WATER QUALITY STATUS REPORT NO. 90

COMPILATION OF WATER QUALITY STUDY EFFORTS ON PEND OREILLE LAKE 1984-'88

Bonner & Kootenai Counties, Idaho

APPENDICES

Idaho Department of Health and Welfare
Division of Environmental Quality
Water Quality Bureau
Boise, Idaho

1989

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APPENDICES

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APPENDICES

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APPENDICES (continued)

APPENDIX 1

Clark Fork River Raw Data (Station #2000256; @ Whitehouse Rapid Below Cabinet Gorge Dam)

APPENDIX 1. CLARK FORK RIVER RAW DATA (#2000256; @ WHITEHORSE RAPIDS BELOW CABINET GORGE DAM)

DATE	STORET CODE DISCHARGE (mean daily flow in cfs)	665 PHOS-TOT MG/L P	70507 PHOS-T ORTHO MG/L P	625 TOT KJEL N MG/L	630 NO2&NO3 N-TOTAL MG/L	610 NH3+NH4- N-TOTAL MG/L	95 CNDUCTVY (lab) MICROMHO
5/31/84	37000						
6/13/84	44300						
7/17/84	17100	<.050	0.010	0.20	0.017	0.007	124
8/27/84	10300	0.010	<.010	0.10	0.041	0.009	163
9/18/84	16600	<.010	<.010		0.004	<.001	
10/29/84	13400	0.020	<010	0.09	0.283	0.016	136
11/26/84	15200	<.010	0.005	0.10	0.015	0.044	188
12/17/84	19000	0.010	<.010	0.20	0.068	0.199	219
1/21/85	10100	0.014		<.10	0.077	0.055	138
2/20/85	13000	0.010	<.010	0.11	0.072	0.053	167
3/25/85	15500	0.010	0.010	0.13	0.210	0.148	218
4/29/85	23900	0.040	0.020	0.21	0.082	0.088	126
5/6/85	36100	0.010	0.010	0.19	0.028	0.028	155
5/11/85	33400	0.020		0.17	0.088	0.074	121
5/20/85	36100	0.010	0.010	0.13	0.045	0.028	127
5/29/85	58400	0.040	0.020	0.13	0.079	0.048	110
6/3/85	47600	0.024	0.021	0.21	0.124	0.036	130
6/11/85	56300	0.140		0.25	0.240	0.030	145
6/17/85	51300	0.013	0.015	0.11	0.139	0.053	145
6/24/85	26800	0.010	0.010	0.18	0.015	0.027	117
7/1/85	21300	0.022	0.010	0.20	0.019	0.097	145
7/8/85	22200	0.016	0.002	0.28	0.088	0.066	154
7/15/85	18700	0.017	0.002	0.14	0.009	0.019	150
7/22/85	14500	0.010	0.002	0.09	0.250	0.097	164
7/29/85	13800	0.012	<.002	0.15	0.029	0.039	175
8/27/85	17600	0.020		0.26	0.024	0.013	167
9/16/85	26700	0.018	0.002	0.11	0.006	0.008	170
11/4/85	23900	0.014	0.002	0.10	0.068	0.070	174
11/18/85	18200	0.010	0.004	<.10	0.046	0.032	160
12/16/85	19200	0.016	0.007	0.13	0.468	0.257	178
1/21/86	16000	0.010	0.010	0.12	0.101	0.093	197
2/24/86	18700	0.011	0.008	0.20	0.050	0.014	200
3/24/86	24700	0.032	0.029	0.20	0.194	0.076	154
4/22/86	24500	0.023	0.019	0.77	0.031	0.035	141
5/12/86	27000	0.034	0.003	0.44	0.262	0.295	147
5/19/86	27000	0.013	0.007	0.25	0.037	0.035	141
5/27/86	42800	0.010	0.002	0.18	0.029	0.053	137
6/5/86	77900	0.016		0.21	0.040	0.030	122
6/9/86	65100	0.016	0.014	0.21	0.040	0.021	136
6/16/86	41200	0.019	0.010	0.20	0.038	0.013	145
6/23/86	28100	0.020	0.004	0.18	0.032	0.008	154

APPENDIX 1. CLARK FORK RIVER RAW DATA (#2000256; @ WHITEHORSE RAPIDS BELOW CABINET GORGE DAM)

DATE	STORET CODE DISCHARGE (mean daily flow in cfs)	665 PHOS-TOT MG/L P	70507 PHOS-T ORTHO MG/L P	625 TOT KJEL N MG/L	630 NO2&NO3 N-TOTAL MG/L	610 NH3+NH4- N-TOTAL MG/L	95 CNDUCTVY (lab) MICROMHO
6/30/86	23600	0.015	<.002	0.18	0.061	0.155	158
7/7/86	21300	0.010	0.005	0.16	0.027	0.018	158
7/14/86	17700	0.046	0.002	0.19	0.025	0.011	166
7/21/86	17300	0.009	0.002	0.11	0.009	0.004	170
7/28/86	8780	0.015	0.001	0.14	0.047	0.085	179
8/25/86	13000	0.009	0.003	0.10	0.112	0.133	187
10/6/86	15000			0.16	0.056	0.269	183
10/20/86	13500	0.017	0.013	0.15	0.018	0.009	188
12/1/86	13600	0.007	0.003	0.08	0.037	0.011	179
12/15/86	16700	0.030	0.002	0.15	0.068	0.015	184
1/26/87	19800	0.007	0.005	0.10	0.095	0.042	185
2/9/87	12300	0.007	0.001	0.11	0.078	0.018	192
3/16/87	15500	0.014	0.002	0.17	0.062	0.035	180
4/13/87	22700	0.011	0.002		0.014	0.018	182
5/4/87		0.019	<.002	0.17	0.038	0.015	136
5/11/87	37200	0.021	<.002	0.05	0.057	0.014	123
5/18/87	39100	0.015	0.004	<.05	0.044	0.014	141
5/26/87	27700	0.017	0.004	0.18	0.034	0.036	141
6/1/87	30900	0.009	<.002	0.17	0.029	0.034	149
6/8/87	13500	0.013	<.002	0.22	0.012	0.044	163
6/15/87	19800	0.013	0.003	0.02	<.001	0.029	161
6/22/87	22700	0.019	0.002	0.33	0.007	0.044	163
6/29/87	15700		0.003	0.22	0.020	0.071	166
7/6/87	10800	0.010	0.001	0.25	0.074	0.123	163
7/14/87	10300	0.020	<.002	0.20	0.004	0.001	171
7/20/87	11600	0.012	0.002	0.15	0.127	0.046	180
7/27/87	17300	0.018	0.005	0.17	0.055	0.045	180
8/17/87	12600			0.17	0.072	0.043	151
9/22/87	12700	0.010	0.003	0.13	0.076	0.135	174
11/30/87	17500	0.013	0.003	0.16	0.139	0.111	185
1/4/88	11500	0.014	0.002	0.12	0.067	0.046	189
1/25/88	5320	0.004	0.004	<.01	0.032	0.052	191
2/29/88	16100	0.016	0.002	0.26	0.054	0.043	184
3/14/88	19900	0.010	<.002	0.09	0.013	0.008	184
4/18/88	33000	0.016	<.002	0.12	0.023	0.010	161
4/25/88	33800	0.027	0.002	0.11	0.033	0.025	143
5/2/88	26000	0.019	<.002	0.16	0.030	0.004	133
5/9/88	23600	0.014	0.002	0.23	<.001	0.019	151
5/16/88	36000	0.017	<.002	0.35	0.002	0.018	149
5/23/88	23000	0.012	<.002	0.16	0.016	0.011	132
5/31/88	25100	0.130	0.002	0.19	0.028	0.011	110

APPENDIX 1. CLARK FORK RIVER RAW DATA (#2000256; @ WHITEHORSE RAPIDS BELOW CABINET GORGE DAM)

DATE	STORET CODE DISCHARGE (mean daily flow in cfs)	665 PHOS-TOT MG/L P	70507 PHOS-T ORTHO MG/L P	625 TOT KJEL N MG/L	630 NO2&NO3 N-TOTAL MG/L	610 NH3+NH4- N-TOTAL MG/L	95 CNDUCTVY (lab) MICROMHO
6/6/88	29200	0.013	0.004	0.19	0.042	0.042	120
6/13/88	32700	0.015	<.002	0.20	0.020	0.150	138
6/20/88	26800	0.013	0.002	0.20	0.030	0.032	136
6/27/88	18400	0.016	0.004	0.16	0.024	0.012	143
7/5/88	18500	0.013	<.002	0.20	0.004	0.018	138
8/1/88	14900	0.014	<.002	0.21	0.012	0.014	172
8/20/88	5510	0.011	0.002	0.14	0.025	0.019	177
9/20/88	6080	0.014	0.002	0.15	0.135	0.107	184

APPENDIX 1. CLARK FORK RIVER RAW DATA (#2000256; @ WHITEHORSE RAPIDS BELOW CABINET GORGE DAM)

DATE	900 TOT HARD CACO3 MG/L	916 CALCIUM (MG/L)	927 MAGNESIUM (MG/L)	410 T ALK CACO3 MG/L	956 SILICA TOTAL MG/L	80154 NON-FILT. RESIDUE (Susp. Sed.)	USGS Data SUSPENDED SEDIMENT (mg/l)
5/31/84							6.0
6/13/84							7.0
7/17/84	76		5.5	76	8.0	4	2.0
8/27/84	88	26	6.8	92	7.0	3	1.0
9/18/84	96	26	7.1	94	6.0	2	2.0
10/29/84	88			88	6.0		3.0
11/26/84	96			92	7.0	<2	2.0
12/17/84	96	29	7.1	93	7.0		1.0
1/21/85	96	27	7.0	91	8.0	<2	1.0
2/20/85	92	24	7.0	89	10.0	2	2.0
3/25/85	92	27	7.2	91	9.0	<2	3.0
4/29/85	64	19	5.3	67	9.0	4	4.0
5/6/85	72	19	5.7	72	10.0		5.0
5/11/85	60	18	4.5	60	7.0	4	5.0
5/20/85	64	18	4.9	67	6.0	5	5.0
5/29/85	52	16	4.1	54	5.0	<2	8.0
6/3/85	60	18	4.8	64	6.0	<2	7.0
6/11/85	68	19	5.1	68	5.0	9	7.0
6/17/85	92	19	5.3	68	5.0	<2	5.0
6/24/85	68	16	5.5	75	2.0	<2	4.0
7/1/85	76	21	5.5	76	6.0	<2	2.0
7/8/85	76	21	5.8	79	6.0	<2	3.0
7/15/85	76	18	6.0	81	6.0	3	2.0
7/22/85	84	24	6.1	84	5.0	<2	2.0
7/29/85	80	24	6.3	87	6.0	<2	4.0
8/27/85	88	22	6.6		5.0		3.0
9/16/85	88	26	6.8	70	7.0	3	3.0
11/4/85	88	24	6.5	88	6.0	2	5.0
11/18/85	76	22	6.0	82	6.0	3	3.0
12/16/85	88	26	6.6	96	7.0	<2	2.0
1/21/86	88	26	6.9	94		<2	2.0
2/24/86	92	26	6.7	93	7.0	<2	2.0
3/24/86	72	21	5.5	79	10.0	3	6.0
4/22/86	68	19	5.2	71	5.0	3	6.0
5/12/86	72	21	5.2	76	7.0	3	3.0
5/19/86	72	19	5.1	71	7.0	<2	3.0
5/27/86	68	19	4.9	70	7.0	6	3.0
6/5/86	64	18	4.0	63	6.0	12	14.0
6/9/86	64	19	4.7	67	6.0	6	10.0
6/16/86	72	21	4.8	71	7.0	6	6.0
6/23/86	72	21	5.3	74	7.0	3	

APPENDIX 1. CLARK FORK RIVER RAW DATA (#2000256; @ WHITEHORSE RAPIDS BELOW CABINET GORGE DAM)

DATE	900 TOT HARD CACO3 MG/L	916 CALCIUM (MG/L)	927 MAGNESIUM (MG/L)	410 T ALK CACO3 MG/L	956 SILICA TOTAL MG/L	80154 NON-FILT. RESIDUE (Susp. Sed.)	USGS Data SUSPENDED SEDIMENT (mg/l)
6/30/86	80	22	5.4	78	7.0	3	3.0
7/7/86	80	21	5.8	81	6.0	3	2.0
7/14/86	84	22	6.0	82	7.0	5	2.0
7/21/86	84	21	6.3	89	6.0	<2	2.0
7/28/86	84	24	6.5	91	6.0	<2	3.0
8/25/86	92	26	6.6	93	5.5	<2	2.0
10/6/86	92	24	7.1		5.8		2.0
10/20/86	92	24	7.1	90	5.0	2	1.0
12/1/86	92	26	6.6	94		2	2.0
12/15/86	92	27	6.9	86		<2	1.0
1/26/87	92	26	6.9	96	6.0	<2	4.0
2/9/87	96	26	6.7	92	6.0	<2	1.0
3/16/87	88	22	6.9	92	6.0	3	2.0
4/13/87	84	23	6.4	86	7.0	<2	2.0
5/4/87	64	18	4.7	62	7.0	<2	4.0
5/11/87	60	16	4.1	58	7.0	2	5.0
5/18/87	60	13	4.3	57	6.5	<2	4.0
5/26/87	68	20	5.0	70	6.3	2	3.0
6/1/87	76	21	5.2	74	6.0		3.0
6/8/87	76	21	5.4	77	6.2	2	3.0
6/15/87	76	21	5.5	77	6.7	<2	1.0
6/22/87	76	21	5.8	80	6.7	3	2.0
6/29/87	80	21	6.0	82	6.6	3	2.0
7/6/87	80	22	6.0	82	6.6	2	1.0
7/14/87	84	22	6.1	87	6.3	<2	1.0
7/20/87	84	24	6.4	87	6.9	3	2.0
7/27/87	84	24	6.6	86	6.8	<2	3.0
8/17/87	92	25	6.8	90	7.5		4.0
9/22/87	92	25	6.9	91	4.3	4	2.0
11/30/87	96	27	7.1	95	5.3	2	1.0
1/4/88	96	29	6.9	94	5.7	<2	2.0
1/25/88	100	27	7.1	97	6.1	<2	3.0
2/29/88	100	27	6.9	94	5.6	<2	3.0
3/14/88	92	27	6.7	88	4.9		2
4/18/88	84	22	5.7	79	6.0	<2	3.0
4/25/88	76	21	5.2	62	6.4	<2	3.0
5/2/88	68	18	5.3	66	6.5	5	3.0
5/9/88	72	21	5.3	72	6.5	5	3.0
5/16/88	76	21	5.4	73	6.1	3	3.0
5/23/88	68	19	4.8	64	6.3		2.0
5/31/88	60	18	4.4	62	6.9	2	2.0

APPENDIX 1. CLARK FORK RIVER RAW DATA (#2000256; @ WHITEHORSE RAPIDS BELOW CABINET GORGE DAM)

DATE	900 TOT HARD CACO3 MG/L	916 CALCIUM (MG/L)	927 MAGNESIUM (MG/L)	410 T ALK CACO3 MG/L	956 SILICA TOTAL MG/L	80154 NON-FILT. RESIDUE (Susp. Sed.)	USGS Data SUSPENDED SEDIMENT (mg/l)
6/6/88	60	18	4.2	56	7.2	6	2.0
6/13/88	64	18	4.7	62	7.5	<2	2.0
6/20/88	68	19	4.9	64	7.0	3	4.0
6/27/88	76	19	5.4	69	7.0	<2	2.0
7/5/88	80	22	5.6	72	7.3	2	2.0
8/1/88	84	24	6.5	81	7.1	6	2.0
8/20/88	88	24	6.4	89	7.5	<2	2.0
9/20/88	92	25	7.1	93	7.1	2	2.0

APPENDIX 1. CLARK FORK RIVER RAW DATA (#2000256; @ WHITEHORSE RAPIDS BELOW CABINET GORGE DAM)

DATE	USGS Data SUSPENDED SEDIMENT (tons/day)	76 TURBIDITY	403 pH	1002 ARSENIC (total recoverable) (ug/l)	1027 CADMIUM (tot. recoverable) (ug/l)	1042 COPPER (total recoverable) (ug/l)	1092 ZINC (total recoverable) (ug/l)
5/31/84	496.0						
6/13/84	869.0						
7/17/84	119.0	1.4	7.9	<10	<1	<10	15
8/27/84	22.0	1.1	8	<10	<1	10	10
9/18/84	91.0	1.4	7.7	<10	0.6	10	10
10/29/84	98.0	1.0	7.5	<10	0.5	<10	<10
11/26/84	83.0	1.1	7.9	<10	0.4	20	<10
12/17/84	81.0	1.0	7.5	<10	1.1	20	35
1/21/85	40.0	1.0	7.5	<10	<0.5	<5	<10
2/20/85	144.0	0.8	7.3	<10	2.1	20	<10
3/25/85	160.0	2.5	7.4	<10	56	60	35
4/29/85	295.0	2.5	7.5	<10	1.8	<10	<10
5/6/85	474.0	2.0	7.2	<10	30	<10	<10
5/11/85	479.0	2.5	7.5	<10	6.3	<10	<10
5/20/85	478.0	2.6	7.9	<10	42	30	42
5/29/85	1460.0	3.1	7.3	<10	2	<10	<5
6/3/85	913.0	3.5	7.1	<10	0.6	<10	21
6/11/85	1320.0	3.7	7.5	<10	<1	<10	<5
6/17/85	714.0	1.5	7.7	<10	<1	<10	<5
6/24/85	320.0	1.3	7.7	<10	<1	<10	<5
7/1/85	99.0	1.2	7.6	<10	21	10	35
7/8/85	156.0	1.0	7.7	<10	95	10	366
7/15/85	64.0	1.0	7.7	<10	78	<10	132
7/22/85	147.0	0.8	7.6	<10	55	<10	122
7/29/85	225.0	1.3	7.6	<10	65	10	367
8/27/85	120.0			<10	160	<10	540
9/16/85	214.0	1.2	7.6	<10	48	<10	130
11/4/85	332.0		7.6	<10	37	<10	123
11/18/85	198.0	0.8	8.1	<10	5.6	<10	24
12/16/85	176.0	0.8	7.8	<10	6.7	<10	10
1/21/86	110.0	0.4	7.9	<10	3	<10	<10
2/24/86	130.0	0.7	7.8	<10	1.5	<10	<10
3/24/86	400.0	3.9	7.6	<10	1.3	<10	10
4/22/86	539.0	1.6	7.5	<10	0.7	<10	<10
5/12/86	214.0	1.5	7.9	<10	1.1	<10	<10
5/19/86	251.0	1.1	7.8	<10	0.8	<10	<10
5/27/86	314.0	1.4	7.8	<10	2.1	<10	<10
6/5/86	3010.0		7.9	<10	0.9	10	10
6/9/86	1800.0	6.3	7.8	<10	<.5	<10	10
6/16/86	654.0	2.3	8	<10	<.5	<10	<10
6/23/86		0.7	7.9	<10	0.7	<10	<10

APPENDIX 1. CLARK FORK RIVER RAW DATA (#2000256; @ WHITEHORSE RAPIDS BELOW CABINET GORGE DAM)

DATE	USGS Data SUSPENDED SEDIMENT (tons/day)	76 TURBIDITY	403 pH	1002 ARSENIC (total recoverable) (ug/l)	1027 CADMIUM (tot. recoverable) (ug/l)	1042 COPPER (total recoverable) (ug/l)	1092 ZINC (total recoverable) (ug/l)
6/30/86	225.0	0.9	7.5	<10	0.7	<10	<10
7/7/86	131.0	1.1	8	<10	<.5	<10	<10
7/14/86	116.0	0.6	7.7	<10	<.5	<10	10
7/21/86	68.0	0.9	8	<10	6.3	20	10
7/28/86	66.0	0.9	8	<10	6.2	20	10
8/25/86	78.0	0.5	8	<10	2.4	10	<10
10/6/86	107.0			<10	1	<10	<10
10/20/86	42.0	0.9	8	<10	0.5	<10	<10
12/1/86	100.0	0.7	8	<10	0.9	<10	9
12/15/86	73.0	0.8	7.7	<10	17	<10	<10
1/26/87	299.0	0.8	7.8	<10	95	70	50
2/9/87	61.0	0.5	7.8	<10	5.1	10	<10
3/16/87	90.0	1.2	7.9	<10	2	10	<10
4/13/87	168.0		7.5	<10	1.1	10	10
5/4/87	384.0	1.2	7.7	<10	1.2	<10	<10
5/11/87	478.0	1.8	7.6	<10	0.5	<10	<10
5/18/87	383.0	1.3	7.8	<10	0.6	<10	<10
5/26/87	253.0	1.7	8.2	<10	<0.5	<10	<10
6/1/87	285.0	1.2		<10	0.6	<10	<10
6/8/87	102.0	1.2	7.8	<10	0.5	<10	<10
6/15/87	60.0	0.7	7.7	<10	<0.5	<10	<10
6/22/87	151.0	1.3	7.8	<10	28	<10	<10
6/29/87	89.0	1.4	7.8	<10	19	10	30
7/6/87	18.0	0.6	7.8	<10	2.4	<10	<10
7/14/87	34.0	0.7	7.9	<10	2.2	<10	<10
7/20/87	58.0	1.1	7.7	<10	0.8	<10	<10
7/27/87	168.0	1.8	7.8	<10	21	<10	60
8/17/87	113.0	1.7	7.8	<10	16	<10	10
9/22/87	89.0	1.7	7.9	<10	1.7	<20	<10
11/30/87	65.0	0.5	7.9	<10	1	<10	<10
1/4/88	113.0	0.5	7.7	<10	1.5	<20	<10
1/25/88	91.0	1.3	7.7	<10	<1	<10	<10
2/29/88	182.0		7.8	<10	18	<10	20
3/14/88	131	0.9	7.7	<10	<.5	<10	<10
4/18/88	292.0	1.2	8.2		0.45	<10	<10
4/25/88	278.0	1.6	7.7		<.5	<10	<10
5/2/88	251.0	1.2	7.8		<.5	<10	<10
5/9/88	266.0	1.2	7.8		<.5	<10	<10
5/16/88	295.0	1.9	7.9		0.45	<10	10
5/23/88	164.0		7.8		<.5	<10	10
5/31/88	185.0	1.4	7.7		0.5	<10	<10

APPENDIX 1. CLARK FORK RIVER RAW DATA (#2000256; @ WHITEHORSE RAPIDS BELOW CABINET GORGE DAM)

DATE	USGS Data SUSPENDED SEDIMENT (tons/day)	76 TURBIDITY	403 pH	1002 ARSENIC (total recoverable) (ug/l)	1027 CADMIUM (tot. recoverable) (ug/l)	1042 COPPER (total recoverable) (ug/l)	1092 ZINC (total recoverable) (ug/l)
6/6/88	178.0	1.1	7.8		0.5	<10	<10
6/13/88	169.0	1.3	7.8		<.5	<10	<10
6/20/88	337.0	1.0	7.6		<.5	<10	<10
6/27/88	138.0	1.0	7.9		<.5	<10	<10
7/5/88	148.0	1.1	7.9		<.5	<10	<10
8/1/88	65.0	1.1	7.9		<.5	<10	<10
8/20/88	22.0	0.8	8.1		<.5	<10	<10
9/20/88	60.0	0.9	7.9		<.5	<10	10

APPENDIX 2

Total Phosphorus Loads to Pend Oreille Lake (Water Years 1985-1988)

APPENDIX 2. Total Phosphorus Loads to Pend Oreille Lake - Water Years 1985-88

WATER YEAR 1985 - TOTAL P LOAD (FROM DEQ/USGS DATA)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/18/84			<.01	16800	
10/1/84	10/28/84	28	<.01	16800	
10/29/84	11/25/84	28	0.02	12100	16,574
11/26/84	12/16/84	21	<.01	15400	
12/17/84	12/31/84	15	0.01	30000	11,007
1/1/85	1/20/85	20	0.01	30600	14,970
1/21/85	2/19/85	30	0.014	14900	15,307
2/20/85	3/24/85	33	0.01	26600	21,471
3/25/85	4/28/85	35	0.01	19700	16,865
4/29/85	5/5/85	6	0.04	27300	16,026
5/6/85	5/12/85	7	0.01	35100	6,010
5/13/85	5/19/85	7	0.02	35500	12,157
5/20/85	5/27/85	8	0.01	35400	6,927
5/28/85	6/2/85	6	0.04	67500	39,625
6/3/85	6/10/85	8	0.024	48300	22,683
6/11/85	6/16/85	6	0.14	70100	144,030
6/17/85	6/23/85	7	0.013	52900	11,775
6/24/85	6/31/85	7	0.01	29600	5,068
7/1/85	7/7/85	7	0.022	18300	6,893
7/8/85	7/14/85	7	0.016	19300	5,287
7/15/85	7/21/85	7	0.017	11800	3,435
7/22/85	7/28/85	7	0.01	27200	4,657
7/29/85	8/26/85	29	0.012	20800	17,705
8/27/85	9/15/85	20	0.02	14800	14,480
9/16/85	9/30/85	15	0.018	26400	17,435
	WY1985		ANNUAL TP LOAD (KG/YR)		430,388
			AVG. DAILY TP LOAD (KG/DAY)		1,179

• Average TP concentration 9/18/84 - 9/16/85, excluding <.01 values on 9/18 and 11/26/84 = 0.023 mg/l

• Average flow (per observance) = 29983 cfs

APPENDIX 2. Total Phosphorus Loads to Pend Oreille Lake - Water Years 1985-88

WATER YEAR 1985 - TOTAL P LOAD - CALCULATED BY INSERTING AVERAGE TP CONCENTRATION (.023 MG/L) INTO THOSE DATES FOR WHICH TP WAS REPORTED AS <.01 (10/1/84 & 11/26/85)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/18/84			<.01	16800	
10/1/84	10/28/84	28	0.023	16800	26,464
10/29/84	11/25/84	28	0.02	12100	16,574
11/26/84	12/16/84	21	0.023	15400	18,194
12/17/84	12/31/84	15	0.01	30000	11,007
1/1/85	1/20/85	20	0.01	30600	14,970
1/21/85	2/19/85	30	0.014	14900	15,307
2/20/85	3/24/85	33	0.01	26600	21,471
3/25/85	4/28/85	35	0.01	19700	16,865
4/29/85	5/5/85	6	0.04	27300	16,026
5/6/85	5/12/85	7	0.01	35100	6,010
5/13/85	5/19/85	7	0.02	35500	12,157
5/20/85	5/27/85	8	0.01	35400	6,927
5/28/85	6/2/85	6	0.04	67500	39,625
6/3/85	6/10/85	8	0.024	48300	22,683
6/11/85	6/16/85	6	0.14	70100	144,030
6/17/85	6/23/85	7	0.013	52900	11,775
6/24/85	6/31/85	7	0.01	29600	5,068
7/1/85	7/7/85	7	0.022	18300	6,893
7/8/85	7/14/85	7	0.016	19300	5,287
7/15/85	7/21/85	7	0.017	11800	3,435
7/22/85	7/28/85	7	0.01	27200	4,657
7/29/85	8/26/85	29	0.012	20800	17,705
8/27/85	9/15/85	20	0.02	14800	14,480
9/16/85	9/30/85	15	0.018	26400	17,435
	WY1985		ANNUAL TP LOAD (KG/YR)		475,046
			AVG. DAILY TP LOAD (KG/DAY)		1,301

WATER YEAR 1986 - TOTAL P LOAD (FROM DEQ/USGS DATA)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/16/85			0.018	26400	
10/1/85	11/3/85	34	0.018	26400	39,520
11/4/85	11/17/85	14	0.014	24600	11,794
11/18/85	12/15/85	28	0.01	24500	16,780
12/16/85	1/20/86	36	0.016	32500	45,789
1/21/86	2/23/86	34	0.01	20400	16,965
2/24/86	3/23/86	29	0.011	24000	18,727
3/24/86	4/21/86	29	0.032	24700	56,066
4/22/86	5/11/86	20	0.023	33300	37,468
5/12/86	5/18/86	7	0.034	26400	15,369
5/19/86	5/26/86	8	0.013	31000	7,886
5/27/86	6/4/86	9	0.01	38800	8,541
6/5/86	6/8/86	4	0.01	79500	7,778
6/9/86	6/15/86	7	0.016	66800	18,300
6/16/86	6/29/86	14	0.019	40400	26,286
6/30/86	7/6/86	7	0.015	27800	7,140
7/7/86	7/13/86	7	0.01	24200	4,144
7/14/86	7/20/86	7	0.046	21500	16,934
7/21/86	7/27/86	7	0.009	12600	1,942
7/28/86	8/24/86	28	0.015	8190	8,414
8/25/86	9/30/86	37	0.009	14400	11,729
			ANNUAL TP LOAD (KG/YR)		377,569
			AVG. DAILY TP LOAD (KG/DAY)		1,034

- Average TP concentration 11/4/85 - 8/25/86 = 0.017 mg/l
- Average flow (per observance) = 30294 cfs

WATER YEAR 1987 - TOTAL P LOAD (FROM DEQ/USGS DATA)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
8/25/86			0.009	14400	
10/1/86	10/5/86	5	0.009	14400	1,585
10/6/86	10/19/86	14	0.009	19300	5,948
10/20/86	11/30/86	42	0.017	15700	27,419
12/1/86	12/14/86	14	0.007	18600	4,459
12/15/86	1/25/87	42	0.03	27200	83,829
1/26/87	2/8/87	14	0.007	27100	6,496
2/9/87	3/15/87	36	0.007	22700	13,992
3/16/87	4/12/87	28	0.014	16600	15,917
4/13/87	5/3/87	21	0.014	31200	22,437
5/4/87	5/10/87	7	0.014	35600	8,534
5/11/87	5/17/87	7	0.021	35400	12,728
5/18/87	5/25/87	8	0.015	35500	10,420
5/26/87	5/31/87	6	0.017	31200	7,784
6/1/87	6/7/87	8	0.009	35200	6,199
6/8/87	6/14/87	7	0.013	12600	2,805
6/15/87	6/21/87	7	0.013	17300	3,851
6/22/87	6/28/87	7	0.019	23900	7,775
6/29/87	7/5/87	7	0.019	18600	6,051
7/6/87	7/13/87	8	0.01	7660	1,499
7/14/87	7/19/87	6	0.02	13000	3,816
7/20/87	7/26/87	7	0.012	11600	2,383
7/27/87	8/16/87	21	0.018	21500	19,879
8/17/87	9/21/87	35	0.018	11000	16,951
9/22/87	9/30/87	9	0.01	15900	3,500
			ANNUAL TP LOAD (KG/YR)		296,256
			AVG. DAILY TP LOAD (KG/DAY)		812

- Average TP concentration 10/4/86 - 9/21/87 = 0.014
- Average flow (per observance) = 21929

WATER YEAR 1988 - TOTAL P LOAD (FROM DEQ/USGS DATA)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/22/87			0.01	16000	0
10/1/87	11/29/87	60	0.01	16000	23,482
11/30/87	1/3/88	35	0.013	17500	19,476
1/4/88	1/24/88	21	0.014	11500	8,270
1/25/88	2/28/88	35	0.004	5320	1,822
2/29/88	3/13/88	14	0.016	16100	8,821
3/14/88	4/17/88	35	0.01	19900	17,036
4/18/88	4/24/88	7	0.016	33000	9,040
4/25/88	5/1/88	7	0.027	33800	15,626
5/2/88	5/8/88	7	0.019	26000	8,458
5/9/88	5/15/88	7	0.014	236000	56,571
5/16/88	5/22/88	7	0.017	36000	10,479
5/23/88	5/30/88	8	0.012	23000	5,401
5/31/88	6/5/88	6	0.013	25100	4,789
6/6/88	6/12/88	7	0.013	29200	6,500
6/13/88	6/19/88	7	0.015	32700	8,398
6/20/88	6/26/88	7	0.013	26800	5,965
6/27/88	7/4/88	8	0.016	18400	5,761
7/5/88	7/31/88	27	0.013	18500	15,883
8/1/88	9/19/88	50	0.014	14900	25,512
9/20/88	9/30/88	10	0.014	6080	2,082
			ANNUAL TP LOAD (KG/YR)		259,372
			AVG. DAILY TP LOAD (KG/DAY)		709

- Average TP concentration 11/30/87 - 9/20/88 = 0.014
- Average flow (per observance) = 33147

APPENDIX 3A

Pend Oreille Lake (Station #2000257) Water Column Profile Data

APPENDIX 3A. PEND OREILLE LAKE (STATION # 2000257) - WATER COLUMN PROFILE DATA

Station No.: 2000257
Lat/Long: 48 06 50.0 116 27 10.0 2
Location: PEND OREILLE LK BET GRANITE PT @ TALACHE LANDING
County: BONNER
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: 840817

AVERAGE ('84-'87) SECCHI DEPTH (M) 8.3

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
9/12/84						
		7				
TIME	SURFACE		15.1	110	11.7	7.5
1000	5		15.3	108	11.6	7.6
	10		15.3	108	11.6	7.6
	15		15	106	11.7	7.7
	20		14.8	92	12.1	7.5
	25					
	30		10.2	88	12.4	7.5
	35					
	40		7.6	82	12.9	7.5
	45					
	49		6.6	80	13.6	8.1

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
10/1/84						
		9				
TIME	SURFACE		13.9		9	7.2
1230	5		13		8.8	7.2
	10		13		8.9	7.2
	15		13		8.8	7.1
	20		12.9		8.9	7.1
	25		12.5		9	7.1
	30		9.6		9.5	7.1
	35		7.8		9.8	7.2
	40		6.3		10.3	7.2
	45		6		10.3	7.3
	49		6.1		9.7	7.5

APPENDIX 3A. PEND OREILLE LAKE (STATION # 2000257) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
10/24/84						
		8				
TIME	SURFACE		10.7		9.1	6.5
100	5		10.7		9.2	7.4
	10		10.7		9.1	7.4
	15		10.7		9.1	7.4
	20		10.6		9.1	7.4
	25		10.7		9.1	6.8
	30		10.5		9.1	6.9
	35		9.3		9.2	7.5
	40		7.5		9.3	7.6
	45		6.3		9.3	7.7
	49		5.8		9.2	7.7

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
4/11/85						
		13				
TIME	SURFACE		3.3		9.9	
1130	5					
	10		2.2		9.9	
	15					
	20		1		9.7	
	25		2.1		9.6	
	30					
	35		2.7		9.4	
	40					
	45		1.9		9.3	
	49					

APPENDIX 3A. PEND OREILLE LAKE (STATION # 2000257) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
5/21/85						
		5.5				
TIME	SURFACE					
1100	5					
	10					
	15					
	20					
	25					
	30					
	35					
	40					
	45					
	49					

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
7/2/85						
		6				
TIME	SURFACE		20			
1130	5		17			
	10		16			
	15		14			
	20		12			
	25		10			
	30		9			
	35		9			
	40		9			
	45		9			
	49		9			

APPENDIX 3A. PEND OREILLE LAKE (STATION # 2000257) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
7/31/85						
		10				
TIME	SURFACE		23.1	160	9.6	
1145	5		22.3	156	9.1	
	10		18.3	140	10.1	
	15		11.4	120	10.7	
	20		9.9	116	9.7	
	25		7	110	9.4	
	30		6	108	9	
	35		5.7	108	8.6	
	40		5.1	106	8.2	
	45		4.7	106	7.6	
	49		4.6	106	7.2	

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
8/13/85						
		8				
TIME	SURFACE		18.2	136	8.8	
1030	5		18	134	8.6	
	10		16.1	126	8.7	
	15		14.8	122	8.7	
	20		9.6	108	8.8	
	25		8.8	106	8.7	
	30		8.2	106	8.7	
	35		6.6	102	8.9	
	40		6.1	100	9	
	45		5.6	98	9.1	
	49		5.2	96	9.4	

APPENDIX 3A. PEND OREILLE LAKE (STATION # 2000257) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
9/24/85						
		8.5				
TIME	SURFACE		14.2	140		
100	5		14	138		
	10		13.9	138		
	15		13.9	138		
	20		13.9	136		
	25		11.9	130		
	30		8.9	122		
	35		7.3	118		
	40		6.3	116		
	45		5.7	114		
	49		5.2	114		

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
4/21/86						
		8				
TIME	SURFACE		7.4	120	11.7	7.8
1230	5		5.2	116	11	7.9
	10		4.9	114	10.8	7.8
	15		4.9	114	10.7	7.8
	20		4.8	114	10.4	7.8
	25		4.8	114	10.2	7.8
	30		4.7	114	9.9	7.7
	35		4.7	114	9.6	7.7
	40		4.4	114	9.1	7.6
	45		4.3	114	8.2	7.8

APPENDIX 3A. PEND OREILLE LAKE (STATION # 2000257) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
6/3/86						
		4.5				
TIME	SURFACE		20.2	142	12.7	7.8
1300	5		9.9	126	12.9	7.8
	10		7.5	122	11.5	7.5
	15		6.8	120	10.8	7.6
	20		6.1	118	10	6.7
	25		5.5	116	9.6	7.6
	30		5.3	116	9.3	7.5
	35		5.1	116	9.1	7.5
	40		5	116	8.9	7.4
	45		4.9	116	8.6	7.4
	49		4.7	116	8.2	7.2

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
8/5/85						
		9.5				
TIME	SURFACE		21.2	170	11.6	7.6
1130	5		18.7	160	11.7	7.4
	10		17.8	152	12	7.2
	15		14.8	140	11.3	7.1
	20		12.2	132	10.2	7
	25		8.1	122	9.3	6.9
	30		6.6	120	8.9	6.9
	35		6	118	8.5	6.8
	40		5.7	118	8.1	6.8
	45		5.3	116	7.6	6.8
	49		5.2	118	7.2	67

APPENDIX 3A. PEND OREILLE LAKE (STATION # 2000257) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
9/15/86						
		9.5				
TIME	SURFACE		15.9	150	10.5	7.8
1040	5		15.6	152	10.7	7.7
	10		15.7	150	10.9	7.6
	15		15.8	148	11	7.5
	20		13.7	140	9.9	7.5
	25		8.3	124	9.2	7.3
	30		7.5	122	9.3	7.3
	35		5.9	118	9.3	7.3
	40		5.5	118	9.2	7.2
	45		5.1	116	8.9	7.2
	49		4.9	116	8.6	7.3

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
6/3/87						
		9.5				
TIME	SURFACE		13	120	12	8.9
1100	5		11.8	118	11.9	8.9
	10		10.3	116	11.3	8.8
	15		7.8	112	10.6	8.7
	20		7.6	112	10.7	8.7
	25		7.1	112	10.5	8.7
	30		6.8	110	10.5	8.7
	35		6.4	110	10.4	8.6
	40		6	108	10.2	8.6
	45		5.4	106	9.9	8.5
	49		5.3	106	9.8	8.4

APPENDIX 3A. PEND OREILLE LAKE (STATION # 2000257) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
7/13/87					Average Secchi Transparenc	
		7.5				
TIME	SURFACE		11.5	158	11.3	9.1
1200	5		14.2	148	11.5	9.1
	10		14.7	148	12.6	8.8
	15		12	124	11.4	8.7
	20		9.5	118	10.5	8.7
	25		7.2	114	9.8	8.8
	30		6.4	114	9.9	8.8
	35		6	112	9.9	8.8
	40		5.5	110	10	8.7
	45		5.1	110	9.9	8.7
	49		4.9	108	9.9	8.7

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
9/3/87						
		9				
TIME	SURFACE		18.8	154	10.1	9
1050	5		18.7	152	10.3	8.9
	10		17.5	148	10.4	8.8
	15		15.6	142	10.5	8.7
	20		11.7	124	9.3	8.5
	25		9.5	118	8.7	8.5
	30		7.8	114	8.3	8.5
	35		6.6	110	8.1	8.5
	40		6.1	108	7.8	8.5
	45		5.6	108	7.6	8.5
	49		5.3	106	7.2	8.5

APPENDIX 3B

Pend Oreille Lake (Station #2000257) Euphotic Zone Data

APPENDIX 3B. PEND OREILLE LAKE (STATION #2000257) - EUPHOTIC ZONE DATA

Station No.: 2000257 EUPHOTIC ZONE DATA
Lat/Long: 48 06 50.0 116 27 10.0 2
Location: PEND OREILLE LK BET GRANITE PT @ TALACHE LANDING
County: BONNER
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: 840817

DATE	PHOTIC ZONE DEPTH (=2.5x Secchi depth)	00610 NH3-N MG/L N	00630 NO2+NO3 - N MG/L N	00625 KJELDAHL-N MG/L N	00665 TOTAL-P mg/l MG/L P	70507 ORTHO-P MG/L P
9/12/84	15	0.016	0.003	0.2	0.01	
10/1/84	24		0.004	0.15	<.01	
10/24/84	20		0.014	0.07	.05?	
4/11/85	32		0.087	0.11	<.01	
5/21/85	12		0.162	0.03	<.01	<.01
7/2/85	15	0.084	0.097	0.13	0.008	0.005
7/31/85	25	0.061	0.02	0.12	0.008	<.002
8/13/85	20	0.041	0.037	0.11	0.008	<.002
9/24/85	24	0.381	0.181	0.43	0.002	<.001
4/21/86	20	0.055	0.086	0.09	0.007	0.007
6/3/86	12	0.013	0.011	0.13	0.008	0.001
8/5/86	25	0.076	0.023	0.12	0.005	0.003
9/15/86	24	0.003	0.022	0.1	0.006	<.001
6/3/87	25	0.024	0.017	0.14	0.012	0.002
7/13/87	18	0.053	0.085	0.06	0.008	<.002
9/3/87	21	0.003	0.013	0.08	0.006	
MEAN*	21	0.079	0.058	0.14	0.007	0.004
MINIMUM	12	0.003	0.011	0.06	0.002	0.001
MAXIMUM	25	0.381	0.181	0.43	0.012	0.007

*Means calculated by excluding "< detection limit" values

APPENDIX 3B. PEND OREILLE LAKE (STATION #2000257) - EUPHOTIC ZONE DATA

DATE	00671 FIELD FILTERED ORTHO-P	00095 LAB CONDUCTIVITY MICROMHOs	00900 TOT. HARDNESS MG/L CaCO3	00410 TOTAL ALKALINITY MG/L CaCO3	00929 SODIUM MG/L Cl	00940 CHLORIDE MG/L Na
9/12/84						
10/1/84						
10/24/84		169	84	83		
4/11/85		180	84	84		
5/21/85		184	80	84		
7/2/85		147	76	76		
7/31/85		172	76	76		
8/13/85		170	72	83		
9/24/85		154	80	84		
4/21/86	0.003	172	84	85		
6/3/86		158	80	78		
8/5/86		161	80	81		
9/15/86		169	76	85		
6/3/87		166	80	78		
7/13/87		158	76	77	2.7	0.9
9/3/87						
MEAN*	0.003	163	78	80	2.7	0.9
MINIMUM	0.003	154	72	76	2.7	0.9
MAXIMUM	0.003	172	84	85	2.7	0.9

APPENDIX 3B. PEND OREILLE LAKE (STATION #2000257) - EUPHOTIC ZONE DATA

DATE	00956 SILICA MG/L Si02	00076 TURBIDITY NTU	00403 pH	80154 SUSP. SEDIMENT MG/L	00530 SUSP. SOLIDS MG/L	01002 ARSENIC (tot. rcvrble uG/L)
9/12/84						<10
10/1/84	6					<10
10/24/84	5				<2	<10
4/11/85	7	0.4	7.5	<2		<10
5/21/85	6	0.7	7.7			<10
7/2/85	4	0.4	7.9	<2		
7/31/85	4	0.4				
8/13/85	6	0.3	7.7			
9/24/85	7	0.3	7.6			
4/21/86		0.5	8			
6/3/86		0.5	8.2			
8/5/86	6	0.3	8.2			
9/15/86			8			
6/3/87	5.8		8.1			
7/13/87	5.5		8.2			
9/3/87						
MEAN*	5.5	0.4		<2	<2	<10
MINIMUM	4.0	0.3	7.6			
MAXIMUM	7.0	0.5	8.2			

APPENDIX 3B. PEND OREILLE LAKE (STATION #2000257) - EUPHOTIC ZONE DATA

DATE	01025 CADMIUM (tot. rcvrble uG/L)	01045 IRON (tot. rcvrble uG/L)	01055 MAN-GANESE (tot. rcvrble uG/L)	01042 COPPER (tot. rcvrble uG/L)	01092 ZINC (tot. rcvrble uG/L)	01051 LEAD (tot. rcvrble uG/L)
9/12/84	<1	20	<10	<10	11	
10/1/84	<.5			<10	10	<10
10/24/84	<.5	<10	<10			
4/11/85	<.5			10	<10	
5/21/85	<1			<10	<5	
7/2/85	<.5			<10	<10	<5
7/31/85	<.5			<10	<10	<10
8/13/85	<.5			<10	<10	<10
9/24/85	<.5				<5	
4/21/86						
6/3/86						
8/5/86						
9/15/86						
6/3/87						
7/13/87						
9/3/87						
MEAN*	<.5		<10		11	
MINIMUM		<10		<10	<5	<5
MAXIMUM		20		10	11	<10

APPENDIX 3B. PEND OREILLE LAKE (STATION #2000257) - EUPHOTIC ZONE DATA

DATE	71900 MERCURY (tot) rcvrble uG/L)
9/12/84	
10/1/84	<.5
10/24/84	
4/11/85	
5/21/85	
7/2/85	
7/31/85	
8/13/85	
9/24/85	
4/21/86	
6/3/86	
8/5/86	
9/15/86	
6/3/87	
7/13/87	
9/3/87	
MEAN*	<5
MINIMUM	
MAXIMUM	

APPENDIX 3C

Pend Oreille Lake (Station #2000257) 50m Data

APPENDIX 3C. PEND OREILLE LAKE (STATION # 2000257) - 50m DATA

Station No.: 2000257 50 M DATA
Lat/Long: 48 06 50.0 116 27 10.0 2
Location: PEND OREILLE LK BET GRANITE PT @ TALACHE LANDING
County: BONNER
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: 840817

DATE	00610 NH3-N MG/L N	00630 NO2+NO3 - N MG/L N	00625 KJELDAHL-N MG/L N	00665 TOTAL-P mg/l MG/L P	70507 ORTHO-P MG/L P	00671 FIELD FILTERED ORTHO-P
10/1/84		0.068	0.06	<.01		
10/24/84						
7/3/85	0.05	0.09	0.09	0.004	<.002	
4/21/86	0.075	0.093	0.1	0.008	0.007	0.009
6/3/86	0.025	0.082	0.09	0.008	0.005	
8/5/86	0.021	0.094	0.07	0.018	0.006	
9/15/86	<.001	0.104	0.05	0.008	0.004	
6/3/87	0.045	0.064		0.012	0.003	
7/13/87	0.022	0.117	0.09	0.007	<.002	
9/3/87	<.001	0.069	0.08	0.003		
MEAN*	0.040	0.087	0.08	0.009	0.005	0.009
MINIMUM	0.021	0.064	0.05	0.003	0.003	0.009
MAXIMUM	0.075	0.117	0.10	0.018	0.007	0.009

*Means calculated by excluding "< detection limit" values

APPENDIX 3C. PEND OREILLE LAKE (STATION # 2000257) - 50m DATA

DATE	00095 LAB CONDUCTIVITY MICROMHOs	00900 TOT. HARDNESS MG/L CaCO3	00410 TOTAL ALKALINITY MG/L CaCO3	00929 SODIUM MG/L Cl	00940 CHLORIDE MG/L Na	00956 SILICA MG/L SiO2
10/1/84						6
10/24/84						
7/3/85	188	84	84			4
4/21/86	178	80	84			
6/3/86	169	84	85			
8/5/86	177	80	84			6
9/15/86	169	84	85			
6/3/87	180	84	84			6.4
7/13/87	171	84	82	2.7	0.9	6.2
9/3/87						
MEAN*	176	83	84	2.7	0.9	5.7
MINIMUM	169	80	82	2.7	0.9	4.0
MAXIMUM	188	84	85	2.7	0.9	6.4

APPENDIX 3C. PEND OREILLE LAKE (STATION # 2000257) - 50m DATA

DATE	00076 TURBIDITY NTU	00403 pH
10/1/84		
10/24/84		
7/3/85	0.4	7.6
4/21/86	0.4	8.1
6/3/86	0.2	8.2
8/5/86	0.2	8.1
9/15/86		8.1
6/3/87		8
7/13/87		8
9/3/87		
MEAN*	0.3	
MINIMUM	0.2	7.6
MAXIMUM	0.4	8.2

APPENDIX 3C. PEND OREILLE LAKE (STATION # 2000257) - 50m DATA

Station No.: # 50 M DATA
Lat/Long: 48 06 50.0 116 27 10.0 2
Location: PEND OREILLE LK BET GRANITE PT @ TALACHE LANDING
County: BONNER
Basin No.: #
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: #

DATE	01002 ARSENIC (tot. rcvrble uG/L)	01025 CADMIUM (tot. rcvrble uG/L)	01042 COPPER (tot. rcvrble uG/L)	01092 ZINC (tot. rcvrble uG/L)	01051 LEAD (tot. rcvrble uG/L)
10/1/84					
10/24/84	<10	<.5	<10	10	
7/3/85		<.5	<10	<10	<10
4/21/86					
6/3/86					
8/5/86					
9/15/86					
6/3/87					
7/13/87					
9/3/87					
MEAN*	<10	<.5	<10	10	<10
MINIMUM				<10	
MAXIMUM				10	

APPENDIX 4A

Pend Oreille Lake (Station #2000258) Water Column Profile Data

APPENDIX 4A. PEND OREILLE LAKE (STATION # 2000258) - WATER COLUMN PROFILE DATA

Station No.: 2000258
Lat/Long: 48 10 05.0 116 16 45.0 2
Location: PEND OREILLE LK 1 1/2 MI S OF SHEEPHERDER PT
County: BONNER
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: 840817

AVERAGE ('84-'87) SECCHI DEPTH (m) 7.0

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLYD OXY	pH (field)
9/12/84						
		7				
TIME	SURFACE		15.6	112	11.9	7.5
1110	5		15.6	112	12.1	7.6
	10		15.5	112	12	7.6
	15		15.5	110	12	7.5
	20		12.4	98	12.3	7.5
	25					
	30		9.2	86	13.2	7.6
	35					
	40		8.4	84	13.3	7.7
	45					
	49		7.4	80	13.4	8.3

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLYD OXY	pH (field)
10/1/84						
		8				
TIME	SURFACE		13.7		9.5	7.9
1300	5		12.8		9.3	7.9
	10		12.6		9.6	7.9
	15		12.3		9.4	7.9
	20		11.8		9.1	7.9
	25		11.3		8.1	7.8
	30		9.2		8.2	7.8
	35		8.2		8	7.7
	40		7		8.1	7.2
	45		6.4		8.2	7.3
	49		6.3		7.9	7.4

APPENDIX 4A. PEND OREILLE LAKE (STATION # 2000258) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
10/24/84						
		8				
TIME	SURFACE		10.4		9.5	6.8
1145	5		10.4		9.6	6.8
	10		10.4		9.6	6.8
	15		10.4		9.6	6.8
	20		9.9		9.7	6.8
	25		9.4		9.7	6.8
	30		8.1		9.9	6.8
	35		7.5		10	6.9
	40		6.7		10.2	7
	45		6.5		10	7.1
	49		6.2		10	7.2

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
4/11/85						
		9				
TIME	SURFACE		4.1			
1200	5					
	10		4.7			
	15					
	20		4.9			
	25					
	30		4.7			
	35					
	40		5			
	45					
	49		4.4			

APPENDIX 4A. PEND OREILLE LAKE (STATION # 2000258) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLYD OXY	pH (field)
5/21/85						
		4.5				
TIME	SURFACE					
1130	5					
	10					
	15					
	20					
	25					
	30					
	35					
	40					
	45					
	49					

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLYD OXY	pH (field)
7/2/85						
		3.5				
TIME	SURFACE		20			
1220	5		17			
	10		13			
	15		11			
	20		10			
	25		8			
	30		8			
	35		8			
	40		8			
	45		8			
	49		8			

APPENDIX 4A. PEND OREILLE LAKE (STATION # 2000258) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
7/31/85						
		9.5				
TIME	SURFACE		22.6	162		
1215	5		21.3	156		
	10		19.7	148		
	15		15	130		
	20		10.8	118		
	25		9	114		
	30		7.9	112		
	35		6.6	110		
	40		5.8	108		
	45		5.1	106		
	49		4.9	106		

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
8/13/85						
		9				
TIME	SURFACE		19	140		
	5		17.6	132		
	10		14.7	122		
	15		10.2	112		
	20		9.4	108		
	25		7.6	104		
	30		6.6	102		
	35		5.7	100		
	40		5.4	100		
	45		5	100		
	49		4.8	98		

APPENDIX 4A. PEND OREILLE LAKE (STATION # 2000258) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
9/24/86						
		8				
TIME	SURFACE		14.5	140		
1100	5		14.2	140		
	10		14.2	140		
	15		14.2	140		
	20		14.1	138		
	25		11.6	130		
	30		9.2	122		
	35		8	118		
	40		6.6	116		
	45		6.1	114		
	49		5.7	114		

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
4/21/86						
		7.5				
TIME	SURFACE		7.1	120	10.6	8
1345	5		4.7	114	9.9	7.9
	10		4.5	114	9.9	7.9
	15		4.4	114	9.8	7.9
	20		4.4	114	9.7	7.8
	25		4.3	114	9.6	7.8
	30		4.2	112	9.5	7.8
	35		4.2	112	9.3	7.8
	40		4.2	112	8.9	7.7
	45		4	114	8.5	7.9
	49					

APPENDIX 4A. PEND OREILLE LAKE (STATION # 2000258) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
6/3/86						
		0.5				
TIME	SURFACE		16.6	114	13.8	7.8
1400	5		15.7	114	13.6	7.5
	10		9.5	118	11.4	7.7
	15		7.9	118	10.8	7.7
	20		5.7	116	9.8	7.7
	25		5.6	116	9.6	7.6
	30		5.5	116	9.3	7.6
	35		5.3	116	9	7.6
	40		5.3	116	8.7	7.6
	45		5.2	116	8.3	7.5
	49		5.1	116	7.8	7.5

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
8/5/86						
		9.3				
TIME	SURFACE		21.6	170	13.1	8.2
1200	5		18.3	154	12.5	8.2
	10		15.6	142	12.1	8.2
	15		11.3	132	10.7	8.2
	20		8.8	128	10.2	8.2
	25		6.9	120	9.9	8.2
	30		6.2	118	9.7	8.2
	35		5.6	116	9.5	8.2
	40		5.3	116	9.2	8.2
	45		5.2	116	8.4	8.1
	49		5	116	7.8	8

APPENDIX 4A. PEND OREILLE LAKE (STATION # 2000258) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLYD OXY	pH (field)
9/15/86						
		9.5				
TIME	SURFACE		16.8	180	8.7	7.8
1130	5		15.3	150	10.3	7.8
	10		15	148	10.2	7.8
	15		13.8	142	9.9	7.7
	20		12.7	140	10	7.6
	25		9.8	128	9.5	7.6
	30		8.6	124	9.4	7.5
	35		7.7	122	9.2	7.4
	40		6.7	120	9	7.4
	45		5.9	118	8.8	7.4
	49		5.5	120	8.5	7.4

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLYD OXY	pH (field)
6/3/87						
		4				
TIME	SURFACE		14.5	122	10.9	
1210	5		11.8	118	10.9	
	10		11.5	116	10.9	
	15		10.5	116	10.9	
	20		8.7	114	10.5	
	25		7.4	112	10	
	30		6.1	108	9.6	
	35		5.3	106	9.2	
	40		4.9	106	8.8	
	45		4.7	104	8.3	
	49		4.6	104	7.8	

APPENDIX 4A. PEND OREILLE LAKE (STATION # 2000258) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
7/13/87						
		7.3				
TIME	SURFACE		20	158	11.6	
1300	5		17.8	148	11.3	
	10		14.3	132	11.2	
	15		12	128	10.7	
	20		11.7	126	10.6	
	25			118	9.5	
	30		7.9	116	9	
	35		7	114	8.9	
	40		6.2	112	8.7	
	45		5.7	110	8.5	
	49		5.2	108	8.6	

APPENDIX 4B

Pend Oreille Lake (Station #2000258) Euphotic Zone Data

APPENDIX 4B. PEND OREILLE LAKE (STATION # 2000258) - EUPHOTIC ZONE DATA

Station No.:	2000258
Lat/Long:	48 10 05.0 116 16 45.0 2
Location:	PEND OREILLE LK 1 1/2 MI S OF SHEEPHERDER PT
County:	BONNER
Basin No.:	130200
Basin:	CLARK FORK-PEND OREILLE RIVER
Survey Began:	840817

DATE	PHOTIC ZONE DEPTH (=2.5x Secchi depth)	00610 NH3-N MG/L N	00630 NO2+NO3 - N MG/L N	00625 KJELDAHL-N MG/L N	00665 TOTAL-P mg/l MG/L P	70507 ORTHO-P MG/L P
9/12/84	20	<.001	0.002	0.13	0.01	
10/1/84	20		0.02	0.14	<.01	
10/24/84	20		0.011	0.08	<.01	
4/11/85	24		0.079	0.11	<.01	
5/21/85	12		0.091	0.02	<.01	<.01
7/2/85	9	0.061	0.073	0.19	0.009	0.007
7/2/85	9	0.037	0.063	0.16	0.013	0.006
7/31/85	24	0.086	0.14	0.12	0.008	<.002
8/13/85	22.5	0.063	0.058	0.1	0.008	<.002
9/24/85	20	0.082	0.045	0.26	0.002	0.001
4/21/86	18	0.621	0.165	0.07	0.01	0.005
6/3/86	1	0.035	0.042	0.21	0.023	0.008
8/5/86	25	0.04	0.02	0.13	0.004	0.004
9/15/86	24	<.001	0.027	0.12	0.007	0.002
6/3/87	10	0.022	0.013	0.14	0.015	0.002
7/13/87	18	0.022	0.017	0.14	0.008	<.002
MEAN*	17	0.107	0.054	0.13	0.010	0.004
MINIMUM	1	0.022	0.011	0.02	0.002	0.001
MAXIMUM	25	0.621	0.165	0.26	0.023	0.008

*Means calculated by excluding "< detection limit" values

APPENDIX 4B. PEND OREILLE LAKE (STATION # 2000258) - EUPHOTIC ZONE DATA

DATE	00671 FIELD FILTERED ORTHO-P	00095 LAB CONCUCTIVITY MICROMHOs	00900 TOT. HARDNESS MG/L CaCO3	00410 TOTAL ALKALINITY MG/L CaCO3	00929 SODIUM MG/L Cl	00940 CHLORIDE MG/L Na
9/12/84						
10/1/84						
10/24/84		174	80	88		
4/11/85		177	80	87		
5/21/85		167	80	75		
7/2/85		145	76	75		
7/2/85		145	72	74		
7/31/85		172	80	77		
8/13/85		170	80	83		
9/24/85		159	80	83		
4/21/86	0.003	178	84	82		
6/3/86		124	60	65		
8/5/86		163	80	81		
9/15/86		169	84	84		
6/3/87		158	80	76		
7/13/87		161	80	78	2.7	0.7
MEAN*	0.003	162	78	79	2.7	0.7
MINIMUM	0.003	124	60	65	2.7	0.7
MAXIMUM	0.003	178	84	88	2.7	0.7

APPENDIX 4B. PEND OREILLE LAKE (STATION # 2000258) - EUPHOTIC ZONE DATA

DATE	00956 SILICA MG/L SiO2	00076 TURBIDITY NTU	00403 pH	80154 SUSP. SEDIMENT MG/L	00530 SUSP. SOLIDS MG/L
9/12/84					
10/1/84	7				
10/24/84	6				<2
4/11/85	9	0.4	7.5	<2	
5/21/85	5	0.7	7.4	<2	
7/2/85	4	0.5	7.9	<2	
7/2/85	4	0.5	7.8	<2	
7/31/85	4	0.6	7.7		
8/13/85	6	0.3	7.6		
9/24/85	7	0.3	7.5		
4/21/86		0.4	8.2		
6/3/86		9	8.2		
8/5/86	6	0.3	8.1		
9/15/86		8.1			
6/3/87	5.9		8.1		
7/13/87	5.9		8.2		
MEAN*	5.8	1.9		<2	<2
MINIMUM	4.0	0.3	7.4		
MAXIMUM	9.0	9.0	8.2		

APPENDIX 4B. PEND OREILLE LAKE (STATION # 2000258) - EUPHOTIC ZONE DATA

DATE	01002 ARSENIC (tot. rcvrble uG/L)	01025 CADMIUM (tot. rcvrble uG/L)	01045 IRON (tot. rcvrble uG/L)	01055 MANGANESE (tot. rcvrble uG/L)	01042 COPPER (tot. rcvrble uG/L)	01092 ZINC (tot. rcvrble uG/L)
9/12/84	<10	<1	20	<10	<10	10
10/1/84	<10	<.5			<10	10
10/24/84	<10	<.5			<10	<10
4/11/85	<10	<.5			10	<10
5/21/85	<10	<1			<10	10
7/2/85		<.5			<10	<10
7/2/85		<.5			<10	<10
7/31/85		<.5			<10	<10
8/13/85		<.5			<10	<10
9/24/85		<.5				<5
4/21/86						
6/3/86						
8/5/86						
9/15/86						
6/3/87						
7/13/87						
MEAN*	<10		20	<10	10	10
MINIMUM	0	<.5			<10	<10
MAXIMUM	0	<1			10	10

APPENDIX 4B. PEND OREILLE LAKE (STATION # 2000258) - EUPHOTIC ZONE DATA

DATE	01051 LEAD (tot. rcvrble uG/L)	71900 MERCURY (tot) rcvrble uG/L)
9/12/84		
10/1/84	<10	<.5
10/24/84		
4/11/85		
5/21/85		
7/2/85	<5	
7/2/85	<5	
7/31/85	<10	
8/13/85	<10	
9/24/85		
4/21/86		
6/3/86		
8/5/86		
9/15/86		
6/3/87		
7/13/87		
MEAN*		<.5
MINIMUM	<5	
MAXIMUM	<10	

APPENDIX 4C

Pend Oreille Lake (Station #2000258) 50m Data

APPENDIX 4C. PEND OREILLE LAKE (STATION # 2000258) - 50M DATA

Station No.: 2000258
Lat/Long: 48 10 05.0 116 16 45.0 2
Location: PEND OREILLE LK 1.5 MI S OF SHEEPHERDER PT
County: BONNER
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: 840817

DATE	00610 NH3-N MG/L N	00630 NO2+NO3 - N MG/L N	00625 KJELDAHL-N MG/L N	00665 TOTAL-P mg/l MG/L P	70507 ORTHO-P MG/L P	00671 FIELD FILTERED ORTHO-P
10/1/84		0.075	0.07	0.01		
10/24/84						
4/21/86	0.062	0.218	0.19	0.007	0.005	0.011
6/3/86	0.02	0.076	0.13	0.012	0.003	
8/5/86	0.03	0.097	0.14	0.004	0.006	
9/15/86	<.001	0.094	0.05	0.007	0.003	
6/3/87	0.037	0.099	0.09	0.01	0.004	
7/13/87	0.011	0.068	0.11	0.004	0.002	
MEAN*	0.032	0.104	0.11	0.008	0.004	0.011
MINIMUM	0.011	0.068	0.05	0.004	0.002	0.011
MAXIMUM	0.062	0.218	0.19	0.012	0.006	0.011

*Means calculated by excluding "< detection limit" values

APPENDIX 4C. PEND OREILLE LAKE (STATION # 2000258) - 50M DATA

DATE	00095 LAB CONDUCTIVITY MICROMHOs	00900 TOT. HARDNESS MG/L CaCO3	00410 TOTAL ALKALINITY MG/L CaCO3	00929 SODIUM MG/L Cl	00940 CHLORIDE MG/L Na	00956 SILICA MG/L SiO2
10/1/84						7
10/24/84						
4/21/86	178	84	85			
6/3/86	169	80	83			
8/5/86	171	76	84			7
9/15/86	169	88	86			
6/3/87	174	84	82			6.3
7/13/87	171	80	83	2.7	0.8	6.4
MEAN*	172	82	84	2.7	0.8	6.7
MINIMUM	169	76	82	2.7	0.8	6.3
MAXIMUM	178	88	86	2.7	0.8	7.0

APPENDIX 4C. PEND OREILLE LAKE (STATION # 2000258) - 50M DATA

DATE	00076 TURBIDITY NTU	00403 pH	01002 ARSENIC (tot. rcvrble uG/L)	01025 CADMIUM (tot. rcvrble uG/L)	01042 COPPER (tot. rcvrble uG/L)	01092 ZINC (tot. rcvrble uG/L)
10/1/84						
10/24/84			<10	<.5	<10	10
4/21/86	0.4	8.2				
6/3/86	0.4	8.2				
8/5/86	0.1	8.1				
9/15/86		8				
6/3/87		8				
7/13/87		7.9				
MEAN*	0.3		<10	<.5	<10	10
MINIMUM	0.1	7.9				
MAXIMUM	0.4	8.2				

APPENDIX 5A

Pend Oreille Lake (Station #2000259) Water Column Profile Data

APPENDIX 5A. PEND ORIELLE LAKE (STATION # 2000259) - WATER COLUMN PROFILE DATA

Station No.: 2000259
Lat/Long: 48 14 55.0 116 20 30.0 2
Location: PEND OREILLE LK BET HOPE AND ANDERSON PT
County: BONNER
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER

#2000259 AVERAGE (1984-87) SECCHI DEPTH (meters) 7.1

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		7.5				
9/12/84						
TIME	SURFACE		16.5	114	12	7.6
1230	5		16.4	114	11.5	7.6
	10		16.2	114	12.3	7.6
	15		15.3	108	12	7.6
	20		14.3	106	12.1	7.6
	25					
	30		9.5	88	13	7.4
	35					
	40		8.3	84	13.2	7.6
	45					
	49		7.4	80	7.8	7.8

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		8				
10/1/84						
TIME	SURFACE		13.8		8.5	7.8
1500	5		13.3		8.4	7.9
	10		13.3		8.1	7.9
	15		13.1		8.1	7.9
	20		12.9		8	7.9
	25		12.4		7.8	7.8
	30		10.9		7.9	7.8
	35		9.6		8.1	7.8
	40		8.9		8.1	7.8
	45		8.1		8.1	7.8
	49		6.1		8.1	7.9

APPENDIX 5A. PEND ORIELLE LAKE (STATION # 2000259) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		8				
10/24/84						
TIME	SURFACE		10.8		9.4	7.4
1400	5		10.7		9.3	7.4
	10		10.7		9.3	7.4
	15		10.7		9.5	7.4
	20		10.7		9.8	7.2
	25		10.6		9.8	7.5
	30		9.4		10	7.5
	35		7.5		10.5	7.6
	40		6.6		10.4	7.7
	45		5.9		9.9	7.8
	49		5.6		9.9	7.9

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		6				
4/11/85						
TIME	SURFACE		4.7			
1300	5					
	10		4.7			
	15					
	20		4.7			
	25					
	30		4.7			
	35					
	40		4.7			
	45					
	49		4.7			

APPENDIX 5A. PEND ORIELLE LAKE (STATION # 2000259) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		4				
5/21/85						
TIME	SURFACE					
1315	5					
	10					
	15					
	20					
	25					
	30					
	35					
	40					
	45					
	49					

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		5				
7/2/85						
TIME	SURFACE		21			
1400	5		17			
	10		15			
	15		12			
	20		11			
	25		10			
	30		8			
	35		8			
	40		8			
	45		8			
	49		8			

APPENDIX 5A. PEND ORIELLE LAKE (STATION # 2000259) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		9.5				
7/31/85						
TIME	SURFACE		24	164		
1245	5		22.9	158		
	10		18.1	142		
	15		12.7	126		
	20		10.8	118		
	25		9.4	114		
	30		7.4	110		
	35		6.5	108		
	40		5.8	108		
	45		5.4	106		
	49		5	106		

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		8.5				
8/13/85						
TIME	SURFACE		19.7	140		
1220	5		19.3	138		
	10		18.2	132		
	15		12.2	114		
	20		8.9	108		
	25		8	106		
	30		6.7	104		
	35		5.9	102		
	40		5.5	100		
	45		4.9	98		
	49		4.7	98		

APPENDIX 5A. PEND ORIELLE LAKE (STATION # 2000259) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		8.5				
9/24/85						
TIME	SURFACE		15.2	142		
1230	5		14.5	142		
	10		14.4	142		
	15		14.3	140		
	20		13.1	134		
	25		11.9	124		
	30		8.6	120		
	35		6.1	116		
	40		5.5	114		
	45		5.2	114		
	49		5.1	114		

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		3.75				
4/21/86						
TIME	SURFACE		9.2	116	10.7	8.1
1455	5		6.6	112	10.6	8.1
	10		6.2	112	9.9	8
	15		5.8	110	9.8	7.9
	20		5.7	110	9.7	7.9
	25		5.5	110	9.4	7.8
	30		5.3	110	9.2	7.8
	35		5	110	8.9	7.8
	40		4.6	108	8.2	7.8
	45		4.3	108	7.7	7.8
	49					

APPENDIX 5A. PEND ORIELLE LAKE (STATION # 2000259) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		1.5				
6/3/86						
TIME	SURFACE		19.7	128	14.2	7.8
1445	5		14.3	118	12.5	7.7
	10		10.3	120	11.1	7.8
	15		8.9	120	10.6	7.7
	20		7.8	120	9.9	7.7
	25		6.7	116	9.3	7.6
	30		6.4	116	9	7.6
	35		5.6	114	8.5	7.5
	40		5.2	112	8	7.5
	45		5.1	112	7.6	7.5
	49		5	112	7	7.5

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		9				
8/5/86						
TIME	SURFACE		22.2	174	12.6	8.4
1245	5		21	166	13	8.3
	10		17.2	150	12.1	8.3
	15		12.9	136	10.5	8.3
	20		10.7	130	9.7	8.3
	25		8.7	124	9.3	8.4
	30		8.1	122	9.2	8.4
	35		7	120	9.1	8.4
	40		5.6	116	8.4	8.4
	45		5.2	116	7.7	8.4
	49		5	116	7.3	8.3

APPENDIX 5A. PEND ORIELLE LAKE (STATION # 2000259) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		9.5				
9/15/86						
TIME	SURFACE		16.1	152	10.5	8
1220	5		16	152	10.9	8
	10		16	152	11	7.8
	15		15.2	146	10.8	7.8
	20		12.3	136	10	7.7
	25		8.5	126	9.3	7.6
	30		6	118	9.2	7.6
	35		5.5	118	9	7.6
	40		4.9	118	8.5	7.6
	45		4.7	116	8.2	7.6
	49		4.7	116	7.8	7.6

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		9.5				
6/3/87						
TIME	SURFACE		15.3	120	9.4	
1300	5		12.7	116	9.4	
	10		12.3	114	9.4	
	15		11.8	114	9.4	
	20		10.1	114	9.3	
	25		7.8	112	9.3	
	30		6.7	110	9.2	
	35		6	108	9.2	
	40		5.4	106	9.2	
	45		5.3	106	9.2	
	49		5.2	106	9.2	

APPENDIX 5A. PEND ORIELLE LAKE (STATION # 2000259) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		7.5				
7/13/87						
TIME	SURFACE		20.5	158	11.8	
1400	5		19.3	152	11.6	
	10		16.4	142	11.3	
	15		11.2	124	9.7	
	20		9.9	120	8.9	
	25		8.5	118	8.6	
	30		7.8	116	8.3	
	35		7	114	8	
	40		6.2	112	7.4	
	45		5.9	110	6.9	
	49		5.6	110	6.8	

APPENDIX 5B

Pend Oreille Lake (Station *2000259) Euphotic Zone Data

APPENDIX 5B. PEND OREILLE LAKE (STATION # 2000259) - EUPHOTIC ZONE DATA

Station No.: 2000259
Lat/Long: 48 14 55.0 116 20 30.0 2
Location: PEND OREILLE LK BET HOPE AND ANDERSON PT
County: BONNER
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: 840817

DATE	PHOTIC ZONE DEPTH (=2.5x Secchi depth)	00610 NH3-N MG/L N	00630 NO2+NO3 - N MG/L N	00625 KJELDAHL-N MG/L N	00665 TOTAL-P mg/l MG/L P	70507 ORTHO-P MG/L P
9/12/84	20	0.003	0.001	0.14	0.01	
10/1/84	20		0.008	0.11	0.015	
10/24/84	20		0.005	0.09	0.02	
4/11/85	15		0.064	0.14	<.01	
5/21/85	12		0.023	0.07	<.01	<.01
7/2/85	9	0.045	0.051	0.14	0.012	0.006
7/31/85	24	0.04	0.065	0.1	0.006	0.002
8/13/85	21	0.033	0.03	0.04	0.015	<.002
9/24/85	24	0.101	0.044	0.16	0.004	0.002
4/21/86	10	0.085	0.074	0.1	0.01	0.005
6/3/86	1	0.038	0.02	0.33	0.015	0.002
8/5/86	25	0.023	0.014	0.18	0.002	0.004
9/15/86	24	0.001	0.018	0.1	0.007	<.001
6/3/87	25	0.02	0.013	0.17	0.012	0.002
7/13/87	18	0.035	0.014	0.13	0.008	0.002
MEAN*	18	0.039	0.030	0.13	0.010	0.003
MINIMUM	1	0.001	0.005	0.04	0.002	0.002
MAXIMUM	25	0.101	0.074	0.33	0.020	0.006

