBS: LECKIE SMOKELESS-T-1
43200.60 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Oct-89	0	2.15	280.0	8850.0	110.02	0.00	110.02	110.02	104.05	104.05
17-Oct-89	7	2.10	248.0	10000.0	134.30		134.30	244.32	128.67	232.72
24-Oct-89	14	1.90	438.5	11000.0	347.65		347.65	591.97	332.41	565.14
31-Oct-89	21	1.70	400.0	19500.0	392.17		392.17	984.14	384.91	950.05
07-Nov-89	28	1.60	400.0	19500.0	404.16		404.16	1388.30	392.27	1342.32
14-Nov-89	35	1.60	414.0	17000.0	361.57		361.57	1749.87	367.91	1710.23
21-Nov-89	42	1.73	408.0	17000.0	358.13		358.13	2108.00	358.82	2069.05
28-Nov-89	49	1.60	470.0	18000.0	421.14		421.14	2529.14	391.73	2460.78
05-Dec-89	56	1.60	402.0	17000.0	352.86		352.86	2882.00	323.95	2784.73
12-Dec-89	63	1.60	458.5	16500.0	426.71		426.71	3308.71	344.17	3128.90
19-Dec-89	70	1.70	457.0	12000.0	347.98		347.98	3656.69	271.56	3400.47
26-Dec-89	77	1.73	494.0	15000.0	338.78		338.78	3995.47	298.09	3698.56
02-Jan-90	84	1.73	420.0	15000.0	278.51		278.51	4273.98	218.66	3917.22
09-Jan-90	91	1.70	455.0	15000.0	251.33		251.33	4525.31	249.44	4166.66
16-Jan-90	98	1.70	444.0	14500.0	238.85		238.85	4764.16	210.73	4377.39

LEACHING TUBS: LECKIE SMOKELESS-T-2
44318.70 grams

DATE	TOTAL DAYS	pH COLD	LEACHATE VOLUME (ml)	SPECIFIC CONDUCT. (uS)	ACIDITY /kg SAMPLE (mg/kg)	ALKALINITY /kg SAMPLE (mg/kg)	NET DAILY ACIDITY /kg SAMPLE (mg/kg)	NET CUMULATIVE ACIDITY /kg SAMPLE (mg/kg)	SULFATE (mg/kg)	CUMULATIVE SULFATE (mg/kg)
10-Oct-89	0	2.20	289.0	8050.0	94.09	0.00	94.09	94.09	83.95	83.95
17-Oct-89	7	2.10	283.0	8550.0	114.79		114.79	208.88	102.51	186.46
24-Oct-89	14	1.85	439.5	9700.0	228.09		228.09	436.97	196.00	382.46
31-Oct-89	21	1.70	402.0	15500.0	243.47		243.47	680.44	222.04	604.50
07-Nov-89	28	1.60	295.0	18500.0	238.90		238.90	919.34	229.08	833.58
14-Nov-89	35	1.60	379.0	15500.0	284.94		284.94	1204.28	244.83	1078.41
21-Nov-89	42	1.76	398.0	16000.0	290.88		290.88	1495.16	260.59	1339.00
28-Nov-89	49	1.60	355.0	16000.0	259.45		259.45	1754.61	247.99	1586.99
05-Dec-89	56	1.60	311.0	15500.0	245.31		245.31	1999.92	230.89	1817.88
12-Dec-89	63	1.65	419.0	15000.0	321.16		321.16	2321.08	278.01	2095.89
19-Dec-89	70	1.70	479.0	11500.0	371.80		371.80	2692.88	309.42	2405.32
26-Dec-89	77	1.75	353.0	16000.0	228.18		228.18	2921.06	215.65	2620.97
02-Jan-90	84	1.75	397.0	15500.0	245.65		245.65	3166.71	200.77	2821.74
09-Jan-90	91	1.71	362.0	15000.0	201.69		201.69	3368.40	217.98	3039.72
16-Jan-90	98	1.80	408.0	14000.0	231.14		231.14	3599.54	192.03	3231.75

LIST OF CAPTIONS

FIGURE 1. - Titration curve for pulverized Smeal and pulverized Eagle Eye

FIGURE 2. - Titration curve for Smeal fines and Eagle Eye fines

FIGURE 3. - Titration curve for Smeal 1/4"-1/2" size fraction and Eagle Eye 1/4"-1/2" size fraction

FIGURE 4. - pH vs. time for Smeal and Eagle Eye columns 1 through 4

FIGURE 5. - Specific conductance vs. time for Smeal and Eagle Eye columns 1 through 4

FIGURE 6. - Net daily acidity vs. time for Smeal and Eagle Eye columns 1 through 4

FIGURE 7. - Net cumulative acidity vs. time for Smeal and Eagle Eye columns 1 through 4

FIGURE 8.- Sulfate load vs. time for Smeal columns 1 Through 4

FIGURE 9. - Sulfate load vs. time for Eagle Eye columns 1 through 4

FIGURE 10. - Cumulative sulfate vs. time for Eagle Eye columns 1 through 4 and Smeal columns

FIGURE 11. - Sulfate vs. acidity for Smeal columns 1 through 4

FIGURE 12. - Sulfate vs. acidity for Eagle Eye columns 1 through 4

LIST OF CAPTIONS--Continued

LIST OF CAPTIONS--Continued

FIGURE 26. - Acid load and cumulative acidity vs. time for Preston County # 3 tubs

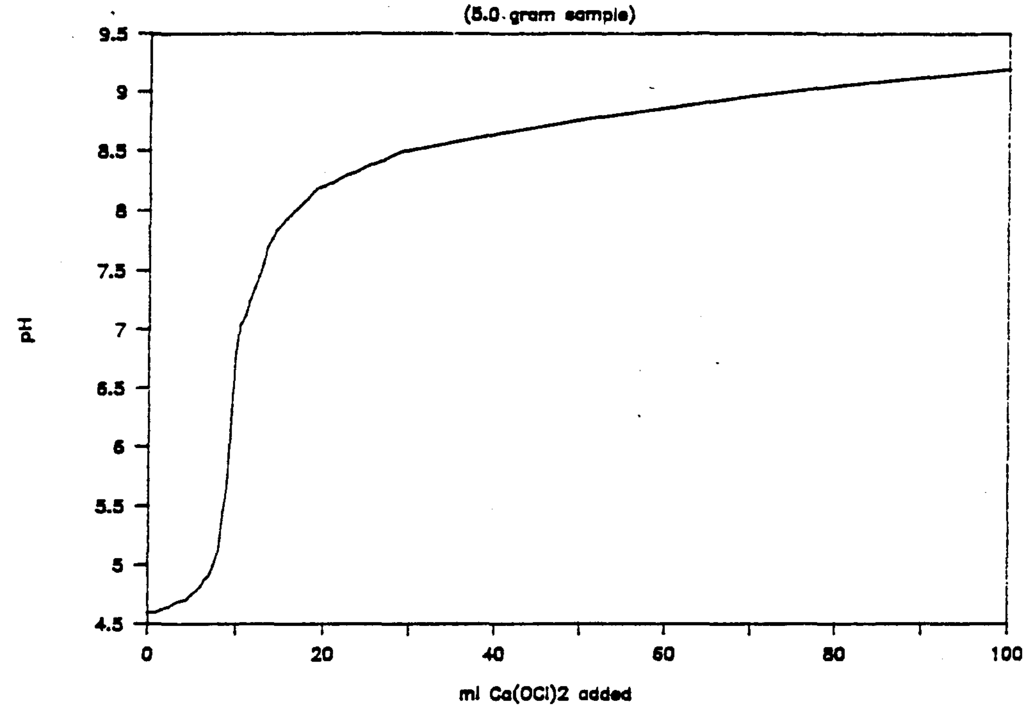
FIGURE 27. - Sulfate and cumulative sulfate vs. time for Preston County # 3 tubs

FIGURE 28. - pH and specific conductance vs. time for Leckie Smokeless tubs

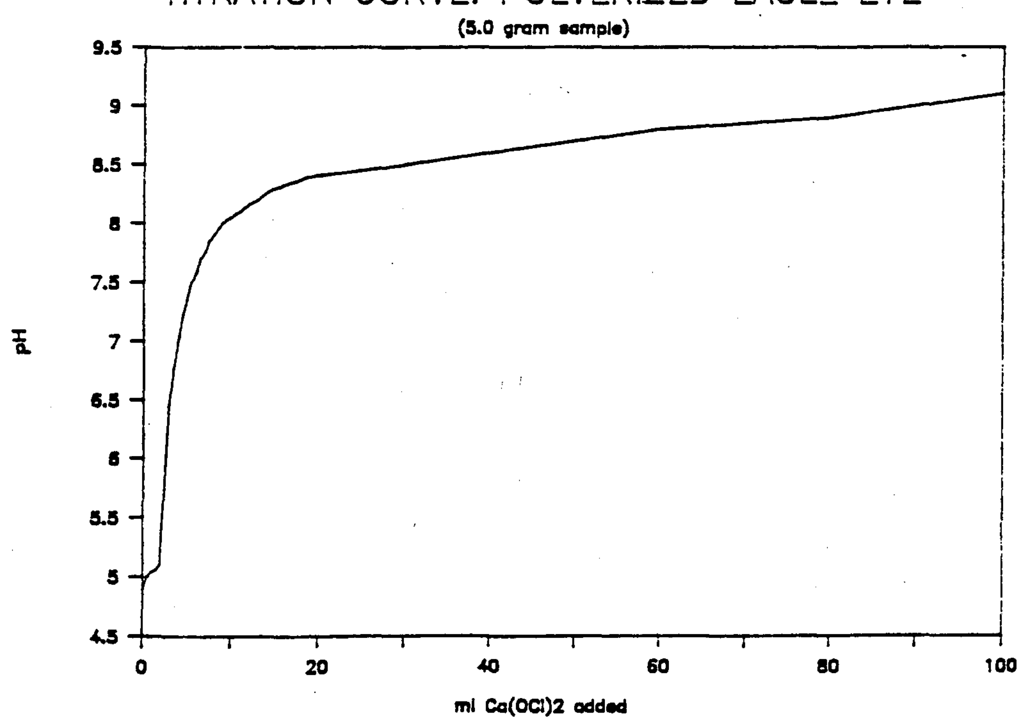
FIGURE 29. - Acid load and cumulative acidity vs. time for Leckie Smokeless tubs

FIGURE 30. - Sulfate and cumulative sulfate vs. time for Leckie Smokeless tubs

TITRATION CURVE: PULVERIZED SMEAL

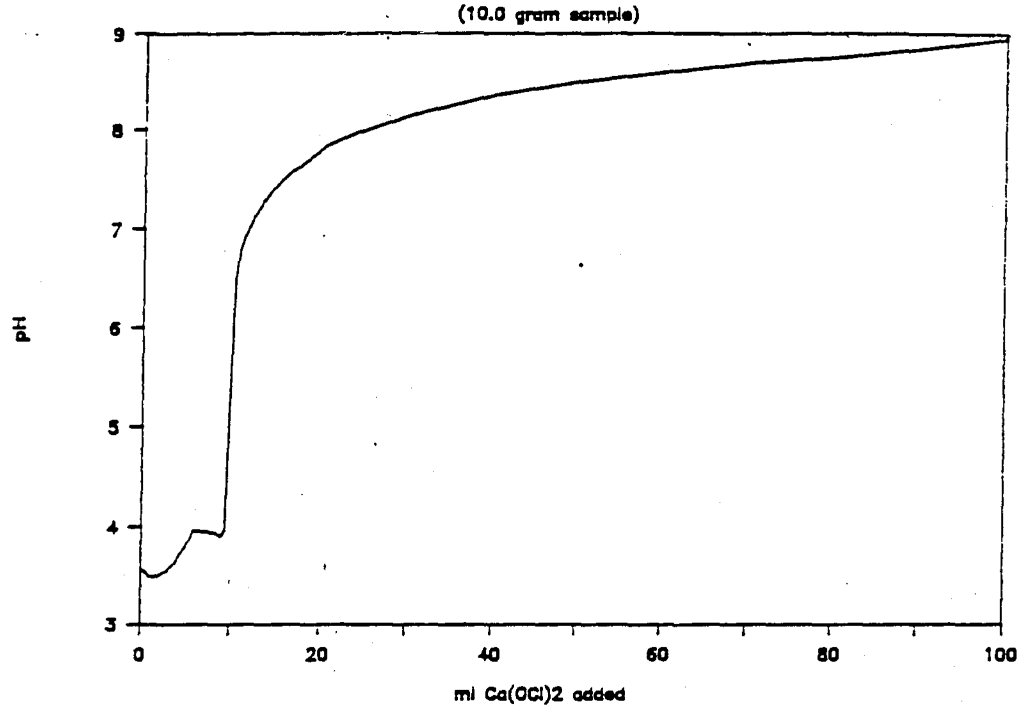


TITRATION CURVE: PULVERIZED EAGLE EYE



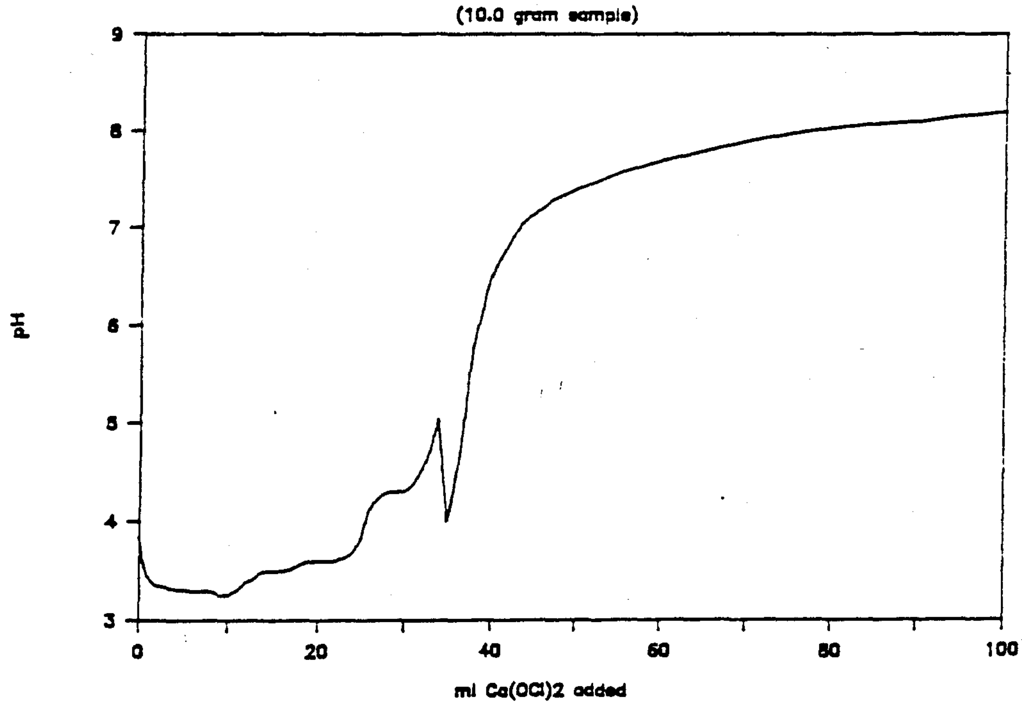
TITRATION CURVE: SMEAL FINES

(10.0 gram sample)

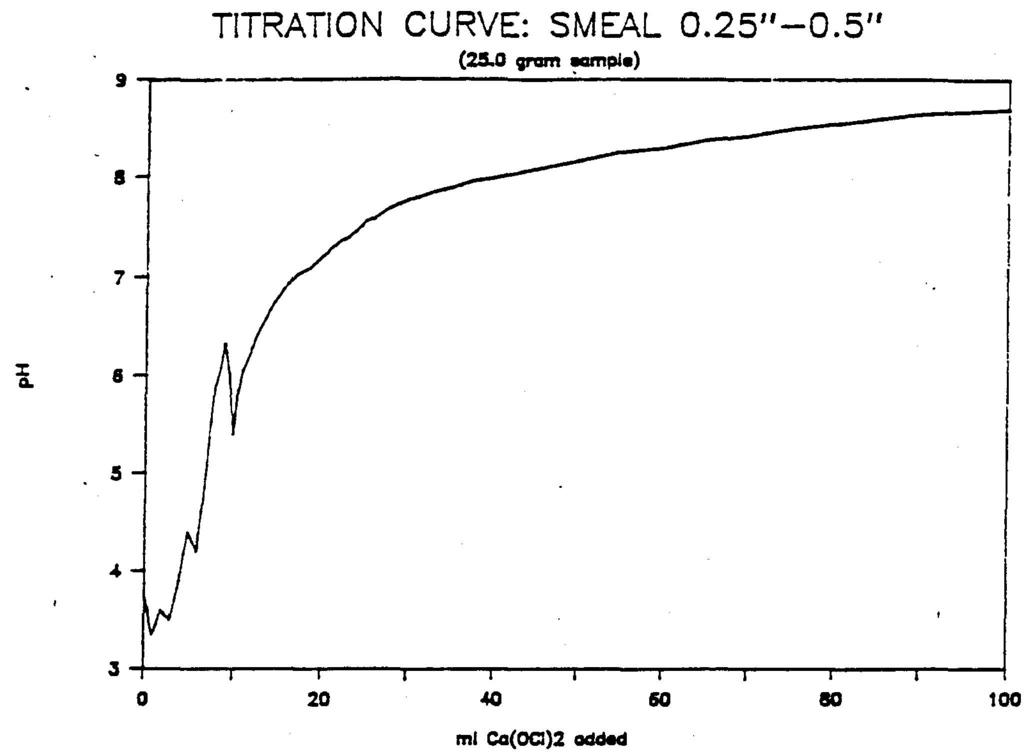


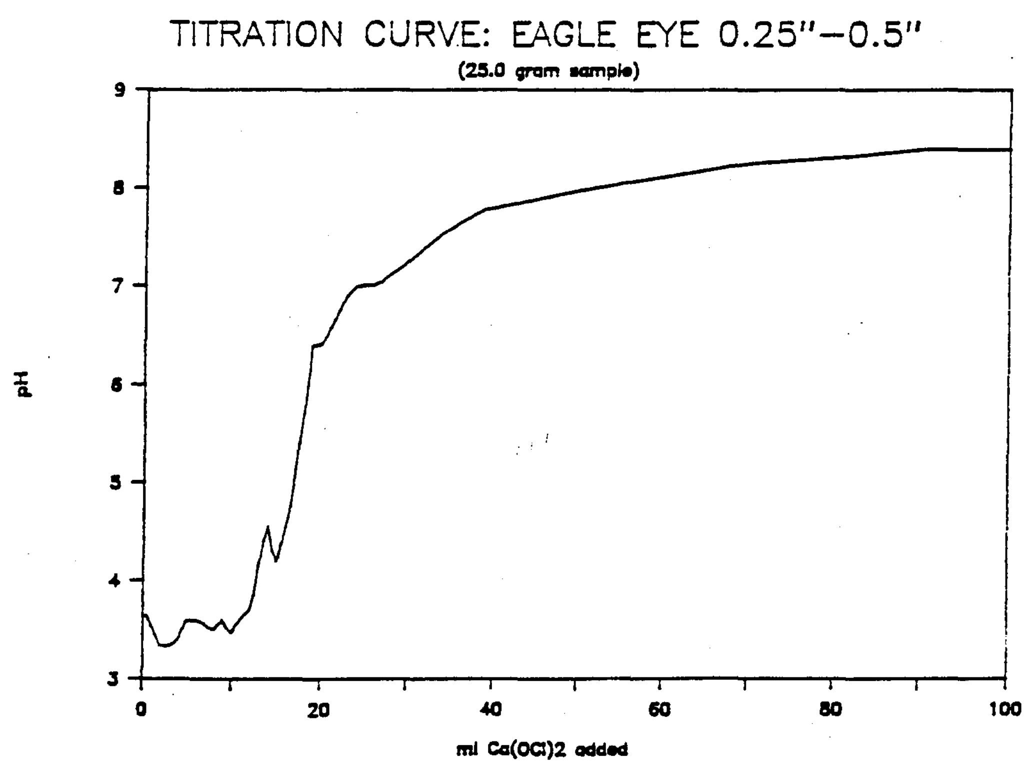
TITRATION CURVE: EAGLE EYE FINES

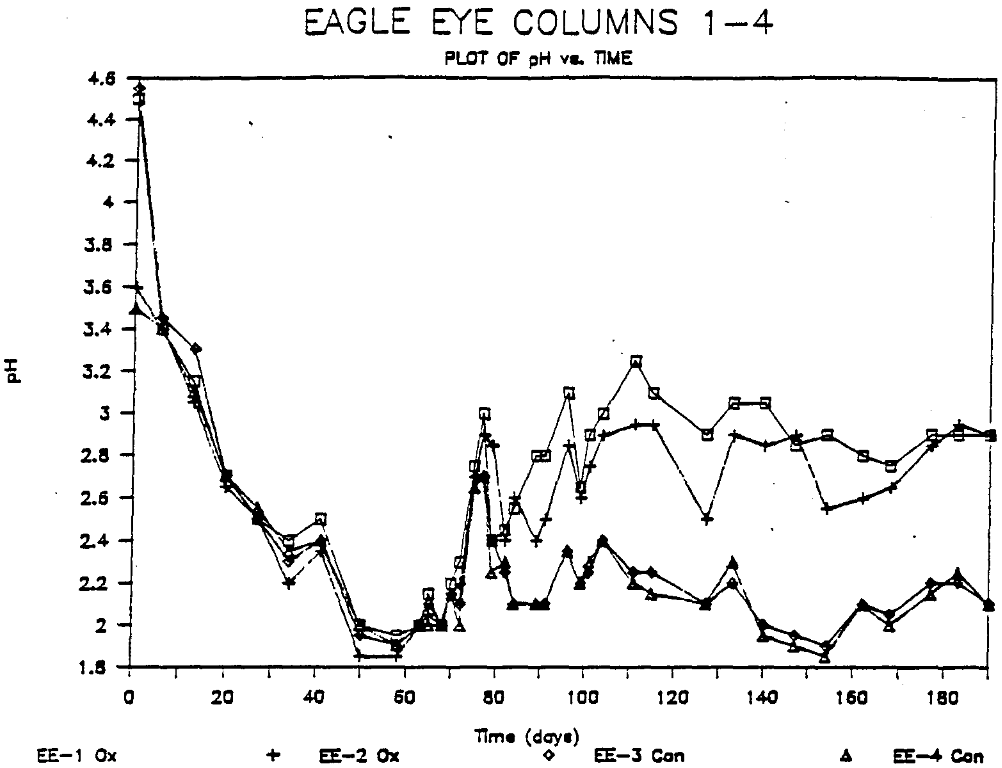
(10.0 gram sample)



