TECHNICAL MEMO

TREATABILITY TESTING PERFORMED AT HALLIBURTON NUS LABORATORY PITTSBURGH, PENNSYLVANIA

FOR

EG&G

ROCKY FLATS PLANT

STABILIZATION PROJECT

DECEMBER 1991

EG&G ROCKY FLATS
ENVIRONMENTAL MANAGEMENT DEPARTMENT

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1.0 INTRODUCTION

This document summarizes the treatability study activities conducted at the HALLIBURTON NUS Laboratory located in Pittsburgh, Pennsylvania. These activities were conducted in support of the Rocky Flats stabilization project. The activities conducted consist of the following:

- Polymer Testing
- Chlorination Testing
- Dewatering Tests
- Clarification Testing
- Buchner Funnel Filtration Testing
- Belt Filter Press Testing

Several miscellaneous tests were also conducted in an attempt to improve dewaterability of the sludge.

This document consists of four sections. Section 1.0 is this brief introduction. Section 2.0 describes the testing procedures and provides summaries of the treatability test data. Section 3.0 provides discussions of the results. Section 4.0 provides conclusions based on the results and recommendations for future work.

Appendix A contains a copy of the laboratory logbook.

2.0 TEST PROCEDURES

2.1 MATERIAL PROCESSING

Prior to conducting any tests with the Solar Pond sludges, it was first necessary to process the sludges, thereby duplicating anticipated field conditions. The process flow sheets shown in the Design Basis Memo for Pond Sludge Processing (Brown & Root, 1991) called for the pond sludge to be processed through a hydrocyclone. The underflow (+325 mesh solids) was estimated to be 30 to 35 percent solids. The overflow (-325 mesh solids) went to a clarifier for clarification/thickening. The estimated feed concentration to the clarifier was 3 to 5 percent, while the clarifier underflow was estimated to be equivalent to the solids in the solar ponds. The cyclone and clarifier underflows would then be combined, producling a feed material for high pressure dewatering of approximately 30 to 35 percent solids. This particle separation was duplicated in the laboratory by sieving the sludges through 10, 100, 150, and 325 mesh sieves. The sieving was conducted for sludges from Pond 207 A, 207 B North, 207 B Center, and 207 B South.

Approximately 8 gallons of each sludge was sieved. The material that was retained on the 10 mesh sieve was nominal and consisted of grass, asphalt, and twigs. The following weights were recorded for the greater than 10 mesh material:

- Pond 207 A - 27.29 grams
- Pond 207 BN - 88.75 grams
- Pond 207 BC - 64.64 grams
- Pond 207 BS - 5.69 grams

Upon completing the sieving of the sludges, the minus 325 mesh material was analyzed for percent solids. The percent solids analysis was conducted by collecting 50 ml of homogenous sample of the minus 325 mesh slurry and then filtering it on Watman 40 filter paper with a Buchner Funnel. The residual filter cake and filter paper were then dried in an oven at 110°C.

hyd water loss greater than "free" water

The results of the percent solids analysis for the minus 325 mesh material are as follows:

- Pond 207 A - 4.1 percent
- Pond 207 BN - 5.3 percent
- Pond 207 BC - 1.3 percent
- Pond 207 BS - 5.9 percent

The minus 325 mesh material served as the feed material for polymer screening tests, bulk tests, and thickening tests.

Following the selection of a polymer to aid gravity settling of the minus 325 mesh solids (see Section 2.2), the remaining minus 325 mesh material was flocculated and gravity settled. The thickened solids were then combined with the plus 325 mesh solids to produce the feed material for high pressure dewatering tests. The final volumes and percent solids of the sludges are as follows:

Pond	Thickened Sludge Volume	Percent Solids
207A	4750 ml	35.4
207BN	2865 ml	31.8
207BC	4365 ml	12.6
207BS	3015 ml	36.7

2.2 POLYMER TESTING

Tests were conducted on both chlorinated and nonchlorinated sludge (minus 325 mesh) to select a flocculant that would aid settling and thickening of the solids. Because of the limited volume of sludge available for testing, an exhaustive evaluation of all available polmers was not conducted. Instead, one vendor (betz Laboratories, Inc.) was selected to test the polymers within the vendor's product line.

2.2.1 Nonchlorinated Sludge

Prior to initiating the polymer testing approximately 500 ml of each pond sludge (minus 325 mesh) was placed in graduated cylinder and allowed to settle overnight. The thickened sludge depths following approximatley 8 hours are as follows:

Pond	Settled Solids	Supernatant	Total Depth
207 BN	2.125"	3.0"	5.125"
207 BS	6.81"	0.38"	7.125"
207 BC	3.875"	3.25"	7.125"
207 A	2.75"	4.375"	7.125"

Review of the above data indicates that the minus 325 sludge from Pond 207 BS did not settle, whereas minus 325 mesh sludge from the other ponds settled to 39 to 54 percent of the original volume.

The polymer testing was conducted by Mr. G. Gailey of Betz Laboratories, Inc. In general, the tests were conducted by placing 400 ml of a particular sludge in three 500 ml beakers. The beakers were then simultaneously mixed (40 rpm) to homogenize the sample. Different polymers were added to each beaker at similar dosages. The sludge was thoroughly mixed for 1 minute at 74 rpm and then for 2 minutes at 40 rpm. The sludge was visually evaluated to determine if flocs were formed at the applied dosage. If no flocculation was observed, then additional polymer was added to each beaker. This procedure was continued until an optimum polymer and dosage were selected. Table 2-1 summarizes the results of polymer testing using nonchlorinated sludge.

TABLE 2-1

SUMMARY OF POLYMER TESTING
(Non Chlorinated Sludge)

Pond	Run No.	Polymer[1]	Polymer Feed Concentration	Total Polymer Addition		Result	Comment
				ppm	Pound Neat Polymer/ 1000 lb Solids		
207BC	1	3315 Anionic	0.1%	24.4	2.0	Slight floc formation	
	1	3325 Anionic	0.1%	24.4	2.0	Slight floc formation	
	1	3360 Cationic	0.1%	36.1	2.0	Small flocs formed	
	2	3354 Cationic	0.1%	36.1	3.0	Marginal floc formation	
	2	3398 Cationic	0.1%	36.1	3.0	Marginal floc formation	
	3	3360 Cationic	0.1%	24.4	2.0	Good floc formed	Polymer of choice because of lower dosage
	3	3398 Cationic	0.1%	36.1	3.0	Good floc formed	Slight scum on top of supernatant
	4	3392 Cationic	1.0%	697.7	60.0	No floc formed	
207BS	1	3375 Cationic	1.0%	49.6	1.8	No floc formed	
	1	3398 Cationic	0.1% 1.0%	47.6 49.6	20.4 1.8	No floc formed No floc formed	20 ml added @ 0.1% and 2 ml added @ 1.0% solution
	1	3360 Cationic	0.1%	47.6	1.8	No floc formed	
	2	3392 Cationic	1.0%	1397.8	58.5	No floc formed	
207A	1	3398 Cationic	0.1%	Large Dose		Small flocs formed	Good settling
	1	3315 Cationic	0.1%	Large Dose		Small flocs formed	Minimal settling
	1	3360 Cationic	0.1%	69.8	2.2	Fine floc	Settled better than 3398
	2	3325 Anionic	0.1%	Not Measured		No floc formed	Did not work
	2	3375 Cationic		Not Measured		No floc formed	Did not work

TABLE 2-1
SUMMARY OF POLYMER TESTING
(Non Chlorinated Sludge)
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Pond	Run No.	Polymer[1]	Polymer Feed Concentration	Total Polymer Addition		Result	Comment
				ppm	Pound Neat Polymer/ 1000 lb Solids		
207A	3	3392 Cationic	1.0%	243.9	7.4	Small floc	Moderate settling
	3	3392 Cationic	1.0%	365.5	11.1	Small floc	
207BN	1	3360 Cationic	0.1%	36.1	.14	Good floc	
	1	3398 Cationic	0.1%	120.3	.47	Good floc	
	2	3392 Cationic	1.0%	124.0	.29	Good floc	Rapid settling
	2	3392 Cationic	1.0%	62.0	.14	Flocs did not form	
	2	3392 Cationic	1.0%	99.2	.23	Good floc	

(1) All polymers are products of Betz Laboratories, Inc.

Note: Test run numbers with the same number were conducted simulateously.

2.2.2 Chlorinated Sludge

Several observations were made which suggested that there was significant biological activity present in the sludges, including a septic odor and the observation that when the sludge was left in a sealed container, the material expanded and seeped from the bottles, probably because of gas generation from biological activity.

To confirm that biological activity existed in the sludge, three 50 ml aliquots were collected and placed in sealed containers. One sample was treated with calcium hypochlorite, one sample was stored at 4°C, and one sample was stored at ambient temperature. The samples were observed the following day. The sample that was stored at ambient temperature showed leakage from the container, while the other two samples showed no evidence of leakage. This observation suggest that biological activity occurred in the samples.

The above observation, combined with the inability of Pond 207 BS sludge to settle, which was believed to be affected by the presence of microorganisms, resulted in the decision to chlorinate the sludge. The sludge was chlorinated with granular calcium hypochlorite (65 percent calcium hypochlorite). Further discussion of chlorination testing is provided in Section 2.3. All of the polymer testing was redone using sludge samples that were chlorinated.

The polymer tests conducted on the chlorinated samples were conducted by collecting 200 ml of sludge and adding a dosage of polymer. The material was then mixed by hand using a glass stirring rod. The results of the polymer tests on chlorinated sludge are summarized in Table 2-2.

2.3 CHLORINATION TESTING

As explained in the earlier sections, a decision was made to chlorinate the sludges to improve settleability. To determine the correct concentration of a chlorinating agent necessary to kill the microorganisms, an experiment was set up to add several dosages of calcium hypochlorite and analyze the samples for standard plate count and residual chlorine.

TABLE 2-2

SUMMARY OF POLYMER TESTING
(Chlorinated Sludge)

Pond	Polymer(1)	Polymer Feed Concentration	Total Polymer Addition		Result	Comment
			ppm	Pound Neat Polymer/ 1000 lb Solids		
207A	3360 Cationic	1.0%	37.3	2.2	Flocs formed	
207BS	1192 Anionic	1.0%	498.1	37	No reaction	
	3360 Cationic	1.0%	24.9	1.9	Formed flocs	
	3360 Cationic	1.0%	49.8	3.8	Formed flocs	
	3360 Cationic	1.0%	37.3	2.8	Formed flocs	Formed best floc
207BC	3360 Cationic	1.0%	12.5	2.0	Formed flocs	Flocs did not settle well due to foam from mixing. After approximately 15 minutes all material floated. The material then settled after further shaking.
	3360 Cationic	1.0%	49.8	8.0	Formed flocs	After 1/2 hour some material floated
	3360 Cationic	1.0%	24.9	4.0	Formed flocs	Flocs settled well
207BN	3392 Cationic	1.0%	74.7	3.5	Very little floc formed	
	3360 Cationic	1.0%	49.8	2.3	Formed good flocs	
207B N, S, and C	3360 Cationic	1.0%	49.8	4.3	Formed floc	Some material floated because of foam resulting from mixing.

(1) All polymers are products of Betz laboratories, Inc.

?? = "C" Center

A chlorine solution was prepared using 25 grams of calcium hypochlorite (65 percent) with 225 ml of deionized water. This is equivalent to a 7.2 percent solution of calcium hypochlorite.

For each pond, 400 ml of "as-received" sludge was treated with chlorine solution. The chlorine solution was added to achieve three different concentrations (i.e., 6500, 12,300, and 18,500 ppm) The sludge and chlorine solution was mixed for 15 minutes and then sampled for chlorine residual and plate count. Additionally, each raw sample was analyzed for percent solids. The results of the chlorination tests are summarized in Table 2-3.

2.4 SETTLING TESTS

Settling test were conducted to determine the rate at which the sludge settled and the rate that the sludge thickened. The first test is referred to as a Bulk Settling Rate (BSR) Test and the latter is a Thickening Test. The results of each test are compared to determine which test result is the controlling factor for the design of a clarification/thickening unit.

2.4.1 Bulk Settling Rate Testing

The BSR testing was conducted on sludge from Pond 207 A and Ponds 207 B North, Center, and South. All of the sludge for this testing was sieved to minus 325 mesh. Testing was conducted on sludge that was untreated, sludge that was oxidized with calcium hypochlorite, and sludge that was oxidized with calcium hypochlorite (65 percent) and flocculated with polymer (Betz 3360). Polymer was added at the optimum dosage as determined from the earlier polymer tests. All of the BSR tests were conducted using sludge that was diluted with the appropriate pond water at a 1 to 5 dilution. This dilution was necessary to allow discrete settling of the individual particles as required by the test method.

The BSR tests were conducted by first placing the sludge, at the appropriate dilution, in a 1000 ml graduated cylinder. The sludge was then mixed using a rubber stopper on a glass stirring rod to provide a uniform mix. A stop watch was used to measure the time required for the bulk of the sludge to settle.

TABLE 2-3

SUMMARY OF CHLORINATION TESTING

Pond	% Solids	Calcum Hypochlorite Dosage	Plate Count	Residual Chlorine	Selected Dosage Calcium Hypochlorite	
					PPM	lb/1000 lbs Dry Solids
207A	8.5%	0 mg/l 16,700 mg/l 11,100 mg/l 5,900 mg/l	2000 colonies/ml 4 colonies/ml 11 colonies/ml 19 colonies/ml	NA 27 mg/l 22 mg/l 32 mg/l	16,700	120 lbs.
207BN	14.9%	0 mg/l 16,700 mg/l 11,100 mg/l 5,900 mg/l	2000 colonies/ml 3 colonies/ml 2 colonies/ml 3 colonies/ml	NA 2000 mg/l 34 mg/l 4900 mg/l	11,100	40 lbs.
207BC	4.1%	0 mg/l 16,700 mg/l 11,100 mg/l 5,900 mg/l	440 colonies/ml 2 colonies/ml 1 colonies ml 10 colonies/ml	NA 12 mg/l 12 mg/l 22 mg/l	5,900	70 lbs.
207BS	6.3%	0 mg/l 16,700 mg/l 11,100 mg/l 5,900 mg/l	160 colonies/ml 6 colonies/ml 3 colonies/ml 61 colonies/ml	NA 16 mg/l 14 mg/l 344 mg/l	11,100	100 lbs.
Composite 207B Ponds(1)	8.5%	0 mg/l 16,700 mg/l 11,100 mg/l 5,900 mg/l	1800 colonies/ml 4 colonies/ml <1 colonies/ml 2 colonies/ml	NA 1800 mg/l 1100 mg/l 800 mg/l	11,100	120 lbs.

(1) Composite was blended using equal volumes from each pond.

Times were recorded as the sludge settled past the 800, 600, and 400 ml marks on the graduate cylinder. The data was then used to determine the design overflow of a clarification unit required to adequately settle the sludge. The following formula was used:

$$BSR(ft/hr) = \frac{cc \times 60\ min/hr}{min. \times (Cylinder\ calibration\ cc/ft)}$$

where, cylinder calibration for 1.0 L cylinder = 883 cc/ft.

The BSR and design overflows are summarized in Table 2-4. The design overflows are based on a flow rate of 315 gpm from the hydrocyclone to the clarifier.

During the BSR testing it was observed that sludge from Ponds 207 B North and South had a tendency to float as opposed to settle. This observation was attributed to gases becoming entrained in the sludge during mixing when calcium hypochlorite was added.

For each pond, samples were analyzed for percent solids and bulk densities after the sludge was allowed to settle for 30 minutes in the graduate cylinder. These results are summarized below:

Pond	Percent Solids	Bulk Densities*
207 A	9.5 percent	—
207 BN	7.9 percent	1.15 (SG)
207 BC	2.4 percent	—
207 BS	—	—
207 B (combined)	5.4 percent	—

* Bulk densities are reported as specific gravity.

All of the analyses for percent solids and bulk density have not been completed.

TABLE 2-4

SUMMARY OF BULK SETTLING RATE TESTING

Pond Name	Chlorinated (Yes/No)	Polymer Addition (Yes/No)	BSR (ft/hr)	Design Overflow Rate[(1)] (gal/day-ft^2)	Comments
207B North	N	N	12.23	413	Very cloudy supernatant - sludge somewhat agglomerated
	N	N	10.80	468	Very cloudy supernatant - sludge somewhat agglomerated
	Y	N	3.83	1320	Very clear supernatant
	Y	N	4.29	1178	Very clear supernatant
	Y	Y	18.32	276	Clear supernatant - good floc
	Y	Y	19.19	263	Clear supernatant - good floc
207B South	N	N	N/A	N/A	Material not settling after 5 min. - color change from green to brown
	Y	N	N/A	N/A	Color change from green to brown - material not settling after 5 min. - lots of foam
	N	Y	N/A	N/A	Most material floated - supernatant very cloudy - flocs in liquid
	N	Y	N/A	N/A	50 ml floated/300 ml settled - less material floats with every run
	N	Y	2.41	2099	Supernatant had pin flocs
	N	Y	42.92	118	3 ml of polymer added - slow settling rate
	N	Y	6.80	744	Good floc, but poor settling
	N	Y	N/A	N/A	5 ml of Polymer added - 250 ml floated/100 ml settled
	N	Y	N/A	N/A	Most material remained suspended - less material floated
	Y	Y	N/A	N/A	Immediate floc formation. - Within 45 min. everything floated

TABLE 2-4
SUMMARY OF BULK SETTLING RATE TESTING
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Pond Name	Chlorinated (Yes/No)	Polymer Addition (Yes/No)	BSR (ft/hr)	Design Overflow Rate(1) (gal/day-ft²)	Comments
207B South	Y	N	N/A	N/A	Flocs formed - Yellow supernatant's pH went from 9 to 7
	Y	N	N/A	N/A	Cloudy supernatant formed - very fluffy sludge - pH of 7
	Y	Y	N/A	N/A	Very clear supernatant - very fluffy flocs
	Y	Y	N/A	N/A	Material floated
207A	N	N	7.88	641	Supernatant very turbid
	N	N	7.52	672	
	Y	N	9.77	517	Somewhat cloudy supernatant
	Y	N	8.19	617	Good floc formed
	Y	Y	27.64	183	Clearer supernatant - floc settled quickly
207B Center	N	N	N/A	N/A	Material not settling after 5 min.
	Y	N	2.61	1940	
	Y	N	2.93	1726	Pin floc in supernatant
207B Composite	N	Y	58.24	87	Supernatant only blue/green color
	N	N	4.99	1013	Supernatant blue/green
	Y	N	5.26	961	
	Y	N	4.10	1233	
	Y	Y	17.17	294	Supernatant clear with some suspended floc - some floc floated.
	Y	Y	15.68	322	

(1) Based on a flow of 315 gpm.

2.4.2 Thickening Tests

The thickening tests were conducted for each pond using minus 325 mesh material. All of the sludge was oxidized with 65 percent calcium hypochlorite and flocculated with polymer (Betz 3360) at the optimum dosage as determined from the earlier polymer testing.

The test was conducted by placing 1000 ml of sludge in a 1 L graduated cylinder and measuring the decrease in volume over a 24 hour period. The graduate cylinder was equipped with a rake mechanism which rotated between 10 and 30 rpm. Additionally, a similar test was conducted without the rake mechanism to serve as a control for each pond. The results of the thickening tests are reported as square feet, which represents the area needed to provide the necessary capacity to thicken the sludge. The results are as follows:

Pond	Thickening Area
207 A	3,920 $ft.^2$
207 BN	11,255 $ft.^2$
207 BC	No Data
207 BS	8,960 $ft.^2$

No data are reported for Pond 207 BC because the sludge thickened too rapidly to collect data points. This would suggest that this pond would not be a limiting factor for the design of the thickener.

2.5 SLUDGE DEWATERING TESTS

Sludge dewatering tests were conducted using a Buchner funnel, the Denver Equipment Piston Press, and the Larox Pressure Filter. During the initial dewatering tests the Denver Equipment Piston Press was used; however, once it was determined that the sludge was not readily dewaterable as is, the Buchner Funnel was used as a qualitative screening device to test the effect of various additives on the dewaterability of the sludge. It was observed that if sludge mixed with a particular additive was successfully dewatered or unsuccessfully dewatered on the Buchner funnel, then similar results would be found on either of the pressure filters.

All dewatering tests were conducted on combined sludge. The minus 325 mesh material was oxidized with 65 percent calcium hypochlorite and flocculated with Betz 3360 polymer. This sludge was allowed to settle for approximately 4 hours; the supernatant was then decanted off the sludge using a vacuum. This sludge was then combined with plus 325 mesh material, which was also chlorinated with calcium hypochlorite. The sludge was combined at a ratio of 0.28 to 1.0 (quantity of minus 325 mesh material to quantity of plus 325 mesh material). This preprocessing and recombination of sludge simulated what was to occur in the actual process train. (Hydrocyclone circuit)

2.5.1 Buchner Funnel Tests

Initial testing quickly indicated the sludge could not be successfully dewatered without the addition of additives to enhance dewaterability. The sludge appeared to blind on the filter paper, possibly due to the large amount of fine particles. Because of the difficulties encountered in dewatering the sludge, a Buchner funnel was used as a qualitative screening mechanism for various additives mixed with sludge.

Several additives were unsuccessful in improving dewaterability, including Betz 3360 polymer, lime plus polymer, diatomaceous earth, sand, and dilution with deionized water.

There were several additives, which were moderately successful, including lime addition to a pH of 11 with a reaction time of approximately 1.5 hours. Lime addition to pH of 10 after treatment with chlorine dioxide was also moderately successful.

The addition of lime/cement, lime/flyash (Type C), and lime/flyash/cement were successful in dewatering the sludge from Pond 207 A, 207 BN, BC, and BS. The combination of lime/cement/flyash appeared to be the most successful dewatering mixture based on a visual observation of the cake and the dewatering rate. Once the optimum mixture was determined, several additional tests were conducted to determine the effect of decreasing the quantity of cement and flyash. The results indicated that the filtration rate decreased as the quantity of additives decreased. Percent solids analysis were conducted and filtrate volumes were measured for select filter cakes. The Buchner funnel dewatering tests are summarized in Table 2-5.

Additional testing conducted on the Buchner funnel consisted of dewatering each pond sludge using the optimum mixture of lime/flyash/cement and collecting the filtrate volume. The filtrate was then filtered through a .45 micron filter and analyzed for the TCLP metals and pH. This data would represent the quantity of dissolved metals present in the filtrate from a dewatering process. These results are summarized in Table 2-6.

2.5.2 Dewatering Tests With The Denver Equipment Piston Press

The laboratory Piston Press is a device designed to measure the filtration characteristics of sludge at pressures up to 2000 psi. The pressure is supplied by an air driven ram pump. The ram is driven by compressed air at approximately 90 psi. The pressurized water is fed to the press through a flexible hydraulic hose. The press consists of a steel cylinder with internal dimensions of 7.874 inches long by 3 inches in diameter. One end of the cylinder contains a hydraulic port which delivers pressure to the internal piston. The other end of the cylinder has an end cap which is screwed on and off to fill or remove sample. The Piston Press was used for dewatering tests when initial thinking was that the sludge was amenable to dewatering. Initially, testing was conducted with Pond 207 A and 207 BS sludge "as is." The material was observed to blind the filter cloth (preventing the flow of water) probably because of the large number of fine particles and/or the presence of an organic slime layer around the discrete particles. After the initial test with the Piston Press, it was realized that the material was not dewaterable without some type of pretreatment. As a result of this finding, relatively few tests were actually conducted with the Piston Press.

Additives such as Type C Flyash and cationic polymer were used to improve filterability. Both additives failed to increase the filtration rate of the sludge. The results of the Piston Press dewatering test are provided in Table 2-7.

TABLE 2-5
SUMMARY OF BUCHNER FUNNEL DEWATERING TESTS

Pond	Run No.	Sludge Volume	Additives	Run Time	Filtrate Volume	Cake Percent Solids	Comments
207BC	1	200 ml	2000 ml 1% polymer (3360)	143 min.	Not measured		Poor dewatering
	2	100 ml	100 ml DI water 4 ml 1% polymer (3360)	33 min.	Not measured	NA	Poor dewatering despite good floc formation
	3	200 ml	2.15 g $Ca(OH)_2$ 7 ml of 1% polymer (3360) 150 ml DI water	5 min.	Not measured	NA	pH = 9.5. Slight improvement over previous runs
	4	100 ml	100 ml DI water 2.15 g $Ca(OH)_2$ 22 g Portland Cement	4 min.	Not measured	50.8%	Good filtration
	5	100 ml	100 ml DI water 22 g Portland Cement	15 min.	Not measured	NA	
	6	200 ml	4.3 g $Ca(OH)_2$ 44 g Portland Cement	9 min.	Not measured	50.8%	
207BS	1	100 ml	100 ml DI water 6.4 g Diatomaceous Earth	18 min.	Not measured	NA	Poor filtration.
	2	100 ml	100 ml DI water 2.15 g $Ca(OH)_2$ 29.3 g Type C Flyash	4 min.	Not measured	62.9%	pH = 12 Good filtration
	3	---	14.9 g cement 100 ml DI water	2.50 min.	Not measured	64.9%	Materials added to mixture from 207BS, Run No. 2
207BC	1	100 ml	100 ml DI water 240 g sand	4 min.	28 ml	NA	Sample still wet
	2	100 ml	100 ml DI water 40 g sand	4 min.	35 ml	NA	Sample still wet
	3	100 ml	100 ml DI water 2.15 g $Ca(OH)_2$ 29.3 g flyash 14.9 g cement	4.50 min.	140 ml	NA	pH = 12 Sample filtered well
	4	100 ml	100 ml DI water 2.15 g $Ca(OH)_2$ 17.6 g flyash 14.9 g cement	5.50 min.	170 ml	NA	pH = 12

TABLE 2-5
SUMMARY OF BUCHNER FUNNEL DEWATERING TESTS
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Pond	Run No.	Sludge Volume	Additives	Run Time	Filtrate Volume	Cake Percent Solids	Comments
207BC	5	100 ml	100 ml DI water 2.15 g $Ca(OH)_2$ 14.9 g cement	6.50 min.	170 ml	NA	pH = 12
	6	100 ml	100 ml DI water 2.15 g $Ca(OH)_2$ 11.7 g flyash 6.6 g cement	8.00 min.	164 ml	NA	pH = 12
	7	100 ml	100 ml DI water 2.15 g $Ca(OH)_2$ 29.3 g flyash	6.00 min.	182 ml	NA	pH = 12
	8	100 ml	100 ml DI water 2.15 g $Ca(OH)_2$ 6.6 g Portland Cement 29.3 g flyash	3.50 min.	139 ml	NA	pH = 12
207BS	1	200 ml	none	16 min.	17.5 ml	NA	Sludge was sheared for 5 min. prior to filtration. Volume increased to 400 ml from air entrainment. Poor filtration.
	2	200 ml	476 mg/l of 1.0% polymer	16 min.	16 ml	NA	Material formed good floc but dewatered poorly
	3	400 ml	238 mg/l of 1.0% polymer	16 min.	50 ml	NA	Test was conducted on - 325 mesh material. After polymer addition sludge floated. Poor filtration.
	1	100 ml	Lime addition to pH 11 100 ml of DI water	7.5 min.	160 ml	NA	Sludge was not chlorinated. Sludge was moderately filterable compared to lime, flyash, and cement mixture.
	2	180 ml	Oxidation with chlorine dioxide. Lime to pH 10	8 min.	180 ml	NA	Sludge was moderately filterable compared to lime, flyash, and cement mixture
	3	200 ml	Oxidation with chlorine dioxide	20 min.	100 ml	NA	Sludge was still very wet

NA - Not Analyzed
Note: Bulk Densities: Sand = 100 lb/ft^3 (literature value) and Diatomaceous Earth = 20 lb/ft^3 (literature value).

TABLE 2-6

TCLP METAL ANALYSIS ON FILTRATE

Analysis	Pond 207A	Pond 207BN	Pond 207BC	Pond 207BS
Arsenic	<0.1 mg/l	0.3 mg/l	0.5 mg/l	0.4 mg/l
Barium	0.056 mg/l	3.7 mg/l	3.3 mg/l	3.6 mg/l
Cadmium	<0.02* mg/l	0.024 mg/l	0.032 mg/l	0.011 mg/l
Chromium	<0.05*mg/l	0.54 mg/l	0.421 mg/l	0.47 mg/l
Lead	<0.05 mg/l	0.12 mg/l	0.08 mg/l	<0.05 mg/l
Selenium	<0.1 mg/l	0.4 mg/l	0.1 mg/l	0.1 mg/l
Silver	0.03 mg/l	0.10 mg/l	0.67 mg/l	<0.01 mg/l
pH	11.9	11.9	11.8	11.9

* Elevated detection limit due to sample matrix interference.

