USAF ENVIRONMENTAL HEALTH LABORATORY (AFLC)

UNITED STATES AIR FORCE

KELLY AFB, TEXAS 78241

BIODEGRADABILITY AND TOXICITY OF LIGHT WATER® FC206, AQUEOUS FILM FORMING FOAM

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N O T I C E

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I. SUMMARY

Light Water ®, FC206, is an aqueous film forming foam (AFFF) used for fire fighting. Biodegradability studies show that it can be biologically treated in controlled concentrations up to 200 ul/l in synthetic sewage on a continuous basis. Higher concentration appear amenable to treatment in oxidation ponds over long time periods. Toxicity studies with fathead minnow juveniles and fry indicate that FC206 is less toxic than AFFF's previously tested. The 96-hour LC_{50} for fathead minnow juveniles and fry were 1080 ul/l and 170 ul/l respectively. Using a 0.05 application factor, a concentration unit of 54 ul/l is recommended for discharge to any waters containing aquatic life.

II. INTRODUCTION

This is the fourth report on the biodegradability and toxicity of a commercial aqueous film forming foam used to fight fires by the Air Force. The results of studies of Light Water® (FC206) a product of Minnesota Mining and Manufacturing Co., St Paul, Minn, are presented here. The FC206 is used to make a six percent solution for the fire fighting operations. This study was conducted at the request of Hq USAF/SGPA and Hq USAF/PREE.

III. DISCUSSION

A. Composition

Results of analysis at this laboratory are shown in Table 1. The specific gravity of the concentrate is 1.020 with a pH of 7.8.

Table 1. Composition of FC206.

PARAMETER	QUANTITY
Water	~70%
Diethylene Glycol Monobutyl Ether	~27%
Flurocarbon (Structure not Determined)	~ 2%
Sodium Sulfate	~ 1%
Chemical Oxygen Demand	500,000 mg/l
Total Organic Carbon	96,000 mg/l
Surfactants (MBAS as LAS)	41,000 mg/l
Fluorine	14,000 mg/l

B. Respiration Studies

1. Biochemical Oxygen Demand

The need for measurement of biochemical oxygen demand (BOD) over incubation periods in excess of the standard five days has been pointed out by several investigators and reported previously (5). Additionally, incubation at 25°C rather than the standard 20°C allows determination of the Ultimate BOD in a shorter time period without adverse affects on the micro-organism composition although temperatures in excess of 30°C would alter composition (2). Figure 1 is a curve showing the BOD over a 20-day period as measured with the E/BOD Respirometer as previously reported (13). Table 2 is a summary of these E/BOD measurements.

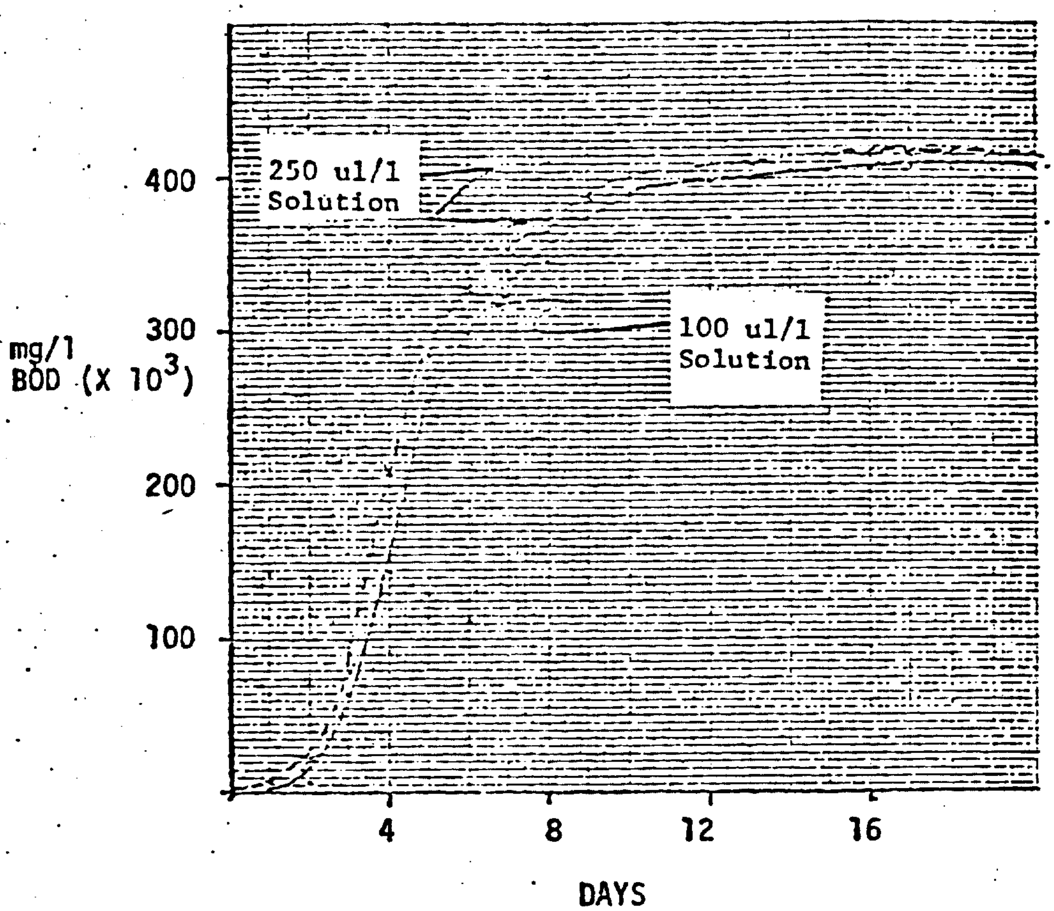


Figure 1. Biological Oxygen Demand as a Function of Time of FC 206 by USAF Environmental Health Laboratory, Kelly AFB TX, 1974.

Table 2. Summary of Data From Measurement of Extended BOD of FC206 at 25°C with the E/BOD Respirometer

	mg/l	Percent of E/BOD_{20}
E/BOD_5	2.68×10^5	65.2
E/BOD_{10}	3.95×10^5	96.1
E/BOD_{15}	4.10×10^5	99.7
E/BOD_{20}	4.11×10^5	

2. Warburg Respirometer Studies

Figure 2 shows the variation in oxygen uptake with respect to concentration of the FC206. Acclimation of the microorganisms can be seen by the increase in oxygen uptake rates at the higher concentrations with respect to time. Since the dilution of FC206 from normal usage is to a six percent solution, oxygen up take was not measured beyond the 10 percent solution.

C. Pilot Plant Studies

1. Two bench-scale activated sludge pilot plants were fed increasing concentrations of FC206 in synthetic sewage of composition shown in Table 3. The plants began to show solids loss at an FC206 concentration of 200 to 225 ul/l. Most of the solids loss appeared to be physical in nature from the foaming action forcing the solids over the side of the reactor. Tables 4 and 5 are summaries of the measured parameters for each plant. Table 6 shows the recovery of solids in the first plant when the FC206 concentration was lowered from 500 ul/l to 200 ul/l.