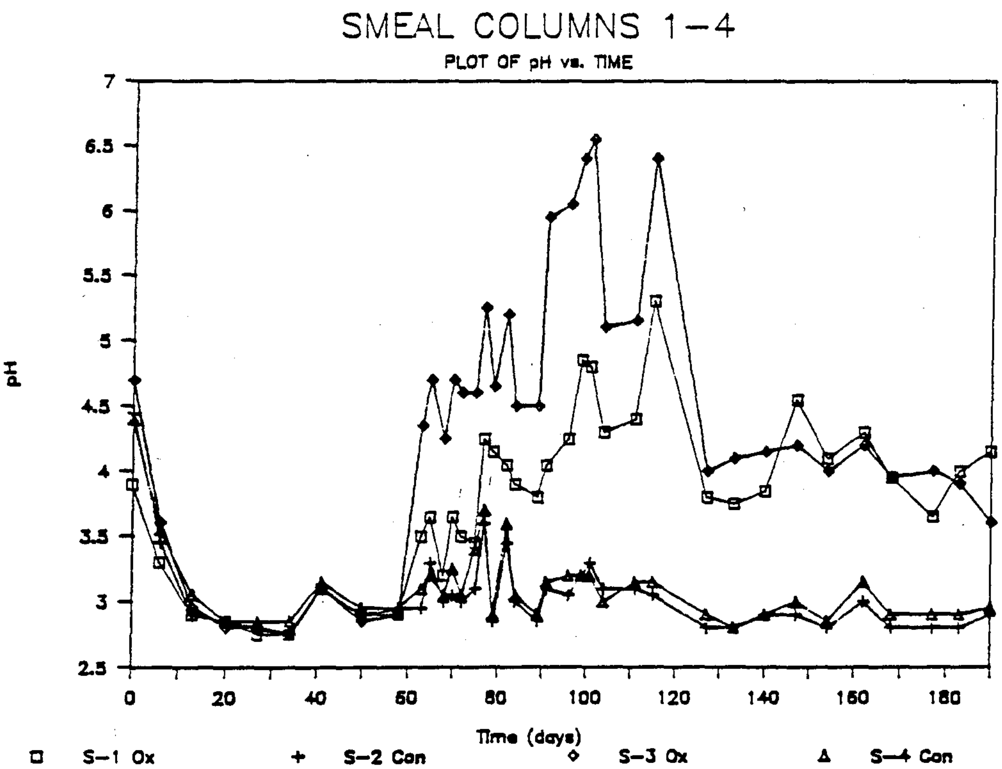
M


TITRATION CURVE: SMEAL 0.25"–0.5"
(25.0 gram sample)
pH
9
8
7
6
5
4
3
0
20
40
60
80
100
ml Ca(OCl)2 added


TITRATION CURVE: EAGLE EYE 0.25"–0.5"
(25.0 gram sample)
pH
9
8
7
6
5
4
3
0
20
40
60
80
100
ml Ca(OCl)2 added

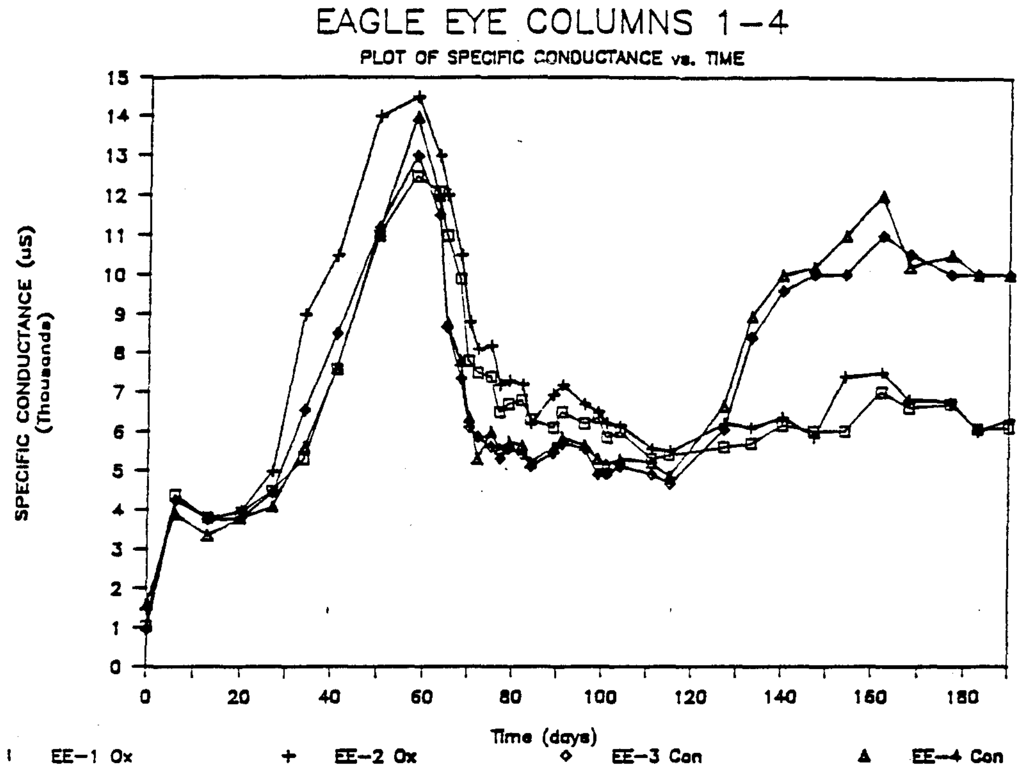


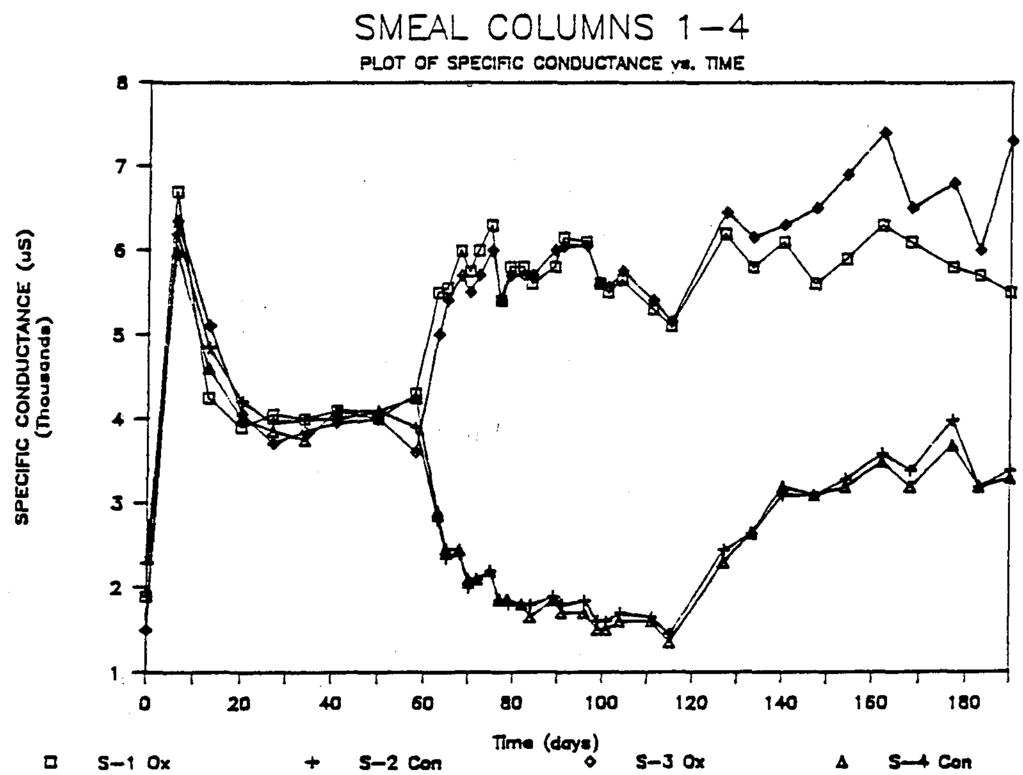
EAGLE EYE COLUMNS 1-4
PLOT OF pH vs. TIME
pH
Time (days)
EE-1 Ox
+ EE-2 Ox
◇ EE-3 Con
△ EE-4 Con



SMEAL COLUMNS 1-4
PLOT OF pH vs. TIME
pH
Time (days)
□ S-1 Ox
+ S-2 Con
◇ S-3 Ox
△ S-4 Con

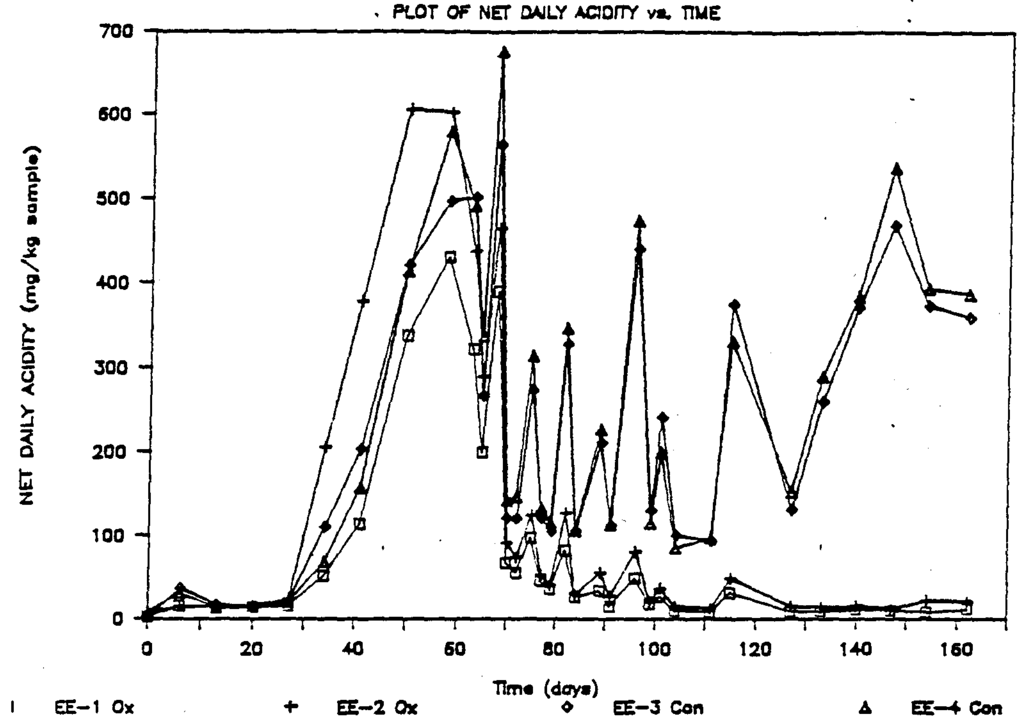
113


EAGLE EYE COLUMNS 1-4
PLOT OF SPECIFIC CONDUCTANCE vs. TIME
SPECIFIC CONDUCTANCE (uS)
(Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
20
40
60
80
100
120
140
160
180
Time (days)
EE-1 Ox
EE-2 Ox
EE-3 Con
EE-4 Con


SMEAL COLUMNS 1-4
PLOT OF SPECIFIC CONDUCTANCE vs. TIME
SPECIFIC CONDUCTANCE (uS)
(Thousands)
1
2
3
4
5
6
7
8
0
20
40
60
80
100
120
140
160
180
Time (days)
S-1 Ox
S-2 Con
S-3 Ox
S-4 Con