TABLE 2-7

SUMMARY OF DEWATERING TESTS
DENVER EQUIPMENT PISTON PRESS

Pond	Test No.	Sludge Volume	Additives	Pressure	Run Time	Filtrate Volume	Cake Thickness	Comments
207A	1	550 ml	None	1500 psi Increased to 2000 psi after 17 min.	25 min.	31 ml	---	Poor filtration, 1/8" material was not dewatered.
	2	550 ml	None	1500 psi Increased to 2000 psi after 15 min.	18 min.	34 ml	---	Used Whatman 41 filter paper - Poor filtration.
	3	275 ml	20% dry wt. Type C flyash (19.25g)	1500 psi	8 min.	30 ml	1CM	Only small part of material dewatered.
	4	500 ml	30 ml of 1% Polymer (3360)	1500 psi	15 min.	24 ml	---	No cake was formed, poor filtration.
	5	450 ml	None	1500 psi	150 min.	260 ml	3/4"	Still some water present above filter cake.
207BS	6	400 ml	None	1500 psi	60 min.	70 ml	3/16"	All sludge not dewatered.
207BC	7	200 ml	50 ml 1% Polymer (3360)	1500 psi	---	150 ml	3/16"	Some sludge not dewatered.

2.5.3 Dewatering Tests With The Larox Pressure Filter

The Larox Pressure Filter (LABOX PF 25 LABORATORY FILTER) is a laboratory filter which simulates the filtration, pressing, and drying operations performed in a full-scale filter. The pressure filter has a filtration area of 25 cm^2. The filter cloth used for testing was constructed of polyester and had an air permeability of 4.6 $ft^3/ft^2 \cdot min$.

The Larox Pressure Filter was used for dewatering tests primarily after various additives were successfully screened on the Buchner funnel; therefore, the majority of the testing was relatively successful. The primary additives were lime, flyash, and cement which were tried in various combinations. However, lime was always added to a pH of approximately 12. A summary of these dewatering tests is provided in Table 2-8.

The testing consisted for the most part of varying pressure, run time, and fill cycles to provide adequate design information for Larox to size a full-scale unit. The most successful mixture for dewatering consisted of lime, flyash, and cement. This mixture was used on all pond sludge and found to produce a suitable filter cake based on percent solids and visual observations. Additionally, a filter cake from each sludge was sampled and submitted for TCLP extraction and metal analysis. These results are provided in Table 2-9.

2.6 MISCELLANEOUS TESTS

Upon discovering the difficulties in dewatering the pond sludges, several other tests were conducted in an attempt to improve the dewaterability of the sludges. The following three tests were conducted:

- Centrifuging the sludge
- Sonication of the sludge
- Shearing the sludge

The centrifuge test was conducted by taking 37 ml of Pond 207 BC sludge and placing it in a centrifuge tube. The sludge was centrifuged for 5 minutes at 3000 rpm. The following visual observations were noted:

TABLE 2-8

SUMMARY OF FILTRATION TESTS
LAROX FILTER

Pond	Run No.	Sludge Volume(1)	Additives	Pressure	Filtration Time	Filtrate Volume	Cake Thickness	Cake Percent Solids	Comments
207BS	1	150 ml	None	195 psi	20 min.	20 ml	---	---	Only 1/16" of material dewatered.
	2	150 ml	3.2 g $Ca(OH)_2$ 33 g cement	195 psi	5 min	100 ml	1/2"	70.1%	Good filtration, cake was 1/2" thick.
	3	450 ml	9.5 g $Ca(OH)_2$ 99 g cement	195 psi 195 psi	50 sec. 5 min.	125 ml	1"	59.1%	Added in two layers, first = 150 ml, second = 75 ml. Top of cake was a little wet.
	4	450 ml	9.5 g $Ca(OH)_2$ 99 ml cement	78 psi 78 psi 195 psi	52 sec. 170 sec. 6 min.	150 ml	1-1/8"	62.1%	Material was added in three layers (150 ml, 50 ml, 50 ml); the first two were at 78 psi and the last at 195 psi.
	5	450 ml	9.7 g $Ca(OH)_2$ 132.2 g flyash	195 psi	4 min.	75 ml	3/4"	57%	Cake still wet. Added 150 ml in one layer.
	6	450 ml	9.7 g $Ca(OH)_2$ 132.2 g flyash	78 psi 195 psi	50 sec. 6 min.	---	1-1/8"	64.7%	Cake still soupy. First layer = 150 ml Second layer = 50 ml
	7	600 ml	13 g $Ca(OH)_2$ 175.5 g flyash 89.1 g cement	78 psi 195 psi	50 sec. 6 min.	120 ml	1-1/4"	76.7%	First layer = 150 ml Second layer = 50 ml
	8	600 ml	13 g $Ca(OH)_2$ 175.5 g flyash 89.1 g cement	78 psi 78 psi 195 psi	50 sec. 1 min 4 min.	---	1-1/4"	69.5%	Sludge added in two layers; the first was 150 ml, and the second was 50 ml. The pressure was increased to 195 psi after the second layer was filtered at 78 psi for 1 min.
207BC	9	600 ml	13 g $Ca(OH)_2$ 175.5 g flyash 89.1 g cement	78 psi 78 psi 195 psi	50 sec. 60 sec. 4 min.	90 ml	1-1/8"	70.8%	Sludge added in two layers; the first was 150 ml, and the second was 50 ml. The pressure was increased to 195 psi after the second layer was filtered at 78 psi for 1 min.
	10	600 ml	13 g $Ca(OH)_2$ 175.5 g flyash 89.1 g cement	78 psi 78 psi 195 psi	50 sec. 60 sec. 3 min.	90 ml	1-1/8"	69.6%	Sludge added in two layers; the first was 150 ml, and the second was 50 ml. The pressure was increased to 195 psi after the second layer was filtered at the 78 psi for 1 min.

TABLE 2-8
SUMMARY OF FILTRATION TESTS
LAROX FILTER
PAGE TWO

Pond	Run No.	Sludge Volume[1]	Additives	Pressure	Filtration Time	Filtrate Volume	Cake Thickness	Cake Percent Solids	Comments
207BC	11	600 ml	13 g $Ca(OH)_2$ 175.5 g flyash 89.1 g cement	195 psi	5 min.	80 ml	7/8"	76.0%	Added 1 layer of 150 ml.
207A	12	600 ml	13 g $Ca(OH)_2$ 25.7 g flyash 50.5 g cement	78 psi 195 psi	50 sec. 6 min.	---	---	NA	Poor filtration.
	12A	600 ml	13 g $Ca(OH)_2$ 175.5 g flyash 89.1 g cement	78 psi 78 psi 195 psi	50 sec. 50 sec. 6 min.	100 ml	1-1/4"	70.5%	Sludge added in two layers; the first was 150 ml; the second was 50 ml. The pressure was held at 78 psi for 50 sec. then raised to 195 psi for 6 min. on the second layer.
207BN	13	600 ml	13 g $Ca(OH)_2$ 175.5 g flyash 89.1 g cement	78 psi 78 psi 195 psi	50 sec. 50 sec. 6 min.	80 ml	1-1/4"	75.4%	Sludge added in two layers; the first was 150 ml; the second was 50 ml. The pressure was held at 78 psi for 50 sec. then raised to 195 psi for 6 min. on the second layer.
	14	600 ml	13 g $Ca(OH)_2$ 175.5 g flyash 89.1 g cement	78 psi 78 psi 195 psi	50 sec. 50 sec. 6 min.	80 ml	1-1/4"	74.9%	Sludge added in two layers; the first was 150 ml; the second was 50 ml. The pressure was held at 78 psi for 50 sec. then raised to 195 psi for 6 min. on the second layer.

(1) Not all of the initial sludge volume was added to the Larox filter.

TABLE 2-9

TCLP ANALYSIS OF DEWATERED SLUDGE CAKE

Compound	TCLP Regulatory Value for the RCRA Characteristic of Toxicity	F006, F007, and F009 LDR Standard	Pond 207A	Pond 207B North	Pond 207B Center	Pond 207B South
Arsenic	5.0 mg/l	---	<0.1 mg/l	<0.1 mg/l	<0.1 mg/l	<0.1 mg/l
Barium	100.0 mg/l	---	2.8 mg/l	2.4 mg/l	5.4 mg/l	5.0 mg/l
Cadmium	1.0 mg/l	0.066 mg/l	<0.005 mg/l	<0.005 mg/l	<0.005 mg/l	<0.005 mg/l
Chromium	5.0 mg/l	5.2 mg/l	0.16 mg/l	0.19 mg/l	0.16 mg/l	0.14 mg/l
Lead	5.0 mg/l	0.51 mg/l	0.05 mg/l	0.05 mg/l	<0.05 mg/l	<0.05 mg/l
Mercury	0.2 mg/l	---	<0.002 mg/l	<0.0002 mg/l	<0.0002 mg/l	<0.002 mg/l
Selenium	1.0 mg/l	---	<0.01 mg/l	<0.1 mg/l	<0.1 mg/l	<0.1 mg/l
Silver	5.0 mg/l	0.072 mg/l	<0.01 mg/l	<0.01 mg/l	<0.1 mg/l	<0.01 mg/l
pH	---	---	11.5	11.4	11.5	11.4
Nickel	---	0.32 mg/l	NA	NA	NA	NA

NA: Not Analyzed.
Note: Nickel is least soluble at a pH of 10.5 and is less than 0.32 mg/l at a pH of 11.5. Additionally, the raw sludge from 207 A, 207 BN, BC, and BS were below the LDR limit for nickel in the Solar Pond Characterization results.

- 10.5 ml of air/gas was expelled during the centrifuging
- 4 ml of liquid was present
- 13 ml of fine-grained material was present
- 2 ml of coarser material was present

The sonication test was conducted by placing 75 ml of Pond 207 BC sludge in a beaker which was then placed in a water bath in a sonication cleaner. After 3 minutes, the sludge showed no visible effects from the sonication. The sludge was then sonicated for an additional 13 minutes. There did not appear to be any significant difference in the physical characteristics of the sludge, although some degassing did occur. The sludge was also sonicated on a high energy sonicator, which is used for chemical extraction of soils and sludges. The sludge was sonicated for 6 minutes with no apparent effect on the sludge.
The shear test was conducted by placing 200 ml of Pond 207 BS sludge in a beaker and mixing the sludge with a blender (rpm approximately 10,000 to 12,000) for 5 minutes. The sludge was visually observed to increase from 200 ml to 400 ml from entrained gases. The sludge was then placed on a Buchner funnel to determine if the filterability of the sludge was improved. After 16 minutes of filtration time the sludge was still wet and only 17.5 ml of filtrate was collected.

2.7 BELT FILTER PRESS TESTING

Belt filter press testing was conducted by Messrs J. Jones and W. Chung of Roediger. The purpose of this qualitative testing was to determine if the sludge is amenable to belt press dewatering. The test was conducted on sludge from Pond 207 A and combined sludges from Ponds 207 BN, BC, and BS. Testing was conducted on chlorinated and nonchlorinated sludge.

The test procedure consisted of mixing polymer with sludge to form flocs, which were dewatered on a coarse screen by rolling the sludge back and forth, simulating gravity dewatering on a full-scale belt press. Once the free water was removed, the sludge was placed on a section of belt cloth, which was folded over and squeezed by hand to remove additional water. At the completion of the dewatering step, the cloth was visually observed to determine if the cake would separate from the filter cloth.

The testing was conducted using a cationic polymer supplied by the Roediger personnel. The polymer was a Stockhausen product (Praestol 644 BC) which was used at 0.2 percent solution. The Betz 3360 polymer which had previously been used in the treatability study was tried; however, it appeared to have lost its activity due to age and was not used again.

The initial percent solids of sludge from Pond 207 A was 5.4 percent, and for sludges from combined Ponds 207 BN, BC, and BS was 9.5 percent. Table 2-10 summarizes the results of belt filter press testing. The data indicate that chlorination with calcium hypochlorite improved the dewatering. Chlorination visually improved the flocculation of the sludge. The sludge with polymer addition and chlorination was dewatered to 28.6 percent and 36.0 percent solids for combined Ponds 207 BN, BC, BS and 207 A, respectively.

TABLE 2-10

SUMMARY OF BELT FILTER PRESS TESTING

POND	CHLORINATION	POLYMER	PERCENT SOLIDS	
			GRAVITY DEWATERING	PRESSURE DEWATERING
207B N,C,S	NO	YES	14.1%	21.0%
	NO	NO	(1)	(1)
	YES	YES	16.0%	28.6%
207A	NO	YES	20.4%	29.2%
	YES	YES	29.1%	36.0%

(1) Test was not successful; no samples collected.

3.0 DISCUSSION OF TESTING RESULTS

3.1 MATERIAL PROCESSING

Several observations were made from the extensive handling of the sludges. The first observation is the amount of plus 10 mesh material in the 207 A, BN, BC, and BS Ponds is relatively insignificant. The amount of plus 10 mesh material ranged from 2.8×10^{-3} to 1.8×10^{-4} percent by weight. This material consisted of grass, twigs, and asphalt (i.e., material that may have been blown into the ponds from the berms). Although this material does not appear to be a typical waste, it must be considered a RCRA hazardous waste because of the mixture rule as defined in 40 CFR 261.3. This material is listed for the same hazardous waste identification numbers as the Solar Ponds.

The second observation is the sludge consists primarily of very fine sized particles. It is estimated that there are 4 times more solids less than 325 mesh than plus 325 mesh based on the quantities of material after sieving.

The sludge was a very thick paste when thickened to between 30 and 40 percent solids. This material had a consistency similar to catsup.

The sludge from all of the ponds had a strong odor similar to sewage. The presence of biological activity is a result of sewage being dumped into the solar ponds historically. As a result of sewage present in the sludges and waters, disinfection might be required as part of the treatment process to comply with acceptance criteria specified by the Nevada Test Site. The NVO-325 states that waste can not be accepted if pathogens are present. Disinfection also improved the settling and filtration characteristics of the sludge.

3.2 POLYMER TESTING

As indicated earlier, various polymers were tested for both nonchlorinated and chlorinated sludge. Because of the need to chlorinate the sludge for disinfection and improved material handling, only the results of the polymer testing with the chlorinated sludge will be discussed.

Testing indicated that a cationic polymer was successful in promoting flocculation of the four solar pond sludges processed to minus 325 mesh. The polymer selected was a Betz product designated 3360. The following dosages were selected:

Pond	Dosage(ppm)	Dosage(Neat Polymer)
207 A	75	2.23 lbs./1000 lbs. dry solids
207 BN	100	2.31 lbs./1000 lbs. dry solids
207 BC	50	4.00 lbs./1000 lbs. dry solids
207 BS	75	2.79 lbs./1000 lbs. dry solids

Dry solids are based on the percent solids results of the minus 325 mesh material. The percent solids for Ponds 207 A, BN, BC, and BS are 3.5, 4.5, 1.3,and 2.8, respectively.

3.3 CHLORINATION TESTING

Initial handling of the 207A and 207B-N/C/S sludges (-325 mesh material) revealed that the material would not settle in a timely fashion. This observation was more pronounced for sludge from 207B-S. The poor settling characteristic was believed to be related to biological activity in the sludge. A decision was made to chlorinate the sludge to kill the biomass. The chlorinating agents evaluated were sodium hypochlorite (at 5 percent) and calcium hypochlorite (at 65 percent). These were chosen due to their availability. Because a large volume of sodium hypochlorite (at 5 percent) would be required compared to a relatively smaller volume of the more concentrated calcium hypochlorite, testing proceeded with calcium hypochlorite. After the addition of calcium hypochlorite, the sludge was observed to settle at a faster rate than nonchlorinated sludge. The addition of polymer further optimized the settling rate of the sludges. The optimum settling of the sludge was found to be a combination of the chlorinating agent followed by polymer addition.

As testing progressed, an observation was made which indicated that when calcium hypochlorite was added to pond water, a precipitate was formed. The precipitate was believed to be either calcium hydroxide or calcium sulfate (gypsum). The precipitate was weighed and found to be approximately 3 percent of the weight of water. Because of the concern of producing additional solids that would require solidification, additional chlorinating agents were evaluated. The following reagents were evaluated:

- Chlorine Dioxide
- Hydrogen Peroxide
- Nitrogen Trichloride
- Sodium Hypochlorite
- Sodium Chlorite

The following briefly describes the results of the evaluation.

Chlorine Dioxide, ClO_2 (at 5 percent): One test was conducted to qualitatively evaluate the performance of chlorine dioxide. Because of the difficulties and health hazards of generating concentrated chlorine dioxide gas in the laboratory, a dilute solution was made for testing using Anthium Dioxide (International Dioxide Inc.). A large dilution was required to approach the theoretical concentration needed due to the solubility of chlorine dioxide in water (0.3 percent solution). After oxidation, a change in the physical characteristics of the sludge was observed. The material color changed from greenish blue to yellowish white. After oxidation, the pH was 2.

Hydrogen Peroxide, H_2O_2 (50 percent): Limited qualitative testing was performed. Upon addition, no reaction occurred for approximately 20 minutes. When the exothermic reaction occurred, substantial gas evolution and foaming were observed. No visible oxidation of the blue dye in the pond water was observed.

Nitrogen Trichloride, NCl_3: Initial testing revealed unfavorable solubility characteristics with lower temperatures. This material is relatively insoluble at temperatures below approximately 70°F.

Sodium Hypochlorite, NaClO (15 percent): Qualitatively evaluated in laboratory. No visual sign of biomass degradation and no change in physical characteristics after 2 hours. No apparent reaction.

Sodium Chlorite, $NaClO_2$ (31.25 percent): Qualitatively evaluated in laboratory. No visual sign of biomass degradation and no change in physical characteristics after 2 hours. No apparent reaction.

In summary, the only material evaluated in the laboratory that was successful was calcium hypochlorite. However, this material must be given further consideration before being used for further treatability studies or remediation because of the production of precipitate. Chlorine dioxide was somewhat successful; however, this material is not appropriate for further testing in the laboratory for the following reasons:

1. The method of addition is by adding the material in a liquid form by using an activator, which requires additional tap water. The concentration is limited by the solubility of chlorine dioxide in water (0.3 percent). This requires the addition of significant quantities of water to approach the required oxidant concentration.

2. It is not feasible to produce chlorine dioxide gas in the laboratory at the quantities required to oxidize approximately 1200 gallons of sludge and water from all of the ponds.

Although chlorine dioxide does not appear appropriate for the laboratory, it is readily applicable for remediation. Gas generation can be produced under controlled conditions, which are both safe and practical.

Chlorine gas is another oxidant that can be utilized safely in the field but has limitations in the laboratory similar to those of chlorine dioxide.

Ozone is a third oxidant which can be safely produced in the field under controlled conditions. Unlike chlorine gas and chlorine dioxide, ozone can be safely produced in the laboratory using a laboratory-scale generator. Operations must be conducted in a hood to avoid exposure to laboratory personnel.

3.4 SETTLING TESTS

Two different tests were conducted to determine the settling and thickening characteristics of the sludges from the Solar Ponds. These tests were conducted to determine if the area required for sludge clarification or the area required for sludge thickening was the limiting factor for sizing a clarifier.

3.4.1 Bulk Settling Rate Tests

The bulk settling rate tests indicate that the "as received" sludge settled very slowly and was not at a rate acceptable for a full-scale remediation system. To enhance the settling rate the sludge was chlorinated with calcium hypochlorite and/or flocculated with polymer (Betz 3360).

The results of these tests indicated that addition of calcium hypochlorite was necessary to improve settling characteristics. However, in some instances, the sludge from Ponds 207 BN and BS tended to float following chlorination and polymer addition. This phenomenon appeared to be a result of gases, generated during the oxidation reactions, entrained in the floc.

The addition of polymer improved settling characteristics of the nonchlorinated sludge and the chlorinated sludge. In all cases the chlorinated sludge with polymer addition produced the best settling characteristics.

The pond sludge that settled at the slowest rate was 207 BN. The bulk settling rate was determined to be 18.32 ft/hr which is equivalent to a design overflow rate of 1645 gal/ft^2-day. Based on the design flowrate of 315 gpm from the cyclone to a clarification unit, the clarification area required is 276 ft^2. This area is equivalent to a 20 ft diameter clarification unit or an inclined plate separator with the approximate dimensions of 19'x 17'x 9'(H x L x W).

3.4.2 Thickening Tests

The thickening tests were conducted to determine the area required to produce a more concentrated sludge. Tests were conducted on sludge that was chlorinated with calcium hypochlorite and flocculated with cationic polymer. The results from the thickening tests indicated that significantly more area was required to thicken the sludge as compared to clarification.

The sludge from Pond 207 BN required the largest area for thickening. The area was determined to be approximately 11,255 ft^2. A thickener with a diameter of 120 ft would be required to thicken 207 BN sludge at a flow rate of 315 gpm, or 5 inclined plate separators, each with approximate dimensions of 21'x 22'x 13', would be required. This is a relatively large area and is not practical because of space limitations.

3.5 SLUDGE DEWATERING TESTS

The dewatering tests determined that the sludge cannot be dewatered "as is" without treatment to improve the physical characteristics. The sludge from all of the Solar Ponds contain a significant amount of fine particles similar in size to silt and clay material. Typically, clay-like material is somewhat difficult to dewater. In addition, the presence of sewage appears to have enhanced biological activity in the ponds, which also causes difficulties when dewatering this type of a sludge. The difficulties encountered when attempting to dewater the sludge may be a result of the fine particles becoming surrounded by biomass, which results in a matrix that blinds itself during pressure filtration.

The test results suggest that all of the sludges are similar in nature with regard to dewaterability. Additionally, the results indicate that tests conducted using the Buchner funnel, Denver Piston Press, and the Larox unit provide similar conclusions (i.e., a sludge mixed with a particular additive will or will not be dewaterable on all three devices). Because of these observations, the following discussion will be generic in nature with regard to specific pond sludge and the device on which the sludge was tested.

Upon determining that the sludge was not dewaterable "as is," various materials were mixed with the sludge in an attempt to improve the dewaterability of the sludge. The first additive tried was Type C Flyash. This was added as a bulking agent, to improve the drainage of free water and to prevent the sludge from binding. At a dosage of 20 percent dry weight of the sludge, dewatering was unsuccessful. Several other bulking agents were mixed with the sludge such as diatomaceous earth and sand. Neither of these additives were successful in improving the dewaterability of the sludge.

Cationic polymer was added to the sludge to improve the dewaterability by forming flocs. The polymer successfully formed flocs, resulting in significant amounts of visible free water in the sludge. When the flocced material was dewatered, it compressed and blinded, thereby preventing the free water from draining. Polymer addition was also tried in combination with the addition of lime to a pH of 9.5. This test indicated a slight improvement when compared to the test with only polymer added but still was not considered successful.

A dewatering test was conducted with lime addition to pH of 11 after a reaction time of 1.5 hours. This test provided results that indicated the sludge was dewaterable without the addition of flyash and cement but at one half the optimum dewatering rate. Tests were also conducted with lime/flyash mixed with sludge and cement/lime mixed with sludge. Both mixtures indicated that the sludge could be successfully dewatered with these additives. The optimum mixture appeared to be lime/flyash/cement when mixed with sludge. In all of the latter tests lime was added to a pH of approximately 12. For the optimum mixture, the approximate quantities of sludge and additives are as follows (on a dry weight basis):

- Sludge at 35 percent solids = 2000 lbs.
- Hydrated lime = 96 lbs.
- Type C flyash = 1307 lbs.
- Cement = 673 lbs

Another test was conducted which proved to be moderately successful. During this test, sludge was first oxidized with chlorine dioxide then lime was added to a pH of 10.

The common factor in all of the tests which were successful, or demonstrated that the sludge could be dewatered, was the addition of lime. Improvement was enhanced by the addition of flyash and/or cement following the addition of lime.

3.5.1 Equipment Filtration Rates

This section summarizes the equipment required to process 10 tons per hour of dry solids based on laboratory tests. These equipment sizes are based on the testing conducted by each vendor and vary substantially because the testing was significantly more successful during the Larox testing. The success of the Larox unit was a result of extensive testing on a Buchner funnel to determine the optimum additives and the quantity of material to be added to allow successful filtration.

The most successful test conducted by Denver Equipment was on Pond 207 BC sludge with the addition of lime and cement. Based on this test, Denver Equipment indicated that twelve 3-meter, 500-series tube presses would be required to process 10 ton of dry solids per hour (See Denver Equipment Test Report in Appendix B).

The most successful test conducted by Larox was with the addition of lime, flyash, and cement at the quantities mentioned previously. This mixture was used for all three pond sludges with similar success. Based on these results, Larox indicated that a cycle time of 11 minutes would result in a filter cake with 70 percent solids at a capacity of 42.0 lbs/ft^2-hour. This rate would require two Larox PF19 filter presses each with a filter area of 203.4 ft^2. one → 42 #/ft²/hr x 203.4 ft² x ton/2000# = 4.27 TPH (Product) @ 70% solids

3.5.2 TCLP Results

TCLP metals analysis was conducted for each pond sludge after dewatering with the Larox pressure filter using the optimum admixture formulation. The formulation consisted of lime, cement, and flyash. The metals results shown in Table 2-9 are compared to the constituents of RCRA characteristic wastes for toxicity and to the Land Disposal Restriction (LDR) values for the metal constituents of F006, F007, and F009. The results indicate that all values are less than the regulatory values. The sludges were not analyzed for nickel but should not be present at levels above regulatory values because the solubility of nickel is at a minimum at pH 10.5. The pH value of the TCLP leach is approximately 11.4, which suggests that nickel will not be soluble in the leachate solution.

3.6 BELT FILTER PRESS TESTING

The belt filter press testing proved to be successful. The percent solids achieved in laboratory testing (28.6 percent to 36.0 percent) is considered to be relatively high for belt presses and should increase when the sludge is dewatered on an actual belt press.

A significant observation was made during the testing. The sludge cake at approximately 30 to 35 percent solids did not appear pumpable and must be handled as a solid. The sludge cake appearance is different than that of the combined sludge which was used for the pressure filtration testing, even though the percent solids were similar. It is believed that sludges used for the pressure filtration tests were pumpable and could be handled as a slurry.

The observation that the sludge cake from the filter press is not pumpable has significant consequences regarding the placement of the dewatered sludge cake into one of the B Ponds for temporary storage. No acceptable methods of extracting the sludge from the ponds exist because the material can not be pumped. Other methods would be required to remove sludge from the pond or other methods of temporary storage would be required. Additionally, because the sludge is not considered pumpable, belt press dewatering may not be compatible with pressure filtration because of the inability to fill the Larox unit by pumping.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results from testing to date, this section will provide conclusions and recommendations for future treatability study work.

4.1 SLUDGE THICKENING

Sludge thickening tests were conducted on the minus 325 mesh material that had been hand-sieved to simulate the particle separation to be accomplished by the hydrocyclone. The minus 325 mesh material was estimated to exit the hydrocyclone at 3 to 5 percent solids, therefore, requiring thickening prior to being recombined with the plus 325 mesh material. Both sizes would be recombined prior to pressure filtration.

After the completion of the testing, a decision was made to eliminate the hydrocyclone since it may not work properly due to the nature of the sludge. As a result of eliminating the hydrocyclone, the thickening test results are no longer applicable to this design. However, the data is useful to provide information pertaining to physical characteristics of the sludge.

The following conclusions summarize the sludge dewatering tests:

- The minus 325 mesh sludge settled at a quicker rate after chlorination with 65 percent calcium hypochlorite.
- The minus 325 mesh sludge flocculated better after chlorination with 65 percent calcium hypochlorite.
- A Betz cationic polymer (3360) was found to be an effective flocculating agent for Ponds 207 A, BN, BC, and BS. The optimum dosage for flocculation ranged between 50 and 100 ppm (2.23 to 4.00 pounds of neat polymer per 1000 pounds of dry solids).
- The percent solids after settling for approximately 4 hours approached the densities in the ponds and ranged from 9 to 21 percent.

- The sludge required a larger surface area for thickening when compared to clarification. The limiting pond for each parameter was 207 BN. The area needed for clarification is 275 ft^2 and for thickening is 11,255 ft^2.