*Means calculated by excluding "< detection limit" values

APPENDIX 5B. PEND OREILLE LAKE (STATION # 2000259) - EUPHOTIC ZONE DATA

DATE	00671 FIELD FILTERED ORTHO-P	00095 LAB CONDUCTIVITY MICROMHOs	00900 TOT. HARDNESS MG/L CaCO3	00410 TOTAL ALKALINITY MG/L CaCO3	00929 SODIUM MG/L Cl	00940 CHLORIDE MG/L Na
9/12/84						
10/1/84						
10/24/84		176	84	84		
4/11/85		177	88	89		
5/21/85		167	72	68		
7/2/85		145	72	73		
7/31/85		172	76	79		
8/13/85		170	76	82		
9/24/85		159	80	84		
4/21/86	0.008	162	76	75		
6/3/86		126	60	65		
8/5/86		161	80	81		
9/15/86		163	80	84		
6/3/87		156	76	75		
7/13/87		161	80	79	2.7	0.9
MEAN*	0.008	161	77	78	2.7	0.9
MINIMUM	0.008	126	60	65	2.7	0.9
MAXIMUM	0.008	177	88	89	2.7	0.9

APPENDIX 5B. PEND OREILLE LAKE (STATION # 2000259) - EUPHOTIC ZONE DATA

DATE	00956 SILICA MG/L SiO2	00076 TURBIDITY NTU	00403 pH	80154 SUSP. SEDIMENT MG/L	00530 SUSP. SOLIDS MG/L	01002 ARSENIC (tot. rcvrble uG/L)
9/12/84						<10
10/1/84	9					<10
10/24/84	5				<2	<10
4/11/85	7	0.5	7.6	<2		<10
5/21/85	6	1.2	7.4	<2		<10
7/2/85	4	0.5	7.9	<2		
7/31/85	4	0.5	7.8			
8/13/85	6	0.4	7.6			
9/24/85	6	0.3	7.8			
4/21/86		0.8	8			
6/3/86		2.8	8.2			
8/5/86	6	0.3	8.1			
9/15/86			8.2			
6/3/87	5.7		8			
7/13/87	5.9		8.2			
MEAN*	5.9	0.8		<2	<2	<10
MINIMUM	4.0	0.3	7.4			
MAXIMUM	7.0	2.8	8.2			

APPENDIX 5B. PEND OREILLE LAKE (STATION # 2000259) - EUPHOTIC ZONE DATA

DATE	01025 CADMIUM (tot. rcvrble uG/L)	01045 IRON (tot. rcvrble uG/L)	01055 MANGANESE (tot. rcvrble uG/L)	01042 COPPER (tot. rcvrble uG/L)	01092 ZINC (tot. rcvrble uG/L)	01051 LEAD (tot. rcvrble uG/L)
9/12/84	<1	10	<10	<10	4	
10/1/84	<.5			<10	10	<10
10/24/84	<.5			<10	<10	
4/11/85	<.5			8	<10	
5/21/85	<1			10	8	
7/2/85	<.5			<10	<10	<5
7/31/85	<.5			<10	<10	<10
8/13/85	<.5			<10	<10	<10
9/24/85	<.5				<5	
4/21/86						
6/3/86						
8/5/86						
9/15/86						
6/3/87						
7/13/87						
MEAN*		10	<10	9	7	
MINIMUM	<.5			8	4	<5
MAXIMUM	<1			10	10	<10

APPENDIX 5C

Pend Oreille Lake (Station #2000259) 50m Data

APPENDIX 5C. PEND OREILLE LAKE (STATION # 2000259) - 50M DATA

Station No.: 2000259
Lat/Long: 48 14 55.0 116 20 30.0 2
Location: PEND OREILLE LK BET HOPE AND ANDERSON PT
County: BONNER
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: 840817

DATE	00610 NH3-N MG/L N	00630 NO2+NO3 - N MG/L N	00625 KJELDAHL-N MG/L N	00665 TOTAL-P mg/l MG/L P	70507 ORTHO-P MG/L P	00671 FIELD FILTERED ORTHO-P
10/1/84		0.102	0.09	<.01		
10/24/84						
8/12/85	0.044	0.126	0.04	0.009	0.004	
4/21/86	0.031	0.082	0.13	0.015	0.012	0.014
6/3/86	0.021	0.146	0.18	0.009	0.006	
9/15/86	0.003	0.113	0.04	0.009	0.007	
6/3/87	0.038	0.075	0.06	0.01	0.003	
7/13/87	0.008	0.045	0.08	0.009	<.002	
MEAN*	0.024	0.098	0.09	0.010	0.006	0.014
MINIMUM	0.003	0.045	0.04	0.009	0.003	0.014
MAXIMUM	0.044	0.146	0.18	0.015	0.012	0.014

*Means calculated by excluding "< detection limit" values

APPENDIX 5C. PEND OREILLE LAKE (STATION # 2000259) - 50M DATA

DATE	00095 LAB CONDUCTIVITY MICROMHOs	00900 TOT. HARDNESS MG/L CaCO3	00410 TOTAL ALKALINITY MG/L CaCO3	00929 SODIUM MG/L Cl	00940 CHLORIDE MG/L Na	00956 SILICA MG/L SiO2
10/1/84						5
10/24/84						
8/12/85	188	84	86			7
4/21/86	169	80	80			
6/3/86	163	84	83			
9/15/86	169	88	83			
6/3/87	174	84	83			6.5
7/13/87	168	84	83	2.7	0.7	6.4
MEAN*	172	84	83	2.7	0.7	6.2
MINIMUM	163	80	80			6.4
MAXIMUM	188	88	86			7.0

APPENDIX 5C. PEND OREILLE LAKE (STATION # 2000259) - 50M DATA

DATE	00076 TURBIDITY NTU	00403 pH	01002 ARSENIC (tot. rcvrble uG/L)	01025 CADMIUM (tot. rcvrble uG/L)	01042 COPPER (tot. rcvrble uG/L)	01092 ZINC (tot. rcvrble uG/L)
10/1/84						
10/24/84			<10	<.5	<10	10
8/12/85	0.3	7.6		<.5	<10	10
4/21/86	1.2	8.1				
6/3/86	0.4	8.2				
9/15/86		8.1				
6/3/87		8				
7/13/87		7.8				
MEAN*	0.6		<10	<.5	<10	10
MINIMUM	0.3	7.6				
MAXIMUM	1.2	8.2				

APPENDIX 5C. PEND OREILLE LAKE (STATION # 2000259) - 50M DATA

DATE	01051 LEAD (total rcvrble uG/L)
10/1/84	
10/24/84	
8/12/85	<10
4/21/86	
6/3/86	
9/15/86	
6/3/87	
7/13/87	
MEAN*	<10
MINIMUM	
MAXIMUM	

APPENDIX 6A

Pend Oreille Lake (Station #2000260) Water Column Profile Data

APPENDIX 6A. PEND ORIELLE LAKE (STATION # 2000260) - WATER COLUMN PROFILE DATA

STORET RETRIEVAL DATE 87/02/27
Station No.: 2000260
Lat/Long: 48 14 15.0 116 37 35.0 2
Location: PEND OREILLE R UNDER POWER LINES-DOVER LMBR YD
County: BONNER
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: 840817

#2000260 AVERAGE (1984-87) SECCHI DEPTH (m) 4.6

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		4				
9/12/84						
TIME	SURFACE		16.3	110	12.3	7.5
1330	5		16.2	108	12.2	7.5
	10		16.2	108	12.1	7.6
	15		16.1	108	12.3	7.6

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		6				
10/1/84						
TIME	SURFACE		12.9		9.3	8
1600	5		12.3		9.4	8.1
	10		12.2		9.1	8.1
	15		12.1		8.9	8.2

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		5.5				
10/24/84						
TIME	SURFACE		9.5		9.8	7.1
1500	5		9.5		10	7.6
	10		9.4		9.9	7.7
	15		9.3		9.2	7.3

APPENDIX 6A. PEND ORIELLE LAKE (STATION # 2000260) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		2				
4/11/85						
TIME	SURFACE		7.9			
1400	5		8			
	10		7.3			
	15					

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		2.2				
5/21/85						
TIME	SURFACE					
	5					
	10					
	15					

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		4.5				
7/2/85						
TIME	SURFACE		23			
1500	5		20			
	10		18			
	15		18			

APPENDIX 6A. PEND ORIELLE LAKE (STATION # 2000260) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		5				
7/31/85						
TIME	SURFACE		24.1	156		
1400	5		23	154		
	10		22.8	152		
	15		22.7	152		

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		6.5				
8/13/85						
TIME	SURFACE		19.5	138		
1320	5		18.9	136		
	10		18.9	136		
	15		18.7	134		

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		8				
9/24/86						
TIME	SURFACE		14.5	140		
1300	5		14.2	138		
	10		14.1	138		
	15		14.1	138		

APPENDIX 6A. PEND ORIELLE LAKE (STATION # 2000260) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		2.75				
4/21/86						
TIME	SURFACE		8	114	9.3	7.8
1600	5		7.8	114	9.1	7.9
	10		7.7	114	8.5	8.1
	15					

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		2				
6/3/86						
TIME	SURFACE		17.4	126	9.7	7.5
1530	5		15.7	122	9.1	7.4
	10		15.2	120	8.6	7.4
	15					

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		7				
8/5/85						
TIME	SURFACE		22.4	170	9.7	8.8
1430	5		21.7	164	9.8	8.7
	10		20.3	158	9.1	8.6
	15		17.9	154	7.8	8.6

APPENDIX 6A. PEND ORIELLE LAKE (STATION # 2000260) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		4				
6/3/87						
TIME	SURFACE		15.5	120	9.7	
1345	5		13.7	114	9.2	
	10		13.5	114	9	
	15		13.4	112	8.6	

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		5				
7/13/87						
TIME	SURFACE		21.2	160	8.9	
1520	5		19.2	148	8.7	
	10		18.9	146	8	
	15		18.4	144	7.5	

APPENDIX 6B

Pend Oreille Lake (Station #2000260) Euphotic Zone Data

APPENDIX 6B. PEND OREILLE LAKE (STATION # 2000260) - EUPHOTIC ZONE DATA

Station No.: 2000260
Lat/Long: 48 14 15.0 116 37 35.0 2
Location: PEND OREILLE R UNDER POWER LINES-DOVER LMBR YD
County: BONNER
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: 840817

DATE	PHOTIC ZONE DEPTH (=2.5x Secchi depth)	00610 NH3-N MG/L N	00630 NO2+NO3 - N MG/L N	00625 KJELDAHL-N MG/L N	00665 TOTAL-P mg/l MG/L P	70507 ORTHO-P MG/L P
9/12/84	12	0.025	<.001	0.25	0.02	
10/1/84	15		0.004	0.17	0.01	
10/24/84	12		0.014	0.09	<.01	
4/11/85	5		0.023	0.14	<.01	
5/21/85	6		0.015	0.09	<.01	0.01
7/2/85	15	0.022	0.036	0.15	0.012	0.007
7/31/85	12	0.02	0.023	0.16	0.006	<.002
8/13/85	15	0.031	0.128	0.05	0.02	0.003
9/24/85	18	0.092	0.042	0.17	0.007	0.002
4/21/86	7.5	0.031	0.023	0.14	0.012	0.016
6/3/86	1	0.017	0.088	0.18	0.017	0.002
8/5/86	18	0.039	0.014	0.15	0.004	0.004
9/15/86	12	0.003	0.018	0.13	0.008	0.003
6/3/87	10	0.022	0.007	0.13	0.015	0.002
7/13/87	12	0.014	0.009	0.14	0.009	<.002
MEAN*	11.4	0.029	0.032	0.14	0.012	0.005
MINIMUM	1.0	0.003	0.004	0.05	0.004	0.002
MAXIMUM	18.0	0.092	0.128	0.18	0.020	0.016

*Means calculated by excluding "< detection limit" values

APPENDIX 6B. PEND OREILLE LAKE (STATION # 2000260) - EUPHOTIC ZONE DATA

DATE	00671 FIELD FILTERED ORTHO-P	00095 LAB CONCUCTIVITY MICROMHOs	00900 TOT. HARDNESS MG/L CaCO3	00410 TOTAL ALKALINITY MG/L CaCO3	00929 SODIUM MG/L Cl	00940 CHLORIDE MG/L Na
9/12/84						
10/1/84						
10/24/84		176	80	86		
4/11/85		174	84	88		
5/21/85		130	68	65		
7/2/85		141	72	69		
7/31/85		166	76	76		
8/13/85		170	76	82		
9/24/85		159	80	85		
4/21/86	0.008	157	76	80		
6/3/86		131	64	67		
8/5/86		156	72	68		
9/15/86		169	80	83		
6/3/87		149	72	71		
7/13/87		151	72	76	2.7	0.9
MEAN*	0.008	156	75	77	2.7	0.9
MINIMUM	0.008	130	64	65	2.7	0.9
MAXIMUM	0.008	176	84	88	2.7	0.9

APPENDIX 6B. PEND OREILLE LAKE (STATION # 2000260) - EUPHOTIC ZONE DATA

DATE	00956 SILICA MG/L SiO2	00076 TURBIDITY NTU	00403 pH	80154 SUSP. SEDIMENT MG/L	00530 SUSP. SOLIDS MG/L	01002 ARSENIC (tot. rcvrble uG/L)
9/12/84						<10
10/1/84	8					<10
10/24/84	8				<2	<10
4/11/85	8	2	7.6	<2		<10
5/21/85	4	1.5	7.3			<10
7/2/85	4	0.9	7.9	<2		
7/31/85	4	1	7.8			
8/13/85	7	0.5	7.7			
9/24/85	6	0.7	7.8			
4/21/86		2.4	7.8			
6/3/86		1.5	8.2			
8/5/86	5	0.5	8.4			
9/15/86			8.2			
6/3/87	5.9		8.1			
7/13/87	5.8		8.2			
MEAN*	6.0	1.2		<2	<2	<10
MINIMUM	4.0	0.5	7.3			
MAXIMUM	8.0	2.4	8.4			

APPENDIX 6B. PEND OREILLE LAKE (STATION # 2000260) - EUPHOTIC ZONE DATA

DATE	01025 CADMIUM (tot. rcvrble uG/L)	01045 IRON (tot. rcvrble uG/L)	01055 MANGANESE (tot. rcvrble uG/L)	01042 COPPER (tot. rcvrble uG/L)	01092 ZINC (tot. rcvrble uG/L)	01051 LEAD (tot. rcvrble uG/L)
9/12/84	<1	40	<10	<10	10	
10/1/84	<.5			<10	10	<10
10/24/84	<.5			<10	<10	
4/11/85	<.5			10	<10	
5/21/85	<1			10	7	
7/2/85	<.5			<10	<10	<5
7/31/85	<.5			<10	10	<10
8/13/85	<.5			<10	<10	<10
9/24/85	<.5				<5	
4/21/86						
6/3/86						
8/5/86						
9/15/86						
6/3/87						
7/13/87						
MEAN*		40	<10	10	9	
MINIMUM	<.5			<10	<5	<5
MAXIMUM	<1			10	10	<10

APPENDIX 6B. PEND OREILLE LAKE (STATION # 2000260) - EUPHOTIC ZONE DATA

DATE	71900 MERCURY (tot. rcvrble uG/L)
9/12/84	
10/1/84	<.5
10/24/84	
4/11/85	
5/21/85	
7/2/85	
7/31/85	
8/13/85	
9/24/85	
4/21/86	
6/3/86	
8/5/86	
9/15/86	
6/3/87	
7/13/87	
MEAN*	<.5
MINIMUM	
MAXIMUM	

APPENDIX 7A

Pend Oreille Lake (Station #2000261) Water Column Profile Data

APPENDIX 7A. PEND OREILLE LAKE (STATION # 2000261) - WATER COLUMN PROFILE DATA

Station No.: 2000261
Lat/Long: 47 58 10.0 116 30 21.0 2
Location: BAYVIEW-L PEND OREILLE BTWN BAYVIEW & BERNARD PK
County: KOOTENAI
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: 850607

#2000261 AVERAGE (1984-87) SECCHI DEPTH (meters) 9.1

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLYD OXY	pH (field)
		4.5				
5/21/85						
TIME	SURFACE					
	5					
	10					
	15					
	20					
	25					
	30					
	35					
	40					
	45					
	49					

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLYD OXY	pH (field)
		6				
7/2/85						
TIME	SURFACE		21			
1015	5		18			
	10					
	15		15			
	20		12			
	25		12			
	30		10			
	35		9			
	40		9			
	45		9			
	49		8			

APPENDIX 7A. PEND OREILLE LAKE (STATION # 2000261) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		11				
7/31/85						
TIME	SURFACE		22.7	156		
1100	5		22.3	154		
	10		22	150		
	15		11.7	118		
	20		9.1	114		
	25		7.6	110		
	30		6.8	108		
	35		5.8	106		
	40		5.1	104		
	45		4.7	104		
	49		4.6	104		

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		10				
8/13/85						
TIME	SURFACE		18.2	136		
1440	5		17.6	134		
	10		17.5	134		
	15		17.3	132		
	20		17.1	130		
	25		12.1	116		
	30		8.6	108		
	35		7.3	104		
	40		6.5	104		
	45		5.8	102		
	49		5.5	102		

APPENDIX 7A. PEND OREILLE LAKE (STATION # 2000261) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		9.5				
9/24/86						
TIME	SURFACE		14.3	136		
1500	5		13.5	136		
	10		13.3	134		
	15		13.3	134		
	20		12.1	126		
	25		8.8	120		
	30		6.9	116		
	35		6.3	116		
	40		5.6	114		
	45		5.1	114		
	49		5	114		

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		14				
4/21/86						
TIME	SURFACE		4.8	116	11.4	7.5
930	5		4.5	116	11.2	7.4
	10		4.4	116	11.1	7.4
	15		4.4	114	11	7.4
	20		4.4	114	10.8	7.3
	25		4.4	114	10.7	7.3
	30		4.3	114	10.6	7.2
	35		4.3	114	10.4	7.2
	40		4.3	114	10.1	7.1
	45		4.3	114	9.8	7
	49		4.3	114	9.3	6.9

APPENDIX 7A. PEND OREILLE LAKE (STATION # 2000261) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLYD OXY	pH (field)
		6				
6/3/86						
TIME	SURFACE		19.6	164	7.6	
1030	5		13.3	138	7.6	
	10		9.3	124	7.4	
	15		8.3	122	7.4	
	20		7.7	120	7.4	
	25		7.1	120	7.2	
	30		6.5	118	7.1	
	35		5.8	116	7.1	
	40		5.6	116	7	
	45		5.4	116	6.9	
	49		5.2	118	7	

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLYD OXY	pH (field)
		9.5				
8/5/85						
TIME	SURFACE		20.5	164	12.6	8.6
1630	5		20.2	160	12.9	8.6
	10		16.4	146	12.3	8.6
	15		13.9	138	11.5	8.5
	20		9.6	128	11	8.5
	25		7.5	122	10	8.6
	30		6.5	120	9.4	8.6
	35		5.6	118	9	8.7
	40		5.2	118	8.6	8.7
	45		5	118	8.2	8.7
	49		4.9	118	7.7	8.6

APPENDIX 7A. PEND OREILLE LAKE (STATION # 2000261) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		9				
9/11/86						
TIME	SURFACE		17.9	156	11	7.7
1020	5		17.8	154	11.1	7.5
	10		13.2	138	9.9	7.5
	15		8.9	126	9.1	7.4
	20		8.2	124	9.1	7.6
	25		7.9	124	9	7.5
	30		7.6	122	8.9	7.3
	35		7.3	122	8.8	7.2
	40		6.7	120	8.7	7.1
	45		6.1	120	8.6	7.1
	49		5.6	120	8.5	7

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		11.3				
6/3/87						
TIME	SURFACE		10.1	120	11	
1530	5		8.6	116	10.5	
	10		8.2	114	10.3	
	15		8	114	10.3	
	20		7.9	114	10.1	
	25		7.9	114	10	
	30		7.8	114	9.8	
	35		7.5	112	9.4	
	40		7.1	110	9.1	
	45		6.1	110	8.3	
	49		5.8	108	8	

APPENDIX 7A. PEND OREILLE LAKE (STATION # 2000261) - WATER COLUMN PROFILE DATA

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		9				
7/13/87						
TIME	SURFACE		20.6	158	12.3	
1700	5		17.4	146	11.5	
	10		16.1	138	11.6	
	15		14.9	134	11.3	
	20		11.1	124	10	
	25		9.1	118	9.2	
	30		7.5	114	8.5	
	35		6.6	112	8.2	
	40		6.2	112	7.9	
	45		5.5	110	7.5	
	49		5.1	108	7.3	

DATE	DEPTH (M)	SECCHI DEPTH	TEMP	COND (field)	DISSLVD OXY	pH (field)
		9.3				
9/3/87						
TIME	SURFACE		15.2	154	9.5	
	5		15.2	152	9.6	
	10		18.5	148	9.5	
	15		14.1	136	9.5	
	20		13.3	132	9.4	
	25		9.9	118	9.5	
	30		7.3	114	9.5	
	35		6.7	112	9.5	
	40		6.5	112	9.5	
	45		5.9	110	9.5	
	49		5.2	108	9.5	

APPENDIX 7B

Pend Oreille Lake (Station #2000261) Euphotic Zone Data

APPENDIX 7B. PEND OREILLE LAKE (STATION # 2000261) - EUPHOTIC ZONE DATA

Station No.: 2000261
Lat/Long: 47 58 10.0 116 30 21.0 2
Location: BAYVIEW-L PEND OREILLE BTWN BAYVIEW & BERNARD PK
County: KOOTENAI
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: 850607

DATE	PHOTIC ZONE DEPTH (=2.5x Secchi depth)	00610 NH3-N MG/L N	00630 NO2+NO3 - N MG/L N	00625 KJELDAHL-N MG/L N	00665 TOTAL-P mg/l MG/L P	70507 ORTHO-P MG/L P
5/21/85	12		0.016	0.12	<.01	<.01
7/2/85	15	0.076	0.174	0.21	0.012	
7/2/85	15	0.036	0.045	0.22	0.011	0.005
7/31/85	28	0.02	0.011	0.12	0.007	0.003
8/13/85	25	0.032	0.19	0.08	0.008	<.002
9/24/85	25	0.081	0.038	0.19	0.005	0.001
4/21/86	35	0.023	0.069	0.2	0.005	0.004
6/3/86	15	0.013	0.012	0.35	0.009	0.003
8/5/86	25	0.037	0.013	0.11	0.002	0.004
9/11/86	24	0.007	0.044	0.1	0.007	0.002
6/3/87	25	0.024	0.017	0.13	0.011	0.002
7/13/87	24	0.008	0.005	0.11	0.006	<.002
9/3/87	21	<.001	0.006	0.21	0.005	
MEAN*	22	0.032	0.049	0.17	0.007	0.003
MINIMUM	12	0.007	0.005	0.08	0.002	0.001
MAXIMUM	35	0.081	0.190	0.35	0.012	0.005

*Means calculated by excluding "< detection limit" values

APPENDIX 7B. PEND OREILLE LAKE (STATION # 2000261) - EUPHOTIC ZONE DATA

DATE	00671 FIELD FILTERED ORTHO-P	00095 LAB CONDUCTIVITY MICROMHOs	00900 TOT. HARDNESS MG/L CaCO3	00410 TOTAL ALKALINITY MG/L CaCO3	00929 SODIUM MG/L Cl	00940 CHLORIDE MG/L Na
5/21/85		177	80	84		
7/2/85		164	76	74		
7/2/85		147	76	77		
7/31/85		172	76	79		
8/13/85		170	76	83		
9/24/85		164	88	83		
4/21/86	0.005	169	84	82		
6/3/86		158	80	79		
8/5/86		161	76	79		
9/11/86		161	80	83		
6/3/87		169	84	81		
7/13/87		161	80	79	2.7	0.7
9/3/87						
MEAN*	0.005	164	80	80	2.7	0.7
MINIMUM	0.005	147	76	74	2.7	0.7
MAXIMUM	0.005	177	88	84	2.7	0.7

APPENDIX 7B. PEND OREILLE LAKE (STATION # 2000261) - EUPHOTIC ZONE DATA

DATE	00956 SILICA MG/L SiO2	00076 TURBIDITY NTU	00403 pH
5/21/85	4	0.9	7.8
7/2/85	4	0.4	7.8
7/2/85	4	0.4	7.9
7/31/85	4	0.6	7.8
8/13/85	6	0.3	8
9/24/85	7	0.2	7.5
4/21/86		0.2	7.7
6/3/86		0.3	8.3
8/5/86	6	0.3	8.2
9/11/86			8
6/3/87	5.6		8
7/13/87	5.9		8
9/3/87			
MEAN*	5.2	0.4	
MINIMUM	4.0	0.2	7.5
MAXIMUM	7.0	0.9	8.3

APPENDIX 7C

Pend Oreille Lake (Station #2000261) 50m Data

APPENDIX 7C. PEND OREILLE LAKE (STATION # 2000261) - 50M DATA

Station No.: 2000261
Lat/Long: 47 58 10.0 116 30 21.0 2
Location: BAYVIEW-L PEND OREILLE BTWN BAYVIEW & BERNARD PK
County: KOOTENAI
Basin No.: 130200
Basin: CLARK FORK-PEND OREILLE RIVER
Survey Began: 850607

DATE	00610 NH3-N MG/L N	00630 NO2+NO3 - N MG/L N	00625 KJELDAHL-N MG/L N	00665 TOTAL-P mg/l MG/L P	70507 ORTHO-P MG/L P	00671 FIELD FILTERED ORTHO-P
4/21/86	0.039	0.068	0.22	0.007	0.004	0.008
6/3/86	0.022	0.091	0.13	0.007	0.003	
8/5/86	0.04	0.09	0.08	0.004	0.006	
9/11/86	0.001	0.099	0.05	0.006	0.004	
6/3/87	0.026	0.035	0.06	0.011	0.003	
7/13/87	0.008	0.058	0.08	0.009	<.002	
9/3/87	0.001	0.07	0.07	0.006		
MEAN*	0.020	0.073	0.10	0.007	0.004	0.008
MINIMUM	0.001	0.035	0.05	0.004	0.003	0.008
MAXIMUM	0.040	0.099	0.22	0.011	0.006	0.008

*Means calculated by excluding "< detection limit" values

APPENDIX 7C. PEND OREILLE LAKE (STATION # 2000261) - 50M DATA

DATE	00095 LAB CONDUCTIVITY MICROMHOs	00900 TOT. HARDNESS MG/L CaCO3	00410 TOTAL ALKALINITY MG/L CaCO3	00929 SODIUM MG/L Cl	00940 CHLORIDE MG/L Na	00956 SILICA MG/L SiO2
4/21/86	170	88	82			
6/3/86	169	84	83			
8/5/86	171	84	83			6
9/11/86	169	84	84			
6/3/87	174	84	81			6.2
7/13/87	171	84	82	2.7	1.0	6.5
9/3/87						
MEAN*	171	85	83	2.7	1.0	6.2
MINIMUM	169	84	81	2.7	1.0	6.0
MAXIMUM	174	88	84	2.7	1.0	6.5

APPENDIX 7C. PEND OREILLE LAKE (STATION # 2000261) - 50M DATA

DATE	00076 TURBIDITY NTU	00403 pH
4/21/86	0.2	7.8
6/3/86	0.2	8.2
8/5/86	0.1	8.1
9/11/86		8
6/3/87		8.1
7/13/87		7.9
9/3/87		
MEAN*	0.2	
MINIMUM	0.1	7.8
MAXIMUM	0.2	8.2

APPENDIX 8A

Algal Growth Potential Bioassay Results - 1984

APPENDIX 8A.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL RESEARCH LABORATORY
200 S.W. 35TH STREET
CORVALLIS, OREGON 97333

NOVEMBER 20, 1984

NOV 1984
DIVISION OF ENVIRONMENT
COEUR D'ALENE OFFICE

MR. MIKE A. BECKWITH
SENIOR WATER QUALITY SPECIALIST
STATE OF IDAHO
DEPT. HEALTH AND WELFARE
DIVISION OF ENVIRONMENT
2110 IRONWOOD PARKWAY
COEUR D' ALENE, IDAHO 833814

DEAR MIKE:

ENCLOSED YOU WILL FIND ALGAL ASSAY RESULTS FOR THE 7 LAKE SITES TESTED. PLEASE CHECK THE SAMPLING DATES AND SITES FOR ACCURACY. IF YOU FIND ANY ERRORS OR OMISSIONS PLEASE LET ME KNOW SO I CAN BRING THE RECORDS UP TO DATE.

THERE WAS NO METAL TOXICITY FOUND IN THE BLACK LAKE SAMPLES. THESE LAKE WATERS ARE THE MOST PRODUCTIVE IN THIS SET OF SAMPLES. THE WATERS WERE ALL PRIMARILY PHOSPHORUS LIMITED. THEREFORE, THE CONTROL YIELDS, AS WELL AS THOSE SPIKED WITH 1.00N, 1.00E, AND N+E, ARE REPRESENTATIVE OF THE GROWTH POTENTIAL OF BOTH GREEN AND BLUE-GREEN ALGA.

THE LAKE COEUR D' ALENE STATIONS AT CAVE BAY AND MID LAKE WERE CONSISTENTLY OLIGOTROPHIC WITH PRIMARY NUTRIENT LIMITATION CAUSED BY PHOSPHORUS. FOUR OF THE 8 SAMPLES TESTED PRODUCED LOW YIELDS CAUSED BY THE PRESENCE OF HEAVY METALS. ALL OF THE SAMPLES DISPLAYING GROWTH INHIBITION WERE VERIFIED TO CONTAIN ZINC IN CONCENTRATIONS HIGH ENOUGH TO PRODUCE THE EFFECT.

ALL LAKE PEND OREILLE SAMPLES WERE OLIGOTROPHIC WITH THE ONE EXCEPTION OF STATION #3 COLLECTED 10/07/84. THAT STATION WAS MODERATELY PRODUCTIVE WITH A YIELD OF 1.39 MG DRY WEIGHT S. CAPRICORNUTUM / LITER. THIS STATION APPEARS TO REFLECT THE LOCALIZED IMPACT OF INFLOW FROM THE CLARK FORK RIVER. ONE SAMPLE IS NOT SUFFICIENT TO DETERMINE IF THIS PRODUCTIVITY IS REPRESENTATIVE OF STATION #3.

ONLY ONE OF THE 6 LAKE PEND OREILLE SAMPLES DISPLAYED GROWTH INHIBITION. STATION #2 HAS ALGAL GROWTH INHIBITION AND THE CAUSE WAS SUPPORTED BY METALS ANALYSIS WITH MEASUREMENT OF 0.016 MG ZINC / LITER.

SIX HEAVY METALS WERE ANALYZED FOR IN EACH SAMPLE (CU, CR, ZN, NI, CD, AND HG). ONLY ZINC WAS FOUND IN MEASUREABLE QUANTITIES.

REPORT ON THE RESULTS OF ALGAL ASSAYS PERFORMED ON WATERS COLLECTED IN LAKE PEND OREILLE, IDAHO

BY

JOSEPH C. GREENE, MICHAEL A. LONG AND CATHY LEE BARTELS

U.S. ENVIRONMENTAL PROTECTION AGENCY
CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY
HAZARDOUS MATERIALS ASSESSMENT TEAM
200 S.W. 35TH STREET
CORVALLIS, OREGON 97333

ALGAL ASSAYS WERE PERFORMED ON LAKE PEND OREILLE AT THE REQUEST OF REPRESENTATIVES OF THE DIVISION OF ENVIRONMENT, DEPARTMENT OF HEALTH AND WELFARE, STATE OF IDAHO. WATER SAMPLES WERE COLLECTED BY EMPLOYEES OF THE DIVISION OF ENVIRONMENT IN AUTOCLAVABLE CONTAINERS FURNISHED BY EPA. SAMPLES WERE SHIPPED BY THE US POSTAL SERVICE AND WERE GENERALLY RECEIVED IN TWO TO THREE DAYS.

ALGAL ASSAYS WERE PERFORMED FOLLOWING THE METHODS OUTLINED IN THE SELENASTRUM CAPRICORNUTUM ALGAL ASSAY BOTTLE TEST (MILLER, GREENE AND SHIROYAMA, 1978).

SIX WATER SAMPLES WERE COLLECTED AT 4 STATIONS ON LAKE PEND OREILLE DURING THE PERIOD FROM SEPTEMBER 12, TO NOVEMBER 2, 1984. THE STATIONS WERE:

- STATION #2 BETWEEN GRANITE PT. & TALACHE LANDING;
- STATION #3 1 1/2 MILES SO. OF SHEEPHERDER PT.;
- STATION #4 BETWEEN HOPE, ID. AND ANDERSON PT.;
- STATION #5 UNDER POWERLINE AT DOVER LUMBER YARD.

EVERY WATER SAMPLE TESTED WAS PRIMARILY GROWTH LIMITED BY PHOSPHORUS AND SECONDARILY LIMITED BY NITROGEN. STATION #3 PRODUCED THE HIGHEST CONTROL YIELD OF ALL SAMPLES TESTED. THE 1.39 MG DRY WEIGHT/LITER PUTS THIS STATION WITHIN THE MODERATELY HIGH PRODUCTIVITY CLASSIFICATION (0.81-6.00 MG DRY WEIGHT/LITER) PROPOSED BY MILLER, MALONEY AND GREENE (1974). ONLY THE AUTOCLAVED AND FILTERED SAMPLE FROM STATION #4 WAS OF LOW PRODUCTIVITY (0.00-0.10 MG DRY WEIGHT/LITER). THE SAMPLES FROM STATIONS #2 AND #5 WERE MODERATELY PRODUCTIVE (0.11-0.80 MG DRY WEIGHT/LITER).

THE SAMPLE COLLECTED OCTOBER 1 AT STATION #2 WAS THE ONLY WATER TO CONTAIN MEASUREABLE AMOUNTS OF HEAVY METALS. ALGAL GROWTH INHIBITION WAS CAUSED BY THE ANALYZED CONCENTRATION OF 0.016 MG ZINC/LITER. THE

0.12 MG DRY WEIGHT/LITER YIELD ACHIEVED IN THE CONTROL CULTURES WAS INCREASED BY ADDITION OF THE METAL CHELATOR *EDTA* TO 1.95 MG DRY WEIGHT/LITER. *T*HE CONTROL YIELD HAD 93.8% INHIBITION OF GROWTH RELATIVE THE YIELD FOUND IN THE CULTURES SPIKED WITH 1.00 MG *EDTA*/LITER.

*T*HE LABORATORY ALGAL RESPONSE ESTABLISHES THAT THE ZINC ANALYSIS IS REAL AND THE MEASURED CONCENTRATION IS BIOLOGICALLY ACTIVE. *H*OWEVER, ONE MUST NOT PLACE TOO MUCH EMPHASIS ON THIS INFORMATION RELATIVE TO A POTENTIAL TOXIC EFFECT OF ZINC ON INDIGENOUS ALGAL SPECIES. *T*HE INDIGENOUS ALGA, LONG EXPOSED TO THE METALS ORIGINATING FROM SOURCES UP THE *C*LARK *F*ORK *R*IVER, ARE NOT LIKELY TO RESPOND TO THIS LOW LEVEL OF METAL.

REFERENCES

*M*ILLER, *W.E.*, *J.C.* *G*REENE AND *T.* SHIROYAMA. 1978. SELENASTRUM CAPRICORNUTUM *P*RINTZ *A*LGAL *A*SSAY *B*OTTLE *T*EST: *E*XPERIMENTAL *D*ESIGN, *A*PPLICATION, AND *D*ATA *I*NTERPRETATION *P*ROTOCOL. *U.S.* *E*NVIRONMENTAL *P*ROTECTION *A*GENCY, *C*ORVALLIS, *O*REGON. *EPA*-600/9-78-018.

*M*ILLER *W.E.*, *T.E.* *M*ALONEY AND *J.C.* *G*REENE. 1974. *A*LGAL *P*RODUCTIVITY IN 49 LAKE WATERS AS DETERMINED BY ALGAL ASSAYS. *W*ATER *R*ES. 8:667-679.

US EPA, HAZARDOUS MATERIALS ASSESSMENT TEAM - CORVALLIS, OREGON

14-DAY ALGAL GROWTH POTENTIAL TESTS

SITE: LAKE PEND OREILLE, BONNER CO., IDAHO
STATION: MID LAKE - BETWEEN GRANITE POINT AND TALACHE LANDING. ORD AND EAST POINTS.
STORET NO.: 2000257
PRETREATMENT: AUTOCLAVED AND FILTERED

NUTRIENT SPIKES (MG/LITER)

NOTE	SAMPLE DATE	CONTROL	1.00 N	0.05 P	N+P	1.00 E	N+E	P+E	N+P+E	LIMITING FACTORS	CERL ID	ZINC (MG/L)
	09/12/84	0.24	0.27	2.33	21.84	0.14	0.14	2.38	21.30	P/N	6339003	-
	10/01/84	0.12	0.25	1.13	11.52	1.95	2.30	2.63	26.48	M/P/N	6342001	0.016
	10/24/84	0.43	0.64	1.97	33.93	0.64	0.51	2.07	28.58	P/N	6345001	-

P=PHOSPHORUS; N=NITROGEN; E=EDTA; M=HEAVY METALS INHIBITION.

ICAPES ELEMENTAL CHEMICAL ANALYSIS

SAMPLE DATE	ALGAL TEST CODE	CERL ID	MG /LITER ZN	CA	MG	S
091284	092184B	6339003	<	24.501	6.387	-
100184	101284A	6342001	0.016	25.501	6.669	2.904
102484	110284A	6345001	<	24.553	6.981	3.173

TECHNICON

SAMPLE DATE	ALGAL TEST CODE	CERL ID	NO2 + NO3	NH3	TSIN	PREDICT. YIELD	TOTAL PHOS.	ORTHO PHOS>	PREDICT. YIELD
091284	092184B	6339003	<0.010	<0.005	-	-	0.015	0.005	2.15
100184	101284A	6342001	<0.010	<0.005	-	-	<0.010	<0.005	-
102484	110284A	6345001	<0.010	0.008	0.008	<1.00	0.017	<0.005	-

(-) THE ELEMENT WAS NOT ANALYZED.
(<) = ANALYSIS WAS PERFORMED BUT RESULTS FELL BELOW THE LEVEL OF DETECTION.

US EPA, HAZARDOUS MATERIALS ASSESSMENT TEAM - CORVALLIS, OREGON

14-DAY ALGAL GROWTH POTENTIAL TESTS

SITE: LAKE PEND OREILLE, BONNER CO., IDAHO
STATION: 1 1/2 MILES SOUTH OF SHEEPHERDER POINT [CLARK FORK CONFLUENCE].
STORET NO.: 2000258 RIVER MILE: 136.3
PRETREATMENT: AUTOCLAVED AND FILTERED

NOTE	SAMPLE DATE	CONTROL	1.00 N	0.05 P	N+P	1.00 E	N+E	P+E	N+P+E	LIMITING FACTORS	CERL ID	ZINC (MG/L)
		NUTRIENT SPIKES (MG/LITER)										
	10/01/84	1.39	1.40	2.11	26.20	1.55	1.63	1.50	20.59	P/N	6342002	-

P=PHOSPHORUS; N=NITROGEN; E=EDTA; M=HEAVY METALS INHIBITION.

ICAPES ELEMENTAL CHEMICAL ANALYSIS

SAMPLE DATE	ALGAL TEST CODE	CERL ID	ZN	CA	MG	S
			MG /LITER			
100184	101284B	6342002	<	26.084	6.898	2.984

TECHNICON

SAMPLE DATE	ALGAL TEST CODE	CERL ID	NO2 + NO3	NH3	TSIN	PREDICT. YIELD	TOTAL PHOS.	ORTHO PHOS>	PREDICT. YIELD
100184	101284B	6342002	0.014	<0.005	0.014	<1.00	0.019	<0.005	-

(-) = THE ELEMENT WAS NOT ANALYZED.
(<) = ANALYSIS WAS PERFORMED BUT RESULTS FELL BELOW THE LEVEL OF DETECTION.

* US EPA, HAZARDOUS MATERIALS ASSESSMENT TEAM - CORVALLIS, OREGON *

14-DAY ALGAL GROWTH POTENTIAL TESTS

SITE: LAKE PEND OREILLE, BONNER CO., IDAHO
STATION: BETWEEN HOPE, ID. AND ANDERSON POINT CLARK FORK CONFLUENCE].
STORET NO.: 2000259 RIVER MILE: 128.8
PRETREATMENT: AUTOCLAVED AND FILTERED

	SAMPLE	NUTRIENT SPIKES (MG/LITER)								LIMITING	CERL	ZINC
NOTE	DATE	CONTROL	1.00 N	0.05 P	N+P	1.00 E	N+E	P+E	N+P+E	FACTORS	ID	(MG/L)
	09/12/84	0.06	0.08	4.91	24.05	0.05	0.50	2.78	15.99	P/N	6339006	-

P=PHOSPHORUS; N=NITROGEN; E=EDTA; M=HEAVY METALS INHIBITION.

ICAPES ELEMENTAL CHEMICAL ANALYSIS

SAMPLE DATE	ALGAL TEST CODE	CERL ID	MG /LITER ZN	CA	MG	S
091284	092184D	6339006	<	25.102	6.542	-

TECHNICON

SAMPLE DATE	ALGAL TEST CODE	CERL ID	NO2 + NO3	NH3	TSIN	PREDICT. YIELD	TOTAL PHOS.	ORTHO PHOS)	PREDICT. YIELD
091284	092184D	6339006	<0.010	<0.005	-	-	0.021	<0.005	-

(-) = THE ELEMENT WAS NOT ANALYZED.
(<) = ANALYSIS WAS PERFORMED BUT RESULTS FELL BELOW THE LEVEL OF DETECTION.

* US EPA, HAZARDOUS MATERIALS ASSESSMENT TEAM - CORVALLIS, OREGON *

14-DAY ALGAL GROWTH POTENTIAL TESTS

SITE: LAKE PEND OREILLE, BONNER CO., IDAHO
STATION: UNDER POWER LINES AT DOVER LUMBER YARD. CLARK FORK CONFLUENCE].
STORET NO.: 200260 RIVER MILE: 113 0.2
PRETREATMENT: AUTOCLAVED AND FILTERED

NOTE	SAMPLE DATE	CONTROL	1.00 N	0.05 P	N+P	1.00 E	N+E	P+E	N+P+E	LIMITING FACTORS	CERL ID	ZINC (MG/L)
		NUTRIENT SPIKES (MG/LITER)										
	11/02/84	0.46	0.69	2.07	36.68	0.51	0.44	2.38	35.42	P/H	6345002	-

P=PHOSPHORUS; N=NITROGEN; E=EDTA; H=HEAVY METALS INHIBITION.

ICAPES ELEMENTAL CHEMICAL ANALYSIS

SAMPLE DATE	ALGAL TEST CODE	CERL ID	ZN	CA	MG	S
			MG /LITER			
102484	110284B	6345002	<	22.588	6.649	3.117

TECHNICON

SAMPLE DATE	ALGAL TEST CODE	CERL ID	NO2 + NO3	NH3	TSIN	PREDICT. YIELD	TOTAL PHOS.	ORTHO PHOS>	PREDICT. YIELD
102484	110284B	6345002	<0.010	0.001	0.001	<1.00	<0.010	<0.005	-

(-) = THE ELEMENT WAS NOT ANALYZED.
(<) = ANALYSIS WAS PERFORMED BUT RESULTS FELL BELOW THE LEVEL OF DETECTION.

APPENDIX 8B

Algal Growth Potential Bioassay Results - 1986

APPENDIX 8B

RESULTS OF FRESHWATER ALGAL ASSAYS CONDUCTED ON WATER SAMPLES COLLECTED FROM SPIRIT LAKE AND LAKE PEND OREILLE, IDAHO

APRIL AND SEPTEMBER 1986

by

Carolyn E. Gangmark
Joseph M. Cummins

U.S. Environmental Protection Agency
Environmental Services Division
Region 10 Laboratory
Manchester, Washington 98353

January 15, 1987

INTRODUCTION AND OBJECTIVES

In March 1986, the Idaho Department of Health and Welfare, Division of Environment, requested that EPA Region 10 assist the State of Idaho by conducting algal assays on composite water samples collected from Spirit Lake and Lake Pend Oreille, Idaho. Selenastrum capricornutum was to be used to assess the growth potential of water samples from the two lakes. This growth potential/nutrient assessment was to be conducted on samples collected from the same stations during the spring (April) and again during the height of the growing season (September). There was to be one composite sample from Spirit Lake and three composites from Lake Pend Oreille.

The Spirit Lake work was requested in order to verify that the Lake is nitrogen limited in the spring and to determine the nutrient that limits algal growth in the late summer.

Lake Pend Oreille assays were to verify differences in productivity between water samples collected from the south end, middle and northern outlet arm of the Lake.

METHODS

SAMPLE COLLECTION

Spirit Lake samples were comprised of composited, euphotic zone (0-6m) waters collected at three different stations. The station numbers were 2000287, 2000288, and 2000289. They are located mid-lake dividing the Lake into three equal sections east to west (Fig. 1). For simplicity, this composite will be referred to throughout this report as 2000288. Water was collected with a Van Dorn sampler and composited in an acid-washed, 5-gal polyethylene carboy. A subsample was then transferred into an acid-washed, 2.5-gal polyethylene bottle for transport. Spirit Lake samples were collected April 16th and September 10th, 1986.

Lake Pend Oreille samples were collected and composited in the same manner as the Spirit Lake samples (Station 200025, 0-20m; 2000260, 0-7.5m; and 2000261, 0-35m). Station 2000257 is located between Granite Point and Talache Landing. Station 2000260 is under the powerline at Dover Lumber Yard and Station 2000261 is at the extreme south end of the Lake between Bayview and Lakeview (Fig. 2). Pend Oreille water samples were collected April 22nd and September 12th and 15th, 1986.

SAMPLE HANDLING AND PRETREATMENT

All water samples arrived at the EPA Region 10 Laboratory within 8 days of sampling. Samples were air-transported in coolers, on ice and received within one day of shipment. Once at the Laboratory, they were stored at 4°C, in the dark, until (within 1 day) a pH was determined and a chemistry subsample was collected. The 2-gal samples were then autoclaved for 80 min, left to cool overnight, and again stored at 4°C, in the dark, until assayed. The samples collected in April and September were assayed on May 21st and October 21st, 1986, respectively.

Prior to initiating the assays, the samples were bubbled with CO_2 to lower the pH of the sample to approximate the original pH measured in the field. Samples were then filtered through a 142 mm Millipore filter, having a pore size of 0.45 um to remove debris that may have confounded Coulter Counter cell number/volume determinations. At this point, more subsamples were collected for chemistry so that a "before" and "after" (autoclaving and filtering) chemical profile could be established.

CHEMICAL ANALYSIS

Chemical analyses were performed not only to determine the effects of autoclaving and filtering, but also to help characterize the samples especially with respect to nutrient and metal content. The following analyses were performed. Results for both assays are presented in Tables 1 and 2.

GENERAL	NUTRIENTS	METALS (TOTAL AND DISSOLVED)	
Conductivity	Phosphorus-Total	Arsenic	Lead
pH	Phosphorus-Dissolved	Cadmium	Mercury
Hardness-Total	Phosphorus-Dissolved-Ortho	Chromium	Nickel
Alkalinity-Total	Nitrate-Nitrite Nitrogen	Copper	Zinc
	Ammonia Nitrogen	Iron	

All of the chemical analyses were performed by the Chemistry staff of the EPA Region 10 Laboratory according to appropriate standard methods (APHA, 1985, Standard Methods for the Examination of Water and Wastewater; USEPA, 1979, Methods for Chemical Analysis of Water and Wastes).

ALGAL ASSAY

The two sets of four samples collected were assayed by "The *Selenastrum capricornutum* Printz Algal Assay Bottle Test" developed by Miller, Greene and Shiroyama (1978). The assay was designed to provide preliminary information on the following aspects of algal productivity:

1. the algal growth potential of the waters sampled,
2. the nutrients limiting algal growth, and
3. the possible inhibition of algal growth by metals.

SAMPLE TREATMENTS

Each sample was divided among nine Erlenmeyer flasks (200 mL/flask). Each flask was then spiked (or not) with one of the treatments listed below. In both assays, two sets of sample 2000261 were poured instead of one. The extra set was analyzed chemically so that theoretical spike values could be confirmed for quality assurance purposes. The results of these analyses (presented in Tables 3 and 4) confirm that the desired spike quantities were delivered with minimal variation.

1. Control (No additions)
2. Control + N (1.0 mg/L as $NaNO_3$)
3. Control + P (0.05mg/L as K_2PO_4)

4. Control + Na_2EDTA (1.0 mg/L as Disodium Ethylene-dinitrilo tetraacetate)

- the following permutations

5. Control + N + P
6. Control + P + Na_2EDTA
7. Control + N + Na_2EDTA
8. Control + N + P + Na_2EDTA

- and

9. Control + Algal Assay Medium (All contituents of algal assay medium including 4.2 mg N/L + 0.186 mg P/L + 0.3 mg Na_2EDTA/L)

Each treatment flask was innoculated with 200,000 S. capricornutum cells. This innoculum size was determined with a hemacytometer count. Each flask (treatment) was then divided among three 250-mL Erlenmeyer flasks (60 mL/flask). The small flasks were placed in a random fashion on an illuminated shaker table and left to incubate for 14 days (24°C, 400 ft-c and 100 rpm).

GROWTH MEASUREMENTS

Algal cell counts and volume determinations were made on days 6, 9 and 14 during both assays. Cell counts were made using a Coulter electronic particle counter equipped with a mean cell volume computer. "Coulter counts" were calibrated each day against a hemacytometer count and the computer's lower threshold adjusted to reflect the visual count. Measurements of the volume of algal biomass (um^3/L) were converted to dry weights (mg dry weight/L) based on the "algal volume - dry weight" relationship established for S. capricornutum cultured in the defined algal assay medium for 14 days. All comparisons of algal growth were based on the maximum standing crop (in mg dry weight/L) of algae after 14 days of growth. The actual and predicted 14-day standing crop values for both assays are presented in Tables 5 and 6.

RESULTS AND DISCUSSION

SPIRIT LAKE

Total soluble inorganic nitrogen (TSIN) levels were low in the April sample and slightly increased in September. What little nitrogen that appeared in the September sample was comprised primarily of ammonia and not the nitrate and nitrite forms seen in April.

Total and dissolved phosphorus values were slightly higher in April than in September. Dissolved ortho phosphorus values during both seasons were at or below detection limits.

Total copper and total iron values were greater in the September sample than in the April sample (copper, 10 ug/L vs. 2 ug/L and iron, 39 ug/L vs. 27 ug/L). Dissolved iron values were less than the 1 ug/L detection limit in April and September. Total and dissolved mercury values were somewhat greater in April than in September (total, 0.09 ug/L vs. 0.05u ug/L and dissolved, 0.14 ug/L vs. 0.05u ug/L). These spring values exceed the recommended freshwater chronic toxicity criterion of 0.012 ug/L set forth in the USEPA Quality Criteria for Water 1986, Update #1. Nickel and zinc concentrations fell very near or below detection limits during both seasons.

Hardness values (both before and after autoclaving and filtering) were very low at station 2000288 both in spring and summer. Conductivity and alkalinity values were low and similar between the spring and summer samples. However, the September sample was different, in that, autoclaving seemed to increase (4-fold) both conductivity and alkalinity.

RESULTS OF BIOASSESSMENT AT STATION 2000288

Spring: Moderately High Productivity (1.07 mg/L dry weight)
Summer: Moderately Productive (0.307 mg/L dry weight)

The algal assays performed on Spirit Lake (Station 2000288) indicated that algal growth was primarily phosphorus limited in the spring and nitrogen/phosphorus co-limited in the summer. In both seasons, the addition of Na_2EDTA stimulated growth. The Na_2EDTA was, however, more effective in the spring. This may signal the presence of a slightly toxic metal or group of metals, possibly more abundant in the April composite. Mercury is the one metal we analyzed for (in a somewhat limited chemistry scan) that may have inhibited algal growth to a greater extent in the spring. It is also possible that the addition of Na_2EDTA may have made some of the insoluble iron in the sample bioavailable.

LAKE PEND OREILLE

Total nitrogen values in April Lake Pend Oreille water samples were greater than September values both at the mid-lake station and at the south end of the Lake. This April nitrogen seemed to be in the form of nitrate and nitrite. In September, the nitrate-nitrite forms were almost undetectable, and small increases in ammonia values were evident, again at the mid-lake station and the southern end. The northern outlet arm water samples of the Lake were low in nitrogen during both seasons.

Phosphorus values in Lake Pend Oreille water samples were fairly variable between "before autoclaving and filtering" and "after". There were small increases in the amounts of total and dissolved phosphorus detected in the mid-lake (April and September) and southern end samples (September only) after autoclaving and filtering. This indicates that autoclaving released bound phosphorus, or that phosphorus was introduced due to contamination, or that the increases were due to variability in chemistry results. In all cases, dissolved and dissolved ortho phosphorus values, were at, below or very close to detection limits, even after autoclaving.

Metals values were generally higher in the April than in the September samples, perhaps as a result of greater precipitation in the spring. Total iron (not dissolved) at the northern arm outlet was much higher in April at 123 ug/L than the indeterminately low value recorded for the September sample. Lead values during both seasons were below detection. (There was a dissolved lead value of 48 ug/L recorded for Station 2000257 in April. However, beacause this level was not reflected in the "total" lead determination, it was probably due to contamination during analysis). Mercury levels at all stations were greater in April, and in all cases April values exceeded the EPA recommended freshwater chronic toxicity criterion of 0.012 ug/L. Nickel values were very close to or below detection limits for all but one station in the April set of samples. That station, from the south end of the Lake, contained 66 ug/L total nickel. All zinc values were less than the detection limit.

During both seasons, Lake Pend Oreille water samples seemed to fall within a "moderately hard" range in terms of a $CaCO_3$ concentration (76.3-86.6 mg/L $CaCO_3$). In every case, total hardness decreased after autoclaving and filtering and then ranged between 52.9 and 59.8 mg/L $CaCO_3$.

Conductivities during both seasons and from station to station varied little, ranging from 154 umhos/cm at the northern arm outlet in April to 180 umhos/cm at the south end of the lake in April. Again, in all cases, conductivities decreased after autoclaving and filtering.

Initial alkalinity values (before autoclaving and filtering) were greater in April water samples than in the September samples. However, autoclaving and filtering made the values from spring to summer virtually indistiguishable.

RESULTS OF BIOASSESSMENT AT STATION 2000257

Spring: Moderately High Productivity (1.39 mg/L dry weight)
Summer: Moderately Productive (0.371 mg/L dry weight)

The composite from the "the open water station in the deepest part of the Lake" was phosphorus limited in the spring and nitrogen/phosphorus co-limited in the summer. The addition of Na_2EDTA to sample 2000257 enhanced algal production to a greater extent in the spring than in the summer composite. As was the case with the Spirit Lake sample, higher mercury concentrations in the spring and the subsequent chelation of this metal and any others that may have contributed to toxicity would have had this growth-promoting effect.

RESULTS OF BIOASSESSMENT AT STATION 2000260

Spring: Moderately Productive (0.389 mg/L dry weight)
Summer: Moderately Productive (0.188 mg/L dry weight)

The composite from the northern outlet arm of Lake Pend Oreille was primarily phosphorus limited, but really co-limited by both nitrogen and phosphorus in the spring and in the summer. The summer composite supported the least algal growth of any of the samples assayed. The addition of Na_2EDTA again enhanced algal growth to a greater extent in the spring than in the summer.

RESULTS OF BIOASSESSMENT AT STATION 2000261

Spring: Moderately High Productivity (1.37 mg/L dry weight)
Summer: Moderately Productive (0.209 mg/L dry weight)

The composite samples from the extreme south end of the Lake were limited primarily by phosphorus during both seasons. The phosphorus-spiked samples resulted in greater algal production in the spring than in the summer because there was more nitrogen available in the spring sample. The addition of Na_2EDTA did little or nothing to promote algal production in the spring and summer samples.

SUMMARY

Spirit Lake did not appear to be nitrogen limited in the spring. The addition of phosphorus stimulated more growth than did the addition of nitrogen. Chemistry assessments predicted this nutrient relationship. In summer, neither the addition of nitrogen or phosphorus alone stimulated any significant algal growth. However, in combination, and especially in the presence of Na_2EDTA, this sample outproduced all the others (which had been spiked in the same manner).

There did appear to be a minor shift in algal productivity potential at two stations in Lake Pend Oreille between 1984 and 1986 (IDHW-DOE, 1984). The two stations assayed in both 1984 and 1986 were Stations 2000257 (mid-lake or #2) and 2000260 (northern arm outlet or #5).

The northern outlet arm composite sampled November, 1984 displayed more algal growth potential than did composites collected in either April or September, 1986 (0.46 mg/L vs. 0.389 or 0.188 mg/L). The mid-lake station displayed the opposite pattern. The April, 1986 composite standing crop, cannot, of course, be directly compared with summer or fall production in 1984, but it did display considerably greater productivity than any of the 1984 composites. (1.39 mg/L vs. 0.24, 0.05, 0.12 or 0.43 mg/L). The September standing crop values were also somewhat greater than their 1984 counterparts (0.371 mg/L vs. 0.24, or 0.05 mg/L).

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United States Environmental Protection Agency. 1979. Methods for chemical analysis of water and wastes. Environmental Monitoring and Support Laboratory, Cincinnati, Ohio. EPA-600/4-79-020.

Figure 2. Lake Pend Oreille Sampling Stations

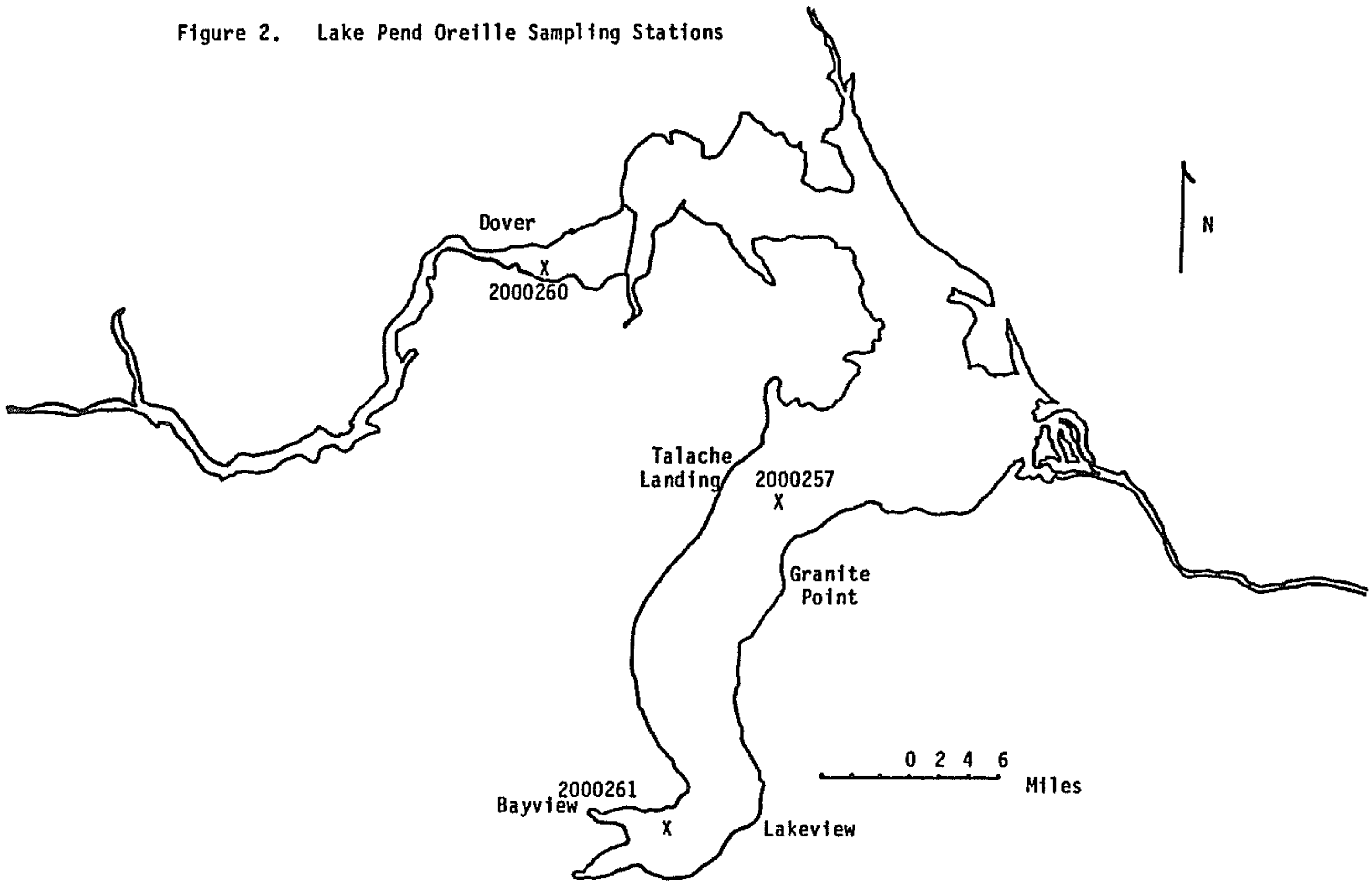

Table 3.

Idaho Lakes Nutrient Assessment, Sample #2000261 Unspiked and Spiked With Nutrients and EDTA, April, 1986

	Total Phos. (mg/L)	Dis. Phos. (mg/L)	Dis. Ortho Phos. (mg/L)	$NO_3 + NO_2$ (mg/L)	NH_3 (mg/L)	TSIN (mg/L)
Control[a]	0.005u	0.005u	0.005u	0.085	0.008	0.093
Control + N[b]	0.012	0.005u	0.005u	1.08	0.026	1.11
Control + P[c]	0.058	0.056	0.044	0.085	0.063	0.148
Control + E[d]	0.016	0.012	0.005u	0.083	0.025	0.108
Control + N[b] + P[c]	0.058	0.056	0.037u	1.09	0.025	1.12
Control + P[c] + E[d]	0.060	0.056	0.041u	0.086	0.032	0.118
Control + N[b] + E[d]	0.010	0.005u	0.005u	1.07	0.024	1.09
Control + N[b] + P[c] + E[d]	0.058	0.054	0.036	1.06	0.024	1.08

[a]Control Control is Sample # 2000261
[b]N Nitrogen Spike is 1.0 mg/L
[c]P Phosphorus Spike is 0.05 mg/L
[d]E EDTA Spike is 1.0 mg/L
"u" indicates that the preceding number is the detection limit for that determination and that the value, if any, is less than detection

Maximum possible deviation of P spike was 16% high to 8% low
Maximum possible deviation of N spike was 0.5% high to 2.6% low

	Total Phos. (mg/L)	Dis. Phos. (mg/L)	Dis. Ortho Phos. (mg/L)	$NO_3 + NO_2$ (mg/L)	NH_3 (mg/L)	TSIN (mg/L)
Control + Algal Assay Medium Nutrients (0.186 mg/L P + 4.2 mg/L N)	0.188	0.186	0.169	4.28	0.027	4.31

Table 4.

Idaho Lakes Nutrient Assessment, Sample #2000261 Unspiked and Spiked With Nutrients and EDTA, September, 1986

	Total Phos. (mg/L)	Dis. Phos. (mg/L)	Dis. Ortho Phos. (mg/L)	$NO_3 + NO_2$ (mg/L)	NH_3 (mg/L)	TSIN (mg/L)
Control[a]	0.010	0.010	0.005u	0.008	0.015	0.023
Control + N[b]	0.005m	0.005u	0.005u	0.990	0.017	1.01
Control + P[c]	0.064	0.050	0.040	0.016	0.023	0.039
Control + E[d]	0.008	0.005m	0.005u	0.016	0.033	0.049
Control + N[b] + P[c]	0.060	0.052	0.045	0.990	0.070	1.06
Control + P[c] + E[d]	0.060	0.054	0.045	0.022	0.030	0.052
Control + N[b] + E[d]	0.008	0.010	0.005u	0.930	0.033	0.963
Control + N[b] + P[c] + E[d]	0.052	0.060	0.045	0.930	0.037	0.967

[a]Control — Control is Sample # 2000261
[b]N — Nitrogen Spike is 1.0 mg/L
[c]P — Phosphorus Spike is 0.05 mg/L
[d]E — EDTA Spike is 1.0 mg/L
"u" — indicates that the preceding value is the detection limit for that determination and that the value, if any, is less than detection
"m" — indicates that the preceding value is the detection limit for that determination and that value is equal to the detection limit

Maximum possible deviation of P spike was 10% high to 12% low
Maximum possible deviation of N spike was 1.8% low to 8.6% low

Control + Algal Assay Medium Nutrients (0.186 mg/L P + 4.2 mg/L N)	0.188	0.190	0.180	4.10	0.017	4.12

Table 5. Actual and Predicted 14 Day Standing Crops (mg/L dry weight) Measured in Spirit Lake and Lake Pend Oreille Water Samples Collected April 16 and 22, 1986.

Sample Treatment	Predicted Primary Limiting Nutrient*	Spirit Lake Composite Actual	Spirit Lake Composite Predicted	Lake Pend Oreille 2000257 Actual	Lake Pend Oreille 2000257 Predicted	Lake Pend Oreille 2000260 Actual	Lake Pend Oreille 2000260 Predicted	Lake Pend Oreille 2000261 Actual	Lake Pend Oreille 2000261 Predicted
Control (No additions)	N,P,N or P,P	1.07	0.646	1.39	< 2.15	0.389	< 2.15	1.37	< 2.15
Control + N	P,P,P,P	0.976	2.15	1.54	< 2.15	0.441	< 2.15	0.889	< 2.15
Control + P	N,N,N,N	5.26	0.646	5.68	< 3.15 ≥ 2.96	1.29	< 0.570	8.21	3.53
Control + Na_2EDTA	N,P,N or P,P	3.53	0.646	1.88	< 2.15	0.553	< 2.15	1.43	< 2.15
Control + N + P	P,P,P,P	38.8	23.6	30.4	< 23.6 ≥ 21.5	25.9	< 23.6 ≥ 21.5	45.6	< 23.6 ≥ 21.5
Control + P + Na_2EDTA	N,N,N,N	6.54	0.646	7.63	< 3.15 ≥ 2.96	2.53	< 0.570	7.23	3.53
Control + N + Na_2EDTA	P,P,P,P	3.79	2.15	1.66	< 2.15	0.489	< 2.15	1.28	< 2.15
Control + N + P + Na_2EDTA	P,P,P,P	47.5	23.6	45.0	< 23.6 ≥ 21.5	43.0	< 23.6 ≥ 21.5	45.4	< 23.6 ≥ 21.5
Control + Algal Assay Medium	P,P,P,P	160	82.1	189	< 82.1 ≥ 80.0	184	< 82.1 ≥ 80.0	192	< 82.1 ≥ 80.0

Algal Assay Medium Standing Crop after 14 Days was 162 mg/L dry weight.

* Prediction based on chemical analyses. Limiting nutrient symbols correspond with the order of samples left to right.

Table 6. Actual and Predicted 14 Day Standing Crop (mg/L dry weight) Measured in Spirit Lake and Lake Pend Oreille Water Samples Collected September 10, 12 and 15, 1986

Sample Treatment	Predicted Primary Limiting Nutrient*	Spirit Lake Composite		Lake Pend Oreille 2000257		Lake Pend Oreille 2000260		Lake Pend Oreille 2000261	
		Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted
Control (No additions)	N,N,N,N	0.307	1.064	0.371	0.836	0.188	0.456	0.209	0.874
Control + N	P,P,P,P	0.406	< 2.15	0.324	< 2.15	0.242	< 2.15	0.374	< 2.15
Control + P	N,N,N,N	0.470	1.064	0.560	0.836	0.707	0.456	2.47	0.874
Control + Na_2EDTA	N,N,N,N	0.273	1.064	0.273	0.836	0.241	0.456	0.416	0.874
Control + N + P	P,P,P,P	29.5	< 23.6 ≥ 21.5	25.1	< 23.6 ≥ 21.5	29.4	< 23.6 ≥ 21.5	27.6	< 23.6 ≥ 21.5
Control + P + Na_2EDTA	N,N,N;N	2.12	1.064	0.836	0.836	1.12	0.456	2.18	0.874
Control + N + Na_2EDTA	P,P,P,P	0.345	< 2.15	0.252	< 2.15	0.285	< 2.15	0.423	< 2.15
Control + N + P + Na_2EDTA	P,P,P,P	37.3	< 23.6 ≥ 21.5	29.1	< 23.6 ≥ 21.5	30.8	< 23.6 ≥ 21.5	27.1	< 23.6 ≥ 21.5
Control + Algal Assay Medium	P,P,P,P	124	< 82.1 ≥ 80.0	124	< 82.1 ≥ 80.0	107	< 82.1 ≥ 80.0	102	< 82.1 ≥ 80.0

Algal Assay Medium Standing Crop after 14 Days was 93 mg/L dry weight.

* Prediction based on chemical analyses. Limiting nutrient symbols correspond with the order of samples left to right.