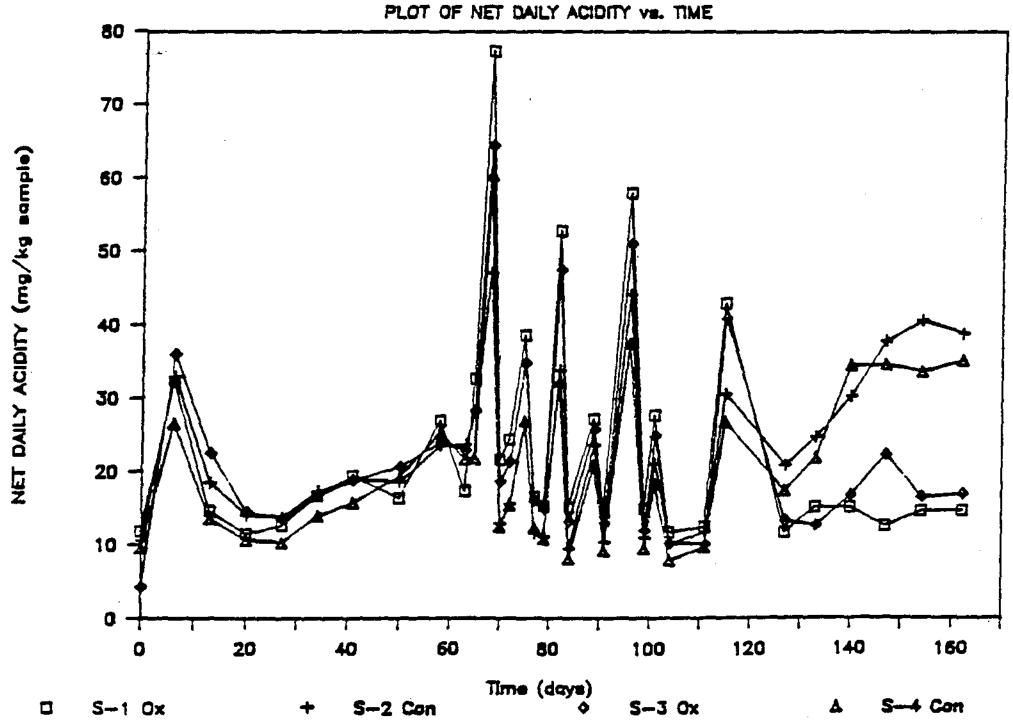
EAGLE EYE COLUMNS 1-4

PLOT OF NET DAILY ACIDITY vs. TIME



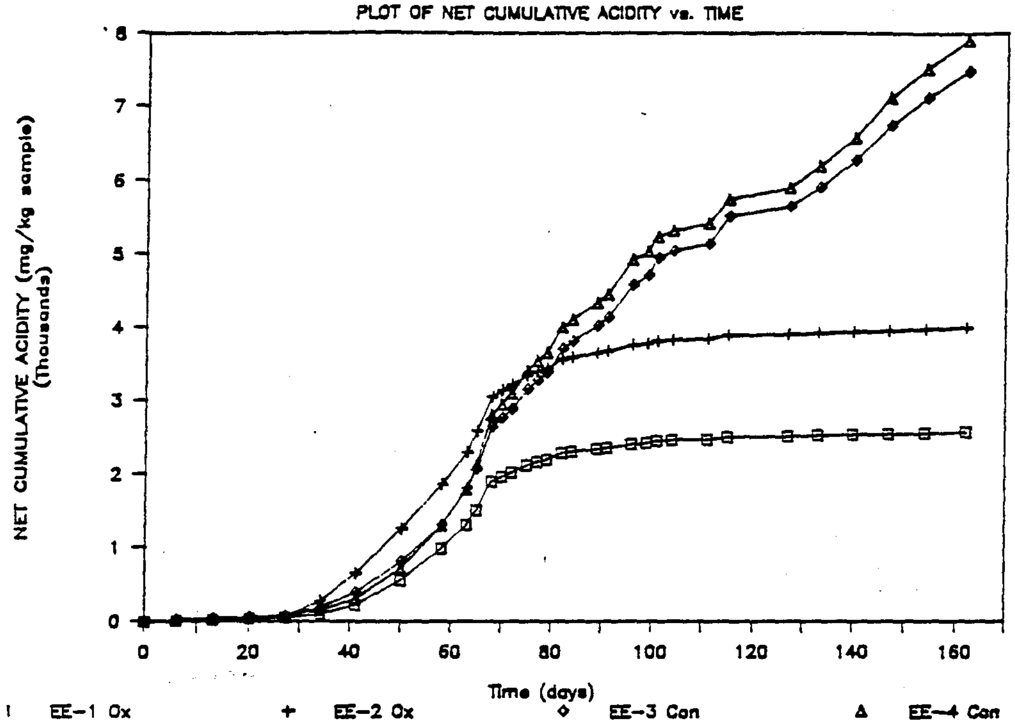
SMEAL COLUMNS 1-4

PLOT OF NET DAILY ACIDITY vs. TIME



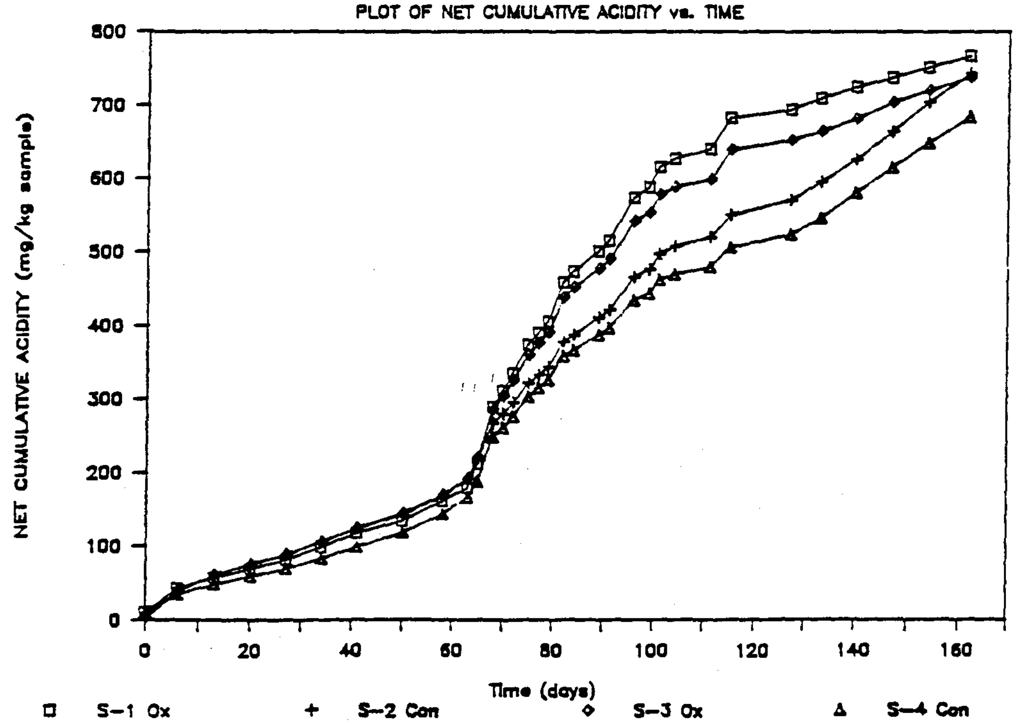
EAGLE EYE COLUMNS 1–4

PLOT OF NET CUMULATIVE ACIDITY vs. TIME



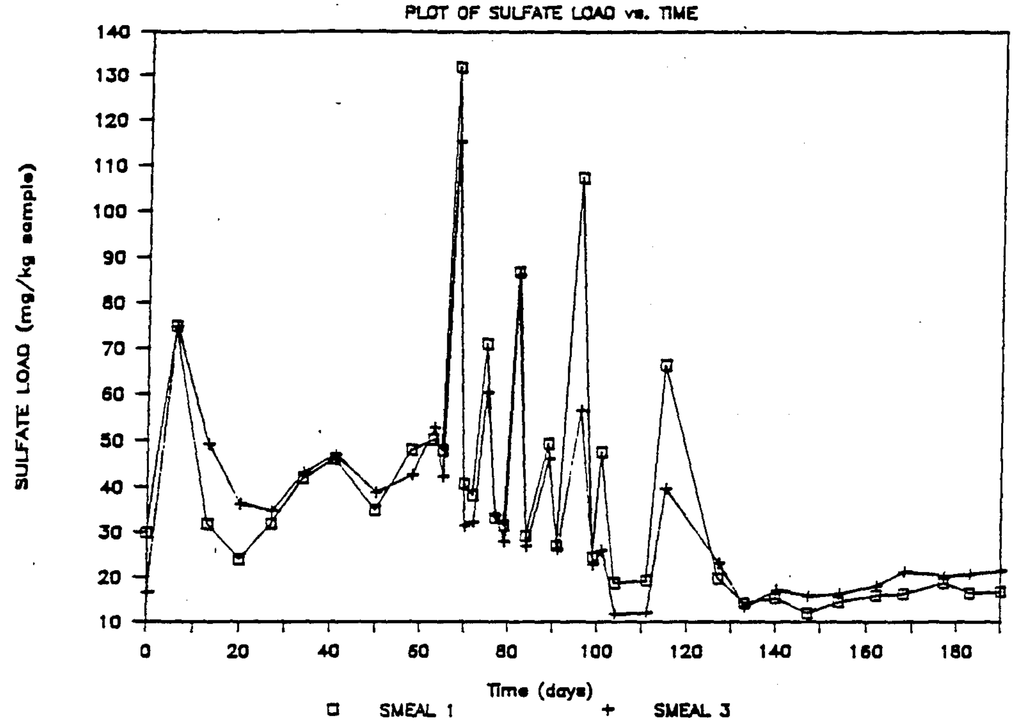
SMEAL COLUMNS 1–4

PLOT OF NET CUMULATIVE ACIDITY vs. TIME



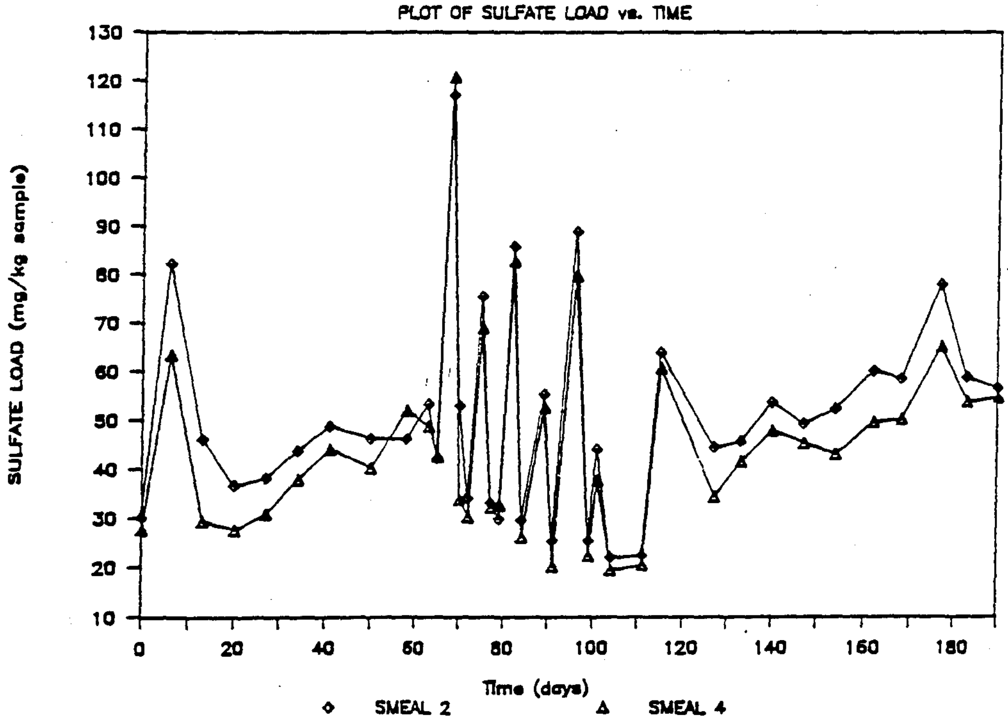
SMEAL COLUMNS 1 & 3 (OXIDIZED)

PLOT OF SULFATE LOAD vs. TIME



SMEAL COLUMNS 2 & 4 (CONTROL)

PLOT OF SULFATE LOAD vs. TIME



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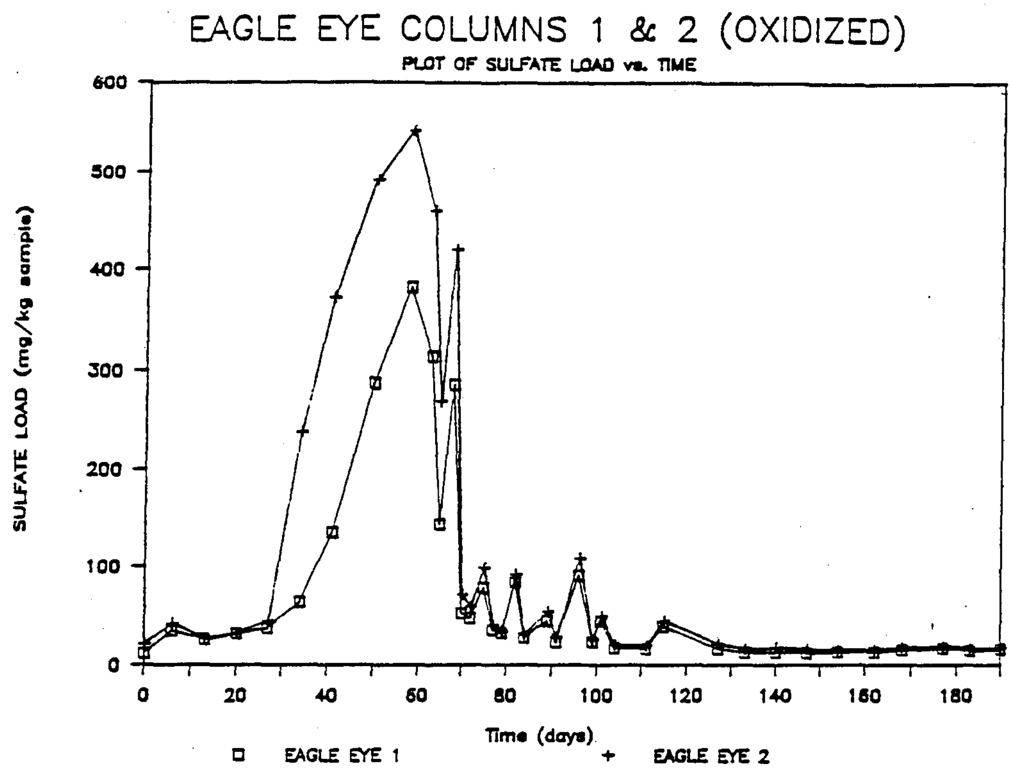
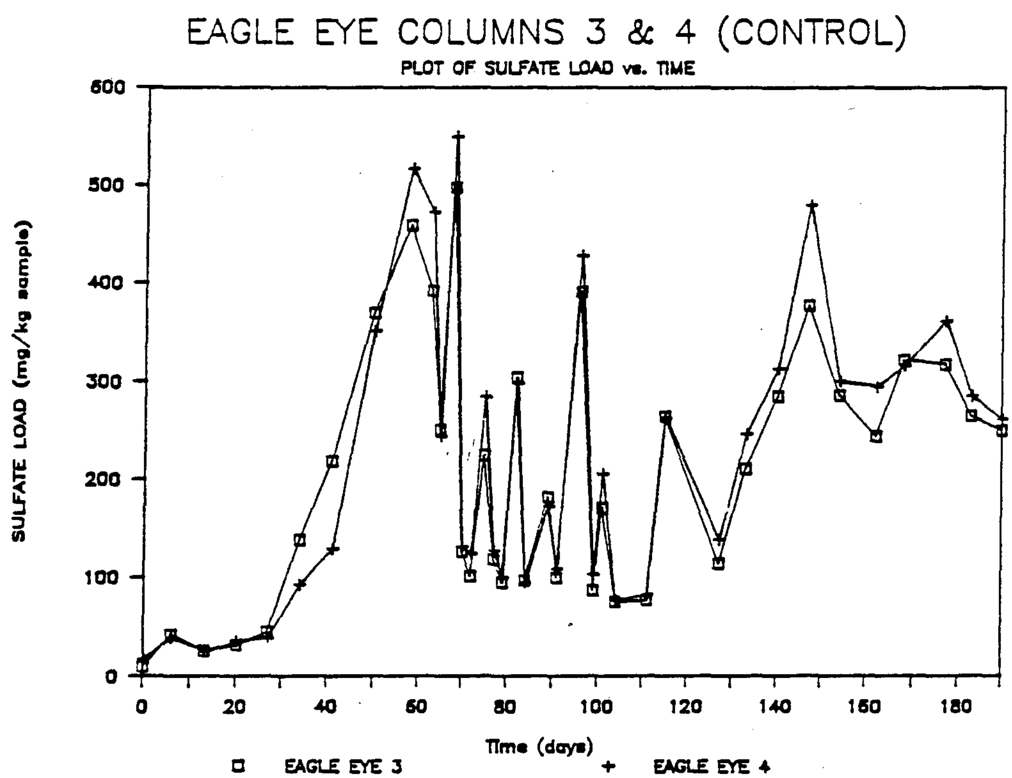
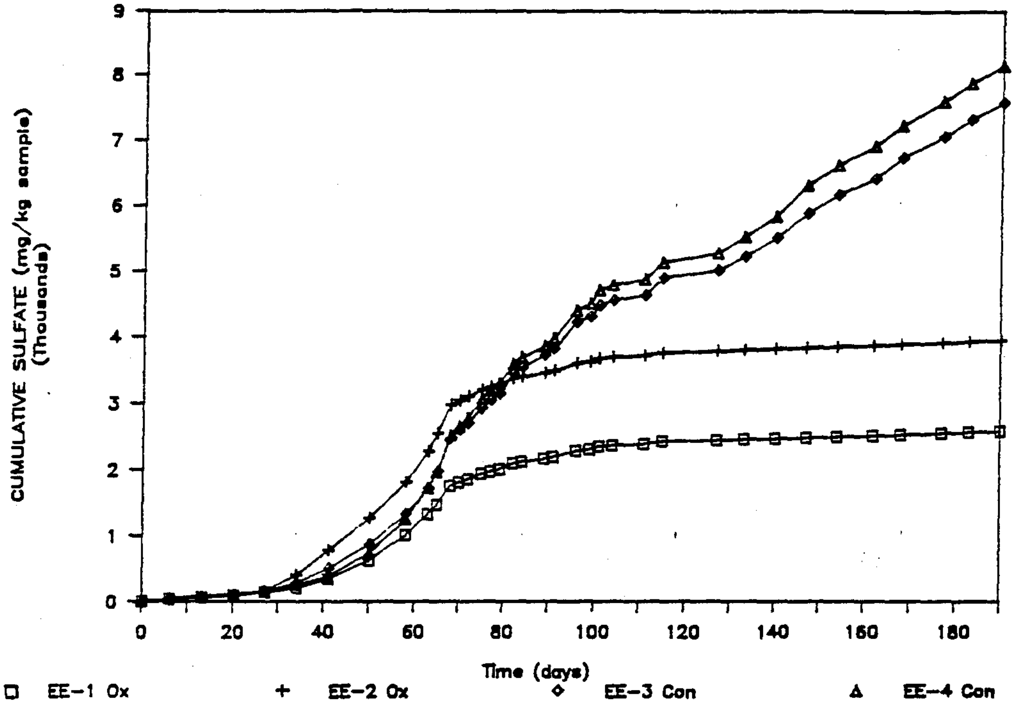

EAGLE EYE COLUMNS 1 & 2 (OXIDIZED)
PLOT OF SULFATE LOAD vs. TIME
SULFATE LOAD (mg/kg sample)
Time (days)
EAGLE EYE 1
EAGLE EYE 2


EAGLE EYE COLUMNS 3 & 4 (CONTROL)
PLOT OF SULFATE LOAD vs. TIME
SULFATE LOAD (mg/kg sample)
Time (days)
EAGLE EYE 3
EAGLE EYE 4