4.2 CHLORINATION TESTS

Oxidation of the sludge with 65 percent calcium hypochlorite was beneficial for sludge handling as well as disinfection of the sludge for pathogens likely to be present from dumping of sewage into the ponds. Of the chlorinating agents tested in the laboratory, calcium hypochlorite is the most practical for disinfecting the sludge. The following conclusions summarize the chlorination testing:

- Calcium hypochlorite (65 percent purity) dosages ranged from 40 to 130 pounds per 1000 pounds of dry solids.
- The addition of calcium hypochlorite to pond water generates a precipitate, which is approximately 3 percent by weight of the water. elucidate. Tot. Tons; yd^3

4.3 PRESSURE FILTRATION DEWATERING TESTS

The pressure dewatering test results are not significantly affected by the decision to eliminate the hydrocylone; however, this data should be qualified somewhat. The recombination of plus 325 mesh material with minus 325 mesh material was done at a ratio of approximately 1.0 to 0.4, respectively. The sludge contains a larger quantity of minus 325 mesh material compared to the plus 325 mesh material, at a ratio of approximately 4 to 1. The presence of this additional amount of fine-grained material may have adverse effects on the filtration rates. Additionally, the pressure filtration tests were conducted with sludge with an initial percent solids of approximately 35 percent, which must be duplicated by equipment other than the hydrocyclone and the clarifier. The following conclusions summarize the pressure filtration tests:

- The "as is" sludge is not amenable to pressure filtration because the sludge blinds on itself.
- The addition of lime improves the filtration rate of sludges.

- The addition of flyash and cement, following pH adjustment with lime, improves the filtration rate.
- The optimum dewatering formulation included the addition of lime to a pH of 12, followed by the addition of Type C flyash and cement in a 1:1:0.5 ratio of dry solids:flyash:cement.
- The optimum dewatering formulation also successfully achieved the LDR requirements for F006, F007, F009, and the TCLP requirements for the characteristic of toxicity.

4.4 BELT FILTER PRESS TESTING

The belt filter press testing was conducted to answer the question of whether this type of filtration is a viable option for dewatering. The following conclusions summarize the results of belt filter press testing:

- The solar pond sludges can be dewatered effectively with a belt filter press to percent solids ranging from 30 to 35 percent.
- The filter cake from the belt filter press does not appear to be pumpable. This means that the cake must be handled as a solid instead of a slurry.

4.5 RECOMMENDATIONS FOR FUTURE TREATABILITY STUDY WORK

Based on the results of the preliminary treatability study testing to date, and the characterization data summarized in the Waste Characterization Report (HALLIBURTON NUS 1991), recommendations for future treatability work are as follows:

Based on characterization data, Pond 207 C and the Clarifier contents will require oxidation to treat cyanide and possibly tetrachloroethene. These contaminants require treatment so the waste will meet the LDR requirements necessary for acceptance at the Nevada Test Site. The sludge from 207 A and the B series ponds will likely require treatment to disinfect the material, thus killing pathogens as required by the Nevada Test Site (NVO-325, 1991). The existing data also suggests that sludge handling is improved (i.e., settling and dewatering activities) following oxidation.

It is recommended that the oxidation be pursued with ozone first, because of the ease of generating ozone in the laboratory. If ozone is not successful, then calcium hypochlorite should be tried. If calcium hypochlorite is successful, the dosage can be converted to a dosage for chlorine gas or chlorine dioxide for remediation.

After completion of the oxidation testing, sludge dewatering will require further evaluation. Design parameters for a belt filter press should be determined by a vendor conducting tests in the Pittsburgh laboratory. Concurrently, Larox should return to the laboratory to determine if pressure filtration is compatible with sludge from the belt filter press. Tests evaluating lime, cement, and flyash are still necessary to produce a filter cake at approximately 60 percent solids with the pressure filter. If these materials are still required, then factorial experiments should be conducted to evaluate the appropriate operating range for the successful formula used on the Larox pressure filter. Testing would then continue with a similar approach as described in the Treatability Study Work Plan for durability and LDR requirements.

At the conclusion of the dewatering tests, factorial experiments should begin on the cement formulation. If pressure filtration is not a viable option, cement formation testing should begin at the percent solids obtained by the belt press and should follow Phase I as described in the existing work plan (HALLIBURTON NUS, 1991). The initial center point of the factorial experiment should begin with the formulation developed for the pressure filtration tests. Testing would continue as described in the work plan. It is believed that a successful formulation will be developed quickly based successful results from the TCLP data from the pressure filtration filter cake.

Testing for the clarifier and 207 C will be conducted in a similar fashion as described in the work plan. Input from work conducted at the HALLIBURTON Services Laboratory in Duncan, Oklahoma, may result in some modifications to the scope and possibly reduce requirements for the testing in Pittsburgh, Pennsylvania.

APPENDIX A

LABORATORY NOTES

Pond 207B - center processing: 10/8/91 ____/TFS

initial volumes: 10 gal sludge (composite)
10 gal pond water from NE, NW, SE & SW quadrants
(40 gal total)

1) initially 2 gal of the sludge composite was taken and put into 1 gal containers to be used for the pressure filtration test at a later date.
pond sludge - 8 gal of sludge was sieved through:
   1) 10 mesh
   2) 60 mesh
   3) 100 mesh
   4) 150 mesh
Approx. 5 gal of the -150 mesh material was then passed through a 325 mesh sieve.

2) ~~obser~~ observations:
+10 mesh material seemed to be nominal for 8 gal of sludge. This material consisted mainly of asphalt/tar chips that can be attributed to the breaking up of the pond liner. Approximately 7 gal of composited pond water was utilized for sieving the raw sludge material through the 10 mesh sieve.

+60 mesh material contained gritty sand residuals
+100 mesh material contained fine sand residuals
& +325 mesh material was grey/green in color and is described as slimy slit like residuals.

Pond 207B - south 10/9/91 ____

1) 2 gal of the sludge composite was put into 2 - 1 gal containers to be used for pressure filtration test.

[signature] 10/14/91

(cont. from 19')

initial vol were: 10 gal (composited) sludge
10 gal pondwater from NE, NW, SE & SW
quadrants (40 gal total)

The remaining 8 gal of sludge was passed through a 10 mesh sieve. Again particles >10 mesh were nominal. No pondwater was needed.

+40 mesh material is described as gritty sand residuals
+100 mesh material was fine sand residuals
And +325 mesh material was a deep olive green (algae?) silty material

Pond 207-A 10/9/91 TCS

1) 2 gal of the sludge composite was taken for pressure filtration test and placed in 2 - 1 gal containers

initial volumes were: 10 gal (composited) sludge
10 gal pondwater from NE, NW, SE & SW quadrants (40 gal total)

the remaining 8 gal of composited sludge was passed through a 10 mesh sieve. +10 mesh particle were mainly small rocks and were nominal mass. Upon opening of the composited sludge material expelled gas from the sludge was noted. No pondwater was added.

+40 mesh material to +325 mesh material ~~consist~~ consisted of sandy material decreasing in size proportional to the increase in # mesh of the sieve. This material was a brownish/muddish color.

[signature] 10/14/91

Pond 207B-North

10/10/91 MJJ/TS
MS/~~[illegible]~~

Initial volumes were: 10 gal (composited) sludge
10 gal pondwater from NE, NW, SE & SW quadrants (40 gal total)

2 gal of the composited sludge was ~~a~~ taken for pressure filtration test to be completed at a later date.

The remaining 8 gal was ~~[illegible]~~ passed through a 10 mesh sieve. +10 mesh material mainly consisted of grass, Although substantial in volume the material was of nominal mass for 8 gal of sludge.

+40 mesh material to +325 mesh material consisted of sandy material decreasing in size proportional to the increasing mesh # of the sieve. This material ~~consisted~~ was a brownish/mud color. Approx. 1 1/2 gal of pondwater was added to complete the sieving.

[signature]

10/14/91

10-9-91 NJS

BALANCE CALIBRATION

MASS DETERMINATION:

ERLEMEYER
NJS ~~[illegible]~~ (125 ml - ER-6)

(1) - ALIQUOT FILTERED w/ 0.40 µm FILTER

143.6185 ± 0.0001 gm	FLASK + ~75 ml	207 BCENTER <325 mesh
74.2877 ± 0.0001 gm	FLASK	
69.3308 ± 0.0002 gm	ALIQUOT	

FILTERED w/
(2) - 40 WHATMAN

ERL. 125 ml - 4

146.0772 ± 0.0001 gm
74.6635 ± 0.0001 gm
71.4137 ± 0.0002 gm

FILTER MASS NJS ~~DUGG~~ (SEE * D36607 - Mettler)

(1)

		FILTER + ~~FILTRATE~~ CAKE
0.0153	± 0.0001 gm	FILTER (.40 µm NUCLEPORE POLYCARBONATE)
	± 0.0002 gm	FILTERED CAKE (WET)

(2)

	± 0.0001 gm	FILTER + CAKE
0.2219	± 0.0001 gm	FILTER (40 WHATMAN)
	± 0.0002 gm	FILTERED CAKE

(3) - FILTER w/ WHATMAN 40 and BUCHNER FUNNEL

FLASK: (#2)

117.6588 ± 0.0001 gm	FLASK + ALIQUOT
71.8552 ± 0.0001 gm	FLASK
45.8036 ± 0.0002 gm	ALIQUOT

0.5270 ± 0.0001 gm FILTER

1.1 % solids

% solids calc's

Pond: 207 A -325 mesh slurry

beginning:

Flask wt.	486.64g
filter paper wt.	0.3336g
beaker wt.	29.8057g
Grad cylinder wt.	94.39g

after filtration.

529.22g ~~560.22g~~ ~~555.72g~~ ~~531.32g~~ ~~524.22g~~

+ filter paper 32.1878g   4.10% solids

145.27g [illegible]

% solids procedure:

1) A 50ml homogeneous aliquot was taken from the -325 mesh slurry.

2) The aliquot was filtered in a bukner funnel with watman 40 filter paper.

3) The residual filter cake and filter paper were placed in a 110°C oven until dry.

4) % solids can then be calculated by:

$$\frac{(\text{dried filter paper + cake wt.}) - (\text{beginning filter paper wt.})}{50\text{ml slurry}} \times 100\% = \%\text{ solids}$$

~~The~~ this procedure was utilized for ponds 207A, 207B-south/north & center. (see pages 7-13)

[signature]

10/10/91

% solids cont.

pond: 207B-centre — 325 mesh Slurry

	beginning:	after filtration:	
Flask wt.	513.51g	555.73g	
filter paper wt.	0.3459g		
beaker wt.	67.7268g	+ filter paper 68.7372g	1.34 % solids
Grad cylinder wt.	94.03g	144.02g	

10/4 lab Results = 1.3% solids

Thomas L. [illegible]

10/10/91

% Solids cont.

Pond 207B-south – 3x5 mesh slurry

beginning:		After filtration:	
Flask wt.	513.67	~~554.89~~ 549.89g	
filter paper wt.	0.3439g		
beaker wt.	97.0372	+ filter paper 100.3536g	5.95% solids
Grad cylinder wt.	94.11g	144.71	

÷ + 4 l pond water

1/4 lab result = 2.8% solids

Thomas [illegible]

10/10/91

% Solids (cont.)

Pond: 207B-north -325 mesh

beginning:		after filtration:	
Flask wt.	487.07g	~~503.84~~ 498.84g	
Filter paper wt.	~~0.3450~~ 0.3395g	33.0816g ← filter paper	5.275% solids
beaker wt.	30.1044g	~~33.1345~~g	~~5.38% solids~~
Grad Cylinder wt.	94.95g	145.58	

+ 1.5l of pond water

lab Results = 4.5% solids.

Thomas L [illegible]

10/10/91

Observations of ~500 ml aliquots of −325 mesh solids - pulled for solids analysis of feed used for polymer testing. Samples pulled 10-10-~~91~~ (PM) and allowed to settle overnight. Settling observations 10-11-91 (7:40 AM):

Photo 1 - of 4 sample jars of solids 7:45 AM		Settled Solids	Supernatant	Total Height
	207B North	2 1/8"	3"	5 1/2"
	207B South	6 13/16"	5/16"	7 1/8"
	207B Central	3 7/8"	3 1/4"	7 1/8"
	207A	2 3/4"	4 3/8"	7 1/8"

Visual Observations

207B North - sludge fine-grained, medium brown - good settling, some matter entrained in top layers of sludge
supernatant brown, cloudy

207B South - sludge dark blue-green, shows virtually no settling
Supernatant dark, bright blue-green (dye)

207B Central - sludge settled to ~50% of original volume. Thicker graded floc; more visible water in top sludge layers than B-north sludge
Supernatant very dark turquoise (opaque) - too dark to see suspended solids

207A - sludge settled to ~40% of original height. Light brown, coarser flocs than 207B-N, similar to 207B-C
Supernatant cloudy brown, somewhat ~~brighter~~ lighter color in top inch.
Gas bubbles adhering to side of bottle

10-11-91

Flocculation Testing
R. Nikestael
T. Snare
M. Sparanza
} Halliburton NUS

Greg Gailey - Betz

Equipment - Gang Stirrer - A&F Machine Products Co.
~ 400 ml waste (-325 mesh solids @ 3.5% solids) ← see previous data
rapid mix ~~64~~ 74 rpm
slow mix - 40 rpm

207B - Center

Run 1 (anionic vs cationic)

3315 - anionic, 0.1% - 1 ml - no affect after 1 min rapid, 2 min slow mixing
+4 ml - slight floc formation
+5 ml - no change - not effective
(left)

3325 - anionic, 0.1% - 1 ml - no affect after 1 min rapid 2 min slow mixing
+4 ml - slight floc formation
+5 ml - no change - not effective
(left cent)

3360 - cationic, 0.1% - 1 ml - no affect after 1 min rapid, 2 min slow mixing
+4 ml - floc size increased slightly
+10 ml - floc size not appreciably bigger
(rt cen)

second beaker
10 ml - small floc after 1 min. rapid, 2 min. slow mixing
this dosage seemed to be the best
(rt)

Pictures 2&3
Beakers w/ polymer & before ___ added to center beaker

Run 2 (cationic vs cationic)

3354 - Cationic, 0.1% - 10 ml - marginal floc - not as good as 3360
+5 ml - better at this dosage, but not as good as 3398

3398 - Cationic, 0.1% - 10 ml - marginal floc - not as good as 3360
+5 ml - better at this dosage - small/medium floc
seems comparable to 3360

[signature]

10-11-91

207 B - Center [Continued]

Run 3

3360 vs. 3398

3360 - Cationic, 0.1% - 10 ml - ~~comparable~~ RMM good floc — Rt beaker

Pictures 4 & 5

3398 - Cationic, 0.1% - 15 ml - good floc - slight scum on top of supernatant — Lt beaker
~~vague~~ RMM

both produced comparable settling characteristics, consistency of floc - Supernatant ~~good~~ RMM too opaque to judge suspended solids loading.
* 3360 selected as polymer of choice because of lower dosage required.

207 B - South

- note: no settling by gravity noted previously on centric sample

Run 1

See p. 25

3375 - Cationic, 1.0% - 1 ml no floc
+1 ml no floc

3398 - Cationic, 0.1% - 10 ml no floc
+10 ml no floc
+2 ml @ 1.0% no floc

3360 - Cationic, 0.1% - 10 ml no floc
+10 ml no floc

Decision to move on to other ponds since this isn't responding. Will deal with this last. Overdosed with 3398 (dosage unknown) → produced floc - will go back and optimize

Richard [signature]

10-11-91

207 A

- sludge appeared to froth (possibly evolving gas) when mixed prior to putting in beakers

Run 1

3398 - cationic, 0.1% - some small floc after extremely large dosages
fairly good settling to ~50% volume
yellow cloudy supernatant

3315 - anionic, 0.1% - some small floc, but minimal settling compared to 3398 and 3360

→ 3360 - anionic, 0.1% - equiv. of 30 ml added to 400 ml
fine floc, - seemed to settle faster than 3398 to ~50% volume
greenish-yellow, cloudy supernatant

3325 - anionic
} didn't work
3575 - cationic

Based on these runs, 3360 appears ~~best~~ better than 3398 based on ① reasonable dosage (vs. 3398) and more rapid settling. But, not great performance (cloudy supernatant)

Pictures 6&7
3398 - L
3360 - LC
3360 - RC
untreated - R

→ tried 3392 cat, 1.0% - 10 ml - small floc, not great performance
~~hardly any settling~~, moderate settling, yellow-brown supernatant but no turbidity evident

" " - 15 ml - small floc, still moderate settling, yellow supernatant but no turbidity evident

* comparison of 3392 & 3360 - better settling, less turbid supernatant (~500 ppm)
can improve settling rate by increasing dosage to 20-25 ml of 1.0% 3392

Pictures 10&11 →

[signature]

10-11-91

207 B - North

Run 1

3360 - cationic, 0.1% - 15 ml added - good floc characteristics
cloudy, yellow-brown supernatant
30 ml total - overfed

3360 (cationic) 0.1% - 30 ml
+
3325 (anionic) 0.1% - 5 ml - anionic tended to neutralize the ~~excess~~ overfeed of cationic

3398 cationic, 0.1% ~ 50 ml - good floc at this high dosage

* 3392 - cationic, 1% - 5 ml - good floc
rapid settling
almost clear supernatant (light yellow color)

3392 - cat, 1% - 2.5 ml - (half dosage from above)
flocs didn't form - not enough polymer

Pictures 8 & 9

+ 5 ml 0.1% 3325 anionic - didn't help any

** cutting dosage to 4 ml of 1% 3392 also worked as well - same results

Pictures
12 & 13 - > 10 mesh solids from all ponds

Richard [signature]

10-11-91

207 B - South

3392 - cationic, 1.0% - 25 ml added - no affect
40 ml " - no affect

further testing required

207 B - Center

additional testing to see if 3392 works

3392 - cationic, 1.0% - 30 ml added - no affect

Richard [signature]

10-11-91

(1) MJJ processed approx 5gal to -325 mesh. This was 10/14/k needed for Bulk settling Rate test and additional polymer tests.

(2) TIS - I added 30g of Calcium Hypochlorite (65% active Cl) to ~1100 ml of -325 mesh material @ 3-5% solids of ponds 207A and 207B-South

A ~~notict~~ noticeable color change from green to brown occurred ~1 min after Cl addition to 207B-South

207A exhibited no ~~notict~~ noticeable changes

both ponds formed after stirring for approx. 5 min to dissolve the Cl agent

(3) 3 aliquots of 100ml were taken from each of the ponds these were -325 mesh material @ 3-5% solids.
1 - untreated as a control } @ ambient
1 - chlorinated }
1 - untreated placed in a ~10°C fridge
these were left to sit over night.

T. [signature]

10/15/91

10/15/91

(1) observations:

Both chlorinated ponds contained in beakers were left w/parafilm capped overnight.

207A: ~200ml settled solids
~200ml floating solids
contained bubbles
cloudy supernatant

207B: ~200ml settled solids
~350ml floating solids
– very clear supernatant

observations on 100 ml aliquots:

207A: chlorinated – pressure generated – gas evolved
untreated – leaked – dark supernatant
refridgerated – no gas evolved

207B – south:
chlorinated – floating solids > settled
clear supernatant
expanded bottle + gas evolved (Cl^- odor)
untreated: settled ~ very little
no gas evolved
leaked
refridgerated: no gas evolved
no leaking

Thomas L. [signature]

10/15/91

Polymer Test on Chlorinated Pond Sludge

Pond 207A: added 1.5 ml of 1% solution of 60 (1160 or 3360?) to 200 ml of chlorinated sludge.

added 1.5 ml of 1% solution to non-chlorinated sludge

Both sludges settled similarly however the supernatent for the chlorinated sample was clear compared to the other sample which was very cloudy

→ Recommend Chlorinated sample ←

Pond 207B South: Polymer 1192

add 20 ml of 1% solution to 200 ml of chlorinated sludge

- No reaction

added 20 ml more

- No reaction

[illegible signature] 10/15/91

207B South : Polymer 60 1% solution

add 1 ml to 200 ml of chlorinated sludge

- flocs formed

add 2 ml to 200 ml of chlorinated sludge

- bigger flocs formed

☆ add 1.5 ml to 200 ml of chlorinated sludge

- not much different from 2 ml

→ Recommend use 1.5 ml dosage

207B Center : pH could not be read because of dye pond

added 5 grams of 65% calcium hypochlorite

207B South : PH ≅ 7.

added 5 grams of 65% calcium hypochlorite

Mark Speranza 10/15/91

Pond 207B center! add .5 ml of a 1% solution of 60 to 200 ml of chlorinated sludge

- formed Floc but did not settle well due to foam from mixing after approx. 15 min. all material floated. after shaking all material sank

~~60 Polymer at 1%
add 2ml to 200 ml of chlorinated sludge~~

~~worked excellent!~~

MPS 10/15/91

added 2 ml of 60 polymer @ 1% to 200 ml of chlorinated sludge

- formed large floc, all settled - after 1/2 hr some floating

☆ added 1 ml of 60 polymer @ 1% to 200 ml of clorinated sludge

- Formed floc and settled

Mark P Speranza 10/15/91

207B North → Added 2ml of 3392 polymer @ 1% to chlorinated sludge (200 ml)

Very little floc formation

Added 2 more ml to sludge

Floc formation was better

☆ 2ml added of 60 Polymer @ 1% solution to 200 ml of chlorinated sludge.

worked excellant

added 2 ml of 60 polymer @ 1% to nonchlorinated sludge.

seemed to work equally well as what worked on chlorinated sludge.

added 2ml of 1192 polymer @ 1% to non-chlorinated sludge

clearer supernatant, but smaller flocs

Mark A perarp 10/15/91

207B Center — added .5 ml of 60 polymer to 200 ml of non-chlorinated sludge.

- very little floc formation

added .5 ml more of polymer

- does not work as well as chlorinated sample

Recommend using chlorinated sludge.

Matt P Speranza

10/15/91

Composite of 207B series pond
200 ml 207B N
200 ml 207B C
200 ml 207B S

add 5 grams of 65% calcium hypochlorite

☆ add 1 ml of 60 polymer @ 1%
to 200 ml of chlorinated sludge

* may need to evaluate defoamer *

formed floc, but because of mixing
there was some floating material

Matt Speranza 10/15/94

Chlorine solution : 200 ml of DI
25 gr of 65% calcium hypochlorite

Chlorination Tests

Pond 207B-South

Test 1 — 80 ml hypochlorite solution added to 400 ml sludge (raw)
10:14:30 mixed for 15 min.
foaming during mixing — color changed to tan/green
Standard plate count (SPC) = 6 colonies/ml
Residual Cl = 10 mg/l

~~Test~~
* Test 2 — 50 ml hypochlorite solution added to 400 ml sludge (raw)
mixed for 15 min.
very little foaming during mixing — color changed to tan/green
SPC = 3 colonies/ml
residual Cl = 14 mg/l

Test 3 — 25 ml hypochlorite solution added to 400 ml sludge (raw)
mixed for 15 min.
no foaming — color still green
SPC = ~~40~~ 61 colonies/ml
Residual Cl = 344 mg/l

All Samples — % solids on raw feed
— Bacti Count on treated (Standard Plate Count)
— Cl_2 residual on treated

[illegible] ⇒ 160 colonies/ml @ 6.3% solids

Richard [illegible]

10-16-91

Pond 207B Central : (As recieved sludge)

SPC = 2 [illegible] — Added 80 ml of Cl solution to 400 ml of pond sludge - mixed for 15 min

Residual = 12 [illegible] — Lots of foam - turned brown from green

SPC = 1 [illegible] — Added 50 ml of Cl solution to

Residual = 12 [illegible] — 400 ml of pond sludge

Lots of foam - turned brown from green

* Added 25 ml of Cl solution to

SPC = 15 [illegible] — 400 ml of pond sludge

Residual = 22 [illegible] — little foam - turned brown from green

samples : Percent solids before chlorination

sampled residual Cl^- and plate counts for all 3 runs

Untreated sample ⇒ SPC = 440 colonies/ml @ 4.1 % solids

Mark Speranza

10/16/9[illegible]

Chlorine solution: 50 gr of 65% calcium hypochlorite in 400 ml of DI water

Pond 207A

1. Mixed 80 ml in 400 ml of Pond 207A Sludge. Turned from Brown/green to gray/brown – lots of foaming
   SPC = 4 colonies/ml
   Residual Cl = 27 mg/l

2. Mixed 50 ml in 400 ml of Pond 207A Sludge. Turned from brown/green to gray/brown – ~~Some~~ lots of foaming
   SPC = 91 colonies/ml
   Residual Cl = 22 mg/l

3. Mixed 25 ml in 400 ml of Pond 207A sludge: Some foam – tan color
   SPC = 19 colonies/ml
   Residual Cl = 32 mg/l

Tests: Initial (untreated) % solids = 8.5%, Initial Plate count = 2000

Tested each sludge after 15 min of mixing for Plate count and residual chlorine

Mark Speranza

10/17/91

Composite 207B N, 207B C, 207B S
1000 ml of each pond sludge

① Mixed 80 ml of Cl solution to 400 ml of sludge
Turned from green to Brown
SPC = 4 colonies/ml
Residual Cl = 1800 mg/l

② Mixed 50 ml of Cl solution to 400 ml of sludge
SPC = 21 colonies/ml
Residual Cl = 1100 mg/l

③ Mixed 25 ml of Cl solution to 400 ml of sludge
No foam SPC = 2 colonies/ml
Residual Cl = 800 mg/l

Tests: (untreated) initial % solids ≈ 8.5%, Plate count = 1800 colonies/ml (CSH)
after 15 min. of mixing tested for plate count and residual Cl

Matt Sprenger 10/17/91

Pond 207B North

1. Mixed 80 ml of Chlorine solution with 400 ml of Pond sludge
   SPC = 3 [illegible]/ml
   Residual Cl = 2000 mg/l

2. Mixed 50 ml of chlorine solution with 400 ml of sludge
   Some foam - not much change in color
   SPC 2 colonies/ml
   Residual Cl = 34 mg/l

3. Mixed 25 ml of chlorine solution with 400 ml of pond sludge
   no [redacted] foam - little change in color
   SPC = 3 colonies/ml
   Residual Cl = 4900 mg/l

Test: Inital (untreated) percent solids (=14.9%), Plate count (2000 [illegible])

After 15 min. of mixing tested for plate count and residual Cl

Matt Speranza   10/17/91

Chlorination of 207B North for pretreatment.

material > 325 mesh was chlorinated with 225 ml of 25gr/200 ml solution of 65% calcium hypochlorite to 1800 ml of sludge

Material < 325 mesh ~~(1265~~ 10.1 liters of sludge → added 1265 ml of solution

Pond 207B Center:

Added 965 ml of chlorine solution to 7.8 l of < 325 mesh sludge

Added chlorine to Ponds 207B South, and 207B North

Mark P Speranza 10/18/91

Made a 1% solution of Polymer Betz 1160. This will be added to the less than 325 mesh material for all of the Ponds prior to recombining with greater than 325 mesh material.

Pond 207B south: Total volume = 11.58 l
will add ~~58~~ 116 ml of polymer

Pond 207B North: Total volume = 15.75 l
will add ~~78.75~~ 158 ml of polymer
added ~~150~~ ml of polymer above dosage to get floc.

Pond 207B Center: Total volume 11.1 l
will add 111 ml of polymer

Pond 207A: Total volume = 9.3 l
will add 93 ml of polymer
added 100 ml more polymer

Mark P [signature] 10/21/91

Decanted water off of settled solids after approx. 3 to 4 hours.

Pond 207B North : Combined 2200 ml of +325 mesh with 625 ml of -325 mesh

Pond 207B center : Combined 3400 ml of +325 mesh with 965 ml of -325 mesh

Pond 207B south : Combined 2350 ml of +325 mesh with 665 ml of -325 mesh

Pond 207A : Combined 3700 ml of +325 mesh with 1050 ml of -325 mesh

---

[illegible signature]

10/7/91

% solids calc's on +/- 325 mesh sludge slurry

207B-North

+325 mesh 2200 ml

beaker wt.	30.1071 g	
sludge wt. (wet)	10.0128 g	34.8%
sludge wt (dry)	3.4833	

−325 mesh 625 ml

beaker wt.	49.9N4 g	
sludge wt. (wet)	10.6126 g	21.1%
sludge wt. (dry)	2.2349	

combined % solids. $\frac{(2200)(34.8) + 625(21.1)}{2825} = 31.8\%$

207B-South

+325 mesh 2350 ml

beaker wt.	67.7211 g	
sludge wt. (wet)	10.4060 g	43.87%
sludge wt (dry)	4.5658 g	

−325 mesh 625 ml

beaker wt	79.9115 g	
sludge wt. (wet)	11.0315 g	9.8%
sludge wt. (dry)	1.0831 g	

combined % solids: $\frac{2350(43.87) + 625(9.8)}{2975} = 36.7\%$

[signature]

10/21/91

% solids (cont.)