Table 3. Composition of Synthetic Sewage Used in Biodegradability Studies

Glucose	160	mg/l
Peptone	160	mg/l
Urea	28.6	mg/l
Na HCO_3	102	mg/l
KH_2 PO_4	32.5	mg/l
Tap Water		

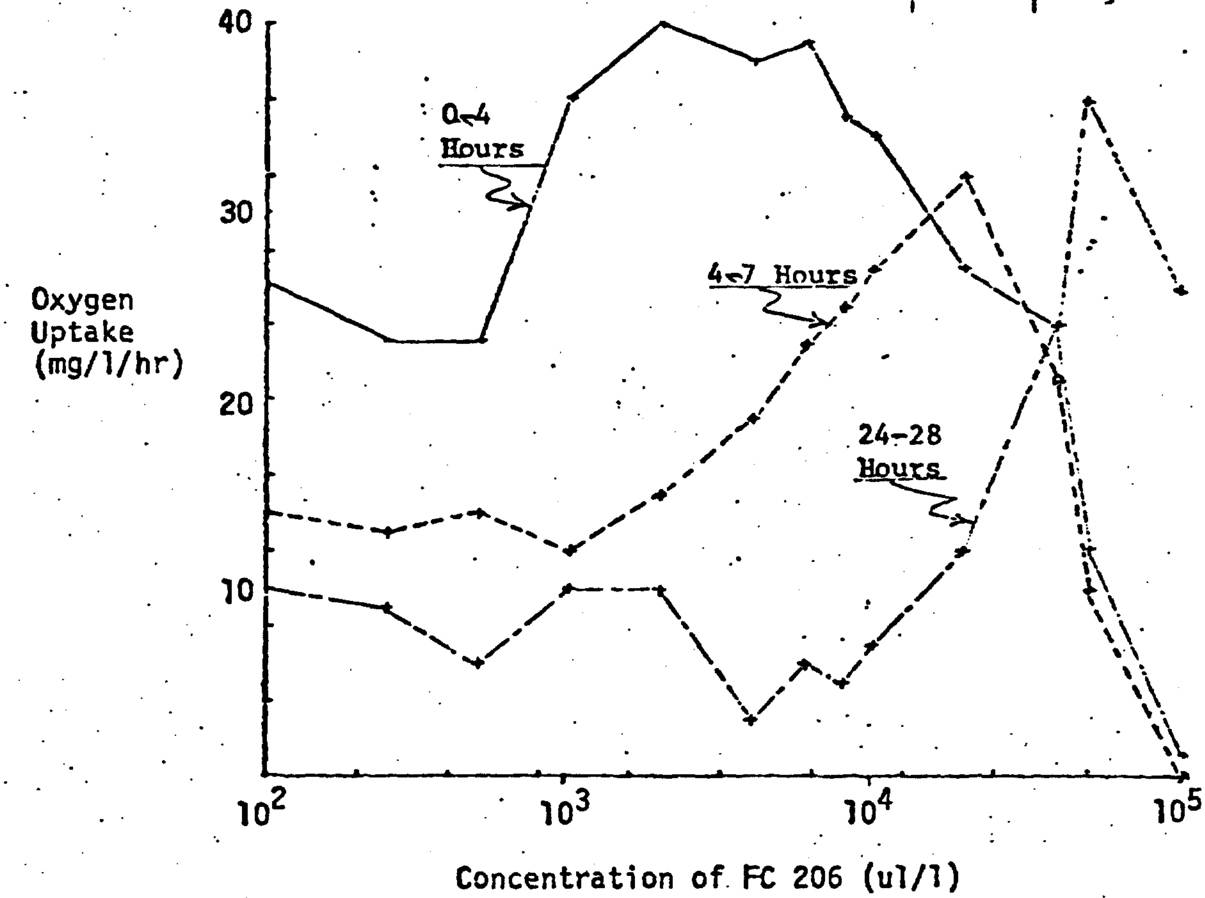


Figure 2. Oxygen Uptake of Varying Concentrations of FC 206 Using the Warburg Respirometer

2. Five Fathead minnows (Pimephales promelas) were placed in each container receiving effluent from each of the plants at the beginning f the study. One fish succumbed in the first plant effluent after 27 days and one in the second plant effluent after 43 days indicating that the effluents were relatively non-toxic. Five giant water fleas (Daphnia magna) were placed in each effluent container on the 36th day and survived to the termination of the study (51 days).

Table 4. Summary of Analysis of Samples From Activated Sludge Pilot Plant No. 1 Receiving FC206 and Synthetic Sewage.

No. of Days	ul/l FC206	mg/l Avg. MLSS	pH Range	D.O. Range mg/l	Percent BOD_5 Removal	Percent TOD Removal
5	50	3045	7.2-7.3	4.0-6.2	97.8	>95.8
3	75	3315	7.1-7.2	4.2-4.4	No Data	>95.4
5	100	3363	7.2-7.3	4.8-5.6	98.9	>95.6
3	200	3587	7.1-7.2	4.0-5.6	98.8	>99
8	300	3016	7.2-7.4	4.0-6.0	92.1	>99
5	400	2685	7.3-7.4	5.8-6.2	97.6	91.5
14	500	1763	7.4-7.8	5.0-7.4	94.8	54.5
1	300	1000	7.7	6.6	17.7	>99
3	200	1513	7.7-8.1	6.0-7.2	85.7	No Data

Table 5. Summary of Analysis of Samples from Activated Sludge Pilot Plant No. 2 Receiving FC206 and Synthetic Sewage.

No. of Days	ul/l FC206	mg/l Avg. MLSS	pH Range	D.O. Range mg/l	Percent BOD_5 Removal	Percent TOD Removal
5	50	2397	7.2-7.5	2.0-6.0	98.0	>96.1
8	75	2648	7.2-7.3	4.8-5.8	98.8	>95.4
3	125	2863	7.3-7.3	4.6-5.6	98.7	>99
8	225	3052	7.2-7.4	4.6-5.4	98.3	>99
5	250	2985	7.0-7.2	4.6-6.0	98.2	>97.9
22	300	2414	7.1-7.4	4.4-7.0	96.5	>98.2

Table 6. Daily Measurement of MLSS in Plant No. 1 From 30th to 51st Days.

Day	ul/l FC206	mg/l MLSS
30	500	2810
31	500	2650
32	500	2820
36	500	840
38	500	1020
39	500	1100
43	500	1100
44	300	1000
45	200	1280
46	200	1460
51	200	1800

D. Toxicity Studies

1. METHODS AND MATERIALS

a. Experimental Animals

Toxicity studies used the fathead minnow (*Pimephales promelas*) to determine the relative toxicity of FC206 solutions -- (Concentrate and pilot plant effluents). Sexually-immature fathead minnows were supplied by the National Fish Hatchery at Uvalde, Texas. The fish were acclimatized to the laboratory conditions and local water for a minimum of 30 days before use. Mean fish weight was 0.913 gm (σ = 0.370). The fish were fed a commercial fish food*. Immature fathead minnow fry used in static bioassays were reared at EHL/K. Age of fry at time of use was 21 days.

b. Exposure Procedure

(1) Continual flow type bioassays used proportional diluting equipment as developed by Mount and Brungs (7) (8). These diluters supplied logarithmic scaled dilutions of the compound being tested to a flow-through chamber for each concentration in which the experimental animals were held. Studies with fry were static bioassays with three fry per each one-liter test concentration.

*Tetramin®, Distributor, Tetra Sales Corp. Heyward, CA 94545.

(2) Bioassays were performed in accordance with principles described in Standard Methods (12) and Sprague (9). Test animals were not fasted prior to testing. They were not fed during the actual assay period. Ten fish were used for each concentration and the control. Exposure chambers were plastic rat cages modified to contain 4 liters of diluted toxicant.