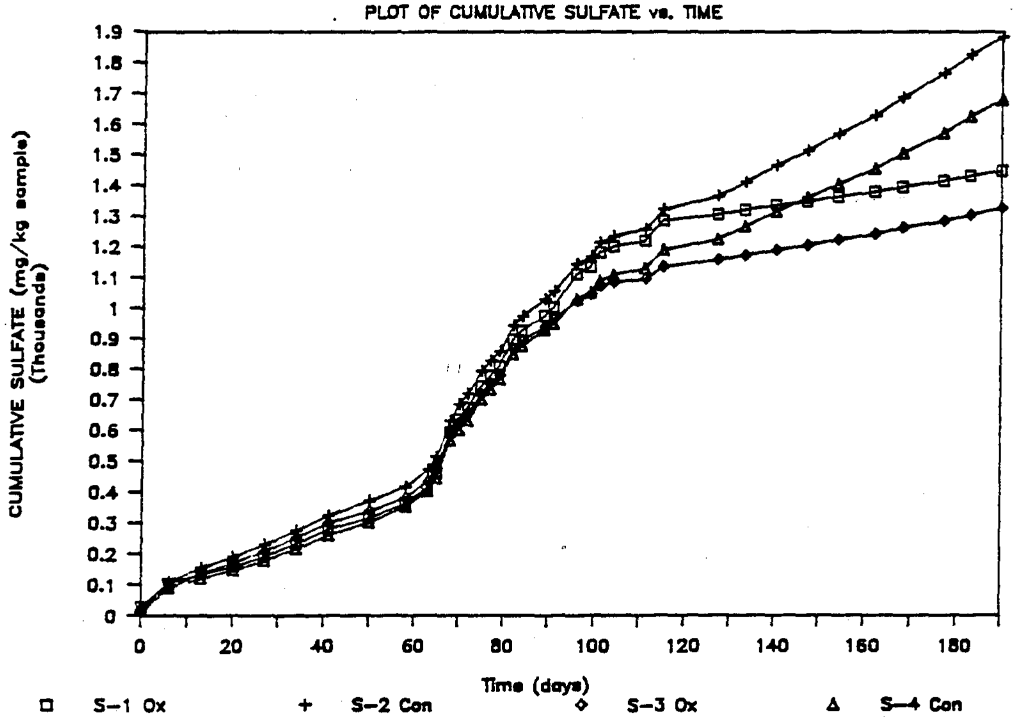
EAGLE EYE COLUMNS 1–4

PLOT OF CUMULATIVE SULFATE vs. TIME

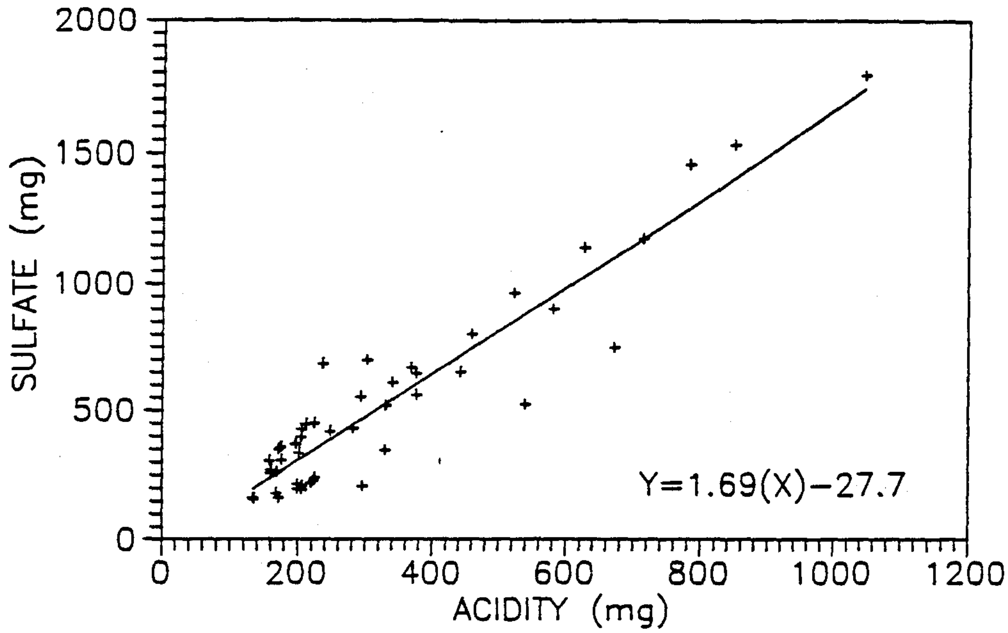


SMEAL COLUMNS 1–4

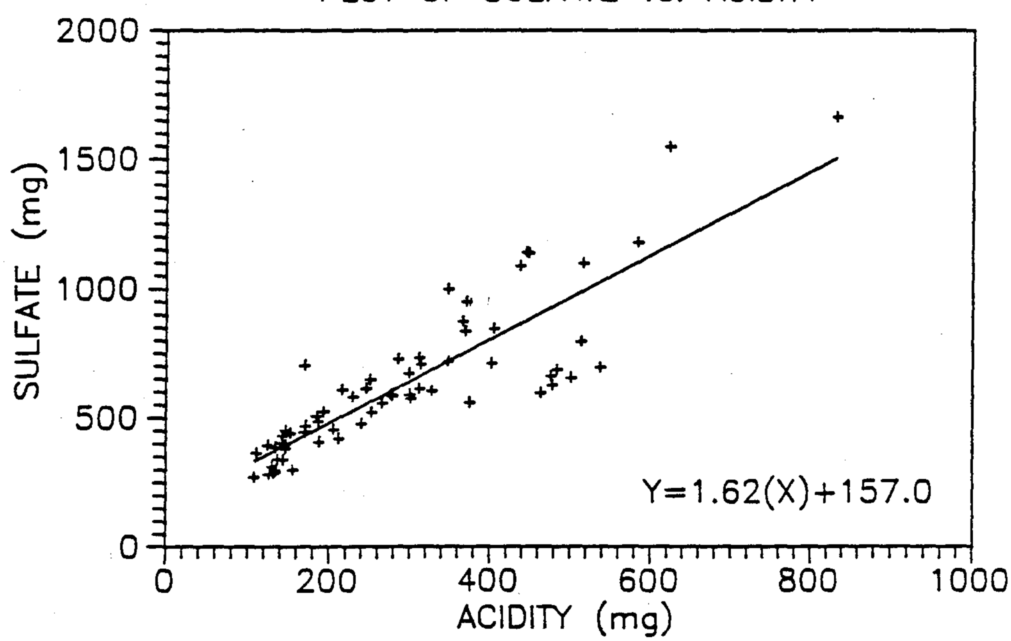
PLOT OF CUMULATIVE SULFATE vs. TIME



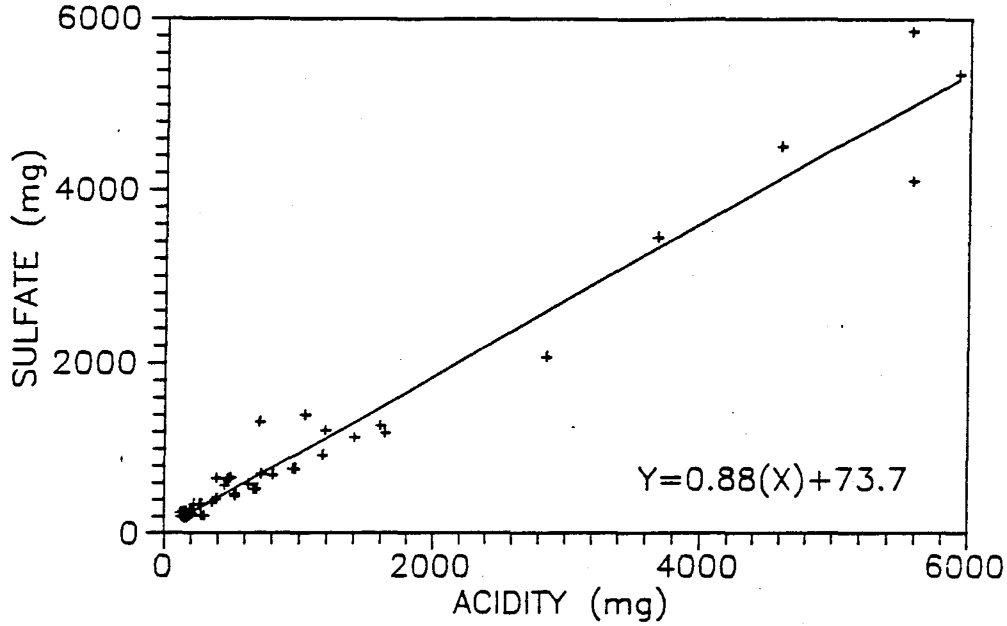
SMEAL COLUMNS 1 & 3 (OXIDIZED)
PLOT OF SULFATE vs. ACIDITY



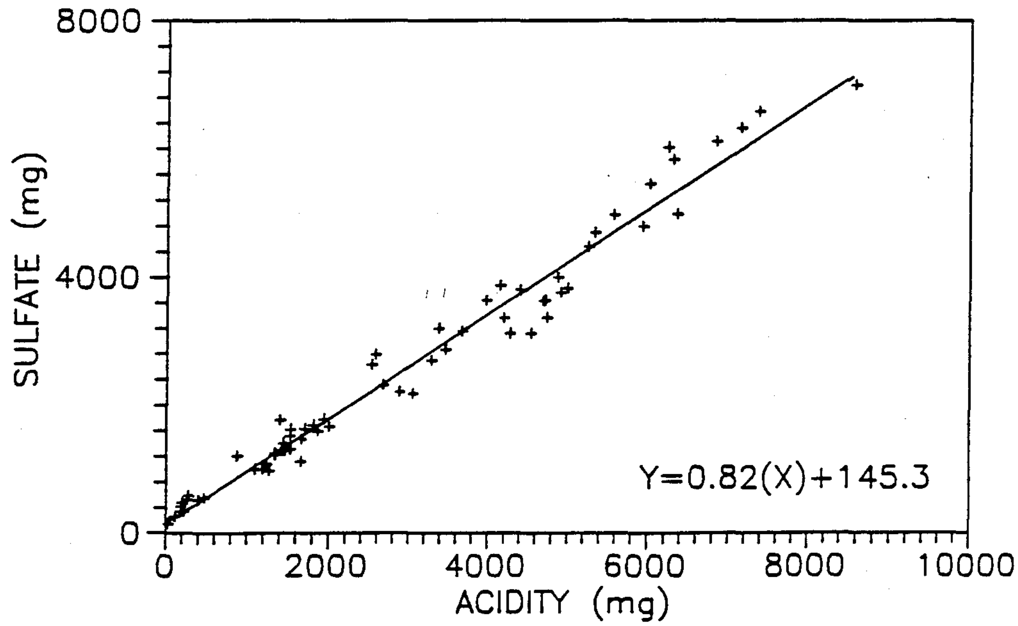
SMEAL COLUMNS 2 & 4 (CONTROL)
PLOT OF SULFATE vs. ACIDITY



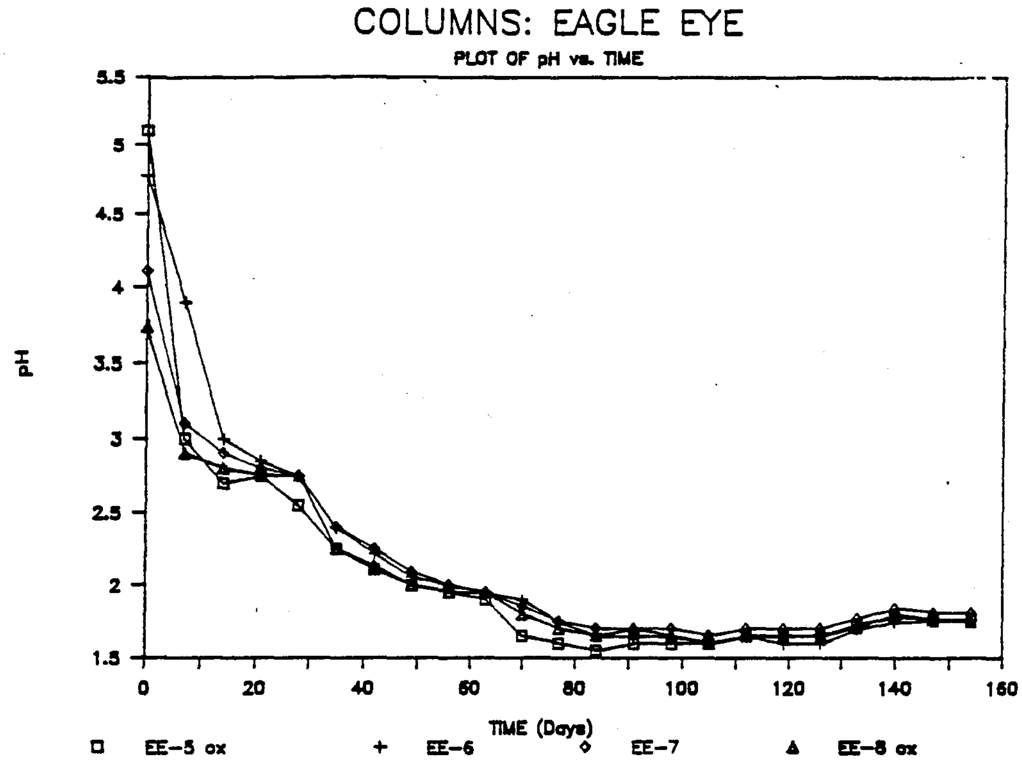
EAGLE EYE COLUMNS 1 & 2 (OXIDIZED)
PLOT OF SULFATE vs. ACIDITY



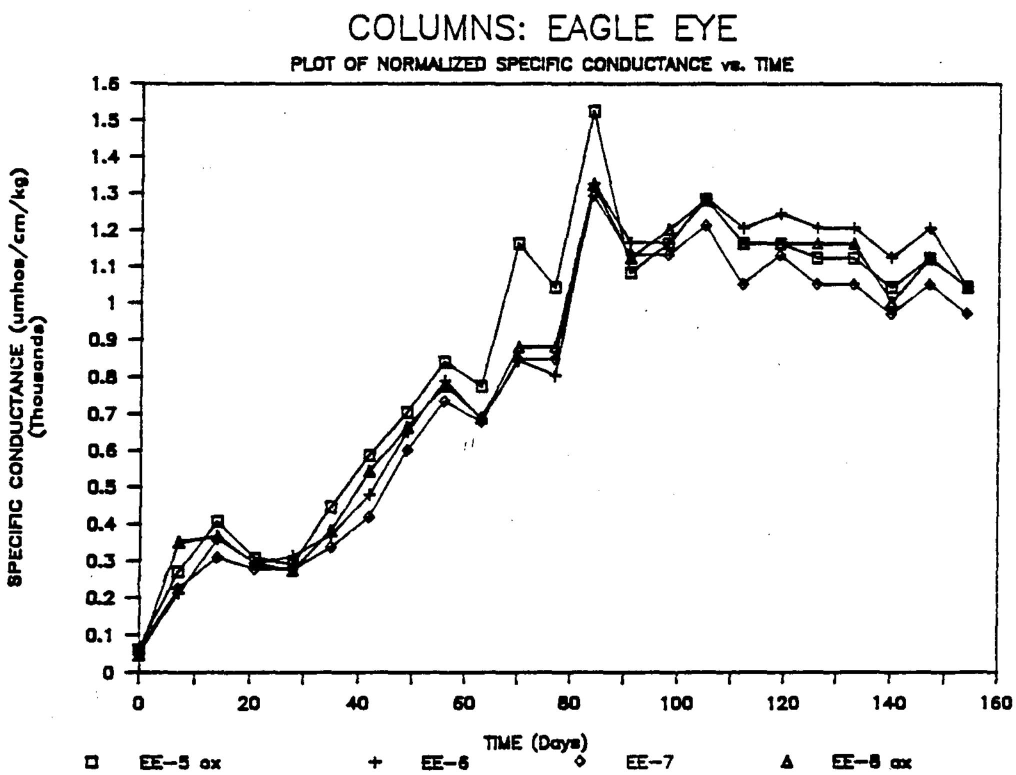
EAGLE EYE COLUMNS 3 & 4 (CONTROL)
PLOT OF SULFATE vs. ACIDITY



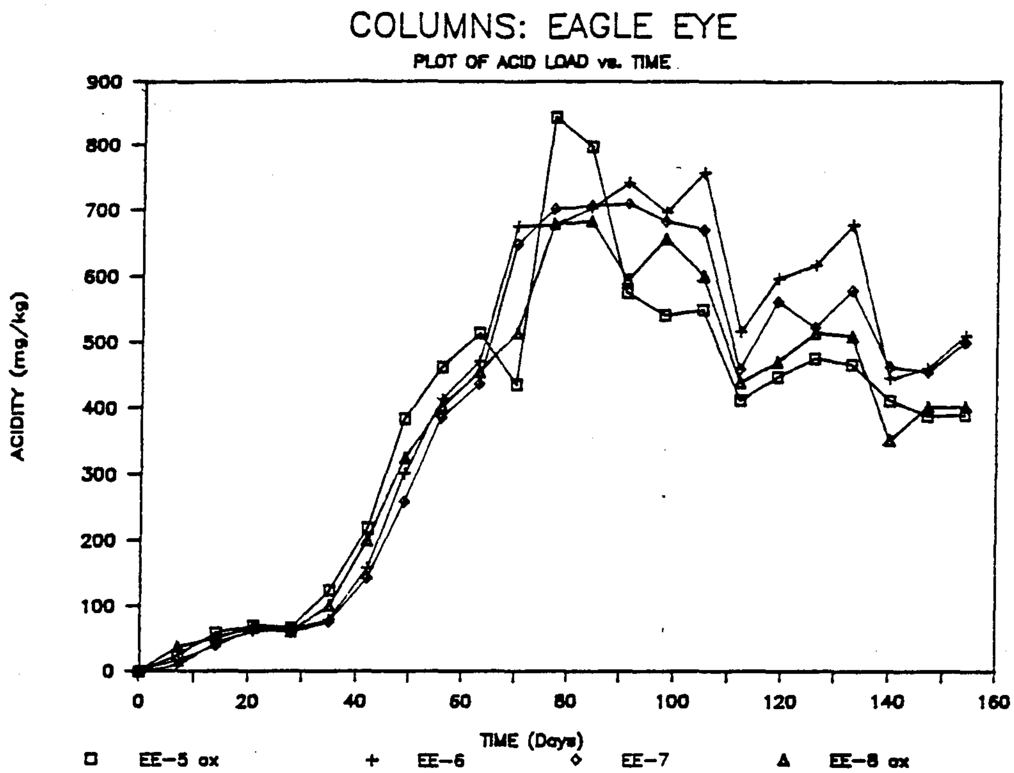
121

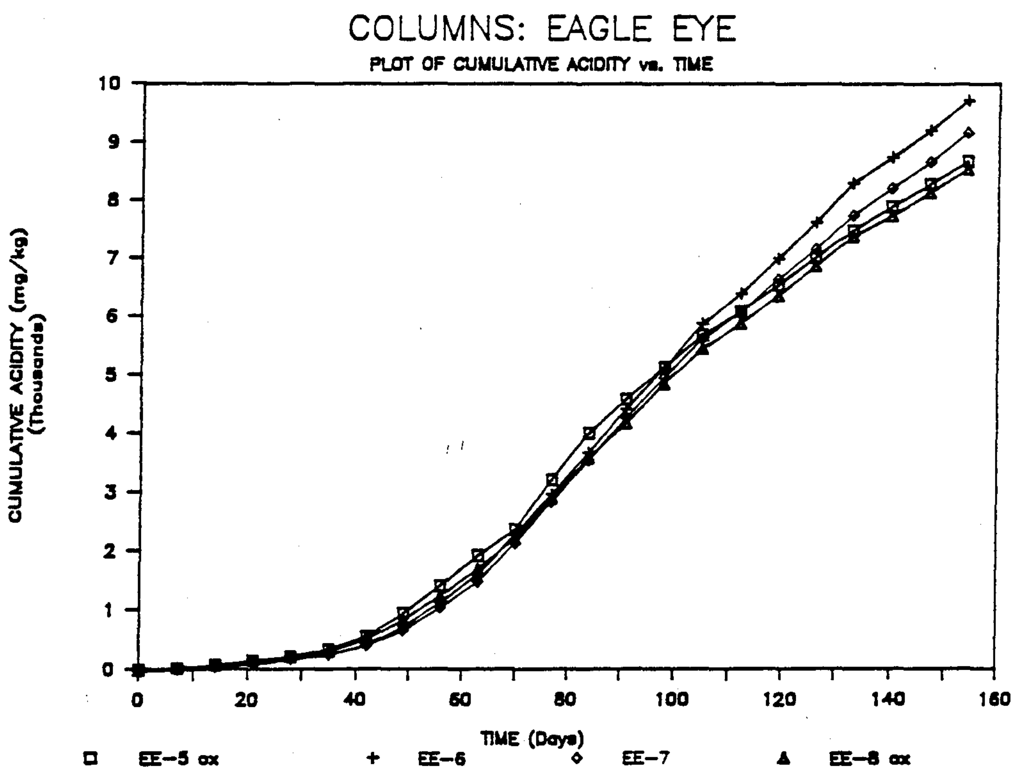


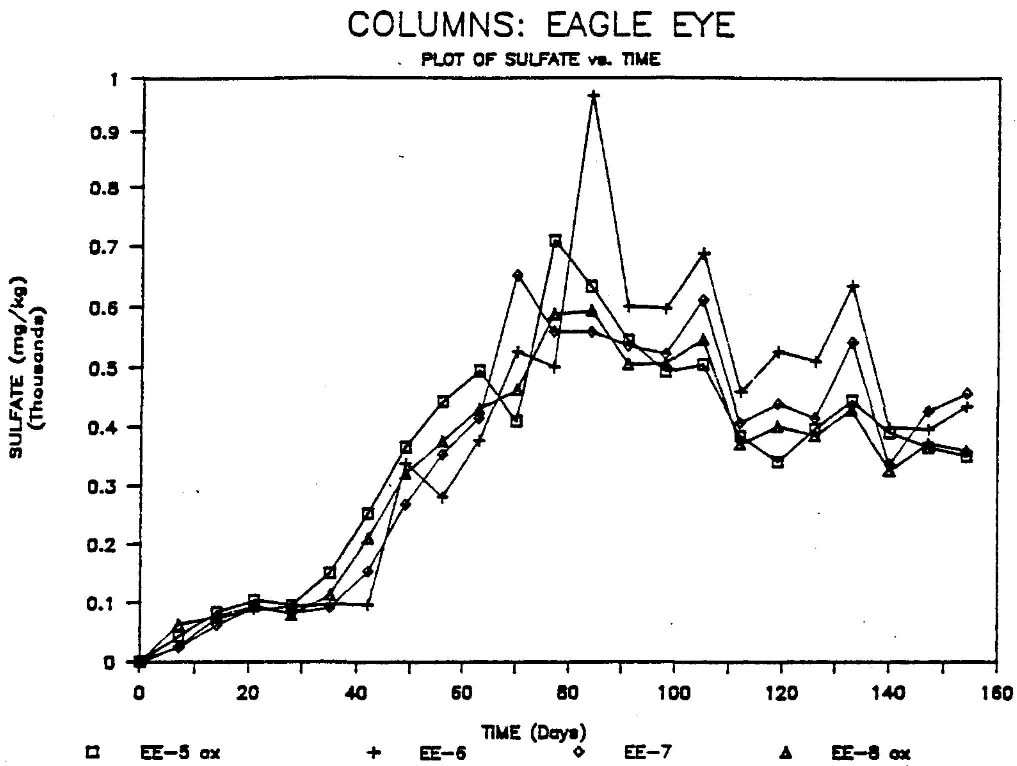
COLUMNS: EAGLE EYE
PLOT OF pH vs. TIME
pH
5.5
5
4.5
4
3.5
3
2.5
2
1.5
0
20
40
60
80
100
120
140
160
TIME (Days)
EE-5 ox
EE-6
EE-7
EE-8 ox