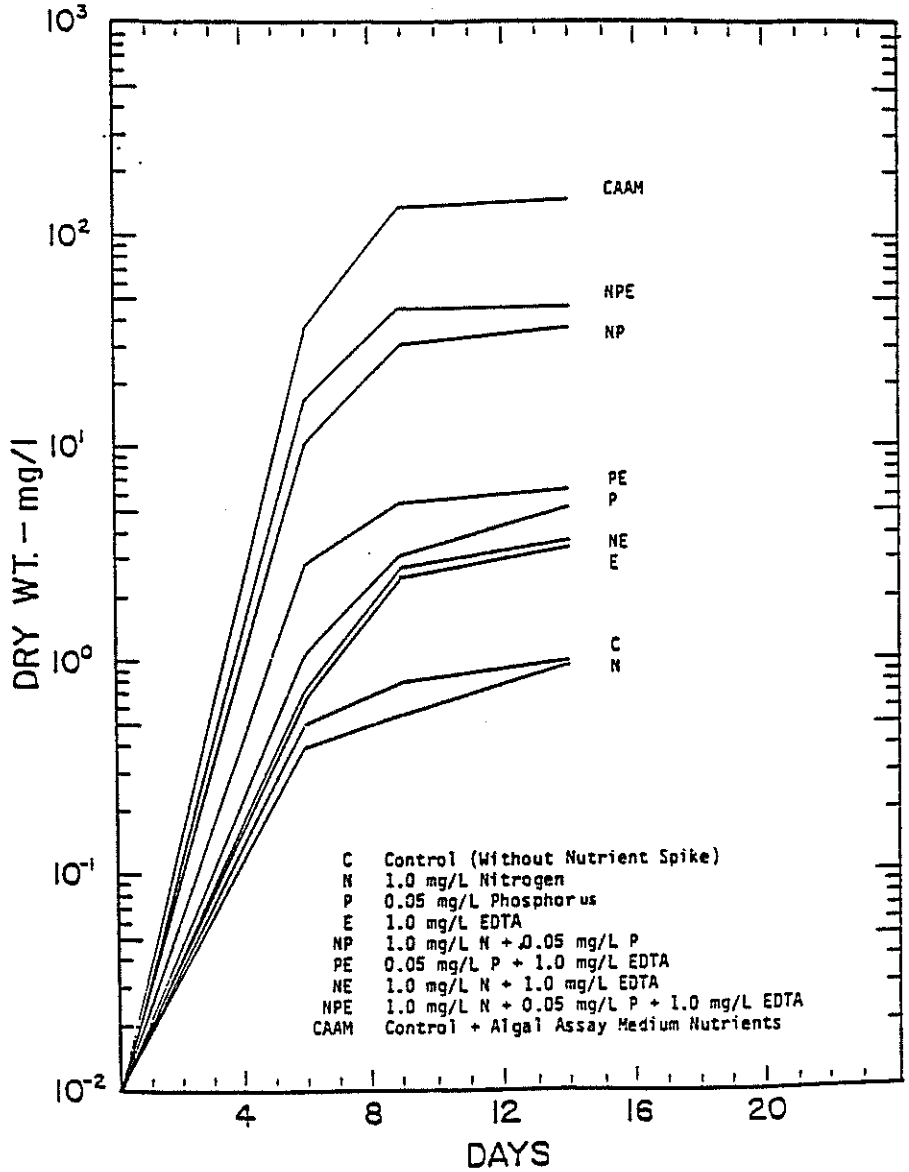

Figure 3. Growth of <u>Selenastrum capricornutum</u> in Spirit Lake Water Collected in April from Stations 2000287, 2000288 and 2000289

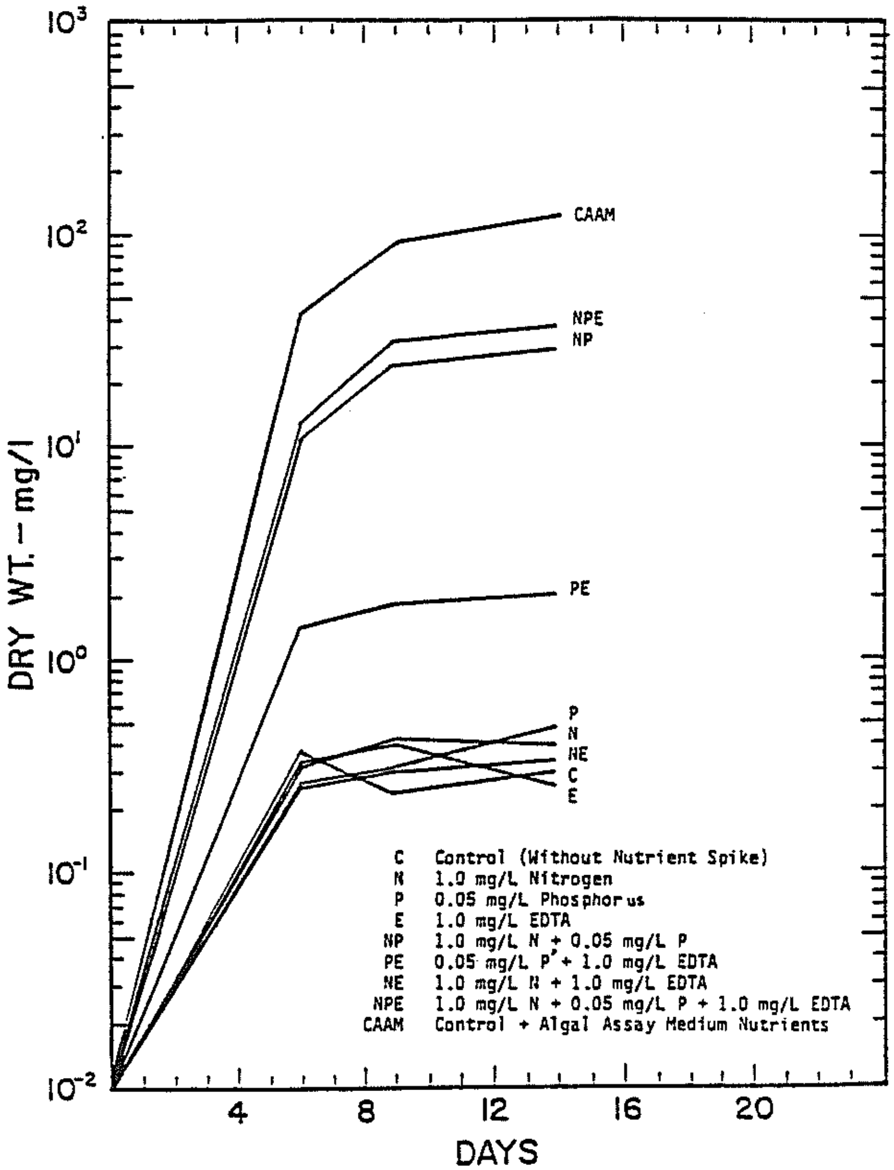

Figure 4. Growth of *Selenastrum capricornutum* in Spirit Lake Water Collected in September from Stations 2000287, 2000288 and 2000289

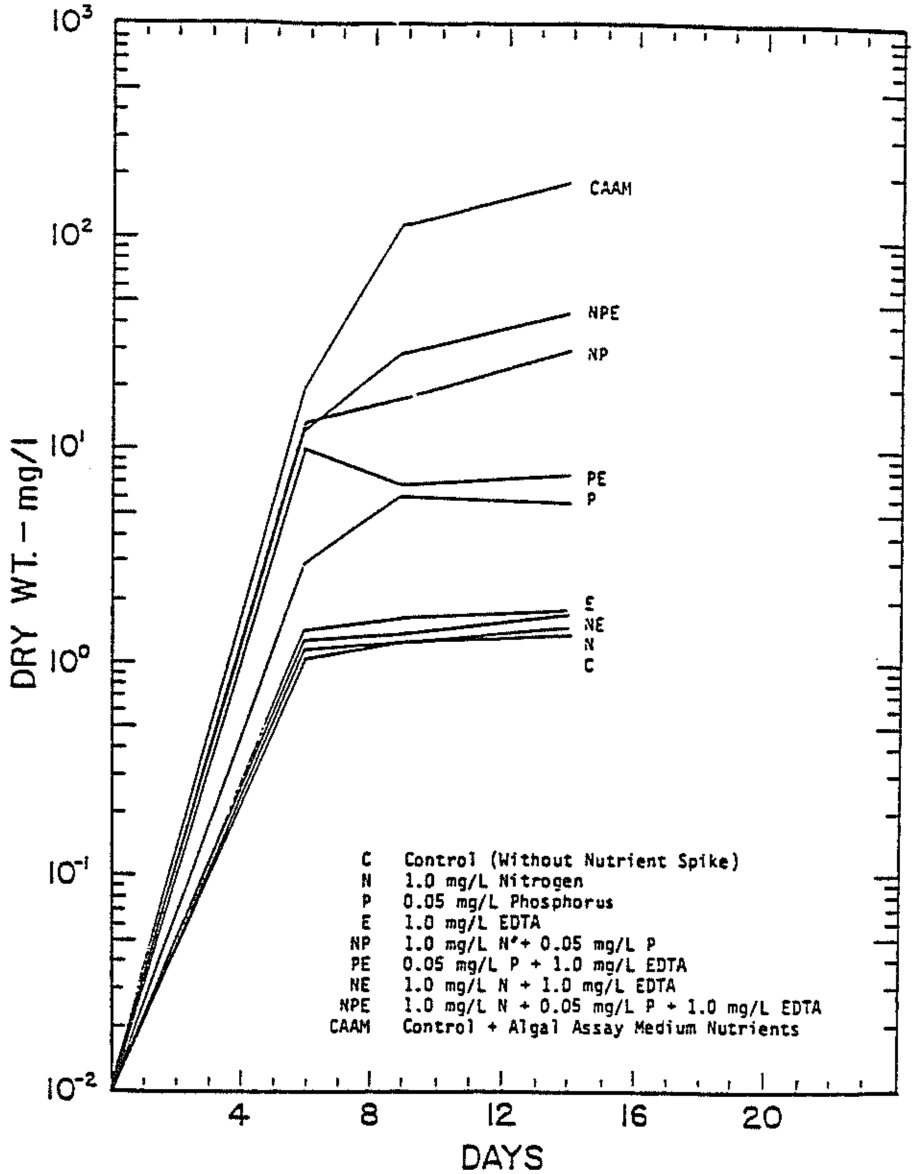

Figure 5. Growth of Selenastrum capricornutum in Lake Pend Oreille Water Collected in April from Station 2000257

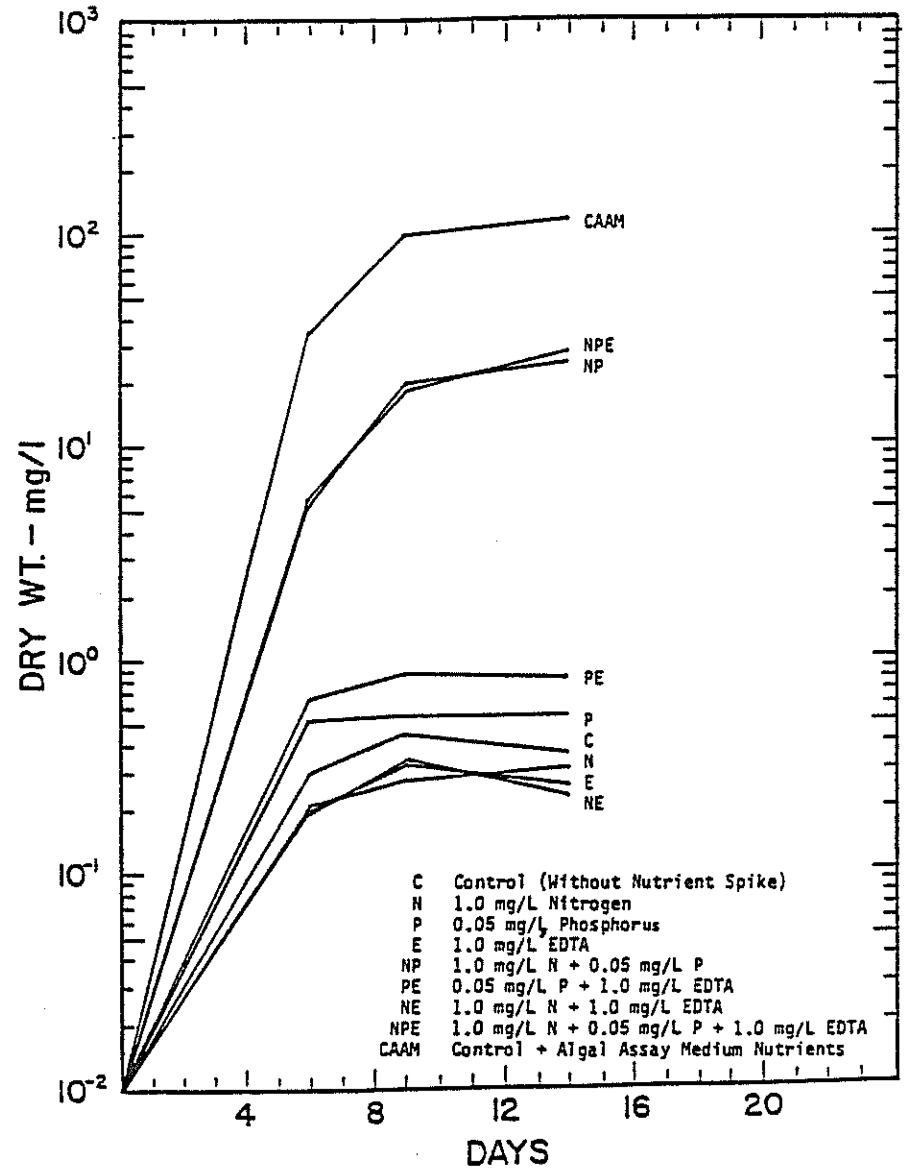

Figure 6. Growth of Selenastrum capricornutum in Lake Pend Oreille Water Collected in September from Station 2000257

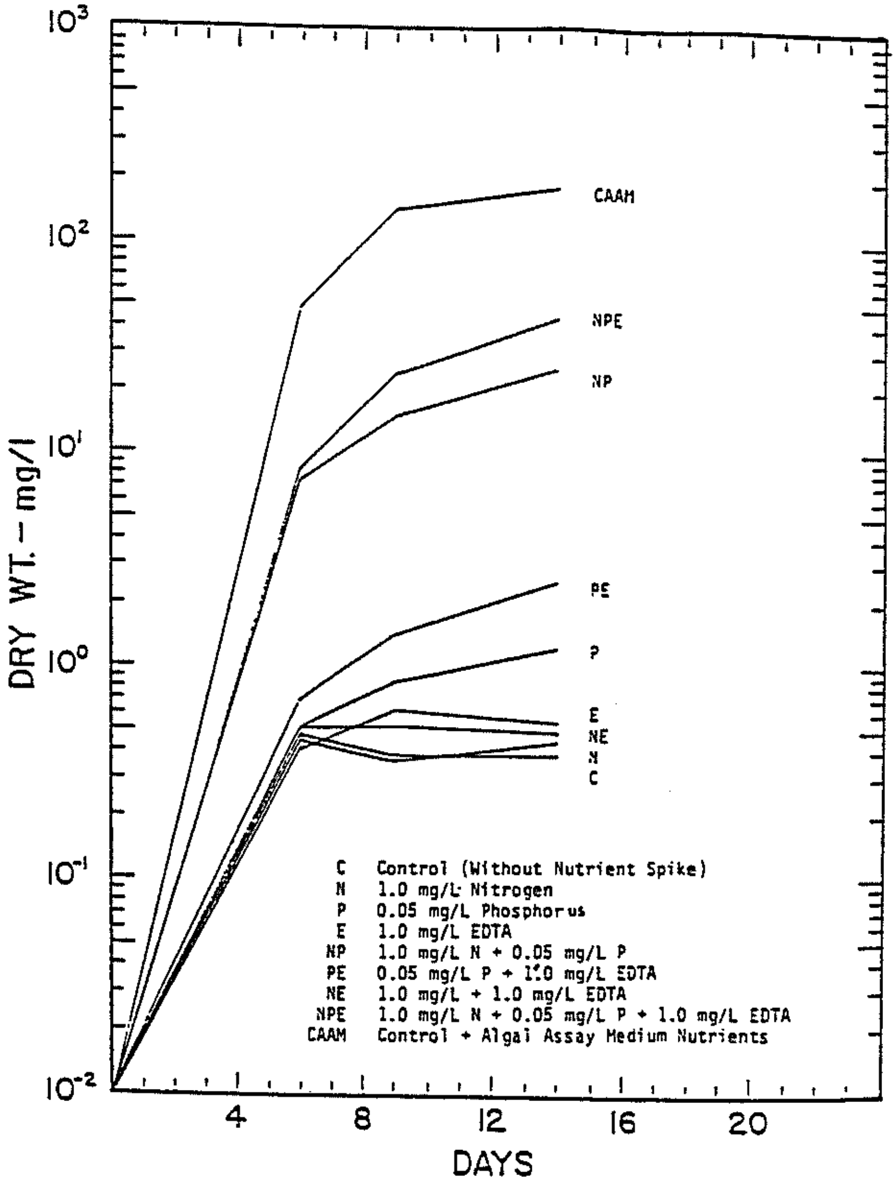

Figure 7. Growth of <u>Selenastrum</u> <u>capricornutum</u> in Lake Pend Oreille Water Collected in April from Station 2000260

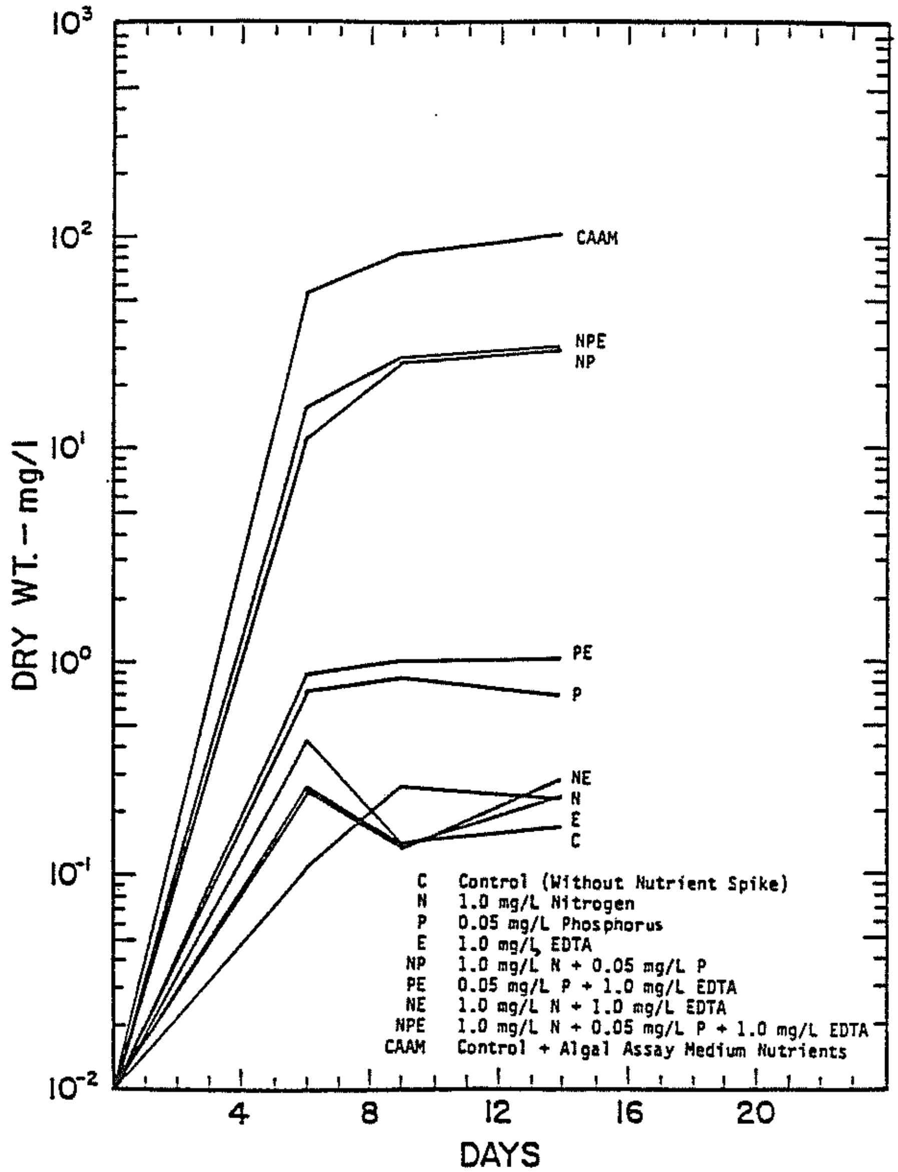

Figure 8. Growth of Selenastrum capricornutum in Lake Pend Oreille Water Collected in September from Station 2000260

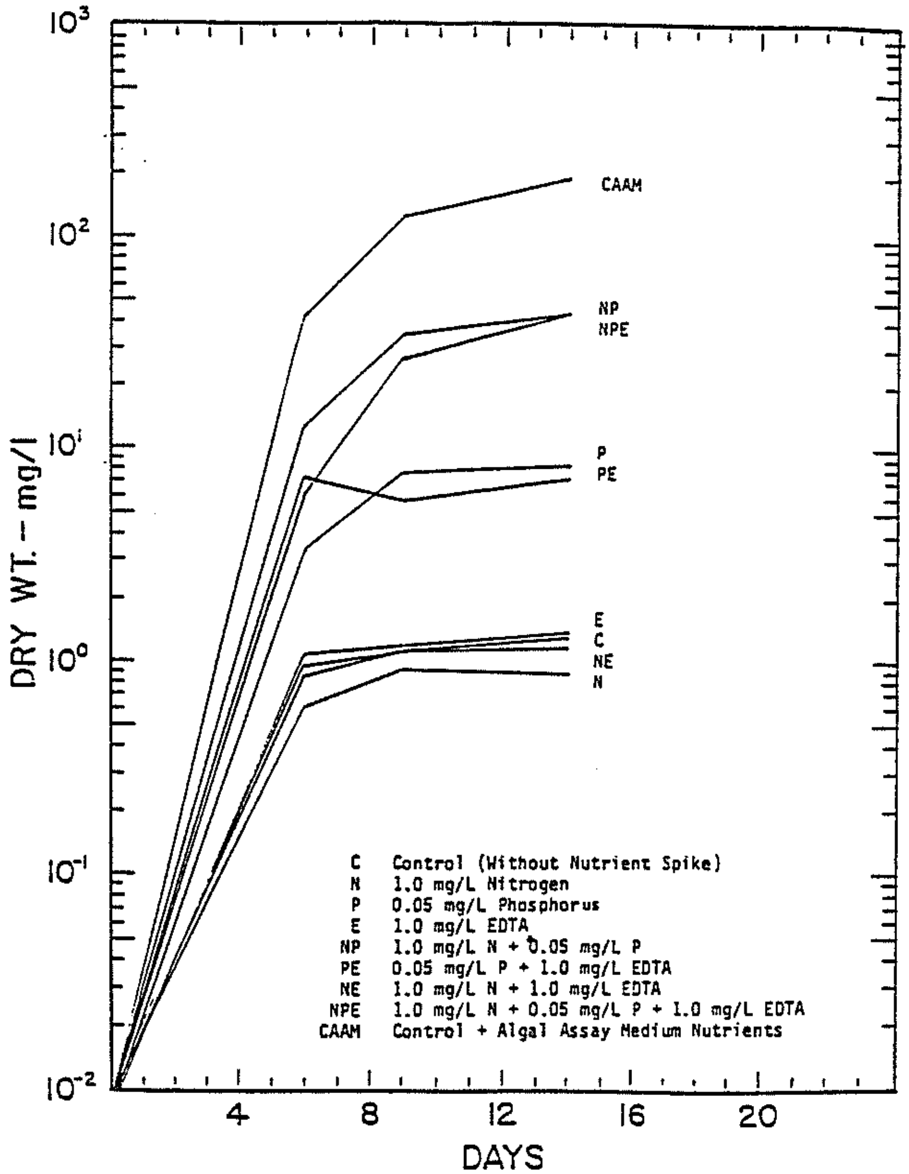

Figure 9. Growth of Selenastrum capricornutum in Lake Pend Oreille Water Collected in April from Station 2000261

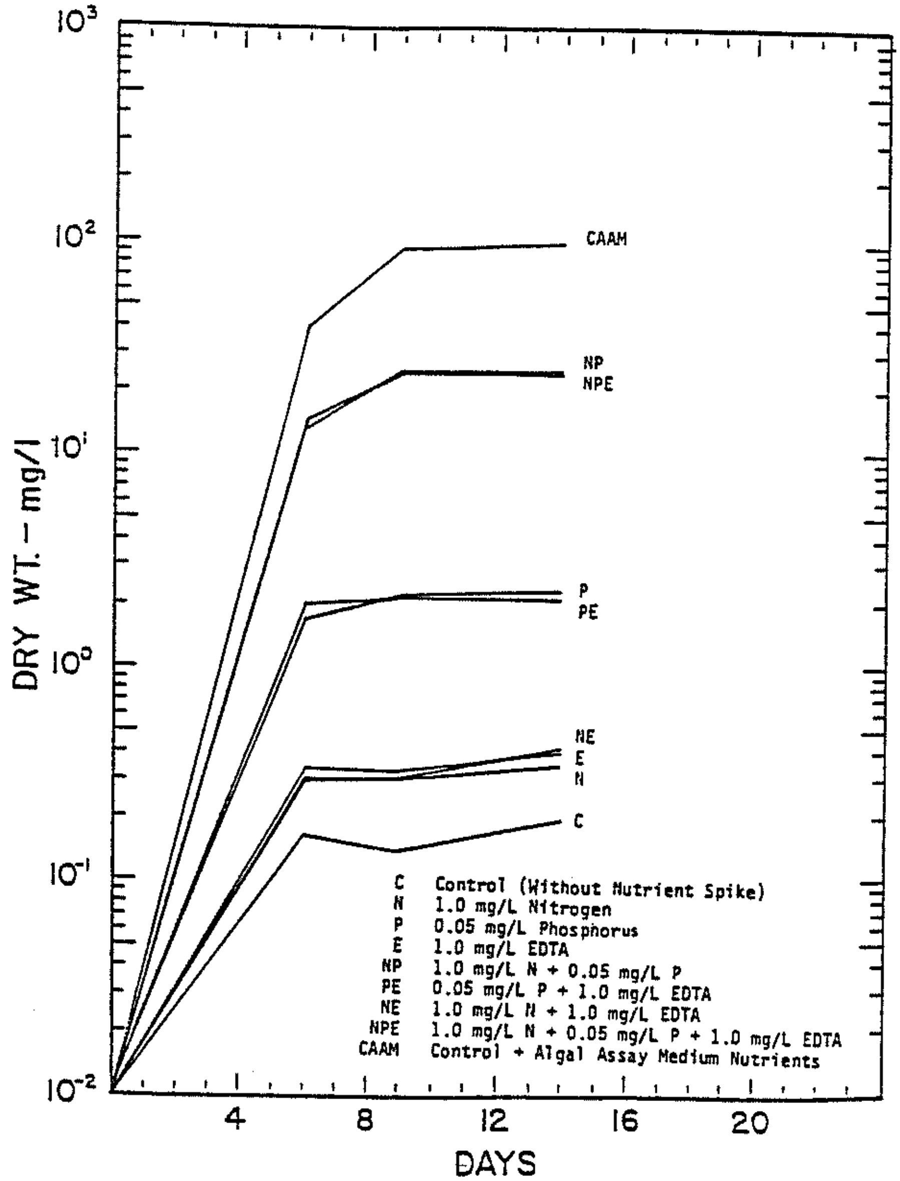

Figure 10. Growth of Selenastrum capricornutum in Lake Pend Oreille Water Collected in September from Station 2000261

Table 1. Chemical and Physical Properties of Spirit Lake and Lake Pend Oreille Water Collected April, 1986.

Parameter		Spirit Lake 2000288 Before A+F[a]	Spirit Lake 2000288 After A+F	Lake Pend Oreille 2000257 Before A+F	Lake Pend Oreille 2000257 After A+F	Lake Pend Oreille 2000260 Before A+F	Lake Pend Oreille 2000260 After A+F	Lake Pend Oreille 2000261 Before A+F	Lake Pend Oreille 2000261 After A+F
Arsenic (ug/L)	D	5	-	6	-	3	-	8	-
	T	5		4		1u		5	
Cadmium (ug/L)	D	0.2u[b]	-	0.2u	-	0.3	-	0.2u	-
	T	0.2u		1.0		1.8		0.2u	
Chromium (ug/L)	D	1u	-	1u	-	1u	-	1u	-
	T	2		2		1		1u	
Copper (ug/L)	D	1	-	3	-	2	-	2	-
	T	2		6		16		4	
Iron (ug/L)	D	1u	-	1u	-	1u	-	1u	-
	T	27		1u		123		1u	
Lead (ug/L)	D	1u	-	48	-	1u	-	1u	-
	T	1u		1u		2u		1u	
Mercury (ug/L)	D	0.14	-	0.27	-	0.23	-	0.23	-
	T	0.09		0.09		0.23		0.32	
Nickel (ug/L)	D	1u	-	1u	-	1u	-	1u	-
	T	2		1u		3		66	
Zinc (ug/L)	D	1	-	1u	-	1u	-	1u	-
	T	1		1u		1u		1u	
Conductivity (umhos/cm)		22.7	22.5	172	125	154	118	180	146
Hardness -T (mg/L)		6.3	5.8	84.8	56.7	76.3	52.9	86.6	59.8
Aklkalinity (mg/L)		18.1	10.2	96.9	52.8	85.3	50.3	94.4	64.3
Phos.-T (mg/L)		0.024	0.022	0.005m	0.016	0.012	0.010	0.008	0.005u
Phos.-D (mg/L)		0.005m[c]	0.008	0.005u	0.010	0.005m	0.005u	0.005m	0.005u
Phos. Dis.-O (mg/L)		0.005u	0.005m	0.005u	0.005u	0.005u	0.005u	0.005u	0.005u
$NO_3 + NO_2$[d] (mg/L)		0.012	0.01m	0.066	0.078	0.005m	0.01u	0.073	0.085
Ammonia (mg/L)		0.005u	0.007	0.005u	0.005u	0.005u	0.005u	0.005u	0.008
TSIN (mg/L)		< 0.017 ≥ 0.012	0.017	< 0.071 ≥ 0.066	< 0.083	< 0.010 ≥ 0.005	< 0.015	< 0.078 ≥ 0.073	0.093
Field pH		7.8		-		-		-	
Lab pH		6.28		6.81		6.79		6.88	
Autoclaved pH		8.76		9.46		9.43		9.26	
Adjusted to pH		7.39		7.47		7.47		7.47	

a Autoclaving at 121°C, 80 min, and filtering through a 0.45 um filter

b "u" indicates that the preceding number is the detection limit for that determination and that the value, if any, is less than the detection limit.

c "m" indicates that the preceding number is the detection limit for that determination and that the value is equal to the detection limit.

d Ion Chromatagraph used in "before" determination and Technicon used in "after" determination.

D Dissolved

T Total

Table 2. Chemical and Physical Properties of Spirit Lake and Lake Pend Oreille Water Collected September, 1986

Parameter		Spirit Lake 2000288 Before A+F[a]	Spirit Lake 2000288 After A+F	Lake Pend Oreille 2000257 Before A+F	Lake Pend Oreille 2000257 After A+F	Lake Pend Oreille 2000260 Before A+F	Lake Pend Oreille 2000260 After A+F	Lake Pend Oreille 2000261 Before A+F	Lake Pend Oreille 2000261 After A+F
Arsenic (ug/L)	D	2	-	1u	-	1	-	1u	-
	T	5		1u		2		1u	
Cadmium (ug/L)	D	0.2	-	1.3	-	0.2u	-	0.2u	-
	T	0.2		1.2		0.2u		0.4	
Chromium (ug/L)	D	1u[b]	-	1u	-	1u	-	1u	-
	T	1u		1u		1u		1u	
Copper (ug/L)	D	1	-	2	-	1u	-	1	-
	T	10		2		1		14	
Iron (ug/L)	D	1u	-	1u	-	1u	-	1u	-
	T	39		1u		1u		1u	
Lead (ug/L)	D	1u	-	1u	-	1u	-	1u	-
	T	1u		1u		1u		1u	
Mercury (ug/L)	D	0.05u	-	0.05u	-	0.05u	-	0.05u	-
	T	0.05u		0.05		0.05u		0.09	
Nickel (ug/L)	D	1u	-	1u	-	1u	-	1u	-
	T	1u		1u		1u		1u	
Zinc (ug/L)	D	1u	-	1u	-	1u	-	1u	-
	T	1u		1u		1u		1u	
Conductivity (umhos/cm)		23.6	92.0	172	134	172	117	170	130
Hardness-T (mg/L)		7.0	7.2	83.8	55.8	82.6	53.4	82.5	59.0
Alkalinity (mg/L)		10.5	47.3	80.1	61.0	79.5	53.5	79.0	55.7
Phos.-T (mg/L)		0.011	0.018	0.005m	0.006	0.005	0.008	0.008	0.010
Phos.-D (mg/L)		0.005m[c]	0.006	0.005m	0.010	0.005m	0.005u	0.005u	0.010
Phos. Dis.-O (mg/L)		0.005m	0.005u	0.005m	0.005u	0.005u	0.005u	0.005m	0.005u
$NO_3 + NO_2$ (mg/L)		0.005	0.005m	0.005u	0.005m	0.005u	0.005m	0.008	0.008
Ammonia (mg/L)		0.027	0.023	0.010	0.017	0.005	0.007	0.008	0.015
TSIN (mg/L)		0.032	0.028	<0.015 >0.010	0.022	<0.010 >0.005	0.012	0.016	0.023
Field ph $\bar{X}$		8.17		7.57		7.53		7.53	
Lab pH		7.43		7.95		8.27		7.95	
Autoclaved pH		9.30		9.17		9.20		9.25	
Adjusted to pH		8.24		7.64		7.57		7.43	

a Autoclaving at 121°C, 80 min, and filtering through a 0.45 um filter
b "u" indicates that the preceding number is the detection limit for that determination and that the value, if any, is less than the detection limit.
c "m" indicates that the preceding number is the detection limit for that determination and that the value is equal to the detection limit.
D Dissolved
T Total

APPENDIX 9

Chlorophyll Analysis Results - Idaho Bureau of Laboratories

APPENDIX 9. Chlorophyll Analysis Results

HWH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Caldwell ☒ Cd'A ☐ Idaho Falls ☐ Lewiston ☐ Pocatell ☐ Twin Fa

Sampling Point Location: LPO Stn. 2 deep	Date Collected: 84 09 12 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Trend ☐ Other ______
Storet No.: 2000257 / Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain
Preserved Sample Submitted — BIOMASS: ☒ Frozen, Light Excluded ☐ Other; SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 84 09 12 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate ______ Exposure Time ______

TRICHROMATIC METHOD (mg/m2)

STORET CODE		
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 3/4 Liter

TRICHROMATIC METHOD (ug/l)

STORET CODE		
(32210)	☒ Chlorophyll-A	0.13
(32212)	☒ Chlorophyll-B	0.14
(32214)	☒ Chlorophyll-C	0.41

BEFORE/AFTER ACIDIFICATION (ug/l)

(32211)	☒ Chlorophyll-A	0.21
(32218)	☒ Pheophytin-A	0.13
(32216)	☒ Total Chlorophyll	0.001 ug/l

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 2/8/85
Date Reported: 2/28/85
Chemist: Johann
Remarks:

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ______

IWH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Caldwell ☒ Cd'A ☐ Idaho Falls ☐ Lewiston ☐ Pocatello ☐ Twin Falls

Sampling Point Location: LPO. Stn. 2	Date Collected: Yr. 84 Mo. 10 Day 01	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Trend ☐ Other
Storet No.: 2000257 — Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain
Preserved Sample Submitted — BIOMASS: ☒ Frozen, Light Excluded ☐ Other; SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: Yr. 84 Mo. 10 Day 01	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate: Exposure Time:

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 3/4 Liter

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☒ Chlorophyll-A	0.20
(32212)	☒ Chlorophyll-B	0.10
(32214)	☒ Chlorophyll-C	0.34

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l

STORET CODE		
(32211)	☒ Chlorophyll-A	0.16
(32218)	☒ Pheophytin-A	0.25
(32216)	☒ Total Chlorophyll	0.002 ug/l

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 2/8/85 Date Reported: 2/28/85

Chemist: Johann

Remarks:

(00116) ☐ Intensive Survey Number

HWH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Orielle St. 2

Date Collected: 85 04 12 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ☐ Trend

Storet No.: 2000257

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

Preserved Sample Submitted
BIOMASS: ☐ Frozen, Light Excluded ☐ Other
SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative

Date Submitted: 85 04 13 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate: Exposure Time:

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: ~~1000~~ 1.5 Liter

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☐ Chlorophyll-A	0
(32212)	☐ Chlorophyll-B	0
(32214)	☐ Chlorophyll-C	0

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l.

STORET CODE		
(32211)	☐ Chlorophyll-A	0
(32218)	☐ Pheophytin-A	8.4
(32216)	☐ Total Chlorophyll a	0 ug/l
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 5/8/85
Date Reported: 4/25/85

Chemist: Johann

Remarks:

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number

-0262

Idaho Department of Health & Welfare
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BUREAU OF LABORATORIES
AQUATIC BIOMASS REPORT
(See Back For Instructions)

OPY DISTRIBUTION
hite - Person Requesting Test
...ry - Laboratory
- Water Quality Bureau (STORET)
enrod - Extra As Needed

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

ampling Point Location: Lake Pend Oreille Sta. 2	Date Collected: 85 05 21 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ____ ☐ Trend
toret No.: 2000257 / Collected By: Beckwith.	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain
eserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other; SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 05 21 (Yr. Mo. Day)	

PERIPHYTON
☐ Natural Substrate

plicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
al Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

lumber of Slides/Replicate | Exposure Time

PHOTOPLANKTON
Number of Replicates Per Sample: 1

Volume Filtered: 1000 ml ~~Liter~~

TRICHROMATIC METHOD (mg/m2) — Periphyton

STORET CODE		
(..228)	☐ Chlorophyll-A	
(..226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l — Photoplankton

STORET CODE		
(32210)	☐ Chlorophyll-A	0.31
(32212)	☐ Chlorophyll-B	0.029
(32214)	☐ Chlorophyll-C	0.16

BEFORE/AFTER ACIDIFICATION (mg/m2)

(..223)	☐ Chlorophyll-A	
(..224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~

(32211)	☐ Chlorophyll-A	0.011
(32218)	☐ Pheophytin-A	~~0~~.52
(32216)	☐ Total Chlorophyll	0.17 ug/l

RETURN TEST RESULTS TO
Name: OOE
Address:
City, State, Zip Code: CDA

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

Completed: 7/9/85 | Date Reported: 11/25/85

*Ash-free dry weight and pigment determinations are from different samples (or subsamples).

emist: Johann

(00116) ☐ Intensive Survey Number ____

arks

WH-0262

OPY DISTRIBUTION
/hite - Person Requesting Test
anary - Laboratory
ink - Water Quality Bureau (STORET)
ioldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES
AQUATIC BIOMASS REPORT
(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Oreielle

Date Collected: 85 07 02 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ________ ☐ Trend

Storet No.: 2000257

Collected By: Beckwith.

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

Preserved Sample Submitted

BIOMASS
☐ Frozen, Light Excluded
☐ Other

SPECIES IDENTIFICATION
☐ Formalin
☐ EPA Preservative

Date Submitted: 85 07 03 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate:

Exposure Time:

TRICHROMATIC METHOD (mg/m2)

STORET CODE		
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

TRICHROMATIC METHOD (~~ug/l~~) mg/l.

STORET CODE		
(32210)	☐ Chlorophyll-A	0.18
(32212)	☐ Chlorophyll-B	0.064
(32214)	☐ Chlorophyll-C	0.25

BEFORE/AFTER ACIDIFICATION (~~ug/l~~) mg/l

STORET CODE		
(32211)	☐ Chlorophyll-A	0.0053
(32218)	☐ Pheophytin-A	0.31
(32216)	☐ Total Chlorophyll	~~0.086~~ ug/l 0.09
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 7/16/85

Date Reported: Johann 11/25/85

Chemist:

Remarks:

*Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ________

WH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES
AQUATIC BIOMASS REPORT
(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Orielle

Date Collected: Yr. 85 Mo. 07 Day 31

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ______ ☐ Trend

Storet No.: 2000257

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain

Preserved Sample Submitted

BIOMASS
☐ Frozen, Light Excluded
☐ Other

SPECIES IDENTIFICATION
☐ Formalin
☐ EPA Preservative

Date Submitted: Yr. 85 Mo. 07 Day 31

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate:

Exposure Time:

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: .95 Liter

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☐ Chlorophyll-A	0.10
(32212)	☐ Chlorophyll-B	0.0028
(32214)	☐ Chlorophyll-C	0

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l.

STORET CODE		
(32211)	☐ Chlorophyll-A	0
(32218)	☐ Pheophytin-A	0.25
(32216)	☐ Total Chlorophyll A in orig sample	0 ug/l
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO

Name: DOE

Address:

City, State, Zip Code: CDA

Date Completed: 9/18/85

Date Reported: 11/25/85

Chemist: Johann

Remarks:

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ______

HWH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Orielle

Date Collected: 85 08 13 (Yr. Mo. Day)

Purpose of Sample (Check One): ☐ Intensive Survey ☐ Other ______ ☐ Trend

Storet No.: 2060257

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☐ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

Preserved Sample Submitted

BIOMASS: ☐ Frozen, Light Excluded ☐ Other

SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative

Date Submitted: 85 08 13 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate: | Exposure Time:

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☐ Chlorophyll-A	0.11
(32212)	☐ Chlorophyll-B	0.0017
(32214)	☐ Chlorophyll-C	0.016

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l.

STORET CODE		
(32211)	☐ Chlorophyll-A	0.011
(32218)	☐ Pheophytin-A	0.16
(32216)	☐ Total Chlorophyll	0.17 ug/l.

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

RETURN TEST RESULTS TO

Name: DOE

Address:

City, State, Zip Code: CDA

Date Completed: 9/18/85

Date Reported: 11/25/85

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

Chemist: Johan

(00116) ☐ Intensive Survey Number ______

Remarks:

WH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Orielle

Date Collected: 85 | 09 | 24 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ______ ☐ Trend

Storet No.: 2000257

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

Preserved Sample Submitted

BIOMASS
☐ Frozen, Light Excluded
☐ Other

SPECIES IDENTIFICATION
☐ Formalin
☐ EPA Preservative

Date Submitted: 85 | 09 | 24 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate:

Exposure Time:

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☐ Chlorophyll-A	0.13
(32212)	☐ Chlorophyll-B	0.06
(32214)	☐ Chlorophyll-C	0.17 ~~0.17~~

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l.

STORET CODE		
(32211)	☐ Chlorophyll-A	0.90
(32218)	☐ Pheophytin-A	.08 0.077
(32216)	☒ Total Chlorophyll A in orig sample	1.45 mg/l
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO

Name: DOE

Address:

City, State, Zip Code: CDA

Date Completed: 11/5/85

Date Reported: 11/25/85

Chemist:

Remarks:

**Ash-free dry weight and pigment determinations are from different samples (or subsamples).*

(00116) ☐ Intensive Survey Number ______

WH-0262

:OPY DISTRIBUTION
/hite - Person Requesting Test
:anary - Laboratory
ink - Water Quality Bureau (STORET)
ioldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: LPO Stn. 3 Clark Fork Mouth.

Date Collected: 84 09 12 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ☐ Trend

Storet No.: 2000258

Collected By: Beckwith.

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

Preserved Sample Submitted

BIOMASS: ☒ Frozen, Light Excluded ☐ Other

SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative

Date Submitted: 84 09 12 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate:
Exposure Time:

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 3/4 Liter

TRICHROMATIC METHOD (mg/m2) — Periphyton

STORET CODE	Parameter	Result
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2) — Periphyton

STORET CODE	Parameter	Result
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

TRICHROMATIC METHOD (~~ug/l~~ mg/l) — Photoplankton

STORET CODE	Parameter	Result
(32210)	☒ Chlorophyll-A	0.25
(32212)	☒ Chlorophyll-B	0.12
(32214)	☒ Chlorophyll-C	0.23

BEFORE/AFTER ACIDIFICATION (~~ug/l~~ mg/l.) — Photoplankton

STORET CODE	Parameter	Result
(32211)	☒ Chlorophyll-A	0
(32218)	☒ Pheophytin-A	1.0
(32216)	☒ Total Chlorophyll	0.002 ug/l

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

RETURN TEST RESULTS TO

Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 2/8/85
Date Reported: 2/28/85

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

Chemist: Johann

(00116) ☐ Intensive Survey Number

Remarks

IWH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location	LPO Stn. 3
Date Collected (Yr. Mo. Day)	84 10 01
Purpose of Sample (Check One)	☒ Intensive Survey ☐ Other ____ ☐ Trend
Storet No.	2000258
Collected By	Beckwith
Time Collected (24 Hr. Clock)	:
Sample Taken From (Check One)	☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain
Preserved Sample Submitted	BIOMASS: ☒ Frozen, Light Excluded ☐ Other; SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative
Date Submitted (Yr. Mo. Day)	84 10 01

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate: ____ Exposure Time: ____

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 3/4 Liter

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☒ Chlorophyll-A	0.26
(32212)	☒ Chlorophyll-B	0.14
(32214)	☒ Chlorophyll-C	0.41

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l

STORET CODE		
(32211)	☒ Chlorophyll-A	0
(32218)	☒ Pheophytin-A	0.72
(32216)	☒ Total Chlorophyll	0.003 ug/l
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m^2)	

RETURN TEST RESULTS TO

Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 2/8/85
Date Reported: 2/28/85

Chemist: Johann

Remarks:

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ____

HWH-0262

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

LAB NAME *(Check One)*
☐ Boise ☐ Caldwell ☒ Cd'A ☐ Idaho Falls ☐ Lewiston ☐ Pocatello ☐ Twin Fall

Sampling Point Location: Lake Pend Orielle #1.3	Date Collected: 85 04 11 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Trend ☐ Other ______
Storet No.: 2000258 — Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain
Preserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other — SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 04 12 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate: — Exposure Time:

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1.5 Liter

TRICHROMATIC METHOD (mg/m2) — Periphyton

STORET CODE		
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

TRICHROMATIC METHOD (~~ug/l~~) mg/l — Photoplankton

STORET CODE		
(32210)	☐ Chlorophyll-A	0
(32212)	☐ Chlorophyll-B	0
(32214)	☐ Chlorophyll-C	0

BEFORE/AFTER ACIDIFICATION (~~ug/l~~) mg/l.

STORET CODE		
(32211)	☐ Chlorophyll-A	0
(32218)	☐ Pheophytin-A	7.3
(32216)	☐ Total Chlorophyll	0 ug/l

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

**Ash-free dry weight and pigment determinations are from different samples (or subsamples).*

(00116) ☐ Intensive Survey Number ______

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 5/6/85 — Date Reported: 4/25/85

Chemist: [signature]

Remarks:

-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Caldwell ☒ Cd'A ☐ Idaho Falls ☐ Lewiston ☐ Pocatello ☐ Twin Falls

Sampling Point Location: Lake Pend Oreille Stn. #3

Date Collected: 85 05 21 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ______ ☐ Trend

Storet No.: 2000258

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain

Preserved Sample Submitted
BIOMASS: ☐ Frozen, Light Excluded ☐ Other
SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative

Date Submitted: 85 05 21 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate:

Exposure Time:

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1000 ml ~~Liter~~

TRICHROMATIC METHOD (mg/m2) — Periphyton

STORET CODE		
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

TRICHROMATIC METHOD (~~ug/l~~ mg) — Photoplankton

STORET CODE		
(32210)	☐ Chlorophyll-A	0.16
(32212)	☐ Chlorophyll-B	0.053
(32214)	☐ Chlorophyll-C	0.15

BEFORE/AFTER ACIDIFICATION (mg/m2) — Periphyton

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

BEFORE/AFTER ACIDIFICATION (~~ug/l~~) — Photoplankton

STORET CODE		
(32211)	☐ Chlorophyll-A	0.627
(32218)	☐ Pheophytin-A	0.24
(32216)	☐ Total Chlorophyll	0.43 ug/l

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

Date Completed: 7/9/85

Date Reported: 11/25/85

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

Chemist: Jóhann

(00116) ☐ Intensive Survey Number ______

Remarks:

VH-0262

DPY DISTRIBUTION
hite - Person Requesting Test
inary - Laboratory
nk - Water Quality Bureau (STORET)
oldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

ampling Point Location: Lake Pend Orielle

Date Collected: 85 07 02 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ______ ☐ Trend

toret No.: 2000258A

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

reserved Sample Submitted

BIOMASS
☐ Frozen, Light Excluded
☐ Other

SPECIES IDENTIFICATION
☐ Formalin
☐ EPA Preservative

Date Submitted: 85 07 03 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

lumber of Slides/Replicate:

Exposure Time:

STORET CODE	TRICHROMATIC METHOD (mg/m^2)	
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

	BEFORE/AFTER ACIDIFICATION (mg/m2)	
(32223)	☐ Chlorophyll-A	
32224)	☐ Pheophytin-A	
32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

STORET CODE	TRICHROMATIC METHOD ~~(ug/l)~~ mg/l	
(32210)	☐ Chlorophyll-A	0.20
(32212)	☐ Chlorophyll-B	0.026
(32214)	☐ Chlorophyll-C	0.11

	BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l	
(32211)	☐ Chlorophyll-A	0
(32218)	☐ Pheophytin-A	0.35
(32216)	☐ Total Chlorophyll	~~0 ug/l~~
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO

Name: DOE

Address:

City, State, Zip Code: CDA

ate Completed: 7/20/85

Date Reported: 7/25/85

hemist: Johann

emarks

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ______

( )262

PY DISTRIBUTION
ite - Person Requesting Test
y - Laboratory
Water Quality Bureau (STORET)
nrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Caldwell ☒ Cd'A ☐ Idaho Falls ☐ Lewiston ☐ Pocatello ☐ Twin Falls

mpling Point Location: Lake Pend Orielle

Date Collected: 85 07 02 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ☐ Trend

oret No.: 20002586

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain

served Sample Submitted

BIOMASS: ☐ Frozen, Light Excluded ☐ Other

SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative

Date Submitted: 85 07 03 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

licate No.	1	2	3
craping Diameter (cm)			
umber of Scrapings/Filter			
l Area/Filter (cm²)			

☐ Colonization Sampler (Slides)

umber of Slides/Replicate

Exposure Time

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

TRICHROMATIC METHOD (mg/m²)

STORET CODE		
(32228)	☐ Chlorphyll-A	
(226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☐ Chlorophyll-A	0.22
(32212)	☐ Chlorphyll-B	0.03
(32214)	☐ Chlorophyll-C	0.14

BEFORE/AFTER ACIDIFICATION (mg/m2)

(223)	☐ Chlorophyll-A	
(224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l.

(32211)	☐ Chlorophyll-A	0.032
(32218)	☐ Pheophytin-A	6.32
(32216)	☐ Total Chlorophyll	0.51 ug/l

RETURN TEST RESULTS TO

Name: DOE

Address:

City, State, Zip Code: CDA

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

Date Completed: 7/16/85

Date Reported: 11/25/85

**Ash-free dry weight and pigment determinations are from different samples (or subsamples).*

hemist: [signature]

(00116) ☐ Intensive Survey Number

marks

HWH-0262

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☒ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Orielle	Date Collected: 85 07 31 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ___ ☐ Trend
Storet No.: 2000258 / Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain
Preserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other; SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 07 31 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate: ___ Exposure Time: ___

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: .90 Liter

Periphyton

STORET CODE	TRICHROMATIC METHOD (mg/m^2)	
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

STORET CODE	BEFORE/AFTER ACIDIFICATION (mg/m^2)	
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

Photoplankton

STORET CODE	TRICHROMATIC METHOD ~~(ug/l)~~ mg/l	
(32210)	☐ Chlorophyll-A	0.11
(32212)	☐ Chlorophyll-B	0.034
(32214)	☐ Chlorophyll-C	0.087

STORET CODE	BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ ug/l.	
(32211)	☐ Chlorophyll-A	0.027
(32218)	☐ Pheophytin-A	0.151
(32216)	☐ Total Chlorophyll A in original sample	0.48 ug/l
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m^2)	

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: COA

Date Completed: 9/18/85
Date Reported: 11/25/85

Chemist: Johann

Remarks:

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ___

WH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Caldwell ☒ Cd'A ☐ Idaho Falls ☐ Lewiston ☐ Pocatello ☐ Twin Falls

Sampling Point Location: Lake Pend Orielle	Date Collected: 85 08 13 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Trend ☐ Other	
Storet No.: 2000258	Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain
Preserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other	SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 08 13 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate:
Exposure Time:

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 950 ml Liter

TRICHROMATIC METHOD

STORET CODE	Periphyton (mg/m^2)	STORET CODE	Phytoplankton (~~ug/l~~ mg/l)
(32228)	☐ Chlorphyll-A	(32210)	☐ Chlorophyll-A: 0.078
(32226)	☐ Chlorphyll-B	(32212)	☐ Chlorophyll-B: 0
(32227)	☐ Chlorophyll-C	(32214)	☐ Chlorophyll-C: 0.0048

BEFORE/AFTER ACIDIFICATION

STORET CODE	Periphyton (mg/m^2)	STORET CODE	Phytoplankton (~~ug/l~~ mg/l)
(32223)	☐ Chlorophyll-A	(32211)	☐ Chlorophyll-A: 0.0053
(32224)	☐ Pheophytin-A	(32218)	☐ Pheophytin-A: 0.12
(32225)	☐ Total Chlorophyll	(32216)	☐ Total Chlorophyll (Chlorophyl A in orig sample): 0.09 ug/l

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m^2)

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 9/26/85
Date Reported: 11/25/85

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

Chemist: Johnson

(00116) ☐ Intensive Survey Number

Remarks:

HWH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☐ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Orielle

Date Collected: 85 | 09 | 24 (Yr. | Mo. | Day)

Purpose of Sample (Check One): ☐ Intensive Survey ☐ Other ______ ☐ Trend

Storet No.: 2000258

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☐ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

Preserved Sample Submitted
BIOMASS: ☐ Frozen, Light Excluded ☐ Other
SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative

Date Submitted: 85 | 09 | 24 (Yr. | Mo. | Day)

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate:
Exposure Time:

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

TRICHROMATIC METHOD (mg/m^2) — Periphyton

STORET CODE		
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2) — Periphyton

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l — Photoplankton

STORET CODE		
(32210)	☐ Chlorophyll-A	0.13
(32212)	☐ Chlorophyll-B	0.047
(32214)	☐ Chlorophyll-C	0.19

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l — Photoplankton

STORET CODE		
(32211)	☐ Chlorophyll-A	0.027
(32218)	☐ Pheophytin-A	0.19
(32216)	☒ Total Chlorophyll A	0.428 ug/l in orig sample. 0.43
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 11/5/85
Date Reported: 11/25/85

Chemist: Johann

Remarks:

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ______

VH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☐ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: LPO Stn. 4

Date Collected: 84 09 12 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ____ ☐ Trend

Storet No.: 2000259

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

Preserved Sample Submitted

BIOMASS
☒ Frozen, Light Excluded
☐ Other

SPECIES IDENTIFICATION
☐ Formalin
☐ EPA Preservative

Date Submitted: 84 09 12 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate:

Exposure Time:

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 3/4 Liter

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☒ Chlorophyll-A	0.21
(32212)	☒ Chlorophyll-B	0.09
(32214)	☒ Chlorophyll-C	0.28

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l

STORET CODE		
(32211)	☒ Chlorophyll-A	0.16
(32218)	☒ Pheophytin-A	0.27
(32216)	☒ Total Chlorophyll	0.002 ug/l

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

Date Completed: 2/8/85

Date Reported: 2/28/85

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

Chemist: Johann

(00116) ☐ Intensive Survey Number ____

Remarks:

HWH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☐ Cd'A ☐ Twin Fa...
☐ Idaho Falls

Sampling Point Location: LPO Stn. 4		Date Collected: Yr. 84, Mo. 10, Day 01	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ___ ☐ Trend
Storet No.: 2000259	Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain
Preserved Sample Submitted — BIOMASS: ☒ Frozen, Light Excluded ☐ Other	SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: Yr. 84, Mo. 10, Day 01	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate: ___ Exposure Time: ___

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m^2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 3/4 Liter

TRICHROMATIC METHOD (~~ug/l~~) mg/l

STORET CODE		
(32210)	☒ Chlorophyll-A	0.19
(32212)	☒ Chlorophyll-B	0.18
(32214)	☒ Chlorophyll-C	0.33

BEFORE/AFTER ACIDIFICATION (~~ug/l~~) mg/l.

STORET CODE		
(32211)	☒ Chlorophyll-A	0.13
(32218)	☒ Pheophytin-A	0.13
(32216)	☒ Total Chlorophyll	0.002 ug/l
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 2/8/85
Date Reported: 4/26/85

Chemist: Johann

Remarks:

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ___

IWH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Fall
☐ Idaho Falls

Sampling Point Location: Lake Pend Oreille Stn. 4		Date Collected: 85 / 04 / 11 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ☐ Trend
Storet No.: 2000259	Collected By: Beckworth	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain
Preserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other; SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative		Date Submitted: 85 / 04 / 12 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate	Exposure Time

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1.5 Liter

Periphyton

STORET CODE	TRICHROMATIC METHOD (mg/m^2)	
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

STORET CODE	BEFORE/AFTER ACIDIFICATION (mg/m2)	
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

Photoplankton

STORET CODE	TRICHROMATIC METHOD ~~(ug/l)~~ mg/l	
(32210)	☐ Chlorophyll-A	0
(32212)	☐ Chlorophyll-B	0
(32214)	☐ Chlorophyll-C	0

STORET CODE	BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l	
(32211)	☐ Chlorophyll-A	
(32218)	☐ Pheophytin-A	7.1
(32216)	☐ Total Chlorophyll	0 ug/l

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 5/6/85
Date Reported: 6/25/85

Chemist: [signature]

Remarks

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number

WH-0262

OPY DISTRIBUTION
'hite - Person Requesting Test
anary - Laboratory
ink - Water Quality Bureau (STORET)
oldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Orielle Stn. #4

Date Collected: 85 05 21 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ____ ☐ Trend

Storet No.: 2000259

Collected By: Beckwith.

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

Preserved Sample Submitted

BIOMASS
☐ Frozen, Light Excluded
☐ Other

SPECIES IDENTIFICATION
☐ Formalin
☐ EPA Preservative

Date Submitted: 85 05 21 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate: | Exposure Time:

TRICHROMATIC METHOD (mg/m2)

STORET CODE		
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1000 ~~liter~~ ml

TRICHROMATIC METHOD (~~ug/l~~ mg/l)

STORET CODE		
(32210)	☐ Chlorophyll-A	0.38
(32212)	☐ Chlorophyll-B	0.081
(32214)	☐ Chlorophyll-C	0.39

BEFORE/AFTER ACIDIFICATION (~~ug/l~~)

STORET CODE		
(32211)	☐ Chlorophyll-A	0.021
(32218)	☐ Pheophytin-A	0.65
(32216)	☐ Total Chlorophyll	0.34 ug/l

RETURN TEST RESULTS TO

Name: DOE
Address:
City, State, Zip Code: CDA

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

Date Completed: 7/9/85

Date Reported: 11/25/85

**Ash-free dry weight and pigment determinations are from different samples (or subsamples).*

Chemist: [illegible signature]

(00116) ☐ Intensive Survey Number ____

Remarks

H 262

PY DISTRIBUTION
ite - Person Requesting Test
- Laboratory
Water Quality Bureau (STORET)
rod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

mpling Point Location: Lake Pend Orielle	Date Collected: 85 Yr. 07 Mo. 02 Day	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ______ ☐ Trend	
oret No.: 2060259	Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain
eserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other	SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 Yr. 07 Mo. 07 Day	

PERIPHYTON

☐ Natural Substrate

icate No.	1	2	3
craping Diameter (cm)			
umber of Scrapings/Filter			
Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

umber of Slides/Replicate | Exposure Time

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

TORET CODE	TRICHROMATIC METHOD (mg/m^2)		STORET CODE	TRICHROMATIC METHOD ~~(ug/l)~~ mg/l	
(3228)	☐ Chlorophyll-A		(32210)	☐ Chlorophyll-A	0.19
(326)	☐ Chlorophyll-B		(32212)	☐ Chlorophyll-B	0.026
(32227)	☐ Chlorophyll-C		(32214)	☐ Chlorophyll-C	0.12

	BEFORE/AFTER ACIDIFICATION (mg/m2)			BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l.	
(223)	☐ Chlorophyll-A		(32211)	☐ Chlorophyll-A	0.0053
(224)	☐ Pheophytin-A		(32218)	☐ Pheophytin-A	0.32
(32225)	☐ Total Chlorophyll		(32216)	☐ Total Chlorophyll	0.085ug/l .09
			(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO

Name: DOE
Address:
City, State, Zip Code: CDA

Completed: 7/16/85 | Date Reported: 11/25/85

hemist: [signature]

arks

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ______

-0262

Y DISTRIBUTION
e - Person Requesting Test
ry - Laboratory
- Water Quality Bureau (STORET)
lenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

npling Point Location: Lake Pend Orielle

Date Collected: 85 09 17 (altered: 09 31) — Yr. / Mo. / Day

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ______ ☐ Trend

ret No.: 2000259

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain

served Sample Submitted

BIOMASS
☐ Frozen, Light Excluded
☐ Other

SPECIES IDENTIFICATION
☐ Formalin
☐ EPA Preservative

Date Submitted: 85 09 31 — Yr. / Mo. / Day

PERIPHYTON

☐ Natural Substrate

eplicate No.	1	2	3
raping Diameter (cm)			
umber of Scrapings/Filter			
otal Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

umber of Slides/Replicate | Exposure Time

TRICHROMATIC METHOD (mg/m2)

ORET CODE		
32228)	☐ Chlorophyll-A	
32226)	☐ Chlorophyll-B	
32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

32223)	☐ Chlorophyll-A	
32224)	☐ Pheophytin-A	
32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 950ml ~~Liter~~

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☐ Chlorophyll-A	0.08
(32212)	☐ Chlorophyll-B	0
(32214)	☐ Chlorophyll-C	0

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l.

(32211)	☐ Chlorophyll-A	0
(32218)	☐ Pheophytin-A	0.23
(32216)	☐ Total Chlorophyll	0 ug/l
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO
Name: DoE
Address:
City, State, Zip Code: CDA

ate Completed: 9/18/85
Date Reported: 4/25/85

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

hemist: [signature]

(00116) ☐ Intensive Survey Number ______

emarks

IWH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Fall
☐ Idaho Falls

Sampling Point Location: Lake Pend oriele.

Date Collected: 85 08 13 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ______ ☐ Trend

Storet No.: 2000259

Collected By: Beckwith.

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

Preserved Sample Submitted

BIOMASS
☐ Frozen, Light Excluded
☐ Other

SPECIES IDENTIFICATION
☐ Formalin
☐ EPA Preservative

Date Submitted: 85 08 13 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate: | Exposure Time:

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 950 ml ~~Liter~~

STORET CODE	TRICHROMATIC METHOD (mg/m^2)		STORET CODE	TRICHROMATIC METHOD ~~(ug/l)~~ mg/l	
(32228)	☐ Chlorphyll-A		(32210)	☐ Chlorophyll-A	0.078
(32226)	☐ Chlorphyll-B		(32212)	☐ Chlorophyll-B	0
(32227)	☐ Chlorophyll-C		(32214)	☐ Chlorophyll-C	0.0048
	BEFORE/AFTER ACIDIFICATION (mg/m2)			BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l.	
(32223)	☐ Chlorophyll-A		(32211)	☐ Chlorophyll-A	0.0053
(32224)	☐ Pheophytin-A		(32218)	☐ Pheophytin-A	0.12
(32225)	☐ Total Chlorophyll		(32216)	☐ Total Chlorophyll	0.09 ug/l.

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m^2)

Date Completed: 9/18/85

Date Reported: [illegible]/85

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

Chemist: Yoham

(00116) ☐ Intensive Survey Number ______

Remarks:

HWH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Fall
☐ Idaho Falls

Sampling Point Location: Lake Pend Orielle	Date Collected: 85 08 13 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Trend ☐ Other ____	
Storet No.: 2000259	Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain
Preserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other	SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 08 13 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate: ____ Exposure Time: ____

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1000 ml ~~Liter~~

TRICHROMATIC METHOD (~~ug/l~~ mg/l)

STORET CODE		
(32210)	☐ Chlorophyll-A	0.087
(32212)	☐ Chlorophyll-B	0.0032
(32214)	☐ Chlorophyll-C	0.047

BEFORE/AFTER ACIDIFICATION (~~ug/l~~ mg/l)

STORET CODE		
(32211)	☐ Chlorophyll-A	0.0053
(32218)	☐ Pheophytin-A	0.14
(32216)	☐ Total Chlorophyll	0.086 ug/l Chl A in original sample
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	.09

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 9/18/85
Date Reported: 12/25/85

Chemist: Dolan

Remarks:

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ____

NH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Orielle	Date Collected: 85 (Yr.) 09 (Mo.) 24 (Day)		Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ____ ☐ Trend
Storet No.: 2000259	Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain
Preserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other	SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 (Yr.) 09 (Mo.) 25 (Day)	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate	Exposure Time

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

TRICHROMATIC METHOD

STORET CODE	Periphyton (mg/m2)	Value	STORET CODE	Photoplankton (~~ug/l~~ mg/l)	Value
(32228)	☐ Chlorphyll-A		(32210)	☐ Chlorophyll-A	0.17
(32226)	☐ Chlorphyll-B		(32212)	☐ Chlorophyll-B	0.185
(32227)	☐ Chlorophyll-C		(32214)	☐ Chlorophyll-C	0.63

BEFORE/AFTER ACIDIFICATION

STORET CODE	Periphyton (mg/m2)	Value	STORET CODE	Photoplankton (~~ug/l~~ mg/l)	Value
(32223)	☐ Chlorophyll-A		(32211)	☐ Chlorophyll-A	0
(32224)	☐ Pheophytin-A		(32218)	☐ Pheophytin-A	0.44
(32225)	☐ Total Chlorophyll		(32216)	☐ Total Chlorophyll	0 ug/l

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2) ____

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 11/5/85
Date Reported: 11/25/85

Chemist: [signature]

Remarks:

*Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ____

WH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☐ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: LPO stn.5 outlet

Date Collected: Yr. 84 Mo. 09 Day 12

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ☐ Trend

Storet No.: 2000260

Collected By: Beckwith.

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

Preserved Sample Submitted

BIOMASS
☒ Frozen, Light Excluded
☐ Other

SPECIES IDENTIFICATION
☐ Formalin
☐ EPA Preservative

Date Submitted: Yr. 84 Mo. 09 Day 12

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate:
Exposure Time:

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m^2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 3/4 Liter

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☒ Chlorophyll-A	0.15
(32212)	☒ Chlorophyll-B	0.10
(32214)	☒ Chlorophyll-C	0.28

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l.

STORET CODE		
(32211)	☒ Chlorophyll-A	0
(32218)	☒ Pheophytin-A	0.29
(32216)	☒ Total Chlorophyll	0.001 ug/l
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m^2)	

RETURN TEST RESULTS TO

Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 2/8/85
Date Reported: 2/28/85

Chemist: Johann

Remarks:

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number

WH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: LPO Stn. 5 outlet	Date Collected: Yr. 84, Mo. 10, Day 01	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Trend ☐ Other ______	
Storet No.: 2000260	Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain
Preserved Sample Submitted — BIOMASS: ☒ Frozen, Light Excluded ☐ Other	SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: Yr. 84, Mo. 10, Day 01	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate:
Exposure Time:

TRICHROMATIC METHOD (mg/m2)

STORET CODE		
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 3/4 Liter

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☒ Chlorophyll-A	0.19
(32212)	☒ Chlorophyll-B	0.09
(32214)	☒ Chlorophyll-C	0.37

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l

STORET CODE		
(32211)	☒ Chlorophyll-A	0.05
(32218)	☒ Pheophytin-A	0.26
(32216)	☒ Total Chlorophyll	0.002 ug/l

(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)

RETURN TEST RESULTS TO

Name: DOE
Address:
City, State, Zip Code: CdA

Date Completed: 2/8/85
Date Reported: 2/28/85

Chemist: Johann

Remarks:

**Ash-free dry weight and pigment determinations are from different samples (or subsamples).*

(00116) ☐ Intensive Survey Number ______

H /H-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Caldwell ☒ Cd'A ☐ Idaho Falls ☐ Lewiston ☐ Pocatello ☐ Twin Fall

Sampling Point Location: Lake Pend Orielle Stn 8	Date Collected: 85 04 11 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Trend ☐ Other	
Storet No.: 2000260	Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain
Preserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other	SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 04 12 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate | Exposure Time

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

STORET CODE	TRICHROMATIC METHOD (mg/m2)		STORET CODE	TRICHROMATIC METHOD ~~(ug/l)~~ mg/l	
(32228)	☐ Chlorophyll-A		(32210)	☐ Chlorophyll-A	0
(32226)	☐ Chlorphyll-B		(32212)	☐ Chlorophyll-B	0
(32227)	☐ Chlorophyll-C		(32214)	☐ Chlorophyll-C	0
	BEFORE/AFTER ACIDIFICATION (mg/m2)			**BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l**	
(32223)	☐ Chlorophyll-A		(32211)	☐ Chlorophyll-A	0
(32224)	☐ Pheophytin-A		(32218)	☐ Pheophytin-A	8.7
(32225)	☐ Total Chlorophyll		(32216)	☐ Total Chlorophyll	0 ug/l

RETURN TEST RESULTS TO	Name: DOE Address: City, State, Zip Code: CDA	(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)
Date Completed: 5/6/85	Date Reported: 4/25/85		*Ash-free dry weight and pigment determinations are from different samples (or subsamples).
Chemist: Upham		(00116)	☐ Intensive Survey Number
Remarks			

V -0262

OPY DISTRIBUTION
/hite - Person Requesting Test
a ry - Laboratory
i. - Water Quality Bureau (STORET)
ic enrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Orielle. Stn. #5

Date Collected: 85 | 05 | 21 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ☐ Trend

Storet No.: 2000260

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

Preserved Sample Submitted
BIOMASS
☐ Frozen, Light Excluded
☐ Other

SPECIES IDENTIFICATION
☐ Formalin
☐ EPA Preservative

Date Submitted: 85 | 05 | 21 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

plicate No.	1	2	3
Scraping Diameter (cm)			
mber of Scrapings/Filter			
al Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate | Exposure Time

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1000 ml ~~Liter~~

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(228)	☐ Chlorophyll-A	
(226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

TRICHROMATIC METHOD (~~ug/l~~ mg/l)

STORET CODE		
(32210)	☐ Chlorophyll-A	0.20
(32212)	☐ Chlorophyll-B	0.052
(32214)	☐ Chlorophyll-C	0.14

BEFORE/AFTER ACIDIFICATION (mg/m2)

(223)	☐ Chlorophyll-A	
(2224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

BEFORE/AFTER ACIDIFICATION (~~ug/l~~)

(32211)	☐ Chlorophyll-A	0
(32218)	☐ Pheophytin-A	0.35
(32216)	☐ Total Chlorophyll	0 ug/l

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Completed: 7/9/85
Date Reported: 11/25/85

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

Chemist: J. [illegible]

(00116) ☐ Intensive Survey Number

Remarks

I-0262

Y DISTRIBUTION
te - Person Requesting Test
ary - Laboratory
- Water Quality Bureau (STORET)
Jenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

npling Point Location: Lake Pend Orielle

Date Collected: 85 07 02 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ______ ☐ Trend

ret No.: 2000260

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain

served Sample Submitted

BIOMASS
☐ Frozen, Light Excluded
☐ Other

SPECIES IDENTIFICATION
☐ Formalin
☐ EPA Preservative

Date Submitted: 85 07 03 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

eplicate No.	1	2	3
craping Diameter (cm)			
umber of Scrapings/Filter			
otal Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

umber of Slides/Replicate | Exposure Time

TRICHROMATIC METHOD (mg/m^2)

TORET CODE		
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m^2)

(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☐ Chlorophyll-A	0.10
(32212)	☐ Chlorophyll-B	0.012
(32214)	☐ Chlorophyll-C	0.059

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l.