(3) Response of the test animals was recorded throughout a 96-hour test period. Probit analysis was performed on the data recorded at 24, 48, 72 and 96 hours of exposure to evaluate quantal response to graded doses. After the first bioassay, a true 96 hour replicate was performed using the same procedures and concentrations as used in the first run. In all these bioassays the test animals were placed into the exposure chambers in a random order by using a table of random numbers. The chambers themselves were positioned in random order. The control chamber contained water from the same water tank as the water that was used as the diluent in the other test chambers. The flow of diluted toxicant into the chamber was adjusted to a retention time of 2 hours. This is equal to a 6 hour, 95% replacement time and insures adequate maintenance of the dissolved oxygen concentration. The quantal response measured was death. A fish was counted as dead when all gill movement ceased. Dissolved oxygen and pH were monitored to insure that the cause of death was not lack of oxygen or changes in pH.

c. Dilution Water

Unchlorinated well water from a deep well was used as the dilution water in these studies. The water was collected in 400 gallon fiberglas trailer-tanks at an on-base well site. The water trailers were hauled to the Laboratory and allowed to sit at least 24 hours before the water was used. Air was bubbled through the water. The water was adjusted by heating or cooling to 24°C before it was run into the proportional diluter. The pH was 7.2 Hardness (EDTA as mg/l $CaCO_3$) was 194. Total alkalinity (as $CaCO_3$) was 160 mg/l.

d. Treatment use of Data

LC_{50}s* or TL_{50}s were determined by the probit analysis method of Litchfield and Wilcoxon. (6) Other statistical treatments such as the $(CHI)^2$ test for "Goodness of Fit" were by standard formulas. (3) To be used in this report and the previous reports on Fire-Fighting foam chemicals, toxicity study results had to fulfill two important criteria. 1) Graded quanted responses had to definitively relate to the logarithms of serial dilutions in each test chamber. 2) the results had to be repli-

*LC_{50}, or Lethal Concentration 50%, is a concentration value statistically derived from the establishment of a dose-related response of experimental organisms to a toxicant. The LC_{50} represents the best estimation of the dose required to produce death in 50% of the organisms. Note that a more toxic chemical has a smaller LC_{50}. The time period for which the 50% response was derived must also be indicated.

cable. The establishment of dose-effect and time-effect relationships allowed scientifically based predictions of the ecological effects of the tested chemicals on a body of water during use, accidental spillage or disposal. Also the relative toxicity of one material could be compared with another; perhaps with the goal of selecting one that would have the least effect on aquatic biota. Finally, the results could be used to set "allowable" or minimal effect concentrations in bodies of water that may receive these materials as waste.

2. Results of Toxicity Studies

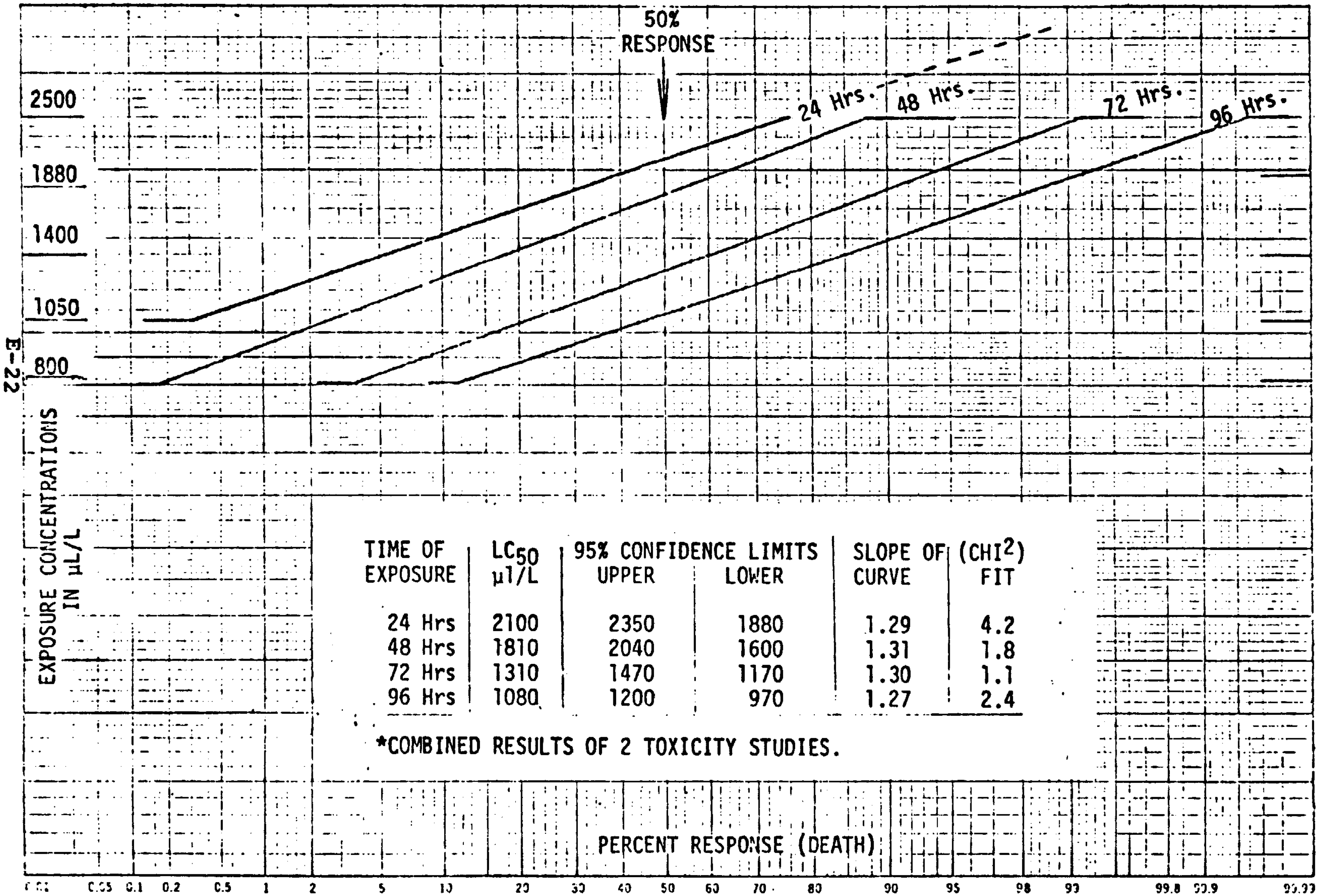
a. The sexually immature minnows were exposed to concentrations of FC206 ranging from 800 ul/l to 2500 ul/l (see Figure 3). At 48, 72 and 96 hours of exposure there was 100 percent death at the 2500 ul/l concentration and no deaths at the 800 ul/l concentration. At 24 hours of exposure there were no deaths in the 1050 ul/l concentration and 75 percent deaths in the 2500 ul/l concentration..

b. Figure 4 illustrates the change in LC_{50} with increasing time of exposure. As the percent of deaths increase with time of exposure (lower LC_{50}s), there is a reduction in the slope of the curve between 72 and 96 hours. The reduction in the slope indicates that the 96 hour value may be approaching the incipient LC_{50} (lethal threshold concentration). Therefore, for FC206, the 96 hour LC_{50} is considered to be an adaquate estimation of the incipient LC_{50} and can be used to set acceptable concentration limits of FC206 for short periods of time.

c. The 96 hour LC_{50} for 3 week old fry was 170 ul/l. The LC_{50} value for fry compared with the 1080 ul/l value for the juvenile fish indicates that the FC206 concentrate is approximately 6 times more toxic to the fry than more mature forms. Thus the increased sensitivity of immature forms indicates that the limits of safety using a 1/10 application factor for short term exposure would provide just adequate protection and that a 1/20 value would be more desirable.