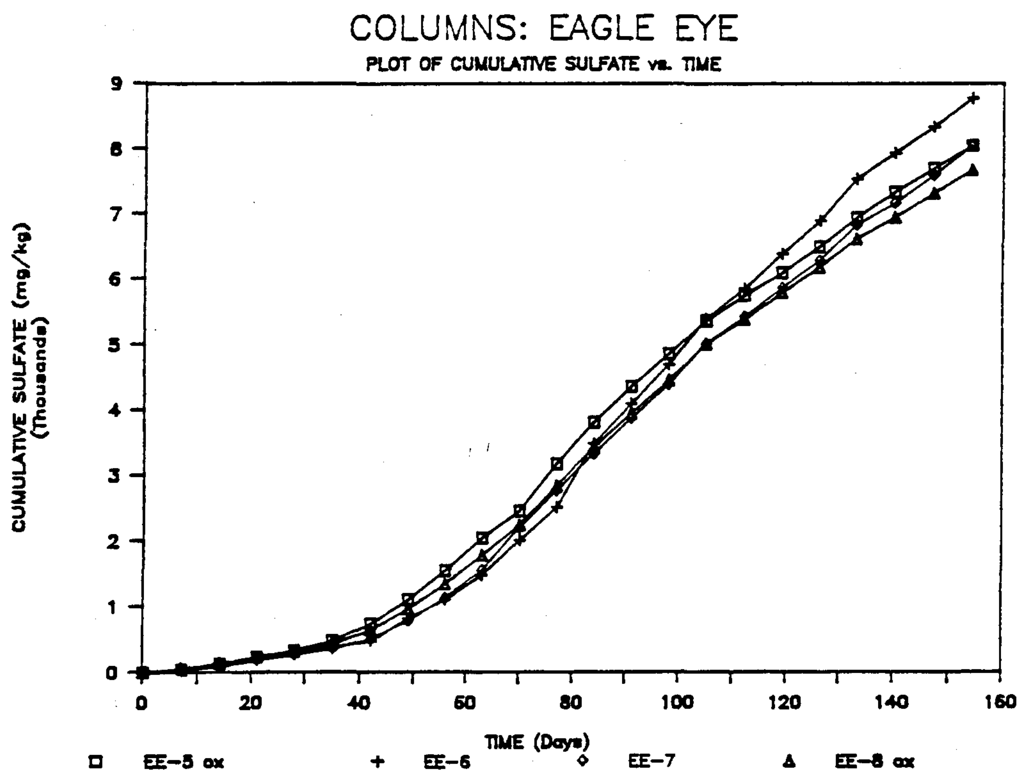


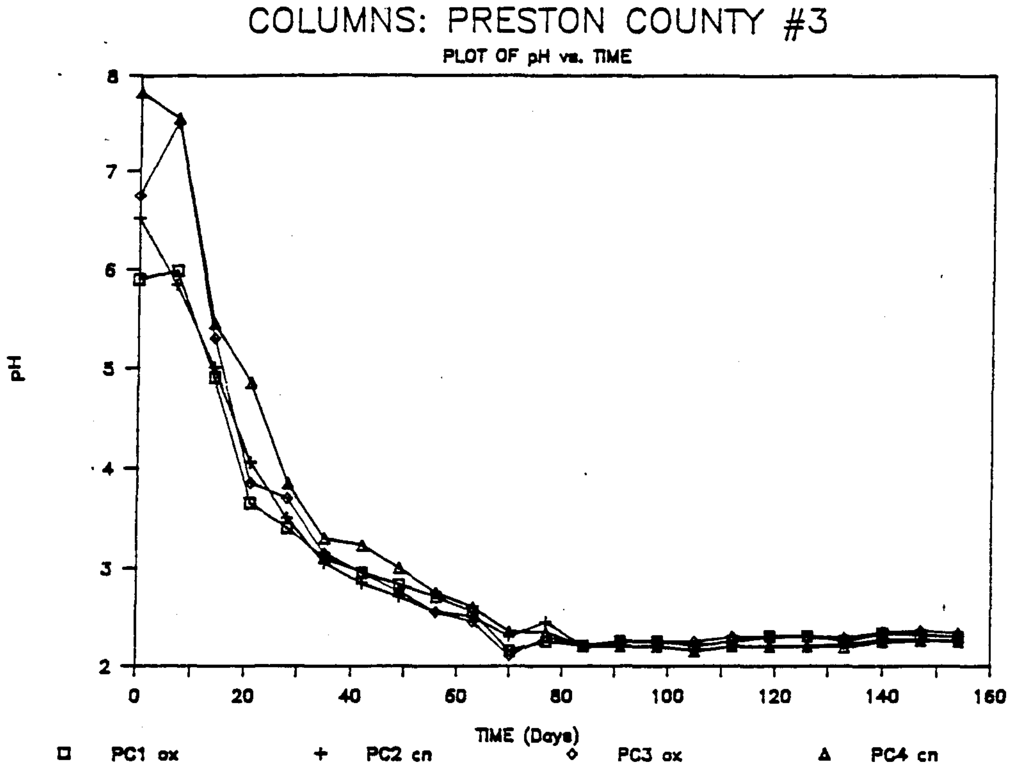
COLUMNS: EAGLE EYE
PLOT OF NORMALIZED SPECIFIC CONDUCTANCE vs. TIME
SPECIFIC CONDUCTANCE (umhos/cm/kg)
(Thousands)
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
80
100
120
140
160
TIME (Days)
EE-5 ox
EE-6
EE-7
EE-8 ox

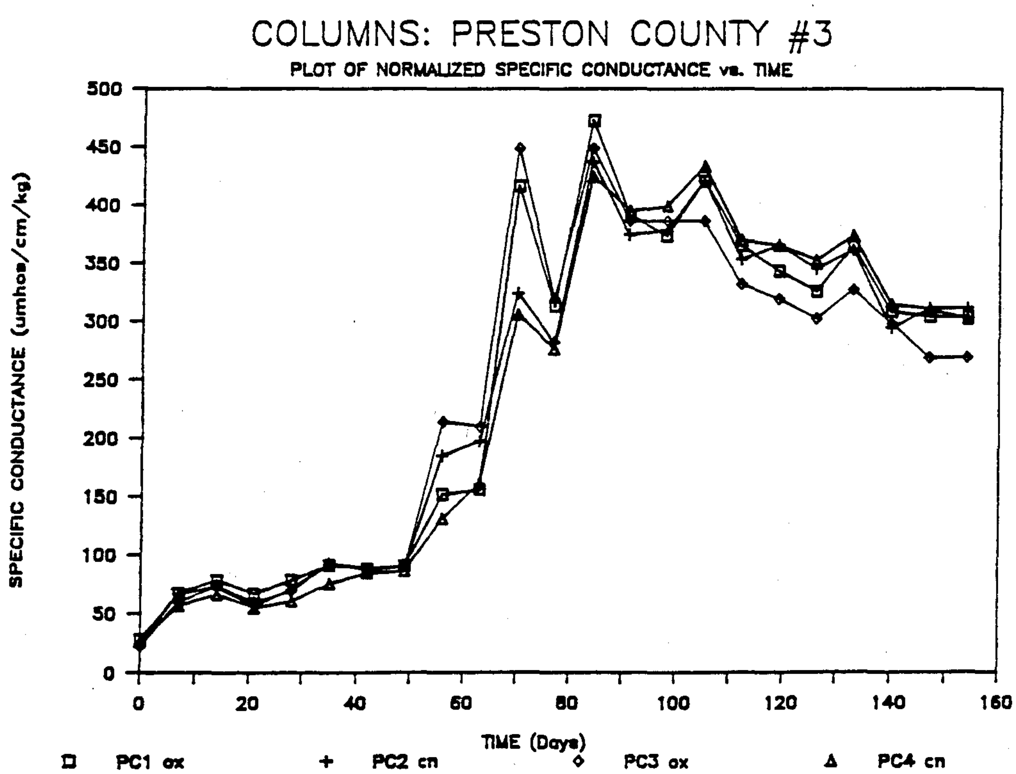

COLUMNS: EAGLE EYE
PLOT OF ACID LOAD vs. TIME
ACIDITY (mg/kg)
TIME (Days)
EE-5 ox
EE-6
EE-7
EE-8 ox

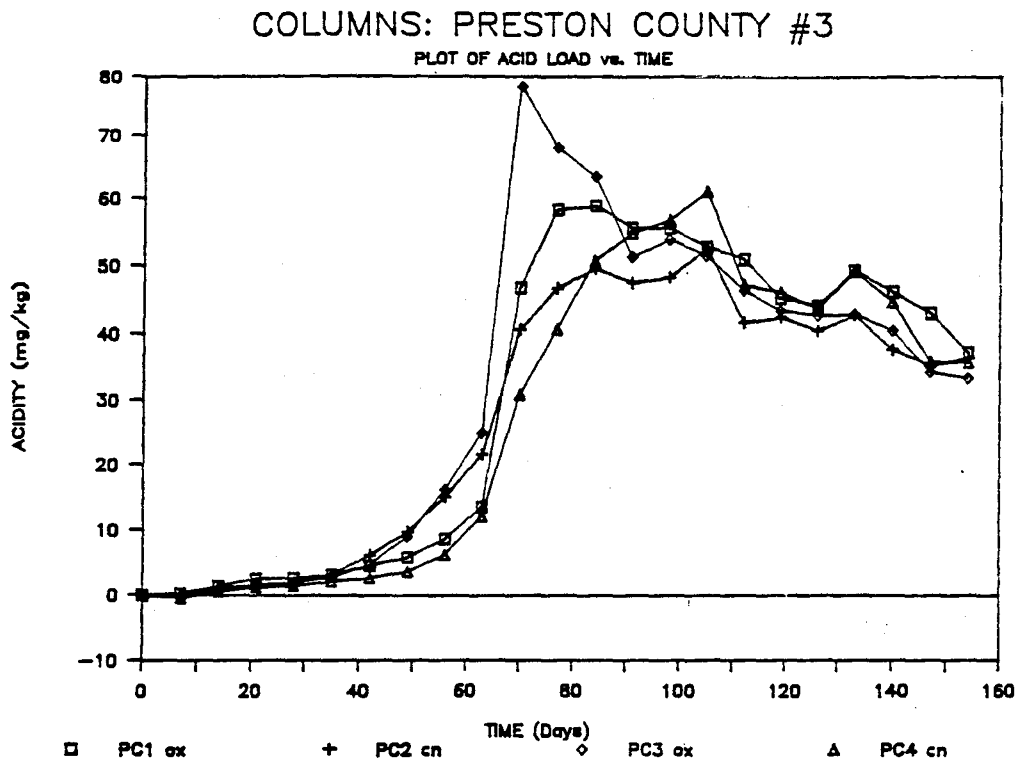

COLUMNS: EAGLE EYE
PLOT OF CUMULATIVE ACIDITY vs. TIME
CUMULATIVE ACIDITY (mg/kg)
(Thousands)
TIME (Days)
EE-5 ox
EE-6
EE-7
EE-8 ox


COLUMNS: EAGLE EYE
PLOT OF SULFATE vs. TIME
SULFATE (mg/kg)
(Thousands)
TIME (Days)
EE-5 ox
EE-6
EE-7
EE-8 ox

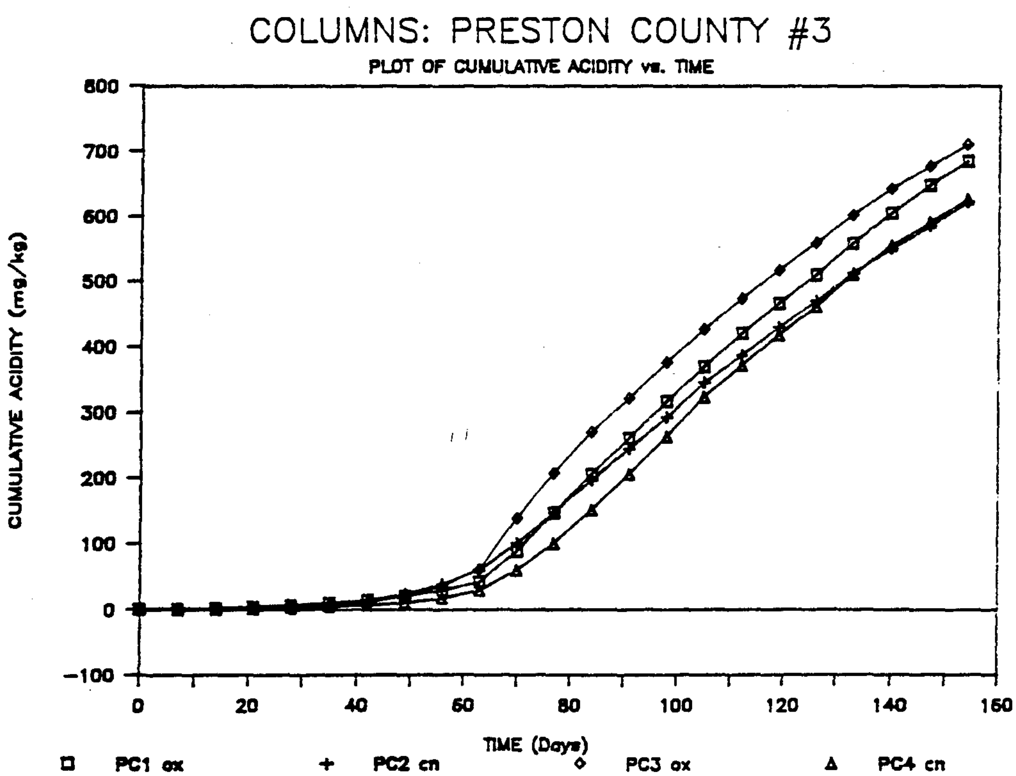

COLUMNS: EAGLE EYE
PLOT OF CUMULATIVE SULFATE vs. TIME
CUMULATIVE SULFATE (mg/kg)
(Thousands)
TIME (Days)
EE-5 ox
EE-6
EE-7
EE-8 ox


COLUMNS: PRESTON COUNTY #3
PLOT OF pH vs. TIME
pH
TIME (Days)
PC1 ox
PC2 cn
PC3 ox
PC4 cn


COLUMNS: PRESTON COUNTY #3
PLOT OF NORMALIZED SPECIFIC CONDUCTANCE vs. TIME
SPECIFIC CONDUCTANCE (umhos/cm/kg)
TIME (Days)
PC1 ox
PC2 cn
PC3 ox
PC4 cn



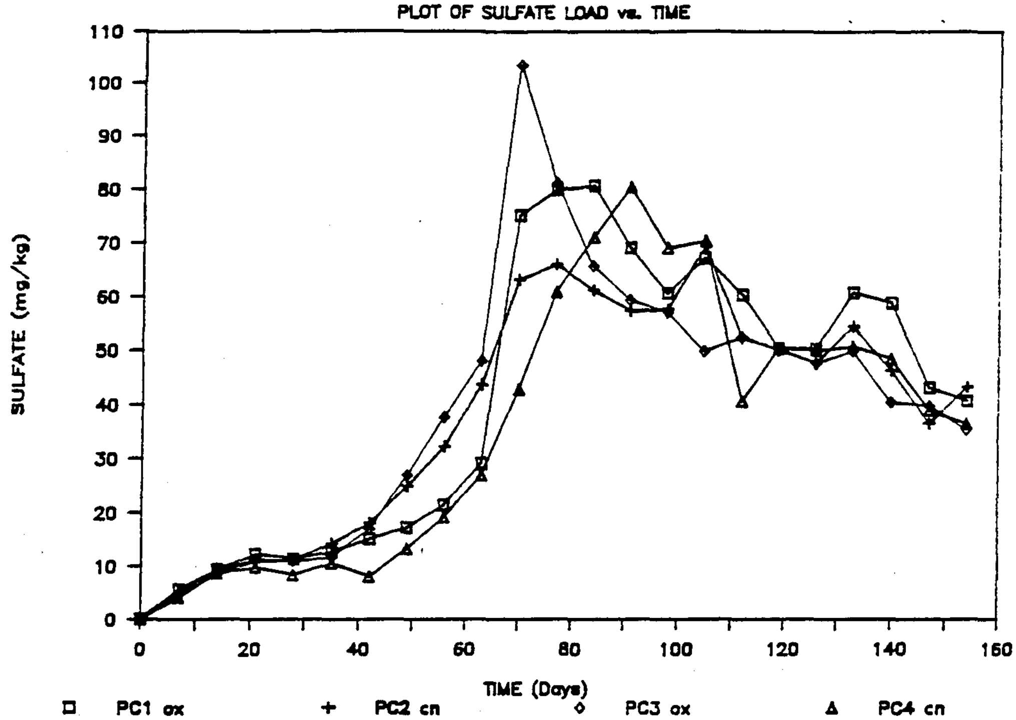
COLUMNS: PRESTON COUNTY #3
PLOT OF ACID LOAD vs. TIME
ACIDITY (mg/kg)
TIME (Days)
PC1 ox
PC2 cn
PC3 ox
PC4 cn



COLUMNS: PRESTON COUNTY #3
PLOT OF CUMULATIVE ACIDITY vs. TIME
CUMULATIVE ACIDITY (mg/kg)
TIME (Days)
PC1 ox
PC2 cn
PC3 ox
PC4 cn