(32211)	☐ Chlorophyll-A	0.042
(32218)	☐ Pheophytin-A	0.10
(32216)	☐ Total Chlorophyll	0.684 ug/l .68
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m^2)	

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ______

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 7/16/85
Date Reported: 11/25/85

Chemist: Johann

Remarks

I- 62

Y DISTRIBUTION
te - Person Requesting Test
- Laboratory
Water Quality Bureau (STORET)
rod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Oreille	Date Collected: 85 07 31 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ☐ Trend
Storet No.: 2000260 — Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain
Preserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other — SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 07 31 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate | Exposure Time

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 750 ml ~~Liter~~

TRICHROMATIC METHOD

STORET CODE (Periphyton)	Periphyton (mg/m2)		STORET CODE (Phytoplankton)	Phytoplankton (~~ug/l~~ mg/l)	
(..228)	☐ Chlorphyll-A		(32210)	☐ Chlorophyll-A	0.049
(..226)	☐ Chlorphyll-B		(32212)	☐ Chlorophyll-B	0.0049
(32227)	☐ Chlorophyll-C		(32214)	☐ Chlorophyll-C	0.0013

BEFORE/AFTER ACIDIFICATION

STORET CODE	Periphyton (mg/m2)		STORET CODE	Phytoplankton (~~ug/l~~ mg/l.)	
(..223)	☐ Chlorphyll-A		(32211)	☐ Chlorophyll-A	0.021
(..224)	☐ Pheophytin-A		(32218)	☐ Pheophytin-A	.0.048
(32225)	☐ Total Chlorophyll		(32216)	☐ Total Chlorophyll	0.46 ug/l

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Completed: 9/17/85 | Date Reported: 11/25/85

Chemist: Johan

Remarks:

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number

HWH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES
AQUATIC BIOMASS REPORT
(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: lake Pend Oreille.		Date Collected: 85 08 13 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ____ ☐ Trend
Storet No.: 2000260	Collected By: Beckwith.	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain
Preserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other	SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 08 13 (Yr. Mo. Day)	

PERIPHYTON
☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate: ____ Exposure Time: ____

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

TRICHROMATIC METHOD (mg/m^2) — Periphyton

STORET CODE		
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2) — Periphyton

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l — Photoplankton

STORET CODE		
(32210)	☐ Chlorophyll-A	0.08
(32212)	☐ Chlorophyll-B	.0035
(32214)	☐ Chlorophyll-C	0.02

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l — Photoplankton

STORET CODE		
(32211)	☐ Chlorophyll-A	0.01
(32218)	☐ Pheophytin-A	0.12
(32216)	☐ Total Chlorophyll	0.171 ug/l .17

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

Date Completed: 9/18/85
Date Reported: 11/25/85

Chemist: [signature]

Remarks:

**Ash-free dry weight and pigment determinations are from different samples (or subsamples).*

(00116) ☐ Intensive Survey Number ____

WH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lakeland Oricle.		Date Collected: 85 09 24 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ____ ☐ Trend
Storet No.: 2000261	Collected By: Beckwith.	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain
Preserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other	SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 09 25 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate:

Exposure Time:

STORET CODE	TRICHROMATIC METHOD (mg/m2)	
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

	BEFORE/AFTER ACIDIFICATION (mg/m2)	
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

STORET CODE	TRICHROMATIC METHOD ~~(ug/l)~~ mg/l	
(32210)	☐ Chlorophyll-A	0.046
(32212)	☐ Chlorophyll-B	0
(32214)	☐ Chlorophyll-C	0

	BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l.	
(32211)	☐ Chlorophyll-A	0
(32218)	☐ Pheophytin-A	0.093
(32216)	☐ Total Chlorophyll	~~0 ug/l~~
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO

Name: DOE

Address:

City, State, Zip Code: CDA

Date Completed: 11/5/85

Date Reported: 11/25/85

Chemist: [signature]

Remarks:

*Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ____

HWH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☐ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Orielle

Date Collected: 85 | 09 | 24 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ____ ☐ Trend

Storet No.: 2000261

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

Preserved Sample Submitted
BIOMASS: ☐ Frozen, Light Excluded ☐ Other
SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative

Date Submitted: 85 | 09 | 24 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate:
Exposure Time:

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 l Liter

TRICHROMATIC METHOD (mg/m^2) — Periphyton

STORET CODE		
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m^2) — Periphyton

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l — Photoplankton

STORET CODE		
(32210)	☐ Chlorophyll-A	0.14
(32212)	☐ Chlorophyll-B	0.079
(32214)	☐ Chlorophyll-C	0.30

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l — Photoplankton

STORET CODE		
(32211)	☐ Chlorophyll-A	0.032
(32218)	☐ Pheophytin-A	.020
(32216)	☐ Total Chlorophyll A in orig sample	0.51 mg/l
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m^2)	

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 11/5/85
Date Reported: 11/25/85

Chemist: Johann

Remarks:

(00116) ☐ Intensive Survey Number ____

V -0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Oreille Bayview	Date Collected: 85 05 21 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ☐ Trend
Storet No.: 2000261 — Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain
Preserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other — SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 05 21 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate: — Exposure Time:

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(32228)	☐ Chlorphyll-A	
(32226)	☐ Chlorphyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1000 ~~liter~~ ml

TRICHROMATIC METHOD (~~ug/l~~ mg/l)

STORET CODE		
(32210)	☐ Chlorophyll-A	0.36
(32212)	☐ Chlorophyll-B	0.023
(32214)	☐ Chlorophyll-C	0.12

BEFORE/AFTER ACIDIFICATION (~~ug/l~~)

(32211)	☐ Chlorophyll-A	0.037
(32218)	☐ Pheophytin-A	0.57
(32216)	☐ Total Chlorophyll	0.60 ug/l
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 7/9/85 — Date Reported: 11/25/85

Chemist: Johnson

Remarks:

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number

'H-0262

PY DISTRIBUTION
ite - Person Requesting Test
nary - Laboratory
k - Water Quality Bureau (STORET)
ldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

mpling Point Location: Lake Pend Oreille

Date Collected: 85 07 03 (Yr. Mo. Day)

Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ☐ Trend

oret No.: 2000261A

Collected By: Beckwith

Time Collected: : (24 Hr. Clock)

Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain

eserved Sample Submitted
BIOMASS
☐ Frozen, Light Excluded
☐ Other

SPECIES IDENTIFICATION
☐ Formalin
☐ EPA Preservative

Date Submitted: 85 07 03 (Yr. Mo. Day)

PERIPHYTON

☐ Natural Substrate

eplicate No.	1	2	3
craping Diameter (cm)			
umber of Scrapings/Filter			
otal Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

umber of Slides/Replicate | Exposure Time

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 900 ml ~~Liter~~

TRICHROMATIC METHOD (mg/m2) — Periphyton

TORET CODE		
32228)	☐ Chlorphyll-A	
32226)	☐ Chlorphyll-B	
32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

32223)	☐ Chlorophyll-A	
32224)	☐ Pheophytin-A	
32225)	☐ Total Chlorophyll	

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l — Photoplankton

STORET CODE		
(32210)	☐ Chlorphyll-A	0.13
(32212)	☐ Chlorphyll-B	0.018
(32214)	☐ Chlorophyll-C	0.082

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~

(32211)	☐ Chlorophyll-A	0.0053
(32218)	☐ Pheophytin-A	0.23 ~~0.1~~
(32216)	☐ Total Chlorophyll	~~0.095 ug/l~~

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

(00573) ☐ Ash-Free Dry Weight* Periphyton (g/m2)

te Completed: 9/9/85 | Date Reported: 11/25/85

**Ash-free dry weight and pigment determinations are from different samples (or subsamples).*

emist: Johan

(00116) ☐ Intensive Survey Number

marks

-0262

OPY DISTRIBUTION
hite - Person Requesting Test
ry - Laboratory
- Water Quality Bureau (STORET)
oldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Caldwell ☒ Cd'A ☐ Idaho Falls ☐ Lewiston ☐ Pocatello ☐ Twin Falls

ampling Point Location: Lake Pend Orielle	Date Collected: 85 07 03 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Trend ☐ Other
toret No.: 2000261B / Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain
reserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other; SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 07 03 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

eplicate No.	1	2	3
Scraping Diameter (cm)			
mber of Scrapings/Filter			
al Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

umber of Slides/Replicate | Exposure Time

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 900 ml ~~Liter~~

TRICHROMATIC METHOD

STORET CODE	Periphyton (mg/m2)		STORET CODE	Photoplankton ~~(ug/l)~~ mg/l.	
(228)	☐ Chlorophyll-A		(32210)	☐ Chlorophyll-A	0
(226)	☐ Chlorophyll-B		(32212)	☐ Chlorophyll-B	1.5
(32227)	☐ Chlorophyll-C		(32214)	☐ Chlorophyll-C	3.8

BEFORE/AFTER ACIDIFICATION

STORET CODE	Periphyton (mg/m2)		STORET CODE	Photoplankton ~~(ug/l)~~	
(223)	☐ Chlorophyll-A		(32211)	☐ Chlorophyll-A	0.027
(32224)	☐ Pheophytin-A		(32218)	☐ Pheophytin-A	0.228
(32225)	☐ Total Chlorophyll		(32216)	☐ Total Chlorophyll	⊗ 0.48 ug/l
			(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Completed: 7/9/85 | Date Reported: 11/25/85

hemist: Johnson

arks

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number

I-02G2

Y DISTRIBUTION
te - Person Requesting Test
ary - Laboratory
. - Water Quality Bureau (STORET)
jenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES
AQUATIC BIOMASS REPORT
(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

npling Point Location: Lake Pend Orrelle		Date Collected: 85 07 31 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Other ____ ☐ Trend
ret No.: 2000261	Collected By: Beckwith	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☒ Lake ☐ Spring ☐ Reservoir ☐ River ☐ Drain
served Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other	SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 07 31 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

eplicate No.	1	2	3
craping Diameter (cm)			
umber of Scrapings/Filter			
otal Area/Filter (cm2)			

☐ Colonization Sampler (Slides)

umber of Slides/Replicate | Exposure Time

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 800 ml ~~Liter~~

TRICHROMATIC METHOD (mg/m^2) — Periphyton

TORET CODE		
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2) — Periphyton

(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l — Photoplankton

STORET CODE		
(32210)	☐ Chlorophyll-A	0.082
(32212)	☐ Chlorophyll-B	0.056
(32214)	☐ Chlorophyll-C	0.20

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l — Photoplankton

(32211)	☐ Chlorophyll-A	0.16
(32218)	☐ Pheophytin-A	0.13
(32216)	☐ Total Chlorophyll	0.32 mg/l
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO
Name: DOF
Address:
City, State, Zip Code: CDA

Date Completed: 9/17/05
Date Reported: 11/25/05
Chemist: [signature]
Remarks

Ash-free dry weight and pigment determinations are from different samples (or subsamples).

(00116) ☐ Intensive Survey Number ____

WH-0262

COPY DISTRIBUTION
White - Person Requesting Test
Canary - Laboratory
Pink - Water Quality Bureau (STORET)
Goldenrod - Extra As Needed

Idaho Department of Health & Welfare
BUREAU OF WATER QUALITY
BUREAU OF LABORATORIES

AQUATIC BIOMASS REPORT

(See Back For Instructions)

LAB NAME *(Check One)*
☐ Boise ☐ Lewiston
☐ Caldwell ☐ Pocatello
☒ Cd'A ☐ Twin Falls
☐ Idaho Falls

Sampling Point Location: Lake Pend Orrelle.	Date Collected: 85 08 13 (Yr. Mo. Day)	Purpose of Sample (Check One): ☒ Intensive Survey ☐ Trend ☐ Other ______	
Storet No.: 2000261	Collected By: Beckwith.	Time Collected: : (24 Hr. Clock)	Sample Taken From (Check One): ☐ Creek ☐ Spring ☐ River ☒ Lake ☐ Reservoir ☐ Drain
Preserved Sample Submitted — BIOMASS: ☐ Frozen, Light Excluded ☐ Other	SPECIES IDENTIFICATION: ☐ Formalin ☐ EPA Preservative	Date Submitted: 85 08 13 (Yr. Mo. Day)	

PERIPHYTON

☐ Natural Substrate

Replicate No.	1	2	3
Scraping Diameter (cm)			
Number of Scrapings/Filter			
Total Area/Filter (cm^2)			

☐ Colonization Sampler (Slides)

Number of Slides/Replicate	Exposure Time

TRICHROMATIC METHOD (mg/m^2)

STORET CODE		
(32228)	☐ Chlorophyll-A	
(32226)	☐ Chlorophyll-B	
(32227)	☐ Chlorophyll-C	

BEFORE/AFTER ACIDIFICATION (mg/m2)

STORET CODE		
(32223)	☐ Chlorophyll-A	
(32224)	☐ Pheophytin-A	
(32225)	☐ Total Chlorophyll	

PHOTOPLANKTON

Number of Replicates Per Sample: 1

Volume Filtered: 1 Liter

TRICHROMATIC METHOD ~~(ug/l)~~ mg/l

STORET CODE		
(32210)	☐ Chlorophyll-A	0.081
(32212)	☐ Chlorophyll-B	0.012
(32214)	☐ Chlorophyll-C	0.065

BEFORE/AFTER ACIDIFICATION ~~(ug/l)~~ mg/l.

STORET CODE		
(32211)	☐ Chlorophyll-A	0.016
(32218)	☐ Pheophytin-A	.12
(32216)	☐ Total Chlorophyll	0.26 ~~mg/l~~ ug/l
(00573)	☐ Ash-Free Dry Weight* Periphyton (g/m2)	

RETURN TEST RESULTS TO
Name: DOE
Address:
City, State, Zip Code: CDA

Date Completed: 9/16/85
Date Reported: 11/25/85

Chemist: Johann

Remarks:

**Ash-free dry weight and pigment determinations are from different samples (or subsamples).*

(00116) ☐ Intensive Survey Number ______

APPENDIX 10A

Phytoplankton Analysis Results - 1985

APPENDIX 10A. 1985 Phytoplankton Analysis Results

A SURVEY AND ECOLOGICAL ANALYSIS OF OREGON AND IDAHO PHYTOPLANKTON

by

James W. Sweet

AQUATIC ANALYSTS
11650 SW Pacific Hwy.
Portland, OR 97223

Final Report Submitted to

Environmental Protection Agency
1200 SW Sixth Ave.
Seattle, WA 98101

Evan Hornig
Bruce Cleland
Project Officers

May, 1986

CONTENTS

INTRODUCTION

Project Scope

Aquatic Analysts was contracted by the Environmental Protection Agency to analyze 130 phytoplankton samples from lakes throughout Oregon (85 samples) and Idaho (45 samples), to investigate relationships between the phytoplankton and associated environmental data, to compile a list of previously analyzed phytoplankton samples from both states, and to provide quality assurance of the results obtained.

This contract is an extension of similar work performed by Aquatic Analysts for EPA during the previous year in which 120 phytoplankton samples were analyzed from Oregon lakes. This final report merges the results of both contracts. An additional 35 phytoplankton samples, analyzed by the investigator as part of other projects, have been included in the database to enhance ecological interpretations of the phytoplankton species; a total of 285 samples have been analyzed.

Phytoplankton Contributions to Lake Studies

The emphasis of this study is to provide information on the interpretation of phytoplankton to benefit persons engaged in lake studies. Specifically, ecological profiles for common Northwest phytoplankton species have been determined, and the relationship between total phytoplankton biovolume and trophic state has been established. A trophic state index based on phytoplankton biovolume is presented.

The phytoplankton community influences, and is influenced by, lake quality, and it is perhaps the most important factor in lake metabolism. The phytoplankton are central to issues of lake water quality, fish production, and other limnological characteristics.

Many limnologists or lake investigators have not fully realized the value of phytoplankton analyses, and some have not included any phytoplankton analyses in their lake studies. There are several factors contributing to this under-utilization of phytoplankton; methods are not standardized and results often differ between phycologists, species identifications require experienced algal taxonomists, and interpretations of phytoplankton results are seriously hindered due to a lack of knowledge of the relationships between phytoplankton and their environment.

This report focuses on reducing these factors by presenting detailed quality assurance results and discussions of controlling the errors associated with phytoplankton analyses, by supplying taxonomic summaries and references to aid in algal species identifications, and by providing suggestions for interpreting phytoplankton results (biovolume, species indicators, and sample comparisons).

Acknowledgements

Mr. Bruce Cleland (Environmental Protection Agency, Seattle) and Mr. Andy Schaedel (Oregon Department of Environmental Quality) initiated this project in 1984; their enthusiam and interest in phytoplankton ecology is refreshing.

Mr. Bruce Cleland was the project officer during the 1985 contract, and Mr. Evan Horning was the project officer for the 1986 contract. The advice, guidance, and support of both project officers is greatly appreciated.

Phytoplankton samples were provided by Dr. Richard Petersen (Portland State University), Mr. Mike Beckwith (Idaho Division of Environment, Coeur d'Alene), Mr. Ray Latham (Idaho Division of Environment, Lewiston), and Dr. John Carter (Ecosystems Research Institute, Inc., Logan). These people also kindly supplied environmental data associated with the phytoplankton samples.

The compilation of previously reported phytoplankton was made possible by the contributions of Dr. Doug Larson (US Army Corps of Engineers, Portland), Dr. Dan Johnson (Portland State University), Mr. Mike Beckwith, Dr. Mike Falter (University of Idaho, Moscow), Mr. Evan Hornig, Mr. Steve Bauer (Idaho Division of Environment, Boise), and Mr. Tim Bartish and Mr. Frank Lane (US Army Corps of Engineers, Walla Walla). Their cooperation and efforts have greatly simplified my search for phytoplankton records.

Independent quality assurance samples were analyzed by Dr. Kathleen Baker, Mr. Stan Geiger, Dr. Paul Kugrens, Dr. Barry Rosen, Dr. George Schumacher, Dr. Robert Sheath, Dr. Sam VanLandingham, and Ms. Krystyna Wolniakowski. Mr. Stan Geiger (Scientific Resources Inc., Portland) also performed independent taxonomic determinations of the most problematic algae; discussions with Stan have contributed greatly to the algae taxonomy in this report.

METHODS

Sample Collection, Preservation, and Preparation

All 1981 and 1982 samples were collected during a Portland State University inventory of Oregon lakes (Johnson etal, 1985); samples were collected just below the surface of the lake at either the deepest part of the lake or near the center of the lake, except for a few samples that were collected from docks or near shore. All 1983 samples were collected by Dr. Richard Petersen, Portland State University, as part of his research on trace metals and phytoplankton. Idaho samples were collected by the Idaho Division of Environment and Ecosystems Research Institute, Inc. as part of their lake studies. All samples were preserved in 1% Lugols solution.

Permanent microscope slides were prepared from each sample by filtering an appropriate aliquot of the sample through a 0.45 micrometer membrane filter (McNabb, 1960). A section was cut out and placed on a glass slide with immersion oil added to make the filter transparent, followed by placing a cover slip on top, with nail polish applied to the periphery for permanency.

Enumeration

Algal units (defined as discrete particles - either cells, colonies, or filaments) were counted along a measured transect of the microscope slide with a Zeiss standard microscope (1000X, phase contrast). Only those algae that were believed to be alive at the time of collection (intact chloroplast) were counted. A minimum of 100 algal units were counted for each sample.

Biovolume Estimates

Average biovolume estimates of each species were obtained from calculations of microscopical measurements of the dimensions of each alga. The number of cells per colony, or the length of a filament, were recorded during the sample analysis to arrive at biovolume per unit-alga. Measurements were generally taken on each alga only in a few samples, unless that alga exhibited a wide size range requiring more frequent measurements.

PHYTOPLANKTON DISTRIBUTIONS IN OREGON AND IDAHO

Previously Published Phytoplankton Records

A massive collection of literature pertaining to Oregon lakes is maintained by Dr. Dan Johnson, Portland State University, Geography Department (most of which was originally supplied by Dr. Doug Larson). This library, supplemented with a few recent publications, was searched for any record of phytoplankton in any Oregon lake.

Phytoplankton records from Idaho lakes have not been centralized or cataloged. Agencies were contacted and requests were made for reports, bulletins, or publications containing any phytoplankton data in any Idaho lake. These agencies included Idaho Division of Environment (Coeur d'Alene, Lewiston, and Boise), University of Idaho (Moscow), US Army Corps of Engineers (Walla Walla), US Geological Survey (Boise), and the Environmental Protection Agency (Seattle). There are probably more phytoplankton reports in Idaho, but were not located due to the limited resources of this project.

The phytoplankton data are presented in Appendix G alphabetically by lake, and chronologically within a lake. The algae listed are in order of abundance when quantitative information was available or implied from discussions within the reference, however, many of the references did not include quantitative data. The compiled phytoplankton distributions include data from this project for the sake of completeness. References for the phytoplankton listings are given in Appendix H.

Phytoplankton Species Observed During This Project

A total of 249 algal taxa were observed (Appendix E). Of these, 36 taxa were either dominant in at least several lakes, or were common in many lakes. Table 3.1 lists the most common phytoplankton species.

Table 3.1. Most Common Phytoplankton Species in Oregon and Idaho (in decreasing order of abundance).

Rhodomonas minuta
Ankistrodesmus falcatus
Chromulina sp.
Cryptomonas erosa
Cyclotella stelligera
Anabaena flos-aquae
Asterionella formosa
Oocystis pusilla
Aphanizomenon flos-aquae
Dinobryon sertularia
Sphaerocystis schroeteri
Achnanthes minutissima
Fragilaria construens
Anacystis marina
Anabaena circinalis
Fragilaria crotonensis
Melosira distans
Stephanodiscus astraea minutula
Dinobryon bavaricum
Synedra radians
Synedra rumpens
Cyclotella ocellata
Crucigenia quadrata
Tabellaria fenestrata
Melosira granulata
Ceratium hirundinella
Rhizosolenia eriensis
Stephanodiscus hantzschii
Staurastrum pinque

Appendix B contains a listing of all phytoplankton samples arranged alphabetically by dominant species.

Geographic Distributions

The majority of phytoplankton species occur throughout the Northwest, in fact, throughout the country. Algae have tremendous dispersal capabilities, and species are not restricted to locales due to their inability to get there. The major influence on geographic distributions of phytoplankton are lake characteristics that tend to be similar in similar geographic areas. Although most algae are widely distributed, several were found more often in certain geographic areas than in others:

Anabaena circinalis - Coastal lakes, Winchester Lake (Idaho).

Anabaena flos-aquae - Cascade lakes.

Anacystis marina - Coastal lakes, Spirit Lake (Idaho).

Aphanizomenon flos-aquae - High desert lakes and reservoirs.

Chromulina sp. - Cascade lakes.

Coelastrum microporum - Lake Oswego (Oregon) only.

Coscinodiscus sp. - Coastal lakes.

Cyclotella ocellata - Northern Idaho lakes only.

Cyclotella stelligera - Coastal lakes.

Oocystis pusilla - Cascade lakes.

Rhizosolenia eriensis - Coastal and Northern Idaho lakes.

Sphaerocystis schroeteri - Cascade lakes.

Spondylosium sp. - Garrison Lake (Oregon) only.

Staurastrum pinque - Winchester Lake (Idaho) only.

Synedra cyclopum - Upper Klamath, Lost Creek, and Crescent Lakes (Oregon).

Synedra minuscula - Bear Lake (Idaho) only.

It is interesting to note the distribution of three algal species that occur in both Oregon coastal lakes and Northern Idaho lakes (*Anabaena circinalis*, *Anacystis marina*, and *Rhizosolenia eriensis*). Although these areas appear distinctly different, some similar factor (such as trace metals?) may be influencing the presence of these algae.

Similarity Indices of Phytoplankton Samples

A similarity index was used to compare phytoplankton samples. The index compares the relative abundance of each species present in two samples and yields a value ranging from 0 for totally dissimilar samples to 100 for identical samples. The formula for the similarity index (modified from Whittaker, 1967) is:

$$\text{SIMILARITY INDEX} = 100 - (\textbf{Sum of DIFFERENCE} / 2)$$

Where DIFFERENCE is the absolute value of the difference of the percent of a given species in two samples.

The similarity index can aid interpretation of phytoplankton results, and was utilized in this study for comparison of the phytoplankton between different lakes, different dates, different sampling sites, and different depths.

Similarity Between Different Lakes.

Similarity Indices were calculated between different phytoplankton samples for those lakes with the same species dominant or common; the highest similarity index values for each lake in this study are listed in Appendix D.

The similarity indices provide an unbiased and qualitative estimate of similarity between phytoplankton samples, but the index value in itself should not be strictly interpreted without considering the species present.

Many of the highest similarities in Appendix D accurately represent similar lakes, such as between many of the high Cascade lakes, Eastern Oregon reservoirs, or coastal lakes. The majority of these lakes are represented by reliable species indicators.

However, the similarity index gives erroneously high values for lakes containing "non-indicator" species (primarily Rhodomonas and Ankistrodesmus) due to the wide range of ecological conditions in which they are found. Ankistrodesmus occurs in ultraoligotrophic to hypereutrophic lakes, and similarity indices calculated on these samples show a high degree of similarity where none exists. An example is the comparison of eutrophic Tenmile Lake located on the Oregon coast, and oligotrophic Glacier Lake in the high Wallowa Mountains. Both have Ankistrodesmus falcatus dominant, resulting in a misleading similarity index of 89 percent.

Similarity Between Different Dates Within a Given Lake.

Phytoplankton vary with time in lakes. It is useful to compare similarity indices calculated for sequential dates; this often clearly illustrates between which dates the phytoplankton change the most, and which periods are similar.

Although this study does not include a detailed time series of phytoplankton samples for any lake, one lake was sampled on four different dates and is used as an example to illustrate the application of similarity indices.

The similarity indices for Winchester Lake, Idaho, for all sequential dates at Station 1 are listed below:

Similarity Index	Dates
27	Jul 17 - Aug 1
77	Aug 1 - Aug 15
11	Aug 15 - Oct 9

These data illustrate a stable period during early August in which there was little change of phytoplankton species. The data also show that the phytoplankton in October are quite different than other times of the year. Comparisons of phytoplankton for other lakes are given in Appendix D. Phytoplankton generally vary less from date to date within a lake than between lakes.

Similarity Between Different Sites Within a Given Lake.

Appendix D provides similarity indices calculated for those lakes that were sampled at different locations on the same date. Generally, phytoplankton species compositions are similar at various locations within a lake, but there are some exceptions (such as East Lake; Stations 1 and 2 were very different on July 23, 1983). The phytoplankton generally vary much less between sites than between dates.

Similarity Between Different Depths Within a Given Lake.

Phytoplankton similarity with depth is variable, and is perhaps influenced most by the degree of lake stratification, but also by many other factors such as lake depth, light limitation, trophic state, etc. Appendix D lists similarity indices for those lakes that were sampled at different depths (epilimnion and hypolimnion). Note that in Big and Blue Lakes, both deep and very oligotrophic, the algae are vastly different in the epilimnion and hypolimnion.

In summary, phytoplankton are generally most similar between stations, with decreasing similarity between depths, dates, and lakes in that order. This information is useful in designing sampling programs for phytoplankton; within a given lake, it would be better to collect phytoplankton on more dates than at more locations, if the overall goal is to characterize the lake's phytoplankton dynamics.

PHYTOPLANKTON - ENVIRONMENT RELATIONSHIPS

Phytoplankton Density, Biovolume, and Chlorophyll Relationships

The range, mean, and median values for phytoplankton density, biovolume, and chlorophyll concentration of all samples analyzed during this project are given in Table 4.1.

Table 4.1. Summary of Densities, Biovolumes, and Chlorophyll Concentrations of All Phytoplankton Samples.

Statistic	Density (#/mL)	Biovolume (cu uM/mL X 1000)	Chlorophyll (ug/L)
Minimum	2	1	0.1
Maximum	10,434	9,844	29.7
Mean	642	445	3.3
Median	323	441	1.7
# Samples	285	285	158

Phytoplankton density, phytoplankton biovolume, and chlorophyll concentration are all estimates of algal standing crop. To determine the relationships between each of these estimates, correlation coefficients were calculated (Table 4.2).

Table 4.2. Correlation of Density, Biovolume, and Chlorophyll.

Parameter	Dens/Biovol	Dens/Chl	Biovol/Chl
Corr. Coeff.	0.60	0.39	0.71
Slope	0.6305	0.0022	0.0034
Y intercept	39.59	1.95	1.83
Ave. Dens.	642.5	626.0	------
Ave. Biovol.	444.7	------	437.1
Ave. Chl.	------	3.30	3.30
# samples	285	158	158

Density is number of algal units (cells, colonies, or filaments) per milliliter.
Biovolume is in cubic micrometers per milliliter X 1000.
Chlorophyll a is in micrograms per liter.

Total algal density and total algal biovolume correlate fairly well (0.60) due to the approximate similarity in size of many common algal species. That is, the three most common phytoplankton species encountered in this survey have average biovolumes of 20, 25, and 20 cubic micrometers per mL (X 1000) for *Rhodomonas*, *Ankistrodesmus*, and *Chromulina*, respectively.

Chlorophyll concentration shows a higher correlation with algal biovolume (0.71) than with algal density (0.39), which is to be expected. Both biovolume and chlorophyll are more direct estimates of algal standing crop than is phytoplankton density. The poorest correlation is between algal density and chlorophyll concentration.

It should be noted that algal units were enumerated for this survey - not algal cells. The algal units vary in size more than individual algal cells, hence, algal units would correlate less well with chlorophyll than would algal cells. Although some phycologists enumerate cells, enumeration methods rely on a random distribution of algal particles on the microscope slide, and it is better statistically to enumerate discrete algal units.

The phytoplankton biovolume represents algal standing crop more accurately than phytoplankton density. An example is oligotrophic Lost Lake (on Mt. Hood), of which 96% of the algae is composed of the very small alga *Chromulina*. The sample has a total algal density of 655 per mL and a total algal biovolume of 21,000 cubic micrometers per mL. The density is characteristic of mesotrophic lakes, but the biovolume is typical of oligotrophic lakes.

Means and Variances of Environmental Parameters Associated With Common Phytoplankton Species

The determination of species ecologies, or more specifically species indicators, has usually been approached by other researchers by observing the range of an environmental parameter for a given species, and usual consider only presence or absence of the species and not quantified abundances.

Assuming that algal species occur at a higher relative abundances under more favorable conditions, more "weight" should be given to those environmental conditions associated with a given alga when it is dominant than when it is rare or of lower relative abundance.

Means of selected environmental parameters for each common phytoplankton species were calculated; the means were weighted by the percent relative abundance of each alga:

$$X = \frac{\text{SUM}(vp)}{\text{SUM}(p)}$$

Where, X is the weighted mean
v is the value of the environmental parameter
p is the percent of the ith species

The means represent average environmental conditions under which the given species occurs.

The variance of each mean is a more sensitive estimate of the variability of a species to a given environmental parameter than is the range. The variances of these weighted means were calculated with the following formula:

$$s^2 = \frac{\text{SUM}\left(\frac{(vp - Xp)^2}{p}\right)}{\text{SUM}(p)}$$

Table 4.3 contains means and standard deviations for selected species and environmental parameters; complete data are provided in Appendix C.

Table 4.3. Means and Standard Deviations for Selected Species and Environmental Parameters (standard deviations in parentheses).

ALGA	TROPHY	T-PHOS	SECCHI	TEMP	COND
ABCR	3.9 (0.4)	59 (32)	1.4 (1.3)	19.5 (2.1)	106 (35)
ABFA	3.1 (0.6)	46 (43)	5.2 (3.0)	18.2 (2.9)	186 (217)
ACMN	2.2 (0.9)	15 (15)	8.4 (6.1)	12.0 (4.8)	63 (76)
ANMR	2.0 (0.1)	8 (3)	5.1 (0.3)	18.1 (3.5)	47 (20)
APFA	4.2 (0.6)	97 (70)	2.0 (2.1)	20.9 (3.1)	138 (52)
ASFO	2.8 (0.6)	23 (12)	4.9 (3.0)	14.3 (4.3)	57 (36)
CCST	2.3 (0.6)	10 (10)	5.3 (1.5)	16.4 (3.5)	51 (21)
CJHR	3.4 (0.8)	59 (30)	3.0 (0.7)	19.8 (0.6)	135 (52)
CXER	3.3 (1.0)	52 (47)	2.8 (2.1)	18.4 (4.1)	65 (43)
DBST	2.8 (0.5)	8 (12)	6.0 (1.8)	19.0 (4.3)	74 (104)
FRCN	3.3 (1.0)	100 (130)	3.7 (3.8)	17.2 (4.3)	100 (71)
FRCR	3.4 (0.6)	22 (12)	4.4 (3.2)	20.9 (2.3)	75 (40)
KMXX	1.8 (0.8)	18 (22)	10.8 (5.7)	17.1 (3.7)	16 (17)
MLGR	3.4 (0.5)	109 (76)	2.6 (1.3)	15.8 (6.1)	265 (182)
OCPU	1.5 (0.6)	9 (15)	11.9 (4.6)	17.3 (4.1)	9 (25)
RDMN	3.1 (0.6)	27 (28)	4.4 (2.2)	19.5 (3.6)	79 (65)
SFSR	2.3 (0.7)	22 (33)	9.9 (3.7)	17.8 (3.9)	33 (50)
STAM	3.6 (0.6)	52 (43)	2.7 (3.5)	16.2 (7.0)	180 (198)

Trophy: 1 = ultraoligotrophic, to 5 = hypereutrophic.
Total phosphorus (ug/L); Secchi (meters); Temperature (^{o}C); Conductivity (umhos/cm).

Codes: ABFA = Anabaena flos-aquae; ACMN = Achnanthes minutissima; ANMR = Anacystis marina; APFA = Aphanizomenon flos-aquae; ASFO = Asterionella formosa; CCST = Cyclotella stelligera; CJHR = Ceratium hirundinella; CXER = Cryptomonas erosa; DBST = Dinobryon sertularia; FRCN = Fragilaria construens; FRCR = Fragilaria crotonensis; KMXX = Chromulina sp.; MLGR = Melosira granulata; OCPU = Oocystis pusilla; RDMN = Rhodomonas minuta; SFSR = Sphaerocystis schroeteri; STAM = Stephanodiscus astraea minutula.

As can be seen in Table 4.3 and Appendix C, the means within a given environmental parameter vary between species, which illustrates that different phytoplankton species are associated with different environmental conditions.

A few comments on Table 4.3 are noteworthy. The alga with the highest trophic rating is Aphanizomenon flos-aquae (APFA), which is a notorious component of algal blooms in highly eutrophic lakes. The lowest temperature means are of diatoms, which are generally known to frequent cooler waters (ASFO, ACMN, STAM, MLGR, and CCST), whereas Fragilaria crotonensis (FRCR) is a notable exception. Chromulina (KMXX) and Oocystis pusilla (OCPU) frequent Cascade lakes that are characterized by very high water transparency and usually cooler water temperatures than lakes at lower elevations. Melosira granulata (MLGR) is often found in eutrophic Eastern Oregon reservoirs during the cooler months (in reservoirs typically containing Aphanizomenon in summer), and its means reflect the conditions of those reservoirs of eutrophy, high phosphorus concentrations, low water transparency, and very high conductivity.

Species Indicators: Predicting Environmental Conditions from Phytoplankton

All of these species means may be used as species indicators for each of the environmental parameters. The species-environmental parameter combinations with the lower standard deviations are more reliable than are those with higher standard deviations. For example, Chromulina (trophy = 1.8) and Anacystis marina (trophy = 2.0) are both oligotrophic indicators, but the occurrence of Anacystis with its lower standard deviation (0.1) is a more reliable indicator than is Chromulina (standard deviation = 0.8).

Quantitative predictions of environmental parameters can be estimated from the means and standard deviations of the phytoplankton species. For a given environmental parameter, each species in a phytoplankton community is associated with a "most probable" parameter value (the mean), and each species' variability associated with that parameter is represented by the standard deviation.

The prediction of an environmental parameter value is strengthened by considering all species in the sample, and further, by utilizing a double weighting of each species based upon their relative abundance and their variability to that environmental parameter. The environmental conditions are more likely representative of the dominant algae; a weighting of the relative abundance thus emphasizes the dominants. Those species with large standard deviations are less reliable indicators than are the species with smaller standard deviations; an inverse weighting of the standard deviation (reciprocal of standard deviation) emphasizes those species with narrower environmental ranges, or tolerances. The formula for predicting a specified environmental parameter is:

$$\text{Predicted value} = \frac{\text{SUM} \ (\ Xp \ / \ s \ )}{\text{SUM} \ (\ X \ / \ s \ )}$$

Where X = mean of the ith species for the given environmental parameter.
p = percent of the ith species.
s = standard deviation of the ith species.

Using samples from the database of this study to predict environmental values is invalid, nevertheless to illustrate the application of interpreting phytoplankton species, 10 randomly selected samples were used to predict values of selected environmental parameters from the phytoplankton data. Table 4.4 gives predicted and actual parameter values for trophic state, total phosphorus, conductivity, and water temperature.

Table 4.4. Predicted and Actual Values of Selected Environmental Parameters (predicted values on left; actual on right).

LAKE	TROPHY	PHOSPHORUS	COND.	TEMP.
Monon	2.0 - 1	20 - 7	19 - 4	17.3 - 11.8
Olive	2.9 - 3	13 - 8	76 - 38	19.2 - 18.2
Owyhee	3.5 - 4	46 - 45	133 - 160	17.2 - 23.0
Pamelia	2.8 - 3	28 - 32	57 - 21	16.1 - 6.5
Phillips	3.1 - 3	28 - 15	75 - 81	19.3 - 21.8
Scott	2.1 - 2	19 - 10	19 - 6	17.4 - 15.0
Torrey	2.2 - 2	23 - 7	22 - 10	17.4 - 18.5
U. Klamath	3.2 - 5	42 - 79	66 - 96	17.8 - 15.0
Walton	3.4 - 3	42 - 39	91 - 112	19.4 - 20.9
Woahink	2.1 - 2	9 - 4	49 - 60	18.2 - 20.2

Trophy: 1 = ultraoligotrophy, to 5 = hypereutrophy.
Total phosphorus (ug/L); conductivity (umhos/cm); temp (^{o}C).

The correlation coefficients between the predicted and actual values are:

Trophic State	$r = 0.84$
Total phosphorus	$r = 0.91$
Conductivity	$r = 0.84$
Temperature	$r = 0.67$

The predicted and actual values agree very well. (These data are illustrative and not statistically valid because the samples are a subset of the database from which the means and standard deviations have been calculated). The predicted environmental parameter values utilizing this "means and variances" approach should be more accurate than those predictions of other approaches that are based simply upon species environmental ranges.

Interpretations of species indicators are useful in lake monitoring programs because species respond to their environment; as the environment changes, so do the phytoplankton species. Changes can be detected by increases or decreases in phytoplankton abundance and by shifts in species composition. For example, an increase in lake phosphorus concentration would tend to increase the relative abundance of those species associated with high phosphorus, while relative abundances of species typical of low phosphorus would decrease.

Phytoplankton Relationships With Lake Trophic Categories

Most lake studies first and foremost estimate the lake's trophic state. The trophic state is, and should be, described in terms of several important environmental parameters that are all related -- total phosphorus, total chlorophyll, water transparency, pH, conductivity, and phytoplankton. Procedures and relationships of all these parameters, except for phytoplankton, are well known.

One of the most important results of this study is the determination of the relationships between phytoplankton and trophic state.

The phytoplankton data can be utilized in two ways to estimate the trophic state of a lake:

1) Interpretations of species indicators, and

2) Interpretation of total phytoplankton biovolume.

Phytoplankton Species Composition.

This report contains means and standard deviations for common phytoplankton species from Oregon and Idaho lakes; these data can be used to estimate trophic state directly, or indirectly from estimates of total phosphorus, Secchi depth, and other parameters which in turn support trophic state estimations. The procedures for interpreting species indicators is outlined in the previous section.

Phytoplankton Abundance.

Table 4.5 gives a summary of the phytoplankton densities, biovolumes, and chlorophyll concentrations of samples analyzed during this project within five trophic categories. The table also includes diversity indices, which show that diversity is NOT related to trophic state, as was once commonly believed. If anything, the diversity tends to be lower in extreme environments (either ultraoligotrophy or hypereutrophy).

Table 4.5. Mean Phytoplankton Characteristics Within Trophic State Categories (with number of samples in parentheses).

Trophic State	Density	Biovolume	Chlorophyll	Diversity
Ultraoligotrophic	93 (20)	7 (20)	0.2 (12)	1.64 (15)
Oligotrophic	228 (77)	105 (77)	1.0 (43)	2.27 (61)
Mesotrophic	656 (90)	329 (90)	3.0 (63)	2.09 (86)
Eutrophic	1066 (57)	1056 (57)	6.9 (35)	2.10 (57)
Hypereutrophic	2546 (7)	1958 (7)	10.1 (5)	1.74 (7)

Densities (#/mL); biovolume (cubic micrometers per mL X 1000); chlorophyll (ug/L); Shannon-Weaver diversity index (log base 2).

Phytoplankton density, biovolume, and chlorophyll are directly related to trophic state, as would be expected.

Phytoplankton Biovolume as a Trophic State Indicator

The trophic states of lakes are based upon the amount of phytoplankton in the lakes, and are qualitatively defined as oligotrophic, mesotrophic, or eutrophic for lakes having low, moderate, or high phytoplankton abundances, respectively. Trophic states can also be quantitatively described by the use of Trophic State Indices (TSIs). Carlson (1977) developed three Trophic State Indices based upon the total phosphorus concentration, chlorophyll concentration, and Secchi disk depth. The indices range from 0 to 100, with lower values representing oliogtrophy and higher values representing eutrophic lakes.

Just as Carlson (1977) developed Trophic State Indices for Secchi disk depth, total phosphorus concentration, and chlorophyll *a* concentration, I have developed an index for phytoplankton biovolume. The index ranges from 0 to 100, and the values align with those of Carlson's index values. The index is defined as:

$$\text{TSI (biovolume)} = (\text{Log}_{10} (B + 1)) * 20$$

Where B is the phytoplankton biovolume in cubic micrometers per milliliter divided by 1000.

Table 4.6 lists Trophic State Index values for phytoplankton biovolume, Secchi disk depth, chlorophyll *a* concentration, and total phosphorus concentration of randomly selected samples from this study's database.

Table 4.6. Trophic State Index values.

LAKE - DATE	TSI-B	TSI-S	TSI-C	TSI-P
Cultus 8-20-81	10	19	8	4
Mink 9-13-82	18	19	15	4
Middle Green 8-14-82	18	32	15	45
Lower Eddeeleo 8-3-82	21	24	8	14
Big 8-29-81	24	23	15	14
Linton 7-21-82	24	22	15	54
Hills Creek 8-18-81	27	38	19	43
Blue 7-21-82	29	20	15	53
Gold 7-18-82	30	38	37	60
Bull Run 9-15-82	31	25	22	42
Cleawox 8-16-82	33	37	30	27
Timothy 11-4-82	33	41	27	54
Wallowa 6-24-82	34	35	27	59
Eel 8-4-81	35	35	30	30
Delintment 6-20-82	36	46	39	68
Bully Creek 6-25-82	37	47	43	72
Laurance 8-19-82	37	33	41	59
Morgan 7-31-82	37	47	36	62
South Twin 7-19-82	38	29	31	45
Coffenbury 10-16-82	41	52	26	52
Hosmer 8-21-81	41	47	40	65
Phillips 7-28-82	41	43	40	43
Fern Ridge 8-11-81	45	60	40	44
Upper Klamath 8-22-82	47	52	45	79
Prineville 11-5-82	48	54	36	59
Warm Springs 6-22-82	48	60	43	65
Diamond 8-22-82	52	41	41	63
Todd 8-16-82	52	32	30	64
Billy Chinook 5-28-82	55	50	48	62
Selmac 9-4-81	55	47	39	60
Mercer 5-2-82	61	49	53	41
Devils 7-17-81	63	49	40	55
Detroit 9-15-82	64	35	36	45
Odell 5-20-82	66	40	48	57
Malheur 7-28-82	69	55	62	79
Unity 7-28-82	72	57	59	68

TSI-B calculated from phytoplankton biovolume.
TSI-S calculated from Secchi disk depth.
TSI-C calculated from chlorophyll *a* concentration.
TSI-P calculated from total phosphorus concentration.

The relationships among the four trophic state indices were examined to estimate the reliability of each index. Table 4.7 gives correlation coefficients calculated between the possible combinations of trophic state indices; each correlation was calculated from 131 samples.

Table 4.7. Correlation Coefficients Between Trophic State Indices.

	TSI-B	TSI-S	TSI-C	TSI-P
TSI-Biovolume	----			
TSI-Secchi depth	0.54	----		
TSI-Chlorophyll	0.76	0.69	----	
TSI-Phosphorus	0.49	0.55	0.51	----

The average correlation coefficient for each index is:

TSI-Chlorophyll	r = 0.65
TSI-Biovolume	r = 0.60
TSI-Secchi	r = 0.59
TSI-Phoshorus	r = 0.52

The "best" trophic state index relative to the others is that calculated from chlorophyll, followed in decreasing order by biovolume, Secchi depth, and total phosphorus. An absolute judgement of the "best" trophic state index cannot be made.

Each index has its advantages and disadvantages, and each is subject to errors. The biovolume index is the most direct estimate of algal standing crop, but biovolume data are sometimes not easily obtained. However, the addition of biovolume calculations to routine phytoplankton enumeration analyses does not require much additional effort. Biovolume accuracy is subject to microscope calibration errors and to measurement of cell size errors, but is not affected by incorrect species identifications.

The Secchi disk depth index assumes the lake transparency is due to phytoplankton, and is in error when suspended particles or dissolved humics are present. Secchi depths are very easy to measure, and there is very little variability between observers.

Chlorophyll can be difficult to measure if the lake is distant from the laboratory - it is not easily preserved, and analyses should be performed soon after collection. Other problems with chlorophyll include varying proportions of chlorophyll in different algae under different growing conditions, and also some of the measured chlorophyll may be derived from sources other than phytoplankton (allochthanous or from vascular plants). Still, chlorophyll is measured fairly easily, is reproducible between different laboratories, and is overall a good estimator of algal standing crop.

The total phosphorus index assumes that phytoplankton are limited by phosphorus, which is often the case but not always. It is easily and accurately measured, but is the least reliable indicator for phytoplankton abundance.

As previously stated, trophic state determinations should be based upon as much information as possible. The utilization of the trophic state index for phytoplankton biovolume will contribute to assessments of water quality.

QUALITY ASSURANCE

Quality assurance of phytoplankton analyses involves estimating the errors associated with sample collection, preservation, enumeration, and species identifications. Several quality assurance investigations and practices were undertaken as part of this project, including:

1) Estimation of variability of sample collection.
2) Estimation of spatial and temporal variability within a given lake.
3) Verification of preservative.
4) Microscope calibration.
5) Determination of acceptable counting intensity.
6) Independent analyses of replicate samples.
7) Independent taxonomic determinations.

This chapter covers the quality assurance necessary for verifying the accuracy of this project's results, but also discusses phytoplankton analyses in detail to provide limnologists with a greater understanding of the errors involved. The objectives of these discussions are to maximize efficiency of phytoplankton sampling programs, to increase the accuracy of phytoplankton analyses, and minimize controllable errors in obtaining phytoplankton results.

Sample Collection

Sample collection errors result from:

1) representation of collected sample (random error),
2) insufficient sampling to represent temporal and spatial changes in phytoplankton populations within a lake, and
3) procedural differences or errors involved in sample collection.

Sample Variability.

The variability associated with sampling a single location within a lake was investigated to determine if samples collected were representative of that site. Two samples were collected from Clear Lake (Lane County) on June 5, 1984 for the purpose of estimating samling, slide preparation, and enumeration errors. Each sample was prepared into two permanent microscope slides, and each slide was counted twice. The total phytoplankton densities (number per mL) were as follows:

Sample 1		Sample 2	
Slide 1	Slide 2	Slide 1	Slide 2
93	100	105	95
83	102	94	112

A nested analysis of variance was calculated for the total algal density (Sokal and Rohlf, 1969). The results indicate that there is no significant difference between samples, slides, or counts.

ANALYSIS OF VARIANCE TABLE
SAMPLES, SLIDES, COUNTS

Source of Variation	df	SS	MS	F_s
Samples	1	98	98.0	1.06
Slides	2	185	92.5	1.44
Counts	4	257	64.2	

Similarity indices were also calculated for all eight estimates of the sample. The similarity indices were averaged for samples, for slides, and for counts. As would be expected, counts on a particular slide were most similar, followed closely by similarity of slides within a sample, and samples were least similar. However, all similarity indices are high and within the same range, indicating all counts are representative of the sampling site in the lake.

Average similarity index of samples = 75.5
Average similarity index of slides = 82.1
Average similarity index of counts = 82.7

Lake Sampling Within Time and Space.

The variability of phytoplankton within time and space is covered in detail in Chapter 3. To reiterate, phytoplankton in a given lake are generally more similar between different stations and different depths than between different dates. That is, the phytoplankton community tends to change fairly often with time, but the changes usually occur throughout the lake at each location. In designing phytoplankton sampling programs, efficiency would be increased if samples were collected on more dates than at more locations within a lake.

Procedural Differences.

Different sampling procedures can result in different phytoplankton estimations. Phytoplankton collected with a plankton net exclude the smaller algae, whereas analyses of whole water samples most often report an abundance of small algae.

Preservation

Although most of the samples analyzed during this project were prepared into permanent microscope slides shortly after the samples were collected, some of the samples were not. These samples were stored for up to three years in bottles with Lugol's preservative.

Four samples that had been prepared into permanent microscope slides shortly after they were collected (1981-1982) were re-filtered after a 2 - 3 year storage period (1984). Comparisons of these sample pairs allow estimates of the effectiveness of the Lugol's preservative over the 2 - 3 year storage period. The results are given in Table 6.1.

Table 6.1. Results of Analyses of Samples to Verify Preservative.

LAKE	YEAR ANALYZED 1981/1982	1984
Big lake 8-29-81		
Total Density (#/mL)	47	36
Chromulina	28	19
Oocystis pusilla	18	15
Sphaerocystis schroeteri	1	1
Munsel Lake 7-20-81		
Total Density (#/mL)	292	240
Rhodomonas minuta	113	108
Cyclotella stelligera	65	50
Anacystis marina	45	36
Cryptomonas erosa	3	22
Chromulina	10	7
Crucigenia tetrapedia	6	5
Ankistrodesmus falcatus	3	5
North Fork Reservoir 9-19-82		
Total Density (#/mL)	314	284
Rhodomonas minuta	101	69
Chlamydomonas	51	45
Cryptomonas erosa	42	33
Melosira granulata	27	24
Dinobryon sertularia	6	21
Asterionella formosa	6	14
Kephyrion spirale	15	14
Suttle Lake 5-25-82		
Total Density (#/mL)	182	233
Asterionella formosa	105	149
Melosira italica	47	56
Fragilaria construens	11	6
Cyclotella comta	-	8
Synedra radians	9	-

The results indicate that the Lugol's preservative is adequate. The minor differences observed are typical of replicate samples, and are not due to a lack of preservation. The samples included soft-bodied microflagellates, colonial blue-green algae, and diatoms; all were preserved intact over the 2 - 3 year storage period.

Preserved samples collected in 1982 were again observed in 1986 with an inverted microscope (Mr. Stan Geiger), and all chloroplasts, flagella, and other cellular structures were still intact after four years of storage. One sample was inadequately preserved, probably due to an insufficient volume of Lugol's solution.

It should be noted that a few samples collected in 1981/1982 were not preserved. These samples fall into two categories: 1) samples were contained in polypropylene bottles, where iodine vapors escape and thus the Lugol's preservative is lost over time, and 2) samples preserved with an insufficient amount of Lugol's solution.

Enumeration

Sources of error during the enumeration portion of phytoplankton analysis include calibration of equipment, magnification utilized, counting intensity (number counted), the ambiguities of counting algae that were dead or alive at the time of collection, and whether cells or colonies are counted.

Calibration.

The formula for the calculation of phytoplankton densities requires accurate measurements of volume of subsample, area filtered, area of field of view on the microscope, and the area of the filter observed. Each contributes some error to the final density estimate.

The microscope used was calibrated with a stage micrometer. All measurements were verified by counting latex spheres of a known concentration (EPA Quality Control sample, EMSL, Cincinnati).

Magnification.

Phycologists' preferences for magnification utilized varies; lower magnification emphasizes larger algae, whereas higher magnification is more likely to include smaller algae. The independent analyses of replicate samples performed as part of this project exhibited some differences due to varying magnifications.

Counting Intensity.

Counting intensity, the number of organisms counted per sample, influences the accuracy of the phytoplankton density estimate. Counting 500 organisms per sample yields a more accurate estimate of phytoplankton than counting 50 organisms. However, counting 500 organisms requires a much greater effort than counting fewer algae.

Two approaches were taken to estimate the accuracy of various counting intensities of a phytoplankton sample.

The first approach was to obtain independent estimates of the phytoplankton density by counting 50, 100, 200, and 300 organisms. Each counting level was independent of the others, that is, different portions of the microscope slide were counted for each estimate. The results are summarized in Table 6.2.

Table 6.2. Phytoplankton Densities at Different Counting Levels.

Parameter	COUNTING LEVEL			
	50	100	200	300
Total per mL	809	759	855	900
Number species	9	10	19	25
Rhodomonas	356	364	355	405
Anabaena	275	258	295	333
Stephanodiscus	49	68	73	24

The sample selected for this test was strongly dominated by two algal species (*Rhodomonas* and *Anabaena* comprise about 80% of the total algae), which is atypical of most phytoplankton samples.

A second approach consisted of counting a more diverse sample in increments of 25 organisms to a total of 400. The counts were not independent; each estimate included the same organisms previous to that estimate plus 25 additional. Sixteen levels in all were obtained. The results are given in Table 6.3.

Table 6.3. Incremental Counts on a Phytoplankton Sample.

# counted	#/mL	# spp	RDMN	SFSR	AKFL	ABXX	CCST	CXER
25	80	6	28.0	24.0	16.0	16.0	4.0	12.0
50	93	7	32.0	22.0	14.0	18.0	6.0	6.0
75	95	16	29.3	22.7	14.7	13.3	6.7	4.0
100	102	19	30.0	22.0	13.0	12.0	7.0	5.0
125	103	19	32.8	20.8	12.8	12.0	7.2	4.0
150	98	20	32.0	18.7	12.7	10.7	8.0	6.0
175	97	21	31.4	18.3	12.6	9.1	9.7	5.1
200	94	22	30.0	19.0	13.5	9.0	10.0	5.0
225	96	23	29.8	18.7	14.2	8.9	9.8	4.9
250	98	24	31.2	18.0	13.2	10.8	8.8	5.2
275	100	26	32.3	17.8	12.7	10.9	8.7	4.7
300	101	27	32.7	18.7	12.0	10.3	8.0	5.0
325	100	28	32.6	18.5	12.3	10.8	7.7	4.6
350	101	28	32.3	19.1	12.3	10.9	7.7	4.6
375	102	28	32.0	19.2	12.0	10.9	7.7	4.3
400	101	30	31.2	19.2	11.7	10.2	8.7	4.5

Numbers listed for species are percent of total density.
See Appendix E for algal species codes.

The results from counting 100 organisms are clearly not significantly different than the results obtained from counting 400 organisms. The total density and each species vary by only a few percent, and much less time and effort is required to count 100 organisms than 400 organisms. The number of species increases with increased counting intensity, but all of these additional species each comprise less than 1% of the total density and are ecologically insignificant.

Viable Algae.

The commonly accepted practice of counting algae that were assumed to be alive at the time of collection (usually determined by the presence of at least a part of a chloroplast within the cell walls) introduces a subjective determination on the part of the analyst. These ambiguous decisions introduce error between phycologists, especially for diatoms which sometimes are present as empty frustules. Some of the discrepancies of the replicate samples analyzed by independent phycologists were caused by counting empty diatom frustules (Crescent Lake).

Algal Units Counted.

Phytoplankton species occur in various forms -- single cells, colonies, and filaments. Although enumeration requires a random distribution of algal species, and only algal entities are randomly distributed, some analysts count algal cells which yield very different densities than counting algal units. There are, however, no ambiguities when estimating phytoplankton biovolume.

Species Identifications

The majority of errors in phytoplankton analysis are due to problems associated with species identifications. Taxonomy, the science of identifying biological organisms, involves grouping related organisms into categories, and assigning a name to organisms with similar characteristics. Organisms possess infinitely variable characteristics, thus the difficulty in identification of a particular taxon.

Algal taxonomy relies largely upon morphometric characteristics, but knowledge of life cycles, physiological/biochemical characteristics, and ecological conditions are often required to delineate some species determinations. Some algae can be identified only with culturing techniques, and others, such as *Anabaena*, require reproductive structures to be present to determine species. Still others, such as *Mallomonas*, require electron microscopy.

Distinguished taxonomists often disagree on species determinations. For example, Drouet (1968) revised the Oscillatoriaceae (blue-green, non-heterocystous algae); he combined many hundreds of species into 25, claiming that most "species" were actually ecotypes (morphological variants due to varying ecological conditions). Drouet has revised other blue-green groups (Drouet, 1973; Drouet and Daily, 1956). Lange-Bertalot (1977) has revised sections of the genus *Nitzschia*, and others have re-classified various groups of algae.

Observed algae often possess characteristics of two or more described species. For example, a diatom may have striae characteristics of one species, but its shape and size may be more like a similarily appearing, but different, species. This is a commonly encountered situation and accounts for the majority of taxonomic discrepancies.

Independent Analyses of Replicate Samples

Replicate phytoplankton samples from ten lakes were independently analyzed by nine phycologists; a total of 42 samples were analyzed (Table 6.4). The results of these quality assurance samples serve to assess the accuracy of algal species identifications and the enumeration of their densities.

Table 6.4. Quality Assurance Samples Analyzed.

LAKE	AQUATIC ANALYSTS	A	B	C	D	E	F	G	H	TOTAL
Clear	1		1			1			1	4
Crescent	1			1					1	3
Davis	1				1		1		1	4
Eel	1		1	1	1		1		1	6
Lost	1					1	1		1	4
Marion	1	1							1	3
Platt	1		1	1					1	4
Suttle	1	1		1	1			1	1	6
Timothy	1		1		1				1	4
Woahink	1				1			1	1	4
TOTAL	10	2	4	4	5	2	3	2	10	42

The results, given in Appendix F, are poorer than expected; species identifications and their densities varied greatly among ALL phycologists. Discrepancies in taxa reported were due to factors (in addition to incorrect identifications) such as different magnifications employed, taxonomic confusions in the literature, and the ambiguity of counting viable (at the time of collection) algae. Errors in density estimates were due to miscalculations and/or miscalibrations, but these errors cannot be assessed from the results of the other phycologists.

Taxonomic differences observed in these 42 sample analyses may be put into four categories:

1) Not recognizing certain algae at all.

2) Disagreement of genera.

3) Disagreement of species, but genera correct.

4) Agreement of species identification.

1) Some phycologists didn't see algae reported by other phycologists. Usually these were small algae, and were not seen by those using low magnification. One phycologist seemed to miss everything.

2) Certain genera are difficult to identify due to their small size and/or lack of distinctive features. These genera are *Rhodomonas*, *Cryptomonas*, *Chroomonas*, *Ochromonas*, *Chromulina*, and *Chrysochromulina* (unaffectionately known as "little round green things"). Round (1981) states that culturing is necessary for the accurate identification of many of these algae.

3) Many species are similarly difficult to identify, but differences are due more to ambiguities of species descriptions rather than lack of distinctive, measurable characteristics. Algae are infinitely variable, and an organism often shares characteristics of two or more described species. Most discrepancies in the replicate analyses fell into this category.

4) Finally, some species possess unique characteristics and may be identified with a high degree of confidence.

Independent Taxonomic Determinations

In 1986, eight samples dominated by "problematic" species were independently analyzed by Mr. Stan Geiger, Scientific Resources, Inc. The algae were identified with a Zeiss inverted microscope, using 1250X magnification. The following problematic algal taxa were discussed between Mr. Geiger and myself:

Anacystis marina

We both agreed on the identity of this alga, with a high degree of confidence.

Ankistrodesmus falcatus

There may have been some errors in some samples in determining the correct identification of this alga. In the eight QA samples, Stan observed *Ankistrodesmus falcatus*, but also some *Quadrigula closterioides*. The two algae are separated mainly on the basis of presence or absence of a gelatinous sheath, but also on the shape of the ends of the cells, its size, and other less distinct characteristics. The sheath of *Quadrigula* can be barely discernible, and other morphometric characteristics overlap and prevent positive identification for some organisms. Overall, we agreed on most of the organisms viewed.

Chromulina sp.

We both agreed on the identification of this genus, but neither of us could identify this alga to species with certainty. Slight doubt remains on the positive identification of the genus.

Cryptomonas erosa

Both of us agreed on the genus identification, but Stan observed 4 to 5 different forms. It could not be determined if these forms were distinct species, or morphological variants of one species. My opinion is that the forms are variants of one species, and my species determination of *C. erosa* is a most probable identification. It may have been more appropriate to report this alga to genus level only.

Gomphosphaeria lacustris

We both agreed on this alga's identity.

Ochromonas sp.

We both agreed on the genus determination, but without a high degree of confidence. This and other microflagellates lack readily observable features that are distinctive, and all microflagellates are difficult to identify with certainty.

Oocystis pusilla

Some confusion remains regarding the positive identification of this species, although there is no doubt the genus has been correctly identified. Agreement of species identification was reached on some of the organisms, but others exhibited shared characteristics of *O. pusilla* and *O. lacustris* (size and interpretation of nodular thickenings).

Rhodomonas minuta

While both agreed on the genus *Rhodomonas*, Stan distinguished 3 different forms within the genus. As with *Cryptomonas*, I am inclined to interpret these forms as morphological variants of one species, and my species determination is a most probable identification.

Sphaerocystis schroeteri

We both agreed on this identification, except in one sample that contained *Dictyosphaerium pulchellum*. This alga is similar to *S. schroeteri* in general appearance, except that cells are connected by mucilaginous strands. Stan observed these strands on a few colonies in the sample, but not on all of them. I did not observe any strands. Our general agreement, however, indicates a fair degree of confidence for this alga's determination.

It should be kept in mind that the above algae are the most problematic taxa within this survey, and the discrepancies discussed were not present in other species within this survey. The majority of species lack ambiguous characteristics, and have been determined with a fairly high degree of certainty.

Quality Assurance Conclusions

Phytoplankton communities vary in a lake with location, depth, and time. In order to accurately estimate the total phytoplankton within a lake, samples must be collected at several locations, at several depths, and at periodic time intervals throughout all seasons.

This report has shown that a single sample collected from a particular site within a lake is representative for that site. That is, there is minimal variability in sampling that site, and also for subsampling that sample for microscope preparation, and counting a portion of that slide. Preservation is not a problem.

Differences in phytoplankton density estimates among the results of the independent analyses were largely due to different magnifications utilized, to incorrectly calibrated microscopes, and to a small degree, taxonomic difficulties.

Counting a minimum of 100 organisms per sample is sufficient to estimate total density and the densities of the common algal species within the sample. Logarithmic increases in counting intensity are required to achieve linear increases in accuracy.

Definite species identifications are often impossible due to the inherent variability in living organisms, and the identifications of many algal species incorporate various degrees of uncertainty. These uncertainties, however, do not invalidate phytoplankton results -- many species are accurately and confidently determined, other species determinations have only minor uncertainities, and the majority of algal genera are identified with high confidence. Certain algae (notably the "microflagellates") cannot be accurately identified even at the genus level by microscopical observations only.

A few differences in the independent quality assurance analyses were due to ambiguities relating to counting algal "units" (cells or colonies of cells), and to counting algae that were viable at the time of collection.

There is a need for some degree of standardization and quality control among phycologists. EPA provides quality control samples (EPA - EMSL, Cincinnati) of latex spheres for microscope calibration, and of phytoplankton for species identifications.

Appendix G. Phytoplankton Records From Idaho Lakes.

LAKE	DATE	REFERENCE	ALGAE
Bear	Apr-28-85	Sweet, 1986	Stephanodiscus astraea minutula, Synedra minuscula, Coscinodi
Black	1983	Hagihara&Beck,85	Melosira, Trachelomonas, Fragilaria, Tabellaria, Nostoc
	Jul, 1985	Kann & Falter,85	Fragilaria, Tabellaria, Asterionella, Melosira
	Aug, 1985	Kann & Falter,85	Nostoc commune
	Sep, 1985	Kann & Falter,85	Melosira, Cyclotella, Nostoc commune, Asterionella
Coccalalla	Apr-21-76	Trial, 1976	Asterionella, Pseudotetraedron, Ochromonas, Cryptomonas
	Jun-15-76	Trial, 1976	Anabaena, Cryptomonas, Phormidium
	Aug-26-76	Trial, 1976	Cyclotella, Chromulina, Fragilaria, Anacystis
	Nov-09-76	Trial, 1976	Melosira, Anabaena, Cryptomonas
Coeur d'Alene	Aug, 1970	Rabe etal, 1973	Melosira, Asterionella, Synedra
	Sep, 1970	Rabe etal, 1973	Tabellaria, Melosira
	Oct, 1970	Rabe etal, 1973	Tabellaria, Melosira, Synedra
	Nov, 1970	Rabe etal, 1973	Tabellaria, Melosira
	Apr-04-75	USEPA, 1977	Melosira, Asterionella, Synedra, Fragilaria, Cryptomonas
	Jul-22-75	USEPA, 1977	Melosira, Aphanizomenon, Fragilaria, Anabaena, Chroomonas
	Sep-09-75	USEPA, 1977	Aphanizomenon, Tabellaria, Cryptomonas, Melosira, Synedra
	May, 1980	Falter & M, 1982	Melosira, Fragilaria
	Aug, 1980	Falter & M, 1982	Tabellaria, Asterionella
	Jun-21-81	Skille etal,1983	Navicula, Anabaena
	Jul-06-81	Skille etal,1983	Asterionella
	Jul-19-81	Skille etal,1983	Nitzschia, Cryptomonas
	Aug-03-81	Skille etal,1983	Anabaena, Cryptomonas
	Aug-17-81	Skille etal,1983	Anabaena, Eudorina
	Sep-30-81	Skille etal,1983	Anabaena, Gloeocystis
	Apr-19-82	Skille etal,1983	Navicula
	May-17-82	Skille etal,1983	Melosira
	May-31-82	Skille etal,1983	Anabaena, Melosira
	Jun-16-82	Skille etal,1983	Anabaena, Navicula, Scenedesmus
	Jun-30-82	Skille etal,1983	Ankistrodesmus, Anabaena
	Jul-12-82	Skille etal,1983	Nitzschia, Ankistrodesmus
	Jul-28-82	Skille etal,1983	Ankistrodesmus, Nitzschia
	Aug-10-82	Skille etal,1983	Asterionella, Eudorina
	Aug-24-82	Skille etal,1983	Asterionella, Scenedesmus
	Oct-05-82	Skille etal,1983	Asterionella, Scenedesmus, Cryptomonas
	Jul-03-85	Sweet, 1986	Asterionella, Cryptomonas, Rhodomonas
Dworshak	Jul-19-72	Falter etal,1975	Anabaena
	Oct-06-72	Falter etal,1975	Mougeotia, Asterionella
	Apr-04-73	Falter etal,1975	Melosira, Fragilaria, Asterionella
	Jun-21-73	Falter etal,1975	Mougeotia, Fragilaria, Asterionella
	Jul-26-73	Falter etal,1975	Anabaena, Fragilaria
	Sep-22-73	Falter etal,1975	Staurastrum, Fragilaria
	May-09-74	Falter etal,1975	Melosira, Fragilaria
	May-22-74	Falter etal,1975	Melosira, Dinobryon
	Jul-23-74	Falter etal,1975	Dinobryon
	Oct-03-74	Falter etal,1975	Aphanizomenon, Anabaena
Hayden	Apr-04-75	USEPA, 1977	Dinobryon, Melosira, Asterionella, Ankistrodesmus, Cyclotella
	Jul-23-75	USEPA, 1977	Dinobryon, Cyclotella, Anabaena, Ankistrodesmus
	Sep-10-75	USEPA, 1977	Stephanodiscus, Chroomonas, Aphanothece

Appendix G. Phytoplankton Records From Idaho Lakes.

