Form 6747-11-B

TECHNICAL REPORT SUMMARY

Date: 8/31/81

TO: TECHNICAL COMMUNICATIONS CENTER – 201-2CN

(Important – If report is printed on both sides of paper, send two copies to TCC.)

Division: Environmental Laboratory (EE & PC)	Dept. Number: 0535
Project: Commercial Chemicals	Project Number: 9970012600
Report Title: Chemical Oxygen Demand of CS-2151	Report Number: 057
To: D. R. Ricker, Commercial Chemicals Division, 53-4N	
Author(s): Eric A. Reiner, Environmental Laboratory/EE & PC, 21-2W-5	Employee Number(s): 47816
Notebook Reference: None (See Environmental Lab Request #6260S)	No. of Pages Including Coversheet:

SECURITY ▶ ☒ Open (Company Confidential) ☐ Closed (Special Authorization)

3M CHEMICAL REGISTRY ▶ New Chemicals Reported ☐ Yes ☒ No

KEYWORDS: (Select terms from 3M Thesaurus. Suggest other applicable terms.)

Chemical Oxygen Demand (COD)
Degradation
Oxidation
EE&PC Div.
Fluorochemical Surfactant

CURRENT OBJECTIVE:

To determine the chemical oxygen demand of CS-2151

REPORT ABSTRACT: (200-250 words) This abstract information is distributed by the Technical Communications Center alert 3M'ers to Company R&D. It is Company confidential material.

The chemical oxygen demand (COD) of CS-2151 was determined in accordance with the Standard Methods reflux method and according to the Standard Ampule COD Method of Oceanography International. The reflux protocol gave a COD of 66,000 mg/kg. The ample method gave a COD of 81,000 mg/kg. Experience with a wide variety of perfluorinated organics has shown that the perfluorinated portions are not oxidized under the conditions of the COD test. The potassium salt of the perfluorinated portion of the subject material was previously tested and showed no chemical oxygen demand. Thus the observed COD appears to be due to the diethanol amine portion of the chemical. The theoretical oxygen dema of CS-2151, assuming complete oxidation of only the diethanolamine portion is 77,000 mg/kg.

Information Liaison Initials: MC

COD OF CS-2151

Introduction

The chemical oxygen demand (COD) test measures the oxygen equivalent of a chemical under strong oxidizing conditions. When compared to theoretical oxygen demand, COD can give an indication of the stability of the component to chemical oxidation. Since most organic compounds are completely degraded in the COD test, this test is frequently used for comparison with the biochemical oxygen demand (BOD) test. For those materials degraded by the COD test, the BOD/COD ratio gives an indication of the completeness of biodegradation.

This report describes the test performed on CS-2151 to evaluate its COD. It provides the data generated in this study and compares the chemical oxygen demand to the theoretical oxygen demand.

Methods and Materials

The 3M Environmental Lab received the test substance on 11/4/80. The sample was a light, yellow liquid. It was reported to contain 25% solids in water. Solid portion of this product is designated CS-2070.

Wade Schiel performed the chemical oxygen demand test in accordance with the standard Environmental Laboratory Protocol (attached) this protocol is based on the Standard Methods chemical oxygen demand procedure. The COD was also measured according to the Oceanography International Standard Ampule COD Method (copy attached). For both procedures, COD's were also run in parallel on potassium hydrogen phthalate (KHP) reference samples.

Results and Discussion

Duplicate determinations by the reflux method gave COD for CS-2151 of 67,000 mg/kg and 66,000 mg/kg. A potassium hydrogen pthalate standard run in parallel with a theoretical COD of 405 mg/l was determined to have a COD of 392 mg/l. Duplicate COD measurements on CS-2151 by the ampule protocol were both 81,000 mg/kg. The parallel standard with a theoretical COD of 176 mg/l was determined to have a COD of 170 mg/l.

Previous studies on FC-98, which is the same fluorochemical except that potassium replaces the diethanolamine, showed that FC-98 had no chemical oxygen demand. Therefore, it appears that the chemical oxygen demand of CS-2151 is due only to oxidation of the diethanolamine portion of the molecule. The theoretical COD of the CS-2151 solids (CS-2070), assuming its fluorochemical portion and NH_3 are not oxidized, is 307,000 mg/kg. Thus, the theoretical COD of CS-2151, which is a 25% aqueous solution is 77,000 mg/kg.

