LAKE LUXEMBOURG

BUCKS COUNTY

WATER QUALITY STANDARDS REVIEW

UAA-LAKE REDESIGNATION EVALUATION

Lake Luxembourg
Stream Code: 02543
Drainage List E

WATER QUALITY MONITORING AND ASSESSMENT SECTION (APF)
DIVISION OF WATER QUALITY ASSESSMENT AND STANDARDS
BUREAU OF WATER SUPPLY AND WASTEWATER MANAGEMENT
DEPARTMENT OF ENVIRONMENTAL PROTECTION

JANUARY 2005

INTRODUCTION

The Department is initiating a correction to the aquatic life use designation in the water quality standards for Lake Luxembourg, Bucks County. It currently has a Cold Water Fishes (CWF) and Migratory Fishes (MF) designation reflecting the condition of its source water. In most cases within Chapter 93, lakes have been classified according to the aquatic life use of their associated streams. As a result, many lakes in Pennsylvania are misclassified. Most lakes cannot and have not achieved their protected use because of natural conditions.

The water impounded within a lake, when warmed by solar radiation, often becomes too warm to support cold water fish species. Also, most Pennsylvania lakes undergo a period of stratification during summer. In early summer, solar radiation warms the surface waters more rapidly than the bottom waters, causing the upper layer to become less dense. This results in thermal stratification where the density gradient between the top and bottom layers prevents mixing of the waters. The epilimnion (surface layer) is made up of uniformly warm, circulating water and floats upon the cold and relatively undisturbed hypolimnion (bottom layer). During the period of thermal stratification, the waters of the hypolimnion are isolated from the atmosphere and cannot be replenished with oxygen. Algae and other organic debris from the epilimnion settle and decompose in the hypolimnion resulting in an increase in biochemical oxygen demand (BCOD) in the bottom waters. In many water bodies, the rate of dissolved oxygen (DO) depletion in the hypolimnion can cause anoxic conditions (DO = 0 mg/l), incapable of supporting an aquatic community. The thermal stratifications and accompanying DO responses discussed above are naturally occurring phenomena - common to cold water or warm water lakes in temperate climates. Due to stratification and anoxic conditions in the hypolimnion, many lakes cannot support cold water fish species during the summer but can support healthy warm water fish species and therefore should be reclassified.

BACKGROUND

Lake Luxembourg is owned by the Bucks County Parks Department and is located in Core Creek County Park, Middletown Township, Bucks County. Lake Luxembourg is located on Core Creek (stream code 02543), which is a tributary to Neshaminy Creek within the Delaware River basin (drainage list E) (Figure 1). Core Creek was impounded in 1975 creating the 166 surface acre lake, which drains a 15.45 mi^2 watershed consisting primarily of agricultural (57%), forested (22%), and residential (17%) areas. Lake Luxembourg has a maximum depth of 26 feet with a mean depth of 10.5 feet with an overall volume of 2,149,713 m^3 of water. There is one permitted industrial discharge upstream of Lake Luxembourg.

WATER QUALITY

Lake Luxembourg typically stratifies during the summer with the thermocline forming between 1 and 4 meters in depth. Once stratification occurs, the DO in the hypolimnion often drops to levels not supportive of a healthy aquatic community (<2 mg/l). Conditions of stratification and an anoxic hypolimnion were evident soon after the lake was formed. Further, lake water temperatures often exceed levels that can support survival of cold water fish species during

summer months (Figures 2-6). Water chemistry parameters are consistent with lakes that are in the hypereutrophic - eutrophic state with frequent algal blooms and high nutrient levels (Tables 1-2). Physical lake data for temperature and DO reveal conditions that are not supportive of cold water fishes.

AQUATIC BIOTA

Lake Luxembourg has a resident, self-supporting warm water fish community that originated from the resident fish population that occurs naturally in Core Creek and from PFBC stockings. Over the history of the lake there have been a total of 23 species captured (Table 3). Examination of catches from trap nets and electrofishing surveys indicated a healthy naturally reproducing population of warmwater species. Natural reproduction is evident upon review of length frequency data (Table 4). Warmwater species such as white perch, white catfish, pumpkinseed, bluegill, white crappie, black crappie, and brown bullheads have length frequency data showing fish lengths are represented in small and large sizes, which is indicative of natural reproduction consisting of multiple year classes. Lake Luxembourg has never supported cold water fish species throughout the summer months and has always been managed by the PFBC as a put-and-take trout fishery and warm water fishery by relying on natural reproduction and supplemental stocking of warmwater fish such as largemouth bass, channel catfish, and walleye (Table 5-6). The PFBC has stocked trout in Lake Luxembourg annually since 1979.