LAKE	DATE	REFERENCE	ALGAE
Mann's	Jun, 1980	Falter & Rein.,82	Kybotion, Ankistrodesmus, Nostoc commune
	Jul, 1980	Falter & Rein.,82	Nostoc commune, Navicula, Fragilaria
	Aug, 1980	Falter & Rein.,82	Nostoc commune, Kybotion, Navicula
	Sep, 1980	Falter & Rein.,82	Navicula, Frustulia
	Oct, 1980	Falter & Rein.,82	
Pend Oreille	Nov-15-52	Stross, 1954	Tabellaria fenestrata, Rhizosolenia eriensis
	Nov-27-52	Stross, 1954	Tabellaria fenestrata, Rhizosolenia eriensis
	Feb-02-53	Stross, 1954	Rhizosolenia eriensis
	Mar-08-53	Stross, 1954	Rhizosolenia eriensis
	Apr-04-53	Stross, 1954	Rhizosolenia eriensis
	May-01-53	Stross, 1954	Rhizosolenia eriensis, Asterionella formosa
	Jun-21-53	Stross, 1954	Tabellaria fenestrata, Asterionella formosa, Rhizosolenia
	Jul-09-53	Stross, 1954	Asterionella formosa, Tabellaria fenestrata
	Jul-27-53	Stross, 1954	Asterionella formosa, Tabellaria fenestrata
	Aug-12-53	Stross, 1954	Tabellaria fenestrata
	1976	Reiman, 1976	Melosira, Cyclotella, Fragilaria, Tabellaria, Asterionella
	Jul-02-85	Sweet, 1986	Asterionella, Cyclotella ocellata, Rhodomonas, Stephanodiscus
	Jul-31-85	Sweet, 1986	Cyclotella ocellata, Cryptomonas, Ankistrodesmus
	Aug-21-85	Sweet, 1986	Rhodomonas minuta, Ankistrodesmus, Cryptomonas
Priest	Sep-07-77	Idaho DOE, 1986	Gloeocystis ampla, Anabaena, Asterionella, Melosira
	Oct-17-77	Idaho DOE, 1986	Anabaena, nanoplankton, Ankistrodesmus
	Jun-02-78	Idaho DOE, 1986	Cyclotella, Synedra, Asterionella, Ankistrodesmus
	Oct-03-79	Idaho DOE, 1986	Cyclotella ocellata, Cyclotella bodanica, misc. greens
	Apr-29-80	Idaho DOE, 1986	Cyclotella comta, Melosira distans, Navicula, Cymbella
	Jul-22-85	Sweet, 1986	Cyclotella stelligera, Rhodomonas, Selenastrum
	Aug-21-85	Sweet, 1986	Cyclotella stelligera, Rhodomonas, Cyclotella ocellata
Soldiers Meadow	Jun, 1980	Falter & Rein.,82	Ankyra, Navicula, Synedra
	Jul, 1980	Falter & Rein.,82	Kybotion, Nostoc commune, Ankistrodesmus
	Aug, 1980	Falter & Rein.,82	Calothrix parietina, Nostoc commune, Kybotion
	Sep, 1980	Falter & Rein.,82	Calothrix parietina, Kybotion, Tabellaria
	Oct, 1980	Falter & Rein.,82	Calothrix parietina, Kybotion, Schroederia
Spirit	1985	Soltero, 1985	Peridinium, Anabaena, Ceratium, microplankton, Cryptomonas
	Jul-16-85	Sweet, 1986	Anabaena affinis, Asterionella, Rhodomonas
	Aug-20-85	Sweet, 1986	Anabaena affinis, Chroococcus minimus, Anacystis
Upper Priest	Sep-07-77	Idaho DOE, 1986	Chlorococcus, Ankistrodesmus, Staurastrum, Stephanodiscus
	Oct-17-77	Idaho DOE, 1986	Cyclotella, Anabaena, Melosira, Ankistrodesmus
	Oct-04-79	Idaho DOE, 1986	misc. blue-green, Dinobryon, Cyclotella ocellata, C. bodanica
	Apr-29-80	Idaho DOE, 1986	Stephanodiscus astraea, Navicula, Melosira italica
	Jul-22-85	Sweet, 1986	Cyclotella ocellata, C. stelligera, Rhizosolenia
	Aug-21-85	Sweet, 1986	Cyclotella ocellata, C. stelligera, Rhizosolenia
Waha	Jun, 1980	Falter & Rein.,82	Nostoc commune, Asterionella, Fragilaria, Staurastrum
	Jul, 1980	Falter & Rein.,82	Fragilaria, Ankistrodesmus, Peridinium
	Aug, 1980	Falter & Rein.,82	Nostoc commune, Sphaerocystis, Fragilaria
	Sep, 1980	Falter & Rein.,82	Nostoc commune, Fragilaria, Asterionella
	Oct, 1980	Falter & Rein.,82	Fragilaria, Asterionella, Kybotion
Winchester	Jul-17-85	Sweet, 1986	Staurastrum pinque, Oocystis lacustris, Anabaena circinalis

LAKE	DATE	REFERENCE	ALGAE
	Aug-01-85	Sweet, 1986	Anabaena circinalis, Cryptomonas erosa, Oocystis lacustris
	Aug-15-85	Sweet, 1986	Anabaena circinalis, Cryptomonas erosa, Aphanizomenon
	Oct-09-85	Sweet, 1986	Rhodomonas minuta, Cryptomonas ovata, Microcystis

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 257

SAMPLE DATE: 85-07-02

TOTAL DENSITY (#/ml): 512

TOTAL BIOVOLUME (cu.uM/ml): 331642

DIVERSITY INDEX: 3.61 Shannon-Weaver (log base 2)
(-sum species % i)(log % species i)

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Asterionella formosa	127	24.8	42644	12.9
2	Cyclotella ocellata	109	21.2	14668	4.4
3	Rhodomonas minuta	50	9.7	996	0.3
4	Cryptomonas erosa	41	8.0	21187	6.4
5	Diatoma tenue elongatum	23	4.4	16297	4.9
6	Stephanodiscus astraea minutula	18	3.5	6338	1.9
7	Cyclotella meneghiniana	18	3.5	6881	2.1
8	Cyclotella kutzingiana	18	3.5	2082	0.6
9	Stephanodiscus hantzschii	14	2.7	1630	0.5
10	Synedra radians	14	2.7	4889	1.5
11	Oocystis pusilla	9	1.8	3599	1.1
12	Synedra delicatissima	9	1.8	5976	1.8
13	Stephanodiscus astraea	9	1.8	72813	22.0
14	Pediastrum duplex	5	0.9	1811	0.5
15	Melosira italica	5	0.9	4264	1.3
16	Nitzschia sp.	5	0.9	543	0.2
17	Tabellaria fenestrata	5	0.9	43460	13.1
18	Fragilaria crotonensis	5	0.9	34225	10.3
19	Fragilaria construens	5	0.9	507	0.2
20	Achnanthes minutissima	5	0.9	226	0.1
21	Ankistrodesmus falcatus	5	0.9	113	0.0
22	Ceratium hirundinella	5	0.9	44365	13.4
23	Navicula sp.	5	0.9	679	0.2
24	Scenedesmus sp.	5	0.9	905	0.3
25	Dinobryon sertularia	5	0.9	543	0.2

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille , Sta 258

SAMPLE DATE: 85-07-02

TOTAL DENSITY (#/ml): 1598

TOTAL BIOVOLUME (cu.uM/ml): 452780

DIVERSITY INDEX: 3.05

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Stephanodiscus hantzschii	741	46.3	88867	19.6
2	Cyclotella ocellata	189	11.8	25484	5.6
3	Rhodomonas minuta	131	8.2	2614	0.6
4	Synedra radians	87	5.5	31365	6.9
5	Asterionella formosa	73	4.5	36186	8.0
6	Stephanodiscus astraea minutula	58	3.6	20329	4.5
7	Cryptomonas erosa	44	2.7	22652	5.0
8	Chroomonas sp.	44	2.7	2832	0.6
9	Melosira granulata angustissima	15	0.9	14521	3.2
10	Diatoma tenue elongatum	15	0.9	10455	2.3
11	Cymbella affinis	15	0.9	60769	13.4
12	Achnanthes lanceolata	15	0.9	2614	0.6
13	Achnanthes sp.	15	0.9	1742	0.4
14	Ankistrodesmus falcatus	15	0.9	363	0.1
15	Diatoma vulgare	15	0.9	28461	6.3
16	Fragilaria vaucheria	15	0.9	4182	0.9
17	Fragilaria construens venter	15	0.9	720	0.2
18	Achnanthes linearis	15	0.9	1917	0.4
19	Dinobryon sp.	15	0.9	1815	0.4
20	Synedra delicatissima	15	0.9	9584	2.1
21	Tabellaria fenestrata	15	0.9	69700	15.4
22	Cyclotella kutzingiana	15	0.9	1670	0.4
23	Cyclotella meneghiniana	15	0.9	5518	1.2
24	Oocystis lacustris	15	0.9	8422	1.9

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 259

SAMPLE DATE: 85-07-02

TOTAL DENSITY (#/ml): 783

TOTAL BIOVOLUME (cu.uM/ml): 322159

DIVERSITY INDEX: 3.64

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella ocellata	196	25.0	26414	8.2
2	Asterionella formosa	150	19.2	48863	15.2
3	Rhodomonas minuta	72	9.2	1435	0.4
4	Stephanodiscus hantzschii	52	6.7	6261	1.9
5	Rhizosolenia eriensis	46	5.8	9368	2.9
6	Cyclotella kutzingiana	39	5.0	4500	1.4
7	Diatoma tenue elongatum	26	3.3	18783	5.8
8	Synedra radians	26	3.3	9392	2.9
9	Synedra delicatissima	26	3.3	17218	5.3
10	Cryptomonas erosa	26	3.3	13566	4.2
11	Tabellaria fenestrata	13	1.7	31306	9.7
12	Nitzschia dissipata	13	1.7	3509	1.1
13	Cyclotella meneghiniana	13	1.7	4957	1.5
14	Stephanodiscus astraea minutula	13	1.7	4565	1.4
15	Ankistrodesmus falcatus	13	1.7	326	0.1
16	Dinobryon sertularia	13	1.7	1565	0.5
17	Nitzschia acicularis	7	0.8	1826	0.6
18	Melosira italica	7	0.8	43006	13.3
19	Fragilaria crotonensis	7	0.8	71221	22.1
20	Scenedesmus quadricauda	7	0.8	1272	0.4
21	Nitzschia frustulum	7	0.8	783	0.2
22	Diploneis puella	7	0.8	1696	0.5
23	Achnanthes minutissima	7	0.8	326	0.1

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 260

SAMPLE DATE: 85-07-02

TOTAL DENSITY (#/ml): 636

TOTAL BIOVOLUME (cu.uM/ml): 219711

DIVERSITY INDEX: 3.95

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Asterionella formosa	134	21.1	42487	19.3
2	Cyclotella ocellata	93	14.7	12593	5.7
3	Rhizosolenia eriensis	76	11.9	13643	6.2
4	Stephanodiscus hantzschii	52	8.3	6297	2.9
5	Diatoma tenue elongatum	29	4.6	20989	9.6
6	Stephanodiscus astraea minutula	29	4.6	10203	4.6
7	Cryptomonas erosa	23	3.7	12127	5.5
8	Cyclotella kutzingiana	23	3.7	2682	1.2
9	Fragilaria construens	23	3.7	3918	1.8
10	Anabaena sp.	17	2.8	17491	8.0
11	Synedra radians	17	2.8	6297	2.9
12	Fragilaria pinnata	12	1.8	700	0.3
13	Nitzschia paleacea	12	1.8	1714	0.8
14	Navicula minima	12	1.8	513	0.2
15	Nitzschia sp.	6	0.9	700	0.3
16	Stephanodiscus astraea	6	0.9	46887	21.3
17	Navicula capitata	6	0.9	2799	1.3
18	Cocconeis placentula	6	0.9	2682	1.2
19	Nitzschia sp.	6	0.9	1399	0.6
20	Cymbella minuta	6	0.9	2157	1.0
21	Achnanthes clevei	6	0.9	875	0.4
22	Navicula reinhartii	6	0.9	3032	1.4
23	Fragilaria construens venter	6	0.9	1119	0.5
24	Navicula scutiformis	6	0.9	1632	0.7
25	Cyclotella meneghiniana	6	0.9	2216	1.0
26	Dinobryon sertularia	6	0.9	700	0.3
27	Achnanthes minutissima	6	0.9	292	0.1
28	Nitzschia dissipata	6	0.9	1568	0.7

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 261

SAMPLE DATE: 85-07-02

TOTAL DENSITY (#/ml): 469

TOTAL BIOVOLUME (cu.uM/ml): 300831

DIVERSITY INDEX: 3.68

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Asterionella formosa	141	30.1	50184	16.7
2	Cyclotella ocellata	57	12.2	7715	2.6
3	Diatoma tenue elongatum	46	9.8	32918	10.9
4	Synedra radians	42	8.9	15087	5.0
5	Stephanodiscus hantzschii	19	4.1	2286	0.8
6	Cyclotella kutzingiana	19	4.1	2191	0.7
7	Rhodomonas minuta	15	3.3	305	0.1
8	Rhizosolenia eriensis	15	3.3	4115	1.4
9	Cryptomonas erosa	15	3.3	7925	2.6
10	Dinobryon sertularia	11	2.4	1372	0.5
11	Melosira italica	11	2.4	39514	13.1
12	Stephanodiscus astraea	11	2.4	91918	30.6
13	Nitzschia paleacea	8	1.6	747	0.2
14	Synedra rumpens	8	1.6	2857	0.9
15	Nitzschia acicularis	8	1.6	2134	0.7
16	Cyclotella sp.	8	1.6	648	0.2
17	Melosira sp.	4	0.8	3810	1.3
18	Chroomonas sp.	4	0.8	248	0.1
19	Stephanodiscus astraea minutula	4	0.8	1333	0.4
20	Fragilaria crotonensis	4	0.8	9601	3.2
21	Synedra ulna	4	0.8	7582	2.5
22	Cyclotella meneghiniana	4	0.8	1448	0.5
23	Synedra delicatissima	4	0.8	2515	0.8
24	Melosira granulata angustissima	4	0.8	4762	1.6
25	Oscillatoria sp.	4	0.8	7620	2.5

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 257

SAMPLE DATE: 85-07-31

TOTAL DENSITY (#/ml): 50

TOTAL BIOVOLUME (cu.uM/ml): 56707

DIVERSITY INDEX: 3.83

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella ocellata	8.8	17.8	1194	2.1
2	Cryptomonas erosa	7.4	15.0	3874	6.8
3	Fragilaria crotonensis	5.6	11.2	24638	43.4
4	Ankistrodesmus falcatus	4.2	8.4	163	0.3
5	Synedra radians	3.7	7.5	1341	2.4
6	Cyclotella comta	2.8	5.6	6341	11.2
7	Synedra delicatissima	2.3	4.7	1536	2.7
8	Asterionella formosa	2.3	4.7	414	0.7
9	Melosira italica	1.9	3.7	3070	5.4
10	Nitzschia acicularis	1.4	2.8	391	0.7
11	Tabellaria fenestrata	1.4	2.8	4458	7.9
12	Oocystis pusilla	1.4	2.8	370	0.7
13	Rhodomonas minuta	1.4	2.8	28	0.0
14	Fragilaria construens	0.9	1.9	156	0.3
15	Melosira granulata angustissima	0.9	1.9	466	0.8
16	Stephanodiscus astraea	0.9	1.9	7488	13.2
17	Oscillatoria sp.	0.5	0.9	466	0.8
18	Stephanodiscus astraea minutula	0.5	0.9	163	0.3
19	Stephanodiscus hantzschii	0.5	0.9	56	0.1
20	Fragilaria construens venter	0.5	0.9	22	0.0
21	Achnanthes clevei	0.5	0.9	70	0.1

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 258

SAMPLE DATE: 85-07-31

TOTAL DENSITY (#/ml): 87

TOTAL BIOVOLUME (cu.uM/ml): 43132

DIVERSITY INDEX: 3.58

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella ocellata	24.8	28.6	3348	7.8
2	Cryptomonas erosa	14.7	17.0	7657	17.8
3	Ankistrodesmus falcatus	13.2	15.2	484	1.1
4	Synedra radians	4.7	5.4	1674	3.9
5	Rhodomonas minuta	3.9	4.5	78	0.2
6	Tabellaria fenestrata	2.3	2.7	7422	17.2
7	Melosira granulata	2.3	2.7	6816	15.8
8	Melosira italica	2.3	2.7	3658	8.5
9	Melosira granulata angustissima	1.6	1.8	1163	2.7
10	Oocystis pusilla	1.6	1.8	411	1.0
11	Scenedesmus quadricauda	1.6	1.8	302	0.7
12	Synedra ulna	1.6	1.8	3085	7.2
13	Ochromonas sp.	1.6	1.8	132	0.3
14	Fragilaria construens venter	0.8	0.9	37	0.1
15	Cyclotella kutzingiana	0.8	0.9	89	0.2
16	misc. desmid	0.8	0.9	128	0.3
17	Aphanizomenon flos-aquae	0.8	0.9	465	1.1
18	Nitzschia sp.	0.8	0.9	93	0.2
19	Fragilaria pinnata	0.8	0.9	47	0.1
20	Amphora perpusilla	0.8	0.9	129	0.3
21	Nitzschia dissipata	0.8	0.9	208	0.5
22	Fragilaria crotonensis	0.8	0.9	3906	9.1
23	Cocconeis pediculus	0.8	0.9	403	0.9
24	Chroomonas sp.	0.8	0.9	50	0.1
25	Anabaena flos-aquae	0.8	0.9	775	1.8
26	Sphaerocystis schroeteri	0.8	0.9	403	0.9
27	Caloneis hyalina	0.8	0.9	171	0.4

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 259

SAMPLE DATE: 85-07-31

TOTAL DENSITY (#/ml): 89

TOTAL BIOVOLUME (cu.uM/ml): 29389

DIVERSITY INDEX: 4.07

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella ocellata	23.1	26.0	3116	10.6
2	Rhodomonas minuta	11.5	13.0	231	0.8
3	Synedra radians	8.0	9.0	2876	9.8
4	Ankistrodesmus falcatus	6.2	7.0	177	0.6
5	Cryptomonas erosa	5.3	6.0	2769	9.4
6	Fragilaria crotonensis	2.7	3.0	5212	17.7
7	Ochromonas sp.	2.7	3.0	226	0.8
8	Melosira granulata	1.8	2.0	1953	6.6
9	Cyclotella kutzingiana	1.8	2.0	204	0.7
10	Melosira granulata angustissima	1.8	2.0	1997	6.8
11	Stephanodiscus hantzschii	1.8	2.0	213	0.7
12	Melosira italica	1.8	2.0	2509	8.5
13	Amphora ovalis	1.8	2.0	1026	3.5
14	Asterionella formosa	1.8	2.0	474	1.6
15	Kephyrion sp.	0.9	1.0	56	0.2
16	Dinobryon bavaricum	0.9	1.0	107	0.4
17	Dinobryon sertularia	0.9	1.0	107	0.4
18	Synedra delicatissima	0.9	1.0	586	2.0
19	Nitzschia sp.	0.9	1.0	107	0.4
20	Navicula graciloides	0.9	1.0	386	1.3
21	Cyclotella comta	0.9	1.0	2015	6.9
22	Achnanthes minutissima	0.9	1.0	44	0.2
23	Aphanizomenon flos-aquae	0.9	1.0	533	1.8
24	misc. desmid	0.9	1.0	146	0.5
25	Achnanthes linearis	0.9	1.0	117	0.4
26	Nitzschia frustulum	0.9	1.0	107	0.4
27	Chlamydomonas sp.	0.9	1.0	288	1.0
28	Oscillatoria sp.	0.9	1.0	888	3.0
29	Scenedesmus quadricauda	0.9	1.0	173	0.6
30	Melosira distans	0.9	1.0	352	1.2
31	Oocystis pusilla	0.9	1.0	235	0.8
32	Fragilaria pinnata	0.9	1.0	53	0.2
33	Nitzschia sp.	0.9	1.0	107	0.4

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 260

SAMPLE DATE: 85-07-31

TOTAL DENSITY (#/ml): 180

TOTAL BIOVOLUME (cu.uM/ml): 58343

DIVERSITY INDEX: 4.51

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Fragilaria construens	24	13.1	7947	13.6
2	Fragilaria pinnata	20	11.1	1201	2.1
3	Fragilaria construens venter	16	9.1	3057	5.2
4	Cocconeis disculus	15	8.1	1092	1.9
5	Achnanthes pinnata	13	7.1	828	1.4
6	Achnanthes clevei	7	4.0	1092	1.9
7	Fragilaria leptostauron	7	4.0	1674	2.9
8	Cyclotella ocellata	7	4.0	982	1.7
9	Achnanthes lanceolata	5	3.0	982	1.7
10	Navicula pupula	5	3.0	1474	2.5
11	Ankistrodesmus falcatus	5	3.0	181	0.3
12	Navicula scutiformis	5	3.0	1528	2.6
13	Navicula minima	4	2.0	160	0.3
14	Synedra radians	4	2.0	1310	2.2
15	Cocconeis placentula	4	2.0	1674	2.9
16	Anabaena flos-aquae	4	2.0	3639	6.2
17	Navicula reinhartii	2	1.0	946	1.6
18	Gomphonema subclavatum	2	1.0	1092	1.9
19	Anabaena circinalis	2	1.0	4367	7.5
20	Amphora perpusilla	2	1.0	302	0.5
21	Navicula sp.	2	1.0	273	0.5
22	Achnanthes sp.	2	1.0	218	0.4
23	Nitzschia paleacea	2	1.0	178	0.3
24	Asterionella formosa	2	1.0	1295	2.2
25	Kephyrion sp.	2	1.0	115	0.2
26	Navicula cryptocephala veneta	2	1.0	173	0.3
27	Caloneis hyalina	2	1.0	400	0.7
28	Navicula sp.	2	1.0	273	0.5
29	Achnanthes peragalli	2	1.0	255	0.4
30	Misc. pennate diatom	2	1.0	318	0.5
31	Cymbella cymbiformes	2	1.0	17506	30.0
32	Achnanthes exigua	2	1.0	204	0.3
33	Amphora ovalis	2	1.0	1052	1.8
34	Navicula cryptocephala	2	1.0	337	0.6
35	Nitzschia sp.	2	1.0	218	0.4

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 261

SAMPLE DATE: 85-07-31

TOTAL DENSITY (#/ml): 62

TOTAL BIOVOLUME (cu.uM/ml): 34373

DIVERSITY INDEX: 3.64

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Asterionella formosa	14.1	22.9	3928	11.4
2	Cyclotella ocellata	13.0	21.1	1757	5.1
3	Ankistrodesmus falcatus	6.8	11.0	424	1.2
4	Synedra radians	5.1	8.3	1833	5.3
5	Melosira italica	3.4	5.5	7452	21.7
6	Fragilaria construens	2.3	3.7	1521	4.4
7	Fragilaria crotonensis	2.3	3.7	6179	18.0
8	Cyclotella comta	1.7	2.8	3854	11.2
9	Synedra delicatissima	1.7	2.8	1490	4.3
10	Oocystis pusilla	1.1	1.8	300	0.9
11	Anabaena flos-aquae	1.1	1.8	1132	3.3
12	Stephanodiscus astraea minutula	1.1	1.8	396	1.2
13	Synedra ulna	1.1	1.8	2252	6.6
14	Aphanizomenon flos-aquae	0.6	0.9	340	1.0
15	Navicula minima	0.6	0.9	25	0.1
16	Nitzschia frustulum	0.6	0.9	68	0.2
17	Amphora perpusilla	0.6	0.9	94	0.3
18	Achnanthes sp.	0.6	0.9	68	0.2
19	Cocconeis disculus	0.6	0.9	42	0.1
20	Fragilaria pinnata	0.6	0.9	34	0.1
21	Cymbella cesatii	0.6	0.9	105	0.3
22	Melosira granulata angustissima	0.6	0.9	424	1.2
23	Nitzschia dissipata	0.6	0.9	152	0.4
24	misc. desmid	0.6	0.9	93	0.3
25	Diatoma tenue elongatum	0.6	0.9	407	1.2

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 257

SAMPLE DATE: 85-08-13

TOTAL DENSITY (#/ml): 103

TOTAL BIOVOLUME (cu.uM/ml): 37125

DIVERSITY INDEX: 2.45

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Rhodomonas minuta	60	58.2	1198	3.2
2	Cyclotella ocellata	10	10.0	1390	3.7
3	Cyclotella comta	7	6.4	14877	40.1
4	Cryptomonas erosa	5	4.5	2434	6.6
5	Ankistrodesmus falcatus	5	4.5	211	0.6
6	Synedra radians	4	3.6	1348	3.6
7	Anabaena flos-aquae	2	1.8	1873	5.0
8	Scenedesmus quadricauda	2	1.8	365	1.0
9	Oocystis pusilla	1	0.9	248	0.7
10	Cyclotella sp.	1	0.9	80	0.2
11	Sphaerocystis schroeteri	1	0.9	487	1.3
12	Oscillatoria sp.	1	0.9	936	2.5
13	Hantzschia amphioxys	1	0.9	192	0.5
14	Fragilaria vaucheria	1	0.9	270	0.7
15	Fragilaria crotonensis	1	0.9	7865	21.2
16	Melosira italica	1	0.9	2646	7.1
17	Elakatothrix gelatinosa	1	0.9	39	0.1
18	Asterionella formosa	1	0.9	667	1.8

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 258

SAMPLE DATE: 85-08-13

TOTAL DENSITY (#/ml): 90

TOTAL BIOVOLUME (cu.uM/ml): 26867

DIVERSITY INDEX: 2.55

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Rhodomonas minuta	48.3	53.6	965	3.6
2	Ankistrodesmus falcatus	9.7	10.7	321	1.2
3	Cyclotella ocellata	8.8	9.8	1194	4.4
4	Cryptomonas erosa	4.8	5.4	2509	9.3
5	Cyclotella comta	3.2	3.6	7302	27.2
6	Chroomonas sp.	2.4	2.7	157	0.6
7	Fragilaria crotonensis	2.4	2.7	5411	20.1
8	Ochromonas sp.	2.4	2.7	205	0.8
9	Melosira italica	1.6	1.8	5303	19.7
10	Synedra delicatissima	1.6	1.8	1062	4.0
11	Sphaerocystis schroeteri	0.8	0.9	418	1.6
12	Asterionella formosa	0.8	0.9	573	2.1
13	Fragilaria sp.	0.8	0.9	161	0.6
14	Oocystis pusilla	0.8	0.9	213	0.8
15	Anabaena sp.	0.8	0.9	804	3.0
16	Fragilaria construens	0.8	0.9	270	1.0

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 259

SAMPLE DATE: 85-08-13

TOTAL DENSITY (#/ml): 142

TOTAL BIOVOLUME (cu.uM/ml): 49010

DIVERSITY INDEX: 2.74

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Rhodomonas minuta	66	46.8	1326	2.7
2	Cryptomonas erosa	26	18.3	13520	27.6
3	Ankistrodesmus falcatus	10	7.3	325	0.7
4	Cyclotella ocellata	8	5.5	1053	2.1
5	Oocystis lacustris	7	4.6	3770	7.7
6	Cyclotella comta	5	3.7	11804	24.1
7	Fragilaria construens	3	1.8	437	0.9
8	Melosira granulata angustissima	3	1.8	2600	5.3
9	Synedra radians	1	0.9	468	1.0
10	Fragilaria crotonensis	1	0.9	2184	4.5
11	Tabellaria fenestrata	1	0.9	3120	6.4
12	Sphaerocystis schroeteri	1	0.9	676	1.4
13	Melosira granulata	1	0.9	2860	5.8
14	Melosira italica	1	0.9	3674	7.5
15	Synedra delicatissima	1	0.9	858	1.8
16	Crucigenia quadrata	1	0.9	110	0.2
17	Chroomonas sp.	1	0.9	85	0.2
18	Fragilaria pinnata	1	0.9	78	0.2
19	Fragilaria construens venter	1	0.9	62	0.1

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 260

SAMPLE DATE: 85-08-13

TOTAL DENSITY (#/ml): 108

TOTAL BIOVOLUME (cu.uM/ml): 31065

DIVERSITY INDEX: 3.83

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Rhodomonas minuta	41	37.9	817	2.6
2	Fragilaria construens venter	7	6.8	1055	3.4
3	Cryptomonas erosa	6	5.8	3267	10.5
4	Chroomonas sp.	5	4.9	340	1.1
5	Ankistrodesmus falcatus	5	4.9	288	0.9
6	Fragilaria pinnata	4	3.9	251	0.8
7	Cocconeis disculus	4	3.9	314	1.0
8	Achnanthes minutissima	2	1.9	105	0.3
9	Fragilaria construens	2	1.9	352	1.1
10	Navicula pupula	2	1.9	565	1.8
11	Cyclotella ocellata	2	1.9	283	0.9
12	Cyclotella comta	2	1.9	4754	15.3
13	Achnanthes sp.	2	1.9	251	0.8
14	Navicula minima	2	1.9	92	0.3
15	Synedra ulna	1	1.0	2084	6.7
16	Navicula sp.	1	1.0	157	0.5
17	Melosira distans	1	1.0	415	1.3
18	Achnanthes lanceolata	1	1.0	188	0.6
19	Navicula anglica	1	1.0	377	1.2
20	Navicula sp.	1	1.0	157	0.5
21	Melosira granulata angustissima	1	1.0	785	2.5
22	Achnanthes clevei	1	1.0	157	0.5
23	Chroococcus dispersus	1	1.0	23	0.1
24	Asterionella formosa	1	1.0	373	1.2
25	Nitzschia linearis	1	1.0	1596	5.1
26	Fragilaria crotonensis	1	1.0	10555	34.0
27	Synedra radians	1	1.0	377	1.2
28	Nitzschia paleacea	1	1.0	103	0.3
29	Navicula mournei	1	1.0	246	0.8
30	Cymbella minuta	1	1.0	387	1.2
31	Navicula cascadensis	1	1.0	63	0.2
32	Achnanthes hungarica	1	1.0	162	0.5
33	Nitzschia frustulum	1	1.0	126	0.4

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, Sta 261

SAMPLE DATE: 85-08-13

TOTAL DENSITY (#/ml): 140

TOTAL BIOVOLUME (cu.uM/ml): 44565

DIVERSITY INDEX: 2.22

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Rhodomonas minuta	84	60.0	1675	3.8
2	Ankistrodesmus falcatus	13	9.5	565	1.3
3	Cryptomonas erosa	12	8.6	6221	14.0
4	Cyclotella comta	11	7.6	24138	54.2
5	Cyclotella ocellata	5	3.8	718	1.6
6	Oocystis lacustris	3	1.9	1542	3.5
7	Sphaerocystis schroeteri	1	1.0	691	1.6
8	Nitzschia paleacea	1	1.0	130	0.3
9	Crucigenia quadrata	1	1.0	452	1.0
10	Chroococcus dispersus	1	1.0	29	0.1
11	Ochromonas sp.	1	1.0	113	0.3
12	Fragilaria construens	1	1.0	2531	5.7
13	Asterionella formosa	1	1.0	1893	4.2
14	Melosira italica	1	1.0	3756	8.4
15	Elakatothrix gelatinosa	1	1.0	112	0.3

APPENDIX 10B

Phytoplankton Analysis Results - 1986

APPENDIX 10B. 1986 Phytoplankton Analysis Results

PHYTOPLANKTON OF SELECTED NORTHWEST LAKES AND RIVERS

Final Report Prepared for:

Environmental Protection Agency
1200 SW Sixth Ave.
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Dave Terpening, Project Officer

Prepared by:

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AQUATIC ANALYSTS
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June, 1987

CONTENTS

INTRODUCTION

Aquatic Analysts was contracted by the Environmental Protection Agency to analyze 228 phytoplankton samples collected from existing projects in Oregon, Idaho, and Washington, and to summarize the environmental conditions associated with the common phytoplankton species.

This contract is the third in a series of similar contracts, with 120 samples analyzed in 1985 and 130 samples in 1986. Phytoplankton and associated environmental data for 1985 and 1986, as well as a literature search of all Northwest phytoplankton records, are included in a previous report (Sweet, 1986).

The projects from which these samples were collected include Lake Chelan in Washington, Pend Oreille, Priest, Coeur d'Alene, Hayden, and Spirit Lakes in Northern Idaho, and in Oregon, projects in the Tualatin and Yamhill River Basins, a survey of Cascade Lakes, and a statewide survey of major Oregon lakes.

For the purpose of determining environmental conditions associated with common Northwest phytoplankton species, a database consisting of phytoplankton, total phosphorus, chlorophyll, Secchi depth, pH, temperature, and conductivity data was compiled from these three yearly projects. A few other projects' data were added to this database (Sweet, 1983; Raymond etal., 1985); these additional projects contain quality controlled data similar to the projects covered under the EPA contracts.

Replicates and redundant samples (samples collected at different sites within a given lake on a given date) were eliminated from this compiled database to lessen biases towards those lakes sampled more intensively. Further, the database was split into two parts for lakes and flowing waters due to different ecological processes in lakes or rivers (eg, oligotrophic rivers may have a higher phosphorus concentration than eutrophic lakes). A total of 332 samples (262 from lakes; 70 from rivers) are included in this database.

The abundance of phytoplankton in lakes is of primary concern in most lake studies, and are typically estimated by algal densities, algal biovolumes, chlorophyll concentrations, water transparency (Secchi depth), and less directly by total phosphorus concentrations. Carlson (1977) has described the relationship between chlorophyll, Secchi depth, and phosphorus; his trophic state indices are well known and widely used. This report includes a trophic state index based upon phytoplankton biovolume, similarly scaled as Carlson's indices.

Ecological profiles for each common phytoplankton species are included in this report. These profiles are based largely upon averages of associated environmental conditions; each average is weighted by the relative species abundance to emphasize those conditions associated with dominant algae. Average trophic state indices (biovolume, chlorophyll, Secchi, and phosphorus) have been calculated for each common algal species. Kéy taxonomic characteristics and notes on the species' distribution are also included in the profiles.

Acknowledgements

Appreciation is expressed to Mr. Dave Terpening (EPA, Contract Officer) for his assistance and administration of this project, and to Mr. Andy Schaedel (Oregon Department of Environmental Quality), Mr. Mike Beckwith (Idaho Division of Environment), and Mr. Clay Patmont (Harper Owes, Seattle) for their contributions of phytoplankton samples and associated environmental data.

METHODS

Sample Collection, Preservation, and Preparation

All phytoplankton samples consisted of whole water samples, preserved with 1% Lugols solution. Most lakes and all flowing water samples were grab samples from the surface; a few lake samples were euphotic zone composites. Associated environmental data for each phytoplankton sample were obtained using similar sampling techniques.

Permanent microscope slides were prepared from each sample by filtering an appropriate aliquot of the sample through a 0.45 micrometer membrane filter (McNabb, 1960). A section was cut out and placed on a glass slide with immersion oil added to make the filter transparent, followed by placing a cover slip on top, with nail polish applied to the periphery for permanency.

Enumeration

Algal units (defined as discrete particles - either cells, colonies, or filaments) were counted along a measured transect of the microscope slide with a Zeiss standard microscope (1000X, phase contrast). Only those algae that were believed to be alive at the time of collection (intact chloroplast) were counted. A minimum of 100 algal units were counted for each sample.

Biovolume Estimates

Average biovolume estimates of each species were obtained from calculations of microscopic measurements of each alga. The number of cells per colony, or the length of a filament, were recorded during sample analysis to arrive at biovolume per unit-alga. Measurements were generally taken on each alga only in a few samples, unless that alga exhibited a wide size range requiring more frequent measurements.

Similarity Indices

A similarity index (SI) was used to compare phytoplankton samples based upon their species compositions. The index compares the relative abundances of each species present in two samples and yields a value ranging from 0 for totally dissimilar samples to 100 for identical samples. The formula for the index (modified from Whittaker, 1967) is:

Similarity Index = 100 - (SUM of DIFFERENCE / 2)

Where DIFFERENCE is the absolute value of the difference of the percent of a given species in two samples.

IDAHO - NORTHERN LAKES

A total of 73 phytoplankton samples were collected during 1986 from Pend Oreille, Priest, Hayden, Coeur d'Alene, and Spirit Lakes in Northern Idaho. Lake Coeur d'Alene was sampled at six stations in mid-August, and the other lakes were sampled, each at several stations, in April, June, July/August, and September.

Phytoplankton Species Observed

A total of 176 algal species were identified from these Idaho lakes. Dominant phytoplankton species include *Cyclotella stelligera*, *Cyclotella ocellata*, *Rhodomonas minuta*, *Stephanodiscus häntzschii*, *Synedra radians*, *Synedra rumpens*, and *Asterionella formosa*. Except for *Rhodomonas minuta*, these are all diatoms.

Table 10 summarizes the dominant phytoplankton species observed in each of these lakes, and Table 11 provides a more detailed distribution of common species by month for each lake.

Table 10. Dominant Phytoplankton Species in Northern Idaho Lakes, 1986.

Lake	April	June	July	August	September
Pend Oreille	STHN	RDMN	-	CCST	RDMN
Priest	SNRM	CCST	CCOC	-	CCST
Hayden	CCST	SNRD	SNRD	-	SNRD
Spirit	ASFO	ASFO	AEXX	-	ABXX
C. d'Alene	-	-	-	ASFO	-

See Appendix F for species codes.

Table 11. Common Phytoplankton Species in Idaho Lakes. (All Stations Averaged).

Species	C d'A	Hayden	Pend Or	Priest	Spirit
(months)	8	467 9	46 89	467 9	467 9
STHN	.	... .	4. ..	... .	... .
STAM	.	... .	46 ..	... .	... .
RDMN	8	.67 9	46 .9	4.. 9	46. 9
CCST	.	4.7 9	.. 89	.67 9	... .
CCOC	.	... .	.6 89	467 9	... .
CYRF	.	... .	4. ..	... .	... .
NZAC	.	... .	4. ..	... .	... .
CXER	8	.67 9	4. ..	... .	... .
ABFA	.	... .	.. 8.	... .	... .
CODS	.	... .	.. .9	... .	... .
SNRM	.	.6. .	.. ..	4.. .	... .
RZER	.	... .	.. ..	.6. 9	... .
DBBV	.	... .	.. ..	.6. .	4.. .
SNRD	.	467 9	.. ..	4.. .	... .
MLIT	.	... .	.. ..	4.. .	... .
ASFO	8	4.. .	.. ..	... .	467 .
ABCR	.	..7 .	.. ..	... .	... .
SFSR	8	... .	.. ..	... .	... .
AEXX	.	... .	.. ..	... .	..7 .
GLXX	8	... .	.. ..	... .	..7 .
ABXX	.	... .	.. ..	... .	... 9
AKFL	.	... .	.. ..	... 9	... .

Numbers in table refer to month when species were common (April, June, July, August, or September).
Periods indicate species not common during that month.
See Appendix F for species codes.

Table 11 is somewhat confusing to interpret because it contains much information. It lists the presence of all common species (first three most abundant species) in each Northern Idaho lake for each month.

This table shows that Rhodomonas minuta is common in all lakes at one time or another. Cyclotella stelligera and Cyclotella ocellata are abundant in Pend Oreille and Priest Lakes; Hayden contained Cyclotella stelligera but not Cyclotella ocellata. Two species of Stephanodiscus are common only in Lake Pend Oreille, and Synedra radians is most common in Hayden Lake.

Phytoplankton Abundances

Table 12 summarizes the phytoplankton densities observed in the Northern Idaho lakes; values refer to averages of all stations.

Table 12. Average Phytoplankton Densities within Northern Idaho Lakes, 1986.

Lake	April	June	July	August	September
Pend Oreille	683	806	-	155	147
Priest	432	2,199	502	-	160
Hayden	542	498	189	-	737
Spirit	3,029	884	298	-	490
C. d'Alene	-	-	-	386	-

Densities in number per mL.

In general, phytoplankton densities were highest in the spring and lowest in the summer. Lake Pend Oreille and Hayden had fairly stable phytoplankton abundances during the sampling period, but Priest and Spirit Lakes each had a spring peak much higher than other sampling times.

The phytoplankton biovolume trophic state indices (average for all stations, all dates) result in the following trophic ranking for these five lakes:

Lake	TSI (average)
Pend Oreille	40.8
Priest	42.2
Coeur d'Alene	46.5
Hayden	48.9
Spirit	52.6

The ranking for these average TSI's are to be loosely interpreted; the stations may not represent typical conditions for each lake, and the sampling dates vary which may include a phytoplankton peak in one lake but not in another. However, as a general guideline, this ranking is useful.

Lake Pend Oreille

Phytoplankton data from Lake Pend Oreille are summarized in Table 13 (species compositions) and Table 14 (phytoplankton densities). More detailed data can be found in Appendix A.

Table 13. Dominant and Co-dominant Phytoplankton Species in Lake Pend Oreille, 1986.

Station	April	June	August	September
257	STHN-STAM	STAM-RDMN	CCST-CCOC	RDMN-CCST
258	---	CCOC-CMMN	CCST-CCOC	CCST-RDMN
259	STHN-STAM	RDMN-CCXX	CCST-CCOC	CCST-RDMN
260	STHN-CYRF	RDMN-STAM	ABFA-CCOC	CODS-ACCV
261	NZAC-RDMN	CXER-STAM	CCST-CCOC	RDMN-CCOC

See Appendix F for species codes.

These species dominating Lake Pend Oreille indicate a mixture of trophic conditions in the lake. The average trophic condititons for the dominant species (from Appendix C) are as follows:

Species	TROPHIC STATE INDICES Biovol	Phos	Secchi	Chl	Overall
STHN	42	54	46	46	47
STAM	47	60	44	44	49
CCST	36	34	35	32	34
CCOC	38	27	31	24	30
RDMN	40	51	38	40	42

These species indicate mesotrophic conditions in Lake Pend Oreille during the spring, and oligotrophic conditions during the summer.

Table 14 provides phytoplankton densities of all samples collected from Lake Pend Oreille. Each station is averaged over all months to estimate station differences, and each month is averaged over all stations to provide seasonal differences.

Table 14. Phytoplankton Densities in Lake Pend Oreille, 1986.

Station	April	June	August	September	Average
257	495	286	91	106	244
258	-	1,297	154	225	559
259	1,108	783	195	145	558
260	801	1,315	156	162	608
261	328	349	181	96	238
Average	683	806	155	147	444

Densities in number per mL.

Station Comparisons

Comparisons between stations are often useful in limnological studies. A common objective is to determine if one site is being affected by a presumed influence, such as a site located near an enriched or toxic inflow.

Phytoplankton are particularly well suited to detect differences between sampling stations. The algae are influenced by their total environment, thus, altered environments result in altered phytoplankton.

Phytoplankton species compositions or abundances can be analyzed to detect differences between stations, but the species compositions are more sensitive to environmental influences than are total abundances. Table 15 presents similarity indices calculated between all possible combinations of stations for each date the phytoplankton were sampled in Lake Pend Oreille.

Table 15. Similarity Indices Between all Stations for Each Month in Lake Pend Oreille, 1986.

Station Pairs	April	June	August	September
257 - 258	-	15	75	63
257 - 259	68	48	70	59
257 - 260	52	56	27	20
257 - 261	39	59	69	46
258 - 259	-	38	76	64
258 - 260	-	30	23	17
258 - 261	-	15	74	41
259 - 260	75	53	28	30
259 - 261	19	37	75	53
260 - 261	14	42	19	22

The data in Table 15 show that the similarities between stations varies during different times of the year. For example, Stations 257 and 258 were quite different in June (SI=15), but in August they were very similar (SI=75). This variability was present for nearly all combinations of station pairs.

The data in Table 15 can be crunched further to provide general indications of which stations were most (and least) similar to all other stations, and which month had the highest (and lowest) overall similarity. The average similarity indices for each station, calculated from all possible station pairs on each date, are as follows:

Station	Average SI
257	51
258	44
259	53
260	33
261	41

These average similarity indices should be interpreted cautiously, but they indicate that Station 259 was overall most similar to all other stations, and that Station 260 was least similar. A casual observation of the species data (Table 13) supports this conclusion.

The average similarity indices for each date are as follows:

Date	Average SI
April	44
June	39
August	54
September	41

These data indicate that during August, the overall species compositions at all stations in Lake Pend Oreille were most similar, and they were least similar during June.

In terms of phytoplankton abundance, Stations 258, 259, and 260 were most similar; each had a spring peak followed by lower summertime densities. Stations 257 and 261 had slightly higher abundances in the spring than in the summer, but not as much as the other stations.

Date Comparisons

Differences in phytoplankton between sampling dates provide insight into important limnological processes influencing the water quality in a lake. For example, stratification usually influences primary production significantly, and phytoplankton changes can assess and document these effects.

Table 16. Similarity Indices Between Successive Dates for each Station in Lake Pend Oreille, 1986.

	STATIONS					
DATE	257	258	259	260	261	Average
Apr - Jun	41	-	21	26	22	27
Jun - Aug	29	16	19	29	22	23
Aug - Sep	35	37	47	45	26	38

Table 16 gives the similarity indices between sequential dates for each station in Lake Pend Oreille. The values are fairly low, indicating large changes in phytoplankton species compositions between sampling dates. The greatest overall changes occurred from April to June and June to August; the least change from August to September reflects more stable conditions.

The average of all station densities show that the maximum phytoplankton abundance was in the spring, with much lower amounts during the summer.

Appendix F. Codes for Common Phytoplankton Species.

CODE	Species
ABFA	Anabaena flos-aquae
ABPL	Anabaena planctonica
ACLN	Achnanthes linearis
ACMN	Achnanthes minutissima
AEXX	Aphanothece sp.
AKFL	Ankistrodesmus falcatus
APFA	Aphanizomenon flos-aquae
ASFO	Asterionella formosa
CCMG	Cyclotella meneghininana
CCOC	Cyclotella ocellata
CCST	Cyclotella stelligera
CJHR	Ceratium hirundinella
CMAF	Cymbella affinis
CODS	Cocconeis disculus
COPC	Cocconeis placentula
CXER	Cryptomonas erosa
CYRF	Chrysococcus rufescens
DBST	Dinobryon sertularia
EGXX	Euglena sp.
FRCR	Fragilaria crotonensis
GFAN	Gomphonema angustatum
GNXX	Gymnodinium sp.
KKLK	Chrysochromulina-like
KMXX	Chromulina sp.
MLDS	Melosira distans
MLGA	Melosira granulata angustissima
MLGR	Melosira granulata
MMXX	Mallomonas sp.
MXCY	Unidentified chrysophyte
NVMN	Navicula minima
NZAC	Nitzschia acicularis
NZPL	Nitzschia palea
OCPU	Oocystis pusilla
RDMN	Rhodomonas minuta
RZER	Rhizosolenia eriensis
SCQD	Scenedesmus quadricauda
SFSR	Sphaerocystis schroederia
SNRD	Synedra radians
SNRM	Synedra rumpens
STAM	Stephanodiscus astraea minutula
STHN	Stephanodiscus hantzschii

Appendix G. References

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PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 257

SAMPLE DATE: 86-04-17

TOTAL DENSITY (#/ml): 495

TOTAL BIOVOLUME (cu.uM/ml): 92659

DIVERSITY INDEX: 2.72

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Stephanodiscus hantzschii	225	45.5	27018	29.2
2	Stephanodiscus astraea minutula	82	16.5	28655	30.9
3	Rhodomonas minuta	65	13.2	1310	1.4
4	Cryptomonas sp.	20	4.1	8187	8.8
5	Cyclotella ocellata	16	3.3	2211	2.4
6	Dinobryon bavaricum	16	3.3	1965	2.1
7	Cyclotella sp.	12	2.5	1044	1.1
8	Cryptomonas erosa	12	2.5	6386	6.9
9	Nitzschia acicularis	8	1.7	2292	2.5
10	Chrysococcus rufescens	4	0.8	348	0.4
11	Cyclotella comta	4	0.8	9293	10.0
12	Ankistrodesmus falcatus	4	0.8	102	0.1
13	Caloneis hyalina	4	0.8	901	1.0
14	Cymbella minuta	4	0.8	1515	1.6
15	Nitzschia sp.	4	0.8	491	0.5
16	Nitzschia frustulum	4	0.8	491	0.5
17	Achnanthes minutissima	4	0.8	205	0.2
18	Fragilaria pinnata	4	0.8	246	0.3

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 259

SAMPLE DATE: 86-04-17

TOTAL DENSITY (#/ml): 1108

TOTAL BIOVOLUME (cu.uM/ml): 245348

DIVERSITY INDEX: 2.05

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Stephanodiscus hantzschii	739	66.7	88658	36.1
2	Stephanodiscus astraea minutula	154	13.9	53872	22.0
3	Nitzschia acicularis	31	2.8	8620	3.5
4	Cryptomonas erosa	23	2.1	12006	4.9
5	Chrysococcus rufescens	15	1.4	1308	0.5
6	Asterionella formosa	15	1.4	5480	2.2
7	Diatoma tenue elongatum	15	1.4	11082	4.5
8	Chlamydomonas sp.	8	0.7	2501	1.0
9	Hannaea arcus	8	0.7	13468	5.5
10	Achnanthes minutissima	8	0.7	385	0.2
11	Gomphonema olivaceum	8	0.7	1732	0.7
12	Ankistrodesmus falcatus	8	0.7	192	0.1
13	Navicula cryptocephala veneta	8	0.7	731	0.3
14	Navicula cryptocephala	8	0.7	1424	0.6
15	Cymbella minuta	8	0.7	2848	1.2
16	Cyclotella sp.	8	0.7	654	0.3
17	Melosira varians	8	0.7	35017	14.3
18	Nitzschia sp.	8	0.7	924	0.4
19	Amphora perpusilla	8	0.7	1278	0.5
20	Nitzschia sp.	8	0.7	924	0.4
21	Fragilaria construens	8	0.7	862	0.4
22	Achnanthes lanceolata	8	0.7	1385	0.6

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 260

SAMPLE DATE: 86-04-17

TOTAL DENSITY (#/ml): 801

TOTAL BIOVOLUME (cu.uM/ml): 219245

DIVERSITY INDEX: 2.05

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Stephanodiscus hantzschii	559	69.8	67030	30.6
2	Chrysococcus rufescens	43	5.4	3693	1.7
3	Fragilaria construens	31	3.9	6951	3.2
4	Stephanodiscus astraea minutula	31	3.9	10861	5.0
5	Fragilaria pinnata	19	2.3	1486	0.7
6	Navicula sp.	12	1.6	1862	0.8
7	Nitzschia linearis	12	1.6	18917	8.6
8	Cocconeis disculus	12	1.6	931	0.4
9	Synedra ulna	12	1.6	24702	11.3
10	Achnanthes linearis	6	0.8	819	0.4
11	Navicula cascadensis	6	0.8	372	0.2
12	Achnanthes exigua	6	0.8	695	0.3
13	Navicula sp.	6	0.8	931	0.4
14	Asterionella formosa	6	0.8	8838	4.0
15	Cymbella cistula	6	0.8	37239	17.0
16	Navicula cocconeiformis	6	0.8	993	0.5
17	Diatoma tenue elongatum	6	0.8	4469	2.0
18	Cymbella affinis	6	0.8	25974	11.8
19	Nitzschia acicularis	6	0.8	1738	0.8
20	Achnanthes sp.	6	0.8	745	0.3

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 261

SAMPLE DATE: 86-04-17

TOTAL DENSITY (#/ml): 328

TOTAL BIOVOLUME (cu.uM/ml): 58786

DIVERSITY INDEX: 2.89

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Nitzschia acicularis	106	32.3	29620	50.4
2	Rhodomonas minuta	61	18.5	1217	2.1
3	Cyclotella ocellata	53	16.1	7141	12.1
4	Stephanodiscus hantzschii	29	8.9	3491	5.9
5	Ankistrodesmus falcatus	24	7.3	595	1.0
6	Stephanodiscus astraea minutula	13	4.0	4628	7.9
7	Cryptomonas erosa	11	3.2	5501	9.4
8	Stephanodiscus sp.	8	2.4	1587	2.7
9	Cyclotella sp.	8	2.4	674	1.1
10	Cryptomonas sp.	8	2.4	3174	5.4
11	Cymbella microcephala	3	0.8	140	0.2
12	Unident. cryptophyte	3	0.8	66	0.1
13	Synedra radians	3	0.8	952	1.6

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 257

SAMPLE DATE: 86-06-03

TOTAL DENSITY (#/ml): 286

TOTAL BIOVOLUME (cu.uM/ml): 128331

DIVERSITY INDEX: 4.14

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Stephanodiscus astraea minutula	36	12.7	14357	11.2
2	Rhodomonas minuta	34	11.9	678	0.5
3	Cyclotella stelligera	31	11.0	2674	2.1
4	Dinobryon bavaricum	22	7.6	5227	4.1
5	Cryptomonas erosa	22	7.6	11326	8.8
6	Asterionella formosa	19	6.8	17231	13.4
7	Stephanodiscus hantzschii	19	6.8	2323	1.8
8	Synedra radians	15	5.1	8469	6.6
9	Cyclotella meneghiniana	15	5.1	5518	4.3
10	Rhizosolenia eriensis	10	3.4	2178	1.7
11	Ochromonas sp.	7	2.5	617	0.5
12	Stephanodiscus sp.	7	2.5	1452	1.1
13	Cymbella minuta	5	1.7	1791	1.4
14	Fragilaria crotonensis	5	1.7	32526	25.3
15	Cyclotella sp.	5	1.7	411	0.3
16	Chrysochromulina sp.	5	1.7	97	0.1
17	Ankistrodesmus falcatus	5	1.7	121	0.1
18	Synedra rumpens	2	0.8	908	0.7
19	Navicula cryptocephala veneta	2	0.8	230	0.2
20	Cryptomonas sp.	2	0.8	968	0.8
21	Mallomonas sp.	2	0.8	920	0.7
22	Sphaerocystis schroeteri	2	0.8	1258	1.0
23	Achnanthes lanceolata	2	0.8	436	0.3
24	Cymbella affinis	2	0.8	10128	7.9
25	Oocystis lacustris	2	0.8	1404	1.1
26	Diatoma vulgare	2	0.8	4743	3.7
27	Cymbella sinuata	2	0.8	339	0.3

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 258

SAMPLE DATE: 86-06-03

TOTAL DENSITY (#/ml): 1297

TOTAL BIOVOLUME (cu.uM/ml): 739914

DIVERSITY INDEX: 4.98

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella ocellata	114	8.8	15392	2.1
2	Cymbella minuta	100	7.7	36912	5.0
3	Cyclotella sp.	71	5.5	6057	0.8
4	Achnanthes minutissima	71	5.5	3563	0.5
5	Achnanthes linearis	71	5.5	9406	1.3
6	Diatoma vulgare	57	4.4	139668	18.9
7	Synedra ulna	57	4.4	141806	19.2
8	Amphora perpusilla	43	3.3	7097	1.0
9	Navicula cryptocephala veneta	43	3.3	4062	0.5
10	Nitzschia frustulum	43	3.3	5131	0.7
11	Nitzschia dissipata	43	3.3	11501	1.6
12	Fragilaria vaucheria	43	3.3	12314	1.7
13	Cymbella sinuata	43	3.3	5986	0.8
14	Cymbella affinis	29	2.2	119288	16.1
15	Fragilaria pinnata	29	2.2	1710	0.2
16	Stephanodiscus astraea minutula	29	2.2	9976	1.3
17	Gomphonema olivaceum	29	2.2	6413	0.9
18	Nitzschia acicularis	29	2.2	7981	1.1
19	Cyclotella meneghiniana	29	2.2	10831	1.5
20	Nitzschia sp.	29	2.2	3420	0.5
21	Gomphonema subclavatum	29	2.2	17102	2.3
22	Achnanthes clevei	14	1.1	2138	0.3
23	Cymbella microcephala	14	1.1	755	0.1
24	Rhodomonas minuta	14	1.1	285	0.0
25	Navicula capitata	14	1.1	13682	1.8
26	Cocconeis placentula	14	1.1	6556	0.9
27	Synedra mazamaensis	14	1.1	3648	0.5
28	Unident. pennate diatom	14	1.1	2494	0.3
29	Surirella ovata	14	1.1	4133	0.6
30	Navicula sp.	14	1.1	2138	0.3
31	Navicula cryptocephala	14	1.1	2637	0.4
32	Navicula tripunctata	14	1.1	15962	2.2
33	Fragilaria construens	14	1.1	3192	0.4
34	Hannaea arcus	14	1.1	24941	3.4
35	Cyclotella comta	14	1.1	32352	4.4
36	Nitzschia sp.	14	1.1	1710	0.2
37	Synedra socia	14	1.1	4703	0.6
38	Stephanodiscus hantzschii	14	1.1	1710	0.2
39	Synedra rumpens	14	1.1	5344	0.7
40	Fragilaria crotonensis	14	1.1	35915	4.9

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 259

SAMPLE DATE: 86-06-03

TOTAL DENSITY (#/ml): 783

TOTAL BIOVOLUME (cu.uM/ml): 182894

DIVERSITY INDEX: 4.50

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Rhodomonas minuta	118	15.0	2357	1.3
2	Cyclotella sp.	90	11.5	7661	4.2
3	Achnanthes minutissima	69	8.8	3467	1.9
4	Cyclotella stelligera	55	7.1	4715	2.6
5	Stephanodiscus astraea minutula	49	6.2	16987	9.3
6	Navicula cryptocephala veneta	42	5.3	3952	2.2
7	Cryptomonas erosa	35	4.4	18027	9.9
8	Nitzschia acicularis	35	4.4	9707	5.3
9	Ankistrodesmus falcatus	28	3.5	1040	0.6
10	Cymbella minuta	21	2.7	7696	4.2
11	Dinobryon bavaricum	14	1.8	6656	3.6
12	Stephanodiscus hantzschii	14	1.8	1664	0.9
13	Synedra rumpens	14	1.8	5200	2.8
14	Fragilaria construens	14	1.8	3883	2.1
15	Synedra radians	14	1.8	4992	2.7
16	Achnanthes lanceolata	14	1.8	2496	1.4
17	Asterionella formosa	14	1.8	29619	16.2
18	Cymbella sinuata	14	1.8	1941	1.1
19	Rhizosolenia eriensis	7	0.9	1248	0.7
20	Scenedesmus quadricauda	7	0.9	1803	1.0
21	Nitzschia sp.	7	0.9	832	0.5
22	Gomphonema angustatum	7	0.9	1248	0.7
23	Synedra ulna	7	0.9	13797	7.5
24	Diatoma vulgare	7	0.9	13589	7.4
25	Achnanthes linearis	7	0.9	915	0.5
26	Chlorella-like	7	0.9	312	0.2
27	Cymbella microcephala	7	0.9	367	0.2
28	Amphora perpusilla	7	0.9	1151	0.6
29	Nitzschia dissipata	7	0.9	1865	1.0
30	Navicula graciloides	7	0.9	3016	1.6
31	Chlamydomonas sp.	7	0.9	2253	1.2
32	Navicula sp.	7	0.9	1040	0.6
33	Nitzschia frustulum	7	0.9	832	0.5
34	Cyclotella meneghiniana	7	0.9	2635	1.4
35	Navicula decussis	7	0.9	1331	0.7
36	Gomphonema sp.	7	0.9	1387	0.8
37	Unident. pennate diatom	7	0.9	1213	0.7

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 260

SAMPLE DATE: 86-06-03

TOTAL DENSITY (#/ml): 1315

TOTAL BIOVOLUME (cu.uM/ml): 1342400

DIVERSITY INDEX: 4.46

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Rhodomonas minuta	203	15.4	4062	0.3
2	Stephanodiscus astraea minutula	160	12.2	56117	4.2
3	Stephanodiscus hantzschii	139	10.6	19176	1.4
4	Cyclotella ocellata	86	6.5	15815	1.2
5	Cyclotella meneghiniana	75	5.7	32413	2.4
6	Cryptomonas erosa	75	5.7	38908	2.9
7	Nitzschia acicularis	53	4.1	14964	1.1
8	Rhizosolenia eriensis	43	3.3	9620	0.7
9	Ankistrodesmus falcatus	43	3.3	1336	0.1
10	Amphora perpusilla	32	2.4	5323	0.4
11	Fragilaria construens venter	32	2.4	2047	0.2
12	Dinobryon bavaricum	32	2.4	5118	0.4
13	Fragilaria construens	32	2.4	556677	41.5
14	Cyclotella stelligera	21	1.6	1817	0.1
15	Fragilaria pinnata	21	1.6	2565	0.2
16	Navicula cryptocephala veneta	21	1.6	2031	0.2
17	Synedra ulna	21	1.6	42542	3.2
18	Cocconeis disculus	11	0.8	802	0.1
19	Gomphonema angustatum	11	0.8	42328	3.2
20	Achnanthes lanceolata	11	0.8	1924	0.1
21	Cyclotella kutzingiana	11	0.8	1229	0.1
22	Navicula pupula	11	0.8	2886	0.2
23	Navicula sp.	11	0.8	1603	0.1
24	Nitzschia frustulum	11	0.8	1283	0.1
25	Nitzschia paleacea	11	0.8	1048	0.1
26	Synedra radians	11	0.8	3848	0.3
27	Achnanthes clevei	11	0.8	1603	0.1
28	Achnanthes peragalli	11	0.8	1496	0.1
29	Navicula sp.	11	0.8	1603	0.1
30	Epithemia turgida	11	0.8	405643	30.2
31	Achnanthes minutissima	11	0.8	534	0.0
32	Achnanthes sp.	11	0.8	1283	0.1
33	Cyclotella sp.	11	0.8	909	0.1
34	Cymbella affinis	11	0.8	44733	3.3
35	Asterionella formosa	11	0.8	3805	0.3
36	Synedra rumpens	11	0.8	4008	0.3
37	Navicula sp.	11	0.8	1603	0.1
38	Diatoma tenue elongatum	11	0.8	7696	0.6

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Lake Pend Oreille, 261

SAMPLE DATE: 86-06-03

TOTAL DENSITY (#/ml): 349

TOTAL BIOVOLUME (cu.uM/ml): 116711

DIVERSITY INDEX: 3.99

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cryptomonas erosa	51	14.7	26679	22.9
2	Stephanodiscus astraea minutula	49	14.0	17059	14.6
3	Dinobryon bavaricum	41	11.8	10442	8.9
4	Rhizosolenia eriensis	36	10.3	7370	6.3
5	Asterionella formosa	33	9.6	19649	16.8
6	Synedra radians	18	5.1	6465	5.5
7	Cyclotella stelligera	15	4.4	1308	1.1
8	Nitzschia acicularis	15	4.4	4310	3.7
9	Ankistrodesmus falcatus	13	3.7	385	0.3
10	Dinobryon sertularia	10	2.9	4310	3.7
11	Cyclotella ocellata	8	2.2	1039	0.9
12	Ochromonas sp.	8	2.2	654	0.6
13	Cyclotella sp.	8	2.2	654	0.6
14	Cyclotella meneghiniana	5	1.5	1950	1.7
15	Mallomonas sp.	5	1.5	1950	1.7
16	Nitzschia paleacea	3	0.7	251	0.2
17	Scenedesmus quadricauda	3	0.7	333	0.3
18	Fragilaria vaucheria	3	0.7	739	0.6
19	Fragilaria crotonensis	3	0.7	6465	5.5
20	Cocconeis placentula	3	0.7	1180	1.0
21	Dictyosphaerium ehrenbergianum	3	0.7	462	0.4
22	Stephanodiscus hantzschii	3	0.7	308	0.3
23	Unident. dinoflagellate	3	0.7	1283	1.1
24	Navicula cryptocephala veneta	3	0.7	244	0.2
25	Chrysochromulina sp.	3	0.7	51	0.0
26	Rhodomonas minuta	3	0.7	51	0.0
27	Fragilaria construens	3	0.7	287	0.2
28	Chlamydomonas sp.	3	0.7	834	0.7

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 25%

SAMPLE DATE: 86-08-11

TOTAL DENSITY (#/ml): 91

TOTAL BIOVOLUME (cu.uM/ml): 31556

DIVERSITY INDEX: 2.68

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella stelligera	40.1	44.1	3410	10.8
2	Cyclotella ocellata	22.4	24.6	3111	9.9
3	Asterionella formosa	3.9	4.2	1376	4.4
4	Rhizosolenia eriensis	3.9	4.2	694	2.2
5	Fragilaria crotonensis	3.1	3.4	12960	41.1
6	Ankistrodesmus falcatus	3.1	3.4	135	0.4
7	Stephanodiscus astraea minutula	3.1	3.4	1080	3.4
8	Synedra rumpens	2.3	2.5	868	2.8
9	Cryptomonas erosa	2.3	2.5	1206	3.8
10	Melosira granulata angustissima	1.5	1.7	2314	7.3
11	Nitzschia sp.	0.8	0.8	96	0.3
12	Melosira italica	0.8	0.8	1453	4.6
13	Chlamydomonas sp.	0.8	0.8	251	0.8
14	Melosira ambigua	0.8	0.8	2272	7.2
15	Dictyosphaerium ehrenbergianum	0.8	0.8	139	0.4
16	Dinobryon sertularia	0.8	0.8	93	0.3
17	Synedra parasitica	0.8	0.8	108	0.3

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 258

SAMPLE DATE: 86-08-13

TOTAL DENSITY (#/ml): 154

TOTAL BIOVOLUME (cu.uM/ml): 45935

DIVERSITY INDEX: 2.71

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella stelligera	79	50.8	6676	14.5
2	Cyclotella ocellata	27	17.8	3711	8.1
3	Mallomonas sp.	7	4.2	2487	5.4
4	Stephanodiscus astraea minutula	7	4.2	2291	5.0
5	Melosira italica	5	3.4	8632	18.8
6	Rhizosolenia eriensis	5	3.4	1178	2.6
7	Fragilaria crotonensis	3	1.7	8797	19.2
8	Nitzschia acicularis	3	1.7	773	1.6
9	Asterionella formosa	3	1.7	1165	2.5
10	Sphaerocystis schroeteri	1	0.8	681	1.5
11	Eunotia sp.	1	0.8	589	1.3
12	Dinobryon sertularia	1	0.8	314	0.7
13	Chlamydomonas sp.	1	0.8	425	0.9
14	Tabellaria fenestrata	1	0.8	3142	6.8
15	Anabaena flos-aquae	1	0.8	2618	5.7
16	Synedra delicatissima	1	0.8	864	1.9
17	Crucigenia quadrata	1	0.8	113	0.2
18	Rhodomonas minuta	1	0.8	26	0.1
19	Achnanthes clevei	1	0.8	196	0.4
20	Navicula capitata	1	0.8	628	1.4
21	Unident. green alga	1	0.8	196	0.4
22	Synedra radians	1	0.8	471	1.0

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 259

SAMPLE DATE: 86-08-11

TOTAL DENSITY (#/ml): 195

TOTAL BIOVOLUME (cu.uM/ml): 50316

DIVERSITY INDEX: 2.57

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella stelligera	112	57.5	9547	19.0
2	Cyclotella ocellata	26	13.3	3499	7.0
3	Asterionella formosa	7	3.5	3999	7.9
4	Stephanodiscus astraea minutula	5	2.7	1814	3.6
5	Melosira granulata angustissima	5	2.7	2164	4.3
6	Rhodomonas minuta	5	2.7	10[illegible]	0.2
7	Cocconeis placentula	3	1.8	1590	3.2
8	Fragilaria crotonensis	3	1.8	13064	26.0
9	Rhizosolenia eriensis	3	1.8	966	1.9
10	Cyclotella meneghiniana	3	1.8	1313	2.6
11	Peridinium cinctum	2	0.9	7258	14.4
12	Nitzschia acicularis	2	0.9	484	1.0
13	Unident. desmid	2	0.9	285	0.6
14	Synedra rumpens	2	0.9	648	1.3
15	Diploneis elliptica	2	0.9	449	0.9
16	Cocconeis disculus	2	0.9	130	0.3
17	Achnanthes clevei	2	0.9	259	0.5
18	Fragilaria construens	2	0.9	194	0.4
19	Cyclotella pseudostelligera	2	0.9	112	0.2
20	Mallomonas sp.	2	0.9	657	1.3
21	Anabaena flos-aquae	2	0.9	1728	3.4
22	Fragilaria construens venter	2	0.9	83	0.2

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 260

SAMPLE DATE: 86-08-11

TOTAL DENSITY (#/ml): 156

TOTAL BIOVOLUME (cu.uM/ml): 157084

DIVERSITY INDEX: 4.45

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Anabaena flos-aquae	34	22.1	79899	50.9
2	Cyclotella ocellata	16	10.5	2202	1.4
3	Cocconeis disculus	11	7.0	816	0.5
4	Fragilaria construens venter	9	5.8	3480	2.2
5	Amphora perpusilla	7	4.7	1204	0.8
6	Stephanodiscus astraea minutula	5	3.5	1903	1.2
7	Fragilaria pinnata	5	3.5	979	0.6
8	Melosira granulata angustissima	4	2.3	3172	2.0
9	Cocconeis placentula	4	2.3	1668	1.1
10	Fragilaria construens	4	2.3	609	0.4
11	Cryptomonas erosa	4	2.3	1885	1.2
12	Asterionella formosa	4	2.3	968	0.6
13	Achnanthes minutissima	4	2.3	181	0.1
14	Achnanthes peragalli	4	2.3	508	0.3
15	Fragilaria crotonensis	4	2.3	22839	14.5
16	Fragilaria vaucheria	2	1.2	522	0.3
17	Cyclotella meneghiniana	2	1.2	689	0.4
18	Nitzschia intermedia	2	1.2	979	0.6
19	Navicula decussis	2	1.2	348	0.2
20	Amphora ovalis	2	1.2	1048	0.7
21	Navicula minima	2	1.2	80	0.1
22	Cyclotella stelligera	2	1.2	154	0.1
23	Fragilaria sp.	2	1.2	3263	2.1
24	Navicula cryptocephala veneta	2	1.2	172	0.1
25	Nitzschia palea	2	1.2	326	0.2
26	Rhizosolenia eriensis	2	1.2	326	0.2
27	Navicula anglica	2	1.2	653	0.4
28	Stauroneis sp.	2	1.2	616	0.4
29	Navicula pseudoscutiformis	2	1.2	317	0.2
30	Chlamydomonas sp.	2	1.2	589	0.4
31	Tabellaria fenestrata	2	1.2	21751	13.8
32	Nitzschia sp.	2	1.2	218	0.1
33	Unident. pennate diatom	2	1.2	317	0.2
34	Melosira italica	2	1.2	1707	1.1
35	Cymbella sinuata	2	1.2	254	0.2
36	Gomphonema gracile	2	1.2	444	0.3

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 261

SAMPLE DATE: 86-08-11

TOTAL DENSITY (#/ml): 181

TOTAL BIOVOLUME (cu.uM/ml): 93429

DIVERSITY INDEX: 2.04

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella stelligera	117	64.7	9972	10.7
2	Cyclotella ocellata	18	9.8	2394	2.6
3	Asterionella formosa	11	6.0	7285	7.8
4	Mallomonas sp.	10	5.3	3629	3.9
5	Fragilaria crotonensis	5	3.0	63027	67.5
6	Rhizosolenia eriensis	5	3.0	1228	1.3
7	Melosira italica	3	1.5	3855	4.1
8	Cosmarium sp.	3	1.5	382	0.4
9	Ankistrodesmus falcatus	3	1.5	68	0.1
10	Dinobryon bavaricum	1	0.8	164	0.2
11	Cryptomonas erosa	1	0.8	709	0.8
12	Selenastrum minutum	1	0.8	109	0.1
13	Dinobryon sertularia	1	0.8	164	0.2
14	Chlamydomonas sp.	1	0.8	443	0.5

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 257

SAMPLE DATE: 86-09-15

TOTAL DENSITY (#/ml): 106

TOTAL BIOVOLUME (cu.uM/ml): 71245

DIVERSITY INDEX: 4.45

	SPECIES	DENSITY	PCT	BIOVL	PCT
1	Rhodomonas minuta	20	18.6	394	0.6
2	Cyclotella stelligera	16	14.7	1322	1.9
3	Melosira granulata	8	7.8	23950	33.6
4	Ochromonas sp.	5	4.9	441	0.6
5	Rhizosolenia eriensis	4	3.9	933	1.3
6	Asterionella formosa	3	2.9	3505	4.9
7	Cryptomonas erosa	3	2.9	1617	2.3
8	Nitzschia frustulum	3	2.9	496	0.7
9	Synedra radians	3	2.9	1120	1.6
10	Mallomonas sp.	3	2.9	1182	1.7
11	Stephanodiscus hantzschii	2	2.0	249	0.3
12	Aphanothece sp.	2	2.0	622	0.9
13	Cyclotella sp.	2	2.0	176	0.2
14	Stephanodiscus astraea minutula	2	2.0	726	1.0
15	Melosira italica	2	2.0	8790	12.3
16	Cryptomonas sp.	2	2.0	829	1.2
17	Melosira granulata angustissima	2	2.0	2074	2.9
18	Cyclotella ocellata	2	2.0	280	0.4
19	Fragilaria crotonensis	2	2.0	4355	6.1
20	Nitzschia sp.	2	2.0	249	0.3
21	Stephanodiscus astraea	1	1.0	8638	11.7
22	Fragilaria construens	1	1.0	929	1.3
23	Cyclotella meneghiniana	1	1.0	394	0.6
24	Cyclotella comta	1	1.0	2354	3.3
25	Synedra delicatissima	1	1.0	684	1.0
26	Navicula cryptocephala	1	1.0	192	0.3
27	Cocconeis placentula	1	1.0	477	0.7
28	Synedra ulna	1	1.0	2064	2.9
29	Quadrigula closterioides	1	1.0	58	0.1
30	Unident. dinoflagellate	1	1.0	518	0.7
31	Nitzschia sp.	1	1.0	124	0.2
32	Scenedesmus quadricauda	1	1.0	270	0.4
33	Navicula sp.	1	1.0	156	0.2
34	Anabaena flos-aquae	1	1.0	1037	1.5
35	Unident. green alga	1	1.0	156	0.2
36	Dictyosphaerium ehrenbergianum	1	1.0	187	0.3

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 258

SAMPLE DATE: 86-09-15

TOTAL DENSITY (#/ml): 225

TOTAL BIOVOLUME (cu.uM/ml): 91984

DIVERSITY INDEX: 4.17

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella stelligera	47	20.8	3978	4.3
2	Rhodomonas minuta	38	16.8	756	0.8
3	Ankistrodesmus falcatus	16	7.2	405	0.4
4	Melosira granulata	14	6.4	29700	32.3
5	Stephanodiscus astraea minutula	13	5.6	4410	4.8
6	Nitzschia frustulum	9	4.0	1296	1.4
7	Cryptomonas sp.	7	3.2	2880	3.1
8	Cyclotella meneghiniana	7	3.2	2736	3.0
9	Synedra radians	5	2.4	1944	2.1
10	Asterionella formosa	5	2.4	1922	2.1
11	Melosira granulata angustissima	5	2.4	2700	2.9
12	Cyclotella ocellata	5	2.4	729	0.8
13	Chroomonas sp.	4	1.6	234	0.3
14	Dinobryon sertularia	4	1.6	648	0.7
15	Melosira italica	4	1.6	10174	11.1
16	Sphaerocystis schroeteri	4	1.6	1872	2.0
17	Amphora perpusilla	4	1.6	598	0.6
18	Navicula cryptocephala	4	1.6	666	0.7
19	Cryptomonas erosa	4	1.6	1872	2.0
20	Achnanthes minutissima	4	1.6	180	0.2
21	Rhizosolenia eriensis	2	0.8	324	0.4
22	Cocconeis pediculus	2	0.8	936	1.0
23	Navicula tripunctata	2	0.8	2016	2.2
24	Stephanodiscus hantzschii	2	0.8	216	0.2
25	Cyclotella sp.	2	0.8	153	0.2
26	Cyclotella kutzingiana	2	0.8	207	0.2
27	Cocconeis placentula	2	0.8	828	0.9
28	Synedra ulna	2	0.8	3582	3.9
29	Fragilaria crotonensis	2	0.8	12096	13.2
30	Chlamydomonas sp.	2	0.8	585	0.6
31	Gomphonema olivaceum	2	0.8	405	0.4
32	Scenedesmus sp.	2	0.8	720	0.8
33	Oocystis lacustris	2	0.8	216	0.2

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 259

SAMPLE DATE: 86-09-15

TOTAL DENSITY (#/ml): 145

TOTAL BIOVOLUME (cu.uM/ml): 97575

DIVERSITY INDEX: 4.22

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella stelligera	28	19.5	2402	2.5
2	Rhodomonas minuta	22	15.3	442	0.5
3	Cyclotella ocellata	17	11.9	2322	2.4
4	Ankistrodesmus falcatus	7	5.1	184	0.2
5	Stephanodiscus astraea minutula	6	4.2	2150	2.2
6	Rhizosolenia eriensis	6	4.2	1106	1.1
7	Mallomonas sp.	5	3.4	1867	1.9
8	Melosira granulata angustissima	4	2.5	4303	4.4
9	Cryptomonas erosa	4	2.5	1916	2.0
10	Fragilaria crotonensis	4	2.5	37148	38.1
11	Synedra radians	4	2.5	1327	1.4
12	Cryptomonas sp.	4	2.5	1474	1.5
13	Achnanthes exigua	4	2.5	413	0.4
14	Anabaena flos-aquae	2	1.7	9827	10.1
15	Melosira granulata	2	1.7	4729	4.8
16	Amphora ovalis	2	1.7	1420	1.5
17	Sphaerocystis schroeteri	1	0.8	639	0.7
18	Navicula cryptocephala veneta	1	0.8	117	0.1
19	Fragilaria construens	1	0.8	138	0.1
20	Oocystis lacustris	1	0.8	147	0.2
21	Oocystis pusilla	1	0.8	221	0.2
22	Anacystis marina	1	0.8	369	0.4
23	Cyclotella meneghiniana	1	0.8	467	0.5
24	Ceratium hirundinella	1	0.8	12039	12.3
25	Chroomonas sp.	1	0.8	80	0.1
26	Fragilaria construens venter	1	0.8	59	0.1
27	Nitzschia sigmoidea	1	0.8	2088	2.1
28	Cyclotella sp.	1	0.8	104	0.1
29	Navicula salinarum	1	0.8	585	0.6
30	Fragilaria pinnata	1	0.8	74	0.1
31	Nephrocytium sp.	1	0.8	467	0.5
32	Unident. green alga	1	0.8	184	0.2
33	Cyclotella comta	1	0.8	2789	2.9
34	Dinobryon sertularia	1	0.8	1032	1.1
35	Anabaena circinalis	1	0.8	2948	3.0

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 260

SAMPLE DATE: 86-09-15

TOTAL DENSITY (#/ml): 162

TOTAL BIOVOLUME (cu.uM/ml): 43782

DIVERSITY INDEX: 4.91

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cocconeis disculus	20	12.3	1484	3.4
2	Achnanthes clevei	12	7.3	1781	4.1
3	Cyclotella ocellata	10	6.1	1336	3.1
4	Achnanthes lanceolata	10	6.1	1701	4.1
5	Fragilaria construens venter	8	4.9	570	1.3
6	Fragilaria pinnata	8	4.9	831	1.9
7	Rhodomonas minuta	6	3.7	119	0.3
8	Stephanodiscus astraea minutula	6	3.7	2078	4.7
9	Fragilaria crotonensis	6	3.7	6633	15.1
10	Fragilaria construens	6	3.7	5099	11.6
11	Cryptomonas erosa	4	2.4	2058	4.7
12	Navicula cryptocephala veneta	4	2.4	376	0.9
13	Achnanthes minutissima	4	2.4	198	0.5
14	Achnanthes exigua	4	2.4	443	1.0
15	Mallomonas sp.	4	2.4	1504	3.4
16	Diploneis elliptica	4	2.4	1029	2.4
17	Navicula pseudoscutiformis	2	1.2	346	0.8
18	Synedra rumpens	2	1.2	742	1.7
19	Cymbella minuta	2	1.2	732	1.7
20	Mougeotia sp.	2	1.2	700	1.6
21	Cyclotella comta	2	1.2	4491	10.3
22	Fragilaria leptostauron	2	1.2	364	0.8
23	Navicula sp.	2	1.2	297	0.7
24	Navicula anglica	2	1.2	712	1.6
25	Navicula viridula	2	1.2	890	2.0
26	Navicula capitata	2	1.2	950	2.2
27	Gomphonema gracile	2	1.2	485	1.1
28	Caloneis hyalina	2	1.2	435	1.0
29	Gomphonema angustatum	2	1.2	356	0.8
30	Achnanthes peragalli	2	1.2	277	0.6
31	Melosira varians	2	1.2	1286	2.9
32	Unident. pennate diatom	2	1.2	1039	2.4
33	Gomphonema clevei	2	1.2	178	0.4
34	Diatomella balfouriana	2	1.2	594	1.4
35	Stephanodiscus hantzschii	2	1.2	237	0.5
36	Cyclotella stelligera	2	1.2	168	0.4
37	Amphora perpusilla	2	1.2	328	0.8
38	Oocystis pusilla	2	1.2	119	0.3
39	Fragilaria vaucheria	2	1.2	570	1.3
40	Elakatothrix gelatinosa	2	1.2	168	0.4

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Pend Oreille, 261

SAMPLE DATE: 86-09-15

TOTAL DENSITY (#/ml): 96

TOTAL BIOVOLUME (cu.uM/ml): 26654

DIVERSITY INDEX: 2.99

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Rhodomonas minuta	47.8	50.0	956	3.6
2	Cyclotella ocellata	9.6	10.0	1291	4.8
3	Cyclotella stelligera	5.7	6.0	488	1.8
4	Cryptomonas erosa	3.8	4.0	1989	7.5
5	Rhizosolenia eriensis	2.9	3.0	687	2.6
6	Mallomonas sp.	2.9	3.0	1096	4.1
7	Ankistrodesmus falcatus	2.9	3.0	72	0.3
8	Oocystis parva	1.9	2.0	115	0.4
9	Stephanodiscus astraea minutula	1.9	2.0	670	2.5
10	Synedra radians	1.9	2.0	689	2.6
11	Oocystis pusilla	1.9	2.0	115	0.4
12	Cyclotella comta	1.9	2.0	4342	16.3
13	Melosira granulata	1.9	2.0	5787	21.7
14	Melosira italica	1.0	1.0	1802	6.8
15	Sphaerocystis schroeteri	1.0	1.0	497	1.9
16	Unident. green alga	1.0	1.0	143	0.5
17	Nitzschia acicularis	1.0	1.0	268	1.0
18	Achnanthes minutissima	1.0	1.0	48	0.2
19	Navicula cascadensis	1.0	1.0	57	0.2
20	Fragilaria crotonensis	1.0	1.0	4821	18.1
21	Anacystis sp.	1.0	1.0	287	1.1
22	Cocconeis placentula	1.0	1.0	440	1.7

APPENDIX 11A

Attached Benthic Algae (Periphyton) in Lake Pend Oreille, Idaho
(Falter & Kann 1987).