Figure 3

QUANTAL RESPONSE CURVES* OF FISH EXPOSED TO FC 206

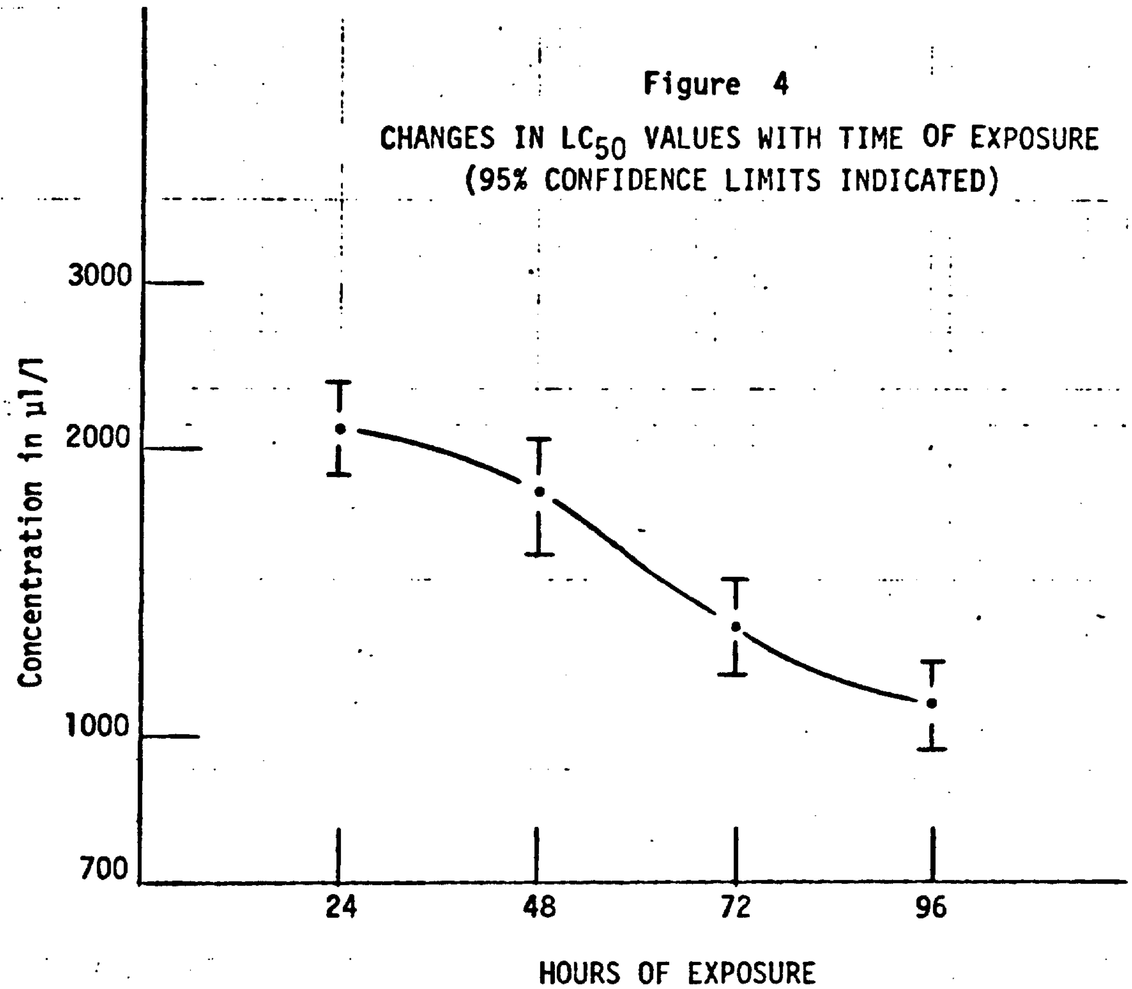


TIME OF EXPOSURE	LC_{50} µl/L	95% CONFIDENCE LIMITS UPPER	LOWER	SLOPE OF CURVE	(CHI^2) FIT
24 Hrs	2100	2350	1880	1.29	4.2
48 Hrs	1810	2040	1600	1.31	1.8
72 Hrs	1310	1470	1170	1.30	1.1
96 Hrs	1080	1200	970	1.27	2.4

*COMBINED RESULTS OF 2 TOXICITY STUDIES.

Figure 4

CHANGES IN LC_{50} VALUES WITH TIME OF EXPOSURE
(95% CONFIDENCE LIMITS INDICATED)



E. Comparison with AFFF's Previously Studies

1. Table 7 is a summary of the various parameters measured for each of the AFFF products studied thus far. (4,5,13). The greater percentage of the ultimate BOD being measured in the first five days on the newer products indicates a more rapid degree of biodegradability.

Table 7. Comparison of Various Parameters of AFFF's

	3M - LIGHT WATER			NAT'L FOAM SYSTEMS	
PARAMETER	FC199	FC200	FC206	AOW 3	AOW 6
pH	4.6	7.6	7.8	7.8	7.9
Specific Gravity	1.02	0.989	1.020	1.062	1.031
Water		59%	70%	72%	72%
Diethylene Glycol Monobutyl Ether		39%	27%	10%	10%
COD $(X10^3)$	550 mg/l	730 mg/l	500 mg/l	500 mg/l	350 mg/l
TOC $(X10^3)$		235 mg/l	96 mg/l	130 mg/l	100 mg/l
BOD_u $(X10^3)$	18 mg/l	450 mg/l	411 mg/l	354 mg/l	300 mg/l
BOD_5 (% BOD_u)	37	2	65	45	45

2. Table 8 summarizes the daily changes in LC_{50}'s during 96-hour bioassays for each of the AFFF concentrates previously studied.

Table 8. Changes in Toxicity of AFFF's to Fathead Minnows with increase in time of exposure.

	LC_{50} (Concentrations in µl/l)				
	3M - LIGHT WATER			NAT'L FOAM SYSTEMS	
	FC199	FC200	FC206	AOW 3	AOW 6
24-Hour	650	*	2100	1030	635
48-Hour	588	135	1810	820	255
72-Hour	450	97	1300	630	245
96-Hour	398	97	1080	600	225

*No mortality in 24 hours in one bioassay but 50% in highest concentration (150 µl/l) in duplicate bioassay.

IV. CONCLUSIONS

A. No acute toxicity to activated sludge microorganims was exhibited by FC206 up to 100,000 ul/l of the concentrate in synthetic sewage/activated sludge. Dilution of the concentrate for fire fighting operations is six percent (60,000 ul/l).

B. Respiration studies indicate that acclimation of microorganisms to concentrations up to 100,000 ul/l could occur and would allow successful waste treatment in oxidation ponds.

C. Bench scale - activated sludge treatment plants effectively treated concentrations of 200 ul/l on a continuous feed basis. Above this concentrations, sludge microorganisms were not able to build rapidly. This was probably due primarily to the physical removal of solids through foaming rather than direct toxicity to the microorganisms. Fathead minnows and daphnia lived in effluent from the plant being fed 500 ul/l.

D. In acute toxicity studies in which the test fish (Pimaphales promelas) were exposed to continously replenished concentrations of FC206, the 96 hour LC_{50} was 1080 ul/l (0.11%). The 96 hour value was considered to be an adequate estimation of the incipient LC_{50} (lethal threshold concentration) and suitable for use with application factors to predict "safe levels" for short-term exposure periods.

E. In comparing toxicities, FC206 concentrate was approximately six times more toxic to fry than the larger juvenile Fathead minnows. Also, FC206 concentrate was less toxic to Fathead minnows than previously tested fire fighting foams.

V. RECOMMENDATIONS

A. Wastewater from fire-fighting training operations should be passed through a gravity oil separator. The waste should then be held in a pond for natural oxidation and decomposition or pumped to a secondary sewage treatment facility at a controlled flow rate. Secondary treatment could be provided with the domestic sewage such that the influent to the sewage treatment plant will not contain in excess of 20 ul/l of the FC206. This recommendation is based on training exercises and is not necessarily intended for operational use.

B. Using the 96 hour LC_{50} of 1080 ul/l and an application factor of 0.05, the calculated "safe level" of FC206 concentrate is 54 ul/l for short term exposure. For situations in which the aquatic animals will be exposed more than 4 days, concentration of FC206 should not exceed 20 ul/l in the affected body of water.

VI. REFERENCES

1. Cairns, J., Jr., "Fish Bioassays - Reproducibility and Rating", Revista de Biologia, Vol 7, No. 21 & 2, (1969), pp 1-12.

2. Caskey, William, Personal Communication, Dept of Microbiology, Texas A & M University, College Station, TX.

3. Dixon, W.J., F. J. Massey, Introduction to Statistical Analysis, 3rd ed., McGraw-Hill, New York, 1969.

4. LeFebvre, E.E. 1971. "Biodegradability and Toxicity of Light Water ." Report No. EHL(K) 71-36. USAF Environmental Health Laboratory, Kelly AFB, Tx.

5. LeFebvre, E.E. and J.F. Thomas. 1973. "Biodegradability and Toxicity of AER-O-Water 3 and AER-O-Water 6 Aqueous Film Forming Foam". Report No. EHL(K) 73-22. USAF Environmental Health Laboratory, Kelly AFB, Tx.