207 B - Center

+ 325 mesh — 3400 ml

beaker wt.	27.7905 g	
sludge wt. (wet)	10.5016 g	12.0%
sludge wt. (dry)	1.2603 g	

− 325 mesh — 965 ml

beaker wt.	72.8072 g	
sludge wt. (wet)	10.6096 g	14.7%
sludge wt. (dry)	1.5567	

combined % solids: $\frac{(3400)(12.0) + (965)(14.7)}{4365} = 12.6\%$

207 A

+ 325 mesh — 3700 ml

beaker wt.	66.7035 g	
sludge wt. (wet)	10.2208 g	45.2%
sludge wt. (dry)	4.6242	

− 325 mesh — 1050 ml

beaker wt.	66.6247 g	
sludge wt. (wet)	11.8618 g	
sludge wt. (dry)	1.2069 g	10.2%

combined % solids: $\frac{(3700)(45.2) + (1050)(10.2)}{4750} = 35.4\%$

[signature]

10/24/91

Denver Equipment Co. Piston Press Dewatering Tests

Ninestiel } HNUS
Sivire
Sp-mini

Karen Torbert - Brown & Root

Tom Saunders - Denver

Filter Cloth was 4 CFM permeability

207A ~550 ml added to press

Test # 1 Press was increased to 1500 PSI

after 17 min 18 ml of filtrate was produced. Pressure was increased to 2000 PSI

@ 20 min. 22 ml was produced
- Test was aborted due to poor filtration. likely because of fine particles and gel like qualitity.

- Press was taken apart - material directly next to the filter was dewatered well - approx 1/8" the remaining material was unchanged.

Final reading after 25 min. was 31 ml.

- Removed approximately 50 to 100 ml of sludge to redo test with Watman 41 filter paper
- Supernatant yellowish color

[signature] 10/22/91

Test # 2 Redo test to determine if a larger diameter filter paper will improve filterability.

Pressure = 1500 psi

Min	Volume
2	15 ml
3	17 ml
5	20 ml
8	24 ml
11	28 ml
13	30 ml
15	32

@ 16 min. increased pressure to 2000 psi

16	32
17	34
18	34

ended test — did not work much better than first test
1/8" was dewatered by filter — the rest of the sample was unchanged.

Test #3

we have 275 ml of 207A sludge
add 20% by dry weight of fly ash (western ash Company)
flyash added = 19.25 grams

Started @ 2000 psi reduced to 1500 psi

Matt Sprenger

Time (min)	Vol (ml)
1	12
2	16
3	18
4	20
5	23
6	25
7	27
8	30

Did not work -

amount of sludge next to filter that was dewatered was very ~~...~~ small approx. 1 cm

Test #4

Added 30 ml of 1% 3360 polymer to 500 ml of sludge

Test done @ 1500 psi

Time	Vol. (ml)
1	14
4	17
7.30	20
12.30	24
15	24

No cake was formed

[signature]

Pond 207B North : 450 ml of sludge

1500 psi

min	vol.
10	5
30	26
60	34
2	50
3	52
4	59
5	66
6	72
8	82
9	86
10	90
15	108
18.3	118
20	122
25	136
↓	
150	260

Still some water present in top of filter – compressed from 2 3/8" to 3/4"

Mark D'Jpernnyh

207.3 South : 400 ml of Sludge
@ 1500 psi

Time	Vol
0	20
1	25
4	32
7	36
30	55
45	63
50	66
60	70
~15 hrs 8:15 AM 10/23/91	121 ml

(10/22/91 ↑ / ↓ 10/23/91)

0 psi residual pressure

Pressure left on overnight and allowed to gradually ~~relieve~~ reduce to 0. Cake thickness ~ 3/16". Still residual sludge in piston not dewatered. Released OK. However, test deemed unsuccessful because not all sludge was dewatered, and what was dewatered took too much time

Pond 207 B Center :

Sonication Test – 75 ml in beaker, placed in water bath in sonication cleaner. Tested for 3 minutes. No noticeable results.
Start 9:39 – 9:42 9:43 Turned back on till 9:56 [model EM/C Corp BP-1 cleaner]
Still no water layer, but sludge appears to be degassing.

Centrifuge Test – 37 ~~25~~ ml – tested 5 min. @ 3000 rpm 4½ ml liquid, ~13 ml fine ~~intermediate~~ layer of sludge, ~ 2 ml of coarse sludge
~ 10.5 ml of air/gas expelled during test

Richard [signature]

10/23/91

Sonication Test - Continued

Sample from sonicator test taken to higher energy sonicator.
Tested for 6 min. - no apparent effect

Diluted to 200 ml with DI water. Pressed on Denver Piston Press at 1500 psi

207B - Center - Flocculation
400 ml sludge - added 100 ml of 0.1% 3360 polymer
Final volume ~ 430 ml (~70 ml gas lost during floc mixing?)

200 ml aliquot to Buchner Funnel Test
200 ml aliquot to Denver Equipment

Buchner Funnel Test

12:33 → 2:50

Sludge Cake Sample
Sample A

@ ___ psi vacuum using Whatman 41 paper
cake removed after lunch break - no free water drops.
all free water pulled through cake
~ 1/4" cake thickness - sample retained for % Solids analysis

Denver Equipment Test

All sludge dewatered - ~150 ml filtrate
~50 ml cake

Sludge Cake Sample B

bottom 3/16" good cake, top 1/4" looser cake

Richard [signature]

10/23/91

207B Center

Dilution of Sludge Test

207B Center

100 ml sludge + 100 ml DI water → add floc - 4 ml of 1% Betz 3360. Good Large floc! ~~, the~~

Buchner Funnel Test
- Slow dewatering — test aborted after 33 min. - still sucking cake

* Much bigger, better floc at 1:1 water dilution, But still doesn't dewater any quicker.

Addition of Lime, ~~Dilut~~ Polymer Addition, Dilution

200 ml sludge - 207 B Center
added 5 ml $Ca(OH)_2$ - pH to 9.5 approx.
added 7 ml of 1% Betz 3360 - ~~nic~~ very fine pin floc
final volume ~170 ml (loss of gases?)

diluted with ~150 ml of D.I.

Buchner Funnel - aborted after 5 min. of sucking, since it had all pulled all free water through

Possible slight improvement (with lime) [qualitative appraisal based of speed of filtration over first 5-10 minutes] over previous run.

Richard [signature]

10/23/91

Addition of Lime / Cement

100 ml 2073 centr + 100 ml DI = 200 ml
added 5 ml lime as $Ca(OH)_2$
added 20 ml Type II Portland cement − pH ~ 11

final volume ~200 ml after mixing

Buchner Funnel − pulled cake in ~4* minutes

* First good results in Buchner funnel − sample collected for % solids

Sample C
50.8%

▽

Addition of Cement after Dilution

100 ml 2073 centr + 100 ml DI = 200 ml
added 20 ml Type II Portland cement − pH ~ 10 ~~~ 4 min~~

final volume ~ 200 ml

5:13 Buchner Funnel − pulled cake in ~15 − no cake sample for % solids

Addition of Cement − No Dilution

Buchner funnel − 200 ml 2073-centr + ~~20~~ 40 ml (+10 ml lime) Cement − Type II ~ 9 min to get dry cake
sample taken for % solids [Sample D] = 50.8%

Pressure filter test − 1½ min w/ ~~5/16~~ 5/32" cake of 100 ml 2073 centr + 5 g lime ($Ca(OH)_2$) + 20 g cement Type II
Sample taken − [Sample E] = 76.4%
wet wt = 39.7305 gr

same filtering time on a solids basis as test at top of page

Richard [signature]

10/23/91

LAROX

Test # 1 Pond 207B ~~Center~~ South

Added approx. 150 ml of sludge

Press is at approx 195 psi
Filter cloth is 4.6 CFM air percability

Filtrate is very slow with a green color

Press was stoped after 20 min.

20 ml of Filtrate was collected

approximately 1/16" of material dewatered

Material blinded -

Test # 2 Pond 207B South

150 ml sludge, 7.5 ml of lime (PH = 7)
30 ml of Type II cement

added lime and mixed for 5 min. (PH ≅ 11)
added cement and mixed for 5 min. (PH ≅ 12)

wet wt = 58.1

Sample put in press ≈ 135
loss sample due to gas loss ?

much better filtration - Filtration run = 5 min.
Total filtrate = 100 ml (green)
Cake was approx 1/2" from 2½ to 3"
cake was broken
[Larox Cake Sample 1]

(Picture 2A + 2B of cake)

[signature]

10/24/91

Buchner funnel test

Test # 1 - 100 ml of sludge diluted with 100 ml of dI water & add 20 ml of diatomacious earth (celite)

2078 south

9:24 Start End 9:42

Failure - poor filtration

Test # 2 - 100 ml of sludge with 100 ml of DI water

2078 south

5 ml of lime (mixed 5 min)
25 ml of flyash (mixed 5 min)
after 4 min good cake

pH ≅ 12

Filter Cake Sample Larox #4
62.9 % solids wet wt = 61.96 g

Test # 3

add 13.5 ml of cement to mixture of flyash lime from Labrox test # 6, then added 100 ml of DI water

~~increase~~ after 2:50 dry cake

LAROX # 7 % Solids = 64.4
wet wt = 72.17 gr

[signature]

10/24/91

Test # 3 Pond 207B South

450 ml sludge, 22.5 ml of lime and 90 ml of Type II cement

After 5 min mixing (pH ≈ 12) added cement mixed for 5 min.

@ 195 PSI
a) added 150 ml to press (50 sec run)
b) added ≈ 50 to 75 ml to press (5 min run after addition)

Take Percent solids (LAROX Cake Sample # 2)
wet wt = 90.49 gr @ 59.[illegible] solids

Top of Cake was a little wet (1" wide) and stuck to top of press

Picture # 22 of the cake

Filtrate volume = 125 ml

Test # 4 Pond 207B South

Material added to press after 25 min since cement addition.

@ 78 PSI a) added 150 ml to press (52 sec)
@ 78 PSI b) added approx 50 to 75 ml (170 sec)
@ 195 PSI c) added approx 50 to 75 ml (6 min)

Cake thickness = 1 1/8"
Filtrate vol = 150 ml
Larox # 3 % solids = 62.1% solids
wet weight = 112.63 g

Mark P Speranza

10/24/91

Test # 5 207B South

450 ml sludge
22.5 ml of lime (mixed 5 min)
113 ml of Flyash (mixed 5 min)

pH = 12

195 PSI a) 150 ml 4 min press
1 min air

cake was somewhat wet

Picture # 23 of cake

Filtrate volume = 75 ml

Filtrate thickness 3/4"

LAROX # 5 % solids = 57.0
Wet Wt = ~~[illegible]~~g 74.05 g

Test # 6 207B South
Lime / flyash in two cycles

78 PSI a) added 150 ml (50 sec)
195 PSI b) added 50 ml (6 min)

cake was still soupy - cake thickness = 1 1/8"

LAROX # 6 % solids = 64.7
Wet Wt = 102.87 g

Mark P Esperanza 10/24/91

Test # 7 207B South

~~400~~ 600 ml sludge
Lime = 30 ml
Flyash = 150 ml pH = 12
cement = 81 ml
mixed each for 5 min. (6 min. from cement)

78 PSI a) added 150 ml (50 sec)
195 PSI b) added 50 ml (6 min)

cake 1¼" (thickness) TCLP ?

Filtrate 120 ml volume

LAROX # 8 % solids = 76.7
wet wt = 113.7

Test # 8

same mixture as test # 7

78 psi a) added 150 ml (50 sec)
78 psi b) added 50 ml (1 min then increased to 195 psi for 4 min.
1 min air blow
cake was good broke towards top

LAROX # 9 % solids = 69.5%
wet wt = 134.07
Picture # 24 cake thickness 1¼"

Mark P Speranza 10/24/91

100 ml sludge

5 ml lime
25 ml flyash
16 ml cement

207B Center

Test # 9

pH = 12

600 ml of sludge
30 ml of lime
150 ml of flyash
81 ml of cement

mixed for 5 min each

78psi a) 150 ml (50 sec)
78psi b) 50 ml after 60 sec increased to 195 psi. for 4 min

cake thickness = 1 1/8"
filtrate vol. = 90 ml

cake looked good

Lorox ~~Test~~ # 10 % Solids = 70.8%

Wet Wt 115.44 gr.

TCLP

Mark P [illegible]

10/24/91

Test # 10

Same as # 9

except ~~[illegible]~~ pressure time at
195 psi is 3 min
Filtrate vol = 90 ml
cake thickness = 1 1/8" [illegible]
Larox # 11 % solids = 64.6

Test # 11

go to driest point

195 psi @ 150 ml for 5 min

filtrate Vol. = 80 ml
Cake thickness = 7/8"

Larox # 12 % solids = 76.0
wt wet weight = 93.84 g

Mark P. Esperanza 10/24/91

Test # 12 207A

pH = 8

600 ml sludge
30 ~~5~~ ml lime
22 ml fly ash
46 ml cement.

pH = 12

78 psi a) added 150 ml @ 50 sec
195 psi b) added 50 ml

Poor filtration — go back to orginal formula
400 ml of sludge high
add – 78 ml flyash
add – 8 ml cement

78 psi a) added 150 ml (50 sec)
b) added 50 ml 50 sec then (@ 78 psi) to 195 psi
for 6 min.

good cake

Filtrate volume = 100 ml
Cake thickness = 1¼"

~~Test~~ Larox # 13 % solids = 70.5%
TCLP
wet weight: 139.72g

MarkP Esperanza 10/24/91

Test # 13   207B North

600 ml sludge
30 ml of lime
150 ml of Flyash
81 ml of cement

mixed for 5 min each

pH = 11 or 12

78 psi a) 150 ml (50 sec)
b) 50 ml @ 78 psi for 50 sec
then at 195 psi for 6 min
1 min air blow
cake thickness - 1 1/4 +
filtrate Volume = 80 ml

good cake

Larox test # 13 % solids = 75.4%
wet weight = 143.5 g

10/24/91

Test # 14

2078 N
same as test #13

a) 150 ml @ 78 psi 50 sec
b) 50 ml @ 78 psi 50 sec
then 195 psi @ 6 min

3 min air blow

Filter cake thickness – 1¼"
Filtrate volume = 80 ml

Larox # 14 % solids = 74.4
wet weight = 147.82 g

Mark Pelperanga

10/24/91

Pond 207B North

Nonchlorinated

250 ml of -325 sludge with 750 ml of pondwater

~~Sample is pulling~~

	Cylinder vol.	Time	
Run #1	1000 to 600	2:04	
Run #2	1000 to 700	1.40	Run #4
Run #3	800	1:15	1:21
	700		
	600	1:57	2:10
	500		
	400	2:31	2:37

190 ml of sludge @ 3:30

very cloudy supernatent - sludge somewhat aggomerated

Added chlorine to sample

after about one hour sludge was floating after stirring the sludge it settled

Matt P Esperanza

10/25/91

7 day sample

1000 ml of chlorinated 207B North

Run #1

Vol	Time
800	2:00
600	3:41
400	7:06

very clear supernatent

Run #2

Vol	Time
800	1:53
600	3:29
400	6:20

Add Polymer

5 ml of 3360 to 1000 ml of chlorinated sludge — 207B North

Vol.	Time
800	28 sec
600	55 sec
400	1:29

Vol	Time
800	22 sec
600	42 sec
400	1:13

Clear supernatent, good Floc
Let material settle for 1/2 hr
then took % solids
BSR

[signature]

10/29/91

Pond 207B South

200 ml of sludge with 800 ml of pondwater

Material ~~&~~ is not settling

5 min to settle from 1000 to 900 cc

Will chlorinate sludge

Sludge turned brown from green when chlorine was added

~~Slg~~ Sludge floated after about 5 min.
lots of foam present

Run # 1 ~~after 5 min not settling~~
lots of foam.

Added 5 ml of polymer
all material ~~rs~~ floated

Run # 1

Vol	Time
200	40 sec
400	1:25
600	1:58
700	2:33

Material floated *

Mark P D [illegible]

Run # 2

Vol.	Time
300	1:44

Most of the material floated - 30 ml settled to bottom of graduate

supernatent was very cloudy - Flocs were in the liquid, got clear with time

Run # 3

floated = 50 ml
settled = 300 ml

less material floates every run

let material sit over night - most of material was settled -
mixed material for Run #4

Vol.	Time.
900	~~2:09~~ 2:07
800	4:08
700	6:00
600	8:28

Supernatent had pin flocs in it. Flocs that settled were smaller

Will do again See pg 115

Mark Speranza

10/29/91

Pond 207A Sludge

200 ml of sludge diluted with 800 ml of pond water

Run #1

Time	Vol.
1:46	800
2:49	600
3:27	400

Supernatant very turbid
50 ml of sludge @ bottom @ 4:00

Run # 2

Time	Vol.
1:48	800
2:37	600
3:37	400

Use sample that was chlorinated on 29th
200 ml mixed with 800 ml of pond water
chlorinated pond water

Run #1

Time	Vol.
1:21	800
2:09	600
2:47	400

35 - 40 ml of sludge after 4:00
~~Clear~~ supernatent was clear than nonchlorinated but still cloudy

Run #2

Time	Vol
1:47	800
2:31	600
3:19	400

Mark P-Speranza[illegible]

10/30/91

$\frac{4}{5}$ 800 = $\frac{3200}{5}$ 640

Added 3 ml of polymer (3360)
to chlorinated sludge

Good floc was formed

Run #1

Time	Vol
16	800
36	600
59	400

Supernatent was much clearer, flocs settled very quickly when put in graduated cylinder. The flocs were damaged in trying to mix the sludge — test was biased slow

---

added ~~100~~ 400 ml of sludge to 600 ml of pond water

added 3ml of polymer.

Placed material in graduated cylinder to settle for 1/2 hr for % solids and dry Bulk density

Mark P Speranza 10/30/91

Acc #
5903

Pond 207B Center

added 200 ml of nonchlorinated sludge to 800 ml of pondwater

Run # 1	Time	Vol
		800
		600
		400

Material does not appear to be settling after 3:00 min — difficult to see due to dye in water & sludge

---

200 ml of chlorinated sludge with 800 ml of pondwater

Run # 1	Time	Vol.
	5:29	800
	7:42	600
	10:26	400

Run # 2	Time	Vol
	4:22	800
	7:05	600
	9:17	400

Pin flocs present in the supernatent

Mark Speranza

10/30/91

Added 5 ml of polymer to 1000 ml of chlorinated sample

Run # 1

Time	Vol
:34	800
1:09	600
1:25	400

at 4:00 Sludge vol. = 210 ml

200 ml + 800 ml of water with 5ml of polyr

Run # 2

Time	Vol
:48	800
1:16	600
1:52	400

@ 4:00 min vol = 300 ml

---

after Run # 1 settled for ½ hour water was decanted for % solids and bulk density

Mark P Speranza

10/30/91

856-7700

20713 South

added 200 ml of sludge to 800 ml of water

added 3 ml of polymer

Run # 1

Time	Vol.
16	800
27	600
38	400

after 4 min of settling 200 ml of sludge

200 ml sludge + 800 ml of water + 3 ml of sludge

Run # 2

Time	Vol
	800
	600
	400

Material was well flocced but did not settle - with in ~~to~~ 4:00 min.

~~Let sludge sit for 1/2 hr then decanted. Sampled for % solid + Bulk density~~

Mark P Esperanza 10/30/91

207B South

200 ml of sludge 800 ml of water
5 ml of polymer

Most of the sludge floated (250 ml
@ 2:25. Some sludge settled (100 ml)

Poured material back in to beaker
then back in graduate — less material
~~f~~loated — most of the material did
neither. after 2:58

Mark P. DeSperanza

10/30/91

Composite of 207B Ponds

200 ml of Center, north & South sludge
= 600 ml composite
~~[illegible] ml~~
267 ml of center, north, & south water
+ 200 ml of sludge

Time	Vol
3:20	800
4:32	600
5:27	400

10:00 = 200 ml of sludge

Supernatent was blue/green but not Sludge

---

add 5 ml of polymer to nonchlorinated Sample

Time	Vol
16	800
21	600
28	400

Supernatent is blue/green

Mark P Speranza 10/30/91

Chlorinated composite
200 ml of sludge and 800 ml of pond water

Run #1

Time	Vol
2:35	800
3:49	600
5:10	400

after 10 min 280 ml of sludge

Run #2

Time	Vol
3:44	800
5:30	600
6:38	400

---

added 5 ml of ~~[illegible]~~ polymer to sample

Run #1

	Time	Vol
28	~~[illegible]~~	800
1:02	~~[illegible]~~	600
1:35		400

Supernatent clear but lots of floc in supernatent, some floc floated

after 4:00 min 170 ml vol.

Mark Esparanza

10/30/91

Run # 2 200 ml of sludge 800 ml of water and 5 ml of polymer

Time	Vol
43	200
1:14	400
1:44	600

sludge is floating

after 5 min ≈ 200 ml of sludge

Mark P. Esperanza

10/30/91

Mix Time Evaluation

- 600 ml of 207B South Sludge
- add 50 ml of Cl solution
  25 gr in 200 ml of DI water

~~Sample time~~

- added 2 ml of .1% polymer solution
- each sample is 10 ml

Time Sampled	Floated		Settled
initial (Before Cl^-)			X
2.5			X
5			X
7.5			X
10			X
15	X	~~neither~~	
20 A (			X
20 B (5x dilution)	X		
25 A		neither	
25 B (5x dilution)	X		X (50/50) some in middle of tube

Mark P Speranza

10/30/91

Duplicated Test at 5x dulition for BSR - added pond water then dry Cl -

Time	Float	Settle
0	X	X (50/50)
2.5	X	X (50/50)
5	~~(settle floated)~~	X
7.5		X
10	X (.25%)	X (.75%)
12.5	~~X (.25%)~~	~~X (...)~~
15	X (40%)	X (60%)

Bulk Settling Rate for 207B South

added 200 ml chlorinated sludge
" 730 ml of water
" 70 ml of chlorine solution

formed flocs immediatly some settled some floated

- settled very slowly with out polymer
- added 5 ml of 1% polymer

@4:00 min
Vol. = 190 ml

Time	Vol
:17	800
:32	600
:44	400

30 ml did not settle

(everything floated within 45 min)

Mark Esperanza

10/30/91

added Chlorine solution to 207B South water and formed flocs

pH went from 9 to 7 from Cl addition

added lime to pH = 11

formed flocs – yellow supernatent

≈ 100 ml of sludge after 10 min

207B South

90 ml of water pH = 8 or 9
10 ml of Cl solution pH = 7 to 8

formed sludge => pH = 7
very fluffy

Cloudy supernatent.

18 ml of sludge

Mark Sparanga 10/30/91

2073 South Sludge 350 ml (chlorinated)
added 10 ml of Ferrous Sulfate
200 ml sludge + 800 ml of water
added chlorine to oxidize water

created approx. 950 ml of sludge

Time	Vol
8	800
17	600
25	400

very clear supernatant
very fluffy flocs
not compacted

@ 4:00 sludge = 300 ml

Mark Speranza

10/30/91

Pond 207B South (BSR)

200 ml of sludge and 800 ml of ponduwater
5 ml of polymer material floated

250 ml after 5800 min

Time	Vol
200	.24
400	.51
600	1.43

Took sample after 30 min
140 ml of sludge

Mark P Esparanza 11/4/91

54

17.88

9.5%

A 2.4%

#5 B center 7.9%

B North

#6 5.4%

207 combine

#7

2500 - 15000

Shear Test – 207B South

Sheared sludge in a blender for 5 min. (200 ml combined sludge)

volume increased to 400 ml from air entrainment

51 25
35:25

filtration on a buchner funnel is very poor

After 16 min – 17.5 ml of filtrate was collected

Added 10 ml of polymer to 200 ml of sludge

58

placed on buchner funnel

After 16 min – 30.5 ml of filtrate collected

Pond 207B South – 325 mesh Sludge

23:40

Floced 400 ml of sludge w/10 ml of polymer – Sludge floated

placed in buchner funnel
After 16 min 50 ml of filtrate

Mark P[illegible]

11/4/91

Filtrate TCLP metals prep

Pond 207B-centre
200 ml sludge (combined)
+ 10 ml lime
+ 50 ml flyash
+ 34 ml cement type I-II (pH=12)

filter thru whatman 41 (did not filter well)
collected filtrate and filtered thru 0.45 um paper
take filtrate (thru 0.45) sample for TCLP metals

decon

207B-North
200 ml sludge (combined)
+ 10 ml lime
+ 50 ml flyash
+ 34 ml cement type I-II (pH=12)

filter thru whatman 41
collected filtrate and filtered thru 0.45 um paper
take filtrate (thru 0.45) sample for TCLP metals

decon

207A
200 ml sludge (combined)
+ 10 ml lime
+ 50 ml flyash
+ 34 ml cement type I-II (pH=12)

filter thru whatman 41
collected filtrate and filtered thru 0.45 um paper
take filtrated (thru 0.45) sample for TCLP metals

Thomas J [signature]

11/14/91

Pond 207B South

200 ml sludge combined
+ 10 ml lime
+ 50 ml flyash
+ 34 ml cement Type I-II

pH = 12

filter thru Whatman 41
collect filtrate and filter
thru .45 um, sample for TCLP

mark Speranza 11/4/91

Filtration Test (Buchner Funnel)

(1)
100 ml of sludge 207B center
100 ml of DI water
150 ml of Sand

after 4 min sample is still wet
Filtrate vol = 28 ml

(2)
100 ml of Sludge 207B center
100 ml of DI water
25 ml of sand

After 4 min Sample is wet
Filtrate vol. = 35 ml

(3)
100 ml of sludge 207B center
100 ml of DI water
5 ml of lime
25 ml of flyash
13.5 ml of cement

pH = 12

Sample was dry after 4:30 min
filtrate volume 140 ml

Mark Speranza 11/5/91

n × d
17' × 2 1/4

(4) 100 ml of sludge 207B center
100 ml of DI water
5 ml lime
15 ml of flyash
13.5 ml of Cement
pH = 12

5:30 min to dry
filtrate vol. = 170 ml

(5) 100 ml of sludge 207B center
100 ml of DI water
5 ml of lime
0 ml of flyash
13.5 ml of Cement pH = 12

6:30 min to dry
filtrate volume = 170 ml

---

(6) 100 ml of sludge 207B center
100 ml of water
5 ml of lime
10 ml of flyash
6 ml of cement pH = 12

dry after 8 min
filtrate vol = 164 ml

Mark Speranza 11/5/91

(7) 100 ml of sludge 207 B Center
100 ml of DI water
5 ml of lime
0 cement
25 ml flyash

pH ~ 12

6 min sample was dry
filtrate vol. = 182 ml
* high vol *

(8) 100 ml sludge 207B center
100 ml of DI water
5 ml of lime
6 ml of cement
25 ml of flyash
pH = 12

dry at 3:30
filtrate vol. = 139 ml

[signature] 11/5/91

PERFORMED THICKENING TEST ON POND 207B SOUTH
MARK JONNET & TOM SNARE BEGAN TEST.
TOM PREPARED SAMPLE BY CHLORINATING IT
AND ADDING 5 ml OF POLYMER 1% SOLUTION 3360

TEST BEGAN @ 8:20 am NOVEMBER 7, 1991

ELAPSED TIME HOUR - MINUTES	TOP OF BLANKET ml	RANGE OF TOP OF BLANKET ml	TOP OF 2ND LAYER ml
0 - 0	1030		
0 - 1	1020		
0 - 2	1010		
0 - 5	980		
0 - 15	810		
0 - 30	640		
0 - 45	550		
1 - 0	520		
1 - 15	507.5	505-510	
1 - 30	480		
1 - 45	465		
2 - 0	455		
2 - 15	450		
2 - 30	445		
2 - 45	442.5	425-460	
3 - 0	435	420 - 450	
3 - 15	430	410 - 450	490
3 - 30	425	410 - 440	490
3 - 45	420	410 - 430	490
4 - 0	415	400 - 430	500
4 - 15	410	400 - 420	505
4 - 30	407.5	395 - 420	505
4 - 45	405	390 - 420	530
5 - 0	400	390 - 410	540

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11/7/91

[signature]

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ELAPSED TIME HOUR - MIN	TOP OF BLANKET ml	RANGE TOB ml	TOP OF 2ND LAYER ml	SPEED OF RAKE RPM
5 - 15	400	390 - 410	520	
5 - 30	397.5	385 - 410	510	
5 - 45	395	380 - 410	510	12
6 - 0	392.5	380 - 405	510	12
6 - 15	392.5	380 - 405	500	12
6 - 30	390	380 - 400	505	12
6 - 45	390	380 - 400	495	12
7 - 0	390	380 - 400	495	12
7 - 15	387.5	375 - 400	510	12
7 - 30	385	~~370~~ - 400	540	12
7 - 45	385	370 - 400	540	12
8 - 0	385	370 - 400	520	12
24 - 0	370	360 - 380	570	30

@ 3 hrs - 15 minutes NOTICE A LAYERING

1030 - 490 SUPERNANT (3RD LAYER)
490 - 430 MIX LAYER (2ND LAYER)
430 - 0 BLANKET (1ST LAYER)

BOTTOM OF RAKE @ 35 ml
TOP OF RAKE @ 280 ml
HANDLE OF RAKE @ 460 ml
CLAMP HOLDING RAKE @ 350 ml

CHLORINATED SAMPLE FROM 207B CENTER

11/7/91

PERFORMED SLUDGE THICKENING TEST ON SAMPLE FROM POND 207B CENTER USED 10 ml OF POLYMER 1% SOLUTION 3360 IN ABOUT 1000ml OF SAMPLE. RAN TWO TESTS 1) ON SOLUTION DESCRIBED ABOVE WITH A RAKE. 2) ON SOLUTION DESCRIBED ABOVE WITHOUT A RAKE.