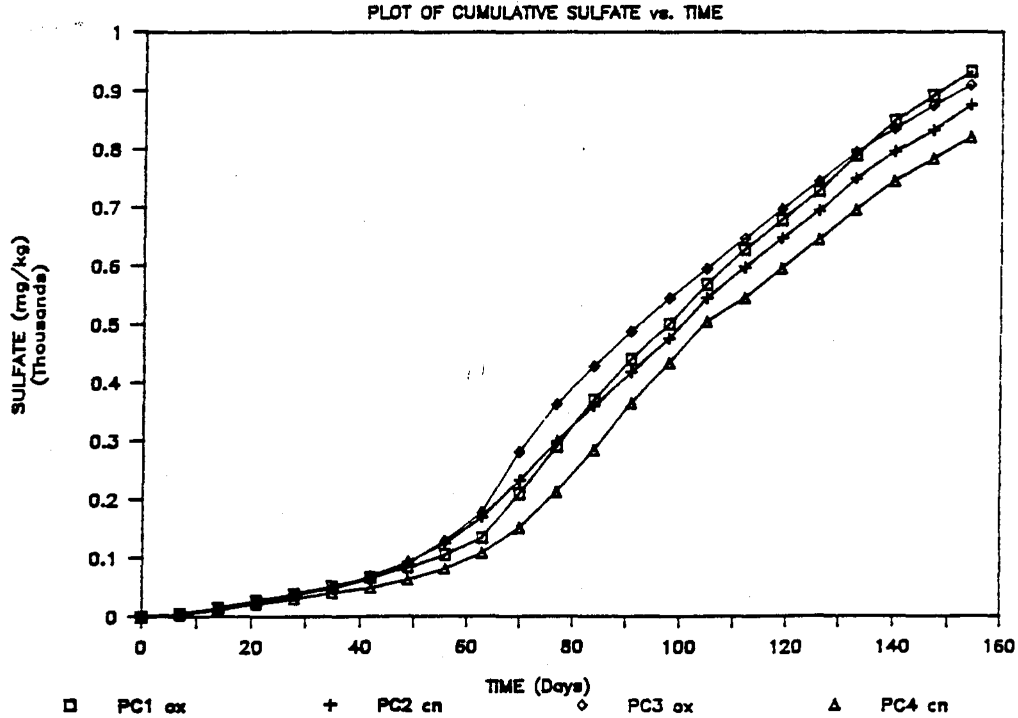
COLUMNS: PRESTON COUNTY #3

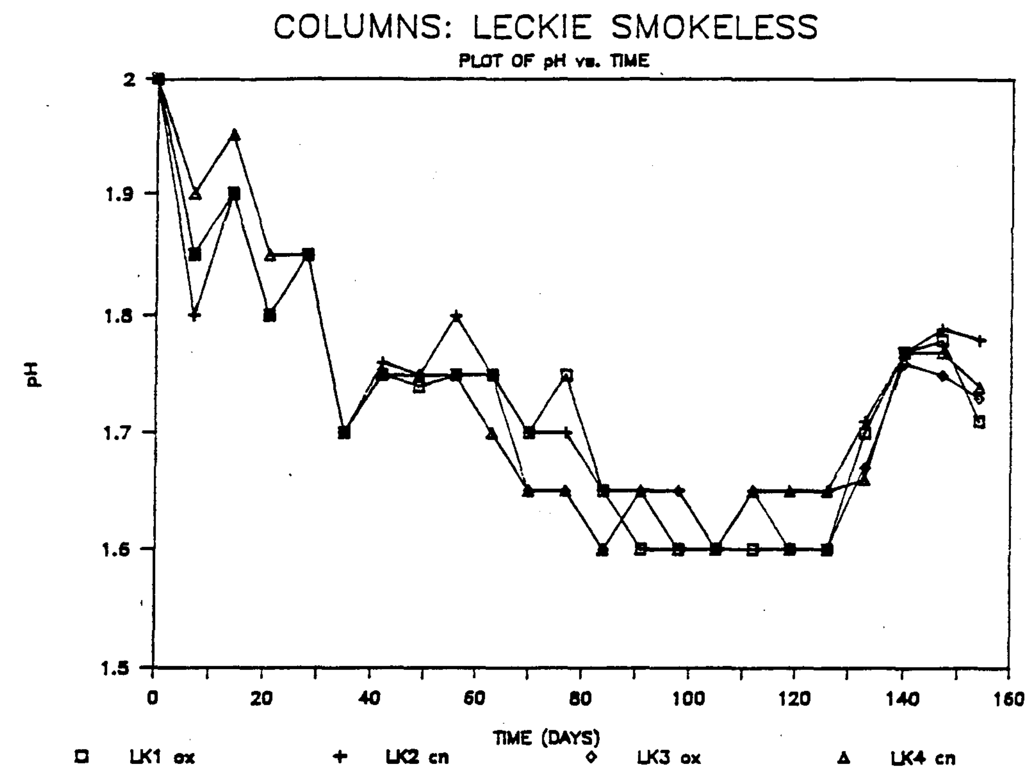
PLOT OF SULFATE LOAD vs. TIME

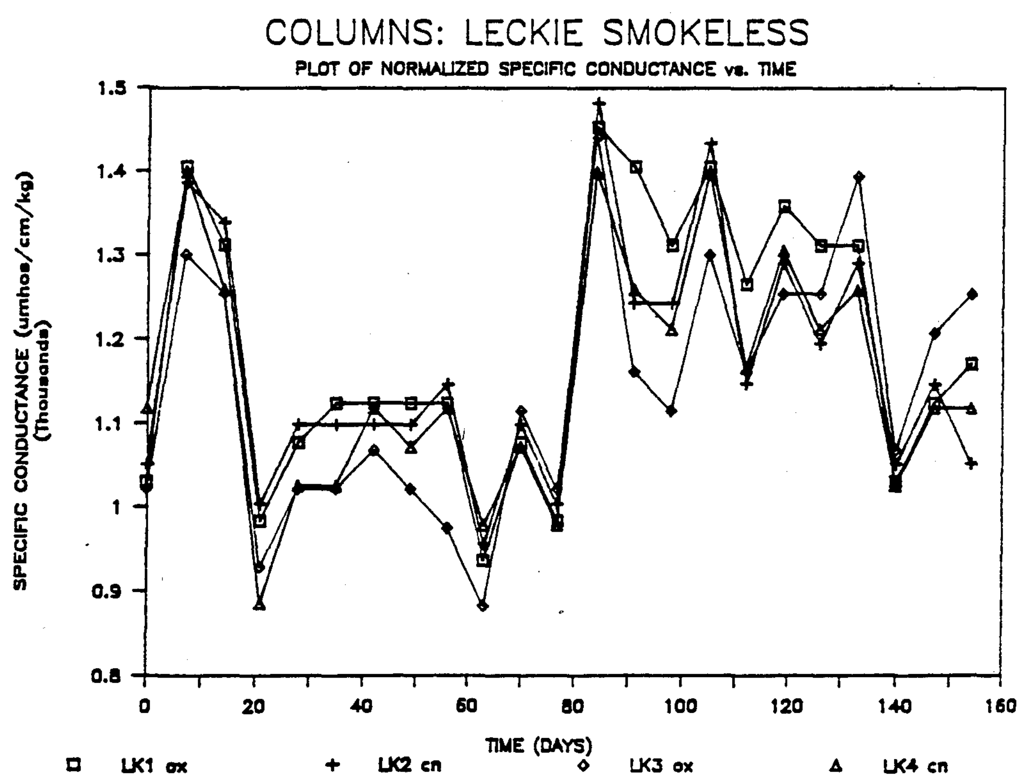


COLUMNS: PRESTON COUNTY #3

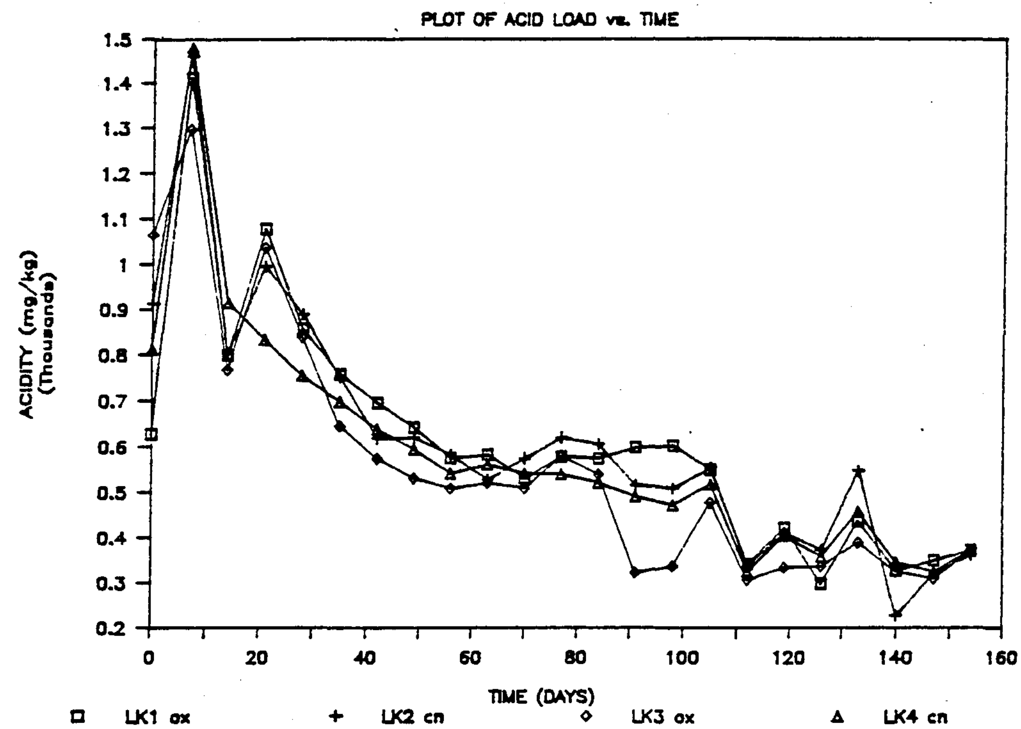
PLOT OF CUMULATIVE SULFATE vs. TIME



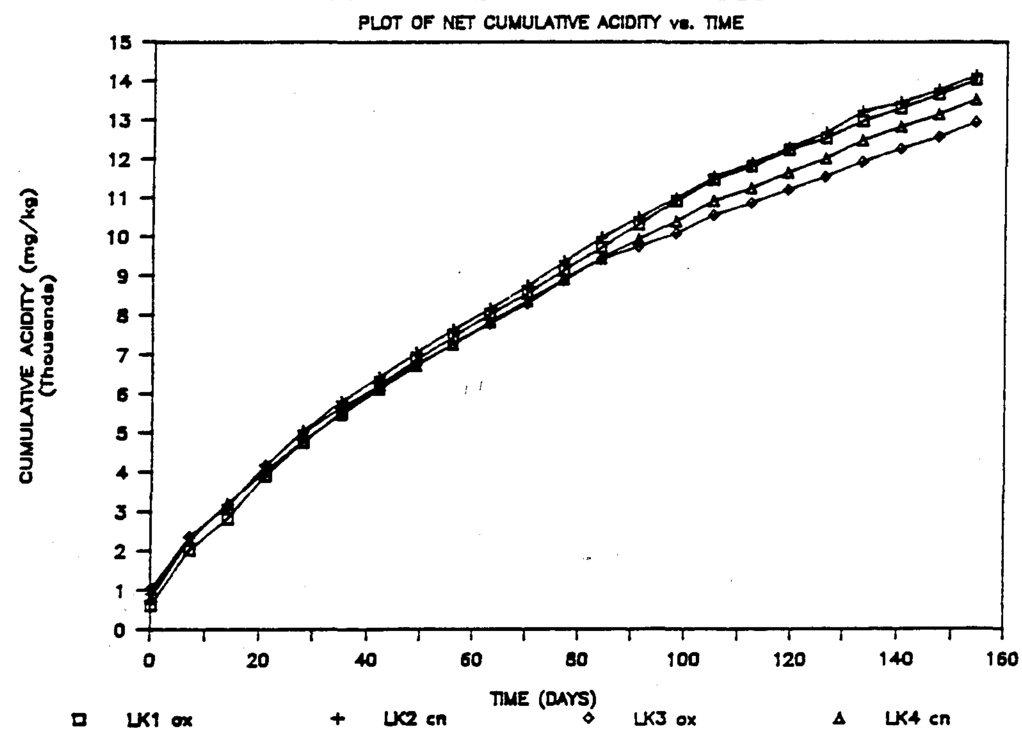

COLUMNS: LECKIE SMOKELESS
PLOT OF pH vs. TIME
pH
2
1.9
1.8
1.7
1.6
1.5
0
20
40
60
80
100
120
140
160
TIME (DAYS)
LK1 ox
LK2 cn
LK3 ox
LK4 cn


COLUMNS: LECKIE SMOKELESS
PLOT OF NORMALIZED SPECIFIC CONDUCTANCE vs. TIME
SPECIFIC CONDUCTANCE (umhos/cm/kg)
(Thousands)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0
20
40
60
80
100
120
140
160
TIME (DAYS)
LK1 ox
LK2 cn
LK3 ox
LK4 cn

COLUMNS: LECKIE SMOKELESS



COLUMNS: LECKIE SMOKELESS



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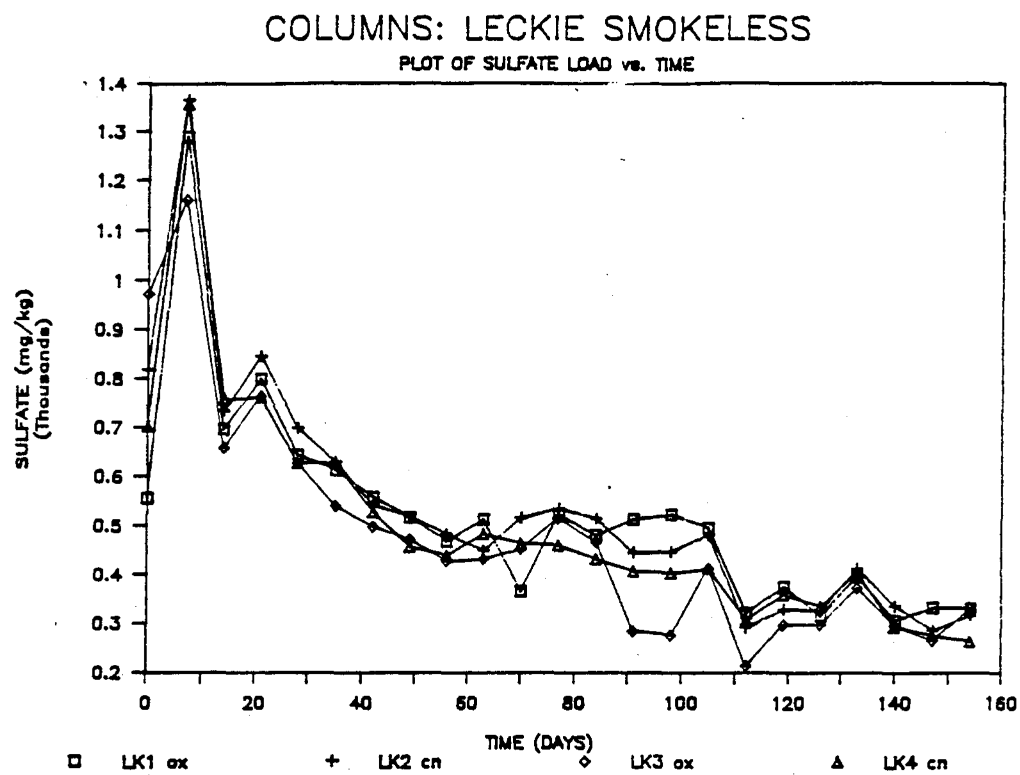
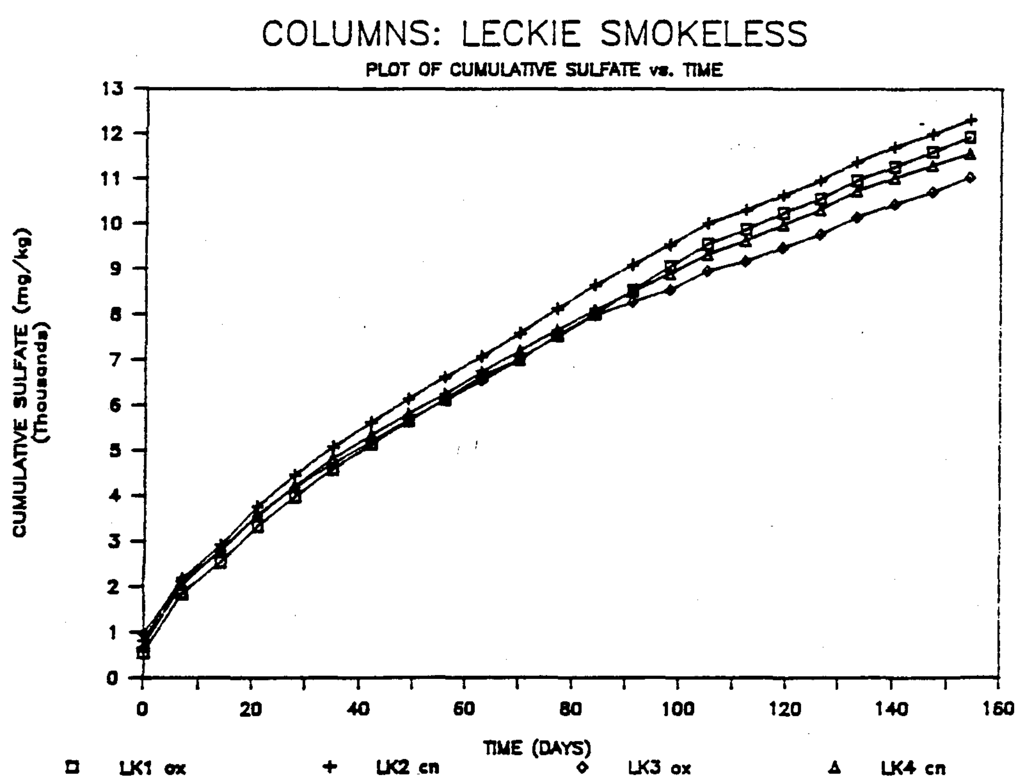


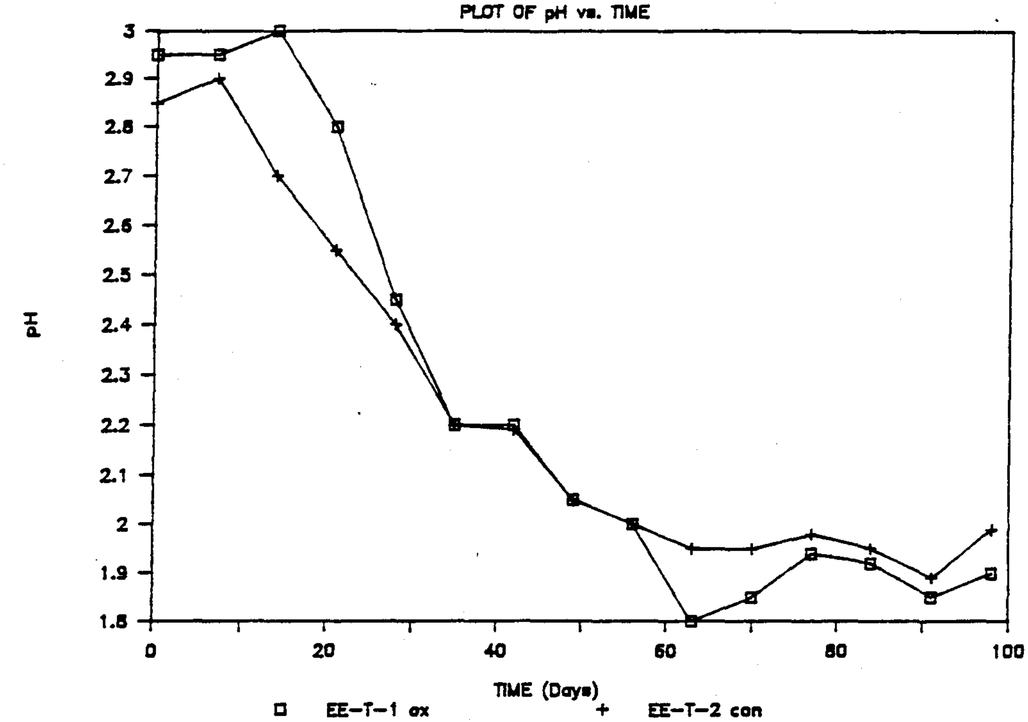
COLUMNS: LECKIE SMOKELESS
PLOT OF SULFATE LOAD vs. TIME
SULFATE (mg/kg)
(Thousands)
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
20
40
60
80
100
120
140
160
TIME (DAYS)
LK1 ox
LK2 cn
LK3 ox
LK4 cn



COLUMNS: LECKIE SMOKELESS
PLOT OF CUMULATIVE SULFATE vs. TIME
CUMULATIVE SULFATE (mg/kg)
(Thousands)
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
140
160
TIME (DAYS)
LK1 ox
LK2 cn
LK3 ox
LK4 cn