APPENDIX 11A.

ATTACHED BENTHIC ALGAE (PERIPHYTON) IN LAKE PEND OREILLE, IDAHO.

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December, 1987

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ABSTRACT

Attached algae in the littoral zone of Pend Oreille Lake, a large (383 km^2), deep (Z_{max} = 380 m), meso-oligotrophic lake in north Idaho was studied for comparison to estimates of pelagic productivity. The study monitored periphyton growth rates (AFODW and chlorophyll *a*) during July and August, 1986 on both artificial and natural substrate throughout the 38,300 ha lake. Unglazed ceramic tiles were suspended at 0.5 and 1.5 m depths and incubated for 30 days in mid-summer.

Natural substrate means for all variables (trichromatic chlorophyll *a*, monochromatic chlorophyll *a*, dry weight, and ash-free fry weight) were higher than those of the artificial substrate. Mean trichromatic chlorophyll *a* and mean ash-free dry weights on the natural substrate were 240% and 1,128% higher, respectively, than the artificial substrate means. Means for all variables were higher on the 0.5 m tile than on the 1.5 m tile; exposed sites, however, showed less difference between depths than did the more sheltered sites. Lakewide mean trichromatic chlorophyll *a* and mean ash free dry weights of 0.5 m tiles were 156% and 52% higher, respectively, than 1.5 m tile means. Trichromatic chlorophyll *a* measures provided less variability than monochromatic estimates and were therefore used to make comparisons between sites. Due to inorganic interference, especially on the wave-washed natural substrates, ash-free dry weight provided a better measure of periphyton biomass than dry weight. Artificial substrate south-lake mean trichromatic chlorophyll *a* was 2.9-fold greater than the mean of mid-lake sites; north-lake sites were 7.6-fold greater than the mean of mid-lake sites. South-lake natural substrate had twice the chlorophyll of mid-lake natural substrate, and 1.6 times the north-lake sites. Mean ash-free dry weights for south-lake sites were twice those of mid-lake sites, and 1.5 times those at north-lake sites.

Cymbella was the chief dominant (~50% by biovolume) on the natural substrate, while *Cymbella*, *Mougeotia*, and *Rhizoclonium* were equally dominant (21.6%, 27.5%, and 20.0%, respectively) on the artificial substrates. Blue-green algae biomass comprised only a small part of the total biomass on either artificial or natural substrates.

Values of chlorophyll *a* and ash-free dry weight were comparable to other lakes showing accelerated eutrophication (2-6 mg/m^2 and ~1.0 g/m^2,

respectively). They also were similar to lakes more shallow in nature, showing moderate littoral periphyton growth despite Pend Oreille's deep nature and large profundal area. Our data suggest accelerating eutrophication of Pend Oreille Lake. Algae growths are significantly greater in developed and relatively confined bays. Continued monitoring and study of attached algae are therefore, warranted in the near future. Given that changes in lake tropic status would first show up in littoral areas (compared to the relatively slow changes in the phytoplankton of pelagic areas), periphyton monitoring should provide valuable refinement to in-depth limnological studies on open waters of the lake.

INTRODUCTION

Although Pend Oreille Lake has been typically classified as a moderately productive oligotrophic system (oligo-mesotrophic) (Rieman and Falter 1976, Falter 1978, Milligan et al. 1983), increasing density of aquatic macrophytes and complaints from homeowners on the increasing growths of periphyton on docks and shoreline areas have caused concern that the trophic nature of the lake may be changing at a faster rate than previously perceived. This concern caused the Idaho Department of Health and Welfare (Division of Environment) to initiate baseline monitoring of limnological conditions in 1985 and 1986 (Beckwith 1986). In all of these studies, however, data has been collected only at deep, open-water sites. Changes in the lake's actual trophic status might initially go unnoticed because the effects of high nutrient loading would first show up in bay and littoral areas. Littoral productivity may not play a large role in overall lake productivity in a large deep lake with steep sides and a low littoral to pelagic area ratio such as Pend Oreille, but productivity changes in shallow, light-rich areas would reflect changes in trophic status more quickly than pelagic waters. Periphyton, the main component of littoral productivity, could then be used to more efficiently monitor changes to the lake system resulting from increased nutrient loading.

The objectives of this study were:

1) to monitor and determine periphyton growth in littoral exposed shore and embayment areas of Lake Pend Oreille; and,

2) to test an inexpensive and statistically reproducible method of periphyton assessment to monitor both long-term changes and between-site differences throughout Pend Oreille's shoreline.

Attached algae is the algal component of periphyton growing on submerged substrate such as rocks (epilithic algae), plants (epiphytic algae), sediments (epipelic algae), or woody debris. The term "periphyton" actually refers to the <u>total</u> attached community (*ie.*, both attached algae and the associated microfauna) but in this paper, we will use the terms synonymously because periphyton is the more common usage in the literature and gravimetric measures of the periphyton community do not separate those two components.

The role of the littoral zone in whole-lake productivity has been well established (Wetzel 1983). This role is more pronounced in lakes which have gently sloping shorelines, and therefore large ratios of littoral area to pelagic area (Loeb et al. 1983, Wetzel 1983). The dominant element of littoral productivity is periphyton, with most of the periphytic contribution being attached algae. Wetzel (1964) showed that attached algae accounted for 69% of the total carbon fixed by autotrophs in a shallow lake (Mean depth = ~1 m). Attached algae can also contribute a high percent of the net annual littoral primary productivity in steep-sided oligotrophic lakes. Loeb et al. (1983) found that attached algae contributed up to 97% of the total littoral productivity in certain oligotrophic lakes. The relative contribution of attached algae to lake production depends upon lake morphometry, water clarity, and availability of substrate.

In addition to this major contribution to littoral and potentially, whole lake productivity, the littoral zone also serves as a buffer both to natural and anthropomorphic events occurring in the watershed. The littoral therefore responds more quickly than pelagic areas to pollutant inputs (Casterlin and Reynolds 1977, Loeb et al. 1983). The spatial distribution of periphyton production has been shown to be positively correlated with the distribution of urban development (Loeb et al. 1983). Littoral periphyton productivity can play a major role in the early and final stages of increasing fertility to the whole lake system (Wetzel 1983). Periphyton monitoring as a pollution indicator has been widely used in lotic systems (Palmer 1969 and Patrick 1973). However, periphyton monitoring in lentic systems has not yet been used to a great extent.

Study Area

Pend Oreille Lake is a large (383 km^2) deep lake (Z_{max} = 380 m) located in the Panhandle area of northern Idaho. It is the receiving water for the Clark Fork River draining a 59,311 km^2 watershed located mostly in northwestern Montana. Water quality of the Clark Fork River has been the focus of concern due to point and nonpoint pollution inputs occurring in Montana. These include mining, agriculture, and suburban nonpoint runoff, sewage effluent from Missoula and other municipalities, and waste from the Stone Container Corporation pulp mill on the Clark Fork River downstream from Missoula. Because Lake Pend Oreille receives all the Clark Fork River discharge, degraded water quality (especially high nutrient and organic loads) of the Clark Fork River would likely cause increased eutrophication in Pend Oreille Lake (Montana Dept. of Health and Environmental Sciences 1985).

METHODS

Artificial Substrate

The original study plan called for the use of mylar strips vertically suspended in the water column at each of 12 sites after the approach of Bjornn et al. (1986). The use of mylar was discarded because of fears that the strips would be too easily damaged in the often violent wave zone of Pend Oreille Lake and by the desirability to use artificial substrates (unglazed ceramic tiles) which more closely resembled natural substrates on the Pend Oreille lakeshore. We were vindicated in the first concern after noting that the test mylar strips often tore at the attachment points and that four of the 12 stations had broken tiles after 30 days incubation.

Artificial substrates (tiles) were placed at twelve sites around the lake. These sites were chosen as representative bay- and open-water areas (Figure 1). Four of these sites were located in populated bays (Scenic Bay Marina, Garfield, Ellisport Bay Marina, and Bottle Bay), two were mid-lake exposed water sites (Talache Landing and Granite Landing), two were south-lake exposed water sites (CMF and Lakewiew), three were north-lake exposed water sites (Sheepherder Point, Warren Island, and Sunnyside), and one site was located in an unpopulated bay (Idlewild Bay).

<u>Populated Bays</u>	
Scenic Bay Marina	- South lake, head of unsewered, heavily populated Scenic Bay
Garfield Bay	- Mid lake, head of lightly populated Garfield Bay
Ellisport Bay Marina	- North lake, on unsewered, heavily populated Ellisport Bay and community of Hope
Bottle Bay	- North lake, on sewered, developed bay
<u>Mid-Lake Exposed Sites</u>	
Talache Landing	- Open, exposed, west lake shore
Granite Landing	- Slightly protected, east lake shore
<u>South Lake Exposed Sites</u>	
CMF	- South exposure, two miles lakeward from Scenic Bay head
Lakeview	- West exposure, open lake opposite Scenic and Idlewild Bays
<u>North Lake Exposed Sites</u>	
Sheepherder Point	- South exposure, open lake near Clark Fork River inflow
Warren Island	- West side of Warren Island
Sunnyside	- South side of Sunnyside Peninsula

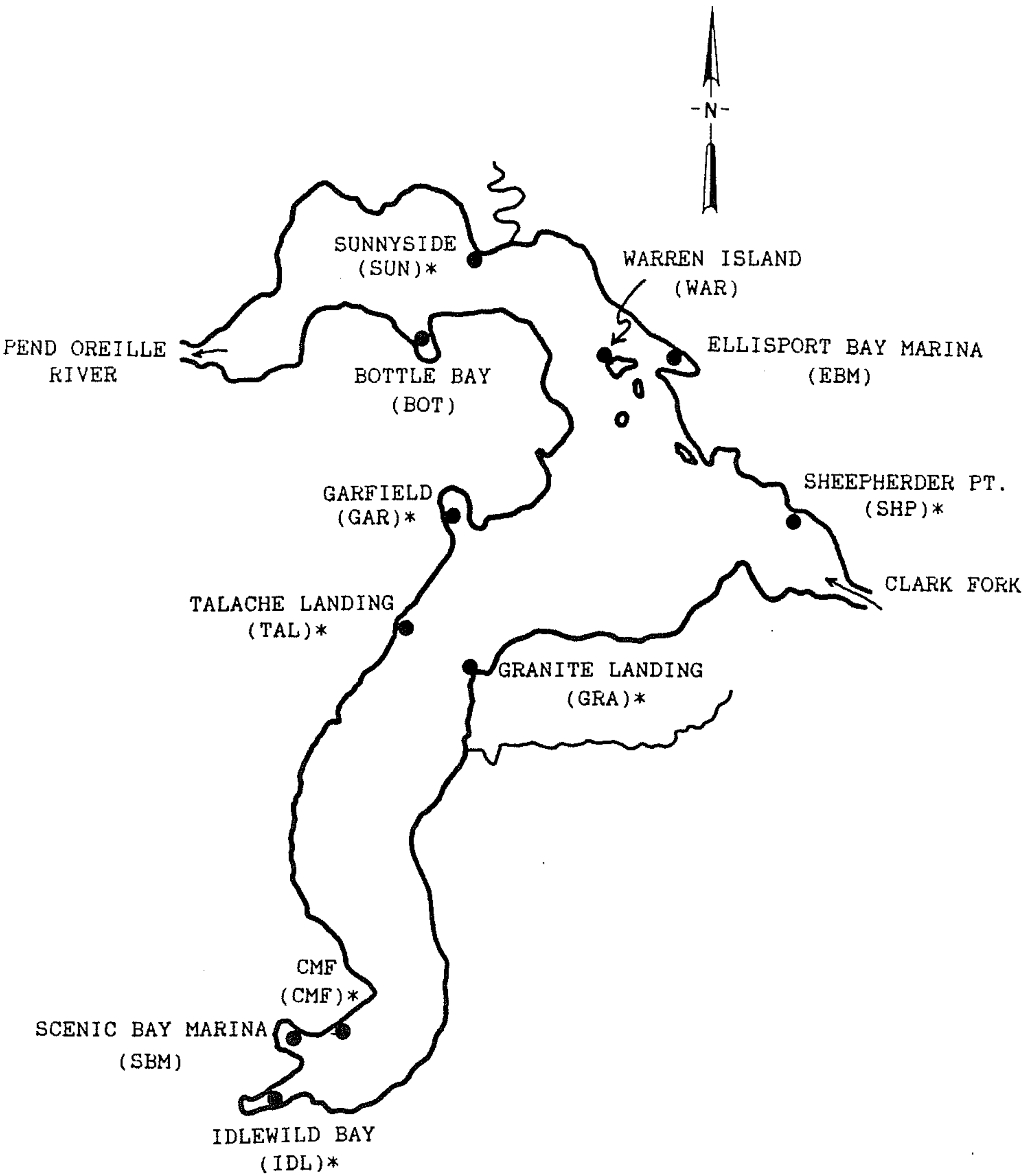

Figure 1. Periphyton sampling sites in Pend Oreille Lake, July-August, 1986. Three-letter abbreviations (in parenthes3s) are used throughout the text as site abbreviations. (* = Both natural and artificial substrates sampled).

Unpopulated Bay

Idlewild Bay - North exposure, one mile from bay head

Preliminary experiments were performed at the CMF site to determine the optimal immersion time (15 days *vs.* 30 days) for the artificial substrate, and to determine which of two types of ceramic tiles (glazed *vs.* unglazed) would provide optimal periphyton growth. These experiments indicated that a 30-day immersion time resulted in mean trichromatic chlorophyll *a* values ~200 percent higher than those for a 15-day immersion period. Trichromatic chlorophyll *a* values on the unglazed tiles were ~50 % percent higher than those of the glazed tiles. Unglazed tiles and a 30-day immersion period were therefore chosen to conduct the monitoring experiment.

We selected rectangular ceramic tiles as our artificial substrate. These were brick red in color, unglazed, and 195 cm^2 in surface area. A 1/8 in. hole was drilled in the bottom of the 0.5 m tile and in the top of the 1.5 m tile, so that the two tiles could be connected by a 1 m length of braided nylon cord. At each study site, five vertically oriented replicate tiles were placed at the 0.5 m depth, and five were placed at the 1.5 m depth. At each site, the five replicate submerged pairs were attached in a row to a dock, piling, or fallen tree.

Placement and Retrieval

Because of the large size of Pend Oreille Lake, two successive days were required to place tiles at all twelve sites. Tiles were submersed at the six southern sites on July 15, 1986, and on July 16 for the six northern sites (Figure 1). After a 30-day incubation period, the tiles were collected on two successive days and then scraped with a stiff nylon brush. The growth on each tile was rinsed with distilled water into a 50 ml plastic centrifuge tube. The centrifuge tubes were kept on ice in the dark for the remainder of the day until filtering that evening. A small qualitative periphyton sample was also scraped from the edge of the tile and preserved with a solution of Lugol's iodine (1 ml Lugols per 100 ml of sample). That evening, each cooled sample was brought to a known volume in a graduated cylinder, shaken, and two duplicate samples then vacuum-filtered onto separate Whatman GF/C glass fiber filters. Each duplicate filter was then assumed to contain biomass from half the tile surface area (97.5 cm^2). The filters were frozen until laboratory analysis the following week.

One filter from each sample was used for analysis of trichromatic and monochromatic chlorophyll *a*, and pheophytin. The second filter was used for gravimetric determination of dry weight (ODW at 105 C) and ash free dry weight (AFODW after drying at 105 C, ashing at 500 C, re-wetting, and drying again at 105 C). Calculated results were reported on a per-unit area basis. Standard Methods For The Examination of Water and Waste Water were followed in the above analysis (APHA 1985). Calculation of the Autotrophic Index was also made (AFDW:Chlorophyll *a* ratio). The qualitative sample preserved in Lugol's iodine was mixed and an aliquot placed onto a depression slide (inverted microscope at 200X) for determination of percent composition by biovolume of the dominant attached algae genera. The slide was scanned to ensure an even distribution of algae before we determined mean percent composition in three fields.

Natural Substrate

To provide comparison of artificial substrate (tiles) with natural substrate (shoreline rocks) and comparison of spatial variation occurring on natural substrate around the lake, three replicate rocks were randomly selected from seven of the twelve sites (Figure 1). All rocks were selected within the 0.3-0.7 m zone of littoral areas. A thin section of PCV pipe (d=4.8 cm) was placed on each rock and the periphyton on the rock surface area within the 17.7 cm^2 pipe section scraped, collected, and analyzed as above.

Data Analysis

Analysis of variance (ANOVA) tests were performed to determine the significance of differences between sites, depths, and between artificial and natural substrate. Duncan's New Multiple Range Test was used to determine extent of mean separation when significant differences existed. These tests were performed with SAS GLM procedures (SAS Users Guide 1980). Because graphical plots of our data indicated that variance was proportional to means for all variables, and values of less than 1.0 occurred, a logarithmic transformation ($\log_{10}(X+1)$), was performed (Kirk 1982). Transformed data was used in ANOVA and multiple comparison tests. Confidence intervals ($p \geq 95\%$) were calculated to compare within-site variation of both artificial and natural substrate. All required assumptions of the statistical tests performed were addressed and met.

Because five replicate tiles at a specific site are not sufficient replication to permit statistical inferences to a whole bay or lake area (pseudoreplication) (Hurlbert 1984), ANOVA and Duncan's tests can only be viewed as pertaining to specific sites. For this reason certain non-statistical trends are also presented in a comparison of south-lake, mid-lake and north-lake means.

RESULTS

Trichromatic *vs* Monochromatic Chlorophyll *a*

Because periphyton generally contains varying amounts of chlorophyll breakdown products such as pheophytin (Robinson 1983, Wetzel 1983, Biggs 1985, APHA 1985), monochromatic chlorophyll *a* measurements should be a better indicator of viable chlorophyll. Monochromatic chlorophyll *a* and pheophytin variability within our replicates and some negative pheophytin values suggested, however, that inherent problems with the method may preclude their use in comparative studies (Appendix Table 1). Schindler et al. (1973) and Hayman (1979) both found extreme variability with pheophytin and monochromatic chlorophyll *a* measurements and cautioned on their use. Trichromatic chlorophyll *a* measurements were less variable in our study and will therefore be emphasized in this paper.

Artificial *vs* Natural Substrate

ANOVA results are presented in Table 1. For all tested variables (Trichromatic and monochromatic chlorophyll *a*, pheophytin, dry weight, and ash-free dry weight) the natural substrate means combined over all sites were significantly ($p \leq 0.01$) greater than means of either the 0.5 m tiles or the 1.5 m tiles (Table 2). Natural substrate, for example, averaged 17.9 g/m^2 of trichromatic chlorophyll *a* compared to 3.6 mg/m^2 on all tiles (Figures 2 and 4). Monochromatic chlorophyll *a* was 18.3 mg/m^2 on natural substrate compared to 3.6 mg/m^2 on all tiles. Ash-free dry weight was 14.3 g/m^2 on natural substrate compared to 0.96 g/m^2 on all tiles (Figures 3 and 5).

Artificial Substrate

Lake-wide comparisons of the 0.5 m tiles with the 1.5 m tiles showed significant differences ($p \leq 0.05$) between the two depths for trichromatic chlorophyll *a*, dry weight, and ash-free dry weight (Table 1). This difference was because the three most productive sites (IDL, SBM, and EBM) had trichromatic chlorophyll *a* values at the 0.5 m depth (4-10.3 mg/m2) which were up to 8-fold greater than those of the the 1.5 m depth (1.3-4.1 mg/m^2) (Figure 3). Differences between the depths were not as pronounced at other sites. If the the more productive sites were removed from the analysis, no significant differences between tiles at the two depths would exist. Nonetheless,

Table 1. Summary results of analysis of variance tests performed on natural substrate *vs* tiles, 0.5 m tiles *vs* 1.5 m tiles, 0.5 m tiles compared between sites, 1.5 m tiles compared between sites, and natural substrate compared between sites. (* = significant at P≤0.05, ** = significant at P≤0.01.)

VARIABLE	ANOVA TEST INTERACTION	F VALUE
Trichromatic Chl. "a"	0.5 m tile x natural substrate	55.40 **
Monochromatic Chl. "a"	0.5 m tile x natural substrate	41.30 **
Dry Weight	0.5 m tile x natural substrate	549.21 **
Ash Free Dry Weight	0.5 m tile x natural substrate	333.67 **
Autotrophic Index	0.5 m tile x natural substrate	24.02 **
Trichromatic Chl. "a"	1.5 m tile x natural substrate	255.31 **
Monochromatic Chl. "a"	1.5 m tile x natural substrate	116.93 **
Dry Weight	1.5 m tile x natural substrate	713.64 **
Ash Free Dry Weight	1.5 m tile x natural substrate	628.76 **
Autotrophic Index	1.5 m tile x natural substrate	21.16 **
Trichromatic Chl. "a"	0.5 m tile x 1.5 m tile	4.59 *
Monochromatic Chl. "a"	0.5 m tile x 1.5 m tile	1.39
Dry Weight	0.5 m tile x 1.5 m tile	4.06 *
Ash Free Dry Weight	0.5 m tile x 1.5 m tile	4.47 *
Autotrophic Index	0.5 m tile x 1.5 m tile	0.96
Trichromatic Chl. "a"	0.5 m tile + 1.5 m tile x site	12.24 **
Monochromatic Chl. "a"	0.5 m tile + 1.5 m tile x site	10.54 **
Dry Weight	0.5 m tile + 1.5 m tile x site	5.21 **
Ash Free Dry Weight	0.5 m tile + 1.5 m tile x site	5.09 **
Autotrophic Index	0.5 m tile + 1.5 m tile x site	9.27 **
Trichromatic Chl. "a"	0.5 m tile x site	26.38 **
Monochromatic Chl. "a"	0.5 m tile x site	16.04 **
Dry Weight	0.5 m tile x site	14.62 **
Ash Free Dry Weight	0.5 m tile x site	25.43 **
Autotrophic Index	0.5 m tile x site	4.64 **
Trichromatic Chl. "a"	1.5 m tile x site	15.79 **
Monochromatic Chl. "a"	1.5 m tile x site	7.0 **
Dry Weight	1.5 m tile x site	5.57 **
Ash Free Dry Weight	1.5 m tile x site	2.22 *
Autotrophic Index	1.5 m tile x site	5.94 **
Trichromatic Chl. "a"	natural substrate x site	3.13 *
Monochromatic Chl. "a"	natural substrate x site	1.26
Dry Weight	natural substrate x site	0.80
Ash Free Dry Weight	natural substrate x site	2.19
Autotrophic Index	natural substrate x site	0.73

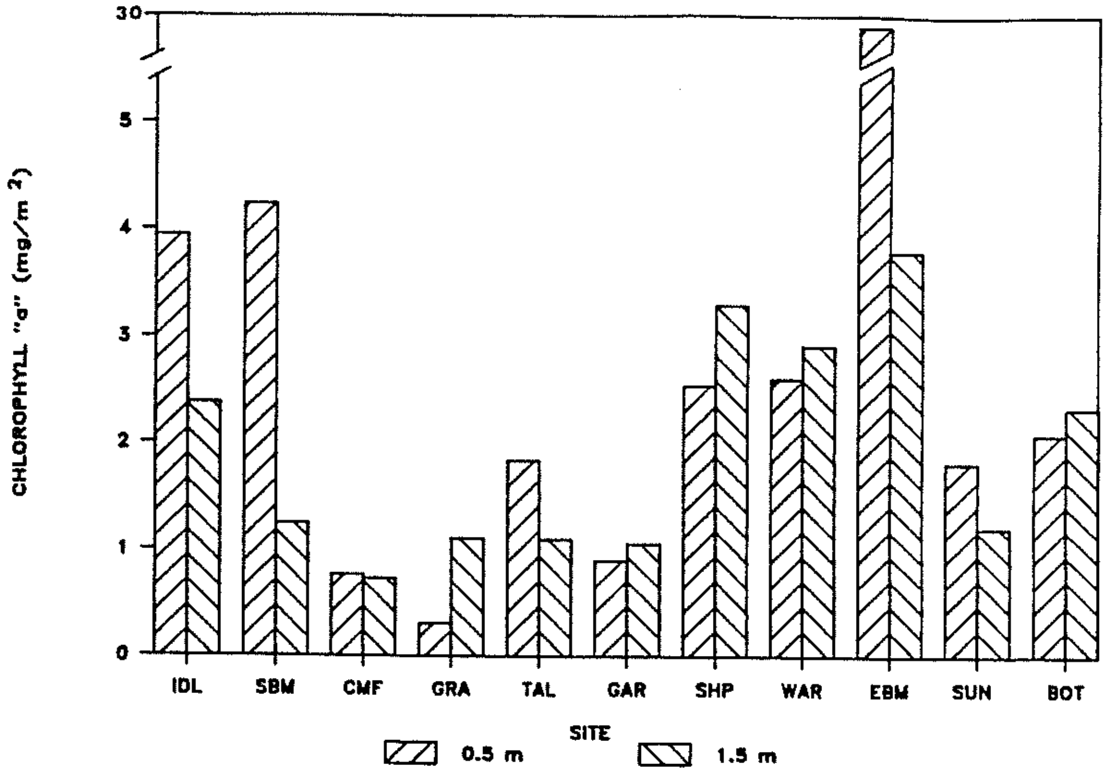

Figure 2. Artificial substrate mean trichromatic chlorophyll a at each site, Pend Oreille Lake, July-August, 1986.

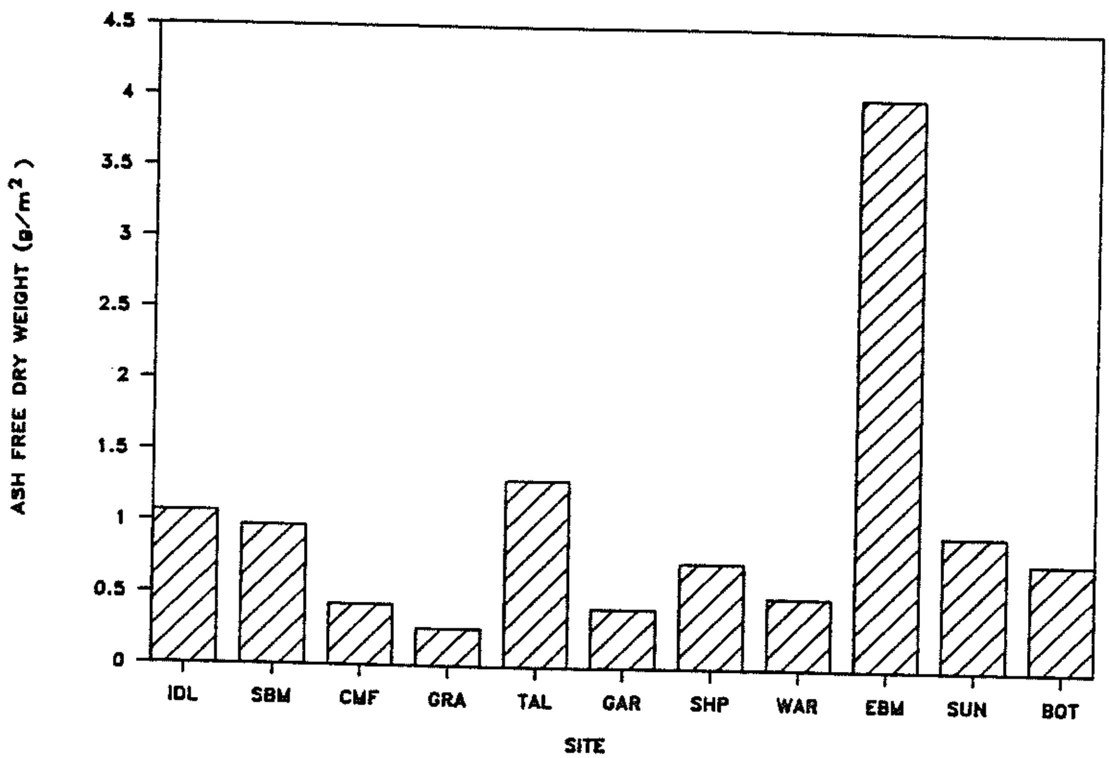

Figure 3. Artificial substrate mean ash free dry weight at each site, Pend Oreille Lake, July-August, 1986.

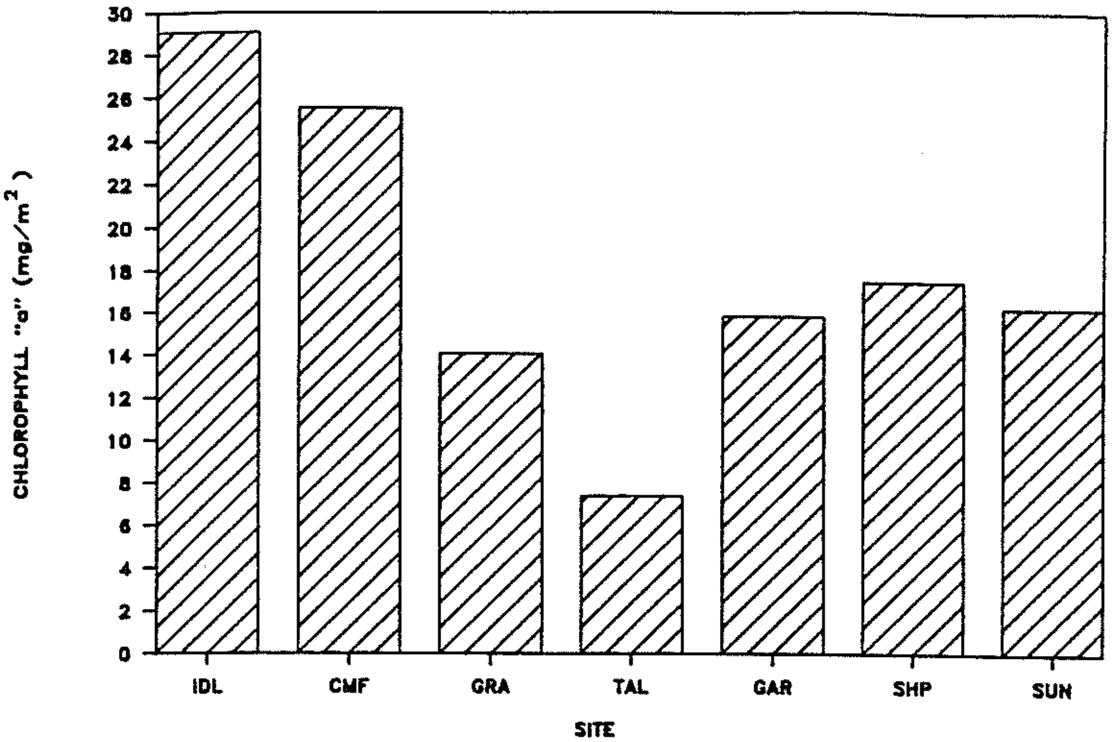

Figure 4. Natural substrate mean trichromatic chlorophyll a at each site, Pend Oreille Lake, July-August, 1986.

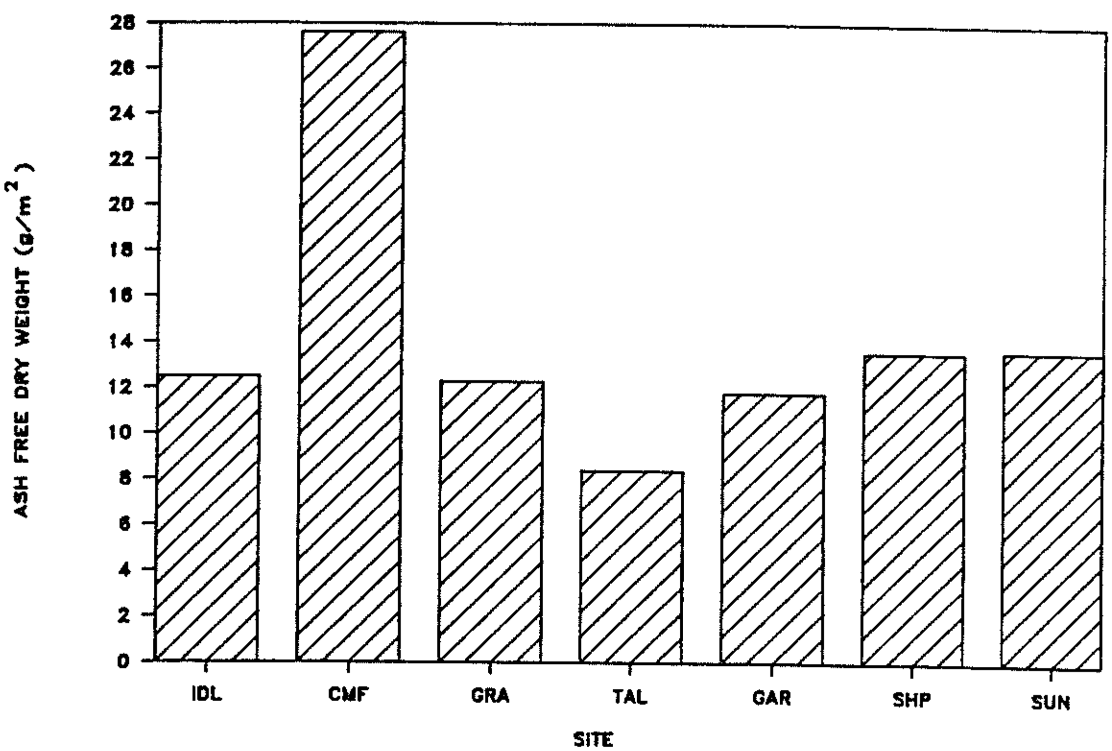

Figure 5. Natural substrate mean ash free dry weight at each site, Pend Oreille Lake, July-August, 1986.

trichromatic chlorophyll *a* averaged 5.27 mg/m^2 on all 0.5m tiles compared to 2.06 mg/m^2 on all 1.5m tiles (Table 2). Monochromatic chlorophyll *a* averaged 5.06 mg/m^2 on all 0.5m tiles compared to 2.25 mg/m^2 on all 1.5m tiles. Additional replication could show these means to be significantly different. Ash-free dry weights at the two depths were closer, averaging 1.16 and 0.76 g/m^2 and 44% and 39% LOI (Loss On Ignition) at the two depths. ANOVA tests performed on 0.5 m tiles and 1.5 m tiles combined for each site showed that significant differences ($p \leq 0.01$) existed between sites for all variables (Table 1).

ANOVA tests performed on 0.5m tiles and 1.5 m tiles separately also showed significant differences between sites for all variables (Table 1). Results of Duncan's New Multiple Range Test for combined and uncombined depths are shown in Tables 3, 4, and 5. Duncan's New Multiple Range Test showed that although differences occurred between sites, within-site variability caused overlap between means (Tables 4 and 5). Because less variability existed within a depth than between depths, and because lake-wide variability was least for the 0.5 m tiles, we will emphasize the 0.5 m tile data in further site comparisons. Although overlap between means does occur, trichromatic chlorophyll *a* for EBM was significantly higher than all other sites, and the four highest sites (EBM, SBM, IDL, and WAR) were significantly higher from the three lowest sites (GAR, CMF, and GRA) (Figure 2 and Table 4). North-lake mean chlorophyll *a* at 0.5 m was 7.6-fold greater than the mean of mid-lake sites; south-lake sites were 2.9-fold greater than the mean of mid-lake sites (Figure 2).

Ash-free dry weight appeared to be a better indicator of biomass than dry weight, probably because of interference from inorganic sand and silt. Mean ash free dry weight on 0.5m tiles at the south-lake sites was 1.2 times the mean of the mid-lake sites; north-lake ash-free dry weight was 2.1 times the mean of the mid-lake sites (Figure 3). Duncan's New Multiple Range Test showed that mean ash free dry weight of EBM was again significantly higher than all other sites (Tables 3-5).

Mean Autotrophic Indices ranged from 144 to 1,004 with a lake-wide mean of 430. Low values typified the chlorophyll-rich north-lake stations (EBM consistently had the lowest AI's) and higher values were found in south- and mid-lake sites.

Table 2. Lake-wide means of chlorophyll *a* and biomass on natural and artificial substrates, Pend Oreille Lake, July-August, 1986.

	Natural mg/m^2	Artificial mg/m^2 0.5m	Artificial mg/m^2 1.5m
Trichromatic Chlorophyll *a*	17.96	5.27	2.06
Monochromatic Chlorophyll *a*	18.31	5.06	2.25
Dry Weight	61,170	2,670	1,974
Ash Free Dry Weight	14,270	1,163	765
Loss-on-Ignition	23%	44%	39%

Table 3. Results of Duncan's New Multiple Range (D.M.R.) Test performed on means of 0.5 m tiles + 1.5 m tiles combined, contrasted by site for all variables. Sites connected by an unbroken vertical line are not significantly different at $P \leq 0.05$.

TRICHROMATIC CHLOROPHYLL "a"					MONOCHROMATIC CHLOROPHYLL "a"					DRY WEIGHT					ASH FREE DRY WEIGHT					AUTOTROPHIC INDEX	
n	Mean mgm^{-2}	Mean $l_{10}(x+1)$	Site	D.M.R.	n	Mean mgm^{-2}	Mean $l_{10}(x+1)$	Site	D.M.R.	n	Mean gm^{-2}	Mean $l_{10}(x+1)$	Site	D.M.R.	n	Mean gm^{-2}	Mean $l_{10}(x+1)$	Site	D.M.R.	Mean	Site
10	16.79	1.07	EBM		10	16.86	1.08	EBM		10	3.71	0.67	EBM		10	2.50	0.48	EBM		862	TAL
6	3.18	0.60	IDL		6	3.12	0.60	IDL		9	3.64	0.64	TAL		9	1.13	0.32	TAL		615	CMF
10	2.93	0.59	SHP		10	3.00	0.56	SHP		10	2.95	0.58	SUN		10	0.89	0.27	BOT		542	GAR
10	2.77	0.57	WAR		10	2.70	0.56	WAR		10	2.48	0.54	SHP		10	0.82	0.26	SHP		541	SUN
10	2.74	0.53	SBM		10	2.68	0.52	SBM		10	2.68	0.54	BOT		10	0.81	0.25	SUN		447	BOT
10	2.23	0.45	BOT		10	2.19	0.44	BOT		10	1.91	0.45	WAR		5	0.78	0.24	IDL		304	SBM
10	1.51	0.40	SUN		10	1.72	0.42	TAL		5	1.47	0.38	IDL		10	0.73	0.23	WAR		284	SHP
10	1.47	0.38	TAL		3	1.52	0.40	GAR		2	1.12	0.33	GAR		10	0.70	0.22	SBM		271	WAR
3	0.95	0.29	GAR		10	1.26	0.32	SUN		10	1.16	0.32	SBM		2	0.49	0.17	GAR		239	IDL
10	0.75	0.24	CMF		10	0.61	0.21	CMF		10	1.11	0.32	CMF		10	0.44	0.16	CMF		196	EBM
2	0.71	0.22	GRA		2	0.44	0.15	GRA		1	0.64	0.21	GRA		1	0.26	0.10	GRA			

Table 4. Results of Duncan's New Multiple Range (D.M.R.) Test performed on means of 0.5 m tiles contrasted by site for all variables. Sites connected by an unbroken vertical line are not significantly different at $P \leq 0.05$.

TRICHROMATIC CHLOROPHYLL "a"

n	Mean mgm^{-2}	Mean $l_{10}(x+1)$	Site	D.M.R.
5	29.77	1.47	EBM	
5	4.24	0.71	SBM	
3	3.95	0.68	IDL	
5	2.61	0.55	WAR	
5	2.55	0.55	SHP	
5	2.12	0.45	SUN	
5	1.84	0.45	TAL	
5	1.81	0.40	BOT	
2	0.90	0.28	GAR	
5	0.77	0.25	CMF	
1	0.31	0.12	GRA	

MONOCHROMATIC CHLOROPHYLL "a"

n	Mean mgm^{-2}	Mean $l_{10}(x+1)$	Site	D.M.R.
5	29.21	1.46	EBM	
5	4.20	0.70	SBM	
3	3.88	0.68	IDL	
5	2.54	0.54	WAR	
5	2.51	0.48	SHP	
5	1.78	0.43	TAL	
5	1.75	0.34	BOT	
5	1.29	0.32	SUN	
2	0.82	0.26	GAR	
5	0.62	0.21	CMF	
1	0.21	0.08	GRA	

DRY WEIGHT

n	Mean gm^{-2}	Mean $l_{10}(x+1)$	Site	D.M.R.
5	6.04	0.83	EBM	
5	4.45	0.72	TAL	
5	3.62	0.65	SUN	
5	2.23	0.51	SHP	
5	2.10	0.48	BOT	
3	2.01	0.48	IDL	
5	1.59	0.41	SBM	
5	1.45	0.38	WAR	
5	1.02	0.30	CMF	
1	0.98	0.30	GAR	
1	0.64	0.21	GRA	

ASH FREE DRY WEIGHT

n	Mean gm^{-2}	Mean $l_{10}(x+1)$	Site	D.M.R.
5	4.02	0.69	EBM	
5	1.31	0.36	TAL	
3	1.07	0.31	IDL	
5	0.97	0.29	SBM	
5	0.95	0.29	SUN	
5	0.76	0.24	BOT	
5	0.74	0.24	SHP	
5	0.50	0.18	WAR	
5	0.43	0.15	CMF	
1	0.42	0.15	GAR	
1	0.26	0.10	GRA	

AUTOTROPHIC INDEX

Mean	Site
749	TAL
597	CMF
527	SUN
396	BOT
291	SHP
285	IDL
252	SBM
202	WAR
144	EBM

Table 5. Results of Duncan's New Multiple Range (D.M.R.) Test performed on means of 1.5 m tiles contrasted by site for all variables. Sites connected by an unbroken vertical line are not significantly different at $P \leq 0.05$.

TRICHROMATIC CHLOROPHYLL "a"

n	Mean mgm^{-2}	Mean $l_{10}(x+1)$	Site	D.M.R.
5	3.81	0.67	EBM	
5	3.3	0.63	SHP	
5	2.92	0.59	WAR	
3	2.41	0.52	IDL	
5	2.33	0.51	BOT	
5	1.24	0.35	SBM	
5	1.21	0.34	SUN	
1	1.10	0.32	GRA	
5	1.10	0.32	TAL	
1	1.06	0.31	GAR	
5	0.73	0.24	CMF	

MONOCHROMATIC CHLOROPHYLL "a"

n	Mean mgm^{-2}	Mean $l_{10}(x+1)$	Site	D.M.R.
5	4.51	0.71	EBM	
5	3.49	0.65	SHP	
1	2.92	0.59	GAR	
5	2.85	0.58	WAR	
5	2.59	0.54	BOT	
3	2.36	0.52	IDL	
5	1.68	0.40	TAL	
5	1.16	0.33	SBM	
5	1.11	0.32	SUN	
1	0.67	0.22	GRA	
5	0.60	0.20	CMF	

DRY WEIGHT

n	Mean gm^{-2}	Mean $l_{10}(x+1)$	Site	D.M.R.
5	3.26	0.59	BOT	
5	2.73	0.58	SHP	
4	2.63	0.54	TAL	
5	2.37	0.52	WAR	
5	2.29	0.51	SUN	
1	1.26	0.35	GAR	
5	1.38	0.34	EBM	
5	1.20	0.34	CMF	
5	0.74	0.24	SBM	
2	0.67	0.22	IDL	

ASH FREE DRY WEIGHT

n	Mean gm^{-2}	Mean $l_{10}(x+1)$	Site	D.M.R.
5	1.01	0.30	BOT	
5	0.97	0.29	WAR	
4	0.94	0.28	TAL	
5	0.90	0.28	SHP	
5	0.98	0.26	EBM	
5	0.67	0.22	SUN	
1	0.57	0.20	GAR	
5	0.46	0.16	CMF	
5	0.43	0.15	SBM	
2	0.35	0.13	IDL	

AUTOTROPHIC INDEX

n	Mean	Mean $l_{10}(x+1)$	Site
4	1004	2.95	TAL
5	633	2.80	CMF
5	554	2.74	SUN
1	538	2.73	GAR
5	488	2.64	BOT
5	356	2.53	SBM
5	339	2.52	WAR
5	276	2.44	SHP
5	247	2.30	EBM
2	171	2.24	IDL

Natural Substrate

ANOVA tests performed on natural substrate showed that a significant difference existed between sites only for trichromatic chlorophyll *a*, and then only at the $p \leq 0.05$ level of significance. With only three replicate rocks collected at a site, variation was too great to show statistically significant differences between sites (Appendix Table 1). Duncan's test showed only that natural substrate trichromatic chlorophyll *a* at IDL and CMF (south-lake) were significantly higher than TAL (mid-lake) (Table 6). A comparison of mean trichromatic chlorophyll *a* at all sites does, however, reveal trends (Figure 4). South-lake natural substrate had twice the chlorophyll of mid-lake natural substrate, and 1.6 times north-lake sites. Ash free dry weight expressed a similar trend. Mean ash-free dry weight for south-lake sites were again twice those of mid-lake sites, and 1.5 times those at north-lake sites (Figure 5).

Periphyton Composition

Percent composition (by biovolume) of the dominant genera for both artificial and natural substrate are shown in Tables 7-9 and Appendix Table 2. On artificial substrate, *Cymbella*, *Rhizoclonium*, and *Mougeotia* were equally dominant by mean percent composition for a site (Table 7). On natural substrate, *Cymbella* was the chief dominant (~50%), with *Mougeotia* second at 12.6% (Table 7). A comparison of artificial substrate with natural substrate (only for sites where data exists for both) reveals that *Cymbella* accounts for 59% of the composition on natural substrate, and only 27.6% of the composition on the artificial substrate (Table 8). Filamentous green algae (*Mougeotia*, *Spirogyra*, and *Rhizoclonium*) comprised 49% of the composition on artificial substrate, but only 7.2% (*Mougeotia* only) on the natural substrate. *Cymbella* composition at south-lake sites is less than both mid- and north-lake sites on artificial substrate (Table 9). However, the filamentous greens *Mougeotia* and *Rhizoclonium* comprised a higher percent composition at south-lake sites than at either mid- or north-lake sites. On natural substrate, *Cymbella* percent composition at south-lake sites was greater than at either mid- or north-lake sites (Table 9).

Table 6. Results of Duncan's New Multiple Range (D.M.R.) Test performed on means of natural substrate contrasted by site for trichromatic chlorophyll "a". Sites connected by an unbroken vertical line are not significantly different at $P \leq 0.05$.

n	Mean mgm^{-2}	Mean $\log_{10}(x+1)$	Site	D.M.R.	
3	29.08	1.45	IDL	┃	
3	25.59	1.40	CMF	┃	
3	17.49	1.24	SHP	┃	┃
3	16.24	1.24	SUN	┃	┃
3	15.87	1.19	GAR	┃	┃
3	14.09	1.16	GRA	┃	┃
3	7.38	0.92	TAL		┃

Table 7. Lake-wide mean percent composition of the dominant algal genera on artificial and natural substrates, Pend Oreille Lake, July-August 1986.

Artificial Substrate		Natural Substrate	
Genus	Percent Composition	Genus	Percent Composition
Mougeotia	27.5	*Cymbella*	50.0
Cymbella	21.6	*Mougeotia*	12.6
Rhizoclonium	20.0	*Other*	10.6
Spirogyra	6.0	*Navicula*	7.6
Other	6.0	*Rhopalodia*	7.5
Navicula	5.7	*Bulbochaete*	5.9
Synedra	5.0	*Synedra*	4.1
Rhopalodia	4.6	*Cyclotella*	1.4
Fragilaria	1.8	*Gomphonema*	0.3
Gomphonema	1.0		
Zygnema	0.6		
Cyclotella	0.2		

Table 8. Lake-wide (only sites where data for both artificial and natural substrate exist) mean percent composition of the dominant algal genera on artificial and natural substrates, Pend Oreille Lake, July-August 1986.

Genus	Artificial Substrate	Natural Substrate
Cymbella	27.6	59.0
Rhizoclonium	24.1	0.0
Spirogyra	13.5	0.0
Mougeotia	11.4	7.2
Synedra	8.8	2.9
Other	5.0	7.7
Rhopalodia	4.9	9.4
Navicula	2.7	6.1
Fragilaria	2.0	0.0
Gomphonema	0.0	0.4
Bulbochaete	0.0	7.3

Table 9. Comparison of south-lake, mid-lake, and north-lake mean percent composition of the dominant algal genera on artificial and natural substrates, Pend Oreille Lake, July-August 1986.

Genus	South-lake	Mid-lake	North-lake
<u>Artificial Substrate</u>			
Cymbella	9.2	24.6	28.5
Rhopalodia	1.8	6.1	6.0
Mougeotia	40.9	28.1	19.3
Fragilaria	0.1	4.6	2.3
Synedra	5.3	3.6	5.1
Other	8.0	7.4	4.5
Navicula	2.7	16.9	5.2
Spirogyra	0.0	0.0	10.8
Rhizoclonium	32.1	0.0	16.8
Gomphonema	0.0	8.7	0.0
Zygnema	0.0	0.0	1.2
Cyclotella	0.0	0.0	0.3
<u>Natural Substrate</u>			
Cymbella	70.3	14.0	47.7
Mougeotia	14.3	34.4	0.0
Rhopalodia	4.1	0.0	14.7
Synedra	5.8	8.9	0.0
Navicula	3.4	13.6	8.8
Other	1.4	22.2	14.1
Gomphonema	0.8	0.0	0.0
Cyclotella	0.0	7.0	0.0
Bulbochaete	0.0	0.0	14.7

DISCUSSION

The spatial and temporal heterogeneity of periphyton distribution is well documented. Subtle differences in substrate and conditions of the microhabitat can greatly influence periphyton development, especially colonization rates (Wetzel 1983). Periphyton growth around a very large lake basin such as Pend Oreille cannot be expected to be homogeneous between sites. Some of the major factors (either limiting or essential) affecting growth and thereby causing between-site variation are water chemistry localized nutrient loading, light availability (solar radiation, water transparency, and turbidity), substrate (type, condition, location, and depth), and water movements (currents and wave action)(Weitzel 1979). Weitzel concluded that, on a global basis, energy variables control periphyton growth and distribution while in a specific water body, nutrient variables are more important. This conclusion basically agrees with that of Brylinsky and Mann (1973) on phytoplankton controlling factors.

Between-site variability can be especially enhanced by shading, water movement restriction, and heterogeneous recruitment from adjacent surfaces such as underwater structures. Wave action can severely limit colonization of near-surface substrate (Austin et al. 1981). In this study, we observed that the three sites of lowest productivity on artificial substrate (CMF, GAR, and GRA) were the most exposed to wave action with fetches of 3 to 10 miles. Our four highest productivity sites (EBM, IDL, SHP, and WAR) were only moderately exposed to strong wave action. These sites had higher growth at the 0.5 m depth that at the 1.5 m depth, while the more exposed sites showed little difference between depths. This suggests that, with calmer water, the higher light available at 0.5 m provides better growth than the deeper 1.5 m tiles, but intense wave action can remove the shallow water high growth advantage. Austin *et al* 1981 cautioned against too-rapid retrieval of artificial substrates through the water, thereby further emphasizing the susceptibility of periphyton cells to slough off. Despite these tendencies, we believe that the 0.5 m tiles better serve the purposes of this study by depicting maximal growth attainable in different regions of the lake. Future work with periphyton growth on exposed lakeshores should further address the problem of variation in aspect and wave exposure.

Artificial substrates do not duplicate growth rates or generic composition found on natural substrate (Brown and Austin 1973, Weitzel 1979, Robinson 1983, Wetzel 1983). We observed greater periphyton growth on the nylon lines, perhaps because of resilience to the strong wave action. Austin et al. (1981) also observed that colonization was better on oval braided nylon line. Differences in surface porosity, sloughing, and submergence time will ensure outcomes different from artificial substrate. Even unglazed tiles are relatively smooth compared to natural granite or wood substrate and have fewer microspaces to aid periphyton attachment. For this reason, we also sampled natural rock substrates for comparison with artificial substrate at seven of the 12 sites. We observed major differences in generic composition between natural and artificial substrate, and highly significant differences in dry weight, ash-free dry weight, and chlorophyll *a* between natural and artificial substrate ($p \leq 0.01$). Artificial substrates provide uniform substrate between sites, thereby reducing within-site variability and permitting better separation of site means to reflect ambient growth conditions (Sladeckova 1962).

Our incubation time of 30 days is well supported by the literature (Brown and Austin 1971, Brown 1973, APHA 1985, Biggs 1985). Austin et al. (1985) observed that short incubation times produced unstable growth, while excessively long periods resulted in cell loss from sloughing and grazing.

For reasons cited above, periphyton in Pend Oreille Lake showed great spatial heterogeneity between sites. Three replicates were often not enough to show statistical differences due to variability within replicates. Even when mean chlorophyll *a* and ash-free dry weight of some sites were two-fold other sites, Duncan's mean separation tests were unable to separate adjacent ranked means. Certain trends were still evident without the use of inferential statistics, however.

We concluded, as in stream channels, dry weight of the periphyton community on natural substrate was a consistently biased estimate because of wave action washing silts and sands onto the rock periphyton community. This would not have been a problem with the tiles, since they were always suspended 2 to 4 m above the bottom, but ash-free dry weight was used to make comparisons between the two substrates. In fact, we observed a mean of 23% ash-free dry weight on natural substrate (which was in the wave-washed shore zone of the lake) compared to a mean of 42% ash-free dry weight on tiles suspended over deeper water at those same sites. Stockner and Armstrong (1971) found a mean of 51% ash-free dry weight on glass slides (30-day incubation) in the Experimental Lakes Area in Canada.

Müller (1983) found a mean of 44% ash free dry weight on natural substrate (dominated by *Cladophora*) in shallow, eutrophic Lake Krageholmssjon in Sweden, and mean dry weights (~500 g/m^2) eight times those in Lake Pend Oreille (61.2 g/m^2). Mean annual chlorophyll *a* on natural substrate in oligotrophic Lake Tahoe was 14 mg/m^2 (Reuter et al. 1983) even though accelerated eutrophication has become a problem over the past 20 years in that lake (Loeb et al. 1983). The natural substrate mean chlorophyll *a* of diatom-dominated communities in Pend Oreille Lake was 18 mg/m^2, or 22% higher than the Lake Tahoe mean. Pend Oreille's mean ash-free dry weight accrual rate of 39 mg/m^2/day on artificial substrate is 31% higher than that for the small, shallow lake 240 (~27 mg/m^2/day on glass slides) of the Experimental Lakes Area (Stockner and Armstrong 1971). Kettunen (1983) found that periphyton on artificial substrate in waters of Lake Saimaa (Finland) polluted with pulping effluents developed 20-40 mg chlorophyll *a*/m^2 in three weeks, compared to 0.5-2.0 mg/m^2 in unpolluted areas of the same lake. Although only one site in Pend Oreille Lake showed chlorophyll values in the range found in polluted areas of Lake Saimaa (0.5 m tiles at EBM had 29.8 mg/m^2 per 30 days), the lake-wide average of 5.27 mg/m^2 is greater than the maximum value of 2.0 mg/m^2 found in unpolluted areas of Lake Saimaa.

A shallow cooling water pond considered to "mildly eutrophic" in central Finland developed periphytic growths of 2 g/m^2 AFODW and 2.5 mg/m^2 chlorophyll *a* in four weeks (Eloranta 1982). These chlorophyll values are less than the Pend Oreille Lake average even though the Finland values were obtained from depths of 0.2 m rather than the 0.5 and 1.5 m depths in Pend Oreille. The Finnish cooling pond study also showed significantly greater periphyton accumulations at shallower depths.

Because Lake Saimaa and the above cooling water pond are both shallow (mean depths = 5.0 and 3.8 m, respectively), the artificial substrate chlorophyll *a* values found in Pend Oreille Lake (between those of unpolluted and polluted values found in Lake Saimaa and higher than the cooling pond) seem to indicate increased nutrient loading to Pend Oreille, especially when Pend Oreille's high mean depth ($\bar{Z}$ = 380 m) and large volume are considered. Chlorophyll *a* concentrations on natural substrates in Pend Oreille Lake were similar to values obtained in Lake Tahoe (also a lake where changing lake trophic status is of concern), again suggesting increased nutrient loading. Austin et al. (1985) noted that *Navicula* and *Synedra* dominance occurred with heavy metal pollution. These taxa in Pend Oreille Lake were generally 10-12% of the composition, suggesting little metals pollution in the lake.

Although no previous periphyton data exists on either artificial or natural substrate in Pend Oreille Lake for comparison, it is evident from visual observations of increased growth on submersed objects that periphyton biomass and distribution have increased over the last decade. Our data on both artificial and natural substrates suggest an increase in the rate of eutrophication when compared to other lentic systems of varying trophic status. With only one season of data, definitive conclusions would be premature. However, our data indicates concern for changing trophic status in Pend Oreille Lake and the need for continued monitoring and study. Because changes in trophic status would first show up in littoral areas and embayments (especially in deep lakes with large profundal areas), periphyton monitoring in Pend Oreille Lake should provide excellent refinement and early warning of eutrophication for any in-depth limnological studies undertaken.

CONCLUSIONS

1. Natural substrate means for all variables (trichromatic chlorophyll *a*, monochromatic chlorophyll *a*, dry weight, and ash-free fry weight) were higher than those of the artificial substrate. Mean trichromatic chlorophyll *a* and mean ash-free dry weights on the natural substrate were 240% and 1,128% higher, respectively, than the artificial substrate means (18.0 and 14,270 mg/m^2 compared to 3.7 and 964 mg/m^2).

2. Means for all variables were higher on the 0.5 m tile than on the 1.5 m tile; exposed sites (CMF, GAR, and GRA) however, showed less difference between depths than did the more sheltered sites (EBM, IDL, SHP, and WAR). Lakewide mean trichromatic chlorophyll *a* and mean ash free dry weight of 0.5 m tiles were 156% and 52% higher, respectively, than 1.5 m tile means.

3. Analytical monochromatic chlorophyll *a* and pheophytin variability within replicates suggests that inherent problems with that method may preclude its use in comparative studies. Trichromatic chlorophyll a measures provided less variability and were therefore used to make comparisons between sites.

4. Due to inorganic interference, especially on the wave-washed natural substrates, ash-free dry weight provided a better measure of periphyton biomass than did dry weight.

5. Artificial substrate (0.5 m) trichromatic chlorophyll *a* for EBM was significantly higher than all other sites, and the four highest sites (EBM, SBM, IDL, and WAR .... two north and two south sites) were significantly different from the three lowest sites (GAR, CMF, and GRA). Artificial substrate (0.5 m) south-lake mean trichromatic chlorophyll *a* was 2.9-fold greater than the mean of mid-lake sites; north-lake sites were 7.6-fold greater than the mean of mid-lake sites.

6. Natural substrate periphyton variance within sites was high due to the inherently high spatial heterogeneity of periphyton in natural systems. Three replicates on the natural substrate were not enough to show statistically significant differences between sites. Trichromatic chlorophyll *a* was shown to be significantly different ($p \leq 0.05$) between sites. Duncan's test, however, showed only that IDL and CMF (south-lake sites) were significantly higher than TAL. Despite high variability, certain non-statistical trends are apparent. South-lake natural substrate had twice the chlorophyll of mid-lake natural substrate, and 1.6 times the north-lake sites. Mean ash-free dry weights for south-lake sites were twice those of mid-lake sites, and 1.5 times those at north-lake sites

7. *Cymbella* was the chief dominant (~50% by biovolume) on the natural substrate, while *Cymbella*, *Mougeotia*, and *Rhizoclonium* were equally dominant (21.6%, 27.5%, and 20.0%, respectively) on the artificial substrates. *Cymbella* composition at south-lake sites was ~3 times less than both mid- and north-lake sites on artificial substrates. The

filamentous green algae *Mougeotia* and *Rhizoclonium*, however, comprised a greater percent composition at south-lake sites than at either mid- or north-lake sites (2.6 times higher than mid-lake sites, and 2.0 times higher than north lake site). *Cymbella* percent composition on natural substrate was five times higher at south-lake sites than mid-lake sites, and 1.5 times higher than north-lake sites. Blue-green algae biomass comprised only a small part of the total biomass on either artificial or natural substrates.

8. Values of chlorophyll *a* and ash-free dry weight were comparable to other lakes showing accelerated eutrophication. They also were similar to more shallow lakes, showing moderate littoral periphyton growth despite Pend Oreille's deep nature and large profundal area.

9. Our data suggest accelerating eutrophication of Pend Oreille Lake. Algae growths are significantly greater in developed and relatively confined bays. Continued monitoring and study of attached algae are therefore, warranted in the near future.

10. Given that changes in lake tropic status would first show up in littoral areas (compared to the relatively slow changes in the phytoplankton of pelagic areas), periphyton monitoring should provide valuable refinement to in-depth limnological studies on open waters of the lake.

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Appendix Table 1. Chlorophyll "a" and biomass data for all sites and all depths in the littoral zone of Pend Oreille Lake, July-August, 1986.

SITE	DEPTH	TRICHROMATIC CHL a (mg/m2)	MONOCHROMATIC CHL a (mg/m2)	PHEOPHYTON (mg/m2)	DRY WEIGHT (mg/m2)	ASH FREE DRY WEIGHT (mg/m2)
EBM	0.50	21.38	20.18	1.29	6742.29	4788.53
EBM	0.50	18.06	16.82	1.50	4397.77	2865.53
EBM	0.50	34.92	37.28	-5.09	3761.90	2689.12
EBM	0.50	39.44	38.67	0.02	8018.14	5341.32
EBM	0.50	35.05	33.12	1.98	7283.81	4427.52
	mean	29.77	29.21	-0.06	6040.78	4022.40
	S.D.	8.43	9.00	2.60	1663.73	1058.93
	± 95 %	9.69	10.35	2.99	1912.93	1217.54
EBM	1.50	3.61	3.64	-0.17	814.33	461.52
EBM	1.50	3.80	3.68	0.14	1182.52	698.43
EBM	1.50	4.94	8.49	-6.19	3633.70	2836.81
EBM	1.50	4.73	4.75	-0.21	542.54	382.55
EBM	1.50	1.97	2.01	-0.14	708.69	532.29
	mean	3.81	4.51	-1.31	1376.36	982.32
	S.D.	1.05	2.17	2.44	1148.05	933.08
	± 95 %	1.21	2.50	2.81	1320.01	1072.84
GAR	Rock	20.31	19.16	1.42	95553.20	19311.54
GAR	Rock	20.22	20.57	-1.70	26388.30	4762.99
GAR	Rock	7.07	5.78	2.02	72663.77	11286.70
	mean	15.86	15.17	0.58	64868.43	11787.08
	S.D.	6.22	6.66	1.63	28769.44	5949.95
	± 95 %	11.43	12.24	2.99	52853.17	10930.83
GAR	0.50	1.04	1.01	-0.01		
GAR	0.50	0.76	0.63	0.18	984.58	415.37
	mean	0.90	0.82	0.09		
	S.D.	0.14	0.19	0.09		
	± 95 %	0.42	0.58	0.29		
GAR	1.50	1.06	2.92	-3.19	1264.56	570.23
WAR	0.50	2.60	2.56	-0.07	2233.76	670.74
WAR	0.50	3.76	3.72	-0.13	1520.96	558.95
WAR	0.50	2.50	2.36	0.09	916.89	321.01
WAR	0.50	2.50	2.41	0.00	1309.69	484.08
WAR	0.50	1.69	1.67	-0.07	1283.03	481.01
	mean	2.61	2.55	-0.04	1452.86	503.16

	S.D.	0.66	0.66	0.07	436.13	114.22
	± 95 %	0.76	0.76	0.09	501.46	131.33
WAR	1.50	3.44	3.43	-0.16	2934.24	1144.57
WAR	1.50	2.79	2.79	-0.15	2377.34	1061.50
WAR	1.50	3.27	3.30	-0.21	1858.39	772.28
WAR	1.50	2.92	3.05	-0.37	2378.37	958.94
WAR	1.50	2.16	1.67	0.76	2293.24	904.58
	mean	2.92	2.85	-0.03	2368.32	968.37
	S.D.	0.44	0.63	0.40	342.38	128.32
	± 95 %	0.51	0.72	0.46	393.66	147.54
BOT	0.50	4.68	4.70	-0.25	2418.36	891.25
BOT	0.50	0.14	-3.32	5.42	1142.52	405.11
BOT	0.50	3.11	2.99	0.08	2751.68	1033.80
BOT	0.50	2.65	1.22	2.15	1769.16	663.56
BOT	0.50	0.00	-6.34	9.70	2428.62	810.22
	mean	2.12	-0.15	3.42	2102.07	760.79
	S.D.	1.80	4.09	3.73	576.24	214.46
	± 95 %	2.07	4.70	4.29	662.55	246.58
BOT	1.50	2.89	2.66	0.27	1126.11	627.67
BOT	1.50	3.40	3.41	-0.19	5478.76	1648.14
BOT	1.50	1.10	1.07	0.01	3910.61	1043.04
BOT	1.50	2.45	3.79	-2.36	4249.06	1186.62
BOT	1.50	1.79	2.01	-0.43	1536.35	555.88
	mean	2.33	2.59	-0.54	3260.18	1012.27
	S.D.	0.81	0.98	0.94	1664.26	397.97
	± 95 %	0.93	1.12	1.08	1913.55	457.58
SUN	Rock	15.83	15.43	0.16	43600.52	13645.62
SUN	Rock	15.07	14.21	0.85	67539.61	14943.59
SUN	Rock	17.81	0.28	29.64	44932.35	12516.95
	mean	16.24	9.97	10.22	52024.16	13702.05
	S.D.	1.15	6.87	13.74	10984.54	991.48
	± 95 %	2.12	12.63	25.24	20180.02	1821.47
SUN	0.50	1.42	1.88	-0.87	3554.73	947.65
SUN	0.50	1.97	-0.53	4.22	5146.46	1305.59
SUN	0.50	1.74	0.69	1.73	2168.12	583.57
SUN	0.50	1.86	1.54	0.47	4213.16	1032.78
SUN	0.50	2.08	2.36	-0.55	3022.44	865.61
	mean	1.82	1.19	1.00	3620.98	947.04
	S.D.	0.23	1.02	1.85	1015.01	234.37

	± 95 %	0.26	1.17	2.12	1167.04	269.48
SUN	1.50	1.49	1.40	0.11	2558.87	907.66
SUN	1.50	1.21	2.41	-2.06	2122.99	547.67
SUN	1.50	0.82	-0.63	2.44	1565.07	523.06
SUN	1.50	1.38	1.30	0.07	2707.58	677.92
SUN	1.50	1.16	1.05	0.14	2478.88	670.74
	mean	1.21	1.11	0.14	2286.68	665.41
	S.D.	0.23	0.98	1.42	408.83	136.38
	± 95 %	0.26	1.13	1.64	470.07	156.81
SHP	0.50	2.28	-0.09	3.91	2214.27	727.15
SHP	0.50	2.46	1.53	1.47	1952.74	610.23
SHP	0.50	2.74	2.76	-0.17	2346.57	750.74
SHP	0.50	2.81	3.32	-0.98	2498.36	894.32
SHP	0.50	2.44	4.94	-4.35	2122.99	725.10
	mean	2.55	2.49	-0.02	2226.99	741.51
	S.D.	0.20	1.69	2.73	186.62	90.72
	± 95 %	0.23	1.94	3.14	214.57	104.30
SHP	Rock	10.49	9.54	1.28	38668.23	10507.92
SHP	Rock	16.13	15.15	1.27	61749.54	17471.81
SHP	Rock	25.87	53.31	-47.69	42799.17	12799.12
	mean	17.49	26.00	-15.05	47738.98	13592.95
	S.D.	6.35	19.45	23.08	10049.48	2897.88
	± 95 %	11.67	35.73	42.41	18462.18	5323.78
SHP	1.50	2.83	2.70	0.10	2514.77	795.87
SHP	1.50	3.45	4.45	-1.85	3384.48	1148.67
SHP	1.50	2.92	3.01	-0.31	2357.85	745.61
SHP	1.50	4.07	3.90	0.07	2559.90	859.45
SHP	1.50	3.24	3.37	-0.40	2816.30	974.32
	mean	3.30	3.49	-0.48	2726.66	904.78
	S.D.	0.44	0.63	0.71	360.41	143.92
	± 95 %	0.51	0.72	0.82	414.40	165.48
SBM	0.50	2.36	2.22	0.16	1601.99	1033.80
SBM	0.50	5.01	4.98	-0.12	1970.18	1205.08
SBM	0.50	5.15	5.33	-0.47	1309.69	791.76
SBM	0.50	5.10	4.94	0.11	1645.06	1030.73
SBM	0.50	3.59	3.53	-0.01	1411.23	812.28
	mean	4.24	4.20	-0.07	1587.63	974.73
	S.D.	1.11	1.17	0.22	227.25	154.63
	± 95 %	1.27	1.34	0.26	261.29	177.79

SBM	1.50	1.01	0.93	0.10	907.66	624.59
SBM	1.50	1.65	1.45	0.28	816.38	451.26
SBM	1.50	1.44	1.45	-0.07	919.96	538.44
SBM	1.50	0.94	0.86	0.10	477.93	254.35
SBM	1.50	1.14	1.11	0.00	577.41	282.04
	mean	1.24	1.16	0.08	739.87	430.14
	S.D.	0.27	0.25	0.12	179.69	143.40
	± 95 %	0.31	0.29	0.13	206.61	164.88
IDL	Rock	22.91	21.64	1.05	85135.58	16365.72
IDL	Rock	19.80	18.46	1.30	22753.99	10440.20
IDL	Rock	44.53	43.61	-0.92	32313.82	10790.09
	mean	29.08	27.90	0.48	46734.46	12532.00
	S.D.	11.00	11.18	0.99	27432.73	2714.61
	± 95 %	20.21	20.54	1.82	50397.45	4987.08
IDL	0.50	2.46	2.41	-0.01	1767.11	791.76
IDL	0.50	4.11	4.07	-0.07	2399.90	1358.92
IDL	0.50	5.28	5.15	0.01	1874.80	1067.65
	mean	3.95	3.88	-0.03	2013.94	1072.78
	S.D.	1.15	1.13	0.03	276.44	231.57
	± 95 %	2.12	2.07	0.06	507.85	425.42
IDL	1.50	2.49	2.45	-0.02	695.36	408.19
IDL	1.50	1.59	1.53	0.04	636.90	284.09
IDL	1.50	3.16	3.09	0.02		
	mean	2.41	2.36	0.02	666.13	346.14
	S.D.	0.64	0.64	0.03	29.23	62.05
	± 95 %	1.18	1.18	0.05	88.94	188.79
TAL	Rock	6.77	8.89	-3.93	59864.66	9074.51
TAL	Rock	7.43	7.39	-0.37	36817.22	6410.85
TAL	Rock	7.94	11.04	-5.88	75846.62	9672.70
	mean	7.38	9.11	-3.39	57509.50	8386.02
	S.D.	0.48	1.50	2.28	16020.48	1417.85
	± 95 %	0.89	2.76	4.19	29431.68	2604.77
TAL	0.50	2.70	2.61	0.00	4716.73	1371.23
TAL	0.50	1.45	1.36	0.06	4158.81	1315.84
TAL	0.50	1.64	1.68	-0.17	1938.38	611.26
TAL	0.50	1.55	1.37	0.21	6631.53	1940.44
TAL	0.50	1.84	1.73	0.08	4797.76	1304.56

	mean	1.84	1.75	0.04	4448.64	1308.67
	S.D.	0.45	0.45	0.12	1506.26	421.78
	± 95 %	0.52	0.52	0.14	1731.88	484.96
TAL	1.50	0.83	0.68	0.19	1164.06	411.27
TAL	1.50	0.85	0.77	0.10	3403.97	1266.62
TAL	1.50	1.49	3.51	-3.52	2611.18	864.58
TAL	1.50	0.85	2.04	-2.08	3334.23	1225.59
TAL	1.50	1.51	1.40	0.11		
	mean	1.10	1.68	-1.04	2628.36	942.01
	S.D.	0.32	1.04	1.51	900.60	344.05
	± 95 %	0.37	1.19	1.73	1035.49	395.58
GRA	0.50	0.31	0.21	0.12	639.97	263.58
GRA	1.50	1.10	0.67	0.56		
GRA	rock	15.07	25.35	-17.46	185090.59	19097.10
GRA	rock	8.05	7.64	0.37	71523.82	6726.87
GRA	rock	19.16	17.84	2.24	57550.88	11027.11
	mean	14.09	16.95	-4.95	104721.76	12283.69
	S.D.	4.59	7.26	8.88	57114.93	5127.69
	± 95 %	8.43	13.33	16.31	104927.46	9420.23
CMF	rock	38.15	32.02	8.04	41568.92	18340.89
CMF	rock	23.88	22.45	0.94	38521.51	19650.14
CMF	rock	14.75	14.71	-0.69	83657.02	44808.20
	mean	25.59	23.06	2.76	54582.48	27599.74
	S.D.	9.63	7.08	3.79	20596.41	12179.95
	± 95 %	17.69	13.00	6.96	37838.26	22376.13
CMF	0.50	0.90	0.86	0.03	976.37	421.52
CMF	0.50	0.79	0.71	0.10	611.26	247.17
CMF	0.50	0.57	0.33	0.35	1586.60	682.02
CMF	0.50	0.83	0.53	0.41	1213.28	505.62
CMF	0.50	0.74	0.66	0.10	693.31	296.40
	mean	0.77	0.62	0.20	1016.16	430.55
	S.D.	0.11	0.18	0.15	356.10	155.29
	± 95 %	0.13	0.20	0.18	409.44	178.56
CMF	1.50	0.91	0.81	0.13	1076.88	492.29

CMF	1.50	0.72	0.58	0.21	1342.51	467.67
CMF	1.50	0.73	0.62	0.16	1828.64	521.00
CMF	1.50	0.69	0.58	0.16	855.35	409.21
CMF	1.50	0.60	0.43	0.28	886.12	405.11
	mean	0.73	0.60	0.19	1197.90	459.06
	S.D.	0.10	0.12	0.05	359.98	45.63
	± 95 %	0.12	0.14	0.06	413.91	52.46

Appendix Table 2. Occurrence and percent composition of dominant algae genera on tiles and rocks in the littoral zone of Lake Pend Oreille, July-August, 1986.