Conclusion

The measured COD values are consistent with the hypothesis that only the diethanolamine portion of the molecule is degraded in the COD test.

Lab Req. No. 6260 (file)

Environmental Lab
Data Sheet
AMPULE
C.O.D.

Date analyzed 12/12/80

Analyst W.G. Silvis

OCEANOGRAPHY INTERNATIONAL
COD PROCEDURE

Spec. 20 No. 1-600 nm Blank % T 100
red bulb & red filter

Sample Description		ml Sample	Dilution Factors	% T	Graph Readout	C.O.D. mg/l
6260	1	2.161g → 100ml 1.0ml	$\frac{100}{2.161} \times \frac{2.5}{1.0}$	44.5	696	81,000 mg/kg
"	2	2.161g → 100ml 1.0 ml	$\frac{100}{2.161} \times \frac{2.5}{1.0}$	44.5	696	81,000 mg/kg
6300	3	1.007g → 100ml 1.0 ml	$\frac{100}{1.007} \times \frac{2.5}{1.0}$	30	TOO LARGE SAMPLE SIZE >900	
"	4	1.007g → 100ml 0.5ml	$\frac{100}{1.007} \times \frac{2.5}{0.50}$	39.1	810 ~~806~~ w/s 12/12/80	400,000 mg/kg
6363	5	1.039 → 100ml 0.50	$\frac{100}{1.039} \times \frac{2.5}{0.50}$	49.0	610	290,000 mg/kg
"	6	1.039 → 100ml 1.0	$\frac{100}{1.039} \times \frac{2.5}{1.0}$	24 (* TURBIDITY)	TOO LARGE SAMPLE SIZE >900	>220,000 IN MIXTURE
STD #35 T.V. = 176 mg/l	7	2.5	—	81.5	170	170 mg/l

Form 674711 B

TECHNICAL REPORT SUMMARY

Date: 8/31/81

TO: TECHNICAL COMMUNICATIONS CENTER – 201-2CN

(Important – If report is printed on both sides of paper, send two copies to TCC.)

Division: Environmental Laboratory (EE & PC)	Dept. Number: 0535
Project: Commercial Chemicals Division	Project Number: 9970012600
Report Title: Biodegradation of CS-2151 (CS-2070)	Report Number: 058
To: Don Ricker, Commercial Chemicals Division, 53-4N	
Author(s): Eric A. Reiner, Environmental Laboratory(EE & PC), 21-2W-5	Employee Number(s): 47816
Notebook Reference: None (see Lab Request #6260S)	No. of Pages Including Coversheet:

SECURITY ▶ ☒ Open (Company Confidential) ☐ Closed (Special Authorization)

3M CHEMICAL REGISTRY ▶ New Chemicals Reported ☐ Yes ☒ No

KEYWORDS: (Select terms from 3M Thesaurus. Suggest other applicable terms.)

Biodegradation
EE&PC Div.
(Env. Lab)
BOD
Fluorochemical
Surfactant

CURRENT OBJECTIVE:

To evaluate the susceptibility of CS-2151 to biodegradation.

REPORT ABSTRACT: (200-250 words) This abstract information is distributed by the Technical Communications Center to alert 3M'ers to Company R&D. It is Company confidential material.

A 20-day biochemical oxygen demand (BOD_{20}) test using concentrations of CS-2151 ranging from 68 to 540 mg/l gave a BOD_{20} for CS-2151 of 69,400 mg/kg (278,000 mg/kg for CS-2070). Oxygen demand is presumed to be due to the diethanolamine portion of the molecule since a previously conducted BOD_{20} test on the sodium salt of the fluorochemical portion of CS-2151 showed no oxygen uptake. The BOD_{20} was equivalent to 90% of the theoretical oxygen demand for the diethanolamine portion of the molecule assuming its complete conversion to CO_2, H_2O, and NH_3. The possibility of partial degradation of the fluorochemical portion of CS-2151 cannot be eliminated by this testing. However, experience with a wide variety of similar compound indicates that the perfluorinated portion of this molecule will not biodegrade.