PUBLIC RESPONSE AND PARTICIPATION SUMMARY

The Department provided public notice of this aquatic life use evaluation and requested any technical data from the general public through publication in the *Pennsylvania Bulletin* on May 31, 2003. A notice was published in Bucks County Courier Times (Levittown, PA) on May 30, 2003. In addition, Lower Makefield, Upper Makefield, Middletown and Newtown townships, Newtown Borough, and the Bucks County Planning Commission were notified of the redesignation evaluation in letters dated May 29, 2003. No additional information was received in response to the publication of these notices.

RECOMMENDATIONS

A review of available data indicates the existing use for Lake Luxembourg is and has always been TSF, MF. The predominance of warm water conditions and concurrent warm water fisheries and put-and-take adult trout found in Lake Luxembourg is the consequence of impounding flowing waters. Such conditions are normal and are expected whenever flowing waters are impounded in areas with temperate climates. These warm water conditions are irretrievable since it is not feasible to remove the reservoirs. The historical data indicates that Lake Luxembourg has supported a warm water fish community and a put-and-take adult trout stocking program since it was constructed and has been managed by the PFBC as such.

It is the Department's conclusion that: 1) the designated use of Lake Luxembourg is more

restrictive than its existing use; 2) the designated use of CWF cannot be attained by implementing effluent limits required under sections 301(b) and 306 of the Federal Clean Water Act (33 U.S.C.A. §§ 1331(b) and 1316); 3) its current use designation cannot be attained by implementing cost-effective and reasonable best management practices (BMPs) for nonpoint source control; and 4) the conditions existing in Lake Luxembourg are the result of limnological processes that occur naturally in impoundments and it is not feasible to restore Core Creek to its original condition by removing Lake Luxembourg or manage it in a way that would result in the attainment of its designated use.

Based on these findings, the Department recommends that the designated use of Lake Luxembourg be changed from its current CWF, MF designation to TSF, MF. This recommendation is based on the physical characteristics of the water body, dominance of warm water fish species, and the management and stocking of warm water fish and adult trout by the PFBC. This recommendation will affect approximately 1.8 miles of the Core Creek directly limited to Lake Luxembourg, which approximates 166 surface acres. All tributaries to Lake Luxembourg will retain their current CWF, MF designations.

REFERENCES

Coastal Environmental Services. 1993. Phase 1 Clean Lakes Study for Lake Luxembourg. May 1993, revised April 1994.

Department of Environmental Protection. File information.

PA Fish and Boat Commission. File information.

Princeton Hydro, LLC. 2002. Final Report of a Phase II Non-Point Source Pollution Implementation Project for Lake Luxembourg/Core Creek Watershed, Core Creek Park, Bucks County, Pennsylvania.

Figure 1. Lake Luxembourg, Bucks County

TABLE 1.
LAKE LUXEMBOURG - WATER CHEMISTRY
Dam Location
Princeton Hydro

Parameter	Units	Date								
		6/5/1991	6/20/1991	7/10/1991	7/25/1991	8/5/1991	8/23/1991	9/18/1991	10/31/1991	11/21/1991
P-total	mg/l	0.03	0.06	0.05	0.23	0.40	0.32	0.20	0.57	0.47
Ortho-P-total	mg/l	0.02	<.01	0.02	0.01	0.07	0.02	0.01	0.02	0.04
NH_3-N	mg/l	0.1	1.0	1.5	1.3	1.9	0.4	0.1	0.1	0.1
NO_2-N + NO_3-N	mg/l	1.35	0.80	0.13	0.07	0.12	0.27	0.32	0.62	0.78
N-Kjeldahl	mg/l	2.2	3.3	3.9	2.8	4.7	3.7	4.2	3.1	3.3
Alkalinity-total	mg/l	46	59	50	47	56	14	33	34	47
Susp. Solids, total	mg/l	21	18	29	36	19	75	24	0	10
Chlorophyll a	µg/l	56.8	-	77.9	45.0	42.3	72.5	81.4	46.2	43.5
Secchi Disk	m	0.35	0.45	0.25	0.50	0.40	0.20	0.25	0.15	0.20

Parameter	Units	Date						
		12/19/1991	1/31/1992	2/20/1992	3/5/1992	4/20/1992	5/4/1992	5/19/1992
P-total	mg/l	0.14	0.11	0.11	0.09	0.11	0.18	0.13
Ortho-P-total	mg/l	0.03	0.02	0.01	0.05	0.05	<.01	<0.01
NH_3-N	mg/l	0.2	0.2	0.1	0.2	0.14	<.1	0.6
NO_2-N + NO_3-N	mg/l	1.29	2.02	2.11	2.23	1.74	1.45	0.83
N-Kjeldahl	mg/l	1.2	1.3	1.1	1.1	1.2	1.1	1.0
Alkalinity-total	mg/l	43	71	40	44	48	48	70
Susp. Solids, total	mg/l	18	15	10	12	3	18	16
Chlorophyll a	µg/l	42.8	35.5	28.6	14.1	34.4	52.8	83.0
Secchi Disk	m	-	-	0.20	0.60	0.50	0.40	0.35