TEST BEGAN ON 11/11/91 @ 8:10 am

TIME HR-MIN	NO RAKE (ml) SANK	NO RAKE (ml) FLOATED	RAKE (ml)	SPEED OF RAKE (RPM)	
0-0	940		980	20	
0-1	250	150	CAUGHT ON RAKE	↓	
0-2	250	150	CAUGHT ON RAKE	↓	
0-5	210	150	CAUGHT ON RAKE	↓	
0-15	190	140	CAUGHT ON RAKE	↓	
0-30	190	130	CAUGHT ON RAKE	30	COULD NOT SLOW RAKE DOWN WOULD STOP IF ANY SLOWER
0-45	180	130	CAUGHT ON RAKE CLOUDED SUPERNANT CAUGHT ON RAKE	↓	
1-0	NO CHANGE		NO CHANGE	↓	
1-15	↓		↓	↓	
1-30	↓		↓	↓	
1-45	↓		↓	↓	
2-0	↓		↓	↓	
2-15	↓		↓	↓	
2-30	↓		↓	↓	
2-45	↓		↓	↓	
3-0	↓		↓	↓	
3-15	↓		↓	↓	
3-30	↓		↓	↓	
3-45	↓		↓	↓	
4-0	↓		↓	↓	
4-15	↓		↓	↓	
4-30	↓		↓	↓	
4-45	↓		↓	↓	

[signature]

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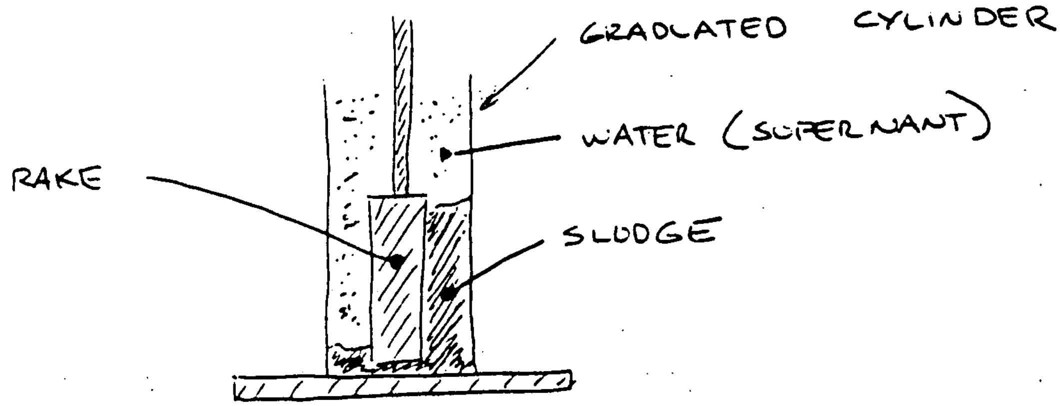
11/11/91

TIME HR-MIN	151 NO RAKE (ml)	RAKE (ml)	SPEED OF RAKE (RPM)
5-0	NO CHANGE	NO CHANGE	NO CHANGE
5-15			
5-30			
5-45			
6-0			
6-15			
6-30			
6-45			
7-0			
7-15			
7-30			
7-45			
8-0			
24-0			

CHLORINATED SAMPLE FROM POND 207B NORTH

THE RAKED SAMPLE FELL QUICKLY BUT DID NOT GO THRU RAKE



CROSS SECTION OF GRADUATED CYLINDER

11/11/91

PERFORMED SLUDGE THICKENING TEST ON SAMPLE FROM POND 207B NORTH. THIS TEST WAS RUN WITH 2 SEPARATE SAMPLES WITH METHOD DESCRIBED ON PAGE 151. THE AMOUNT AND TYPE OF POLYMER IS ALSO THE SAME.

TIME HR-MIN	NO RAKE (ml)	RAKE (ml)	SPEED OF RAKE (RPM)	RANGE TOP OF BLANKET
0-0	920	950	30	
0-1	910	940		
0-2	880	910		
0-5	810	860		
0-10	740	800		
0-15	660	750		
0-30	525	655	15	
0-45	470	595		
1-0	440	545		
1-15	420	505		
1-30	405	470		
1-45	390	445		
2-0	380	420		
2-15	375	395		
2-30	365	380		
2-45	360	365		
3-15	355	355		
3-30	350	350		
3-45	345	340		
4-0	340	330		
4-15	335	320		305-330
4-30	330	317.5		305-330
4-45	330	317.5		300-325
5-0	325	312.5		290-325
5-15	320	307.5		

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11/12/91

TIME HR-MIN	155 NO RAKE (ml)	RAKE (ml)	BLANKET RANGE	SPEED OF RAKE (RPM)
5-30	315	305	290 320	~ 10 RPM
5-45	312.5	305	290 · 320	
6-0	310	305	290 320	
6-15	310	302.5	285 · 320	
6-30	305	302.5	285 - 320	
6-45	305	300	285 · 315	
7-0	302	300	285 - 315	
7-15	300	300	285 · 315	
7-30	300	300	285 - 315	
7-45	297	297.5	280 · 315	
8-0	295	297.5	280 - 315	
24-0	245	290	280 · 300	

@ 24-0 READING A THIRD LAYER APPEARED

BOTTOM OF NEW LAYER @ TOP OF SLUDGE
TOP OF NEW LAYER @ 520 ml

CHLORINATED SAMPLE FROM POND 207A

[signature]

11/12/91

PERFORMED SLUDGE THICKENING TEST ON SAMPLE FROM POND 207A. THE METHOD, POLYMER TYPE AND AMOUNT IS DESCRIBED ON PAGE 151.

TIME HR-MIN	NO RAKE (ml)	RAKE (ml)	SPEED OF RAKE (RPM)
0-0	1000	1050	15
0-1	460	STUCK ON RAKE AS DESCRIBED ON PAGE 153	
0-2	330	NO CHANGE	
0-5	270	↓	
0-10	235		
0-15	220		
0-30	200		
0-45	190		
1-0	190		
1-15	180		
1-30	180		
1-45	175		
2-0	175		
2-15	175		
2-30	170		
2-45	170		
3-0	170		
3-15	170		
3-30	170		
3-45	170		
4-0	170		
4-15	170		
4-30	167.5		
4-45	167.5		
5-0	167.5		
5-15	167.5		
5-30	167.5		
5-45	165	↓	

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11/13/91

[signature]

TIME HR-MIN	159 NO RAKE (ml)	RAKE (ml)	SPEED OF RAKE (RPM)
6-0	160	NO CHANGE	15
6-15	160	↓	↓
6-30	160	↓	↓
6-45	160	↓	↓
7-0	160	↓	↓
7-15	160	↓	↓
7-30	160	↓	↓
7-45	160	↓	↓
8-0	160	↓	↓
24-0	150	↓	↓

SUPERNANT IN NO-RAKE SAMPLE CLEARER THAN SAMPLE WITH RAKE

[signature]

11/13/91

pH Titration of 207B-South "raw" sludge with 0.1 N NaOH to pH 12

20 ml aliquot of "raw" 207BS sludge take for both titrations

Untreated

pH	ml NaOH
8.91	0
9.51	1
9.91	2
10.30	3
10.68	4
10.94	5
11.23	6
11.46	7
11.63	8
11.76	9
11.86	10
11.94	11
12.01	12

treated w/ $Ca(ClO)_2$

pH	ml NaOH
7.04	0
8.06	1
8.48	2
8.79	3
9.11	4
9.35	5
9.60	6
9.85	7
10.07	8
10.18	9
10.30	10
10.39	11
10.45	12
10.47	13
10.53	14
10.61	15
10.71	16
10.78	17
10.90	18
11.02	19
11.10	20
11.20	21
11.29	22
11.36	23
11.50	24
11.54	25
11.58	26

(cont.)

pH	ml NaOH
11.63	27
11.68	28
11.72	29
11.74	30
11.78	31
11.79	32
11.83	33
11.84	34
11.86	35
11.86	36
11.88	37
11.90	38
11.91	39
11.93	40
11.95	41
11.96	42
11.98	43
12.00	44

Thomas L. [signature]

11/13/91

Filterability of 207B-south sludge treated with chlorine dioxide (ClO_2)

ClO_2 soln

940 ml DI
+ 60 ml Anthium Dioxide® (5% ClO_2 complex)
+ 12.39 g activator K

1 l

stirred for 5 min ⇒ 3000 ppm ClO_2/1 l

A 100 ml aliquot of 207B-south sludge was taken
+ 1 l of ClO_2 soln

1100 ml

$$\frac{(1\,l)(3000\,ppm)}{1.1\,l} = 2727\,ppm\ ClO_2$$

Rx time = 15 min stirred

(< 1 count) ⇒ -standard plate count done

this soln of sludge & ClO_2 (1100 ml) was left to settle for ≈ 15 min then 900 ml of clear supernatant was decanted off the top leaving 200 ml of solids & liquid. The 200 ml was filtered in a buchner funnel thru Watman 41 filter paper. In 20 min ~~the~~ less than 100 ml of filtrate was present and the mixture in the filter was very soupy.

Thomas J. [signature]

11/19/91

Samples taken for bulk density/specific gravity (S088)

Samples taken:

Larox #9 (pg 89) P181781 207BC lime/cement/flyash

Larox #12 (pg 93) P181782 207A lime/cement/flyash

~~LA~~
Larox #14 (pg 97) P181783 207BN lime/cement/flyash

★ no samples left from 207BS

Thomas J. [signature]

12/2/91

Rocky Flats

N/A

Cement Cylinder Mix

Wednesday 12/11/91 Trash Preparation:

PW 207 C - Spiked - Trash (dried)
PW 207 BC - Spiked - Trash (dried)

mixed and allowed to soak over night

Thursday 12/12/91:

8:00: Vaccum Filter Prepared Trash
~1 hr - 30 min - to intermediate occasional dry. min

8:30: BATCH Preparation: START

Three BATCHES
Aggregate varies only:
① 100% Sand
② 8% BC Trash & Sand
③ 8% C Trash & Sand

MATERIAL USE
TYPE I-II Cement
Sand ASTM C-1 & ASTM C-
WATER TAP Room Te

MIX: 1:2:3 Ratio
WATER Cement: Aggregate

Mix 1

SAND: 3,000 g
Water: 1,000 g
Cement: 2,000 g

SAND-WATER Mix
Lime added to pH of 11.2

add Cement - wet mixed for 5 min.

exactly 12 cylinders made {very little mix left over.}
Lids marked: MIX 1 12/12/91

173

12/12/91

Rocky Flats

171

"C" WATER

Mix 2 — PW207C spiked Trash & Sand } Aggregate mix

will need two mixes due to volume: Splitting Mix

Aggregate Preparation:

3000 TOTAL → Sand & Trash
92% Sand   8% Dry wt. Trash

3,000 × .92
= 2760 g Sand

(8%) × 3.6 = Wet wt. Trash
.288 × 3,000 g
= 864 g Trash wet

NOTE: TOTAL 3,624 g Aggregate, but 624 g is PW207C spiked fluid. ok

MIX 3:2:1
Aggregate : Cement : Water
All split ½ for double mix

Wet Aggregate 3,624 g
Cement 2,000 g
Water 1,000 g

Water, Trash, Sand
mixed: No Lime added, but have: 11.0 pH
11.1

No adjustment with Lime required.

Wet mixed for 5 min.
12 cylinders made. Labeled: MIX 2 #1

2 extra cylinders disc pictured each of "4" Labeled: MIX 2 extra

14 Total Cylinders for this Batch

175

[signature]

12/12/94

Rocky Flats

"BC" WATER

173

Mix # 3

Aggregate: PW207BC & Trash drained
SAND

Aggregate Preparation:

SAME AS ON Pg 173

92% Sand & 8% Dry Trash

Two ~~batches~~
each: 432g wet trash
1380g sand
500g water
1000g cement
} x2

Mixed Water, Trash, & Sand:
Added Lime for pH of 11.0
(approx. 1g per mix 2g total lime).

Cement added: Wet mixed for 5 min.

TOTAL of 16 cylinders made
12 required
4 extra.

11:30 ~~AM~~ Samples placed
in Coolers with water base
as ~~usual~~ typical ~~[illegible]~~ procedure.

NOTE:
The Remaining wet Trash was weighed
"C" → 1177g
"BC" → 637g

NO

RF Smid

12/12/91

Rocky Flats

M/B

Solubility Test

MATERIAL USED: USED FOR:

Crystals: PS 207C-C BATCHES: 1, 2

Liquid: PW 207C-SW BATCHES: 1

DATA: SEE TABLE I pg 183

Observations: First mix is at room temp. At this temp crystals do not dissolve. Actually crystals seem to expand if anything.

Repe[illegible] Aliquot

To draw sample a magnetic stir used with quick grab method. Best effort to get crystals in the liquid in a representative draw.

Half [illegible] Finished [illegible]

OUT OF CRYSTALS SO ONLY DID HALF Test — Broke to do. ~~this test~~ Shaw's II

12/13/91 Shaw's Test

Solubility Test

MATERIALS USED:

DI WATER
Crystals: PS 207C-C

DATA: SEE TABLE II

Procedure: DI water heated to 150°F and crystals added until water was saturated with crystals. Temp. was dropped and aliquots taken at various temps to determine the solubility or % solids at that specific temperature.

Filtering performed and evaporated to get saturated solution

179

[signature]

12/12/91

~~Att~~ 177

Sludge % Solids

DATA: SEE DATA TABLE III

NOTES Full samples used.

Solubility Test Cont.

Observations:

At 190°F the evaporated saturated ~~[illegible]~~ mixture formed crystals on top "scum" and at bottom.

As the temperature dropped the crystal layer on top disappeared and only a few more crystals remained on bottom.

140°F — crystal layer on top disappearing

100°F — No major crystal formation in sample

80°F — Small amount of crystals forming on bottom.

70°F — More crystals forming Max amount of crystals

The mixture was allowed to sit over the weekend until 7:00 am Monday 12/16/91 and the following are the observations:

- 80% crystals - 20% yellow liquid Temp. 67°F
  or 90% / 10%

Cont. 181

12/13/91

Rocky Flats

Solubility Test Cont

An aliquot was taken to determine the TDS of the supernatant after sitting 2.5 days at approx 67°F - 70°F

of = 67

Label	weight of beaker	weight beaker and mixture	weight beaker and mixture after drying
C 1-1	30.2g	51.5	
C 1-2	30.8g	49.4	

[signature]

12/16/91

Procedure:

Mixed Sample
Heated to Temp.
TS - ~~[illegible]~~ Took sample
TDS - Vacuum Filter for Sample

DATA T. BLE I

MITT

MIXTURE Crystals (ml)	Pond Water (ml)	TS – Total Solids: Weight Dry Beaker (g)	Weight Beaker, and mixture (g)	Weight Beaker mixture after Drying (g)	Weight mixture Total (g)	Weight mixture Dried (g)	% Solids (%)	TDS – Total Dissolved Solids: Weight Dry Beaker (g)	Weight Dry Beaker & mixture (g)	Weight Beaker mixture after drying (g)	Weight Total mixture (g)	Weight mixture dried (g)	% Solids (%)	
Temp = 65°F, Batch #1														
100	400	112.0	173.9	149.6	61.9	37.6	60.7	30.4	76.2	*52.1	45.8	21.7	47.4	1-1
200	300	115.2	168.8	149.0	53.6	33.8	63.0	29.8	64.1	*48.0	34.3	18.2	53.1	1-2
300	200	106.6	180.8	157.6	74.2	51.0	68.7	27.7	44.5	36.7	16.8	9.0	53.6	1-3
400	100	104.9	174.6	162.6	69.7	57.7	82.8	31.0	44.5	*38.2	13.5	7.2	53.3	1-4
Temp = 80°F, Batch #2														
100	400	101.1	177.8	144.3	76.7	43.2	56.3	31.1	61.9	*47.4	30.8	16.3	52.9	2-1
200	300	93.0	180.8	144.7	87.8	51.7	58.9	29.4	55.1	43.3	25.7	13.9	54.1	2-2
300	200	108.3	176.8	157.3	68.5	49.0	71.5	31.4	74.7	54.8	43.3	23.4	54.0	2-3
400	100	111.8	200.1	176.5	88.3	64.7	73.3	31.3	49.3	*39.9	18.0	8.6	47.8	2-4
Temp. = 100°F, Batch No. #3														
100	400													3-1
200	300													3-2
300	200													3-3
400	100													3-4
Temp. = 120°F, Batch #4														
100	400													4-1
200	300													4-2
300	200													4-3
400	100													4-4

Test stopped to perform test in Table II. The second [illegible] [illegible] [illegible].

* NOTE: After Drying it was discovered some sample boiled over, therefore the readings and results are not correct.

N/A

R.F. Smith

12/16/91

Procedure: Mixed sample at 150°F adding crystals to DI water until saturated.

- Filtered with vaccum when max sat. reached (Due to limited crystals)
- Heat/evaporated DI water) until crystals formed
- Allowed temp to drop taking samples at specified temp.

DATA TABLE II

SATURATED Mixture of Crystals and 75 Water @ 150°F

Temp. Mixture (°F)	Weight of Dry Beaker (g)	Weight of Dry Beaker and Mixture (g)	Weight Beaker and mixture after Drying (g)	Total weight of mixture (g)	Weight mixture Dried (g)	% solids (%)
TRIAL #1						
140	106.9	141.7	121.6	34.8	14.7	42.2
130	105.2	146.6	122.6	41.4	17.4	42.0
120	101.8	137.2	116.8	35.4	15.0	42.4
110	107.9	137.9	120.6	30.0	12.7	42.3
100	79.9	113.1	94.1	33.2	14.2	42.8
90	49.2	83.0	64.0	33.8	14.8	43.8
80	74.7	109.8	90.2	35.1	15.5	44.2
70	27.1	61.7	42.2	34.6	15.1	43.6
69	30.5	67.6	46.7	37.1	16.2	43.7
TRIAL #2						
140	108.8	146.2	124.6	37.4	15.8	42.2
130	109.6	141.5	123.0	31.9	13.4	42.0
120	110.3	143.8	124.4	33.5	14.1	42.1
110	94.0	131.5	110.0	37.5	16.0	42.7
100	63.8	100.3	79.6	36.5	15.8	43.3
90	49.9	86.8	65.9	36.9	16.0	43.4
80	31.2	67.7	47.2	36.5	16.0	43.8
70	27.3	62.3	42.7	35.0	15.4	44.0
69	30.1	66.8	46.1	36.7	16.0	43.6
AFTER 2.5 day Rest @ 67°F						
TRIAL 67° #1	30.2	51.5	40.3	21.3	10.1	47.4
TRIAL #2	30.8	49.4	39.6	18.6	8.8	47.3

N/A

[signature]

12/16/91

Procedure:

Get to Solids

See other Book for sample Discriptions.

DATA TABLE III — Rocky Flats

179

SAMPLE	LABLE	Weight of Dry Beaker (g)	Weight Beaker and Sample (g)	Weight Beaker and Sample Dried (g)	Weight of Sample (g)	Weight of Sample dried (g)	% Solids (%)
(A) R x poly pre-pressured	(A)	112.5	120.3	113.6	7.8	1.1	14.1%
(B) Pressure raw + poly	(B)	112.5	120.1	114.1	7.6	1.6	21.0
(C) Ca(ClO)₂ part press.	(C)	114.3	121.8	115.5	7.5	1.2	16.0
(D) Ca(ClO)₂ pressure	(D)	114.1	125.3	117.7	11.2	3.2	28.6
(E) A	(E)	112.6	120.5	114.9	7.9	2.3	29.1
(F)	(F)	113.0	124.4	117.1	11.4	4.1	36.0
(G)	(G)	112.8	118.2	113.9	5.4	1.1	20.4
(H)	(H)	113.9	137.5	120.8	23.6	6.9	29.2
207 A untreated	(I)	147.7	284.0	155.1	136.3	7.4	5.4
207 B untreated	(J)	147.5	272.8	159.5	126.3	12.0	9.5
207 C preliminary Treatment	(K)	114.2	232.2	206.3	118.0	92.1	78 *

C-1 40.3 g
C1-2 39.6 g ?

(K) 109.8 g
3 times broke it
207B [illegible] need weighed again!

* A solid layer formed on the surface and prevented evaporation so a layer of liquid remained. We broke the top layer and placed back in oven.

AJA

RF Smid

12/11/91

Samples collected for fecal & coliform test

PS207C - underlying sludge (from treatability study 10 gal bucket) 12/12/91
P183101

Clarifier Sludge (from treatability study 55 gal drum) 12/12/91
P183102

PS207A - collected from characterization of treatability study sample 12/13/91
P183260

PS207BN - collected from characterization of treatability study samples 12/13/91
P183258

PS207BC - collected from characterization of treatability study samples 12/13/91
P183261

PS207BS - collected from characterization of treatability study samples 12/13/91
P183259

[signature] 12/16/91

Spiking soln. used for trash (pg's 171-175)

3 L of 207C pond water and 3 L of 207BC pond water were spiked with the following:

grams added to each soln.

Mercuric Sulfate $HgSO_4$ MW 296.65 — 0.0466 g
% Hg = 67.6

Cadmium chloride $CdCl_2$ MW 183.3 — 13.34 g
% Cd = 61.3

~~Pottas~~ Potassium Dichromate $K_2Cr_2O_7$ MW 294.2 — 25.24 g
% Cr = 35.4

Nickel Sulfate $NiSO_4 \cdot 6H_2O$ MW 262.8 — 6.40 g
% Ni = 22.3

Lead Nitrate $Pb(NO_3)_2$ MW. 331.2 — 1.1040 g
% Pb = 62.6

Silver Sulfate Ag_2SO_4 MW. 311.8 — 0.3630 g
% Ag = 69.2

Concentrations of metals in each soln.

Hg	10.5 mg/l
Cd	2726 mg/l
Cr	2978 mg/l
Ni	476 mg/l
Pb	230 mg/l
Ag	84 mg/l

193

[signature]

12/16/91

191

830g of dried trash (-#10) was added to each soln.
and left to sit overnight (~14hrs).

densities of trash:

wet ρ = 1.1456 g/cc

dried ρ = 0.3143 g/cc

Thomas J. [illegible]

12/16/91

LAROX

November 1, 1991

Mr. Wayne Henderson
Brown & Root, Inc.
1500 City West Blvd.
Houston, TX 77042

SUBJECT: Test Filtration Report
Inquiry No. U1499/0

Dear Wayne:

Enclosed is our Test Filtration Report describing tests performed on your Rocky Flats Pondcrete Slurry.

Tests indicate that your slurry can be successfully dewatered on the LAROX FILTER. Cake moisture as low as 23.2% was achieved with capacities as high as 50.93 lbs/ft^2, hr.

Thank you for letting LAROX test your slurry. We look forward to further cooperation on this project.

Sincerely yours,

LAROX, INC.

Kevin J. Haggerty
Sales Engineer

KJH:bn

Enclosure

c 1499/0 - Customer File
SW-LT-MG-RW-KH-DC-MT-KPO-Test File
J.J. Helsto/LAROX OY

LAROX EQUIPMENT REPORTS

APPENDIX B

LAROX AND DENVER EQUIPMENT REPORTS

LAROX 11

U1499/0 1

TEST REPORT

TEST DATE October 24, 1991

CLIENT Brown & Root/Halliburton NUS
Houston, TX

LOCATION Halliburton NUS
Pittsburgh, PA

MATERIAL TO BE FILTERED Rocky Flats Pondcrete

1. GENERAL

Tests were conducted using a LAROX PF 25 Laboratory Filter with a filtration area of 25 cm^2. The LAROX simulates the filtration, pressing, and drying operations performed in a full-scale filter.

The testing apparatus consists of the following:

A. Filter Chamber - Complete with polypropylene underdrain, filter cloth, pressing piston and necessary feed ports.

B. Filter Cloth - Type 71-2209-L1, polyester, weight - 30 oz/yd^2, air permeability - 4.6 ft^3/ft^2, min.

C. Closing Devices - Pneumatically driven, complete with necessary manifolds and regulators for pressurizing air.

The purpose of testing is to determine the optimum operation of the LAROX FILTER on your specific slurry. This is accomplished by varying the stages in each filtration cycle and determining the affect on the operation (capacity, moisture content, results, etc.) of the filter.

Testing is performed by first pouring slurry into a chamber. Then, using the pressing piston to squeeze water from the slurry forms a solids cake. For those tests requiring washing, the cake is washed and re-pressed. The formed cake is then air dried. The filter chamber is opened and the cake is removed for weight and moisture measurement. Residual moisture was determined by air drying a small sample of the cake overnight.

2. PROPERTIES (All)

2.1 Slurry
- Brown in color
- slurry will remain in suspension with mixing and recirculation

2.2 Cake
- 1.25" maximum thickness
- brown in color

9730 Patuxent Woods Drive, Columbia, MD 21046 • Phone (301) 381-3314 • Telex 7105622870 larox colb • FAX (301) 381-4490

LAROX

2.3 Filtrate
- clear with tint
- no carryover

2.4 Filter Cloth
- the filtering properties of the cloth are good
- the cake washes easily from the cloth
- The cake discharges easily from the cloth

3. RESULTS(1)

3.1 Moisture
- cycles tested produced moistures that varied between 23.2 and 43.0% (all tests)

3.2 Capacity
- cycles tested produced capacities that varied between 50.93 and 20.02 lbs/ft^2, hr (all tests)

3.3 Cycle Time
- cycle time varied between 9.0 and 14.0 minutes (all tests)
- recommended cycle time for dimensioning the production unit will vary accordingly depending on material composition; the following is for preliminary estimates only:

Pumping	2.0 minutes
Pressing I	5.0 minutes*
Air Blowing	1.0 minutes
Discharge	3.0 minutes

Total Cycle Time	11.0 minutes*

Tests indicate that from the recommended cycle time of 11.0 minutes, results should be as follows: cake moisture @ 30%, capacity 42.0 lbs/ft^2, hr.

* final cycle time can be selected based on required cake moisture and filter capacity.

(1) Results shown are based on all combinations of variables tested and do not represent optimum performance. See recommended cycle time for optimum performance.

LAROX 11

4. SUMMARY

The objectives of these tests were to obtain a cake with the highest solids content possible, to produce clear filtrate and to estimate the capacity and production capabilities of the LAROX FILTER.

The lab tests were conducted in order to observe how well the LAROX FILTER will perform in this application. Various material compositions were tested. These included combinations of the raw sludge with the addition of lime, cement and fly ash at various concentrations. All of the material compositions would be applicable except for the raw slurry without any additives.

Once the process parameters are more defined, LAROX will be happy to perform additional testing or extrapolate the data from these tests and provide filter sizing accordingly.

Overall, the LAROX FILTER produced a very dry and easily handled cake (moisture content as low as 23.2% was achieved) with good capacity. This appears to be an excellent application for the LAROX FILTER.