Information Liaison Initials: MC

BIOCHEMICAL OXYGEN DEMAND OF CS-2151

Introduction

The objective of this study was to obtain an indication of the biodegradability of CS-2151, which is the diethanolamine salt of perfluoro ethylcyclohexane sulfonic acid. Its intended use is as a surfactant for mist suppression in anodizing, electroplating, and etching baths. As a result of these uses, it will be dragged out with parts and will enter the environment with the water used to rinse these parts. When used in strong-acid, etching systems, the ethanolamine portion of the molecule would likely be partially or completely oxidized prior to its entry into the environment.

Methods and Materials

The Environmental Laboratory received the test sample on 11/4/80. The sample was a light, yellow liquid. It was reported to contain 25% solids in water. W. A. Schiel and M. Roberts performed the 5, 10, and 20-day biochemical oxygen tests according to the attached standard Environmental Laboratory protocol. In this testing, four concentrations were used ranging from 68 to 540 mg of CS-2151 per liter of BOD dilution water. There was little oxygen depletion during the first five days, but at 10 and 20 days only the BOD bottle containing 68 mg/l of CS-2151 contained greater than 0.5 mg/l of oxygen residual. The oxygen depletion due to the samples is shown in Table 1 below:

Table 1 - Oxygen depletion due to CS-2151 (i.e., oxygen depletion in sample bottle corrected for oxygen depletion due to seed and water).

CS-2151 Conc.(mg/l)	Oxygen Depletion Due to Sample(mg/l)		
	Day 5	Day 10	Day 20
68	0.06	4.17	4.69
140	0.16	>7.65	--
270	0.20	>7.65	--
540	0.31	>7.6	--

When there is less than 2 mg/l oxygen depletion, the Environmental Laboratory Protocol calls for reporting BOD as less than the BOD value which would have been calculated if the highest test material concentration had shown an oxygen depletion of 2 mg/l. The 5-day BOD was thus reported to be less than 3,700 mg/kg. The BOD at 5 and 10 days was calculated based on the oxygen depletion of the 68 mg/l culture in accordance with the attached protocol. The reported BOD values are, therefore:

BOD_5 - <3,700 mg/kg

BOD_{10} - 62,000 mg/kg

BOD_{20} - 69,000 mg/kg

BOD tests have also been done on the potassium salt of perfluoro ethylcyclohexane sulfonic acid. The 20-day BOD was found to be less than 3,800 mg/l. These results indicate that under these conditions that the perfluorinated portion of the molecule is unlikely to degrade. Assuming no nitrification and no biodegradation of perfluorinated portion of the molecule, the theoretical biochemical oxygen demand would be 77,000 mg/kg (307 mg/kg for the 100% solids material). The observed BOD value was, thus, 90% of the theoretical assuming that only the diethanolamine was biodegraded. Since BOD values rarely reach theoretical oxygen demand, these results indicate essentially complete degradation of the diethanolamine portion of the molecule.

Discussion

The results of this testing when evaluated in conjunction with BOD results on the potassium salt of the fluorochemical portion of this molecule indicate that the fluorochemical portion of the molecule would not biodegrade under the test conditions, while the diethanolamine portion would be completely degraded. The 20-day biochemical oxygen demand test (BOD_{20}) is a test for ready biodegradability. This test alone cannot exclude the possibility that the fluorochemical portion of the molecule may biodegrade after longer periods of acclimation or under more favorable conditions. Such degradation is, however, very unlikely. Literature studies conducted on an ongoing basis for several years have not uncovered articles that describe the biodegradation of a completely perfluorinated organic material. The 3M Environmental Laboratory has also not seen the biodegradation of any 3M perfluorinated organic materials.

Environmental Laboratory
BOD Work Sheet - Samples

3M

Lab Req. No. ▶ 6260 S		BOD Run No. ▶ 80-37	
Analyst: Wade A. Schiel	Date Started: 11-14-80	5 - Day BOD Readings	
M. Roberts		Analyst: W. A. Schiel	Date: 11-19-80

Sample Description: [redacted] 11-18-80 W.A.Schiel CS2151, LIQUID FORM

Initial Dilution: 2.03 grams of Sample diluted to 100 ml with DI water

Initial Dilution Factor: _____ (Dilution factor = 1 if undiluted)

Bottle No.	Conc. of Sample[1]	Sample Size[2]	Initial D.O. (D_1)	Present D.O. (D_2)	Total D.O. Depletion ($D_1 - D_2$)	Depletion Due To Sample #4	Depletion Due To Sample #5	5-Day BOD #4	5-Day BOD #5	5-Day Average BOD
123	68	1.0	8.75	8.55	0.20	0.06	0.12			
81	140	2.0	8.75	8.45	0.30	0.16	0.22			
6	270	4.0	8.75	8.35	0.40	0.26	0.32			
72	540	8.0	8.70	8.25	0.45	0.31	0.37		→	

Report — ~~37,000~~ mg/kg < 3,700 EAR 8-27-81

Note: 1. Conc. = Concentration of sample (ml/l or mg/l) in BOD bottles.