TABLE 2.
LAKE LUXEMBOURG - WATER CHEMISTRY
DAM and UPLAKE LOCATIONS
DEP

Sampling Location : **DAM**	Date	4/29/2004		7/21/2004		8/17/2004		10/13/2004	
Parameter	Units	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Alkalinity	mg/l	45.4	48.2	59.4	57.4	60.4	59.4	37.2	39
Phosphorus	mg/l	0.068	0.089	0.058	0.072	-	-	0.08	0.099
Nitrogen Total	mg/l	2.14	2.12	0.88	1.1	1.29	1.53	1.56	1.64
Total Suspended Solids	mg/l	26	20	6	2	14	10	6	6
Chla	mg/l	0.081	-	0.0498	-	0.1059	-	-	-
Secchi	meter	0.49	-	0.58	-	0.42	-	0.5	-

Sampling Location: **UPLAKE**	Date	4/29/2004	7/21/2004	8/17/2004	10/13/2004
Parameter	Units	Surface	Surface	Surface	Surface
Alkalinity	mg/l	46.8	59.6	59.8	38.4
Phosphorus	mg/l	0.099	0.09	-	0.089
Nitrogen Total	mg/l	2.12	1.04	2.14	1.64
Total Suspended Solids	mg/l	20	12	40	12
Chla	mg/l	0.078	0.0685	0.0908	-
	meter	0.48	0.57	0.33	0.5

TABLE 3.
LAKE LUXEMBOURG - FISH
Species Occurrence
PFBC

Scientific name	Common name	1985	1991	1995
Anguilla rostrata	American Eel	X	X	-
Dorosoma cepedianum	Gizzard shad	-	X	X
Esox niger	Chain pickerel	X	-	-
Cyprinus carpio	Common carp	X	X	X
Notemigonus crysoleucas	Golden shiner	X	X	X
Notropis hudsonius	Spottail shiner	-	X	X
Catostomus commersoni	White sucker	X	X	X
Ictalurus punctatus	Channel catfish	X	X	X
Ameiurus natalis	Yellow bullhead	-	X	X
Ameiurus nebulosus	Brown bullhead	X	X	X
Ameiurus catus	White catfish	X	X	X
Salmo trutta	Brown trout	X	X	-
Oncorhynchus mykiss	Rainbow trout	X	X	X
Fundulus diaphanus	Banded killifish	X	-	-
Morone americana	White perch	X	X	X
Pomoxis nigromaculatus	Black crappie	X	X	X
Pomoxis annularis	White crappie	X	X	X
Micropterus salmoides	Largemouth bass	X	X	X
Lepomis cyanellus	Green sunfish	X	X	-
Lepomis gibbosus	Pumpkinseed	X	X	X
Lepomis macrochirus	Bluegill	X	X	X
Sander vitreus	Walleye	X	X	X
Perca flavescens	Yellow perch	X	-	-
	Total Species:	20	20	17

TABLE 4.
LAKE LUXEMBOURG - FISH
Catch Length/Frequency Distribution
Lake Luxembourg - PFBC

Date	Chain Pickerel	Channel Catfish			Yellow Bullhead	Brown Bullhead			White Catfish		White Perch		
	1985	1985	1991	1995	1995	1985	1991	1995	1991	1995	1985	1991	1995
Size group (mm)													
>50	-	-	-	-	-	-	-	-	-	-	-	-	-
50 - 74	-	-	-	-	-	-	-	-	-	-	-	-	-
75 - 99	-	-	-	-	-	-	-	-	-	-	-	-	-
100 - 124	-	-	-	-	-	-	-	-	-	-	-	7	-
125 - 149	-	-	-	-	-	-	-	-	-	-	-	7	54
150 - 174	-	-	-	-	-	-	-	-	-	-	-	383	751
175 - 199	-	-	-	-	-	-	-	7	-	-	12	1007	478
200 - 224	-	-	-	1	-	-	1	31	-		9	471	75
225 - 249	-	1	-	3	-	-	4	72	-	-	3	30	7
250 - 274	-	-	-	2	1	-	9	47	1	-	1	-	-
275 - 299	-	-	-	1	-	-	5	42	3	-	1	-	-
300 - 324	-	-	-	3	-	2	-	12	1	1	-	-	-
325 - 349	-	-	-	4	-	7	-	-	-	3	-	-	-
350 - 374	-	-	-	2	-	4	-	-	-	-	-	-	-
375 - 399	-	-	2	5	-	-	-	-	-	7	-	-	-
400 - 424	1	-	1	2	-	-	-	-	-	1	-	-	-
425 - 449	-	-	-	3	-	-	-	-	-	4	-	-	-
450 - 474	-	-	-	5	-	-	-	-	-	-	-	-	-
475 - 499	-	-	-	-	-	-	-	-	-	1	-	-	-
500 - 524	-	1	-	4	-	-	-	-	-	-	-	-	-
525 - 549	-	1	-	3	-	-	-	-	-	-	-	-	-
550 - 574	-	-	-	4	-	-	-	-	-	-	-	-	-
575 - 599	-	-	-	4	-	-	-	-	-	-	-	-	-
600 - 624	-	-	-	3	-	-	-	-	-	-	-	-	-
625 - 649	-	-	1	-	-	-	-	-	-	-	-	-	-
650 - 674	-	-	-	1	-	-	-	-	-	-	-	-	-
675 - 699	-	-	1	-	-	-	-	-	-	-	-	-	-
700 - 724	-	-	-	1	-	-	-	-	-	-	-	-	-
725 - 749	-	-	-	-	-	-	-	-	-	-	-	-	-
750 - 774	-	-	-	1	-	-	-	-	-	-	-	-	-
No Size	-	-	-	-	-	-	-	-	-	-	-	-	-