PREPARED BY KH

LAROX

0 Test filter ☐ 0.1 ☐ 0.85 ☐ 2.5 ☐ ______ TEST FILTRATION NO. ______ Page ______

1 CUSTOMER ______

2 INDUSTRY ☐ minerals ☐ foodstuff ☐ pulp and paper ☐ chemicals ☐ other ☐ see overleaf

3 ☐ invoice ☐ no invoice Date: ______ By: ______

4 Suspension description: ______

5 Screen analysis: ______ % ______ mesh Specific surface area: ______ Lbs./Ft.²

6 Cake washing: ☐ no washing ☐ to be washed Wash liquid: ______ Temperature: ____ °F ____ °C

7 Filter aids: ______

8 ______ Place: ______

9 TEST NO.		1	2	3	4	5	6	7	8
10 Duration of pumping	min	1	1	2	2	1	2	2	2
11 I pressing	min	20	5	5	6	4	6	6	3
12 washing	min	—	—	—	—	—	—	—	—
13 II pressing	min	—	—	—	—	—	—	—	—
14 drying	min	1	1	1	1	1	1	1	1
15 discharging	min	3	3	3	3	3	3	3	3
16 Total time used	min	25	10	11	12	9	12	12	9
17									
18 Feed pressure	psi ☑ bar ☐	196	196	196	78/196	→	→		
19 Pressure of press water	psi ☑ bar ☐	196	196						
20 wash water	psi ☐ bar ☐								
21 drying air	psi ☑ bar ☐	73.5	73.5	→	→	→	→	→	→
22									
23 Quantity of slurry	gal ☐ l ☐								
24 wash water	gal ☐ l ☐								
25 filtrate	gal ☑ l ☐	0.20	0.98	1.23	1.47	0.74	0.98	4.18	0.98
26 wash filtrate	gal ☐ l ☐								
27 Air flow	ft³/ft² min ☐ m³/m² min ☐								
28									
29 Temperature of slurry	°F ☐ °C ☐	Amb							
30 wash water	°F ☐ °C ☐								
31 filtrate/wash filtrate	°F ☐ °C ☐								
32 drying air	°F ☐ °C ☐								
33									
34 pH of slurry		7	12	→					
35 filtrate									
36 wash water									
37 wash filtrate									
38									
39 Solids in slurry	% w/w								
40 filtrate	oz/gal ☐ mg/l ☐								
41 wash filtrate	oz/gal ☐ mg/l ☐								
42 Slurry density	lb/gal ☐ g/l ☐								
43									
44 Cake thickness	inch ☑ mm ☐	—	0.5	1.0	1.12	0.75	1.12	1.25	1.25
45 Cake weight	lb ☑ kg ☐		4.76	7.42	9.23	6.07	8.43	9.32	10.95
46 % solids		—	70.1	59.1	62.1	57.0	64.7	76.7	69.5
47 Moisture in cake	% w/w	—	29.5	40.9	37.9	43.0	35.3	23.2	30.5
48 Dry solids in cake	lb ☐ kg ☐	—	3.34	4.39	5.73	3.46	5.45	7.15	7.64
49									
50 Capacity	lb/ft²hr ☑ kg/m²h ☐	—	20.02	23.92	28.66	23.07	27.23	35.7	52.93
51 Capacity	gal/ft²hr ☐ l/m²h ☐								
52 Wash water consumption	gal/ton DS ☐ m³/t DS ☐								
53 Washing result									
54									
55 Cloth 2205 61									
56 Input									
57 Remarks		1-A	2-A	2-B	2-C	3-A	3-D	4-D	4-B

1 - raw slurry

2 - slurry (150 ml) + lime (7.5 ml) + #2 cement (20 ml)

3 - slurry (450 ml) + lime (22.5 ml) + flush (113 ml)

4 - [illegible]

A - pump at 196 psi, one fill

B - pump at 196 psi for 30 sec, add 50 ml and dwindl slurry,

C - 1st/2nd fill at 78 psig, 3rd

LAROX

0 Test filter ☐ 0.1 ☐ 0.85 ☐ 2.5 ☐ ______ TEST FILTRATION NO ______ Page ______

1 CUSTOMER ______

2 INDUSTRY ☐ minerals ☐ foodstuff ☐ pulp and paper ☐ chemicals ☐ other ☐ see overleaf

3 ☐ invoice ☐ no invoice Date: ______ By: ______

4 Suspension description: ______

5 Screen analysis: ______ % ______ mesh Specific surface area: ______ Lbs/Ft³

6 Cake washing: ☐ no washing ☐ to be washed Wash liquid: ______ Temperature: ____ °F ____ °C

7 Filter aids: ______

8 ______ Place: ______

9 TEST NO.		9	10	11	12	13	14	15	16
10 Duration of pumping	min	2	2	1	2	2	2	2	
11 I pressing	min	4	3	5	6	6	6	6	
12 washing	min	–	–	–	–	–	–	–	
13 II pressing	min	–	–	–	–	–	–	–	
14 drying	min	1	1	1	ABORT	1	1	3	
15 discharging	min	3	3	3	3	3	3	3	
16 Total time used	min	10	9	10	12	12	12	14	
17									
18 Feed pressure	psi ☒ bar ☐	78 →							
19 Pressure of press water	psi ☒ bar ☐	196 →							
20 wash water	psi ☐ bar ☐								
21 drying air	psi ☐ bar ☐	73.5	→						
22									
23 Quantity of slurry	gal ☐ l ☐								
24 wash water	gal ☐ l ☐								
25 filtrate	gal ☒ l ☐	0.88	0.88	0.99	–	0.98	0.79	0.79	
26 wash filtrate	gal ☐ l ☐								
27 Air flow	ft³/ft² min ☐ m³/m² min ☐								
28									
29 Temperature of slurry	°F ☐ °C ☐								
30 wash water	°F ☐ °C ☐								
31 filtrate/wash filtrate	°F ☐ °C ☐								
32 drying air	°F ☐ °C ☐								
33									
34 pH of slurry									
35 filtrate									
36 wash water									
37 wash filtrate									
38									
39 Solids in slurry	% w/w								
40 filtrate	oz/gal ☐ mg/l ☐								
41 wash filtrate	oz/gal ☐ mg/l ☐								
42 Slurry density	lb/gal ☐ g/l ☐								
43									
44 Cake thickness	inch ☒ mm ☐	1.125	1.125	0.875	–	1.25	1.30	1.30	
45 Cake weight	lb ☒ kg ☐	9.46	10.58	9.69	–	10.63	11.77	12.12	
46 % solids		70.8	69.6	76.0	–	70.5	75.4	74.9	
47 Moisture in cake	% w/w	29.2	30.4	24.0		29.5	24.6	25.1	
48 Dry solids in cake	lb ☒ kg ☐	6.70	7.36	7.36		7.49	8.87	9.08	
49									
50 Capacity	lb/ft²hr ☒ kg/m²h ☐	40.18	49.10	35.05		37.47	44.37	38.90	
51 Capacity	gal/ft²hr ☐ l/m²h ☐								
52 Wash water consumption	gal/ton DS ☐ m³/t DS ☐								
53 Washing result									
54									
55 Cloth									
56 Input									
57 Remarks		4-E	4-E	4-F	5-F	5-E	5-E	5-E	

5 = same as 4 at different mix ratios

D = 1st pump at 78 psig for 30 sec, 2nd fill at 196 psig.

E = 1st pump at 78 psig, second for 1 min at 78 then 2 min at 196

F = one fill at 78 [illegible]

11

DENVER EQUIPMENT REPORTS

DENVER EQUIPMENT COMPANY

COLORADO SPRINGS, COLORADO U.S.A.

TEST REPORT

NUMBER 91 - P - 40054

DATE November 4, 1991

AUTHOR T. Saunders

SUBJECT: Piston press tests conducted in Pittsburgh on Rocky Flats pond sludge

LOCATION: Pittsburgh, PA

DATE(S): October 22-23, 1991

RECEIVING NUMBER: N/A

ORDER NUMBER: 01-195137

AFD NUMBER:

PRODUCT LINES AFFECTED: Tube Press

REPORT FOR: Halliburton NUS
661 Anderson Drive
Pittsburgh, PA 15220

ATTENTION: Rich Ninesteel

TABLE OF CONTENTS

SUBJECT

This report is for the piston press tests conducted in Pittsburgh on Rocky Flats pond sludge.

INTRODUCTION

Piston press tests were conducted in Pittsburgh on October 22 and 23, 1991. Four samples of Rocky Flats pond waste material were available for testing. Tom Saunders from DECO, Rich Ninesteel, Tom Sinare, and Mike Speranza of Halliburton NUS, Pittsburgh, and Karen Talbert of Brown & Root, Houston, were present on October 22. Wayne Henderson of Brown & Root, Houston, joined the group on October 23, 1991.

The samples as tested were chlorinated sludge with the consistency of pudding. Each of the samples contained entrained gas, possibly as a result of the chlorination, or as entrained air.

The test objectives for the piston press tests were:

- Obtain filter cakes containing 50 to 60% solids from each of the sources
- Determine filter rates at high pressures
- Obtain cost effective filter rates to filter 10 ton/hour
- Investigate filter cake characteristics

Test schemes which were discussed or attempted include:

- Filtration as received
- Addition of fly-ash as a filter aid
- Addition of a flocculent, Betz 3360
- Ultrasonic pretreatment
- pH adjustment with lime
- Addition of diatomaceous earth and fine silica as filter aids
- Cement addition
- Addition of lime and cement.

Centrifuging the material followed by Holo-Flite™ drying was discussed. Vacuum filtration, specifically with pan or belt filters, was also discussed.

RECOMMENDATIONS

The gelatin consistency of the feed material to the Piston Press was not anticipated. Typical feed to a Tube Press is a low viscosity slurry greater than 20% solids, which will fill easily through 5mm feed holes. Conditioning of the feed will be required as proven by the successful test "J" to which lime and cement were both added to the feed sample.

In preapplication work for the Tube Press, a trials test is generally run which is a small Tube Press to further verify the operation under plant conditions. Due to the nature of this application, such testing is not feasible. Because of this, conservative sizing of Tube should be undertaken to guarantee that enough capacity is available to filter all material required.

Consistency of feed is also important with the Tube Press. Due to the nature of the ponds being reclaimed, it is anticipated that the feed will not be consistent. Therefore, additional tests should be conducted. Samples drawn from different parts of the ponds should be tested with the Piston Press using the best method of conditioning to obtain the longest filter time required. The sizing of equipment should be based on this sample.

Spare Tubes should also be included in the design so that when maintenance is required on one Tube, it can be shut down and spare Tubes be put into operation.

DENVER EQUIPMENT COMPANY can make available the Piston Press for Halliburton NUS to conduct additional tests on their own.

Based on the success of this test with the addition of cement, a review of the process flow diagram should be undertaken to verify the initial selection of the equipment. It may be possible to take discharge product from the Tube and put it directly into a containment vessel that could allow compression of the slurry which will harden into a block. This process, would eliminate the need for cementing process downstream from the filters.

OBSERVATIONS

Test objectives were met in only one case. Adequate filter rates were obtained after dilution, 1:1 with water, pH adjustment with lime, and addition of cement, 1:3 cement to solids. This last test produced a filter cake with a moisture content of 25%, much lower than the 40 to 50% target. A filter rate of 1650 lb/hour observed during this test would require 12 tube presses to treat the projected 10 tons/hour. Filter rates were very slow on untreated material. Most of the time in Pittsburgh was spent in attempting various methods of improving this rate. Eventually a combination of dilution, addition of lime to raise the pH, and the addition of type II cement was successful in producing reasonable filtration rates.

The piston press filter cake with the addition of lime and cement was compact and brittle enough to readily discharge from a tube press.

DISCUSSION

The piston press test runs were conducted by preparing a slurry and filtering it at pressure in a piston press. Data collected included:

- Filtration rate
- Filtration time
- Filtrate volume
- Sample temperature
- Sample pH
- Filter cake thickness
- Filter pressure
- Material moisture in/out

Filtrate quality was evaluated, and filter cake characteristics were noted.

Moisture analyses was conducted by NUS personnel.

Ten tests were conducted. Most were aborted before completion due to extremely slow filter rates. Two tests, E and J, were completed and the test data sheets are included at the end of this report. Table 1 summarizes the test schedule.

Table 1: Test Schedule

Test No.	Sample	Press	Additives	
A1	207A	1500	none	
B	207A	1500 2000		Whatman 41 Paper
C	207A	1500	20% add on Fly Ash	Whatman 41 paper
D	207A	1500	Betz 3360 Cationic Polymer	
E	207B North	1500		
F	207B South	1500		
G	207B Center	1500	.25 gm/liter Betz 3360	
H	207B Center	1500	Dilute 50 to 200 with water	Ultrasonic Treatment
I	207B Center	100 500 1000 1500	Dilute 200 to 400 ml add 4 ml 1% Betz 3360	Ramp Pressure
J	207B Center	1500	dilute 100 to 200 with water 5 (vol) Lime 20 (vol) cement	

When using piston press test results to predict the performance and to size tube filter presses, the following points should be noted:

1. Tube presses are currently supplied in standard lengths of 1.8 meters, 2.4 meters, and 3.0 meters. The areas of each of these sized are as follows:

1.8 meter	0.84 m^2
2.4 meter	1.15 m^2
3.0 meter	3.75 m^2

2. Maximum operating pressure for the tube presses are as follows:

1.8 m 200 series	2000 psi
2.4 m 200 series	2000 psi
3.0 m 500 series	1500 psi

3. Turn around time, t_D, includes the slurry filling period, cake compression period at the end of filtration, and the cake discharge period. It is suggested that a value of 120 seconds is used if no better data is available.

4. The following limits are suggested when making output rate predictions:

Cake thickness	2 cm max
	0.3 - 0.5 cm min
Cycle time	4 minutes min

5. Filter cake moisture contents at any specific pressure usually agree within 1% between the piston press and the tube press.

DATA SUMMARY

DENVER

Filter Press Tests

Test Press (psi)	Cake Thickness (in)	Cake Moisture (%)	Filter Time (min)	Cake Description	Filter Clarity (ppm)	Filtration Rate lb/hr
E	.75	21.9	6600	Fibrous Not complete	cloudy	92
J	.156	23.6	90	Brittle	cloudy	1651

EQUIPMENT DESCRIPTION

The piston press is a device for measuring the filtration characteristics of suspensions at pressures up to 345 bar (5016 psi).

The apparatus consists of a machined cylinder made of mild steel, with internal dimensions 0.2 meters (7.874 inches) long X 0.0763 m (3 inches) diameter. The bore is chromium plated and ground to true dimensions. One end contains an hydraulic port. The other end is threaded and the end cap is held in place by a threaded collar. Inside the cylinder is a free piston sealed by 'O' rings. The end cap is sealed by a flat rubber ring which also retains the filter cloth. The filter cloth is supported by a backing cloth on a perforated plate which conducts the filtrate to a central drain port. The press is mounted on an axle which allows rotation in the vertical plane. Locking pins are used to stabilize the press in either vertical position.

Hydraulic pressure is supplied by an air driven ram pump fed from the building water line. The ram is driven by compressed air at approximately 90 psi. The pressurized water is fed to the press through a manifold containing a relief valve, a gauge, and a flexible hydraulic hose to deliver pressure to the test unit.

TEST UNIT SPECIFICATIONS

Piston Press

Size of unit	3 inch diameter
Material contact parts	Mild steel piston Chromed cylinder
Sample volume (Maximum)	500 cc

Date 10/23/91	Denver Charlestown Piston Press		
	Halliburton NUS		
Customer Operating Conditions	Test Run	E	
		psig	Pressure
Sample 207B North			
		gm/cc	Pulp Dens
	2.410	gm/cc	Solids Density
	30	%	Pulp Solids
Tested by:		Deg F	Feed Temp
THS	0.0094	cp	Filtrate Viscosity
	10.00	dry tph	Feed Rate
	240	dry tpd	Feed Rate

			TIME (sec)	VOLUME (cc)
Filter Pressure	1500	psig		
Pulp Volume	450	ml		
Pulp Density	1.2000	gm/cc	10	16
Pulp Solids	31.80	% solids	30	26
Pulp Temperature	73	deg F	60	34
Pulp pH	7.0		120	50
			180	52
Filtrate Volume	260	ml	240	59
Filtrate Density	1.0000	gm/ml	300	66
Filtrate Viscosity	0.9375	cp	360	72
Filtrate Clarity	cloudy	mg/liter	480	82
			540	86
Filter Cake Thickness	0.750	inches	600	90
Filter Cake Moisture	21.90	%	900	108
Filter Cake Density	1.6193	gm/cc	1110	118
Filter Cake Volume	86.87	cc	1200	122
Filter Cake Quality	fibrous not complete		1500	136
Filter Cake Wet Weight	140.68	gm	1800	146
Filter Cake Dry Weight	109.87	gm	6600	260
Total Filtration Time	6600	sec		

Tube Press Filter Rates

42	kg/hr	3 m 500 series tube press rate
92	#/hr	

192 3 meter 500 series tubes required

* Optimum rates are reported for cake thicknesses between the upper limit of 2 cm for efficient discharge from the tube press, and the lower limit of 0.3 cm for efficient cake release from the cloth.

Rates are adjusted for fill volume equivalent to 500 cc in the tube press if the cake thickness does not exceed 2 cm.

Date 10/23/91	Denver Charlestown Piston Press		
	Halliburton NUS		
Customer Operating Conditions	Test Run	J	
	1500	psig	Pressure
100 Sample 207 Center			
100 Water	1	gm/cc	Pulp Dens
5 Lime	2.410	gm/cc	Solids Density
20 Type II Cement	17	%	Pulp Solids
Tested by:		Deg F	Feed Temp
THS	0.0094	cp	Filtrate Viscosity
	10.00	dry tph	Feed Rate
	240	dry tpd	Feed Rate

			TIME (sec)	VOLUME (cc)
Filter Pressure	1500	psig		
Pulp Volume	225	ml		
Pulp Density	1.0750	gm/cc	5	50
Pulp Solids	16.55	% solids	10	70
Pulp Temperature	73	deg F	15	84
Pulp pH	12.0		25	100
			30	110
Filtrate Volume	174	ml	50	140
Filtrate Density	1.0000	gm/ml	60	154
Filtrate Viscosity	0.9375	cp	75	170
Filtrate Clarity	?	mg/liter	90	172
Filter Cake Thickness	0.156	inches		
Filter Cake Moisture	23.58	%		
Filter Cake Density	2.1987	gm/cc		
Filter Cake Volume	18.07	cc		
Filter Cake Quality	fibrous			
Filter Cake Wet Weight	39.73	gm		
Filter Cake Dry Weight	30.36	gm		
Total Filtration Time	90	sec		

Tube Press Filter Rates

749	kg/hr	3 m 500 series tube press rate
1651	#/hr	

12 3 meter 500 series tubes required

• Optimum rates are reported for cake thicknesses between the upper limit of 2 cm for efficient discharge from the tube press, and the lower limit of 0.3 cm for efficient cake release from the cloth.

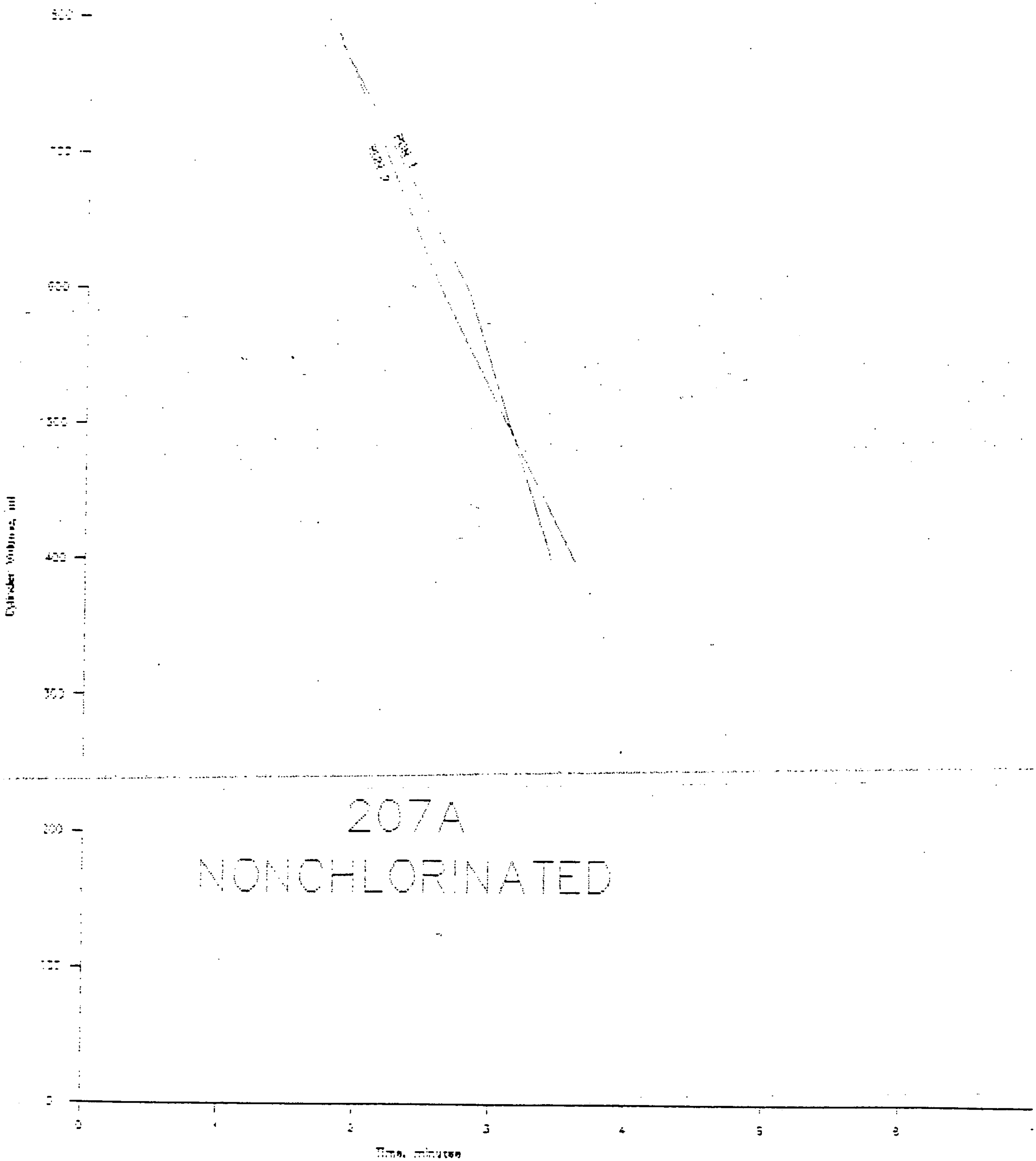
Rates are adjusted for fill volume equivalent to 500 cc in the tube press if the cake thickness does not exceed 2 cm.

APPENDIX C

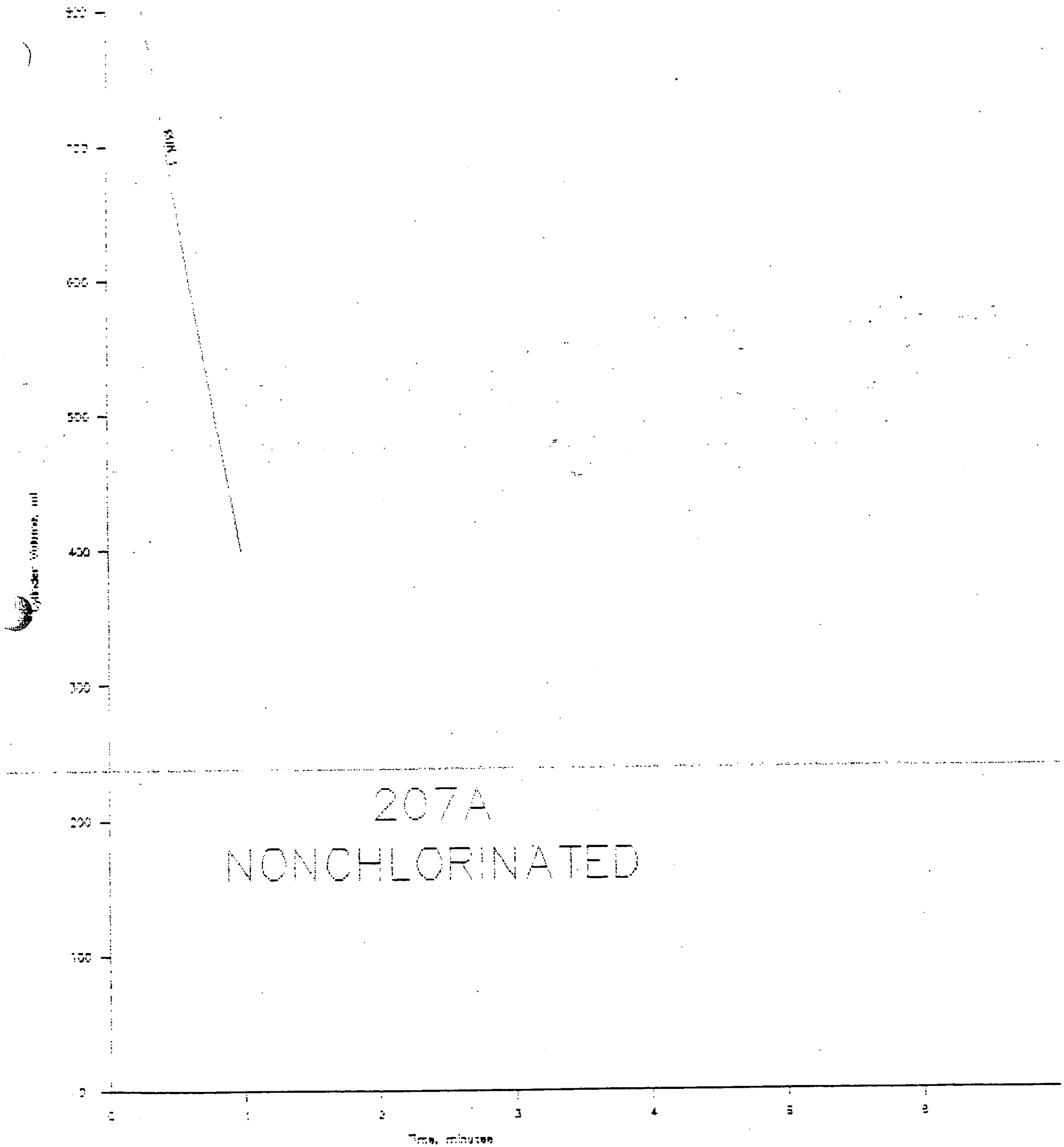
BULK SETTLING RATE AND THICKENING TEST DATA