6. Litchfield, J. T. and F. Wilcoxon, "A Simplified Method of Evaluating Dose Effect Experiments", J. Pharmacology & Experimental Therapeutics, Vol 96, (1949), pp 99-113.

7. Mount, D. I. and W. A. Brungs, "A Device for Continuous Treatment of Fish in Holding Chambers", Transactions of the American Fisheries Society, Vol 96, No. 1, 20 Jan 1967, pp 55-57.

8. Mount, D.I. and W.A. Brungs, "A Simplified Dosing Apparatus for Fish Toxicology Studies", Water Res, (1967), Vol 1, pp 21-29.

9. Sprague, J. B., "Bioassay Methods for Acute Toxicity", Water Res. Vol. 3, (1969), pp 793-821.

10. Sprague, J. B., "Utilizing and Applying Bioassay Results", Water Research, Vol. 4 (1970), pp 3-31.

11. Sprague, J. B., "Sublethal Effects and "SAFE" Concentrations Water Research, Vol. 5 (1971), pp 245-266.

12. Standard Methods for the Examination of Water and Waste Water, 13 ed., American Public Health Assoc., New York, (1971).

13. Thomas, J. F. and E. E. LeFebvre. 1974 "Biodegradability and Toxicity of FC200 Aqueous Film Forming Foam". Report No. EHL(K) 74-3, USAF Environmental Health Laboratory, Kelly AFB, Tx.

APPENDIX

Participants in Study

PARTICIPANTS

Biodegradability and Toxicity of Light Water, FC206 Aqueous Film Forming Foam

Biodegradability Studies:

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Bioassays:

Maj. Roger Inman, Veterniary Ecologist Toxicologist
MSgt Melvin Struck, Laboratory Animal Techician
TSgt Jerold Akey, Laboratory Animal Techician

APPENDIX F

SMALL SCALE AFFF/DYE DISPERSION TEST

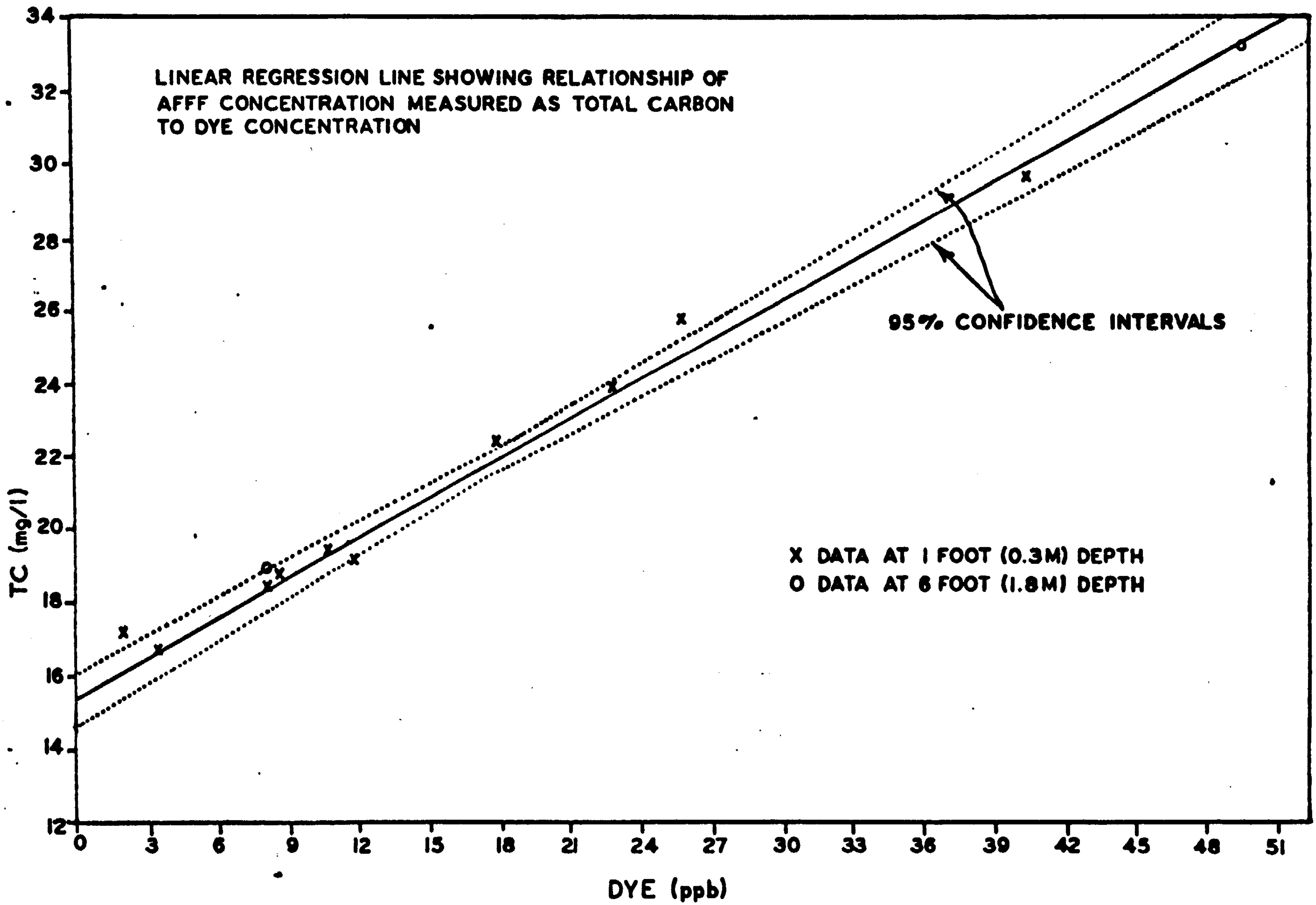
1. A small scale test was conducted in Dungan Basin at the David W. Taylor Naval Ship Research and Development Center, Annapolis Laboratory, on 3 September 1975. Released into the basin was a mixture of 1.2 gal (4.5 ℓ) of AFFF (3M Co. FC-206) and 18.8 gal (71.2 ℓ) of water drawn from the basin. The AFFF/water mixture was dyed to a concentration of 100 ppm (by weight) with rhodamine WT dye. The mixture was poured overboard at 1412 hours from a small boat in the center of the basin. Samples were pumped into collection bottles from depths of one foot (called surface samples, S), six feet, and nine feet from areas within the visible dye patch visually estimated to be those of highest dye concentration. Samples were analyzed for dye concentration, TC, and COD. Results of analyses are contained in table F-1. It was assumed that the increase in TC above background levels was due to the presence of AFFF.

2. Rhodamine dye concentration and TC data for samples collected at the one foot (0.3 m) depth are plotted in figure F-1. The relationship between dye and TC demonstrates that dye can be used to simulate the dispersion of AFFF. Although the rate of change in AFFF and dye was different, the dilution factors remained the same. Therefore, dilution data from an in situ dye dispersion study can be used to develop dilution factors applicable for predicting the decrease in AFFF concentration after release of a known quantity of AFFF under similar conditions in the study area.