1985 data comprised of 4 seine halls and 7 Trap net sets from May and October
1991 data comprised of 3 trap net sets and 1 electrofishing sites from May
1995 data comprised of 4 trap net sets from April

TABLE 4. (cont.)
FISH - Catch Length/Frequency Distribution
PFBC

Date	White Crappie			Black Crappie			Largemouth Bass			Green Sunfish		Pumpkinseed		
	1991	1985	1995	1991	1985	1995	1985	1991	1995	1985	1991	1985	1991	1995
Size group (mm)														
>50	-	-	-	-	1	-	-	-	-	-	-	5	-	-
50 - 74	-	-	-	-	-	-	1	-	-	1	-	44	-	-
75 - 99	-	1	-	-	1	-	9	-	-	-	-	11	2	1
100 - 124	-	1	-	-	3	-	10	1	-	-	-	4	-	1
125 - 149	-	-	2	-	2	1	4	-	1	1	1	15	12	9
150 - 174	127	18	13	1	105	1	3	1	-	-	-	6	1	1
175 - 199	98	145	26	14	64	-	2	-	-	-	-	-	-	-
200 - 224	3	115	35	1	29	-	-	-	-	-	-	-	-	-
225 - 249	4	13	33	1	-	-	-	1	-	-	-	-	-	-
250 - 274	1	-	56	2	-	-	1	1	-	-	-	-	-	-
275 - 299	1	-	34	-	-	1	-	-	-	-	-	-	-	-
300 - 324	1	-	24	-	-	-	1	7	-	-	-	-	-	-
325 - 349	-	-	9	-	1	-	-	6	-	-	-	-	-	-
350 - 374	-	-	4	-	-	-	-	1	-	-	-	-	-	-
375 - 399	-	1	1	-	-	-	-	4	1	-	-	-	-	-
400 - 424	-	-	-	-	-	-	-	2	1	-	-	-	-	-
425 - 449	-	-	-	-	-	-	-	5	-	-	-	-	-	-
450 - 474	-	-	-	-	-	-	1	-	-	-	-	-	-	-
475 - 499	-	-	-	-	-	-	1	-	-	-	-	-	-	-
500 - 524	-	-	-	-	-	-	-	1	-	-	-	-	-	-
525 - 549	-	-	-	-	-	-	-	1	-	-	-	-	-	-
550 - 574	-	-	-	-	-	-	-	-	-	-	-	-	-	-
575 - 599	-	-	-	-	-	-	-	-	-	-	-	-	-	-
600 - 624	-	-	-	-	-	-	-	-	-	-	-	-	-	-
625 - 649	-	-	-	-	-	-	-	-	-	-	-	-	-	-
650 - 674	-	-	-	-	-	-	-	-	-	-	-	-	-	-
675 - 699	-	-	-	-	-	-	-	-	-	-	-	-	-	-
700 - 724	-	-	-	-	-	-	-	-	-	-	-	-	-	-
725 - 749	-	-	-	-	-	-	-	-	-	-	-	-	-	-
750 - 774	-	-	-	-	-	-	-	-	-	-	-	-	-	-
No Size	-	-	-	-	-	-	-	-	-	2	-	-	-	-

TABLE 4. (cont.)
FISH - Catch Length/Frequency Distribution
PFBC

Date	Bluegill			Walleye		
	1985	1991	1995	1985	1991	1995
Size group (mm)						
>50	297	-	-	-	-	-
50 - 74	120	-	-	-	-	-
75 - 99	-	1	1	-	-	-
100 - 124	24	2	6	-	-	-
125 - 149	97	35	18	-	-	1
150 - 174	280	20	30	-	-	1
175 - 199	189	6	15	-	-	4
200 - 224	1	-	-	-	-	1
225 - 249	-	-	-	-	-	1
250 - 274	-	-	-	-	-	-
275 - 299	-	-	-	-	-	-
300 - 324	-	-	-	1	-	-
325 - 349	-	-	-	2	-	-
350 - 374	-	-	-	6	-	-
375 - 399	-	-	-	3	-	-
400 - 424	-	-	-	-	-	1
425 - 449	-	-	-	-	-	2
450 - 474	-	-	-	3	-	1
475 - 499	-	-	-	-	-	-
500 - 524	-	-	-	-	-	1
525 - 549	-	-	-	-	-	-
550 - 574	-	-	-	2	-	-
575 - 599	-	-	-	-	-	1
600 - 624	-	-	-	-	1	-
625 - 649	-	-	-	-	1	2
650 - 674	-	-	-	-	1	-
675 - 699	-	-	-	-	-	2
700 - 724	-	-	-	-	-	1
725 - 749	-	-	-	-	-	-
750 - 774	-	-	-	-	-	-
No Size	-	-	-	-	-	-

TABLE 5.