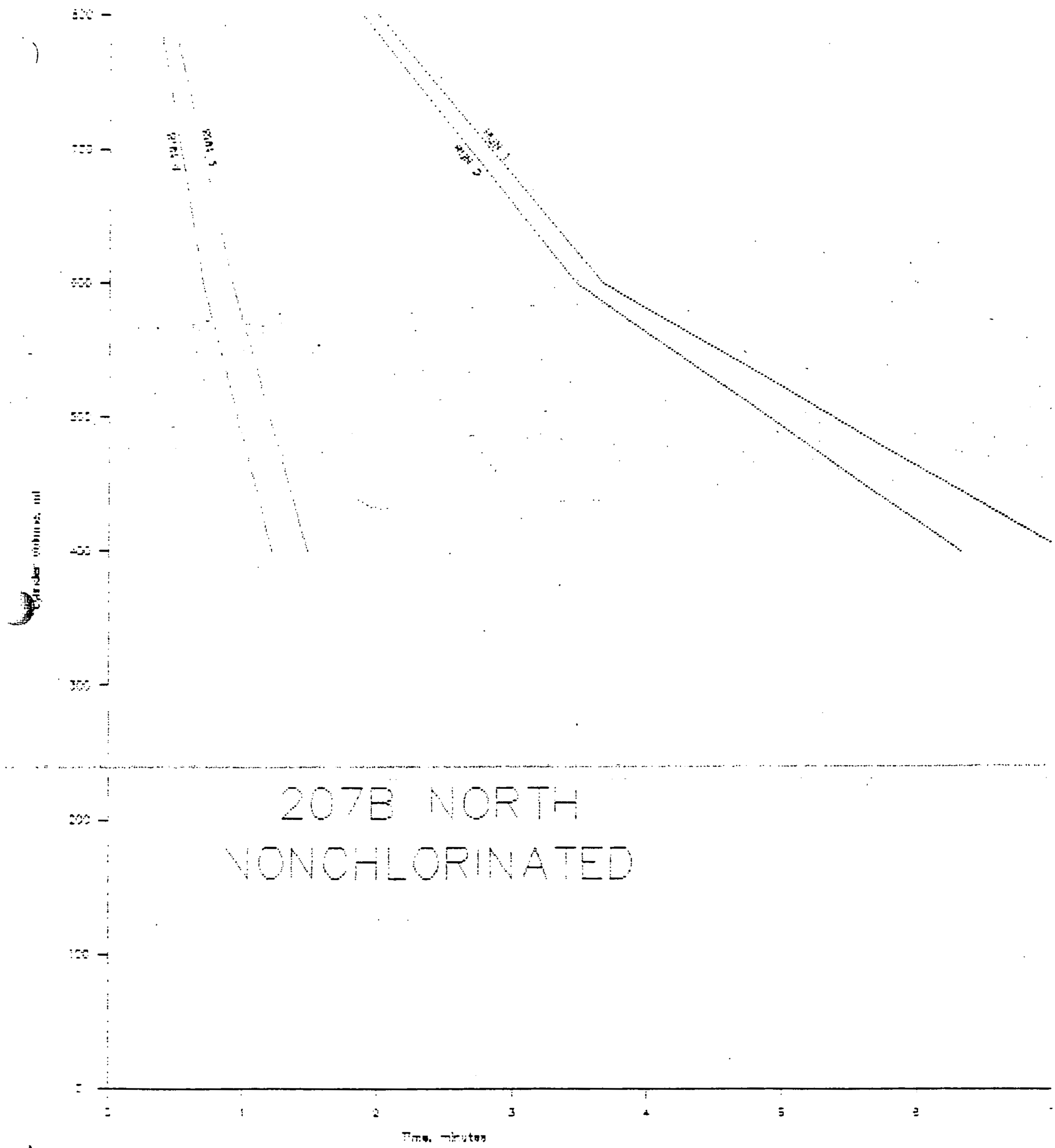
BULK SETTLING RATE DATA

Page No	Pond Name	Run No	Ch	Polymer	Time min	VOLUME cc	BSR (ft/hr) 883 corr	DOR (ft3/hr)
099	207B North	1	No	No	2.07	400	13.15	6.55
099	207B North	2	No	No	1.67	300	12.23	6.12
099	207B North	2	No	No	2.52	400	10.80	5.40
101	207B North	1	Yes	No	7.10	400	3.83	1.91
101	207B North	2	Yes	No	6.33	400	4.29	2.15
101	207B North	3	Yes	Yes	1.43	400	18.32	9.16
101	207B North	4	Yes	Yes	1.43	400	18.32	9.16
103	207B South	1		Yes	2.55	500	13.32	6.66
105	207B South	2		Yes	1.78	500	11.76	5.88
105	207B South	4		Yes	8.47	300	2.41	[illegible]
107	207A	1-1	No	No	3.46	400	7.83	3.94
107	207A	1-2	No	No	3.62	400	7.52	3.76
107	207A	2-1	Yes	No	2.78	400	9.77	4.88
107	207A	2-2	Yes	No	3.32	400	8.19	4.10
109	207A	1	Yes	Yes	0.98	400	27.64	13.82
111	207B Center	1	Yes	No	10.43	400	2.61	1.30
111	207B Center	2	Yes	No	9.26	400	2.93	1.46
113	207B North	1	Yes	Yes	1.42	400	19.19	9.59
113	207B North	2	Yes	Yes	1.87	400	14.55	7.28
115	207B South	1	No	Yes	0.63	400	42.92	21.46
115	207B South	2	No	Yes	4.00	400	6.80	3.40
119	207B Composite		No	Yes	0.47	400	58.24	29.12
119	207B Composite		No	No	5.45	400	4.99	2.49
121	207B Composite	1	Yes	No	5.17	400	5.26	2.63
121	207B Composite	1a	Yes	Yes	1.58	400	17.17	8.58
121	207B Composite	2	Yes	No	6.63	400	4.10	2.05
123	207B Composite	2	Yes	Yes	1.73	400	15.66	7.84
127	207B South		Yes	Yes	0.73	400	37.06	18.53
131	207B South		Yes	Fe	0.42	400	65.29	32.62
133	207B South			Yes	1.72	400	15.83	7.92

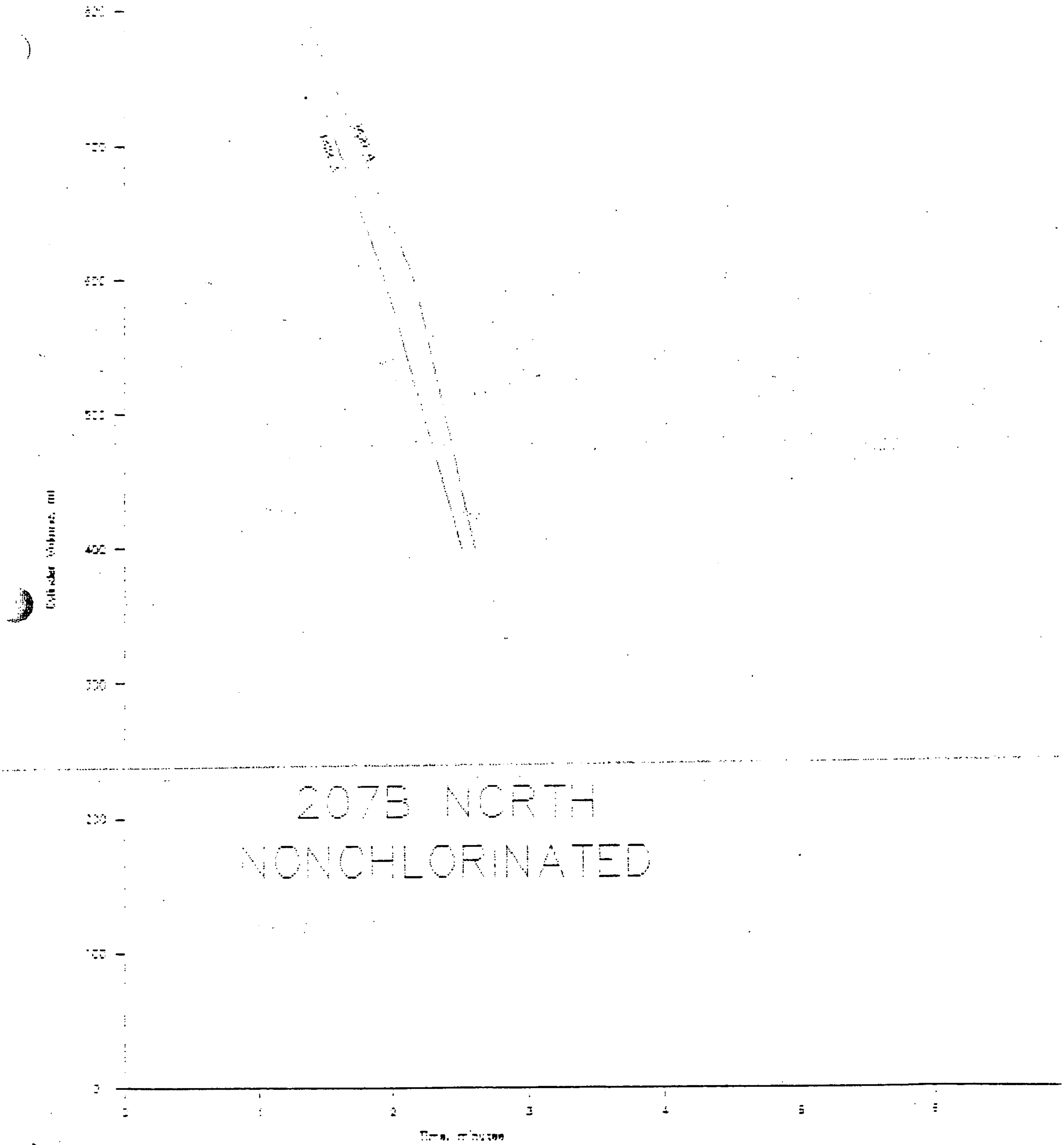


207A
NONCHLORINATED
Cylinder Volume, ml
Time, minutes

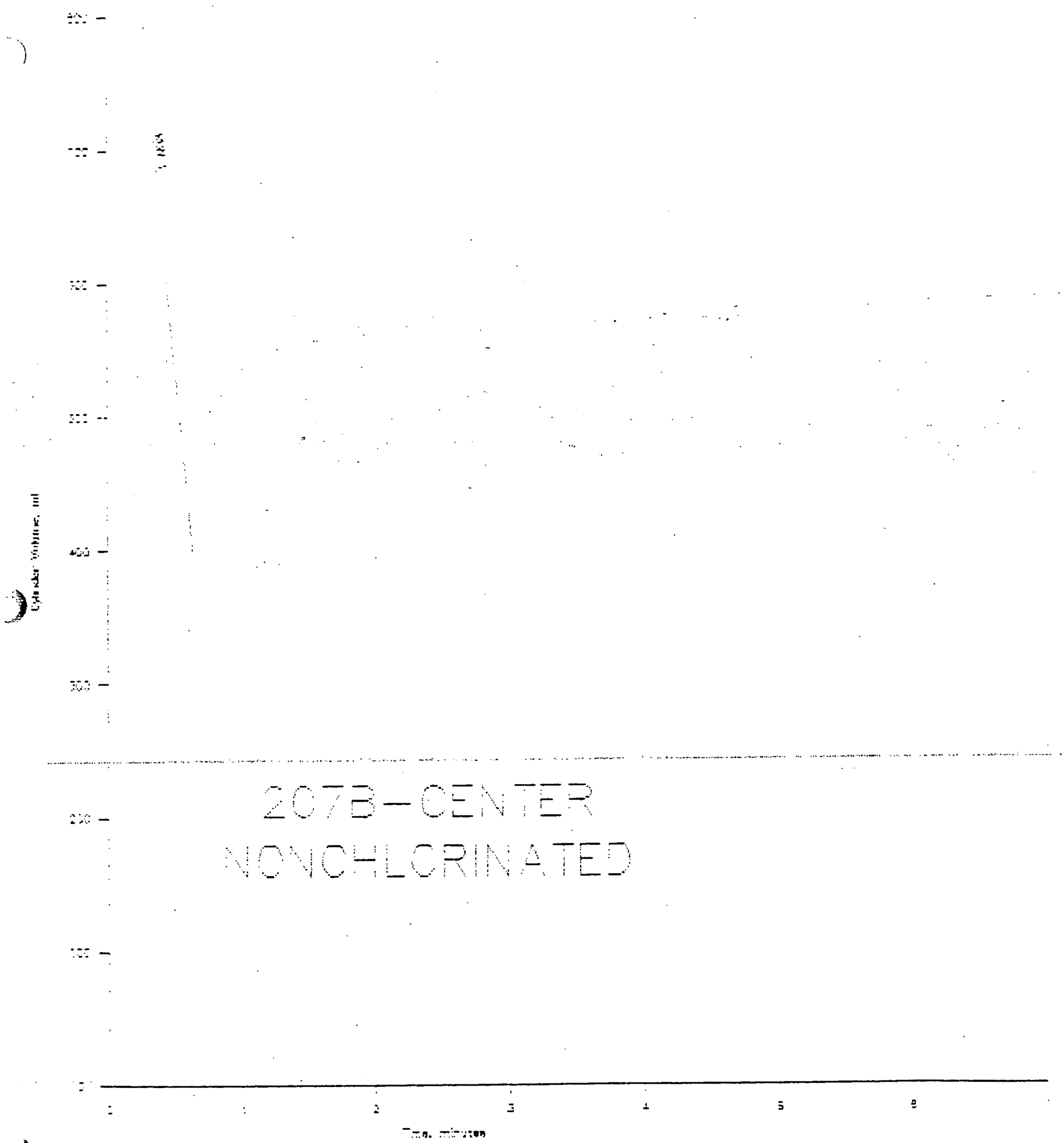

207A
NONCHLORINATED
700
600
500
400
300
200
100
0
1
2
3
4
5
Time, minutes

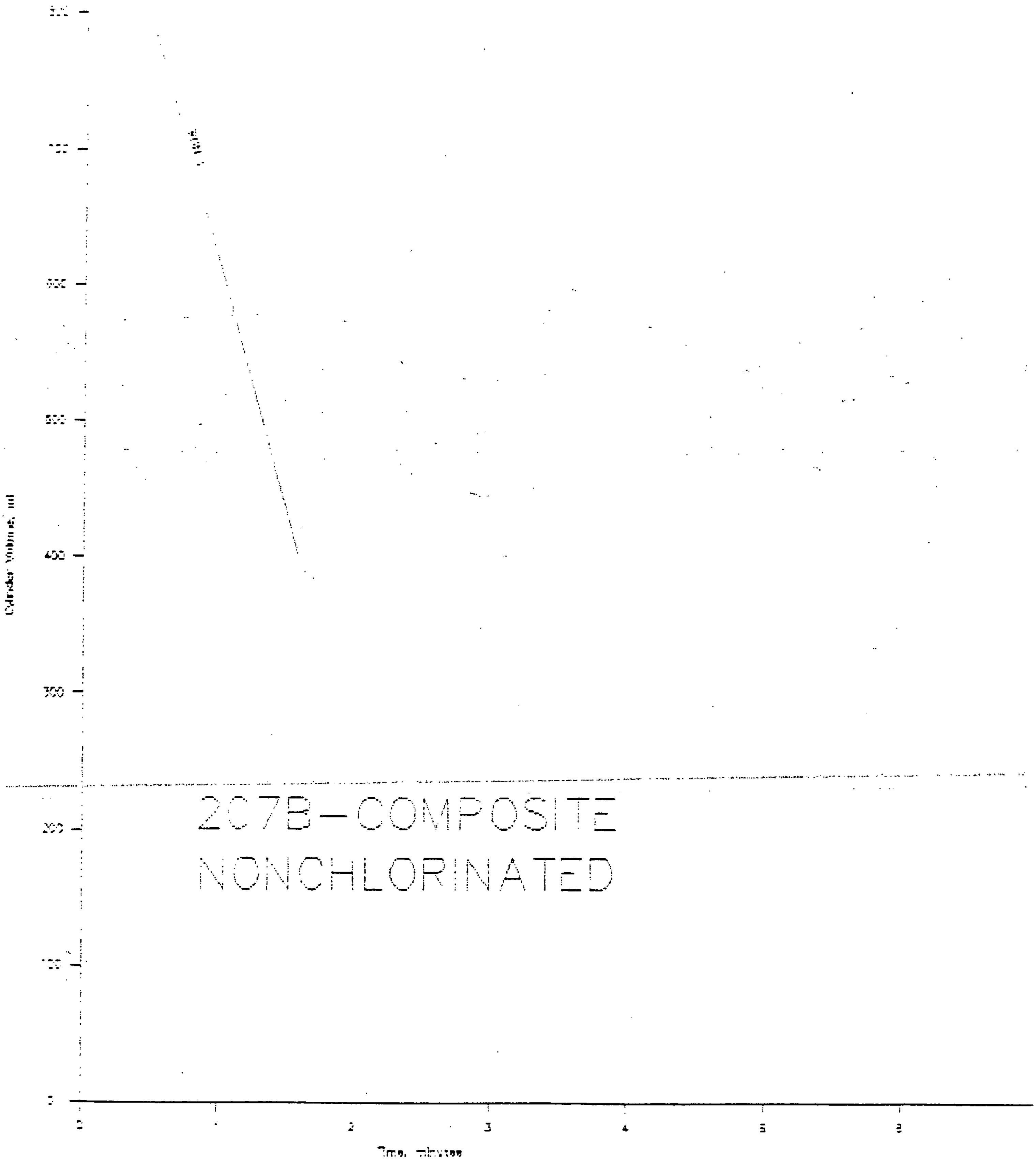


207B NORTH
NONCHLORINATED
800
700
600
500
400
300
200
100
0
1
2
3
4
5
Time, minutes