SHEEPHERDER TILE		SHEEPHERDER ROCKS		CMF TILE		CMF ROCKS	
GENUS	PERCENT COMPOSITION	GENUS	PERCENT COMPOSITION	GENUS	PERCENT COMPOSITION	GENUS	PERCENT COMPOSITION
CYMBELLA	71.1	CYMBELLA	47.3	MOUGEOTIA	36.1	CYMBELLA	91.9
RHOPALODIA	10.2	BULBOCHAETE	29.4	CYMBELLA	22.6	SYNEDRA	4.0
MOUGEOTIA	5.4	RHOPALODIA	7.8	SYNEDRA	15.8	NAVICULA	1.9
FRAGILARIA	5.3	OTHER	15.5	NAVICULA	8.0	GOMPHONEMA	1.6
SYNEDRA	4.4	UNK. COLONIAL BALL		RHOPALODIA	5.5	OTHER	0.6
OTHER	3.6	FRAGILARIA		OTHER	12.0	MOUGEOTIA	
NAVICULA		NAVICULA		PERIDINIUM		CYCLOTELLA	
COCCONEIS		COCCONEIS		ZYGNEMA		UNK EUG	
GOMPHONEMA		SYNEDRA		DIATOMA		OOCYSTIS	
PEDIASTRUM		ULOTHRIX		GOMPHONEMIA		SCENEDESMUS	
SCENEDESMUS		DIATOMA		FRAGILARIA		PEDIASTRUM	
MELOSIRA		SCENEDESMUS		CYCLOTELLA			
DIATOMA		OOCYSTIS		OOCYSTIS			
ANABAENA		CYCLOTELLA		COCCONEIS			
SPIROGYRA		SCHRODERIA		ASTERIONELLA			
CLOSTERIUM		ANKISTRODESMUS		DINOBRYON			
ULOTHRIX		ANABAENA		SPIROGYRA			
CYCLOTELLA		MELOSIRA		ANABAENA			
MICROCYSTIS		COSMARIUM		PHACUS			
ASTERIONELLA		MOUGEOTIA		UNK COL, BALL			
ANKISTRODESMUS		PEDIASTRUM		MICROCYSTIS			
COSMARIUM				PEDIASTRUM			
BULBOCHAETE				ZYGNEMA			

SUNNYSIDE TILE

GENUS	PERCENT COMPOSITION
SPIROGYRA	53.9
CYMBELLA	15.1
SCENEDRA	15.1
RHOPALODIA	4.2
NAVICULA	2.6
FRAGELARIA	2.4
MOUGETIA	2.4
OTHER	4.3
DIATOMA	
MELOSIRA	
TRACHELOMONAS	
COCCONEIS	
OOCYSTIS	
ANABAENA	
SCENEDESMUS	
ANKISTRODESMUS	
PEDIASTRUM	
ZYGNEMA	
ULOTHRIX	
UNK COL BALLS	
DINOBRYON	
COSMARIUM	
GOMPHONEMA	
CYCLOTELLA	

SUNNYSIDE ROCKS

GENUS	PERCENT COMPOSITION
CYMBELLA	48.1
RHOPALODIA	21.8
NAVICULA	17.5
OTHER	12.7
DIATOMA	
FRAGILARIA	
GOMPHONEMA	
MOUGEOTIA	
MELOSIRA	
CYCLOTELLA	
BULBOCHEATE	
SYNEDRA	
ANABAENA	
UNK COL BALL	
SCENEDESMUS	
OOCYSTIS	
PEDIASTRUM	
ASTERIONELLA	

GARFIELD ROCKS

GENUS	PERCENT COMPOSITION
MOUGEOTIA	34.3
CYMBELLA	14.0
NAVICULA	13.6
SYNEDRA	8.9
CYCLOTELLA	7.0
OTHER	22.2
UNK GREEN	
FRAGILARIA	
MELOSIRA	
RHOPALODIA	
OEDOGONIUM	
SPIROGYRA	
GOMPHONEMA	
UNK EUG	
UNK COL BALLS	
DINOBRYON	
TRACHELOMONAS	
ANABAENA	
COCCONEIS	
ASTERIONELLA	
OOCYSTIS	
NEPHROCYTIUM	
MERISMOPEDIA	
DIATOMA	
COSMARIUM	
PEDIASTRUM	
PERIDINIUM	
ULOTHRIX	
SCENEDESMUS	
SCHROEDERIA	

ELLISPORT BAY MARINA TILE

GENUS	PERCENT COMPOSITION
UNKNOWN GREEN	84.0
MOUGEOTIA	9.5
SYNEDRA	6.2
OTHER	0.3
ULOTHRIX	
CYMBELLA	
GOMPHONEMA	
PEDIASTRUM	
ZYGNEMA	
PERIDINIUM	
NAVICULA	
MELOSIRA	
FRAGILLARIA	
CYCLOTELLA	
ANABAENA	
SPIROGYRA	

IDLEWILD TILE

GENUS	PERCENT COMPOSITION
UNKNOWN GREEN	96.3
CYMBELLA	1.7
MOUGEOTIA	1.6
FRAGILARIA	0.3
NAVICULA	0.1
OTHER	<0.1
GOMPHONEMA	
CYCLOTELLA	
SCENEDESMUS	
ANABAENA	
SYNEDRA	
SPIROGYRA	
DIATOMA	

IDLEWILD ROCKS

GENUS	PERCENT COMPOSITION
CYMBELLA	48.7
MOUGEOTIA	28.6
RHOPALODIA	8.1
SYNEDRA	7.5
NAVICULA	4.9
OTHER	2.2
FRAGILARIA	
CYCLOTELLA	
DIATOMA	
MICROCYSTIS	
OOCYSTIS	
GOMPHONEMA	
ANKISTRODESMUS	
SCENEDESMUS	
ANABAENA	
UNK COL BALL	
SPIROGYRA	
PEDIASTRUM	
BULBOCHEATAE	

WARREN ISLAND TILE

GENUS	PERCENT COMPOSITION
CYMBELLA	37.0
NAVICULA	21.7
MOUGOEOTIA	15.8
RHOPALODIA	14.0
OTHER	11.5
CYCLOTELLA	
SYNEDRA	
FRAGILARIA	
ANKISTRODESMUS	
MELOSIRA	
GOMPHONEMA	
ASTERIONELLA	
ANABAENA	

TALACHE LANDING TILE

GENUS	PERCENT COMPOSIT
MOUGEOTIA	28.1
CYMBELLA	24.6
NAVICULA	16.9
GOMPHONEMA	8.7
RHOPALODIA	6.1
FRAGILARIA	4.6
SYNEDRA	3.6
OTHER	7.4
DINOBRYON	
MELOSIRA	
PERIDINIUM	
UNK COL BALL	
CYCLOTELLA	
DIATOMA	
ASTERIONELLA	
ANABAENA	
ULOTHRIX	
OOCYSTIS	
TABELLARIA	
CHLAMYDOMONAS	
COCCONEIS	
ANKISTRODESMUS	
SCENEDESMUS	
SPIROGYRA	

BOTTLE BAY TILE

GENUS	PERCENT COMPOSITION
MOUGEOTIA	63.4
CYMBELLA	19.4
ZYGNEMA	5.9
FRAGILARIA	3.6
CYCLOTELLA	1.6
RHOPALODIA	1.6
NAVICULA	1.6
OTHER	2.9
UNK COL BALL	
GOMPHONEMA	
SYNEDRA	
DIATOMA	
COCCONEIS	
ULOTHRIX	
CRUCIGENIA	
SCENEDESMUS	
OOCYSTIS	
ANABAENA	
COSMARIUM	

SCENIC BAY MARINA TILE

GENUS	PERCENT COMPOSITION
MOUGEOTIA	84.9
CYMBELLA	3.3
OTHER	11.8
BULBOCHAETE	
RHOPALODIA	
MELOSIRA	
SYNEDRA	
FRAGILARIA	
NAVICULA	
COCCONEIS	
UNK EUGLENOID	
CYCLOTELLA	
ZYGNEMA	
ULOTHRIX	
SPIROGYRA	
PERIDINIUM	
PEDIASTRUM	
DIATOMA	

APPENDIX 11B

Periphyton as Indicators of Enrichment in Lake Pend Oreille, Idaho
(Falter & Kann 1989)

LAKE AND RESERVOIR MANAGEMENT, 1989 5(2): 39-48

Periphyton as Indicators of Enrichment in Lake Pend Oreille, Idaho

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ABSTRACT

Periphyton in the littoral zone of Pend Oreille Lake, a large (383 km^2, deep (Z_{max} – 380 m)) meso-oligotrophic lake in northern Idaho, were studied to compare with pelagic productivity and to identify areas of inshore degraded water quality. Periphyton growth was determined on artificial tiles and natural substrates at 0.5 and 1.5 m depths. Means for all measures of production on natural substrates were higher than means for artificial substrate. Indicators of biomass were higher on 0.5 m tiles than those at 1.5 m; exposed sites, however, showed less difference between depths than did the more sheltered sites. Because of inorganic interference, ash-free dry weight provided a better measure of periphyton biomass than dry weight. Significant differences existed between sites, indicating greater algal growths in developed and relatively confined bays. Cymbella was dominant on natural substrate, while Cymbella, Mougeotia, and Rhizoclonium were co-dominant on artificial substrate. Blue-green algae biomass comprised only a small part of the total biomass on either artificial or natural substrates. Periphyton biomass in Pend Oreille Lake was comparable to other lakes showing accelerated eutrophication. Despite Pend Oreille Lake's great depth and large profundal area, littoral productivity was similar to lakes more shallow in nature with higher overall productivity. In-shore water quality degradation was documented at a time when open-lake conditions indicated the lake was meso-oligotrophic. Given that changes in lake trophic status would first show up in littoral areas—compared to the relatively slow changes taking place in the phytoplankton of pelagic areas—periphyton monitoring should provide valuable refinement to in-depth limnological studies on open waters of lakes.

Introduction

Although Pend Oreille Lake has typically been classified as a moderately productive oligotrophic system (oligo-mesotrophic) (Rieman and Falter, 1976; Falter, 1978; Milligan et al. 1983), increasing aquatic macrophyte density and complaints from homeowners of the increasing periphton growths on docks and shoreline areas raised concern that the trophic nature of the lake may be changing at a faster rate than previously perceived. In response, the Idaho Department of Health and Welfare, Division of Environment, initiated baseline monitoring of limnological conditions in 1985 (Beckwith, 1989). In all of these studies, however, data have been collected only at deep, off-shore (pelagic) sites. This approach is typical of lake trophic status studies, whereby trophic status has traditionally been determined only from phytoplankton production (Vollenweider, 1968), excluding littoral periphyton production (Wetzel, 1983a,b). Changes in the lake's actual trophic status might initially go unnoticed because high nutrient loading effects would first show up in bays and littoral areas. Littoral productivity may not play a large role in overall lake productivity in a large, deep lake with steep sides and a low littoral to pelagic area ratio such as Pend Oreille. However, productivity changes in shallow, light-rich areas would reflect changes in trophic status more quickly than pelagic waters. Thus, periphyton, the main component of littoral productivity, could be used to more efficiently monitor changes to the lake system resulting from increased nutrient loading.

The role of the littoral zone in whole-lake productivity has been well established (Wetzel, 1983c). This role is more pronounced in lakes with gently sloping shorelines, and, therefore, large ratios of littoral area to pelagic area (Loeb et al. 1983; Wetzel, 1983d). A dominant element of littoral productivity is periphyton, with most of the periphytic contribution as attached algae. Attached algae is the algal component of periphyton growing on submerged substrates such as rocks (epilithic algae), plants (epiphytic), sediments (epipelic), or woody debris. The term "periphyton" refers to the total attached community (i.e., both attached algae and the associated microfauna) along with organic and inorganic debris (Wetzel, 1983a). Wetzel (1964) showed that attached algae accounted for 69 percent of the total carbon fixed by autotrophs in a large shallow lake (Mean depth = ~1 m). Attached algae can also contribute a high percent of the net annual littoral primary productivity in steep-sided oligotrophic lakes. Loeb et al. (1983) found that attached algae contributed up to 97 percent of the total littoral productivity in certain oligotrophic lakes. The relative contribution of attached algae to lake production depends upon lake morphometry, water clarity, and substrate availability.

In addition to this major contribution to littoral and potentially, whole lake productivity, the littoral zone also serves as a buffer both to natural and anthropogenic events occurring in the watershed. The littoral zone, therefore, responds more quickly than pelagic areas to pollutant inputs (Casterlin and Reynolds, 1977; Loeb et al. 1983; Sand-Jensen, 1983). It has been well demonstrated that littoral periphyton efficiently remove incoming nutrients (Mickel and Wetzel, 1978; Howard-Williams, 1981). The spatial distribution of periphyton production has been positively correlated with the distribution of urban development (Loeb, 1986; Loeb et al. 1983). Littoral periphyton productivity also plays a major role in the early and final stages of increasing fertility to the whole lake system (Wetzel, 1983d). Periphyton monitoring as a pollution indicator has been widely used in lotic systems (Palmer, 1969; Patrick, 1973). However, periphyton monitoring in lentic systems has not yet been used to a great extent.

The objectives of this study were: (1) to assess periphyton growth in littoral exposed shore and embayment areas of Lake Pend Oreille; and (2) to test a reproducible method of periphyton assessment for monitoring both long-term changes and differences between sites.

Study Area

Pend Oreille Lake is a large (383 km^2) deep lake (Z_{max} = 380 m, $\bar{Z}$ = 139 m) located in the Panhandle area of northern Idaho. Algal assays performed in fall 1984 showed the system to be phosphorus limited, with euphotic zone mean (1985-88) total nitrogen and total phosphorus concentrations of 188 mg/m^3 and 9 mg/m^3 (Beckwith, 1989). Pend Oreile Lake is the receiving water for the Clark Fork River, draining a 59,311 km^2 watershed located primarily in northwestern Montana. Mean (1985-88) annual phosphorus loading from the Clark Fork River was 352,061 kg/yr (0.91 g/m^2/yr). Clark Fork River water quality has been the focus of concern resulting from point and nonpoint pollution inputs occurring in Montana. These include mining, agricultural and suburban nonpoint runoff, municipal sewage effluent, and pulp mill waste. Because Lake Pend Oreille receives all the Clark Fork River discharge, degraded water quality—especially high nutrient and organic loads—in the Clark Fork River would likely cause increased eutrophication in Pend Oreille Lake (Montana Dep. Health Environ. Sci. 1985). In addition to tributary loading, localized loading occurs from shoreline development.

Methods

Artificial Substrate

Artificial substrates (tiles) were placed at 12 sites around the lake. These sites were chosen as representative bay and open-water areas (Fig. 1 and Table 1).

Preliminary experiments were performed at the CMF site to determine both the optimal immersion time (15 days or 30 days) for the artificial substrate, and which of the two types of ceramic tiles (glazed or unglazed) would provide optimal periphyton growth. These experiments indicated that a 30-day immersion time resulted in mean chlorophyll *a* values approximately 200 percent higher than for a 15-day immersion period. Chlorophyll *a* values on the unglazed tiles were approximately 50 percent higher than those of the glazed tiles. Unglazed tiles and a 30-day immersion period were chosen to conduct the monitoring experiment.

Rectangular ceramic tiles that were brick red in color, unglazed, and had a 195 cm^2 surface area were selected. A hole 3 ml in diameter was drilled in the bottom of the 0.5 m tile and in the top of the 1.5 m tile, so that the two tiles could be connected by a 1 m length of braided nylon cord. At each study site, five vertical-

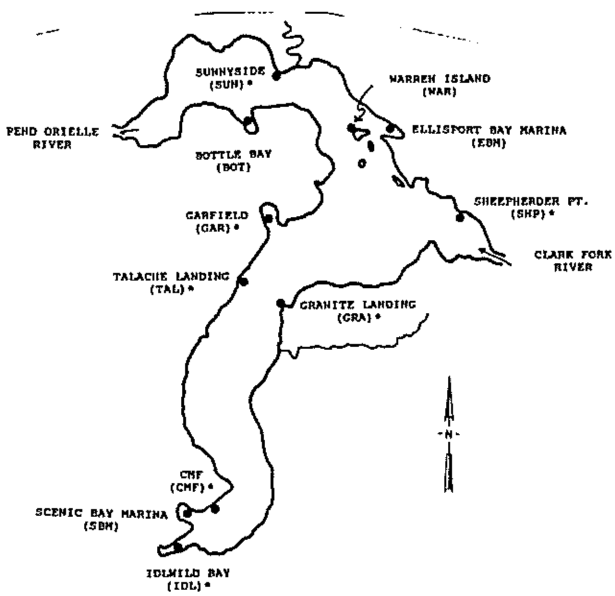

Figure 1.—Periphyton sampling sites in Pend Oreille Lake, July-August, 1986. Three-letter abbreviations (in parentheses) are used as site abbreviations. * = both natural and artificial substrates sampled.

Table 1.—Description of periphyton sampling sites in Pend Oreille Lake, July–August, 1986.

SITE	DESCRIPTION
	Populated Bays
Scenic Bay Marina	—South lake, head of unsewered, heavily populated Scenic Bay
Garfield Bay	—Mid lake, head of lightly populated Garfield Bay
Ellisport Bay Marina	—North lake, on unsewered, heavily populated Ellisport Bay and community of Hope
Bottle Bay	—North lake, on sewered developed bay
	Mid-Lake Exposed Sites
Talache Landing	—Open, exposed, west lake shore
Granite Landing	—Slightly protected, east lake shore
	South Lake Exposed Sites
CMF	—South exposure, two miles lakeward from Scenic Bay head
Lakeview	—West exposure, open lake opposite Scenic and Idlewild Bays
	North Lake Exposed Sites
Sheepherder Point	—South exposure, open lake near Clark Fork River inflow
Warren Island	—West side of Warren Island
Sunnyside	—South side of Sunnyside Peninsula
	Unpopulated Bay
Idlewild Bay	—North exposure, one mile in from bay head

ly oriented replicate tiles were placed at the 0.5 m depth, and five were placed at the 1.5 m depth. At each site, the five replicate submerged pairs were attached in a row to a dock, piling, or fallen tree.

Placement and Retrieval

Tiles were submersed at the six southern sites on July 15, 1986, and on July 16, at the six northern sites (Fig. 1). After a 30-day incubation period, the tiles were scraped with a stiff nylon brush and rinsed with distilled water into a 50 ml plastic centrifuge tube. The centrifuge tubes were kept on ice in the dark for the remainder of the day until filtering that evening. A small qualitative periphyton sample was also scraped from the edge of the tile and preserved with Lugol's solution. That evening, each cooled sample was brought to a known volume in a graduated cylinder, shaken vigorously, and two duplicate samples then vacuum-filtered onto separate Whatman GF/C glass fiber filters. Each duplicate filter was assumed to contain biomass from half the tile surface area (97.5 cm^2). The filters were frozen until laboratory analysis the following week.

One filter from each sample was used for analysis of trichromatic and monochromatic chlorophyll *a* and pheophytin. The second filter was used for gravimetric determination of dry weight (ODW at 105°C) and ash-free dry weight (AFODW after drying at 105°C, ashing at 500°C, re-wetting, and drying again at 105°C). Standard Methods (1985) was followed for all these analyses. The qualitative sample was shaken vigorously for one minute and a subsample was placed onto a sedimentation chamber depression plate for determining percent composition by biovolume of the dominant attached algal genera. The slide was scanned to ensure homogeneous distribution of algae, and fields were counted until standard error as a percent of the mean was less than dominant genera (Wild M-40 inverted microscope at 200X).

Natural Substrate

To compare tile substrates with shoreline rocks as well as spatial variation on natural substrates around the lake, three replicate rocks were randomly selected from seven of the 12 sites (Fig. 1). All rocks were selected within the 0.3-0.7 m zone of littoral areas. A thin section of PVC pipe (d = 4.8 cm) was placed on each rock and the periphyton on the rock surface area within the 17.7 cm^2 pipe section scraped, collected, and analyzed as above.

Data Analysis

Analysis of variance (ANOVA) was performed to determine the significance of differences between sites and depths, and between artificial and natural substrates. Duncan's New Multiple Range Test was used to determine extent of mean separation when significant differences existed. These tests were performed with SAS GLM procedures (Statis. Analy. System Users Guide, 1980). A logarithmic transformation

($\log^{10}(X+1)$) was performed because graphical plots indicated that variance was proportional to means for all variables (Kirk, 1982). Transformed data were used in analysis of variance and multiple comparison tests. Confidence intervals ($p \geq 95$ percent) were calculated to compare within- site variation of both artificial and natural substrate. All required assumptions of the statistical tests performed were addressed and met.

Based on Hurlbert's (1984) discussion of pseudo replication, 5 replicate tiles at a site are not sufficient replication to permit statistical inferences to a whole bay or lake area. Therefore, analysis of variance and Duncan's tests pertain only to specific sites.

Results

Trichromatic versus Monochromatic Chlorophyll *a*

Periphyton generally contain varying amounts of chlorophyll breakdown products such as pheophytin (Wetzel and Westlake, 1974; Robinson, 1983; Biggs, 1985; Standard Methods, 1985). Monochromatic chlorophyll *a* measurements should, therefore, be a better indicator of viable chlorophyll. Although trichromatic chlorophyll a measurements were somewhat less variable between replicates and provided better separation of means, monochromatic results are emphasized here because of potential interference from degradation products associated with trichromatic methodology (Wetzel, 1983b). Schindler (1973) also found a lack of reproducibility using current phaeopigment correction techniques.

Artificial versus Natural Substrate

For all tested variables (Table 2), natural substrate means combined over all sites were significantly ($p \leq 0.01$) greater than means of either the 0.5 m tiles or the 1.5 m tiles. Natural substrate, for example, averaged 18.3 mg/m^2 monochromatic chlorophyll *a* compared to 3.6 mg/m^2 on all tiles (Fig. 2 and 3). Ash-free dry weight was 14.3 g/m^2 on natural substrate compared to 0.96 g/m^2 on all tiles (Fig. 2 and 3).

Artificial Substrate

Lake-wide comparisons of the 0.5 m tiles with the 1.5 m tiles showed significant differences ($p \leq 0.05$) between the two depths only for dry weight and ash-free dry weight (Table 2). Even though mean monochromatic chlorophyll *a* values of 0.5 m tiles were over twofold greater than those of 1.5 m tiles (Table 3), variability of this trend between sites prevented lakewide differences from showing. It was evident, however, that the more productive sites (Idlwild Bay, Scenic Bay Marina, and Ellisport Bay Marina) had chlorophyll *a* values at the 0.5 m depth (3.9-29.2 mg/m^2) up to 6.5-fold greater than values at the 1.5 m depth (1.2-4.5 mg/m^2) (Fig. 2). Differences between depths were not as pronounced at other sites.

Table 2.—Summary results of analysis of variance tests performed on natural substrate versus tiles, 0.5 m tiles versus 1.5 m tiles, 0.5 m tiles compared between sites, 1.5 m tiles compared between sites, 1.5 m tiles compared between sites, and natural substrate compared between sites.

VARIABLE	ANOVA TEST INTERACTION	F VALUE
Monochromatic chl. *a*	0.5 m tile × natural substrate	41.30 **
Dry weight	0.5 m tile × natural substrate	549.21 **
Ash free dry weight	0.5 m tile × natural substrate	333.67 **
Monochromatic chl. *a*	1.5 m tile × natural substrate	116.93 **
Dry weight	1.5 m tile × natural substrate	713.64 **
Ash free dry weight	1.5 m tile × natural substrate	628.76 **
Monochromatic chl. *a*	0.5 m tile × 1.5 m tile	1.39
Dry weight	0.5 m tile × 1.5 m tile	4.06 *
Ash free dry weight	0.5 m tile × 1.5 m tile	4.47 *
Monochromatic chl. *a*	(0.5 m tile + 1.5 m tile) × site	10.54 **
Dry weight	(0.5 m tile + 1.5 m tile) × site	5.21 **
Ash free dry weight	(0.5 m tile + 1.5 m tile) × site	5.09 **
Monochromatic chl. *a*	0.5 m tile × site	16.04 **
Dry weight	0.5 m tile × site	14.62 **
Ash free dry weight	0.5 m tile × site	25.43 **
Monochromatic chl. *a*	1.5 m tile × site	7.0 **
Dry weight	1.5 m tile × site	5.57 **
Ash free dry weight	1.5 m tile × site	2.22 *
Monochromatic chl. *a*	natural substrate × site	1.26
Dry weight	natural substrate × site	0.80
Ash free dry weight	natural substrate × site	2.19

* = significant at $P \leq 0.05$.
** = significant at $P \leq 0.01$.

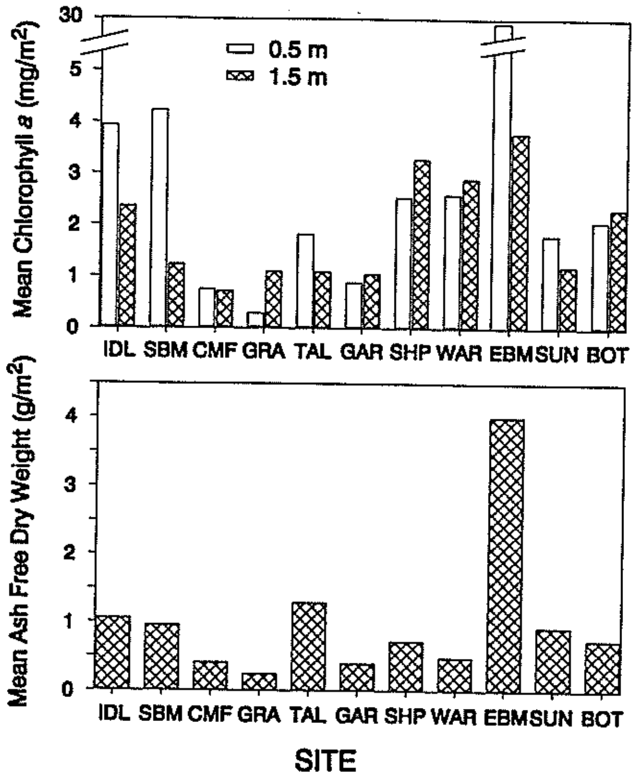

Figure 2.—Mean chlorophyll a, and ash-free dry weight for artificial substrates in Pend Oreille Lake, July-August 1986. (Sites are oriented from south to north.)

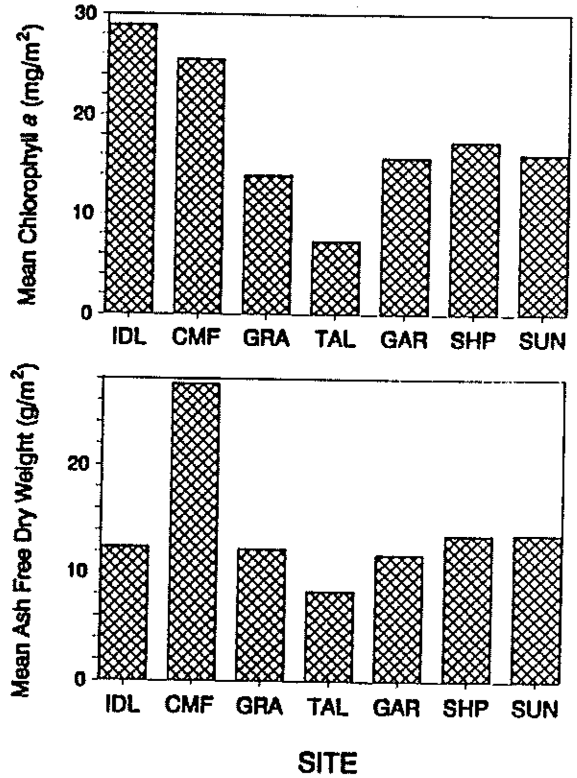

Figure 3.—Mean chlorophyll a, and ash-free dry weight for natural substrates in Pend Oreille Lake, July-August 1986. (Sites are oriented from south to north.)

Table 3.—Lake-wide means of chlorophyll *a* and biomass on natural and artificial substrates, Pend Oreille Lake, July–August 1986.

	NATURAL (mg/m²)	ARTIFICIAL (mg/m²) 0.5 m	1.5 m
Trichromatic chlorophyll *a*	17.96	5.27	2.06
Monochromatic chlorophyll *a*	18.31	5.06	2.25
Dry weight	61,169	2,670	1,974
Ash free dry weight	14,269	1,163	765
Loss on ignition	23%	44%	39%

Data combined from 0.5 m and 1.5 m tiles showed significant differences ($p \leq 0.01$) between sites for all variables (Table 2). In addition, data from 0.5 m and 1.5 m tiles separately also showed significant differences between sites for all variables (Table 2). Because less variability existed within a depth than between depths, and lake-wide variability was least for 0.5 m tiles, the 0.5 m tile data are emphasized in further site comparisons. Duncan's New Multiple Range Test showed that significant differences occurred between sites, although, within-site variability caused much overlap between means (Table 4). North lake mean chlorophyll *a* at 0.5 m was 7.6-fold greater than the mean of mid-lake sites; south lake sites were 2.9-fold greater than the mean of mid-lake sites (Fig. 2).

Ash-free dry weight appeared to be a better indicator of biomass than dry weight, probably because of interference from inorganic sand and silt. Mean ash-free dry weight on 0.5 m tiles at the south lake sites was 1.2 times the mean of the mid-lake sites; north lake ash-free dry weight was 2.1 times the mean of the mid-lake sites (Fig. 2). Duncan's Test showed that Ellisport Bay Marina mean ash-free dry weight was significantly higher than all other sites (Table 4).

Natural Substrate

Natural substrates showed no significant differences between sites for any variables (Table 2). With only three replicate rocks collected at a site, variation was too great to show statistically significant differences between sites.

Periphyton Composition

On artificial substrates, *Cymbella*, *Rhizoclonium* and *Mougeotia* were equally dominant—as determined by mean percent composition based on biovolume

Table 4.—Results of Duncan's New Multiple Range (D.M.R.) Test performed on means of 0.5 m tiles contrasted by site for all variables. Sites connected by an unbroken vertical line are not significantly different at $P \leq 0.05$.

MONOCHROMATIC CHLOROPHYLL a					DRY WEIGHT					ASH FREE DRY WEIGHT				
n	MEAN mgm^{-2}	MEAN $1_{10}(x+1)$	SITE	D.M.R.	n	MEAN gm^{-2}	MEAN $1_{10}(x+1)$	SITE	D.M.R.	n	MEAN gm^{-2}	MEAN $1_{10}(x+1)$	SITE	D.M.R.
5	29.21	1.46	EBM		5	6.04	0.83	EBM		5	4.02	0.69	EBM	
5	4.20	0.70	SBM		5	4.45	0.72	TAL		5	1.31	0.36	TAL	
3	3.88	0.68	IDL		5	3.62	0.65	SUN		3	1.07	0.31	IDL	
5	2.54	0.54	WAR		5	2.23	0.51	SHP		5	0.97	0.29	SBM	
5	2.51	0.48	SHP		5	2.10	0.48	BOT		5	0.95	0.29	SUN	
5	1.78	0.43	TAL		3	2.01	0.48	IDL		5	0.76	0.24	BOT	
5	1.75	0.34	BOT		5	1.59	0.41	SBM		5	0.74	0.24	SHP	
5	1.29	0.32	SUN		5	1.45	0.38	WAR		5	0.50	0.18	WAR	
2	0.82	0.26	GAR		5	1.02	0.30	CMF		5	0.43	0.15	CMF	
5	0.62	0.21	CMF		1	0.98	0.30	GAR		1	0.42	0.15	GAR	
1	0.21	0.08	GRA		1	0.64	0.21	GRA		1	0.26	0.10	GRA	

measurements (Table 5). On natural substrates, *Cymbella* dominanted (50 percent), followed by *Mougeotia* (12.6 percent) (Table 5). A comparison of artificial versus natural substrates—for sites where data existed for both—revealed *Cymbella* accounted for 59 percent of the biovolume on natural substrates, and only 27.6 percent on artificial substrates (Table 6). Filamentous green algae (*Mougeotia* and *Rhizoclonium*) comprised 49 percent of the composition on artificial substrates, but only 7.2 percent (*Mougeotia* only) on natural substrates. *Cymbella* composition at south lake sites was less than both mid- and north lake sites on artificial substrates (Table 7). However, the filamentous greens *Mougeotia* and *Rhizoclonium* comprised a higher percent composition at south lake sites than at either mid- or north lake sites. On natural substrates, *Cymbella* percent composition at south lake sites was greater than at either mid- or north lake sites (Table 7).

Table 5.—Lake-wide mean percent composition of the dominant algal genera on artificial and natural substrates, Pend Oreille Lake, July–August 1986.

ARTIFICIAL SUBSTRATE		NATURAL SUBSTRATE	
GENUS	PERCENT COMPOSITION	GENUS	PERCENT COMPOSITION
Mougeotia	27.5	*Cymbella*	50.0
Cymbella	21.6	*Mougeotia*	12.6
Rhizoclonium	20.0	*Other*	10.6
Spirogyra	6.0	*Navicula*	7.6
Other	6.0	*Rhopalodia*	7.5
Navicula	5.7	*Bulbochaete*	5.9
Synedra	5.0	*Synedra*	4.1
Rhopalodia	4.6	*Cyclotella*	1.4
Fragilaria	1.8	*Gomphonema*	0.3
Gomphonema	1.0		
Zygnema	0.6		
Cyclotella	0.2		

Table 6.—Lake-wide (only sites where data for both artificial and natural substrate exist) mean percent composition of the dominant algal genera on artificial and natural substrates, Pend Oreille Lake, July–August 1986.

GENUS	ARTIFICIAL SUBSTRATE	NATURAL SUBSTRATE
Cymbella	27.6	59.0
Rhizoclonium	24.1	0.0
Spirogyra	13.5	0.0
Mougeotia	11.4	7.2
Synedra	8.8	2.9
Other	5.0	7.7
Rhopalodia	4.9	9.4
Navicula	2.7	6.1
Fragilaria	2.0	0.0
Gomphonema	0.0	0.4
Bulbochaete	0.0	7.3

Table 7.—Comparison of south-lake, mid-lake, and north-lake mean percent composition of the dominant algal genera on artificial and natural substrates, Pend Oreille Lake, July–August 1986.

GENUS	SOUTH-LAKE	MID-LAKE	NORTH-LAKE
Artificial Substrate			
Cymbella	9.2	24.6	28.5
Rhopalodia	1.8	6.1	6.0
Mougeotia	40.9	28.1	19.3
Fragilaria	0.1	4.6	2.3
Synedra	5.3	3.6	5.1
Other	8.0	7.4	4.5
Navicula	2.7	16.9	5.2
Spirogyra	0.0	0.0	10.8
Rhizoclonium	32.1	0.0	16.8
Gomphonema	0.0	8.7	0.0
Zygnema	0.0	0.0	1.2
Cyclotella	0.0	0.0	0.3
Natural Substrate			
Cymbella	70.3	14.0	47.7
Mougeotia	14.3	34.4	0.0
Rhopalodia	4.1	0.0	14.7
Synedra	5.8	8.9	0.0
Navicula	3.4	13.6	8.8
Other	1.4	22.2	14.1
Gomphonema	0.8	0.0	0.0
Cyclotella	0.0	7.0	0.0
Bulbochaete	0.0	0.0	14.7

Discussion

The spatial and temporal heterogeneity of periphyton distribution is well documented (Wetzel, 1983d; Roos, 1983; Sand-Jensen, 1983; Eloranta, 1982). Subtle differences in substrate and microhabitat condition can greatly influence periphyton development, especially colonization rates (Wetzel, 1983d). Periphyton growth around a very large lake basin such as Pend Oreille cannot be expected to be homogeneous between sites. Some of the major factors affecting growth and thereby causing between-site variation are water chemistry, local nutrient loading, light availability (solar radiation, water transparency, and turbidity), substrate (type, condition, location, and depth), and water movements (currents and wave action) (Weltzel, 1979). Weitzel concluded that, on a global basis, energy controls periphyton growth and distribution while, in a specific water body, nutrients are more important. This conclusion basically agrees with Brylinsky and Mann (1973) on phytoplankton controlling factors.

Between-site variability can be especially enhanced by shading, water movement restriction, and heterogeneous recruitment from adjacent surfaces such as underwater structures. Wave action can severely limit colonization of near-surface substrate (Austin et al.). In this study, the three sites of lowest productivity on artificial substrate—CMF, Garfield, and Granite Landing—were the most exposed to wave action with fetches of 5 to 16 kilometers. The four highest productivity sites—Ellisport Bay Marina, Idlwild Bay, Sheepherder Point, and Warren Island—were only moderately exposed to strong wave action. These sites had higher growth at the 0.5 m depth than at the 1.5 m depth, while the more exposed sites showed little difference between depths. This suggested that, with calmer water, increased light availability at 0.5 m provided better growth than the deeper 1.5 m tiles, but intense wave action could remove the shallow water high growth advantage. Austin et al. (1981) cautioned against rapidly retrieving artificial substrates from the water, further emphasizing periphyton cells' susceptibility to sloughing off. Future work with periphyton growth on exposed lakeshores should further address the problem of variation in aspect and wave exposure. Perhaps a 1.0 m depth would provide better separation of means by reducing wave exposure while still providing adequate light for maximum growth.

Artificial substrates do not duplicate growth rates or generic composition found on natural substrate (Brown and Austin, 1973; Weitzel, 1979; Robinson, 1983; Wetzel, 1983d). Greater periphyton growth was observed on the nylon lines, perhaps because of resilience to the strong wave action. Austin et al. (1981) also observed that colonization was better on oval braided nylon line. Differences in surface porosity, sloughing, and submergence time will ensure outcomes different from natural substrate. Even unglazed tiles are relatively smooth compared to natural granite or wood substrate and have fewer microspaces to aid periphyton attachment. For this reason, natural rock substrates were also sampled for comparison with artificial substrate at 7 of the 12 sites. Major differences were observed in generic composition between natural and artificial substrate, and highly significant differences occurred in dry weight, ash-free dry weight, and chlorophyll *a* between natural and artificial substrates ($p \leq 0.01$). By providing uniform substrates at each site, artificial substrates can, however, reduce within-site variability and permit better separation of site means to reflect ambient growth conditions (Sladeckova, 1962; Robinson, 1983).

The incubation time of 30 days is well supported by the literature (Brown and Austin, 1971; Brown, 1973; Standard Methods, 1985; Biggs, 1985). Austin et al. observed that short incubation times produced unstable growth, while excessively long periods resulted in cell loss from sloughing and grazing. Grazing can affect both abundance and composition of attached algal communities (Cuker, 1983).

For reasons cited above, periphyton in Pend Oreille Lake showed great spatial heterogeneity between sites. Despite twofold differences in mean chlorophyll *a* and ash-free dry weight between sites, three or five replicates were often not enough to show statistical differences resulting from variability within replicates. Certain trends were still evident, however, without the use of inferential statistics.

It was concluded that, as in stream channels, periphyton community dry weight on natural substrate was a consistently biased estimate because wave action washed silts and sands onto the rock periphyton community. Although this was not a problem with the tiles—since they were always suspended 2 to 4 m above the bottom—ash-free dry weight provided a better estimate for comparisons between the two substrates. In fact, a mean of 23 percent ash-free dry weight on natural substrate (in the wave-washed shore zone of the lake) compared to a mean of 42 percent ash-free dry weight on tiles suspended over deeper water at those same sites. Stockner and Armstrong (1971) found a 51 percent ash-free dry weight mean on glass slides (30-day incubation) in the Experimental Lakes Area in Canada.

Müller (1983) found a 44 percent ash-free dry weight mean on natural substrate (dominated by *Cladophora*) in shallow, eutrophic Lake Krageholmssjon in Sweden, and mean dry weights (~500 g/m^2) eight times those in Lake Pend Oreille (61.2 g/m^2). Mean annual chlorophyll *a* on natural substrate (2 m depth) in oligotrophic Lake Tahoe was approximately 19 mg/m^2 (Reuter et al. 1983). Despite Tahoe's oligotrophic classification, littoral periphyton growths are thought to indicate a more advanced trophic state caused by excessive shoreline development over the past 20 years (Loeb, 1986; Loeb et al. 1983). This can be compared to the natural substrate mean chlorophyll *a* of diatom-dominated communities in Pend Oreille Lake of 18 mg/m^2. Natural substrate values in oligotrophic Lake Chelan ranged between 1 and 10 mg/m^2 chlorophyll *a* away from tributary influences (Patmont et al. 1988). These authors also identified a 10- to 50-fold chlorophyll *a* increase and local water quality impairment in disturbed areas.

Pend Oreille's mean ash-free dry weight accrual rate of 39 mg/m^2/day on artificial substrate is 31 percent higher than the accrual rate for small, shallow lake 240 (~27 mg/m^2/day on glass slides) of the Experimental Lakes Area (Stockner and Armstrong, 1971). Kettunen (1983) found that periphyton on artificial substrate in waters of Lake Saimaa, Finland, polluted with pulping effluent developed 20-40 mg chlorophyll *a*/m^2 in three weeks, compared to 0.5-2.0 mg/m^2 in unpolluted areas of the same lake. Although only one site in Pend Oreille Lake showed chlorophyll values in the range found in polluted areas of Lake Saimaa (0.5 m tiles at Ellisport Bay Marina had 29.8 mg/m^2 per 30 days), the lake- wide average of 5.27 mg/m^2 is greater than the maximum value of 2.0 mg/m^2 found in unpolluted areas of Lake Saimaa.

A shallow cooling water pond considered to be "mildly eutrophic" in central Finland developed periphytic growths of 2 g/m^2 AFODW and 2.5 mg/m^2 chlorophyll *a* in four weeks (Eloranta, 1982). These chlorophyll values are less than the Pend Oreille Lake mean even though the Finland values were obtained from depths of 0.2 m rather than the 0.5 and 1.5 m depths in Pend Oreille. The Finnish cooling pond study also showed significantly greater periphyton accumulations at more shallow depths than at deeper depths.

Because Lake Saimaa and the above cooling water pond are both shallow (mean depths = 5.0 and 3.8 m, respectively), the artificial substrate chlorophyll *a* values found in Pend Oreille Lake (values between those of unpolluted and polluted values found in Lake Saimaa and higher than the cooling pond) seem to indicate increased nutrient loading to Pend Oreille is occurring, especially when Pend Oreille's high mean depth ($\bar{Z}$ = 139 m) and large volume are considered. Chlorophyll *a* concentrations on natural substrates in Pend Oreille Lake were similar to values obtained in Lake Tahoe (a system where changing lake trophic status is also of concern), again suggesting increased nutrient loading.

Although no previous periphyton data exist on either artificial or natural substrates in Pend Oreille Lake for comparison, it is evident from visual observations of increased growth on submersed objects that periphyton biomass and distribution have increased over the last decade. The data on both artificial and natural substrates suggest an increase in the rate of eutrophication when compared to other lentic systems of varying trophic status. However, caution must be used when comparing data between systems because of the inherent seasonal, spatial, substrate, and microhabitat variability associated with periphyton communities. With only one season of data, definitive conclusions would be premature. However, the data indicate that concern regarding the changing trophic status in Pend Oreille Lake is merited and continued monitoring and study are needed.

Because changes in trophic status would first show up in littoral areas and embayments (especially in deep lakes with large profundal areas), periphyton monitoring in Pend Oreille Lake should provide excellent refinement and early warning of eutrophication for any in-depth limnological studies undertaken. Long-term periphyton monitoring would be valuable for many lakes to detect changes in trophic status before changes are noticed in pelagic areas. Sampling schemes could include the measurement of nutrients and other water chemistry variables at periphyton sampling sites, enabling further refinement of trophic changes and local nutrient inputs.

Conclusions

1. Periphyton on natural substrates displayed higher means than artificial substrates.

2. Attached algal growths were higher on the 0.5 m tile than on the 1.5 m tiles; exposed sites, however, showed less difference between depths than did more sheltered sites.

3. Because of inorganic interference, especially on the wave-washed natural substrates, ash-free dry weight provided a better measure of periphyton biomass than did dry weight.

4. Natural substrate periphyton variance within sites was high as a result of the inherently high spatial heterogeneity of periphyton in natural systems. Three natural substrate replicates were

not enough to show statistically significant differences between sites.

5. *Cymbella* was the chief dominant (~50 percent by biovolume) on the natural substrate, while *Cymbella*, *Mougeotia*, and *Rhizoclonium* were equally dominant (21.6 percent, 27.5 percent, and 20.0 percent) on the artificial substrates. Blue-green algal biomass comprised only a small part of the total biomass on either artificial or natural substrate.

6. Values of chlorophyll *a* and ash-free dry weight were comparable to other lakes showing accelerated eutrophication.

7. Algae growths were significantly greater in developed and relatively confined bays and provide evidence of in-shore water quality degradation at a time when open-lake conditions indicate continued meso-oligotrophy.

8. Given that changes in lake trophic status would first show up in littoral areas (compared to the relatively slow changes in the phytoplankton of pelagic areas), periphyton monitoring should provide valuable refinement to in-depth limnological studies on open waters of lakes (particularly for large oligotrophic lakes).

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APPENDIX 12

U. S. Army Corps of Engineers, Finding of No Significant Impact and Environmental Assessment. Debris Boom Facility Reconstruction at Clark Fork River Mouth

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE, WASHINGTON 98124-2255

REPLY TO ATTENTION OF

APR 14 1989

DIVISION OF ENVIRONMENT
RECEIVED
APR 24 1989
RECEIVED
Coeur d'Alene Field Office

Planning Branch

Mr. Ed Tullock
Idaho Department of Health and Welfare
Division of Environmental Quality
2110 Ironwood Parkway
Coeur d'Alene, Idaho 83814-2687

Dear Mr. Tullock:

The Seattle District, U.S. Army Corps of Engineers, is planning to construct a breakwater at the mouth of the Clark Fork River delta in Lake Pend Oreille, Idaho, to protect the Albeni Falls Dam project debris collection facility. We transmitted a copy of the draft environmental assessment and draft Section 404(b)(1) evaluation report to you for your review and comment in our letter of October 3, 1988. We have revised these documents based on your and other comments, and have attached the final, signed versions of these reports, plus a "Finding of No Significant Impact," for your information.

If you would like to discuss these documents informally, please call Mr. Ken Brunner at telephone (206) 764-3479.

Sincerely,

Philip L. Hall
Colonel, Corps of Engineers
District Engineer

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CENPS-EN-PL-ER 24 March 1989

FINDING OF NO SIGNIFICANT IMPACT
PROTECTION OF DEBRIS CONTROL FACILITIES AT SITE C
CLARK FORK RIVER
ALBENI FALLS DAM PROJECT, IDAHO

1.The action described in the attached environmental assessment is a plan for protection of the Albeni Falls Dam Project Site C Debris Control Facility at the mouth of the Clark Fork River, Lake Pend Oreille, Idaho. The debris control facility is part of the Albeni Falls Dam project and is vital to the safety of the boating public using the reservoir and for the collection of debris before it reaches Albeni Falls Dam. The debris facility at site C is partially protected by a natural spit of land. This spit has been eroding rapidly since project regulation began in 1952 and has been breached in several locations. These breaches in the spit allow wave action to damage the site C debris booms. Accelerated erosion of the spit is occurring which will further expose the site C booms to wave action. The proposed action is to protect the site C debris booms by constructing a rubblemound breakwater on the existing spit of land. The plan also includes deepening of the existing diversion channel to allow debris to enter the holding area at lower water elevations and to provide materials to restore the eroded areas of the spit.

2. The principal positive environmental effects of this undertaking are:

a. continued protection and operation of the Albeni Falls Dam project debris control facility, which will continue to provide safe boating in Lake Pend Oreille, and

b. continued protection of Clark Fork Delta lands from erosion, and

c. improvement of waterfowl nesting and brooding habitat.

3. The principal adverse environmental impacts resulting from this undertaking are:

a. temporary increases in noise levels and fuel emissions from construction equipment, and in turbidity in the area of construction, and

b. loss of a small amount of aquatic vegetation in the diversion channel, and of terrestrial vegetation on the channel banks, as a result of excavation of the channel.

4. Work will be carried out as soon as funds become available and will be conducted in accordance with all applicable laws and regulations. The continued protection of the debris facility and its consequent preservation of

delta lands and retention of boating safety far outweigh the minor, short-term temporary impacts of the project.

5. For the reasons described above, it has been determined that the proposed action will not have a significant adverse effect on the quality of the human environment and does not require the preparation of an environmental impact statement.

4/13/89

DATE

PHILIP L. HALL
Colonel, Corps of Engineers
District Engineer

CENPS-EP-ER

27 March 1989

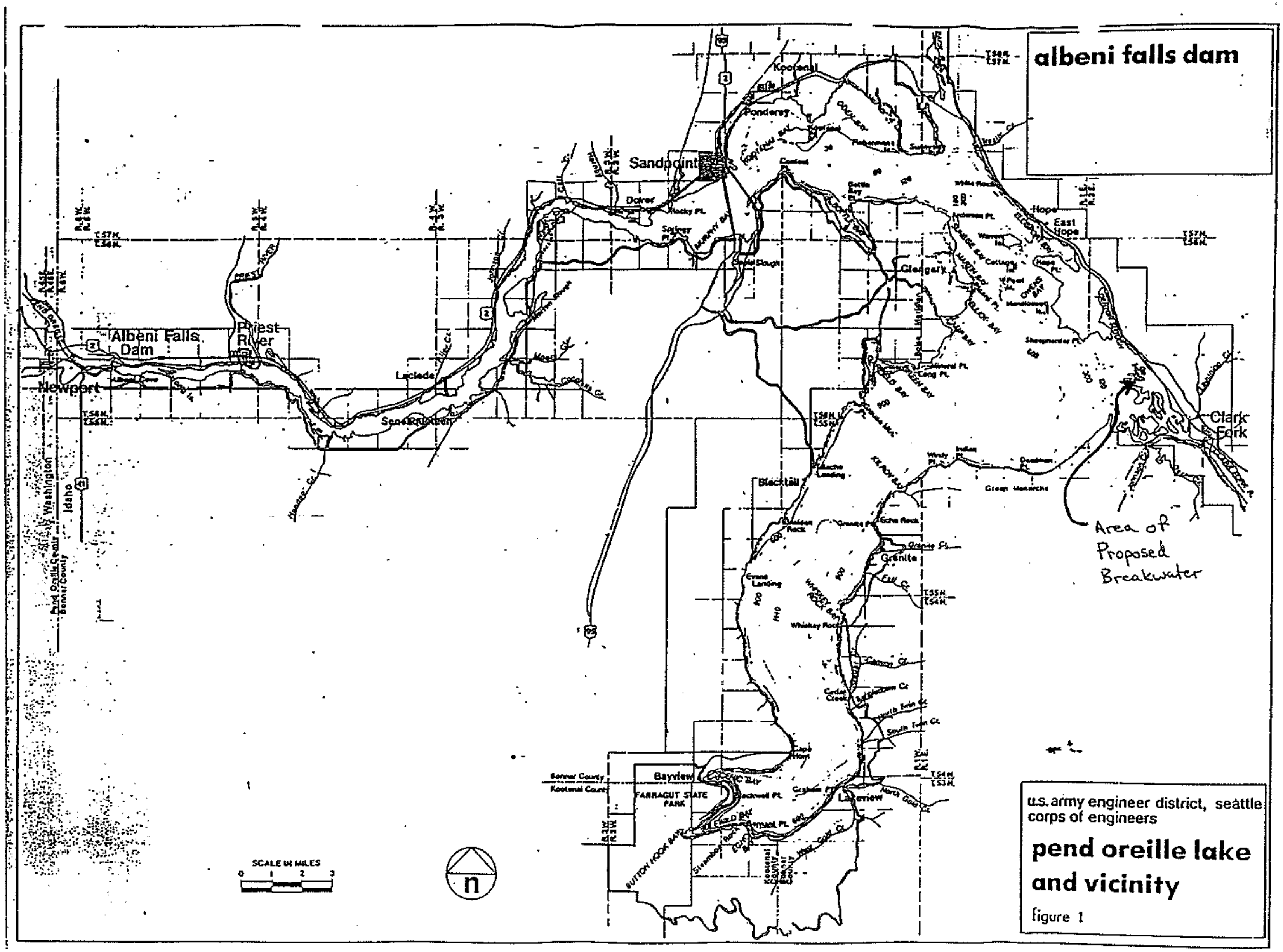
ENVIRONMENTAL ASSESSMENT
DEBRIS BOOM FACILITY
ALBENI FALLS PROJECT, IDAHO

1.0 Introduction. The purpose of this environmental assessment (EA) is to evaluate the impacts of breakwater construction and excavation of a diversion channel to facilitate movement of debris to improve and assure continued operation of the debris deflection/collection booms in the Clark Fork River delta, Lake Pend Oreille, Idaho. This facility operates to prevent debris from entering Lake Pend Oreille in conjunction with Albeni Falls Dam at the outlet of Lake Pend Oreille. Figure 1 is a location map showing Lake Pend Oreille and the locations of the dam and the debris booms. Figure 2 shows the Clark Fork River delta and more precise locations of the booms.

1.1 Description of Existing Project Features. The Clark Fork River delta debris booms consist of three separate log booms strategically situated in the delta to deflect debris coming from the river into a collection facility. Debris is collected and contained during the spring runoff; then it is concentrated in near-shore shallow areas prior to drawdown; and finally, the debris is piled and burned in the holding area when the area is dry. The purpose of this facility is to minimize the amount of debris in the lake to preclude creating hazardous conditions during the boating season if it was not collected, and to prevent the debris from reaching Albeni Falls Dam in order to protect the turbines from material that might pass through them.

The existing debris control system consists of stiff log shear boom segments located at site A (3,800 feet long), site B (1,200 feet long), and site C (1,400 feet long) and a holding/disposal area enclosed with a single log string boom (3,100 feet long). Generally the shear booms are 8 feet wide, are built in sections of 101 or 202 feet in length, and have a shear face of either 3 or 4 feet in height, approximately half of which is submerged when the booms are floating. The dolphins that support the booms against the current and maintain alignment are constructed of three single pilings secured at the top by multiple wraps of wire rope. The dolphins are spaced every 30 to 100 feet depending on the length of the boom sections which they support. The majority are now spaced at 50- to 70-foot intervals.

a. Site A. Site A is located on the main stem of the Clark Fork River approximately 1-1/2 miles west of the town of Clark Fork. A navigation gap near the center allows for passage of small vessels through the boom. Debris is diverted from the main river channel into the North Fork of the river where it is carried downstream to site B.


albeni falls dam
Sandpoint
Kootenai
Ponderay
Dover
Albeni Falls Dam
Priest River
Newport
Laclede
Hope
East Hope
Glengary
Clark Fork
Bayview
FARRAGUT STATE PARK
Granite
Lakeview
Washington
Idaho
Bonner County
Kootenai County
SCALE IN MILES
Area of Proposed Breakwater
u.s. army engineer district, seattle
corps of engineers
pend oreille lake and vicinity
figure 1

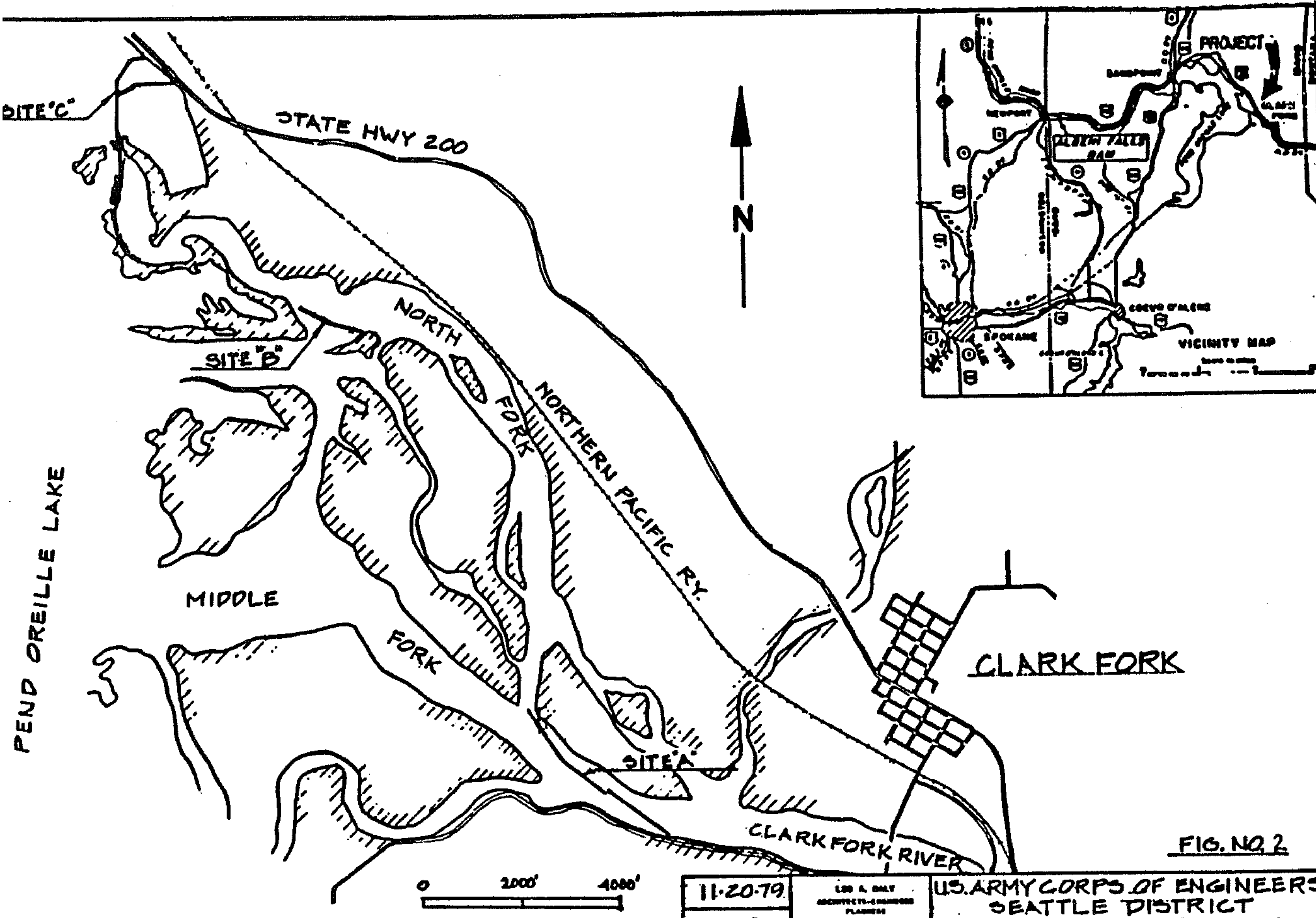


FIG. NO. 2

11-20-79		U.S. ARMY CORPS OF ENGINEERS SEATTLE DISTRICT ALBENI FALLS PROJECT DEBRIS COLLECTION FACILITY PROJECT PLAN
TSM		
NO SCALE		

b. Site B. Site B is located approximately 2 miles downstream from site A on the North Fork and consists of 1,200 feet of shear boom placed across the North Fork of the river. Debris is diverted and travels downstream to site C via a side channel of the North Fork or the North Fork channel. Small vessel passage is provided around the downstream end of the structure.

c. Site C. Site C is located on the north channel slightly less than 1 mile downstream from site B on the northeastern shore of Lake Pend Oreille approximately 1 mile from Sheepherder Point. Site C consists of 1,400 feet of shear boom with a navigation gap (figure 3). Debris is diverted from the North Channel into and through a manmade channel cut through a strip of high ground and into the shallow holding and disposal area. Silty sediments deposited in the channel to the debris holding area prohibit vessel operation and drift handling except during periods of high flow at or near full pool. Even at full pool, handling of debris is cumbersome due to the restricted area of the channel and the volume of material that must pass through the channels.

1.2 Previous Actions and Related Documents. The debris booms were originally constructed in 1955. This is the first time dredging of the diversion channel has been required. No previous environmental documentation for this facility has been prepared.

2.0 Need for Action. The purpose of the proposed project is twofold: (1) construction of a rubblemound breakwater to protect the deflection/collection booms at site C as well as one of the barrier islands of the Clark Fork River delta and (2) excavation of the diversion channel leading to the collection facility to enable passage of debris with less difficulty. Site C is protected by an island that is rapidly eroding away due to wave and wind actions coming from Lake Pend Oreille. Complete erosion of this island would mean certain destruction of the site C log boom, which would allow debris flowing from the Clark Fork to enter Lake Pend Oreille and eventually drift down to Albeni Falls Dam. In addition, the barrier island is the final barrier to wind and waves that originate on the lake and hammer the Clark Fork delta. Loss of the barrier island would mean loss of protection for the upper delta, and would result in certain erosion and loss of much of the delta lands. Construction of the breakwater is necessary to prevent destruction of site C and curb erosion of the Clark Fork delta.

The single log boom holding and disposal area enclosure is held in place by single pilings spaced 50- to 100-foot intervals. The debris is concentrated and secured against the bank using additional string booms within the holding area prior to drawdown of the lake. In most years the driftwood is cut for firewood by local residents. If enough drift has been collected to justify disposal (approximately 20 acres and usually about every 5 years), the material is piled by crawler tractor and burned when the entire holding area is dry after drawdown to elevation 2,051 feet has occurred. Large quantities of debris still remain in the Lightning Creek flood plain, and future high flows will bring much of this debris to the Clark Fork, necessitating excavation of the diversion channel to prevent a massive buildup of debris near the site C boom.

3.0 Alternative Actions.

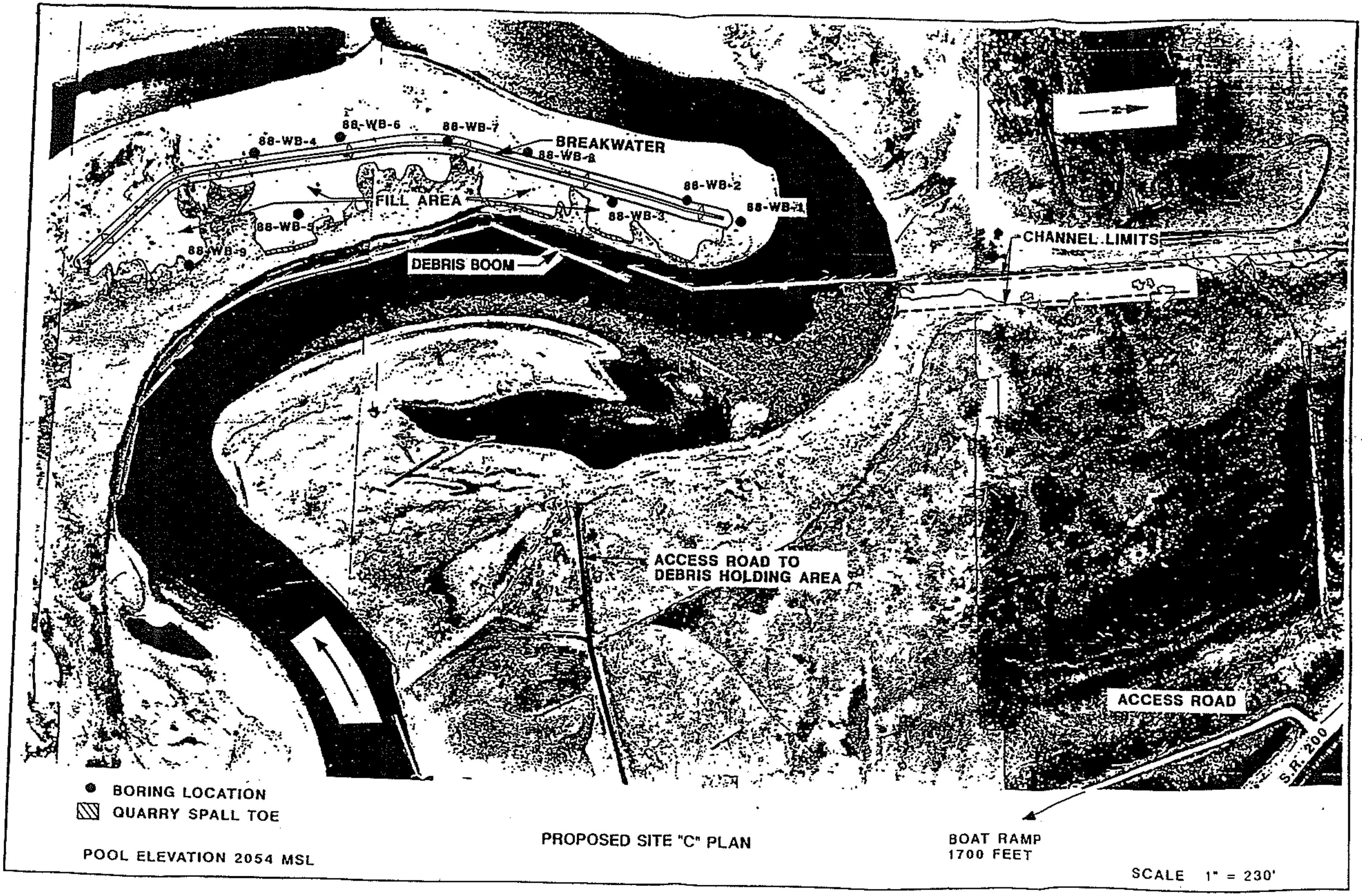
3.1 No Action. The no-action alternative would allow continued and accelerated erosion of the barrier island which presently protects part of site C from wind and wave forces. Erosion of the remaining high ground has increased dramatically in the past several years, and left unchecked, will result in loss of protection for the existing boom structure. Additional break-through upstream of the debris booms is imminent, requiring a major extension of the boom system to ensure control of the debris. Extension of the booms without protection will expose at least 3,000 linear feet of boom to wind and wave forces with a corresponding increase in operation and maintenance (O&M) costs. Should the booms fail, debris would then flow freely into Lake Pend Oreille. Further, delta lands would erode, increasing sedimentation in Lake Pend Oreille, and resulting in further destruction of the Clark Fork delta.

3.2 Proposed Action. The proposed action consists of constructing a 1,870-foot-long rubblemound breakwater consisting of roughly equal amounts of quarry spalls and armor rock and dredging the approximately 700-foot-long diversion channel leading from site C debris boom to the debris collection area (see figures 3 and 4). The breakwater would be constructed on the barrier island that currently protects the debris boom at site C. The material excavated from the diversion channel (about 9,000 cubic yards (c.y.) of sands and silts) would be deposited on the barrier island behind the breakwater (i.e., between the breakwater and the debris boom). As of this writing, a small clamshell dredge or backhoe would be used; dredged material would be loaded onto a barge or truck, transported to the island, and deposited on the island. Because of the need for rehandling of material, disposal would be expensive. It is possible that an alternative disposal site to the east of the diversion channel may be used in lieu of the island to reduce cost.

The construction method of the breakwater is also, as yet, undetermined. Construction may occur during the summer (at full pool elevation) using a barge loaded with rock. The rock would be sequentially dumped at the breakwater site to build the breakwater. An alternative method would require construction of a haul road from the existing project boat ramp overland to the point of land nearest the barrier island. From here, a bridge would be constructed to the island, and truck haul may be used to get material to the island. A barge may be used to get material from the mainland to the island, but this would necessitate an additional rehandling of material. The quarry spalls would be dumped and pushed into position by a bulldozer. The armor rock would likely be placed by a crane. Contractor capabilities could be a determining factor in deciding how and when the breakwater would be built.

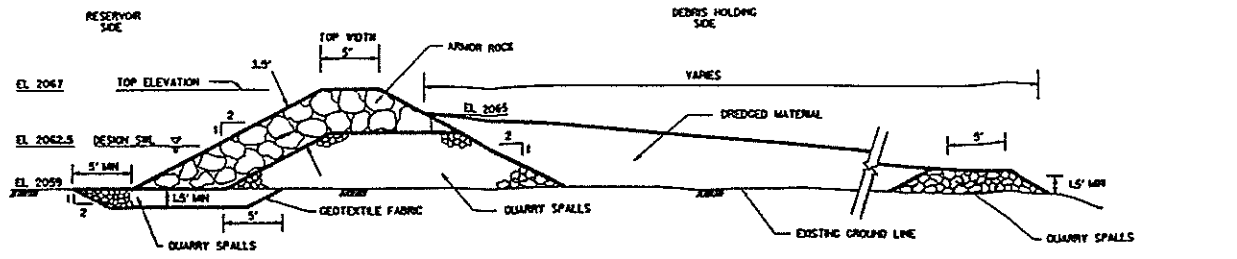
4.0 Environmental Consequences of Proposed Action.

4.1 Noise/Air Quality. Temporary increases in noise levels due to the operation of trucks, bulldozers, dredge, and other machinery will occur. Noise levels are not expected to exceed levels regularly occurring during routine repairs to the log booms and movement and disposal of debris by heavy workboats and bulldozing equipment. However, the construction activity will



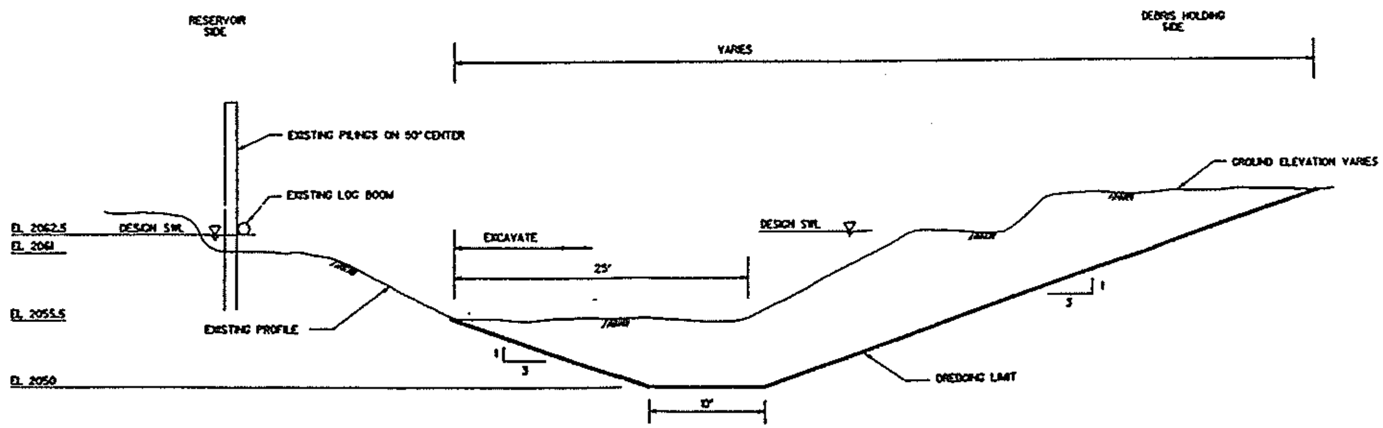
PROPOSED SITE "C" PLAN

FIGURE 3



TYPICAL BREAKWATER SECTION

SCALE 1"=40'
DATUM MSL



TYPICAL DREDGE SECTION

SCALE 1"=40'
DATUM MSL

FIGURE 4

be continued over a period of months (as opposed to the normal, occasional activity). This continual noise may drive away some species of wildlife; on the other hand, some species would become accustomed to the noise and would remain in the area. Increased fuel emissions will occur, but rapid dispersal should result in no adverse impacts.

4.2 Water Quality. Water quality in the Clark Fork River is regulated by the State of Idaho under the Lake Protection Act, June 1974, and the Statutes of the State of Idaho. This area is designated as special resource waters, a classification that allows no reduction in water quality. The proposed project area is devoted to health and recreational use, and human activity is limited to light boating, recreational fishing, and Corps of Engineers' debris boom repairs, all of which have no known impacts on water quality (pers. comm. L.R. Schneider, 1987). Extremely high turbidity levels occur naturally during spring runoff when the Clark Fork River carries a high sediment load to Lake Pend Oreille.

Idaho State Water Quality Standards specify that point source discharges not exceed 5 nephelometric turbidty units (NTU) over background.