LAKE LUXEMBOURG - FISH STOCKING HISTORY

WARMWATER/COOLWATER SPECIES

PFBC

Year	Species	Lifestage	Number Stocked
1996	Walleye	Phase 1	4,950
1995	Walleye	Phase 1	6,000
1995	Channel Catfish	Fingerling	4,150
1994	Walleye	Small Fingerling	33,200
1994	Walleye	Large Fingerling	1,917
1994	Largemouth Bass	Fingerling	12,450
1994	Brown Bullhead	Fingerling	7,032
1993	Walleye	Small Fingerling	33,200
1993	Walleye	Large Fingerling	3,320
1993	Channel Catfish	Fingerling	2,500
1993	Largemouth Bass	Fingerling	4,150
1992	Walleye	Small Fingerling	4,950
1992	Walleye	Fry	124,500
1992	Largemouth Bass	Fingerling	4,150
1991	Walleye	Small Fingerling	3,300
1991	Walleye	Fry	124,500
1991	Largemouth Bass	Fingerling	3,300
1990	Walleye	Small Fingerling	3,300
1990	Walleye	Large Fingerling	1,650
1990	Channel Catfish	Fingerling	2,500
1989	Walleye	Large Fingerling	1,650
1989	Chain Pickerel	Fingerling	1,650
1988	Walleye	Small Fingerling	1,650
1988	Walleye	Large Fingerling	1,650
1988	White Catfish	Fingerling	6,550
1988	Channel Catfish	Fingerling	2,500
1988	Chain Pickerel	Fingerling	1,650
1987	White Catfish	Fingerling	8,300
1987	Channel Catfish	Fingerling	8,300
1987	Chain Pickerel	Fingerling	1,650
1986	Channel Catfish	Fingerling	8,300
1986	Gizzard Shad	Adult	170
1984	Walleye	Large Fingerling	4,150
1983	Chain Pickerel	Fingerling	1,200
1982	Walleye	Large Fingerling	4,150
1982	Chain Pickerel	Fingerling	1,650
1980	Walleye	Small Fingerling	5,000
1980	Black Crappie	Fingerling	4,000
1979	Walleye	Small Fingerling	4,000
1979	Largemouth Bass	Fingerling	4,000
1979	Black Crappie	Fingerling	4,000
1978	Walleye	Fry	425,000
1978	Largemouth Bass	Fingerling	4,250
1978	Black Crappie	Fingerling	4,250
1977	Largemouth Bass	Fingerling	4,000

TABLE 6.

LAKE LUXEMBOURG - FISH STOCKING HISTORY

ADULT TROUT

PFBC

Year	Species	Spring	Fall	Winter	Total
1996	Rainbow Trout	10,300	3,000	3,200	16,500
1995	Rainbow Trout	10,300	3,000	3,200	16,500
1994	Rainbow Trout	11,500	3,000	2,000	16,500
1993	Rainbow Trout	11,500	3,000	2,000	16,500
1992	Rainbow Trout	11,500	3,000	2,000	16,500
1991	Rainbow Trout	10,000	3,000	2,000	15,000
1990	Rainbow Trout	10,000	0	2,500	12,500
1989	Rainbow Trout	10,000	3,000	2,000	15,000
1988	Rainbow Trout	10,000	3,000	2,000	15,000
1987	Rainbow Trout	11,000	3,000	2,000	16,000
1986	Rainbow Trout	11,000	3,000	2,000	16,000
1985	Rainbow Trout	20,600	3,000	2,000	25,600
1984	Rainbow Trout	15,000	3,000	2,000	20,000
1984	Brown Trout	0	1,000	1,000	2,000
1983	Rainbow Trout	17,000	3,000	2,000	22,000
1983	Brown Trout	0	1,000	1,000	2,000
1982	Rainbow Trout	11,400	2,000	1,600	15,000
1982	Brown Trout	0	2,000	1,400	3,400
1981	Rainbow Trout	11,000	2,000	1,600	15,000
1981	Brown Trout	0	2,000	1,400	3,400
1980	Rainbow Trout	7,400	1,200	1,000	6,600
1980	Brook Trout	0	2,800	2,400	2,000
1979	Rainbow Trout	8,000	0	3,000	11,000

FIGURE 2.
LAKE LUXEMBOURG - WATER CHEMISTRY
Temperature and Dissolved Oxygen Profiles - August 26, 1985
PFBC
Vertical lines depict parameter criteria.