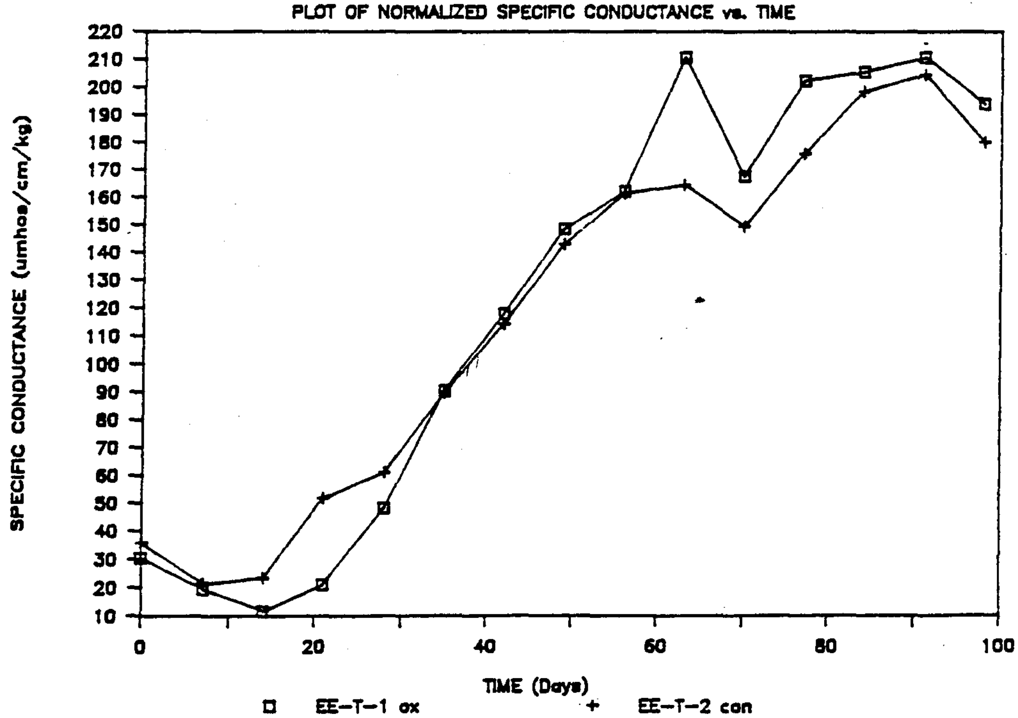
LEACHING TUBS: EAGLE EYE

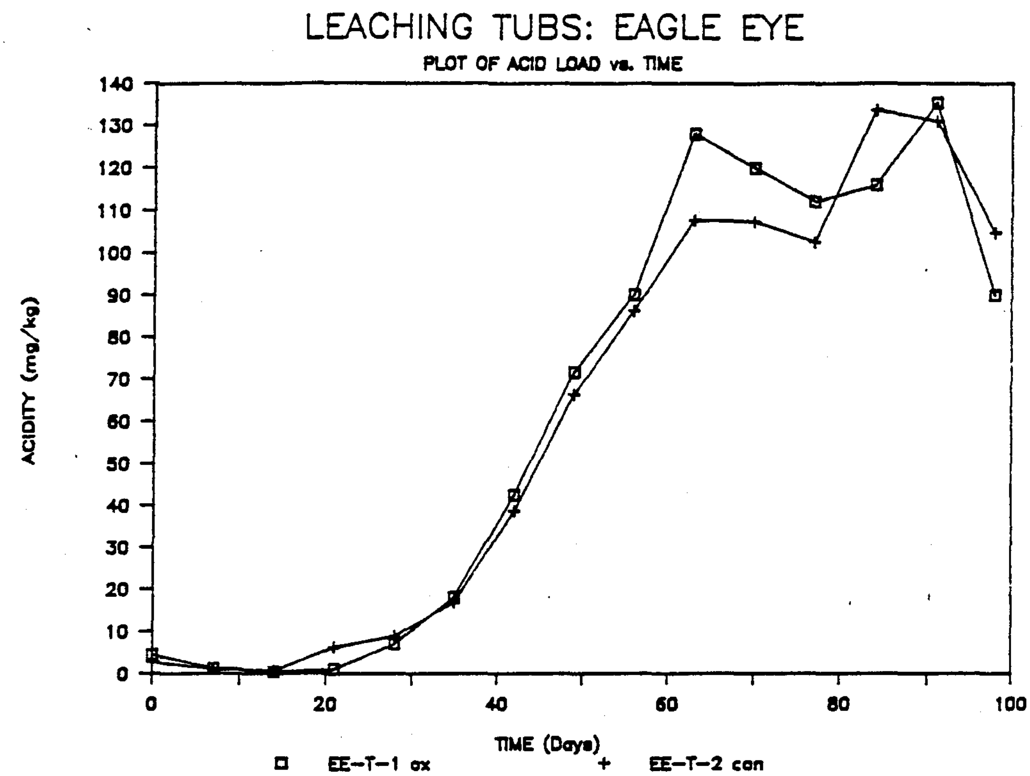
PLOT OF pH vs. TIME

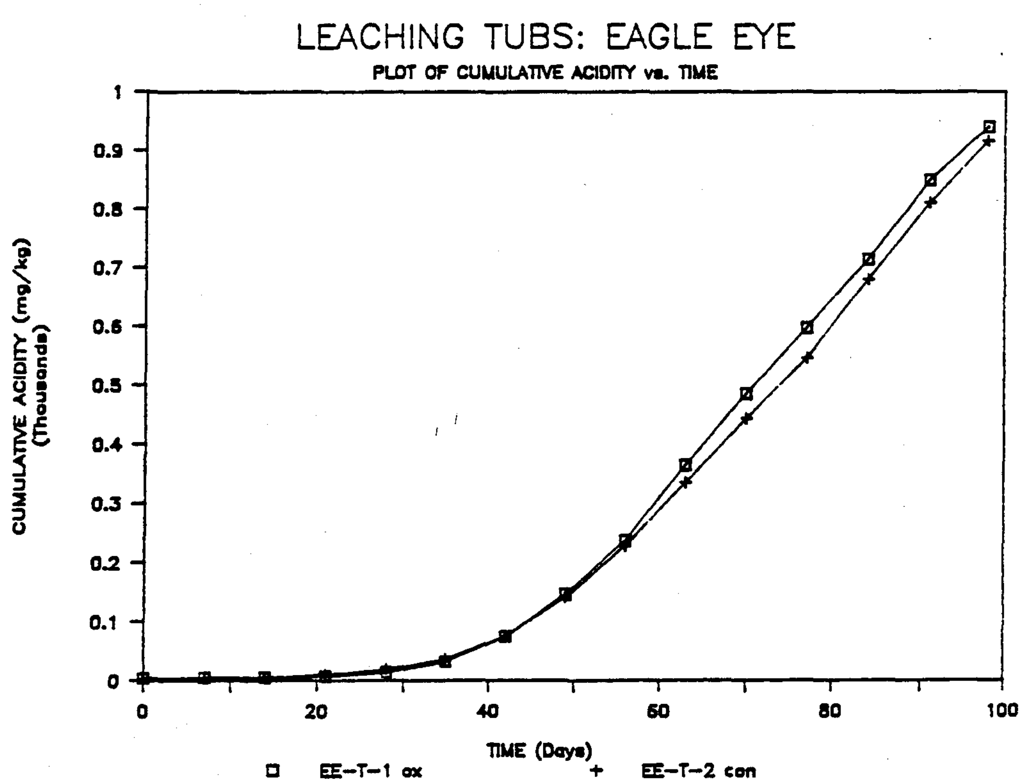


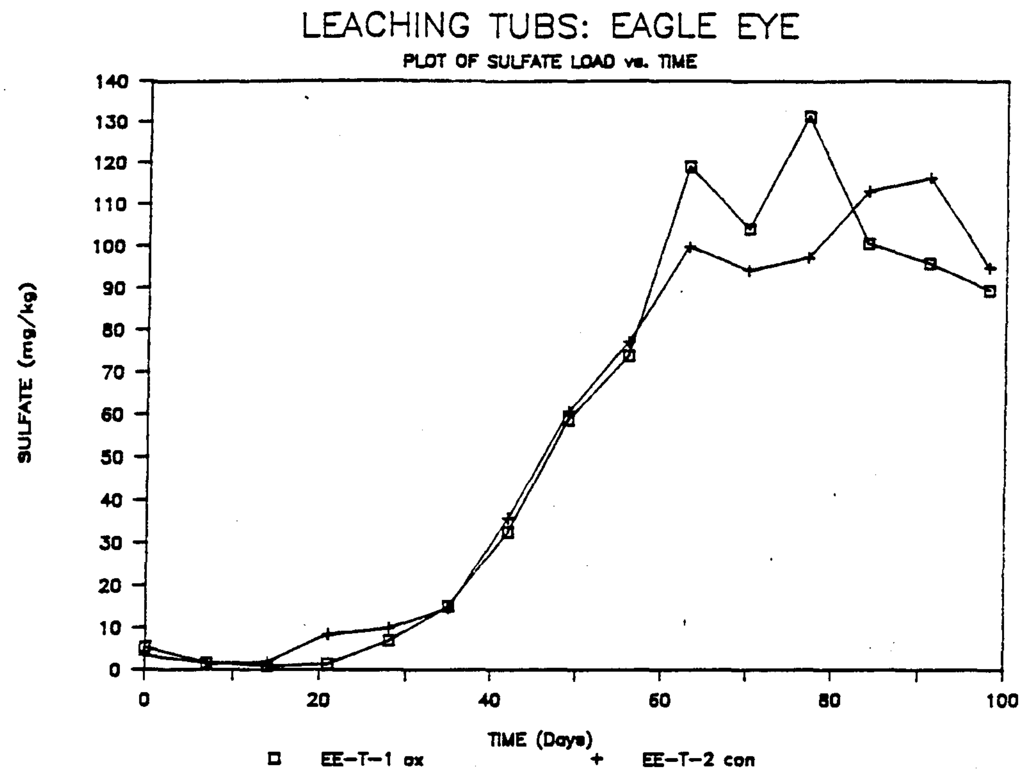
LEACHING TUBS: EAGLE EYE

PLOT OF NORMALIZED SPECIFIC CONDUCTANCE vs. TIME

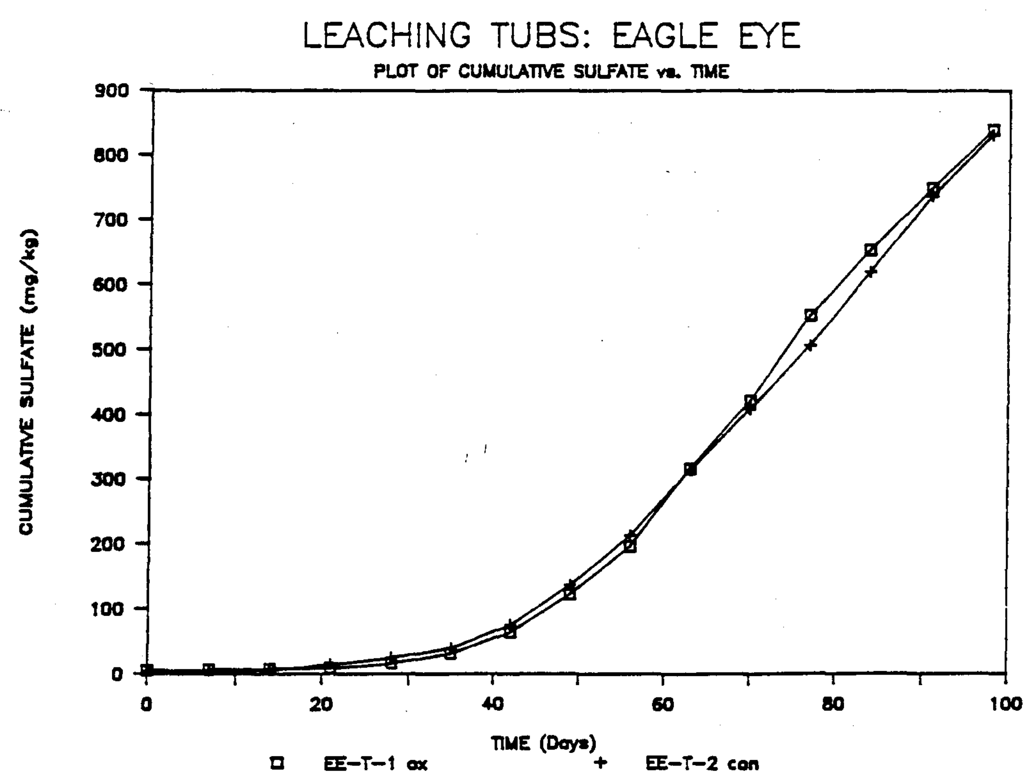



LEACHING TUBS: EAGLE EYE
PLOT OF ACID LOAD vs. TIME
ACIDITY (mg/kg)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
TIME (Days)
EE-T-1 ox
EE-T-2 con

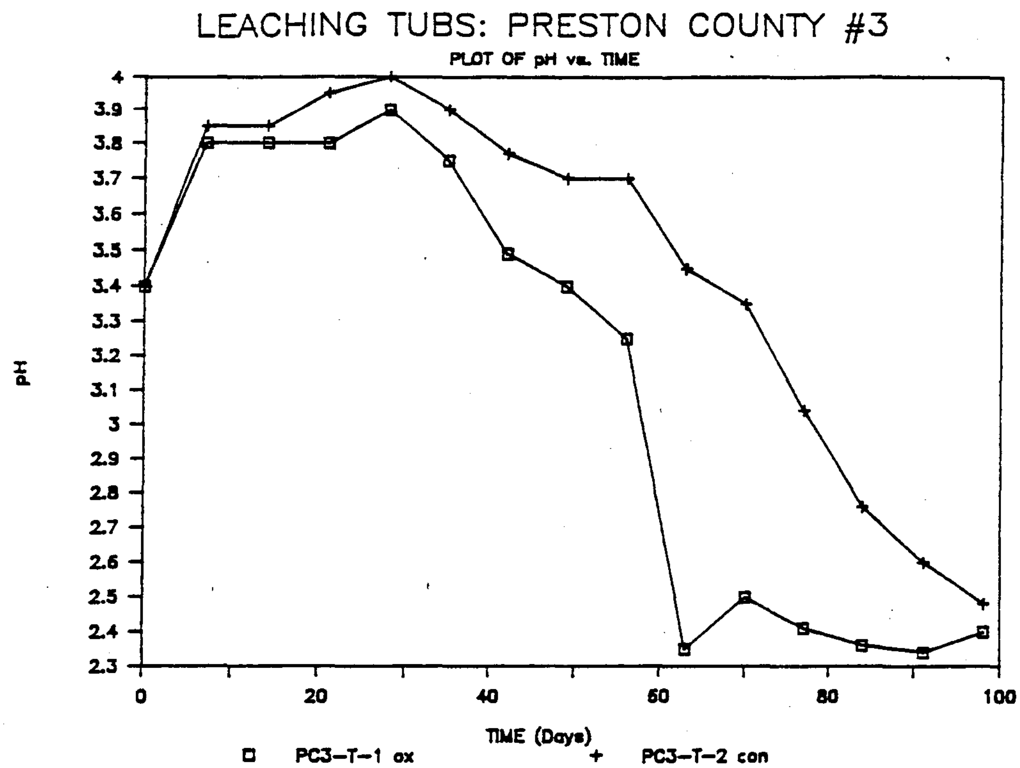

LEACHING TUBS: EAGLE EYE
PLOT OF CUMULATIVE ACIDITY vs. TIME
CUMULATIVE ACIDITY (mg/kg)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
80
100
TIME (Days)
EE-T-1 ox
EE-T-2 con



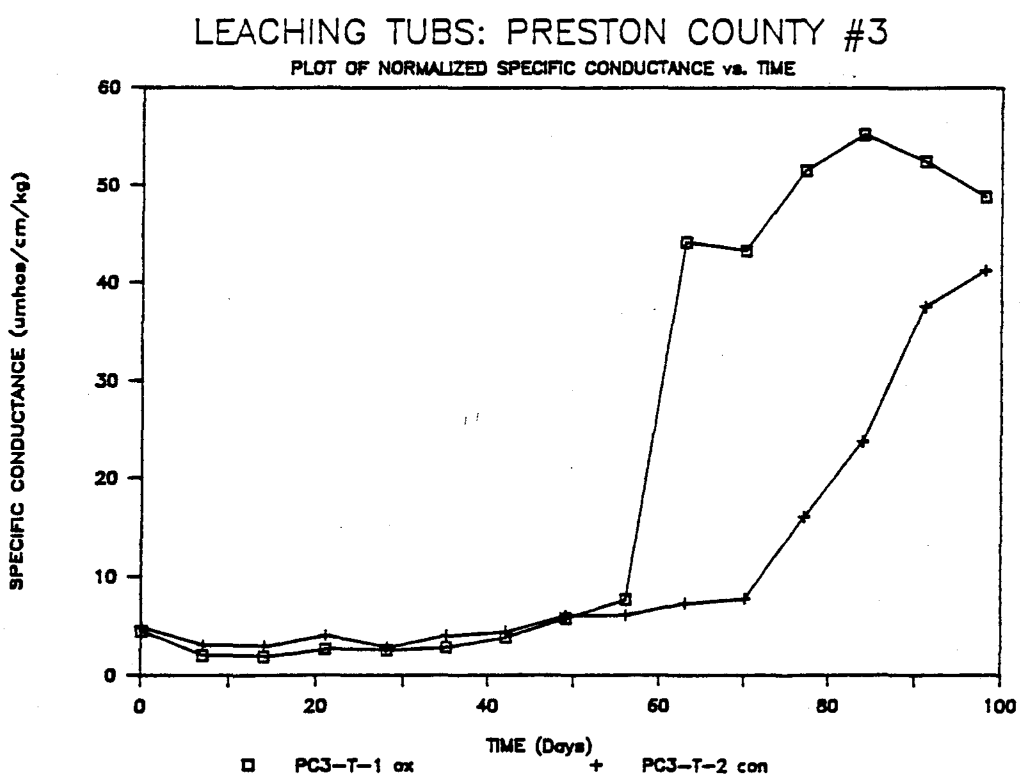
LEACHING TUBS: EAGLE EYE
PLOT OF SULFATE LOAD vs. TIME
SULFATE (mg/kg)
TIME (Days)
EE-T-1 ox
EE-T-2 con



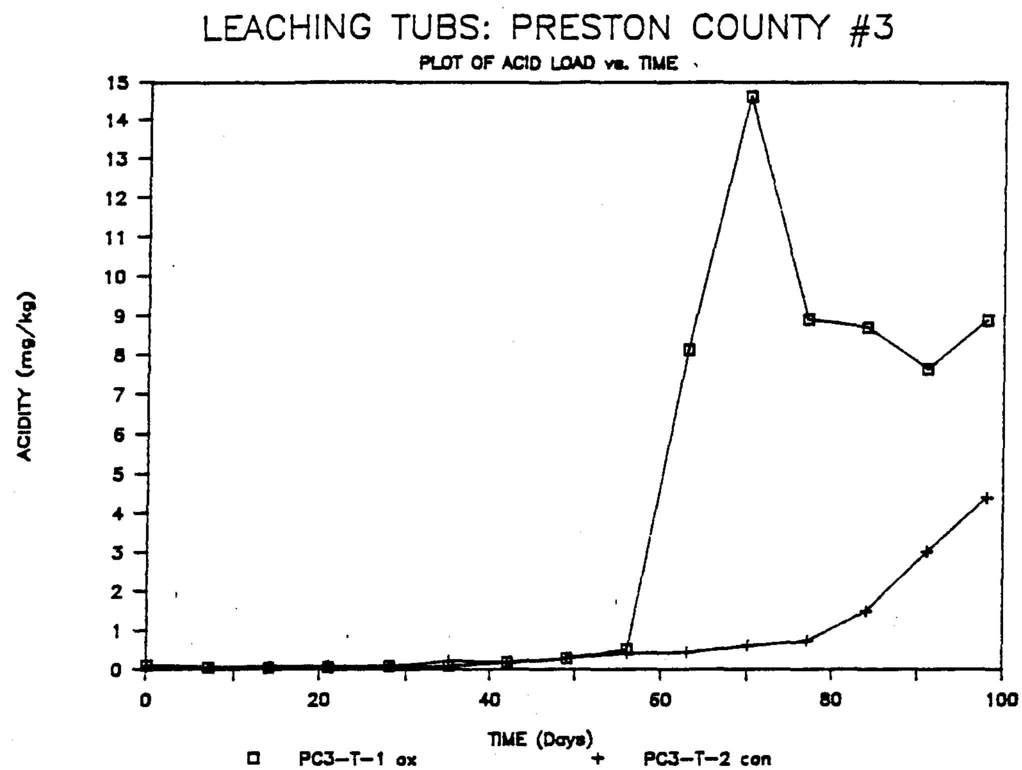
LEACHING TUBS: EAGLE EYE
PLOT OF CUMULATIVE SULFATE vs. TIME
CUMULATIVE SULFATE (mg/kg)
TIME (Days)
EE-T-1 ox
EE-T-2 con

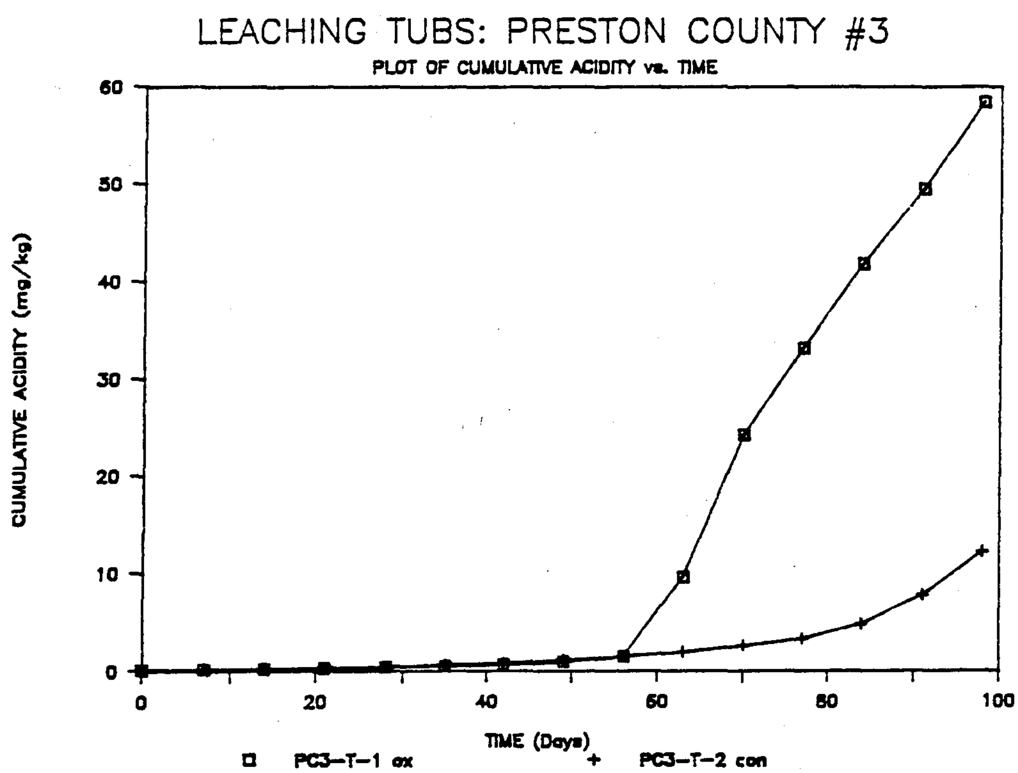


LEACHING TUBS: PRESTON COUNTY #3
PLOT OF pH vs. TIME
pH
TIME (Days)
PC3-T-1 ox
PC3-T-2 con