2. Sample Size = ml or g of sample or diluted sample added to BOD Bottle.

Comments: SAVE BOTTLES IF THERE IS ANY SIGNS OF DEGRADATION.

Form 19756 PWO

Environmental Laboratory
BOD Work Sheet - Samples

3M

Lab Req. No. ▶ 6260 S		BOD Run No. ▶ 80-37	
Analyst: Wade A. Schiel	Date Started: 11-14-80	10 - Day BOD Readings	
M. Roberts		Analyst: W. A. Schiel	Date: 11-24-80

Sample Description: [redacted] 11-18-80 W.A.Schiel CS2151, LIQUID FORM

Initial Dilution: 2.03 grams of Sample diluted to 100 ml with DI water

Initial Dilution Factor: _____ (Dilution factor = 1 if undiluted)

Bottle No.	Conc. of Sample[1]	Sample Size[2]	Initial D.O. (D_1)	Present D.O. (D_2)	Total D.O. Depletion ($D_1 - D_2$)	Depletion Due To Sample #4	Depletion Due To Sample #5	10 - Day BOD #4	10 - Day BOD #5	Average 10 - Day BOD
123	68	1.0	8.75	3.95	4.8	4.17	4.23	62,000	63,000	as mg/kg
81	140	2.0	8.75	<0.5						
6	270	4.0	8.75	<0.5 *						
72	540	8.0	8.70	<0.5 *						

Reported values.

Note: 1. Conc. = Concentration of sample (ml/l or mg/l) in BOD bottles.

2. Sample Size = ml or g of sample or diluted sample added to BOD Bottle.

Comments

SAVE BOTTLES IF THERE IS ANY SIGNS OF DEGRADATION.

* After taken the 10-day DO readings, the DO of each of these bottles was raised to 4.4.

Form 19756 PWO

Environmental Laboratory
BOD Work Sheet - Samples

3M

Lab Req. No. ▸ 6260 S		BOD Run No. ▸ 80-37	
Analyst: Wade A. Schiel	Date Started: 11-14-80	20 - Day BOD Readings	
M. Roberts		Analyst: W. A. Schiel	Date: 12-4-80

Sample Description: [redacted] 11-18-80 W.A.Schiel CS2151, LIQUID FORM

Initial Dilution: 2.03 grams of Sample diluted to 100 ml with DI water

Initial Dilution Factor: (Dilution factor = 1 if undiluted)

Bottle No.	Conc. of Sample[1]	Sample Size[2]	Initial D.O. (D_1)	Present D.O. (D_2)	Total D.O. Depletion ($D_1 - D_2$)	Depletion Due To Sample #4	Depletion Due To Sample #5	20 - Day BOD #4	20 - Day BOD #5	Report Average 20 - Day BOD #4	Report Average 20 - Day BOD #5
123	68	1.0	8.75	2.90	5.85	4.69	4.97	69,400	73,400	69,000 mg/kg	73,500 mg/kg
81	140	2.0	8.75	<0.5							
6	270	4.0	8.75	<0.5 *	3 see 10 day						
72	540	8.0	8.70	<0.5 *	3 readings						

Note: 1. Conc. = Concentration of sample ~~(ml/l or~~ (mg/l) ~~)~~ in BOD bottles.

2. Sample Size = ml or g of sample or diluted sample added to BOD Bottle.

Comments

SAVE BOTTLES IF THERE IS ANY SIGNS OF DEGRADATION.

After the 20-day readings, all of the dilutions were poured into a clean glass jug (1gal). The jug was shaken vigorously vigorously for ~15 sec. to aerate and then incubated @ 20 ± 1°C.