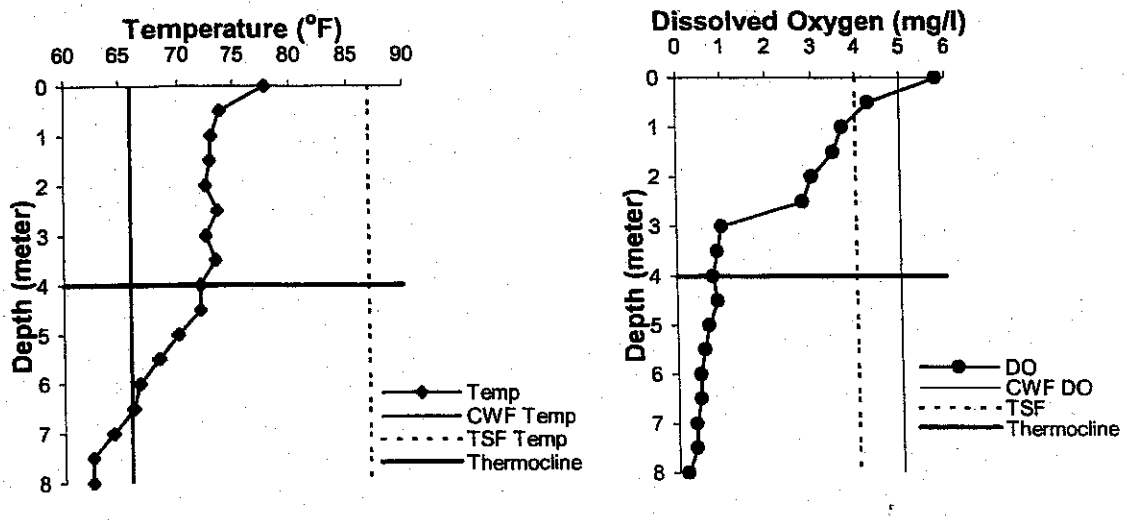


FIGURE 3.
LAKE LUXEMBOURG - WATER CHEMISTRY
Temperature and Dissolved Oxygen Profiles - Dam Location
Coastal
Vertical lines depict parameter criteria.