Short-term impacts to water quality in the form of increased turbidity will occur during dredging operations. Idaho State Water Quality Standards specify that point source discharges not exceed 5 NTU's over background. Excavation of silty sediments in the diversion channel leading to the debris holding area at site C will result in higher turbidity levels, but should be short term and contained primarily to the channel area as a result of bordering land masses. NTU will be monitored during dredging operations to determine whether turbidity exceeds required levels. If dissipation of turbidity is not at expected rates, a sediment curtain may be used. Construction of the breakwater would result in clean rock dumped into the lake (if the summer construction alternative is selected). Because the rock is clean, no impacts to water quality are expected.

Water quality may be slightly affected in the vicinity of site C due to excavation of potentially contaminated sediments in the diversion channel. Significant contamination is not expected as tests at sites B and C for herbicides, semivolatile hazardous substances, and organochlorine pesticides and PCB's showed that these constituents were below significant levels. Likewise, tests for metals also showed them to be at nonsignificant levels. Furthermore, the metals are associated with the solid phase and would not be susceptible to dissolution. Levels of chemicals and metals in the diversion channel are expected to be low as well since it is close to site C testing areas and the sediments are not significantly different in physical grain size or appearance from those at the test sites. On 27 July 1988, three grab samples were taken from the diversion channel (one from each end and one from the middle). The primary concern of those present was to observe whether a significant amount of decaying wood, and consequently wood related compounds, was present in the sediment. The sediment was composed of fine silts and was quite clean based on appearance. It showed a fair amount of gleying and only one sample contained a fragment of wood. Those present agreed that these sediments are no different from those that were tested upstream and would not contain a significant amount of contamination. No one expressed concern over disposal of these excavated sediments on the barrier island. (Those present included Mike Beckwith, Division of Environmental Quality; Jerry Neufeld, Department of Fish and Wildlife; and John Coyle, Jeff Laufle, and Ken Brunner, Corps of Engineers.

4.3 Vegetation. Vegetation communities occurring in the study area include riparian woodland and scrub, wet meadows, and shallow marsh (table 1). Submerged aquatic species are very limited in the proposed project area, probably due to the absence of suitable substrate for rooted vascular plants and the influence of wave action in exposed areas (Econ, Inc., 1980).

The dominant riparian woodland species are cottonwood and alder; scrub species include willow, dogwood, hawthorn, blackberry, reed canarygrass, and Canadian goldenrod. Wet meadows appear to extend upward to approximately the limit of reed canarygrass or to about 2 feet above mean high water. These wetland communities provide feeding and nesting habitat for a variety of birds and small mammals. The shallow marsh community is dominated by reed canarygrass and cattail, while sedges, bentgrass, rushes, smartweed, and pondweed are also present in small concentrations. Field investigations indicate that this community extends from the highwater line (2,062.5 feet) down to about 2,060 feet. The shallow marsh community is an important feeding and nesting habitat for a wide variety of birds, mammals, and fish (U.S. Army Corps of Engineers, 1983; Econ, Inc., 1980).

A small amount of vegetation on the barrier island would be buried by dredged disposal. Dredged sediments from the diversion channel will be utilized to raise the elevation of areas of the barrier island to approximately 2,065 feet (normal elevation at highwater equals 2,062.5) in order that new vegetation requiring drier substrate (primarily grasses and perhaps a few shrubs and trees) can be planted along the berm. This additional vegetation would not only help protect the area from erosion by wind and wind waves but would provide additional habitat for use by wildlife and birds.

4.4 Fish. Species of game fish found in the Clark Fork River delta in the area of the North Fork channel of the Clark Fork River (i.e., site C) include bull trout (Salvelinus confluentus), brown trout (Salmo trutta), cutthroat (Oncorhynchus clarki, Gerrard rainbow trout (kamloops) (O. mykiss), and whitefish (Prosopium williamsoni) (pers. comm. Ned Horner, Cindy Robertson, 1987). Kokanee (Ondorhynchus nerka) released at the Cabinet Gorge Hatchery generally occur in the project area during the month of July. Kokanee are released approximately mid to late July and tend to move into Lake Pend Oreille very quickly, spending minimal time (approximately 5 days) in the back areas of the river. There is no evidence of mainstem spawning in the proposed project area (pers. comm. Ned Horner, 1987).

Resident nongame fish occurring in the project area include squawfish (Ptychocheilus oregonensis), suckers (Catostomus macrocheilus), spiny fish (Percidae, Ictaluridae, Esocidae, Centrarchidae), slimy sculpin (Cottus cognatus), longnose dace (Rhinichthys cataractae), and redside shiners (Richardsonius balteatus).

TABLE 1

VEGETATION OCCURRING IN PROPOSED PROJECT AREA OF THE CLARK FORK DELTA

Scientific Name	Common Name
Riparian	
Populus deltoides	Great Plains Cottonwood
P. trichocarpa	Black Cottonwood
Alnus incana	Mountain Alder
A. sinuata	Sitka Alder
Salix spp	Willow
Cornus sp	Dogwood
Rubus spp	Blackberry
Phalaris arundinacea	Reed Canarygrass
Solidago canadensis	Canadian goldenrod
Crataegus douglasii	Black Hawthorn
Wetland	
Agrostis alba	Redtop
Carex spp	Sedge
Juncus spp	Rushes
Typha spp	Cattail
Polygonum punctatum	Water Smartweed
Potamogeton spp	Pondweed

Fish in the proposed project area are expected to continue to inhabit the river but move out of the immediate area of dredging operations with little or no resultant impact. Log boom repair workboats regularly effect repairs in the proposed project area with no apparent impacts on fish (pers. comm., John Coyle, Ned Horner, 1987).

Kokanee releases occurred in mid-July in 1988 from Cabinet Gorge Hatchery over a period of about 1-1/2 weeks; the fish quickly disperse to Lake Pend Oreille (within approximately 5 days) (pers. comm. Ed Bowles, 1987). A specific time window for dredging operations will be strictly observed in order to avoid conflict with kokanee releases. According to Ed Bowles, Idaho Department of Fish and Game, some turbidity in the water may help protect the young kokanee from predation by squawfish. An adequate margin of safety for kokanee movement through the proposed project area would be shutdown of dredging operations a minimum of 4 days before the releases are to occur and resumption a minimum of 5 days after the last release (pers. comm. Ed Bowles, 1987). This operating window will be observed during dredging activities.

Construction of the breakwater does not require a time window for cessation of work for fish passage, as it will not impact fish habitat or fish. A possible exception to this would be placement of a temporary haul bridge across the channel to the barrier island, if construction is done during the winter. Placement of the bridge would need to be such that it does not impede fish passage. The substrate on which the breakwater will be placed is continually being altered by wave action, such that aquatic vegetation does not exist here. Cover and food for fish is, therefore, minimal, and placement of the breakwater at the proposed location is not expected to result in loss of fish habitat.

4.5 Wildlife. Small numbers of aquatic furbearers are scattered throughout the Clark Fork Delta area and include beaver, muskrat, mink, and river otter. White-tail deer and black bear occur in the area with occasional sightings of moose and elk; however, these animals were probably transients. Shrews, mice, squirrels, and hares inhabit emergent marsh vegetation and riparian and upland areas of the delta (pers. comm. Paul Hanna, Jerry Neufeld, 1987).

No significant impacts to wildlife at site C are expected. Small animals such as shrews and mice would be expected to reestablish populations at site C after construction of the breakwater and placement of dredged material on the barrier island.

4.6 Birds. Sightings of waterfowl in the project area include mallard, wood duck, teal, gadwall, common merganser, and Canada goose. The Clark Fork River delta is a primary Canada goose (*Branta canadensis*) production area. A large goose brooding pasture exists near the maintenance building and boat ramp area, about 1/4-mile east and north of site C. Nest site selection generally occurs in March with incubation occurring through April. From approximately April 1 to July 1 the birds are on the ground foraging in the area (pers. comm. Jerry Neufeld, 1987). Small numbers of redhead ducks may be observed in fall/winter; however, no breeding occurs in the immediate project vicinity (pers. comm. Jerry Neufeld, 1987).

Birds of prey inhabiting riparian and upland areas include hawks, owls, osprey, and bald eagles. Northern Idaho supports one of the densest populations of osprey in the world (U.S. Army Corps of Engineers, 1983). Osprey occur from mid-March through October, and at least six active nests were observed in the Clark Fork delta area in June 1987 (Memorandum, Ken Brunner, 1987). Three pairs of bald eagles appear to be residents near the Clark Fork delta.

Other birds include the great blue heron, a year-round resident. One of two heronries in the Lake Pend Oreille area is located on the mainland across the North Fork channel approximately one-half mile downstream from the intersection of Lightning Creek and Clark Fork River. Gulls, swallows, bobolinks, and other perching birds, and numerous other bird species are highly visible in the project area.

No significant impacts to birds and waterfowl in the proposed project area are expected. Workboat repair and debris disposal activities at the sites occur regularly with no known impacts. A few nests of mallards and sparrows may exist on the barrier island along which the breakwater will be constructed. It is expected that any birds previously nesting in the area will reestablish nesting activities after completion of the breakwater and dredged material disposal, and subsequent enhancement of the habitat.

Canada geese nest near the proposed project area. No known nests exist near the location of the proposed haul road or either possible disposal area. Nor are there geese nests on the barrier island. A large goose brooding pasture near the Corps of Engineers maintenance building would not be directly affected by project construction. However, nesting and brooding birds may be disturbed by the continued construction noise.

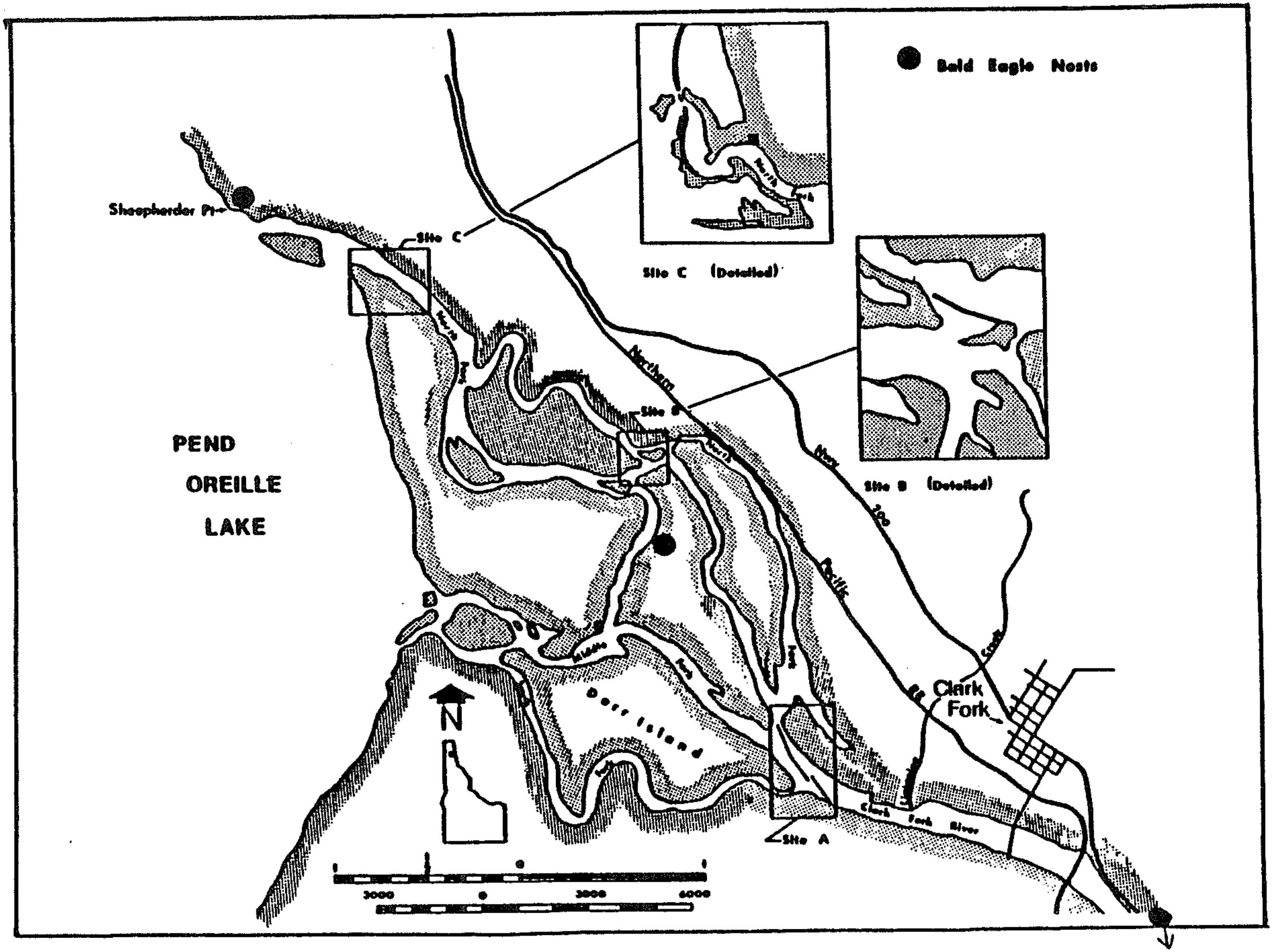
Other birds and waterfowl are expected to avoid the area during excavation operations with no resultant impacts, primarily because the area of construction is away from their nesting and feeding areas.

4.7 Endangered Species. The bald eagle (*Haliaeetus leucocephalus*) is listed as an endangered species in the State of Idaho under the protective provisions of the Endangered Species Act of 1973 as extended by the U.S. Department of the Interior, March 1978. Three possible resident pairs of bald eagles have been observed nesting in the Clark Fork delta area (figure 5).

The bald eagle nest in closest proximity to the construction area is located approximately 2 miles from site C (about 1/3 mile from site B) (figure 5), which is safely within Idaho advisory guidelines for human activity (pers. comm. Jay Crenshaw, 1987). Construction activity would be at least 2 miles from this nest; as such no impacts to bald eagles are expected. A biological assessment evaluating bald eagle behavior in relation to the project has been prepared and transmitted to the U.S. Fish and Wildlife Service (FWS). Response from the FWS has not been received.

4.8 Cultural Resources. Cultural resource reconnaissance studies were completed in the proposed project area in November 1987 (Lawr Salo, 1987). No cultural resources were found in the project impact area, although sites 10BR653, 10BR654, 10BR657, and 10BR658 are nearby. The proposed project will have no effect on cultural resources that may be eligible for the National Register of Historic Places.

5.0 Coordination With Others. Site inspections were held 23 and 25 June 1987, and again on 27 July 1988. Participants from the Seattle District, U.S. Army Corps of Engineers, included John Coyle, Resource Manager at Albeni Falls Project Office, who was the site inspection leader; Jill Gough and Diane M. Hilmo, Civil Project Management Section; Jack Thompson and Ken Brunner, Environmental Resource Section; Jody Derman, Biological Surveys, Inc.; Ned Horner, Jerry Neufeld, Idaho Department of Fish and Game (IDFG); Bob Schneider, Department of Lands (IDL); Mike Beckwith and Gary Gaffney, Department of Health and Welfare, Division of Environment; and Michael Doherty, Walla Walla District, U.S. Army Corps of Engineers. Invited but not participating were the U.S. Fish and Wildlife Service, Boise, Idaho (USFWS), USFS, National Park Service, Environmental Protection Agency, Idaho Division of Environmental Quality, and the Nez Perce Fisheries Management Office. Most agencies felt the project was straightforward and declined to attend the field trip. Letters were received from the USFWS, IDFG, and IDH&W. IDL and Clark Fork Hatchery responded informally by telephone. No negative comments were received.



Bald Eagle Nests
Sheepherder Pt
Site C
Site C (Detailed)
Site B
Site B (Detailed)
PEND
OREILLE
LAKE
Northern
Pacific
RR
Hwy
200
Clark
Fork
Derr Island
Middle
Fork
North
Fork
Site A
Clark Fork River
N
3000
0
3000
6000

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United States Department of the Interior

FISH AND WILDLIFE SERVICE

BOISE FIELD OFFICE
4696 Overland Road, Room 576
Boise, Idaho 83705

September 25, 1988

R. P. Sellevold, P.E.
Chief, Engineering Division
Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124-2255

Re: Breakwater Construction - Lake Pend Oreille
1-4-88-I-344

Dear Mr. Sellevold:

This is our reply to your letter dated August 15, 1988, regarding breakwater construction on the Clark Fork Delta, Lake Pend Oreille, Idaho as it may relate to threatened and endangered species. The biological assessment fulfills the requirements under the Endangered Species Act, as amended, to report to the U.S. Fish and Wildlife Service for possible effects on endangered and threatened species that may be present in the project area.

It is our conclusion, based on our own current information and that which was provided in the excellent biological assessment, that no Section 7 formal consultation will be necessary. However, should the proposed project be modified or new data becomes available on the listed species found in the area, we request that you reconsult with us. This will be important, since it is our understanding that specific dates have not been set as to when the project will be initiated and completed.

Sincerely yours,

For Charles H. Lobdell
Acting Field Supervisor

cc: D. Thorsen, Forest Service, Sandpoint
IDFG, Region 1, Coeur d'Alene

United States Department of the Interior

FISH AND WILDLIFE SERVICE

BOISE FIELD OFFICE
4696 Overland Road, Room 576
Boise, Idaho 83705

October 4, 1988

Mr. Norman Skjelbreia, Design Engineer
Design Branch, Civil Section
Seattle District, Corps of Engineers
Post Office Box C-3755
Seattle, Washington 98124-2255

Re: CENPSEN-CD-88-1
SP# 1-4-88-SP-350

Dear Mr. Skjelbreia:

The U.S. Fish and Wildlife Service (Service) has already provided a list of threatened or endangered species for the project. We have also reviewed the biological assessment and have no further comments regarding threatened or endangered species.

Further, we have reviewed the proposed project in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and have identified no environmental impact that would justify denial or modification of this activity.

Sincerely yours,

Charles H. Lobdell
Acting Field Supervisor

cc: FWS, SE, Boise

STATE OF IDAHO

DEPARTMENT OF HEALTH AND WELFARE

DIVISION OF ENVIRONMENTAL QUALITY
450 West State Street
Boise, ID 83720-9990

October 21, 1988

U.S. Army Corps of Engineers
Seattle District
Design Branch
Box C-3755
Seattle, Washington 98124-2255

ATTN: Norman Skjelbreia

Re: CENPSEN-CD-88-1
(North Fork Clark Fork River, Bonner County, Idaho)

Gentlemen:

We have considered water quality certification of your proposal to construct 1,870 linear feet of rubblemound breakwater approximately 5 feet wide at top and a maximum of 8 feet above the existing ground elevation by placing 7,000 cubic yards of 300 to 1,000-pound rock over 7,000 cubic yards of quarry rock at the mouth of the Clark Fork River near Clark Fork, Bonner County, Idaho; and to use 9,000 cubic yards of material excavated from deepening the diversion channel 5 feet to an elevation of 2,050 feet, with 3 to 1 side slopes, to restore the eroded uplands behind the breakwater as described in public notice number CENPSEN-CD-88-1. To ensure protection of water quality, the following conditions should be included in the Department of the Army permit on the project:

1. Turbidity generated by dredging shall be prevented from entering Pend Oreille Lake or the main body of the Clark Fork River.

2. The disposal and stabilization of the dredge spoils shall be such that they will not re-enter the river or lake. It appears that the spoils will be inundated seasonally; hence, they are to be protected from erosion.

If construction is completed in accordance with the described work plan and above conditions, we certify under Section 401 that this construction will comply with applicable requirements of Sections 301, 302, 303, 306, and 307 of the Clean Water Act, as amended, and will not violate Idaho Water Quality Standards and Wastewater Treatment Requirements.

This certification does not imply approval of the activity by other agencies of the State of Idaho.

Sincerely,

David L. Humphrey
Acting Administrator

cc: IDWR (Northern Region), Haynes
Ed Tulloch/Steve Breithaupt
CORPS-Walla Walla
EPA-IOO

Region I
2320 Government Way
Coeur d'Alene, Idaho 83814-3683
Telephone: (208) 765-3111

October 4, 1988

Mr. Norman Skjelbrela, Design Engineer
US Army Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124-2255

Dear Mr. Skjelbrela:

REFERENCE: CENPSEN-CD-88-1

The Idaho Department of Fish and Game has no objection to the proposal to construct 1,870 feet of rubblemound breakwater at the mouth of the Clark Fork River.

We do request the permit contain the following special conditions:

1. Not allow construction activity during March 1 through April 30 to protect nesting Canada geese.

2. Maintain fish passage through the construction area. Most critical time is September 1 to December 30 and April 1 to June 30. If culverts are used to span the channel to provide access to the island work, they should be sized to keep velocities below 5 ft./sec.

3. Coordinate closely with the department on activities impacting Corps lands licensed to the department.

The closest bald eagle nest is about one mile southeast of the proposed project. We anticipate no interference with this nest from this activity.

Thank you for the opportunity to comment on this proposal. If you need more information, please let me know.

Sincerely,

David W. Ortmann
Regional Supervisor

DWO:JN:amh
CC: Bureau of Wildlife
Bureau of Program Coordination

Region
2320 Government Wa
Coeur d'Alene, Idaho 83814-368
Telephone: (208) 765-311

November 3, 1988

Mr. R.P. Sellevold, PE
Chief, Engineering Division
Corps of Engineers, Seattle District
P.O. Box C-3755
Seattle, WA 98124-2255

Dear Mr. Sellevold:

In reviewing public notice CENPS-EN-CD-88-1, the environmental assessment and the 404 evaluation report, we would like to make a few comments.

Ample mention and recognition were given to kokanee salmon fry releases made from Cabinet Gorge Hatchery in mid-July and the necessary provisions for these fish. However, earlier releases (mid-June) are being evaluated and probably will be utilized over the traditional mid-July releases of the past.

Provisions mentioned in section 2.5 of the 404(b)(1) Draft Evaluation are adequate. We will need to coordinate on the timing of the releases.

Adult kokanee salmon use the delta area for migration to the lower stretches of the Clark Fork River and to Cabinet Gorge Hatchery. Although adequate comments have been made concerning adult passage provisions, we would like to add that our first major return of kokanee salmon will occur during late October, November and December 1990. Completion of this project prior to October 1990 would avoid any possible conflicts in this area.

Sincerely,

David W. Ortmann
David W. Ortmann
Regional Supervisor

DWO:EBS:amh

CC: Bureau of Fisheries
Bureau of Program Coordination
E. Schriever

TELEPHONE OR VERBAL CONVERSATION RECORD For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.		DATE Oct 13, 1988
SUBJECT OF CONVERSATION Albeni Falls Breakwater EA and 404 evaluation report		
INCOMING CALL		
PERSON CALLING Ed Schriver	ADDRESS Clark Fork Hatchery Clark Fork, Idaho	PHONE NUMBER AND EXTENSION (208) 266-1567
PERSON CALLED Ken Brunner	OFFICE CENPS-EP-ER	PHONE NUMBER AND EXTENSION x3624
OUTGOING CALL		
PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
PERSON CALLED	ADDRESS	PHONE NUMBER AND EXTENSION

SUMMARY OF CONVERSATION:

1. Mr. Schriver called to provide comments on the subject reports.

2. a. He was concerned that we did not discuss migrating adult salmon present during fall and early winter. I explained that we did, that we would do what we could to prevent impacts to salmon

b. Mr. Schriver also indicated that the hatchery releases will now be in mid-June, not mid-July as stated in the EA. The revised EA will reflect this change, and change in window for construction. At this time it does not affect construction, since we have not scheduled the construction or let a contract for construction.

c. Mr. Schriver stated one concern with the 404 evaluation report: we state that if material excavated from the diversion channel is contaminated, an alternative to disposal near the breakwater is to disposal on uplands across the channel from the breakwater, and that another alternative is to dispose of the material in deep water of Lake Pend Oreille. The sentence is misleading and will be corrected. What it should say is that a potential option for clean dredged material disposal is in deep water in Lake Pend Oreille (it is not an alternative, nor is it an option for disposal of contaminated material).

Ken Brunner

DA FORM 1 APR 66 751 REPLACES EDITION OF 1 FEB 58 WHICH WILL BE USED.

☆ U.S. G.P.O. 1983-381-646/8225

TELEPHONE OR VERBAL CONVERSATION RECORD For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.		DATE Oct 17, 1988
SUBJECT OF CONVERSATION Albeni Falls Breakwater		
INCOMING CALL		
PERSON CALLING Lance Nielsen	ADDRESS Idaho Dept. of Lands	PHONE NUMBER AND EXTENSION (208) 664-2171
PERSON CALLED Ken Brunner	OFFICE CENPS-EP-ER	PHONE NUMBER AND EXTENSION X3624
OUTGOING CALL		
PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
PERSON CALLED	ADDRESS	PHONE NUMBER AND EXTENSION

SUMMARY OF CONVERSATION:

1. Mr. Nielsen called to relate a couple of comments. The first was that the project appears to be reasonable and worthwhile. The second comment is that, under State of Idaho law, we will need to apply for a state "Encroachment Permit", under section 404 of the Clean Water Act. I asked whether our 404 evaluation report was adequate for that purpose, and responded that a separate application was required. He acknowledged that there is some question whether a Federal agency must abide by state law, but nevertheless hoped that we would comply with the state reqs. I asked him how long the process normally takes; he replied that it usually takes less than 30 days. He will send us an application form along with Department of Lands' comments.

2. Action. At this point, there is no reason not to complete the state's 404 process – since we have no funding for construction, if we complete the process by the end of November, it should not impact any schedule. I will ask for the project manager's concurrence, of course, before completing the application.

Ken Brunner

DA FORM 1 APR 66 751 REPLACES EDITION OF 1 FEB 58 WHICH WILL BE USED.

☆ U.S. G.P.O. 1983-381-646/8225

404(b)(1) EVALUATION
CLARK FORK DEBRIS CONTROL FACILITY REHABILITATION
ALBENI FALLS PROJECT, IDAHO

1.0 Introduction. This evaluation has been prepared pursuant to the proposal by the U.S. Army Corps of Engineers to construct a rubblemound breakwater protected by armor rock (riprap) on a barrier island of the Clark Fork delta. The evaluation also discusses disposal of excavated material behind the breakwater. These actions would be undertaken to protect debris collection booms and other features of the Clark Fork debris collection facility, a part of the Albeni Falls Dam project. The evaluation was prepared according to Section 404(b)(1) of the Clean Water Act in accordance with guidelines promulgated by the Environmental Protection Agency (EPA) (40 CFR 230) for evaluation of the discharge of dredged or fill material into waters of the United States. Completion of the project will protect riparian and wetland habitats and nesting and foraging sites for Canada geese, as well as providing increased safety for waterborne traffic and the turbines at Albeni Falls Dam. Reference to the environmental assessment (EA) and the biological assessment (BA) prepared for this project (December 1987) will be made when considered pertinent.

2.0 Description of the Proposed Discharge. Chemical testing of materials from the North Fork of the Clark Fork River indicates that there is no contamination of the sediments; metals analyses suggest that no metals will be biologically available in concentrations to elicit an impact. Sediments to be taken from the diversion channel and placed on the barrier island are expected to be similar, with the possibility that organic debris may elevate biochemical oxygen demand. Site B materials are primarily coarse to fine sands. Site C materials are composed of fine sands and silts.

Approximately 7,000 cubic yards (c.y.) of quarry spalls and 7,000 c.y. of riprap (armor rock) will be obtained from an existing quarry, placed on a barge or on a truck and hauled via a temporary bridge, and transported to the barrier island at site C. Materials from the diversion channel will be placed on the barrier island from a barge or land equipment such as trucks, front-end loaders, etc. Riprap would be placed on the lakeward side of the breakwater to prevent further erosion from wave action.

2.1 Need for Discharge and Breakwater Construction. The barrier islands of the Clark Fork delta have been eroding due to wave action during the period of time when Lake Pend Oreille is at full pool elevation. These islands provide protection for the debris collection facility as well as important riparian habitat and resting, breeding, and nesting grounds for Canada geese and other species. Construction of the breakwater and placement of dredged materials at the proposed location will restore portions of the barrier island already eroded. Erosion of the fill material is not anticipated due to its placement behind and 2 feet below the breakwater and 2.5 feet above the normal high pool. In addition, riprap will be placed to further protect against erosion. Revegetation of the fill will also aid stabilization.

2.2 Location. The project area is located at the confluence of the Clark Fork River delta and Lake Pend Oreille. The debris booms are located at three sites in the river; the farthest upstream is approximately 4 miles upstream in the main fork of the river; the remaining two are located in the North Fork approximately 2 miles upstream and immediately adjacent to the outer barrier island (figure 1).

2.3 Description of the Disposal and Breakwater Site. The site is a river delta barrier island in an area subject to wave action during the late spring, summer, and early fall months when the lake level is at or near full pool elevation. The total estimated area of the breakwater and fill is 2.5 acres. The lakebed in this area consists primarily of sand and silts deposited by the Clark Fork. Adjacent barrier island habitat types include riparian woodlands and scrub and wet meadows; however, rooted vegetation in this area is limited. Species inhabiting the lake/delta area include bull trout (*Salvelinus confluentus*), brown trout (*Salmo trutta*), cutthroat trout (*S. clarki*), Gerrard rainbow trout (kamloops) (*S. gairdneri*), and whitefish (*Prosopium williamsoni*). Kokanee from the Cabinet Gorge Hatchery pass through the area enroute to Lake Pend Oreille in mid to late July. Wildlife utilizing the barrier island include aquatic furbearers and waterfowl, including Canada geese, raptors, and great blue heron.

2.4 Method of Discharge and Placement of Breakwater Material. Material will be transported by barge and/or truck to the site. Materials from the diversion channel would be brought to the site by barge; these materials will be placed by tractor atop the gravel and nearshore of the island. Riprap would then be placed by a barge-mounted crane or by heavy land-based equipment such as a crane or front-end loader.

2.5 Timing of Discharge and Breakwater Construction. Work may be undertaken during any time of year. If construction occurs during summer a timing window to preclude conflicts with kokanee releases will be observed for approximately 10 days in July (a suggested minimum of 4 days prior to release and 5 days subsequent to release). This will require ongoing close coordination with the Idaho Department of Fish and Game.

2.6 Projected Life of the Disposal Site and Breakwater. The project life of the breakwater and fill is estimated at approximately 25 years. Minor rehabilitation work would be undertaken to restore the breakwater when this becomes necessary. Therefore, the actual life of the structures will be indefinite.

3.0 Potential Impacts on Physical and Chemical Characteristics of the Aquatic Ecosystem.

3.1 Substrate. Existing substrate will be covered and converted to uplands. The completed fill and breakwater will provide a stable substrate for creation of additional habitat.

3.2 Suspended Particulates/Turbidity. Suspended particulates and turbidity will increase during construction operations. Refer to the EA section 4. If dissipation of turbidity is not as expected and exceeds Idaho water quality standards, a sediment curtain may be used.

3.3 Water Quality. No significant concentrations of metals or organic compounds are expected to be released into the water during the proposed work. Potential impacts include increased turbidity or a release of metals bound to the sediments (see appendix B of the EA). As indicated in the above referenced appendix, organic concentrations in the samples collected immediately upstream are too low to anticipate any impact resulting from their release. Short-term, localized impacts on turbidity and suspended sediments will occur during construction; however, impacts are expected to be minimal.

3.4 Current Patterns and Water Circulation. Water from the North Fork of the Clark Fork flows past the project area and is high enough in elevation to be of erosional concern only during spring and summer until Labor Day, when the lake elevation is held at 2,062.5 feet. It is during this time period that the wind generated waves from the south and west have the greatest potential to erode the barrier islands. Following Labor Day and extending into late November, the lake level is dropped to a normal low of 2,051 and as low as 2,049.7 feet in critical water years. During the winter and extending into spring, when the lake begins to refill from increased runoff, the project area is adjacent to very shallow waters or dry. Water movement in the vicinity of the site is very limited during the winter months.

3.5 Normal Water Fluctuations. The annual fluctuation of Lake Pend Oreille ranges, under normal conditions, between 2,062.5 feet and 2,051 feet (levels as high as 2,065.7 and as low as 2,049.7 have occurred). During the summer, the lake is held at full pool. The mandatory fall drawdown period usually begins immediately after Labor Day but not later than 1 October. By 1 November, the lake level must be reduced to elevation 2,060 feet or lower to protect lakeshore property from wind and wave damage. The lake continues to be drafted through the fall, and must be down to elevation 2,056 by late November. The normal winter elevation reached is 2,051 feet. In accordance with an agreement between the State of Idaho and the Corps of Engineers, lake levels throughout the winter are not allowed to drop below that existing on 20 November (this is a target, 1 December is the absolute date) to protect beach spawning kokanee. (In a critical power year, a further drawdown to 2,049.7 feet may occur at any time during the winter.) With the onset of spring floods, the lake is refilled. Full pool is achieved during the month of June.

3.6 Salinity Gradients. No salinity gradients will be affected.

4.0 Potential Impacts on Biological Characteristics of the Aquatic Ecosystem.

4.1 Threatened and Endangered Species. Bald eagles have been identified in the proposed project area. Three possible resident pairs have been observed in the Clark Fork delta area. No nest is closer than 2 miles from the proposed project site. The eagles have used the area for some time and are not noticeably affected by ongoing recreation, construction, and other human activities. There are no impacts anticipated as a result of this proposed project.

4.2 Aquatic Food Web. The proposed project will result in the covering of approximately 2.5 acres of lakebed adjacent to an eroding delta barrier island. This will result in the expansion and creation of additional wildlife habitat and Canada goose nesting areas. The initial construction may decrease productivity in the short term; however, elimination of erosion of the island, restoration of eroded uplands, and the enhancement of the island habitats, will in the long-term increase the productivity of the aquatic/riparian/marsh habitats.

4.3 Wildlife. Impacts to bald eagles are discussed above. Mallards and other waterfowl, which probably utilize the island as a nesting and rearing site, will not be impacted in the long term. Without the project, it is anticipated that within a few years the islands currently used for nesting would be eroded and no longer usable by mallards. The aquatic furbearers, small mammals, songbirds, and waterfowl using the island will not be impacted negatively as a result of this project.

5.0 Potential Impacts on Special Aquatic Sites.

5.1 Wetlands. The adjacent barrier islands are primarily riparian woodland and scrub, wet meadows, and marsh. The adjacent lakebed has very limited populations of submerged aquatic plant species due to wave action and drying of the site during periods of low pool elevation. Completion of the project will ensure protection of these island habitats.

5.2 Sanctuaries and Refuges. No scientific study areas, sanctuaries, or refuges will be affected by the proposed action. Overall impacts are expected to be minimal. Some lakebed area will be lost but in the long term, protection of barrier islands will enhance productivity of the Clark Fork delta.

5.3 Mudflats. Not applicable.

5.4 Vegetated Shallows. There is no submerged aquatic vegetation in the vicinity of the project.

6.0 Potential Effects on Human Use Characteristics.

6.1 Municipal and Private Water Supplies. No private or municipal water supplies will be impacted by the proposed project.

6.2 Recreational and Commercial Fisheries. Potential discharge effects on recreational and commercial fisheries are expected to be minimal. Construction will be timed so that kokanee releases from Cabinet Gorge Hatchery in mid to late July will not be impacted; work will not take place for 4 days prior to release and 5 days after release. Recreational fisheries in the river will only be impacted directly at and adjacent to the project area for a short time period during construction. No long-term impacts are anticipated.

6.3 Water Related Recreation. Recreational boating may be slightly impeded during construction (although alternative routes between the river and lake will continue to be available via the middle and main forks of the Clark Fork); however, following completion of the project, recreational boating safety in Lake Pend Oreille will be assured in the long term.

6.4 Esthetics. The existing views of the Clark fork delta will be changed during the proposed work. The creation of additional riparian woodland and scrub after stabilization and elevation increase on the island will add to the esthetics of the delta in that additional habitat will encourage continued nesting and rearing of mallards and other waterfowl, potential additional use by songbirds, waterfowl, aquatic furbearers, and small mammals.

6.5 Parks, National and Historic Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves. No such areas would be impacted by the proposed work. No National Register eligible cultural resources will be affected by the proposed work.

7.0 Evaluation and Testing of Discharge Material.

7.1 General Evaluation of Dredged or Fill Material. Sediments analyzed from sites B and C indicate no significant contamination due to organic constituents. Tests included: herbicides in soil, semivolatile hazardous substances, and organochlorine pesticides and PCB's. Metals found are included in the following table. (All units are mg/kg, dry weight basis.)

	Station B	Station C (duplicates run)	
Arsenic	5.1	12.0	11.87
Barium	154.	14.6	16.2
Cadmium	3.3	3.44	3.07
Chromium	9.2	8.26	10.08
Copper	99.9	106.	93.8
Lead	67.5	89.3	45.6
Mercury	0.08	0.09	0.07
Nickel	26.	25.1	26.8
Selenium	0.2	0.2	0.2
Silver	0.54	0.49	0.59
Zinc	154.	346.	319.

These figures represent total recovery from moderate acid extraction (EPA method 3050, except for mercury, method 7471) of the sediments followed by furnace atomic absorption spectrophotometry (again except for mercury, which was manual cold vapor AA).

Chain of custody forms and quality control analyses are available for inspection at the Seattle District office of the Corps of Engineers.

Concentrations of these metals at the levels found in these sediments are not considered likely to cause biological effects, particularly since the metals are associated with the solid phase, and would not be susceptible to dissolution by the means to be employed in the sediment's removal and placement.

7.2 Evaluation of Chemical-Biological Interactive Effects.

7.2.1 Results of Material Testing. Chemical analysis of the dredged material from sites B and C revealed no significant organic or metals contamination.

7.2.2 Water Column Effects. No long-term significant water column effects are anticipated as a result of the proposed action. Short-term effects will be limited to increased turbidity in the immediate vicinity of the work area.

7.2.3 Effects on Benthos. No significant chemical effects upon the aquatic biota would be expected.

7.3 Comparison of Excavation and Discharge Sites. The disposal site is comprised primarily of alluvial deposits of fine sand and silt. Site C (diversion) channel sediments closely resemble the disposal site in terms of sediment types. The biological communities are indicative of the varied substrate. Refer to EA section 3.

7.4 Physical Tests and Evaluation. Sediments from site A are gravels and cobbles to 8-inch diameter. Sieve analysis from site B indicates that 93.1 percent of the sediment is sand with 6.6 percent fines. At site C, sand comprised 24.3 percent of the sediment with 75.7 percent of the sediment classified as fines.

8.0 Factual Determinations.

8.1 Physical Substrate Determinations. Approximately 2.5 acres of delta which is submerged for at least 6 months of the year will be covered by the breakwater and will be above lake levels for the entire year. Dredged material disposal will increase the elevation of the barrier island but will not impact any submerged lands.

8.2 Water Circulation, Fluctuation, and Salinity Determinations. The proposed excavation is not expected to adversely impact water movement. At the disposal site, the primary impact will be to reduce or eliminate erosion of the barrier island; changes in circulation and fluctuation will not occur as a result of this project. Salinity is not an issue with this project.

8.3 Suspended Particulates/Turbidity. During construction, suspended particulate levels are expected to increase, resulting in increased turbidity levels. Anticipated impacts are temporary and should occur only during construction. Long-term impacts are not anticipated.

8.4 Contaminants. Based on available information, the potential for contamination of the receiving water is very slight. Although barium, copper, nickel, and zinc are in higher concentrations than background, it is not anticipated that these metals will be biologically available.

8.5 Aquatic Ecosystem and Organisms Determination. The placement of fill materials will eliminate approximately 2.5 acres of shallow delta habitat which is presently above the water level of the lake about 6 months of the year. The proposed work will preclude the erosion of the barrier island and preserve the riparian woodland and wet meadows found on other islands in the delta. This action will preserve the Canada goose nesting and rearing sites on the mainland across the channel from the barrier island.

8.6 Proposed Disposal Site Mixing Zone Determination. Excavation in the diversion channel at site C may result in a downstream turbidity plume, which will be limited to the channel area and be restricted by the adjacent island. NTU will be monitored during construction to ensure compliance with Idaho Water Quality Standards.

8.7 Determination of Cumulative Effects on the Aquatic Ecosystem. Based on the EA and BA, it is considered that the long-term cumulative impact of the proposed project will be positive. The island will be protected from further erosion, additional riparian vegetation will be planted, and the Canada goose nesting and rearing area protected and enhanced. The loss of approximately 2.5 acres of delta shallow habitat (which is dry for about 6 months each year) will be offset by the protection and addition of riparian habitat.

8.8 Determination of Secondary Effects on the Aquatic Ecosystem. The major secondary impact of the project will be the facilitation of debris movement from the mainstem Clark Fork to the North Fork and ultimately into the debris holding area. As a result, recreational boating safety in Lake Pend Oreille will be maintained. This project is not expected to increase boat traffic since protection of the debris collection facility will not enhance the lake for recreational boat use; the project will simply maintain the status quo.

9.0 Proposed and Alternative Actions to Minimize Adverse Effects.

9.1 Actions Concerning the Location of the Fill. The preferred location of the proposed fill would preserve the barrier islands adjacent to the debris collection area and protect the C boom. Alternative placement of the fill will not preserve the island nor protect C boom. Deepwater disposal of the materials in Lake Pend Oreille is an alternative; however, deepwater disposal would not accomplish the protection of the barrier island.

9.2 Actions Concerning the Material to be Discharged. There are no plans to treat or rehandle the materials to be discharged since the materials do not contain toxicants or contaminants in concentrations significant to the aquatic ecosystem.

9.3 Actions Controlling the Material After Discharge. Following placement of materials, no further erosion of materials from the site is expected. Therefore, no further measures to control placement of the dredged materials are necessary.

9.4 Actions Affecting the Method of Dispersion. There are no practicable methods which will result in reduced impacts on water quality due to the manner in which the material is to be placed. No other practicable construction alternative is known that would reduce the turbidity dispersion at the excavation and/or disposal site.

9.5 Actions Related to Technology. No other technology is known that would be both practicable and have fewer discharge effects than the selected construction technique.

9.6 Actions Affecting Plant and Animal Populations. There are no known practicable alternative actions that would minimize adverse construction effects on the plant and animal populations submerged on the river delta. Protection, elevation, and replanting of the barrier island will minimize the impact of the proposal on the delta ecosystem.

9.7 Actions Affecting Human Use. The proposed alternative for discharge of dredged material is not expected to have major impacts on the human populations. Placement of the materials to protect the Canada goose and mallard nesting and rearing areas from erosion will provide continued opportunity for bird watching.

10.0 Analysis of Practicable Alternatives. Under Section 404(b)(2), the applicant must demonstrate that there "is no practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystems, so long as the alternative does not have other significant adverse environmental consequences." Excavation of the diversion channel adjacent to debris boom C is necessary to facilitate movement of the debris out of the north stem of the Clark Fork River and into the debris collection area. Placement of material at the proposed site is needed to preserve the barrier island and protect debris boom C. Riprapping of the site is necessary to preclude the erosion of the fill material.

10.1 Design Alternatives. Alternatives considered for placement of materials were related to the protection of the fill material; the exclusion of riprap was examined. The site selected for placement of the dredged material is exposed to considerable wave action at times when Lake Pend Oreille is held at summer lake levels. Without armoring, material will gradually be eroded; further erosion will lead to the loss of the barrier island. Additional dredged material placement would be required at periodic intervals to provide continued protection of the island. The recommended alternative reduces the need for continued filling of this site. The letter report provides a detailed history of alternative projects considered and discarded.

10.2 Water Dependency. The proposed fill will serve to protect important riparian woodland, scrub, and marsh habitats. The loss of approximately 2.5 acres of seasonally submerged and low quality aquatic habitat will be offset by the protection of these delta island habitats.

10.3 Conclusion of Alternatives. The proposed activity will lead to protection of existing riparian wildlife habitat. The design of the fill has considered possible impacts, minimizes potential impacts to the aquatic ecosystem, and protects and enhances upland habitat.

11.0 Review of Conditions for Compliance.

11.1 Availability of Practicable Alternatives. Based on available information there appears to be no available alternative to the proposed action that would have less long-term impact.

11.2 Compliance with Pertinent Legislation.

11.2.1 State Water Quality Standards and Federal Toxic Effluent Standards (Section 307 of the Clean Water Act). Based on examination of available data, the project appears to be in compliance with these standards.

11.2.2 Threatened and Endangered Species (Endangered Species Act of 1973. The proposed action would not impact bald eagles and therefore would be in compliance with the requirements of the Endangered Species Act.

11.3 Potential for Significant Degradation of Water as a Result of the Discharge of Polluted Material. Based on the information presented above and in the EA, it is concluded that the proposed discharge will not result in the release of contaminants that will have significant adverse effects on human health or welfare, the aquatic ecosystem and wildlife dependent on the ecosystem, and recreation, esthetics, and economic values.

11.4 Measures to Minimize Potential Adverse Impacts on the Aquatic Ecosystem. All appropriate and practicable measures to minimize potential adverse discharge effects have been included in the proposed project.

12.0 Findings. Based on the information available, I have concluded that the proposed action complies with the evaluation criteria set forth in the Section 404(b)(1) guidelines.

4/13/89
DATE

PHILIP L. HALL
Colonel, Corps of Engineers
District Engineer

APPENDIX 13

Influent Total P Loads - Clark Fork River (Water Years 1970-1972)

APPENDIX 13. INFLUENT TOTAL P LOADS FROM CLARK FORK R. WY70-72 (ESTIMATED FROM USGS DATA)

WY1970 TP LOAD (DATA REPORTED IN USGS WATER RESOURCES DATA BOOKS)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
10/21/69	11/18/69	29	0.02	22000	31,211
11/19/69	12/16/69	28	0.01	16200	11,095
12/17/69	1/27/70	42		14300	
1/28/70	2/25/70	29	0.01	12000	8,512
2/26/70	3/24/70	27		13700	
3/25/70	4/26/70	33		26300	
4/27/70	5/17/70	21	0.05	26700	68,574
5/18/70	6/15/70	29	0.01	23800	16,882
6/16/70	7/13/70	28	0.02	72100	98,760
7/14/70	8/17/70	35	0.1	30000	256,830
8/18/70	9/22/70	36		12000	
9/23/70	9/30/70	8	0.01	18400	3,601

NOTE: 7/14 TP value appears too high

•Average TP concentration 10/21/69 - 9/23/70 (excluding 7/14/70 value) = 0.02 mg/l

•Average flow 10/21/69 - 9/23/70 = 23958 cfs

WY 1970 TP LOAD - CALCULATED BY INSERTING AVERAGE OF TP CONCENTRATION (0.02 MG/L) INTO THE 7/14/70 DATE AND THOSE DATES FOR WHICH NO TP CONCENTRATION WAS REPORTED, AND USING THE AVERAGE FLOW (23958 CFS) FOR THE FIRST 20 DAYS OF THE WATER YEAR

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
10/1/69	10/20/69	20	0.03	23958	35,161
10/21/69	11/18/69	29	0.02	22000	31,211
11/19/69	12/16/69	28	0.01	16200	11,095
12/17/69	1/27/70	42	0.02	14300	29,381
1/28/70	2/25/70	29	0.01	12000	8,512
2/26/70	3/24/70	27	0.02	13700	18,096
3/25/70	4/26/70	33	0.02	26300	42,458
4/27/70	5/17/70	21	0.05	26700	68,574
5/18/70	6/15/70	29	0.01	23800	16,882
6/16/70	7/13/70	28	0.02	72100	98,760
7/14/70	8/17/70	35	0.02	30000	51,366
8/18/70	9/22/70	36	0.02	12000	21,133
9/23/70	9/30/70	8	0.01	18400	3,601
		ESTIMATED ANNUAL TP LOAD (KG/YR)			436,229
		ESTMIMATED AVERAGE DAILY TP LOAD (KG)			1,195

APPENDIX 13. INFLUENT TOTAL P LOADS FROM CLARK FORK R. WY70-72 (ESTIMATED FROM USGS DATA)

WY1971 TP LOAD (DATA REPORTED IN USGS WATER RESOURCES DATA BOOKS)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/23/70			0.01		
10/1/70	10/20/70	20	0.01	18400	9,001
10/21/70	11/17/70	28		22200	
11/18/70	12/13/70	26		16700	
12/14/70	1/18/71	36	0.02	21800	38,392
1/19/71	2/22/71	35	1.1	29900	2,815,713
2/23/71	3/22/71	28	0.01	20000	13,698
3/23/71	4/18/71	27	0.01	29200	19,284
4/19/71	5/23/71	35		35800	
5/24/71	6/20/71	28	0.05	42400	145,195
6/21/71	7/25/71	35	0.03	49400	126,874
7/26/71	8/16/71	22	0.05	33300	89,597
8/17/71	9/20/71	35	0.04	21300	72,940
9/21/71	9/30/71	10	2	15700	768,044

NOTE: 1/19 and 9/21 TP concentration values appear much too high

- Average of reported TP concentration values (excluding 1/19 and 9/21 values) = 0.03 mg/l
- Average flow(/observance) =27392 cfs

WY1971 TP LOAD - CALCULATED BY REPLACING HIGH 1/19 AND 9/23 VALUES WITH AVG. VALUE FOR PERIOD (.03 MG/L TP) AND INSERTING AVG. VALUE INTO THOSE DATES FOR WHICH NO TP VALUE WAS REPORTED

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/23/70			0.01		
10/1/70	10/20/70	20	0.01	18400	9,001
10/21/70	11/17/70	28	0.03	22200	45,613
11/18/70	12/13/70	26	0.03	16700	31,862
12/14/70	1/18/71	36	0.02	21800	38,392
1/19/71	2/22/71	35	0.03	29900	76,792
2/23/71	3/22/71	28	0.01	20000	13,698
3/23/71	4/18/71	27	0.01	29200	19,284
4/19/71	5/23/71	35	0.03	35800	91,945
5/24/71	6/20/71	28	0.05	42400	145,195
6/21/71	7/25/71	35	0.03	49400	126,874
7/26/71	8/16/71	22	0.05	33300	89,597
8/17/71	9/20/71	35	0.04	21300	72,940
9/21/71	9/30/71	10	0.03	15700	11,521
		ESTIMATED ANNUAL TP LOAD (KG/YR)			772,713
		ESTMIMATED AVERAGE DAILY TP LOAD (KG)			2,117

APPENDIX 13. INFLUENT TOTAL P LOADS FROM CLARK FORK R. WY70-72 (ESTIMATED FROM USGS DATA)

WY1972 TP LOAD (DATA REPORTED IN USGS WATER RESOURCES DATA BOOKS)

DATE FROM:	DATE TO:	# OF DAYS	[TP] MG/L	Q (CFS)	LOAD (KG)
9/21/71			2		
10/1/71	10/19/71	19	2	15700	1,459,284
10/20/71	11/16/71	28	0.04	23500	64,379
11/17/71	12/5/71	19	0.07	13000	42,291
12/6/71	1/10/72	36	0.07	29500	181,836
1/11/72	2/3/72	24	0.02	23300	27,356
2/4/72	3/2/72	27	0.03	21300	42,201
3/3/72	4/11/72	40	0.04	29700	116,234
4/12/72	5/1/72	20	0.04	38100	74,554
5/2/72	6/13/72	43	0.02	40100	84,353
6/14/72	9/30/72	109	0.06	12100	193,562

NOTES: 9/21/71 [TP] SEEMS MUCH TOO HIGH

- Average TP concentration 10/20/71 - 6/14/72 (for those dates for which TP concentration was reported) = 0.04 mg/l
- Average flow 10/20/71 - 6/14/72 (for those dates for which flow was reported) = 24630 cfs

WY1972 TP LOAD CALCULATED BY REPLACING QUESTIONABLY HIGH 9/21/71 TP CONCENTRATION VALUE WITH AVERAGE VALUE FOR PERIOD (0.04 MG/L); AND USING AVERAGE TP CONCENTRATION AND AVERAGE FLOW TO CALCULATE LOAD FOR REMAINDER OF WATER YEAR (JULY-SEPT).

DATE FROM:	DATE TO:	# OF DAYS	[TP] MG/L	Q (CFS)	LOAD (KG)
9/21/71			0.04		
10/1/71	10/19/71	19	0.04	15700	29,186
10/20/71	11/16/71	28	0.04	23500	64,379
11/17/71	12/5/71	19	0.07	13000	42,291
12/6/71	1/10/72	36	0.07	29500	181,836
1/11/72	2/3/72	24	0.02	23300	27,356
2/4/72	3/2/72	27	0.03	21300	42,201
3/3/72	4/11/72	40	0.04	29700	116,234
4/12/72	5/1/72	20	0.04	38100	74,554
5/2/72	6/13/72	43	0.02	40100	84,353
6/14/72	6/30/72	16	0.04	12100	18,942
JULY		31	0.04	24630	74,704
AUGUST		31	0.04	24630	74,704
SEPT		30	0.04	24630	72,294
		ESTIMATED ANNUAL TP LOAD (KG/YR)			903,032
		ESTMIMATED AVERAGE DAILY TP LOAD (KG)			2,474

APPENDIX 14

Effluent Total P Loads - Pend Oreille River (Water Years 1976-1988)

WATER YEAR 1976 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA (FROM WA-DOE/USGS DATA)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
10/7/75	10/19/75	13	0.01	25300	8,045
10/20/75	11/9/75	21	0.01	32800	16,848
11/10/75	11/16/75	7	0.02	31000	10,616
11/17/75	12/7/75	21	0.01	29000	14,896
12/8/75	12/14/75	7	0.01	31100	5,325
12/15/75	1/4/76	21	0.01	31100	15,975
1/5/76	1/19/76	13	0.01	17200	5,469
1/20/76	2/1/76	21	0.02	24100	24,758
2/2/76	2/22/76	13	0.02	21600	13,737
2/23/76	3/7/76	14	0.01	22400	7,671
3/8/76	3/21/76	21	0.02	19300	19,827
3/22/76	4/11/76	14	0.02	20700	14,177
4/12/76	4/25/76	14	0.02	42000	28,765
4/26/76	5/9/76	14	0.03	45400	46,640
5/10/76	5/23/76	14	0.03	59100	60,715
5/24/76	6/6/76	14	0.03	96000	98,623
6/7/76	6/21/76	15	0.03	60900	67,033
6/22/76	7/11/76	20	0.01	52300	25,585
7/12/76	7/25/76	14	0.01	48600	16,643
7/26/76	8/8/76	14	0.01	24600	8,424
8/9/76	8/22/76	14	0.01	16000	5,479
8/23/76	9/12/76	21	0.02	17200	17,670
9/13/76	9/26/76	14	0.02	11600	7,945
9/27/76	9/30/76	4	0.01	21500	2,104
			ANNUAL TP LOAD (KG/YR)		542,968
			AVG. DAILY TP LOAD (KG/DAY)		1,488

Average TP concentration = 0.017
Average flow (/observance)= 33367

WATER YEAR 1978 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA (FROM WA-DOE/USGS DATA)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/27/76			0.01	21500	
10/1/77	10/24/77	24	0.01	21500	12,621
10/25/77	11/14/77	21	0.01	28300	14,537
11/15/77	12/6/77	22	0.02	26700	28,736
12/7/77	1/10/78	35	0.01	22100	18,920
1/11/78	2/6/78	27	0.02	21100	27,870
2/7/78	3/6/78	28	0.01	19300	13,218
3/7/78	4/11/78	36	0.02	13800	24,303
4/12/78	5/8/78	27	0.02	32000	42,267
5/9/78	6/5/78	28	0.03	43000	88,350
6/6/78	7/10/78	35	0.01	61100	52,308
7/11/78	8/7/78	28	0.01	47700	32,669
8/8/78	9/11/78	35	0.02	15900	27,224
9/12/78	9/30/78	19	0.01	15300	7,111
			ANNUAL TP LOAD (KG/YR)		390,132
			AVG. DAILY TP LOAD (KG/DAY)		1,069
	Average TP concentration =		0.016		
	Average flow (/observance)=		28858		

WATER YEAR 1979 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA (FROM WA-DOE/USGS DATA)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/12/78			0.01	15300	
10/1/78	10/9/78	9	0.01	15300	3,368
10/10/78	11/7/78	29	0.01	25400	18,017
11/8/78	12/13/78	36	0.01	24300	21,398
12/14/78	3/5/79	82	0.06	19400	233,466
3/6/79	4/9/79	35	0.01	17400	14,896
4/10/79	5/9/79	30	0.01	16200	11,888
5/10/79	6/4/79	26	0.08	51600	262,524
6/5/79	7/9/79	35	0.01	53700	45,973
7/10/79	8/6/79	28	0.01	25900	17,738
8/7/79	9/10/79	35	0.01	12900	11,044
9/11/79	9/30/79	20	0.01	17700	8,659
			ANNUAL TP LOAD (KG/YR)		648,970
			AVG. DAILY TP LOAD (KG/DAY)		1,778

NOTE: TP CONCENTRATION SEEMS HIGH ON 12/14/78 AND 5/10/79

Average TP concentration = 0.022

Average flow (/observance) = 26450

WATER YEAR 1980 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA (FROM WA-DOE/USGS DATA AS REPORTED)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/11/31			0.01	17700	
10/1/79	10/16/79	16	0.01	17700	6,927
10/17/79	11/12/79	27	0.02	16400	21,662
11/13/79	12/10/79	28	0.01	25300	17,327
12/11/79	1/7/80	28	0.02	17800	24,382
1/8/80	2/25/80	49	0.02	16900	40,511
2/26/80	3/10/80	13	0.01	14000	4,452
3/11/80	4/7/80	28	0.02	15700	21,505
4/8/80	5/5/80	28	0.18	16700	205,875
5/6/80	6/10/80	36	0.02	30500	53,714
6/11/80	7/7/80	27	0.02	55500	73,307
7/8/80	8/11/80	35	0.03	34800	89,377
8/12/80	9/8/80	28	0.03	8180	16,807
9/9/80	9/30/80	22	0.02	16100	17,327
			ANNUAL TP LOAD (KG/YR)		593,173
			AVG. DAILY TP LOAD (KG/DAY)		1,625

NOTE: TP VALUE SEEMS MUCH TOO HIGH on 4/8/80

Average TP concentration (data as reported) = 0.033

Average TP concentration (excluding high 4/8/80 value) = 0.020

Average flow (/observance)= 22323

WATER YEAR 1980 - TOTAL P LOADS FROM L. PEND OREILLE, ID AT NEWPORT,WA CALCULATED BY REPLACING HIGH 4/8/80 VALUE WITH AVERAGE VALUES (.020 MG/L - CALCULATED BY EXCLUDING 4/8/80 VALUE)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/11/31			0.01	17700	
10/1/79	10/16/79	16	0.01	17700	6,927
10/17/79	11/12/79	27	0.02	16400	21,662
11/13/79	12/10/79	28	0.01	25300	17,327
12/11/79	1/7/80	28	0.02	17800	24,382
1/8/80	2/25/80	49	0.02	16900	40,511
2/26/80	3/10/80	13	0.01	14000	4,452
3/11/80	4/7/80	28	0.02	15700	21,505
4/8/80	5/5/80	28	0.02	16700	22,875
5/6/80	6/10/80	36	0.02	30500	53,714
6/11/80	7/7/80	27	0.02	55500	73,307
7/8/80	8/11/80	35	0.03	34800	89,377
8/12/80	9/8/80	28	0.03	8180	16,807
9/9/80	9/30/80	22	0.02	16100	17,327
			ESTIMATED ANNUAL TP LOAD (KG/YR)		410,173
			AVG. DAILY TP LOAD (KG/DAY)		1,124

WATER YEAR 1981 - TOTAL P LOAD FROM PEND OREILLE LAKE THROUGH PEND OREILLE RIVER (FROM WA-DOE DATA)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/9/80			0.02	16100	0
10/1/8	10/6/80	6	0.02	16100	4,726
10/7/80	11/3/80	27	0.04	24600	64,985
11/4/80	12/2/80	29	0.02	18500	26,246
12/3/80	1/5/80	34	0.03	24100	60,128
1/6/81	2/8/81	34	0.03	5350	13,348
2/9/81	3/9/81	29	0.03	26200	55,754
3/10/81	4/6/81	28	0.02	27400	37,531
4/7/81	5/4/81	28	0.04	17500	47,942
5/5/81	6/8/81	35	0.01	34300	29,364
6/9/81	7/6/81	28	0.02	87200	119,443
7/7/81	8/3/81	28	0.01	44300	30,340
8/4/81	9/1/81	29	0.01	15400	10,924
9/2/81	9/30/81	29	0.02	7440	10,555
			ANNUAL TP LOAD (KG/YR)		511,285
			AVG. DAILY LOAD (KG/YR)		1,401

Average TP concentration = 0.023

Average flow (/observance) = 27691

WATER YEAR 1982 - TOTAL P LOAD FROM PEND OREILLE LAKE THROUGH PEND OREILLE RIVER (FROM WA-DOE DATA)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/2/81			0.02	7440	
10/1/81	10/5/81	5	0.02	7440	1,820
10/6/81	11/9/81	35	0.02	7440	12,739
11/10/81	12/8/81	29	0.02	29900	42,419
12/9/81	1/26/81	49	0.02	20800	49,859
1/27/82	2/15/82	20	0.05	16300	39,870
2/16/82	3/15/82	28	0.04	8130	22,272
3/16/82	4/19/82	35	0.02	34600	59,242
4/20/82	5/10/82	21	0.01	31300	16,078
5/11/82	6/6/82	27	0.03	50500	100,054
6/7/82	7/11/82	35	0.03	58500	150,246
7/12/82	8/17/82	37	0.03	47000	127,608
8/18/82	9/14/82	28	0.03	13800	28,354
9/15/82	9/30/82	16	0.02	7640	5,980
			ANNUAL TP LOAD (KG/YR)		656,539
			AVG DAILY TP LOAD (KG/DAY)		1,799
	Average TP concentration =		0.027		
	Average flow (/observance) =		27159		

WATER YEAR 1983 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA (FROM WA-DOE/USGS DATA)

DATE FROM:	DATE TO:	# OF DAYS	CONC (MG/L)	Q (CFS)	LOAD (KG)
9/15/82			0.02	7640	
10/1/82	10/19/82	19	0.02	7640	7,101
10/20/82	11/16/82	28	0.01	30100	20,615
11/17/82	12/28/82	42	0.02	29500	60,612
12/29/82	1/25/83	28	0.03	13500	27,738
1/26/82	2/22/83	28	0.02	24100	33,011
2/23/83	3/22/83	28	0.02	25200	34,518
3/23/83	4/19/83	28	0.02	27100	37,120
4/20/83	5/24/83	35	0.02	20700	35,443
5/25/83	6/28/83	35	0.02	49700	85,096
6/29/83	7/19/83	21	0.02	31100	31,950
7/20/83	8/23/83	35	0.02	42500	72,769
8/24/83	9/27/83	35	0.01	8740	7,482
9/28/83	9/30/83	3	0.01	17000	1,247
			ANNUAL TP LOAD (KG/YR)		454,702
			AVG. DAILY TP LOAD (KG/DAY)		1,246
	Average TP concentration =		0.018		
	Average flow (/observance) =		26603		

WATER YEAR 1984 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA (FROM WA-DOE/USGS DATA)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/28/83			0.01	17000	
10/1/83	10/25/83	25	0.01	17000	10,396
10/26/83	11/29/83	35	0.02	26400	45,202
11/30/83	12/20/83	21	0.02	24600	25,272
12/21/83	1/17/84	28	0.03	12300	25,272
1/18/84	2/7/84	21	0.02	22400	23,012
2/8/84	3/6/84	27	0.02	22400	29,587
3/7/84	4/10/84	35		20800	
4/11/84	5/8/84	28	0.03	19600	40,271
5/9/84	6/12/84	35	0.06	29300	150,502
6/13/84	7/10/84	28	0.07	49000	234,914
7/11/84	8/14/84	35	0.04	28000	95,883
8/15/84	9/11/84	28	0.04	9280	25,423
9/12/84	9/30/84	19	0.02	13200	12,269
			ANNUAL TP LOAD (KG/YR)		718,003
			AVG. DAILY TP LOAD (KG/DAY)		1,967
	Average TP concentration =		0.034		
	Average flow (/observance) =		23107		

WATER YEAR 1984 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA CALCULATED BY INSERTING AVERAGE TP VALUE (.034 MG/L) INTO 3/7/84 DATE

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/28/83			0.01	17000	
10/1/83	10/25/83	25	0.01	17000	10,396
10/26/83	11/29/83	35	0.02	26400	45,202
11/30/83	12/20/83	21	0.02	24600	25,272
12/21/83	1/17/84	28	0.03	12300	25,272
1/18/84	2/7/84	21	0.02	22400	23,012
2/8/84	3/6/84	27	0.02	22400	29,587
3/7/84	4/10/84	35	0.034	20800	60,543
4/11/84	5/8/84	28	0.03	19600	40,271
5/9/84	6/12/84	35	0.06	29300	150,502
6/13/84	7/10/84	28	0.07	49000	234,914
7/11/84	8/14/84	35	0.04	28000	95,883
8/15/84	9/11/84	28	0.04	9280	25,423
9/12/84	9/30/84	19	0.02	13200	12,269
			ESTIMATED ANNUAL TP LOAD (KG/YR)		778,546
			AVG. DAILY TP LOAD (KG/DAY)		2,133

WATER YEAR 1985 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA (FROM WA-DOE/USGS DATA)

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/12/84			0.02	13200	
10/1/84	10/9/84	9	0.02	13200	5,812
10/10/84	11/13/84	35	0.03	28200	72,426
11/14/84	12/11/84	28	0.02	22000	37,668
12/12/84	1/15/85	35	0.04	15000	41,093
1/16/85	2/5/85	21	0.15	16400	210,601
2/6/85	3/12/85	35	0.03	19400	29,895
3/13/85	4/2/85	21		16400	
4/3/65	5/7/85	35	0.03	12300	18,954
5/8/85	6/11/85	35	0.03	41800	107,355
6/12/85	8/13/85	63	0.02	63500	108,725
8/14/85	9/17/85	35	0.03	9600	44,380
9/18/85	9/30/85	13	0.02	22800	39,038

Average TP concentration = 0.040
Average flow (/observance) = 24309

WATER YEAR 1985 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA CALCULATED BY INSERTING AVERAGE TP VALUE (.040 MG/L) INTO 3/13/85 DATE

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/12/84			0.02	13200	
10/1/84	10/9/84	9	0.02	13200	5,812
10/10/84	11/13/84	35	0.03	28200	72,426
11/14/84	12/11/84	28	0.02	22000	37,668
12/12/84	1/15/85	35	0.04	15000	41,093
1/16/85	2/5/85	21	0.15	16400	210,601
2/6/85	3/12/85	35	0.03	19400	29,895
3/13/85	4/2/85	21	0.04	16400	56,160
4/3/65	5/7/85	35	0.03	12300	18,954
5/8/85	6/11/85	35	0.03	41800	107,355
6/12/85	8/13/85	63	0.02	63500	108,725
8/14/85	9/17/85	35	0.03	9600	44,380
9/18/85	9/30/85	13	0.02	22800	39,038
			ANNUAL TP LOAD (KG/YR)		772,107
			AVG. DAILY TP LOAD (KG/DAY)		2,115

WATER YEAR 1986 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/18/85			0.02	22800	
10/1/85	10/22/85	21	0.02	22800	23,423
10/23/85	11/19/85	27	0.02	28700	37,908
11/20/85	12/10/85	20	0.03	13700	20,106
12/11/85	1/14/86	34	0.02	36600	60,876
1/15/86	3/11/86	55 <.01		23400	
3/12/86	4/15/86	34	0.01	36800	30,604
4/16/86	5/13/86	27	0.03	36900	73,108
5/14/86	6/10/86	27	0.04	26000	68,684
6/11/86	7/8/86	27	0.01	52600	34,738
7/9/86	8/12/86	34	0.01	19300	16,051
8/13/86	9/9/86	27	0.01	8650	5,713
9/10/86	9/30/86	20		15800	

Average TP concentration = 0.020
Average flow (/observance) = 27132

WATER YEAR 1986 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA. CALCULATED BY INSERTING AVERAGE TP VALUE (0.02 MG/L) INTO 1/15 AND 9/10 DATES

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/18/85			0.02	22800	
10/1/85	10/22/85	21	0.02	22800	23,423
10/23/85	11/19/85	27	0.02	28700	37,908
11/20/85	12/10/85	20	0.03	13700	20,106
12/11/85	1/14/86	34	0.02	36600	60,876
1/15/86	3/11/86	55	0.02	23400	62,960
3/12/86	4/15/86	34	0.01	36800	30,604
4/16/86	5/13/86	27	0.03	36900	73,108
5/14/86	6/10/86	27	0.04	26000	68,684
6/11/86	7/8/86	27	0.01	52600	34,738
7/9/86	8/12/86	34	0.01	19300	16,051
8/13/86	9/9/86	27	0.01	8650	5,713
9/10/86	9/30/86	20	0.02	15800	15,459
			ANNUAL TP LOAD (KG/YR)		449,630
			AVG. DAILY TP LOAD (KG/DAY)		1,232

APPENDIX 14. EFFLUENT TOTAL P LOADS WY1976-88 (FROM WA-DOE/USGS DATA)

WATER YEAR 1987 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
8/13/86			0.01	8650	
10/1/86	10/21/86	20	0.01	8650	4,232
10/22/86	11/4/86	13	0.02	23200	14,754
11/5/86	1/13/87	69		25200	
12/10/86	1/13/86			16900	
1/14/87	2/10/87	27	<.01	13500	
2/11/87	3/17/87	34	<.01	17800	
3/18/87	4/14/87	27	0.01	7920	5,231
4/15/87	5/5/87	20	<.01	21100	
5/6/87	6/2/87	27	0.02	38600	50,984
6/3/87	7/7/87	34	0.02	22100	36,758
7/8/87	8/4/87	27	0.01	12700	8,387
8/5/87	9/8/87	34	0.01	8740	7,269
9/9/87	9/30/87	21	0.02	13400	13,766

Average TP concentration = 0.016
Average flow (/observance) = 18430

WATER YEAR 1987 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA. CALCULATED BY INSERTING AVERAGE TP VALUE (0.016 MG/L) INTO 11/5, 12/10/86 AND 1/14, 2/11, 4/15/87 DATES

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
8/13/86			0.01	8650	
10/1/86	10/21/86	20	0.01	8650	4,232
10/22/86	11/4/86	13	0.02	23200	14,754
11/5/86	12/9/86	34	0.016	25200	33,532
12/10/86	1/13/87	34	0.016	16900	22,488
1/14/87	2/10/87	27	0.016	13500	14,265
2/11/87	3/17/87	34	0.016	17800	23,685
3/18/87	4/14/87	27	0.01	7920	5,231
4/15/87	5/5/87	20	0.016	21100	16,515
5/6/87	6/2/87	27	0.02	38600	50,984
6/3/87	7/7/87	34	0.02	22100	36,758
7/8/87	8/4/87	27	0.01	12700	8,387
8/5/87	9/8/87	34	0.01	8740	7,269
9/9/87	9/30/87	21	0.02	13400	13,766
			ANNUAL TP LOAD (KG/YR)		251,866
			AVG. DAILY TP LOAD (KG/DAY)		690

APPENDIX 14. EFFLUENT TOTAL P LOADS WY1976-88 (FROM WA-DOE/USGS DATA)

WATER YEAR 1988 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/9/87			0.02	13400	
10/7/87	11/3/87	27	0.01	24600	16,246
11/4/87	12/8/87	34	0.01	23200	19,294
12/9/87	1/12/88	34	0.02	15000	24,949
1/13/88	2/2/88	20	0.01	11100	5,430
2/3/88	3/8/88	34	0.02	5810	9,664
3/9/88	4/5/88	27	0.01	19300	12,746
4/6/88	5/3/88	27	0.01	21900	14,463
5/4/88	6/7/88	34	0.01	2660	2,212
6/8/88	7/5/88	27		25100	
7/6/88	8/2/88	27	0.01	13600	8,982
8/3/88	9/13/88	41	0.01	12900	12,937
9/14/88	9/30/88	16	0.02	10300	8,062

Average TP concentration = 0.013
Average flow (/observance) = 15456

WATER YEAR 1988 - TOTAL P LOADS FROM PEND OREILLE LAKE THROUGH PEND OREILLE R. AT NEWPORT, WA CALCULATED BY INSERTING AVERAGE (.013 MG.L) TP CONCENTRATION INTO 6/8 DATE

DATE FROM:	DATE TO:	# OF DAYS	CONC(MG/L)	Q (CFS)	LOAD (KG)
9/9/87			0.02	13400	
10/7/87	11/3/87	27	0.01	24600	16,246
11/4/87	12/8/87	34	0.01	23200	19,294
12/9/87	1/12/88	34	0.02	15000	24,949
1/13/88	2/2/88	20	0.01	11100	5,430
2/3/88	3/8/88	34	0.02	5810	9,664
3/9/88	4/5/88	27	0.01	19300	12,746
4/6/88	5/3/88	27	0.01	21900	14,463
5/4/88	6/7/88	34	0.01	2660	2,212
6/8/88	7/5/88	27	0.013	25100	21,550
7/6/88	8/2/88	27	0.01	13600	8,982
8/3/88	9/13/88	41	0.01	12900	12,937
9/14/88	9/30/88	16	0.02	10300	8,062
			ANNUAL TP LOAD (KG/YR)		156,535
			AVG. DAILY TP LOAD (KG/DAY)		429