Form 19756 PWO

Lab Requests - 6262 S
6259 S
6260 S
6261 S
6258 S
6263 S

Environmental Laboratory
BOD Work Sheet - Blanks, Controls, and Standards

3M

Lab Request No. ♦ 6210 S (original)		BOD Run No. ♦ 8-37	
Analyst: M. A. Saheil, M. Roberts	Date Started: 11-14-80	5 · Day BOD Readings	
Seed Type & Source: State Sewage Chemolite	Seed Concentration: 6 ml/l	Analyst: M. Roberts	Date: 11/17/80

Nonseeded Dilution - Water Blank

Bottle No.	Initial D.O. (A_1)	Present D.O. (A_2)	D.O. Depletion ($A_1 - A_2$)	Average D.O. Depletion ($\bar{A}_1 - \bar{A}_2$)
69	8.80	8.80	0.00	
93	8.80	8.75	0.05	
22	8.85	8.75	0.10	0.05

Seeded Dilution - Water Blank (optional)

Bottle No.	Initial D.O. (C_1)	Present D.O. (C_2)	D.O. Depletion ($C_1 - C_2$)	Average D.O. Depletion ($\bar{C}_1 - \bar{C}_2$)
55	8.85	8.75	0.10	
25	8.80	8.70	0.10	
71	8.80	8.75	0.05	0.08

Seed Controls

Bottle No.	Sample Size	Initial D.O. (B_1)	Present D.O. (B_2)	D.O. Depletion ($B_1 - B_2$)
839	20	8.70	7.65	1.05
78	40	8.50	6.40	2.10
21	80	8.00	3.75	4.25
3	160	7.20	<0.5	

Glucose - Glutamic Acid Standard 207 ± 20 mg/l

Bottle No.	Sample Size	Initial D.O. (D_1)	Present D.O. (D_2)	Total D.O. Depletion ($D_1 - D_2$)	Depletion Due To Standard #4	Depletion Due To Standard #5	5-Day BOD #4	5-Day BOD #5	Average 5-Day BOD #4	Average 5-Day BOD #5
99	3.0	8.70	6.45	2.25	2.11	2.17	211	217		
68	5.0	8.80	5.05	3.75	3.61	3.67	216	220	220 mg/l	220 mg/l
21	~~7.0~~ 7.1 (AR) 11/14/80	8.70	3.35	5.35	5.31	5.27	220	223		

Potassium Hydrogen Phthalate Standard (optional) (LR# 6260-2)

Bottle No.	Sample Size	Initial D.O. (D_1)	Present D.O. (D_2)	Total D.O. Depletion ($D_1 - D_2$)	Depletion Due To Standard #4	Depletion Due To Standard #5	5-Day BOD #4	5-Day BOD #5	Average 5-Day BOD #4	Average 5-Day BOD #5
88	3.0	8.75	5.60	3.15	3.01	3.07	301	307		
13	5.0	8.75	3.55	5.20	5.06	5.12	304	307	310 mg/l	310 mg/l
5 (AR)	7.0	8.75	1.30	7.45	7.31	7.37	313	316		

other requests - 6262 S
6259 S
6260 S
6261 S
6258 S
6263 S

...ironmental Laboratory
...OD Work Sheet - Blanks, Controls, and Standards

3M

Lab Request No. ▶ 6210 S (original)		BOD Run No. ▶ 8-37	
Analyst: W. A. Sahil, H. Roberts	Date Started: 11-14-80	10 · Day BOD Readings	
Seed Type & Source: Stale Sewage - Chemolite	Seed Concentration: 6 ml/l	Analyst: W. A. Sahil	Date: 11-24-80

Nonseeded Dilution - Water Blank

Bottle No.	Initial D.O. (A_1)	Present D.O. (A_2)	D.O. Depletion ($A_1 - A_2$)	Average D.O. Depletion ($\bar{A}_1 - \bar{A}_2$)
69	8.80	8.30	0.50	
93	8.80	8.30	0.50	
22	8.85	8.30	0.55	0.517

Seeded Dilution - Water Blank (optional)

Bottle No.	Initial D.O. (C_1)	Present D.O. (C_2)	D.O. Depletion ($C_1 - C_2$)	Average D.O. Depletion ($\bar{C}_1 - \bar{C}_2$)
55	8.85	8.25	0.60	
25	8.80	8.25	0.55	
71	8.80	8.25	0.55	0.567

Seed Controls

Bottle No.	Sample Size	Initial D.O. (B_1)	Present D.O. (B_2)	D.O. Depletion ($B_1 - B_2$)
839	20	8.70	7.40	1.30
78	40	8.50	5.65	2.85
21	80	8.00	2.30	5.70
3	160	7.20	—	