Table F-1
Results of Laboratory Analyses of Water Samples from Dungan Basin Before and After the Addition of AFFF and Rhodamine Dye

Time	Depth (ft)	Depth (m)	Dye Concentration (ppb)	TC (mg/ℓ)	COD (mg/ℓ)
Bkgd	1	0.3	<2	15.6	128
Bkgd	1	0.3	<2	13.8	125
Bkgd	6	1.8	<2	14.8	68
Bkgd	6	1.8	<2	13.8	70
1412	-	-	Release dye, 1.0×10^5 ppb	-	2.6×10^4
1415	1	0.3	8.9	18.6	96
1415	6	1.8	8.3	18.7	80
1417	1	0.3	40.6	29.6	150
1417	6	1.8	49.5	33.2	144
1419	1	0.3	25.7	24.8	160
1419	6	1.8	<2	14.6	84
1420	1	0.3	21.8	23.8	184
1420	6	1.8	<2	14.8	104
1422	1	0.3	17.8	22.4	100
1422	6	1.8	<2	14.8	80
1423	1	0.3	10.9	19.4	68
1423	6	1.8	<2	14.1	148
1424	1	0.3	8.5	18.2	76
1424	6	1.8	<2	15.3	64
1425	1	0.3	3.7	16.6	88
1425	6	1.8	<2	14.1	132
1425	9	2.7	<2	14.1	152
1427	1	0.3	11.9	19.2	100
1427	6	1.8	<2	14.6	68
1427	9	2.7	<2	14.1	188
1430	1	0.3	2.1	17.3	64
1430	6	1.8	<2	13.6	48
1430	9	2.7	<2	14.8	96

FIGURE F-1



LINEAR REGRESSION LINE SHOWING RELATIONSHIP OF AFFF CONCENTRATION MEASURED AS TOTAL CARBON TO DYE CONCENTRATION
95% CONFIDENCE INTERVALS
X DATA AT 1 FOOT (0.3M) DEPTH
O DATA AT 6 FOOT (1.8M) DEPTH
TC (mg/l)
DYE (ppb)
34
32
30
28
26
24
22
20
18
16
14
12
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
51

APPENDIX G

TENTATIVE ALLOCATION PLANS AND CONSTRUCTION

SCHEDULES FOR SHIP CHT SYSTEMS, SWOBS,

AND PIER SEWERS

TABLE G-1
ACTIVITIES WHICH HAVE/PLAN TO HAVE PIERSIDE FACILITIES FOR
SHIP-TO-SHORE SEWAGE TRANSFER TOGETHER WITH FACILITY DESCRIPTION AND STATUS*

15 October 1976

LOCATION	MCON NO.	PCR NO.	DESCRIPTION	STATUS
NORFOLK COMPLEX				
NAVSTA	P-807	W289D	PIERS 7,12,20,21,22,23	CONST.COMPL. FACILITY OPERATING
			PIER 24	UNDER CONST. UNTIL 6/78
			PIER 25	UNDER CONST. UNTIL 7/77
NAB LITTLE CREEK	P-206	W131J	PIERS 56,57,58,59	CONST.COMPL. FACILITY OPERATING
NAVSTA	P-911	W289E	PIERS 2,3,4,5,10	UNDER CONST. UNTIL 1/77
NSY PORTSMOUTH	P-177	W164G	WHARFS 1-12,15,23-27,29-33 35,36,38,39,41-45	UNDER CONST. UNTIL 4/77
NAB LITTLE CREEK	P-207	W131K	PIERS 1-8,11-15,16-19	UNDER CONST. UNTIL 3/77
NSY PORTSMOUTH	P-999	W164A	PIER C	UNDER CONST. UNTIL 4/77
SAN DIEGO COMPLEX				
NAVSTA	P-176	W027D	PIER 4	CONST.COMPL. FACILITY OPERATING
NSSF	P-036	W304A	PIERS 5000,5002, DEPERMING PIER	CONST.COMPL. FACILITY OPERATING
NAS NORIA	P-313	W018L	WHARFS I,J,K	CONST.COMPL.(MUNICIPAL CONN. COMPL.) Lift Station Pump Prob.
NAVSTA	P-179	W027F	PIERS 5,6,8	UNDER CONST. UNTIL 5/77; PIER 5 CONST.COMPL.
			SMALL CRAFT BASIN	CONST.COMPL.
			MOLE PIER	CONST.COMPL.
			PIERS 1,2,3	UNDER CONST. UNTIL 1/78
			PIER 9	PLANNED EST.COMPLETION 12/78
	P-191	W032j	PIER 10	PLANNED EST.COMPLETION 12/79
	P-198	- -	PIERS 11,12,13	PLANNED EST.COMPLETION 12/80
NSC	P-022	W209K	BROADWAY PIER	UNDER CONST. UNTIL 12/76
	P-023	W209j	FUEL PIER PT.LOMA	UNDER CONST. UNTIL 12/77
NUC	P-059	W028D	PIERS 1,2 PT. LOMA	PLANNED EST. COMPLETION 6/78
	P-057	W028C	SAN CLEMENTE ISLAND	PLANNED EST. COMPLETION 7/79
NAB CORONADO	P-093	W220C	PIERS 3,8,13	UNDER CONST. UNTIL 12/77

*NCBC letter to CNO, 25A1:WLR:hla, Control No. 610-23, Seria 5054 of 16 November 1976, enclosure (1).

TABLE 1 (cont.)

LOCATION	MCON NO.	PCR NO.	DESCRIPTION	STATUS
CHARLESTON				
NSC	P-903	W305A	PIER A	UNDER CONST. UNTIL 6/77
NSY			PIERS C,D,F,G,H,J,K,L,M	UNDER CONST. UNTIL 6/77
NAVSTA			PIERS N,P,Q,R,S,T,U	UNDER CONST. UNTIL 6/77
NWS	P-901	W119H	WHARF A, PIERS B,C,	UNDER CONST. UNTIL 11/76
MAYPORT				
NAVSTA	P-964	W049K	WHARFS B,C,D,A	CONST.COMPL. FACILITY OPERATING
PEARL HARBOR COMPLEX				
NSB	P-119	W057G	PIERS S1-S5,S8,S9	CONST.COMPL. (awaiting sewage transfer hose)
NAVSTA	P-991	W165G	PIERS B1-B26,	UNDER CONST. UNTIL 2/77
NSY			B1-B21,GD1-GD5,	UNDER CONST. UNTIL 2/77
			O2, MR NO. 2	UNDER CONST. UNTIL 2/77
NAVSTA	P-991A	W165H	PIERS M1-M4,	UNDER CONST. UNTIL 2/77
NSC			H1-H4,	UNDER CONST. UNTIL 2/77
NSB			S10-S14,S20,S21	UNDER CONST. UNTIL 2/77
NAVSTA	P-179	W165I	A1-A7,S15-S19,F1-F5	UNDER CONST. UNTIL 10/77
NSC			V1-V4,K3-K11	UNDER CONST. UNTIL 10/77
NAVSTA	P-179A	W165J	F12,F13	UNDER DESIGN, EST.COMPL. 7/78
NAVMAG	P-179B	W165J	W1-W5	UNDER DESIGN, EST.COMPL. 3/79
SAN FRANCISCO				
NAS ALAMEDA	P-100	W007M	PIER 3	CONST.COMPL. FACILITY OPERATING
	P-133	W007N	PIERS 1,2	CONST.COMPL. FACILITY OPERATING
NWS CONCORD	P-153	W008F	PIER 2	PLANNED, EST.COMPLETION 6/80
NSY VALLEJO	P-203	W031F	WHARFS 2-20,24	PLANNED, EST.COMPLETION 5/78
			PIERS 21-23	PLANNED, EST.COMPLETION 5/78
NSC OAKLAND	P-002,3,4	W019F	- - - - -	PLANNED, EST.COMPLETION 12/79
PUGET SOUND				
NTS KEYPORT	P-190	W146J	WHARF	UNDER CONST. UNTIL 1/77
NSY BREMERTON	P-166	W144K	PIERS 3-8	PLANNED, EST. COMPLETION 1/80
NSC BREMERTON	P-038	W147N	FUEL PIER	PLANNED, EST. COMPLETION 5/77

TABLE G-1 (cont.)