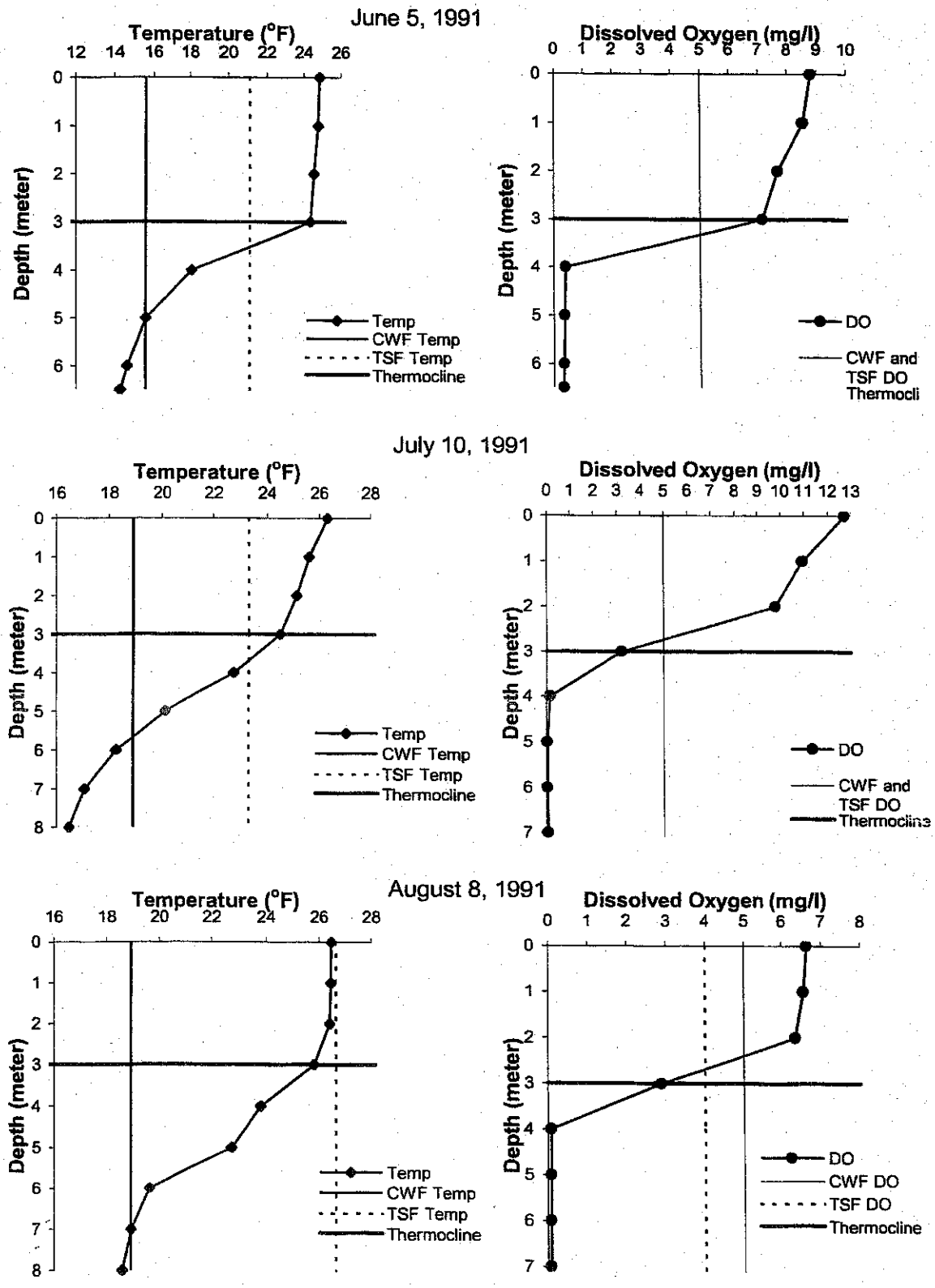
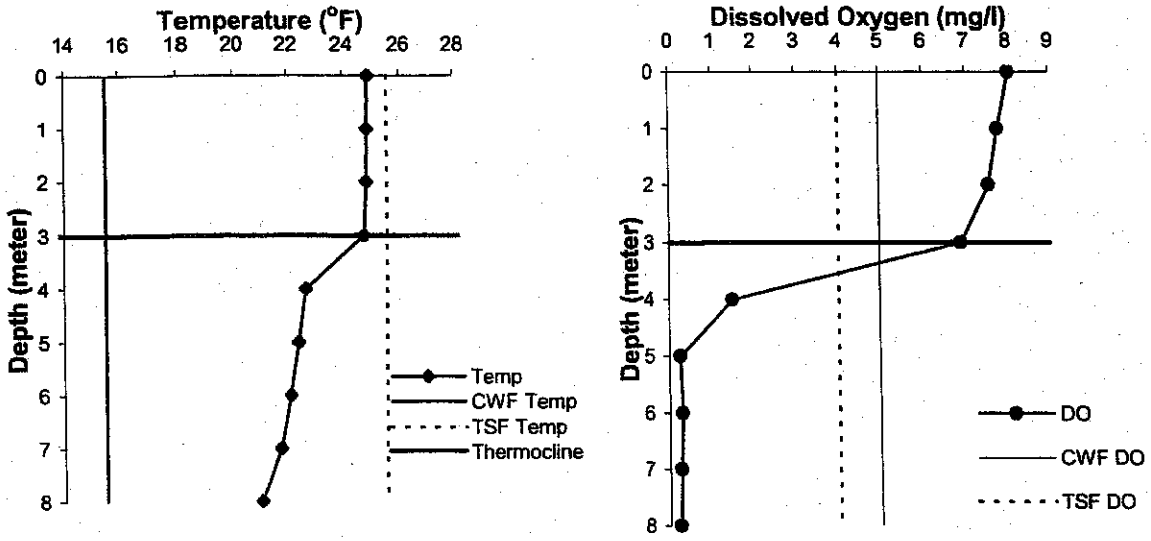
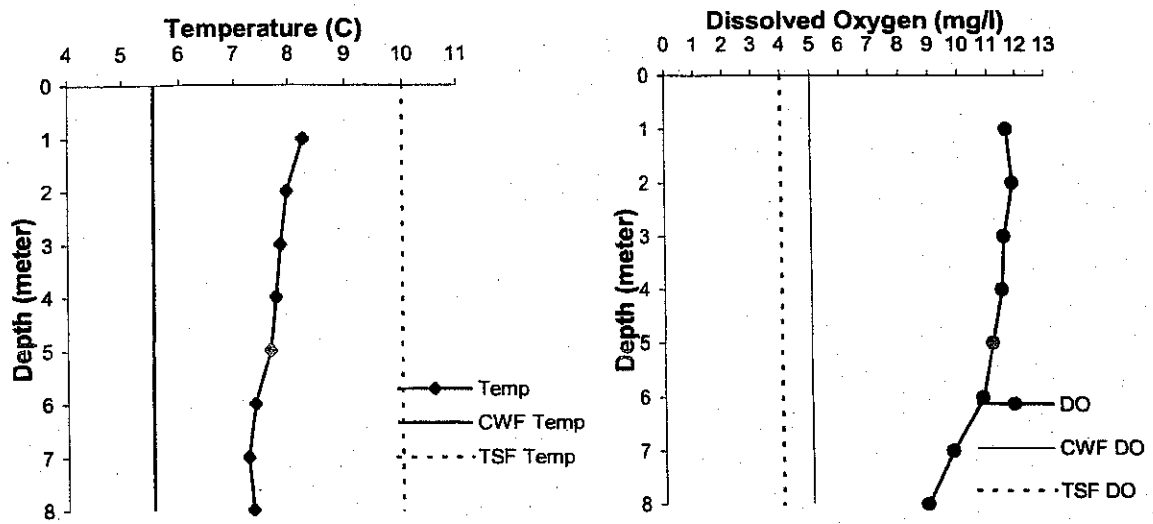