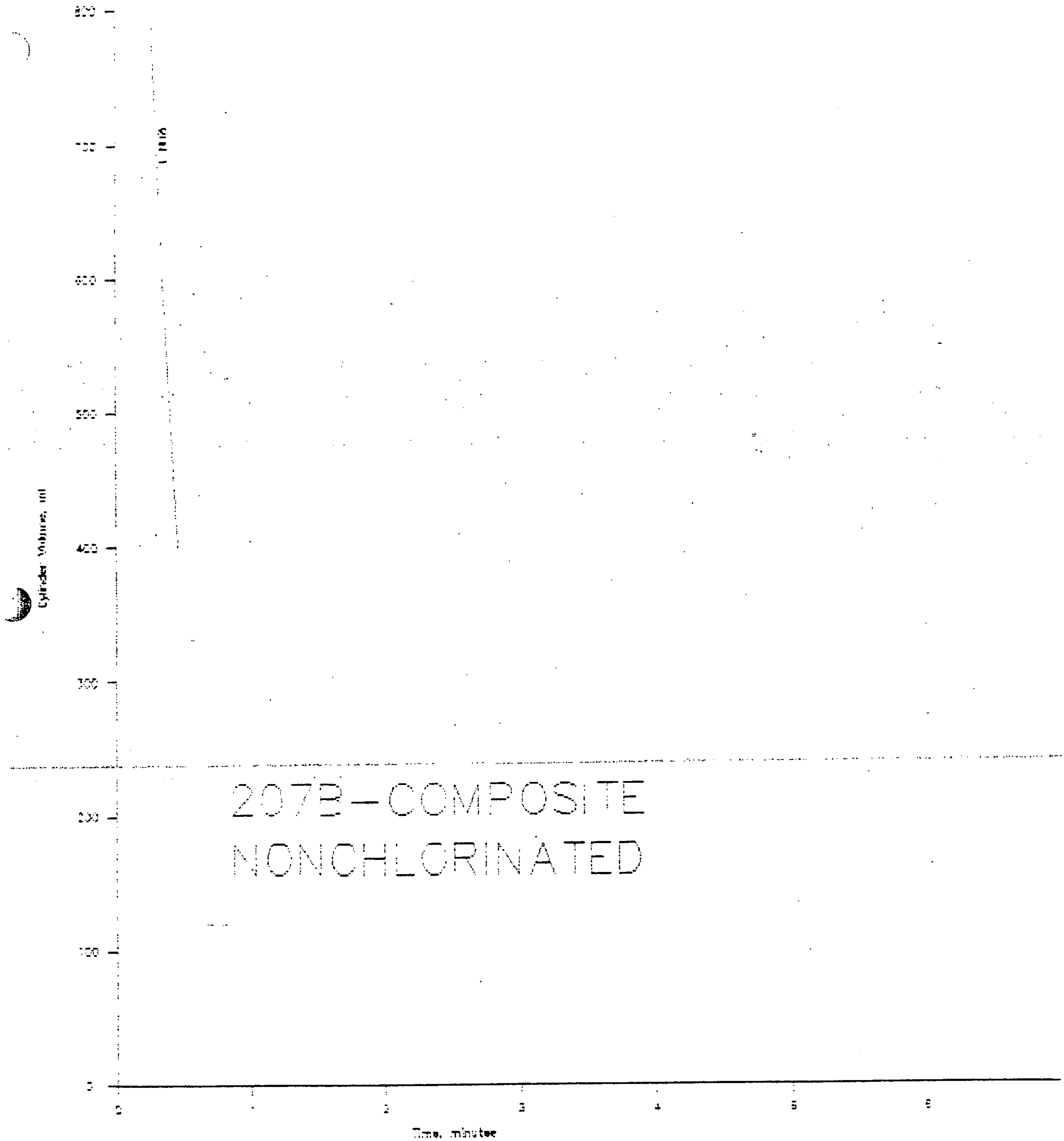


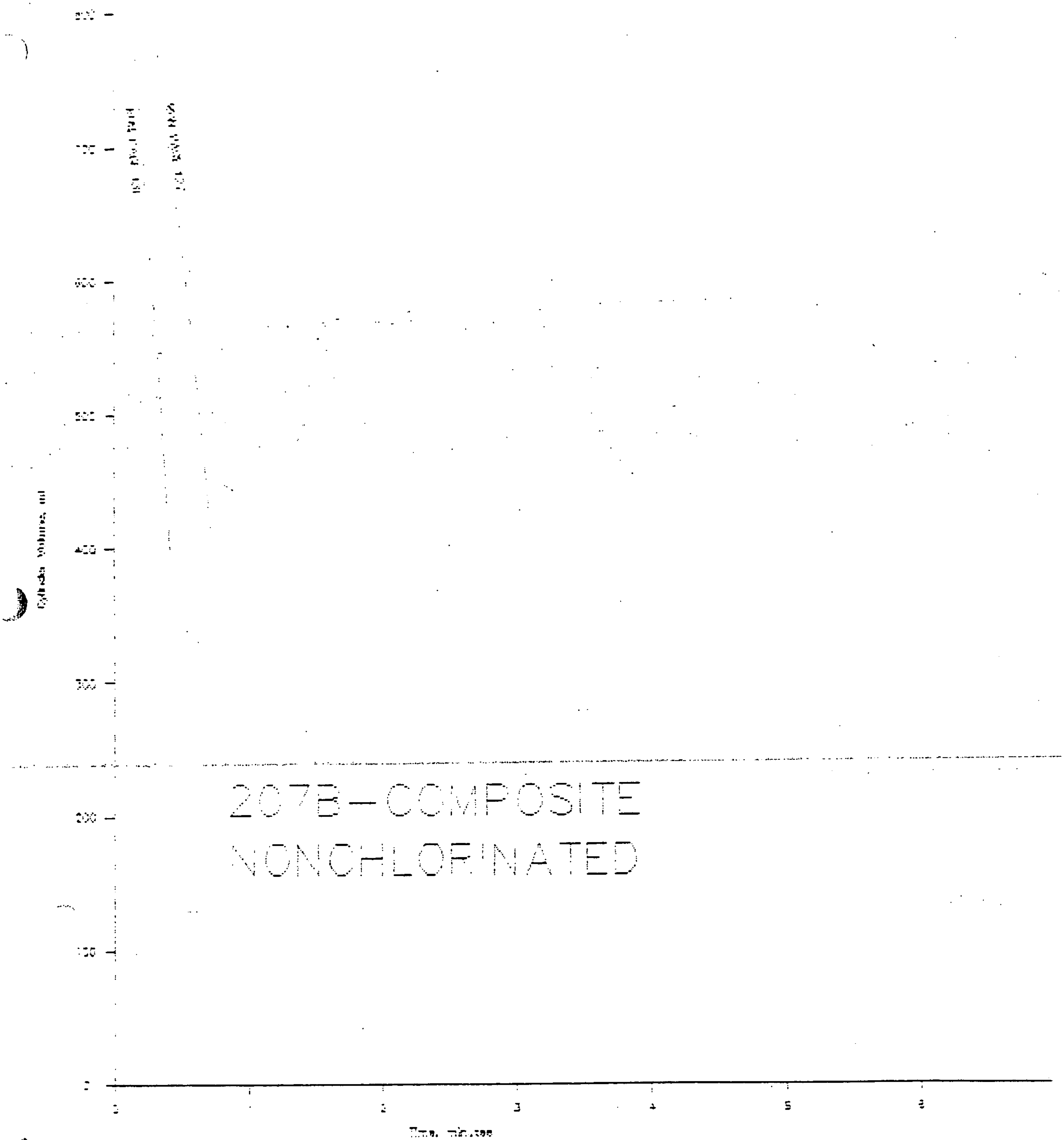
207B NORTH
NONCHLORINATED
400
2
3
4

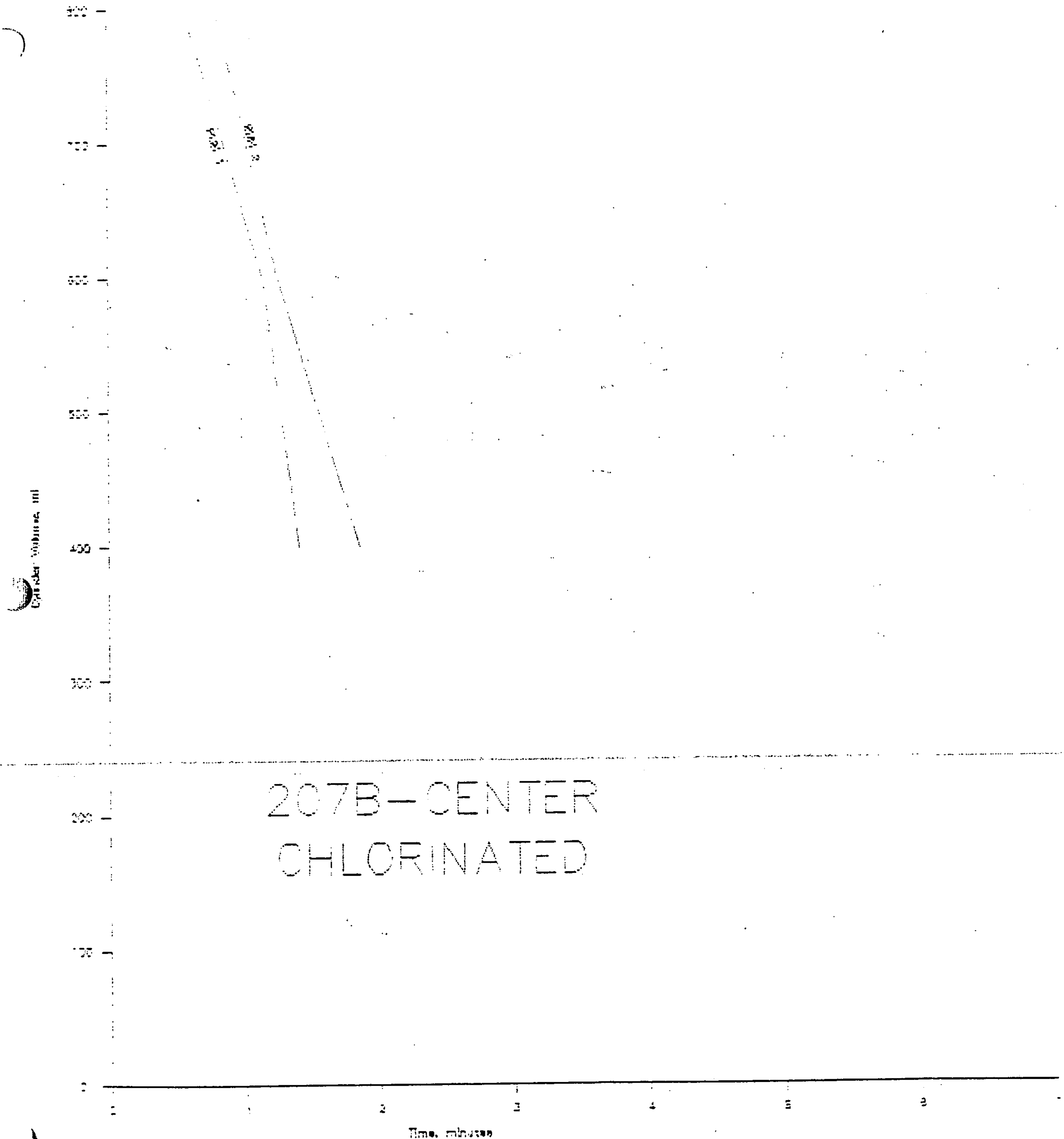

207B—CENTER
NONCHLORINATED

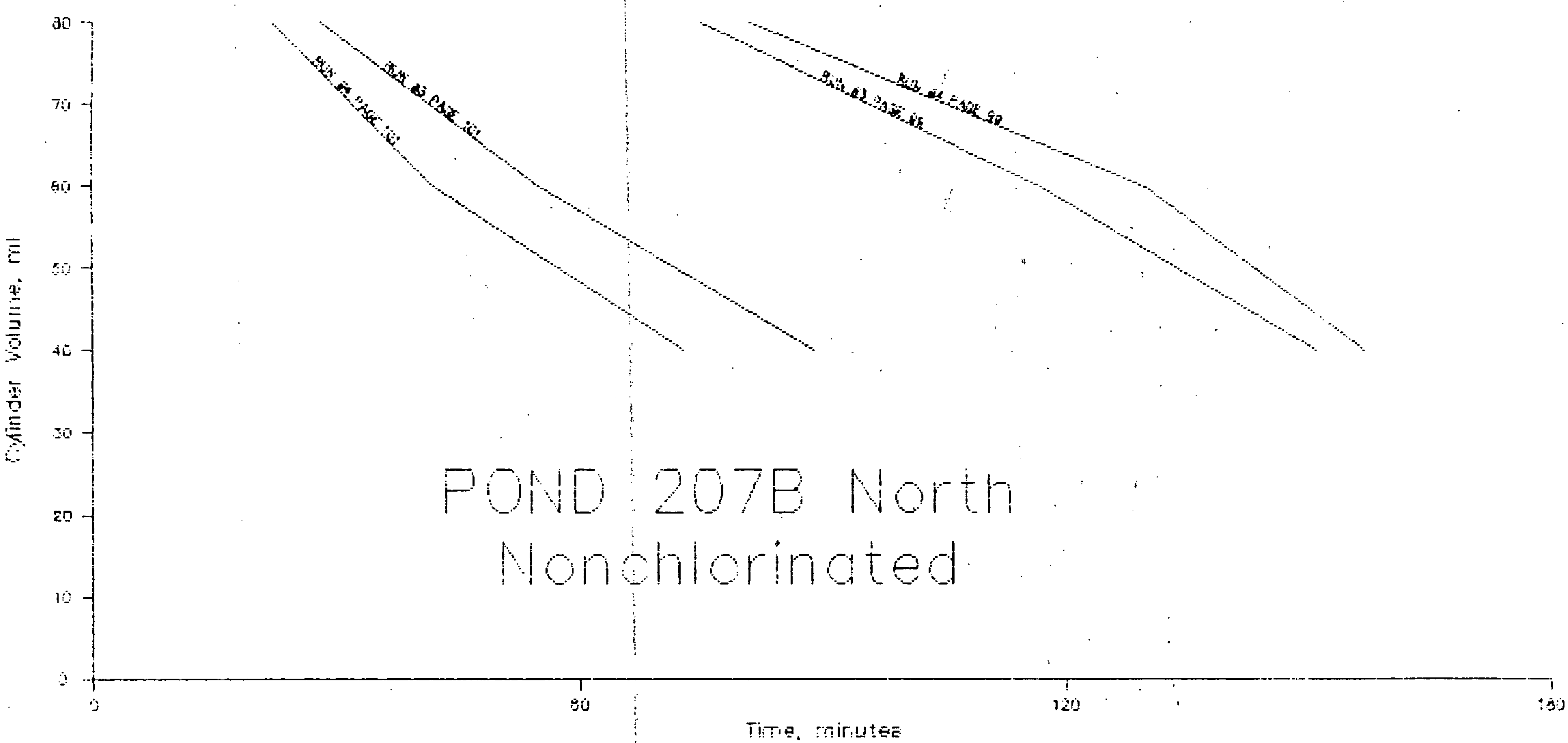


2C7B-COMPOSITE
NONCHLORINATED

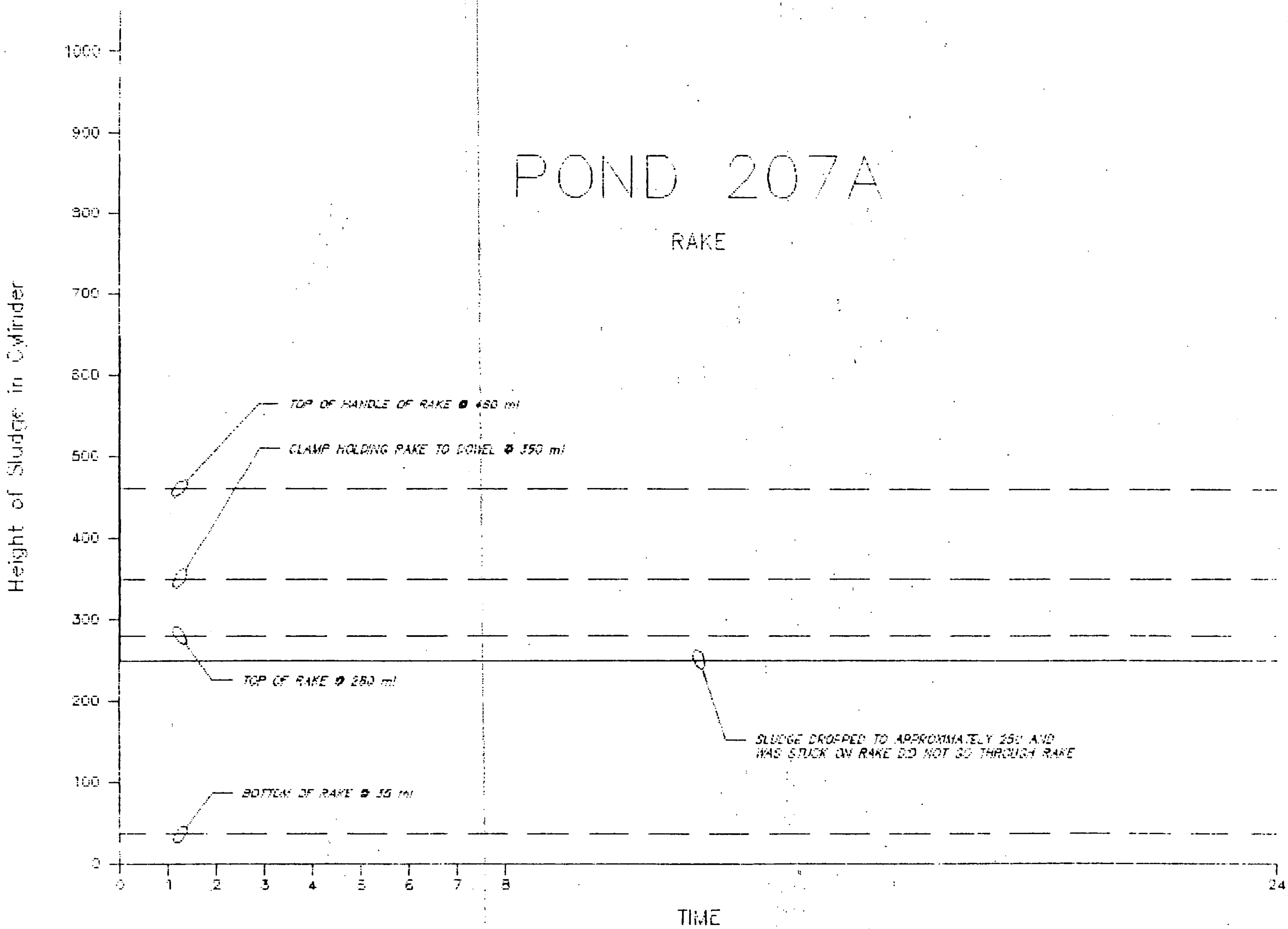

Cylinder Volume, ml
800
700
600
500
400
300
200
100
0
Time, minutes
0
1
2
3
4
5
6
207B—COMPOSITE
NONCHLORINATED

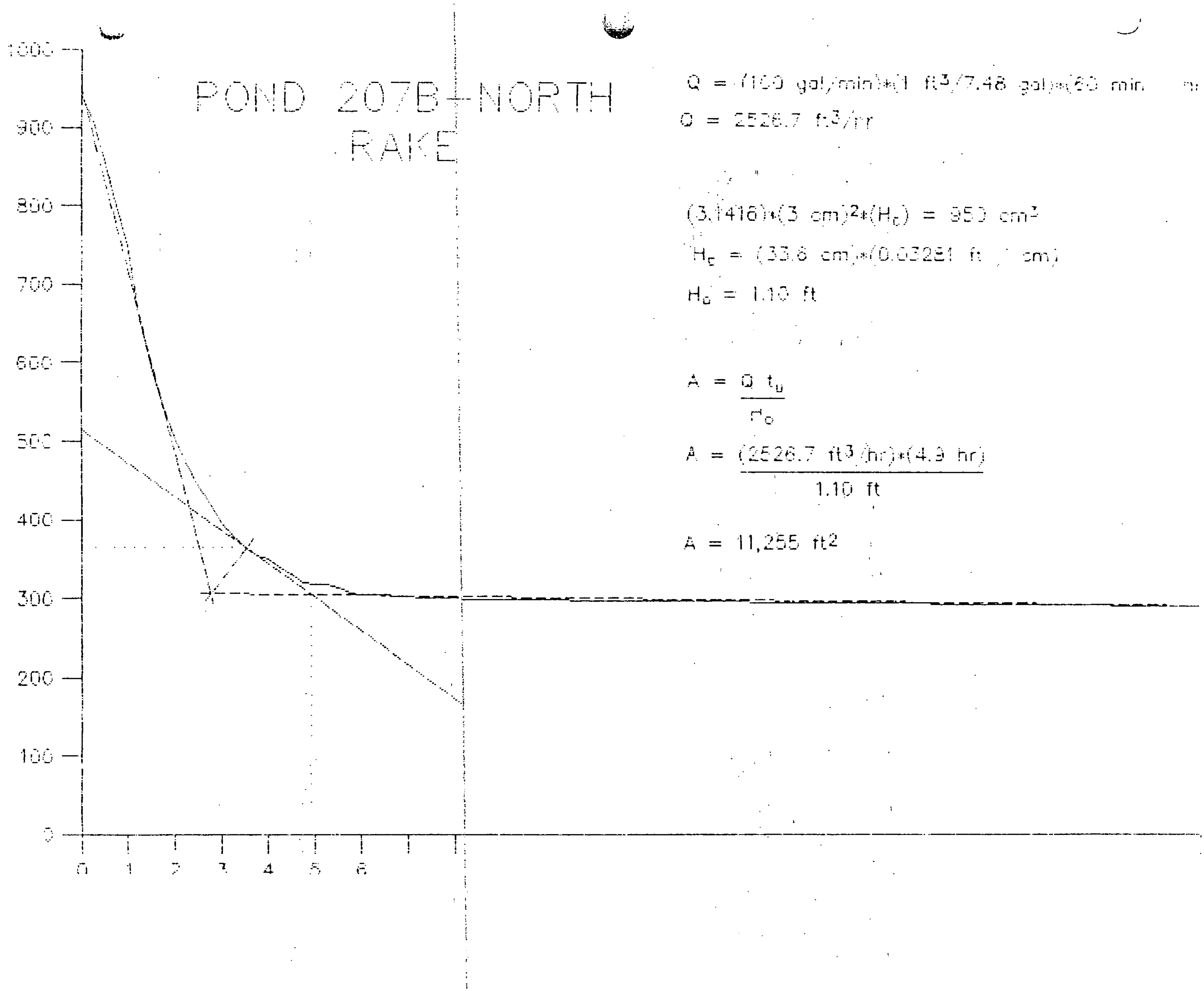

207B-COMPOSITE
NONCHLORINATED


500
400
300
200
0
2
3
4
5
6
Time, minutes
207B—CENTER
CHLORINATED


POND 207B North
Nonchlorinated
Cylinder Volume, ml
Time, minutes
0
10
20
30
40
50
60
70
80
0
60
120
180

THICKENING TEST DATA


POND 207A
RAKE
TOP OF HANDLE OF RAKE @ 460 ml
CLAMP HOLDING RAKE TO DOWEL @ 350 ml
TOP OF RAKE @ 280 ml
BOTTOM OF RAKE @ 35 ml
SLUDGE DROPPED TO APPROXIMATELY 250 AND
WAS STUCK ON RAKE DID NOT GO THROUGH RAKE
Height of Sludge in Cylinder
0
100
200
300
400
500
600
700
800
900
1000
TIME
0
1
2
3
4
5
6
7
8
24



$Q = (160\ gal/min)*(1\ ft^3/7.48\ gal)*(60\ min$

$Q = 2526.7\ ft^3/hr$

$(3.1416)*(3\ cm)^2*(H_c) = 950\ cm^3$

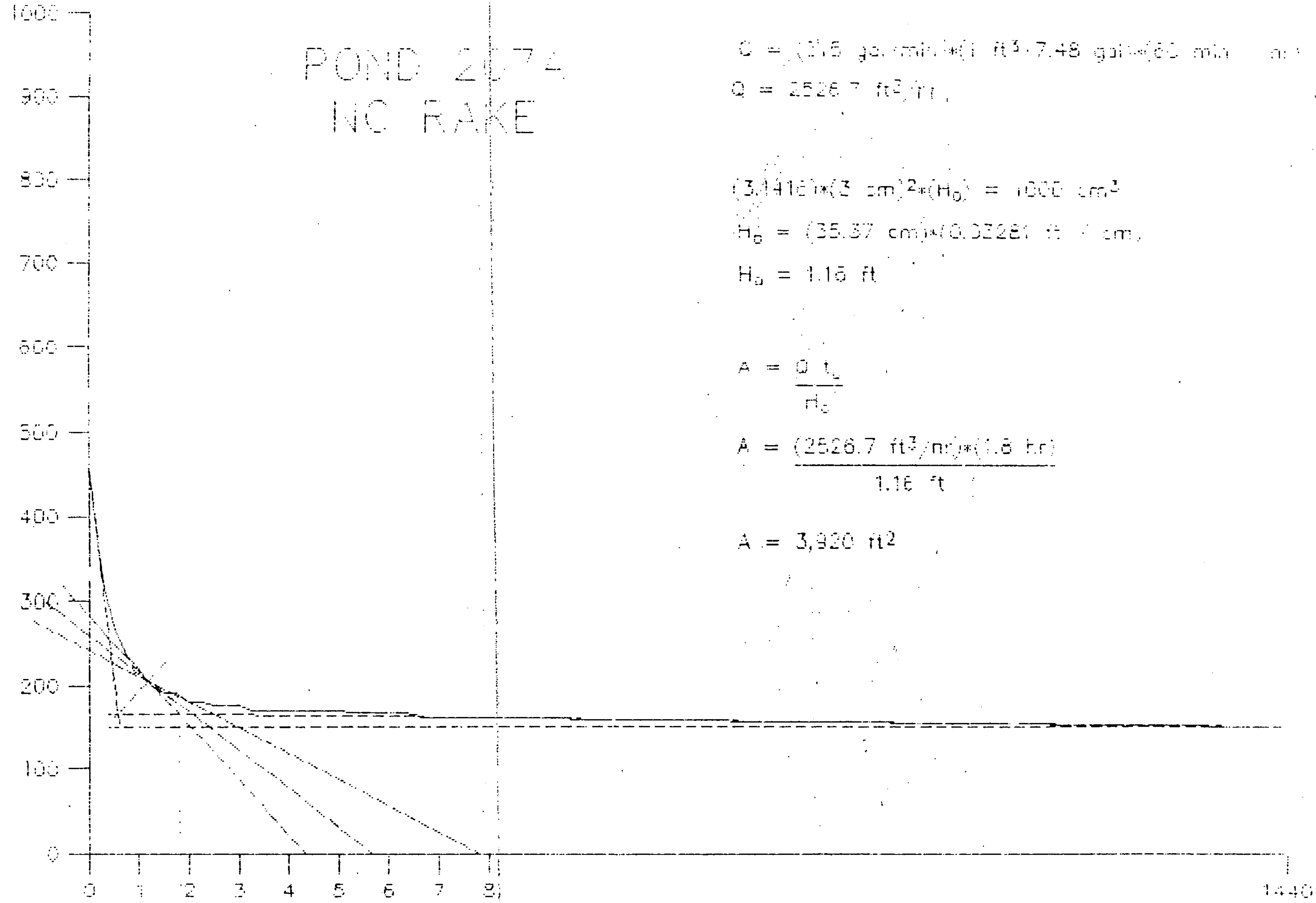
$H_c = (33.6\ cm)*(0.03281\ ft\ /\ cm)$

$H_o = 1.10\ ft$

$$A = \frac{Q\ t_u}{H_o}$$

$$A = \frac{(2526.7\ ft^3/hr)*(4.9\ hr)}{1.10\ ft}$$

$A = 11{,}255\ ft^2$



$Q = (315\ \text{gal/min})*(1\ \text{ft}^3/7.48\ \text{gal})*(60\ \text{min/hr})$

$Q = 2526.7\ \text{ft}^3/\text{hr}$

$(3.1416)*(3\ \text{cm})^2*(H_o) = 1000\ \text{cm}^3$

$H_o = (35.37\ \text{cm})*(0.03281\ \text{ft/cm})$

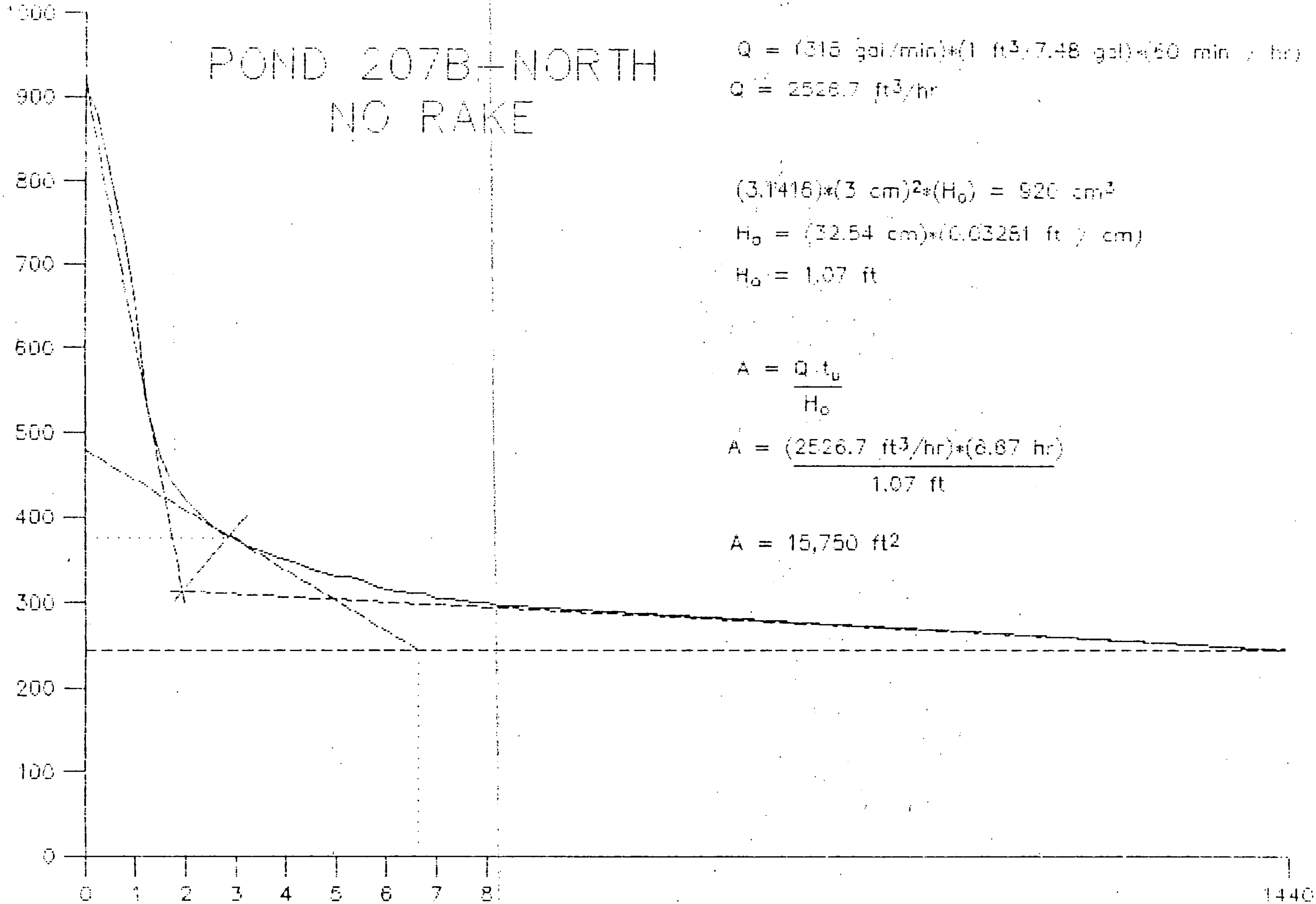
$H_o = 1.16\ \text{ft}$

$$A = \frac{Q\ t_c}{H_o}$$

$$A = \frac{(2526.7\ \text{ft}^3/\text{hr})*(1.8\ \text{hr})}{1.16\ \text{ft}}$$

$A = 3{,}920\ \text{ft}^2$

POND 207B-NORTH
NO RAKE



$Q = (315\ gal/min)*(1\ ft^3/7.48\ gal)*(60\ min\ /\ hr)$

$Q = 2526.7\ ft^3/hr$

$(3.1416)*(3\ cm)^2*(H_o) = 920\ cm^3$

$H_o = (32.54\ cm)*(0.03281\ ft\ /\ cm)$

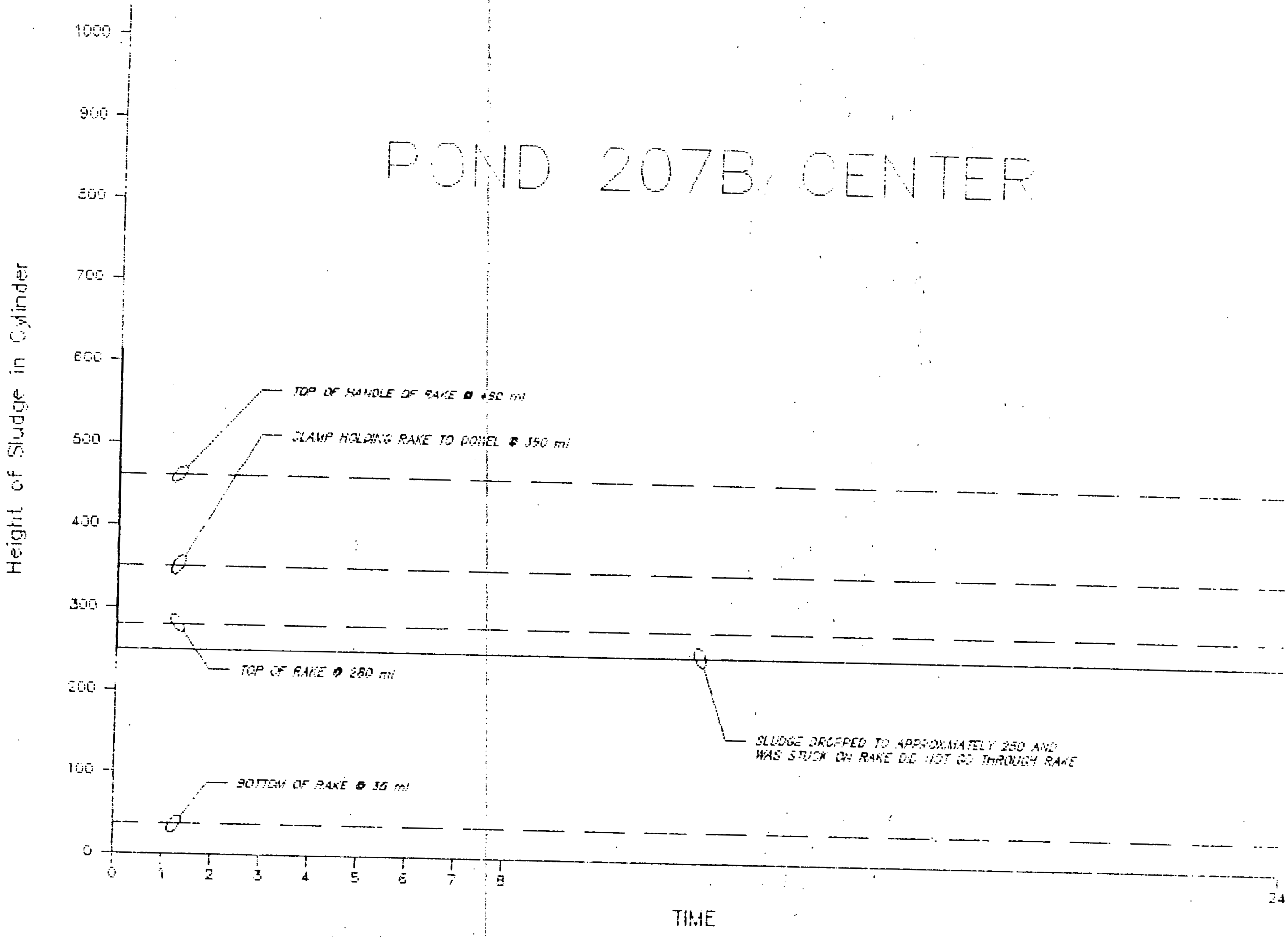
$H_o = 1.07\ ft$

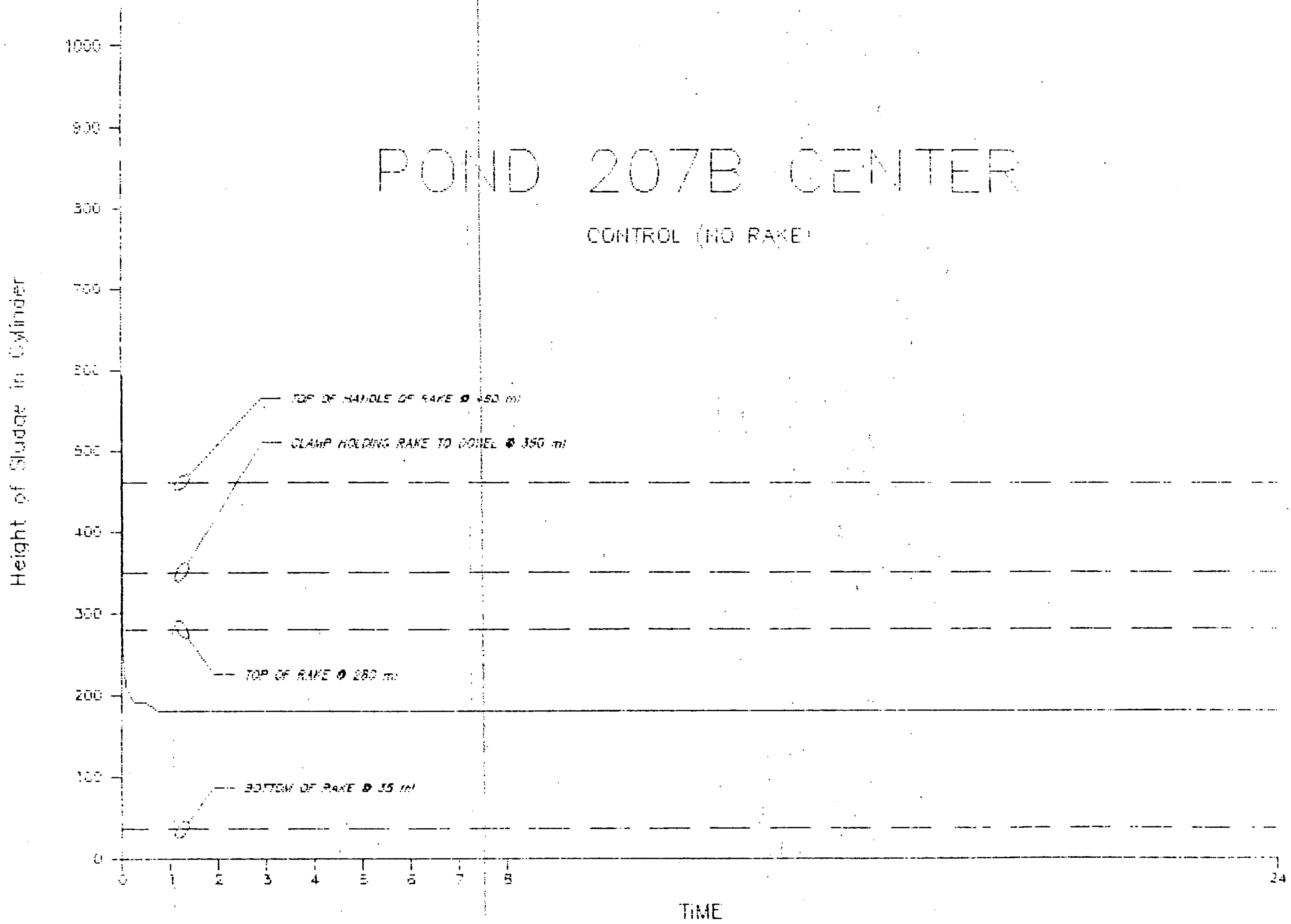
$$A = \frac{Q \cdot t_u}{H_o}$$

$$A = \frac{(2526.7\ ft^3/hr)*(6.67\ hr)}{1.07\ ft}$$

$A = 15,750\ ft^2$

POND 207B, CENTER





POND 207B CENTER
CONTROL (NO RAKE)
TOP OF HANDLE OF RAKE @ 460 ml
CLAMP HOLDING RAKE TO DOWEL @ 350 ml
TOP OF RAKE @ 280 ml
BOTTOM OF RAKE @ 35 ml
Height of Sludge in Cylinder
TIME
0
100
200
300
400
500
600
700
800
900
1000
1
2
3
4
5
6
7
8
24

POND 207B—SOUTH RAKE

$Q = (100\ gal/min)*(1\ ft^3/7.48\ gal)*(60\ min\ /\ hr)$

$Q = 2526.7\ ft^3/hr$

$(3.1416)*(3\ cm)^2*(H_o) = 1030\ cm^3$

$H_o = (38.4\ cm)*(0.03281\ ft\ /\ cm)$

$H_o = 1.19\ ft$

$$A = \frac{Q\ t_u}{H_o}$$

$$A = \frac{(2526.7\ ft^3/hr)*(3.9\ hr)}{1.19\ ft}$$

$A = 8{,}960\ ft^2$