LOCATION	MCON NO.	PCR NO.	DESCRIPTION	STATUS
LONG BEACH				
NAVSTA	P-131	W014F	PIERS 9,11,15	CONST.COMPL.
NSY	P-172	W015I	PIERS 1,2,3,6,E	CONST.COMPL.
NAVSTA	P-133	W014G	PIER 7	UNDER CONST. UNTIL 1/77
NWS SEAL BEACH	P-096	W035C	WHARF	PLANNED, EST. COMPLETION 7/78
GROTON/NEW LONDON				
NSB NEW LONDON	P-157	W040D	PIERS 1-4,6,8-10,12,13,15,17,31	CONST.COMPL.(awaiting sewage transfer hose)
NUSC	P-116	W332A	PIER 7	PLANNED EST. COMPLETION 9/79
PENSACOLA				
NAS	P-999	W051K	PIERS 302,302	CONST.COMPL.(awaiting sewage transfer hose)
WASHINGTON D.C.				
NAVSTA	P-194	W042j	PIERS 1,4	CONST.COMPL. FACILITY OPERATING
PORTSMOUTH N.H.				
NSY	---	---	PIERS 1,2,3	CONST.COMPL. FACILITY OPERATING
ADAK				
NAVSTA	P-834	W002I	PIER 3	PLANNED, EST. COMPLETION 12/79
EARLE				
NWS	P-771	W190A	PIERS 2,3	PLANNED, EST. COMPLETION 6/77
NEW ORLEANS				
NSA	P-047	W063C	PIER 1	PLANNED, EST. COMPLETION 8/79
PANAMA CITY				
NSCL	P-999	W266B	SOUTH DOCK, EAST DOCK	CONST.COMPL (awaiting sewage transfer hose)

TABLE G-1 (cont.)

LOCATION	MCON NO.	PCR NO.	DESCRIPTION	STATUS
PORT HUENEME				
CBC	P-332	W023K	WHARFS 2-6,A	PLANNED, EST. COMPLETION 9/79
YORKTOWN				
NWS	P-336	W136C	PIER 2	UNDER CONST. UNTIL 1/77
PHILADELPHIA				
NSY	P-451	W106D	PIERS 1,2,4	UNDER CONST. UNTIL 11/76
	P-443	W106B	PIERS 5,6	CONST.COMPL.(awaiting sewage transfer hose)
ROOSEVELT ROADS				
NAVSTA	P-997	W111H	PIERS 1,2,3	UNDER CONST. UNTIL 4/77
GUAM				
NAVSTA	P-094	W064K	A,B & V	UNDER CONST. UNTIL 11/76
NAVSHIPREPFAC			L,M,N,& O	UNDER CONST. UNTIL 11/76
NSD			R,S,T, & U	UNDER CONST. UNTIL 11/76
NAVMAG			H	UNDER CONST. UNTIL 11/76
NAVSTA	P-107	W064R	X	PLANNED, EST. COMPLETION 12/79
PORTLAND, OR				
NAVRESCTR	O&MN	W258C	PIERSEWER	AWAITING AWARD OF CONST.CONTRACT (EST.COMPL. OF CONST. 4/77)
TACOMA, WA				
NAVRESCTR	O&MN	W151C	PIERSEWER	AWAITING AWARD OF CONST.CONTRACT (EST.COMPL. OF CONST. 4/77)
EVERETT, WA				
NAVRESCTR	O&MN		PIERSEWER	UNDER CONST. UNTIL 1/77

TABLE G-1 (cont.)

LOCATION	MCON NO.	PCR NO.	DESCRIPTION	STATUS
GALVESTON, TX NAVRESCTR	MCNR P-032	W322A	PIERSEWER STRUCT. #11	PLANNED, EST. COMPLETION 7/77
ST. PETERSBURG, FL NAVRESCTR	MCNR P-241	W329A	PIERSEWER STRUCT. #6	PLANNED, EST. COMPLETION 7/77
BRONX, NY (Fort Schyler) NAVRESCTR	MCNR P-315	W324A	PIERSEWER	PLANNED, EST. COMPLETION 1/78
PERTH AMBOY NAVRESCTR	MCNR P-346	W338A	PIERSEWER	PLANNED, EST. COMPLETION 12/78
PORTLAND, ME NAVRESCTR	MCNR P-343	W340A	PIERSEWER	PLANNED, EST. COMPLETION 10/78
BALTIMORE, MD NAVRESCTR	MCNR P-243	W072A	PIERSEWER	PLANNED, EST. COMPLETION 10/77
JACKSONVILLE, FL			NO PIERSEWER PLANNED	
BOSTON, MA			NO PIERSEWER PLANNED	
NEWPORT, RI (NETC) NAVSTA	P-208	W116N	PIERSEWER PLANNED	

TABLE G-1 (cont.)

LOCATION	MCON NO.	PCR NO.	DESCRIPTION	STATUS
GREAT LAKES, IL			NO PIERSEWER PLANNED	
YOKOSUKA, JAPAN				
LA MADDALENA, IT				
HOLY LOCH, SC			WILL USE SWOB	
ROTA, SPAIN			WILL USE SWOB	
BAHRAIN				
GAETA				
NAPLES				
BROOKLYN, NY (Floyd Bennett Field) NAVRESCTR	MCNR P-319	W337B	PIERSEWER PLANNED	

TABLE G-2

SHIPS WASTE OFFLOAD BARGE (SWOB) ALLOCATION PLAN AND DELIVERY SCHEDULE*

	FY74 PROCUREMENT (OIL)		FY75 PROCUREMENT (OIL)			FY76 PROCUREMENT (OIL & SEWAGE)		TOTAL ALLOCATED	
	ALLOCATED	DELIVERED	ALLOCATED	DELIVERED	TO BE DELIVERED	ALLOCATED (OIL)	ALLOCATED (SEWAGE)	OIL	SEWAGE
NAVSHIPYD Portsmouth	0	0	0	0	1	0	0	1	0
WPNSTA Earle	0	0	2	0	1 (Note 1)	1	0	2	0
NAVSHIPYD Philadelphia	0	0	0	0	0	2	0	2	0
WPNSTA Yorktown	1	1	0	0	0	0	0	1	0
NAVSTA Norfolk	3	3	3	3	0	0	2	6	2
NAVPHIBASE Little Creek	1	1	1	1	0	0	1	2	1
NAVSHIPYD Norfolk	1	1	0	0	0	1	0	2	0
NAVSTA Charleston	2	2	0	0	0	1	0	3	0
NAVSHIPYD Charleston	0	0	0	0	0	0	1	0	1
NAVSHIPYD Puget Sound	2	2	3	3	0	0	0	5	0
NAVSHIPYD Mare Island	1	1	0	0	0	0	0	1	0
NAVFUELDEP Point Molate	0	0	1	0	1-Jan '77	0	1	1	1
NSC Oakland	1	1	0	0	0	0	0	1	0
NAVSHIPYD Long Beach	2	2	0	0	0	0	1	2	1
NAVSTA San Diego	3	3	0	0	0	0	2	3	2
NAS North Island	2	2	0	0	0	0	0	2	0
NAVSHIPYD Pearl Harbor	1	1	0	0	0	0	0	1	0
NAVSTA Pearl Harbor	2	2	1	0	1 (Note 2)	0	3	3	3
NAVSTA Guam	0	0	1	0	1 (Note 2)	0	1	1	1
NAVSTA Subic Bay	0	0	1	0	1 (Note 2)	0	0	1	0
FLEACT Yokosuka	0	0	2	0	2 (Note 3)	0	0	2	0
NAVSTA Rota	0	0	1	0	1 (Note 4)	0	1	1	1
NAVSUPPO La Maddalena	0	0	1	0	1 (Note 4)	0	0	1	0
NAVSTA Roosevelt Roads	0	0	2	0	2-Jan '77	0	0	2	0
NAVSTA Guantanamo Bay	0	0	1	0	1-Jan '77	0	0	1	0
TOTALS	22	22	20	7	13	5	13	47	13

*Information provided by Naval Facilities Engineering Command (NAVFAC 104), 10 January 1977.

Notes:
1. One barge delivered by contractor stored at NAVSHIPYD Puget Sound to be delivered by contractor to final destination.
2. Three barges delivered by contractor in July 1976 to NAVSHIPYD Long Beach to await a Navy tow of opportunity to final destinations.
3. Two barges delivered by contractor in September 1976 to NAVSHIPYD Long Beach to await a Navy tow of opportunity to final destinations.
4. Three barges delivered by contractor in July 1976 to INACTSHIPPAC Portsmouth to await a Navy tow of opportunity to final destinations.