LEACHING TUBS: PRESTON COUNTY #3
PLOT OF NORMALIZED SPECIFIC CONDUCTANCE vs. TIME
SPECIFIC CONDUCTANCE (umhos/cm/kg)
TIME (Days)
PC3-T-1 ox
PC3-T-2 con


LEACHING TUBS: PRESTON COUNTY #3
PLOT OF ACID LOAD vs. TIME
ACIDITY (mg/kg)
TIME (Days)
PC3-T-1 ox
PC3-T-2 con


LEACHING TUBS: PRESTON COUNTY #3
PLOT OF CUMULATIVE ACIDITY vs. TIME
CUMULATIVE ACIDITY (mg/kg)
TIME (Days)
PC3-T-1 ox
PC3-T-2 con

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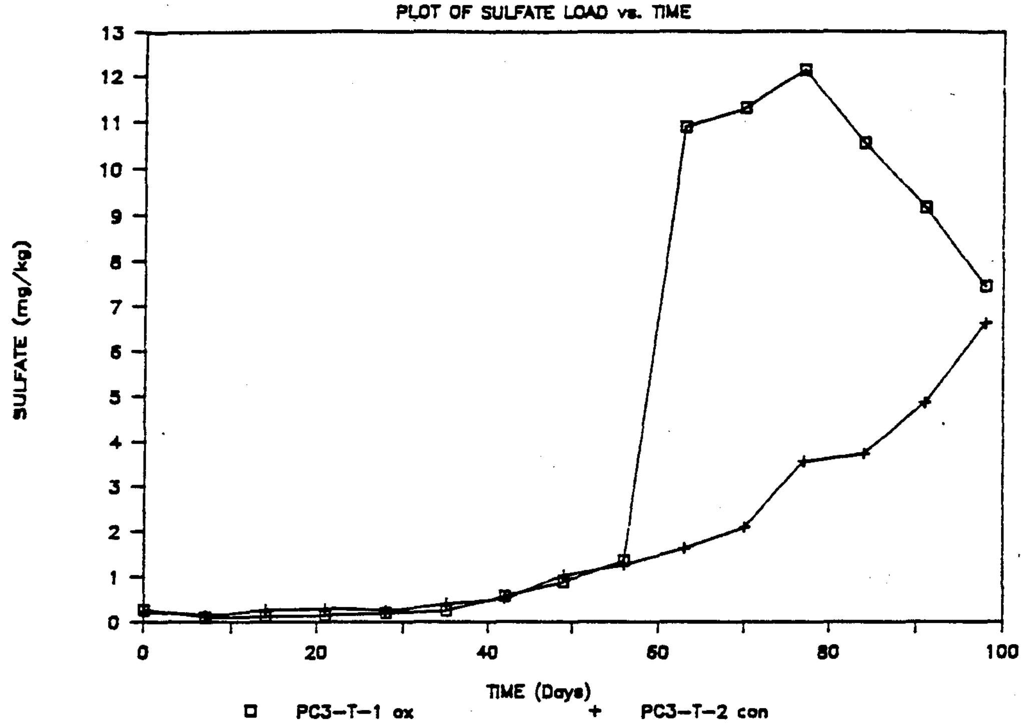
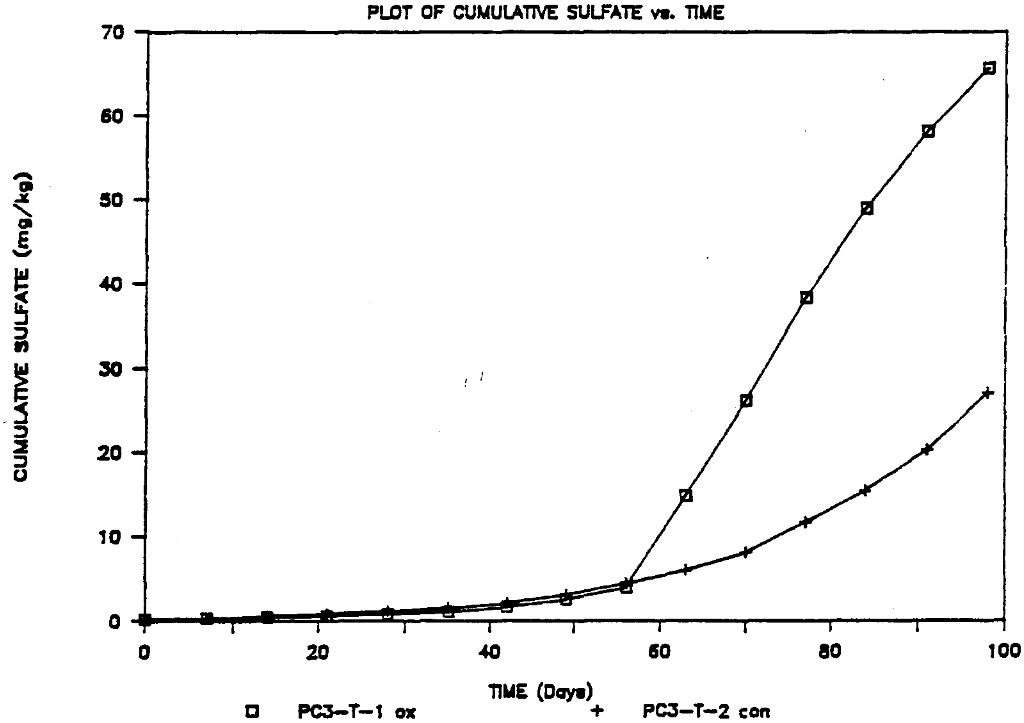
LEACHING TUBS: PRESTON COUNTY #3

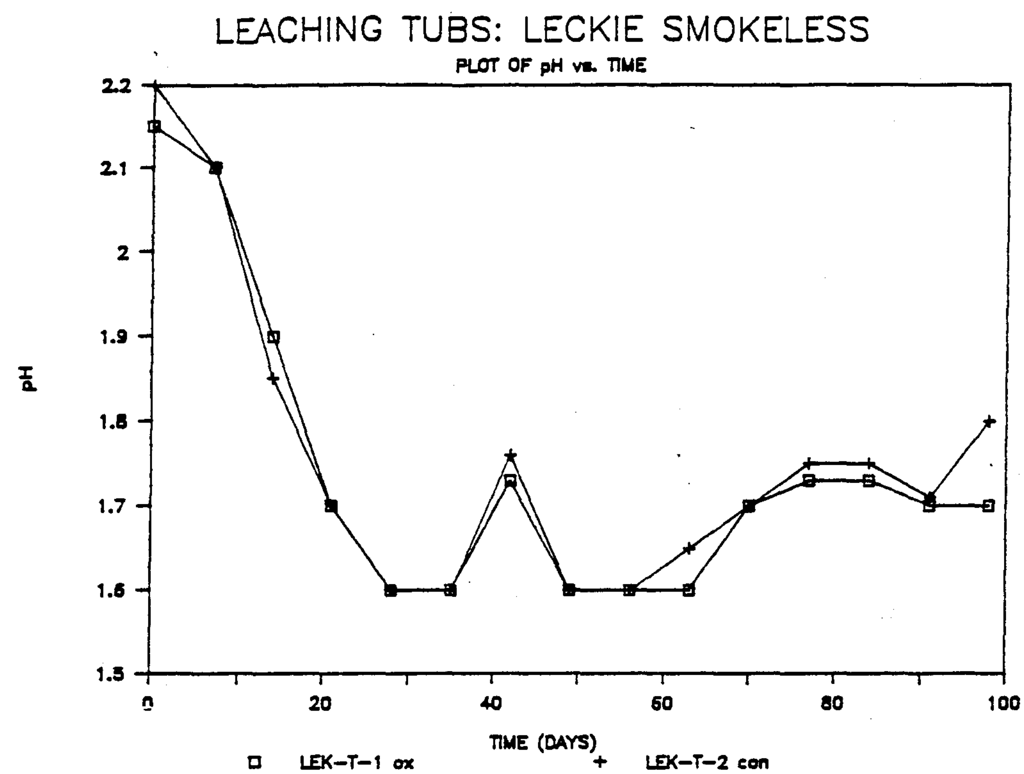
PLOT OF SULFATE LOAD vs. TIME

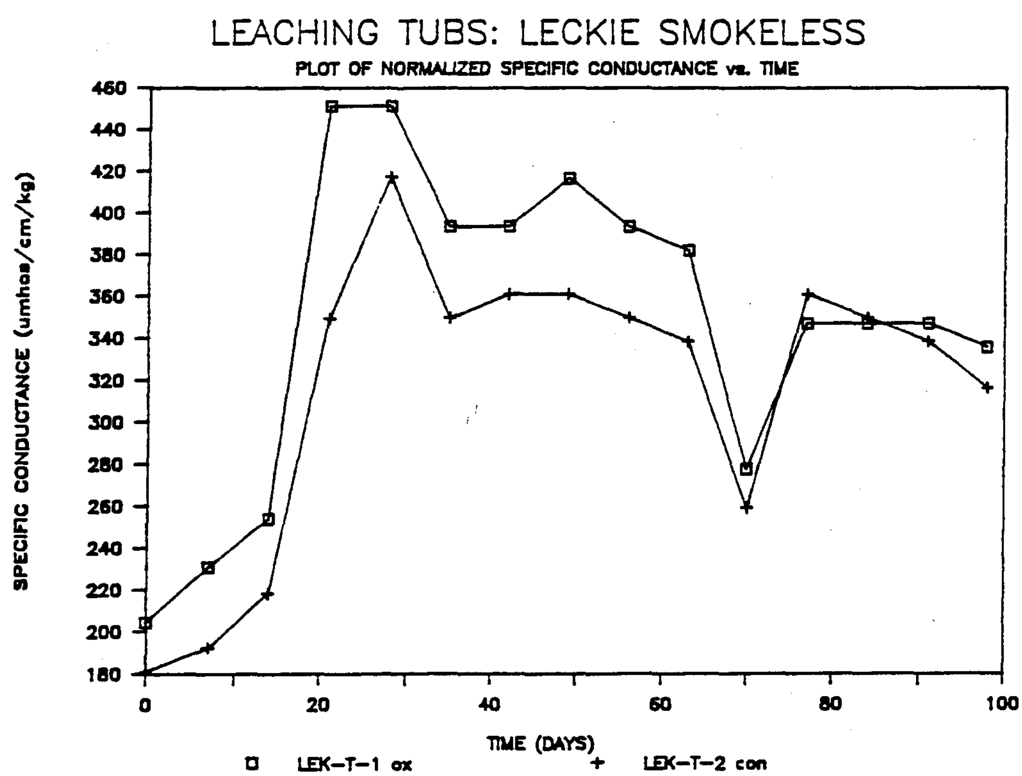


LEACHING TUBS: PRESTON COUNTY #3

PLOT OF CUMULATIVE SULFATE vs. TIME



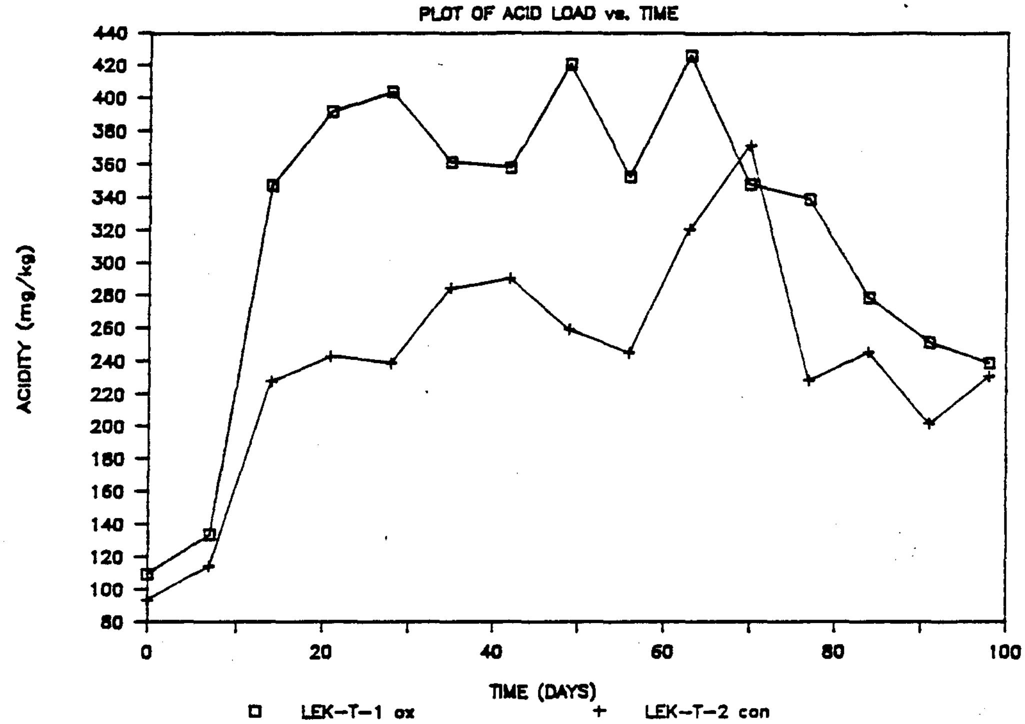

LEACHING TUBS: LECKIE SMOKELESS
PLOT OF pH vs. TIME
pH
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
0
20
40
60
80
100
TIME (DAYS)
LEK-T-1 ox
LEK-T-2 con


LEACHING TUBS: LECKIE SMOKELESS
PLOT OF NORMALIZED SPECIFIC CONDUCTANCE vs. TIME
SPECIFIC CONDUCTANCE (umhos/cm/kg)
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
0
20
40
60
80
100
TIME (DAYS)
LEK-T-1 ox
LEK-T-2 con

135

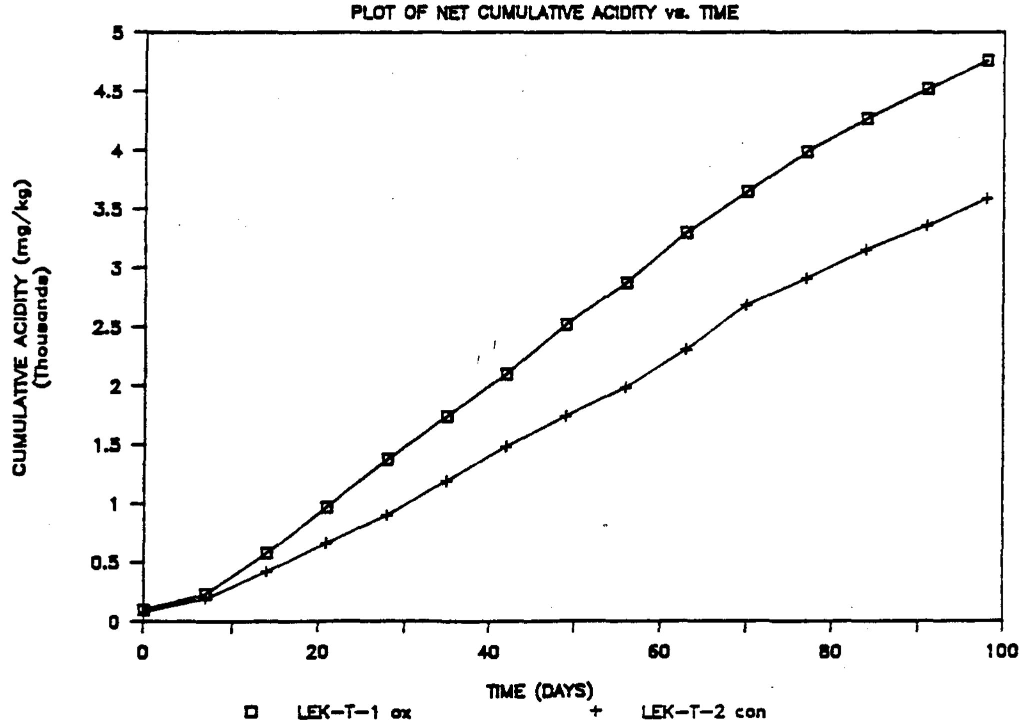
LEACHING TUBS: LECKIE SMOKELESS

PLOT OF ACID LOAD vs. TIME



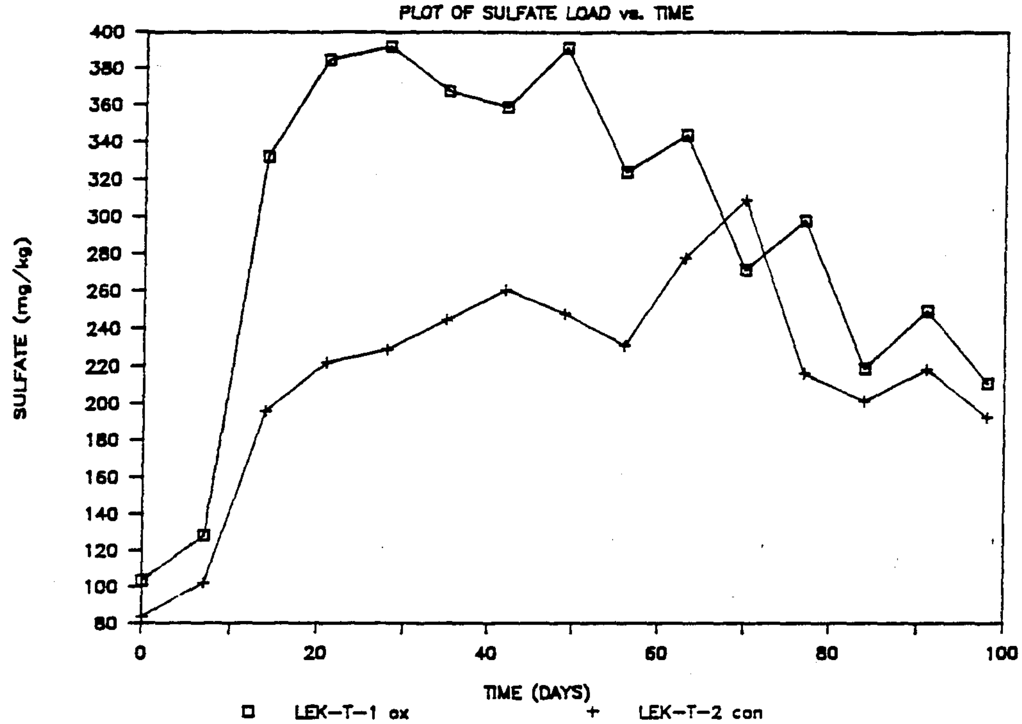
LEACHING TUBS: LECKIE SMOKELESS

PLOT OF NET CUMULATIVE ACIDITY vs. TIME



LEACHING TUBS: LECKIE SMOKELESS

PLOT OF SULFATE LOAD vs. TIME



LEACHING TUBS: LECKIE SMOKELESS

PLOT OF CUMULATIVE SULFATE vs. TIME