Glucose - Glutamic Acid Standard 207±20 mg/l

Bottle No.	Sample Size	Initial D.O. (D_1)	Present D.O. (D_2)	Total D.O. Depletion ($D_1 - D_2$)	Depletion Due To Standard #4	Depletion Due To Standard #5	10/BOD · Day #4	10/BOD · Day #5	Average 10/BOD · Day #4 / #5
99	3.0	8.70	5.90	2.80	2.17	2.24	217	224	#4 / #5
68	5.0	8.80	4.75	4.05	3.43	3.49	206	210	210 / 220
21	7.0 7.1 (#4) 11/14/80	8.70	reading missed was lost 11-24-80						mg/l / mg/l

Potassium Hydrogen Phthalate Standard (optional) (LR# 6260-2)

Bottle No.	Sample Size	Initial D.O. (D_1)	Present D.O. (D_2)	Total D.O. Depletion ($D_1 - D_2$)	Depletion Due To Standard		10/BOD · Day		Average 10/BOD · Day
88	3.0	8.75	5.20	3.55	2.92	2.99	292	299	
13	5.0	8.75	3.05	5.70	5.08	5.14	305	309	300 / 310
54 (#5)	7.0	8.75	0.90	7.85	7.23	7.30	310	313	mg/l / mg/l

other requests – 6268 S
6257 S
6260 S
6261 S
6258 S
6263 S

Environmental Laboratory BOD Work Sheet - Blanks, Controls, and Standards

3M

Lab Request No. ▸ 6210 S (original)		BOD Run No. ▸ 8-37	
Analyst: W. A. Scheil, H. Roberts	Date Started: 11-14-80	20 - Day BOD Readings	
Seed Type & Source: Stale Sewage - Chemolite	Seed Concentration: 6 ml/l	Analyst: W. A. Scheil	Date: 12-4-80

Nonseeded Dilution - Water Blank

Bottle No.	Initial D.O. (A_1)	Present D.O. (A_2)	D.O. Depletion ($A_1 - A_2$)	Average D.O. Depletion ($\bar{A}_1 - \bar{A}_2$)
69	8.80	8.10	0.70	
93	8.80	8.10	0.70	
22	8.85	8.15	0.70	0.70

Seeded Dilution - Water Blank (optional)

Bottle No.	Initial D.O. (C_1)	Present D.O. (C_2)	D.O. Depletion ($C_1 - C_2$)	Average D.O. Depletion ($\bar{C}_1 - \bar{C}_2$)
55	8.85	7.80	1.05	
25	8.80	8.00	0.80	
71	8.80	8.00	0.80	0.883

Seed Controls

Bottle No.	Sample Size	Initial D.O. (B_1)	Present D.O. (B_2)	D.O. Depletion ($B_1 - B_2$)
839	20	8.70	2.90	5.80 ← used for calc
78	40	8.50	< 0.5	
21	80	8.00	< 0.5	
3	160	7.20	—	

Glucose - Glutamic Acid Standard 207 ± 20 mg/l

Bottle No.	Sample Size	Initial D.O. (D_1)	Present D.O. (D_2)	Total D.O. Depletion ($D_1 - D_2$)	Depletion Due To Standard		$\frac{20}{BOD}$ - Day		Average $\frac{20}{BOD}$ - Day	
99	3.0	8.70	5.50	3.20	2.05	2.33	205	233	#4	#5
68	5.0	8.80	2.40	6.40	5.26	5.53	316	332	250	270
21	~~7.0~~ 7.1 (ok) 11/14/80	8.70	2.00	6.70	5.57	5.84	235	247	mg/l	mg/l

Potassium Hydrogen Phthalate Standard (optional) (LR# 6260-2)

Bottle No.	Sample Size	Initial D.O. (D_1)	Present D.O. (D_2)	Total D.O. Depletion ($D_1 - D_2$)	Depletion Due To Standard		$\frac{20}{BOD}$ - Day		Average $\frac{20}{BOD}$ - Day	
88	3.0	8.75	3.20	5.55	4.40	4.68	440	468		
13	5.0	8.75	2.25	6.50	5.36	5.63	322	338	380	400
56 (ok)	7.0	8.75	—						mg/l	mg/l

Form 19755 PWO 11/14/80