TABLE G-3

CHT COMPLETION SCHEDULE*

1 SEPT'76

FY-73

COMP.

CG-11

AS-11
AS-16
AS-31
AS-32
AS-37
ASR-8 (6)
ASR-9
ASR-14

LPH-3

PART.

LPD-6 (* in 7T)
LSD-32 (* in 7T)
LSD-36 (* in 77)

INCR.

CV-60(6)(8)

FY-74

COMPLETES

CG-10, DDG-37
CG-17, DDG-46
CG-27, FF-1049
DD-965, FF-1053
DDG-11, FF-1054
DDG-33, FFG-1

AD-18, AR-7
AD-37, AS-12
AE-21, ATF-100
AE-22, ATF-101
AFS-6, ATF-161
AO-98
AO-147
AOR-1

LPD-7
LST-1179
LST-1182

PARTIALS

CG-26 (* in '78)
CG-28 (* in '76)
CGN-35 (* in '76
DD-835 Note (5)
DD-839 (* in '78)
DD-862 (* in '78)
DD-863 Note (5)
DD-855 Note (5)
DD-836 (* in '78)
DDG-7 (* in '77)
FF-1056 (* in '78)
FF-1057 (* in '7)
FF-1058 (* in '78)
FF-1060 (* in '7)
FFG-2 (* in '79)

AE-27 (* in '76)
AO-149 (* in '79)
ARS-8 (* in '76)
ARS-23 (* in '76)
ARS-24 Note (5)
ARS-25 (* in '76)
ASR-13 (* in '78)
ASR-15 (* in '78)
ATF-96 (* in '76)
ATF-100 (* in '76)
ATF-110 (* in '76)
ASR-16 Note (4)

LKA-113 (* in '78)
LPD-8 (* in '79)
LPD-13 (* in '78)
LSD-28 (* in '79)
LST-1183(* in '78)
LST-1184(* in '78)

INCREMENTALS

CV-67 (8)

FY-75

COMPLETES

CG-29, DDG-31
CG-36, DDG-36
CGN-25, DDG-45
DD-937, FF-1041
DD-938, FF-1059
DD-941, FF-1066
DD-948, FF-1077
DD-950, FFG-5
DD-763, FFG-6
DD-754
DD-927

AD-38, ARS-38
AFS-2, ARS-40
AFS-7, ARS-42
AG-153
AO-99
AOR-2

LKA-116, LSD-37
LPD-1, LST-1180
LPD-10, LST-1185
LPD-11, LST-1186
LPH-7, LST-1187
LPH-10, LST-1191

PARTIALS

LCC-20 (* in '78)

INCREMENTALS

CV-64(8)
CV-66(8)

FY-76-7T

COMPLETES

CG-18, FF-1065
CG-22, FF-1037
DD-931, FF-1050
DD-933, FF-1051
DD-940, FF-1052
DD-943, FF-1062
DD-946, FF-1063
DDG-4, FF-1068
DDG-9, FF-1071
DDG-10, FF-1072
DDG-19, FF-1075
DDG-22, FF-1078
DDG-23, FF-1079
DDG-32, FF-1091
AGFF-1, FFG-3

AD-19, ARS-41
AE-26, AS-34
AE-28, ATS-1
AE-29, ATS-2
AFS-4, ATF-103
AGF-3, ATF-105
AOE-1, ATF-113
AOE-4, ATF-162
AOR-3
AOR-6, AR-5

LCC-19, LSD-29
LKA-112, LSD-35
LPA-248, LSD-38
LPA-249, LSD-39
LPD-5, LST-1181
LPD-9, LST-1188
LPD-12, LST-1189
LPD-14, LST-1195
LPH-9
LPH-11
LPH-12

COMPLETIONS OF PARTIALS

CG-28, CGN-35

AE-27, ATF-96
ARS-8, ATF-106
ARS-23, ATF-110
ARS-25

LPD-6, LSD-32

INCREMENTALS

CV-63(8)

FY-77

COMPLETES

CV-67(6)(7)

CG-20, FF-1076
CG-23, FF-1080
CG-26, FF-1082
CG-30, FF-1083
CG-32, FF-1084
DDG-15, FF-1085
DDG-35, FF-1086
DDG-38, FF-1087
DDG-40, FF-1089
FF-1055
FF-1061
FF-1070
FF-1073
FF-1074

AD-15, ARS-43
AE-23, AS-33
AE-24, AS-36
AE-32, ATF-160
AE-34
AE-35
AFS-1
AO-51
AOE-2
AOR-5
AR-8

LPD-15, LST-1193

COMPLETIONS OF PARTIALS

DDG-7

LSD-36

INCREMENTALS

CV-59 (8)
CV-61 (8)

FY-78

COMPLETES

CVT-16(6)(7)(9)

CV-63 (6)(7)(9)

CG-21, FF-1047
CG-33, FF-1049
FF-1069
DDG-5, FF-1088
DDG-6, FF-1090
DDG-8, FF-1091
DDG-16, FF-1092
DDG-18, FF-1093
DDG-20, FF-1094
DDG-38, FF-1095
DDG-43, FF-1096
DDG-44, DD-942
DD-951 (NRT)

AE-25, AR-6
AE-33
AS-19
AFS-5, AS-18

LSD-33, LKA-115
LSD-36

COMPLETIONS OF PARTIALS

CG-26, FF-1058
DD-886, FF-1060
FF-1056, FFG-2
FF-1057, DD-839
DD-862

ASR-13, ASR-15

LCC-20, LST-1183
LKA-113, LST-1184
LPD-13

INCREMENTALS

CV-61(6)
CV-60(8)
CV-62(6)(8)
CV-63(6)
CV-64(6)
CV-66(7)

FY-79

COMPLETES

CV-60 (7)
CV-62 (7)
CV-64 (7)
CVN-65(6)(7)(8)
CV-66 (6)

CG-31, DDG-46
DDG-2, FF-1066
DDG-13, FF-1067
DDG-14
DDG-17, FF-1097
DDG-24, FF-1038
DDG-39
DDG-42

AFS-3, AGDS-2
AGM-6
ASR-21
ASR-22

LKA-117
LSD-30
LSD-31

COMPLETIONS OF PARTIALS

AO-148

LPD-8
LSD-28

INCREMENTALS

CV-61(7)
CV-59(6)

FY-80

COMP.

CV-59(7)

CG-5
DDG-3
DDG-41

ADE-3

INCR.

CV-61(8)

FY-81

COMP.

CV-61(8)
CV-61(7)
CV-63(7)

CG-18
CG-19

DD-944
DDG-12
DDG-21
FFG-4
FF-1048
FF-1043
FF-1064
FF-1052

ATS-3
ARS-39

LPA-116
LPD-2
LPD-4
LPH-2
LSD-40
LST-1190
LST-1192
LST-1194
LST-1196
LST-1197
LST-1179

TOTAL COMPLETIONS (1)

FY	COMP.	COMP. OF PART.	TOT
'73	10		10
'74	28		28
'75	41		41
'76-'7T	68	11	79
'77	41	2	43
'78	35	16	51
'79	26	3	29
'80	5		5
'81	26		26
GRAND TOTAL			312

Notes: * - Indicates completion to be accomplished in year specified.
(1)- Total completions include completes, completions of partials and completions of incrementals.
(2)- CHT system to be installed, however, not in current overhaul schedules through FY-'81.
(3)- Partial installation - completion undetermined.
(4)- To be stricken in FY-'77.
(5)- Scheduled for decommissioning.
(6)- Fwd. piping portion.
(7)- Aft piping portion.
(8)- Tank portion.

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*CHT Ship/Shore Interface Information Book, Hydronautics Technical Report 7607.1 prepared for NAVSEC 6159, October 1976.

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