FIGURE 3. (cont.)
WATER CHEMISTRY - Temperature and Dissolved Oxygen Profiles

September 18, 1991



November 21. 1991



March 5, 1992

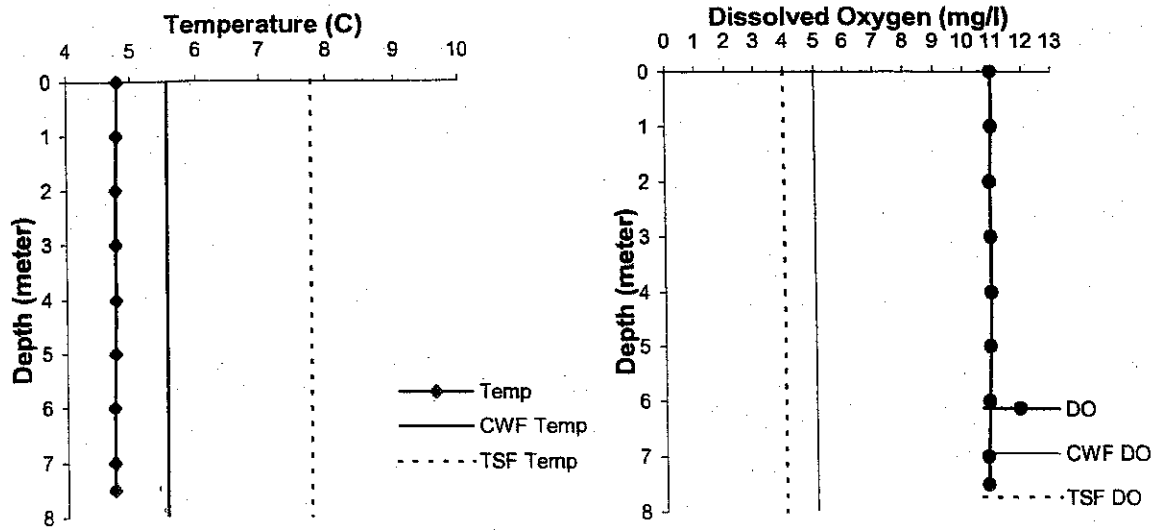


FIGURE 3. (cont.)
WATER CHEMISTRY - Temperature and Dissolved Oxygen Profiles

May 4, 1992

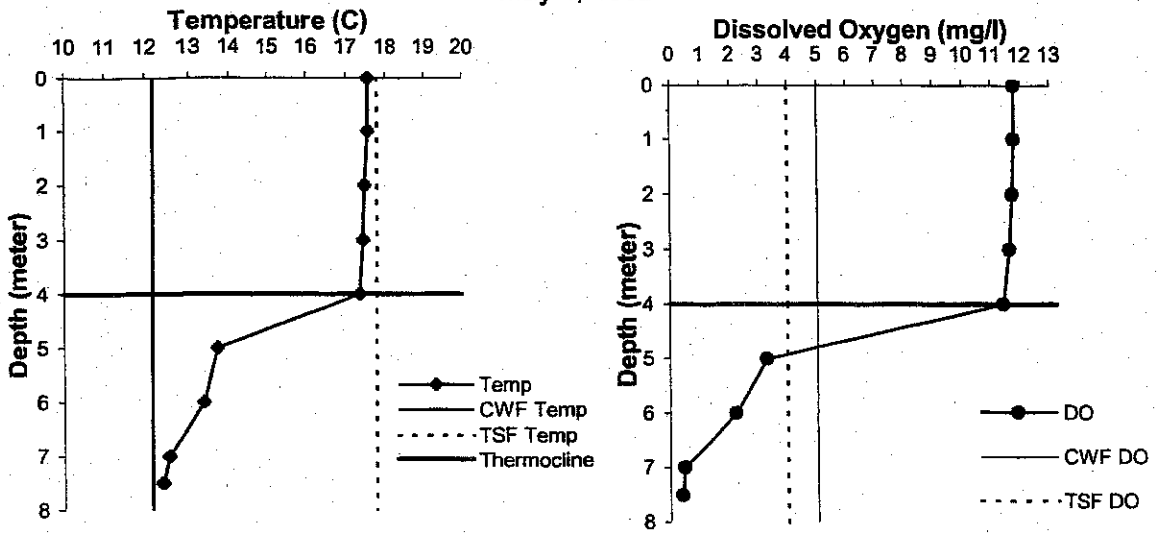
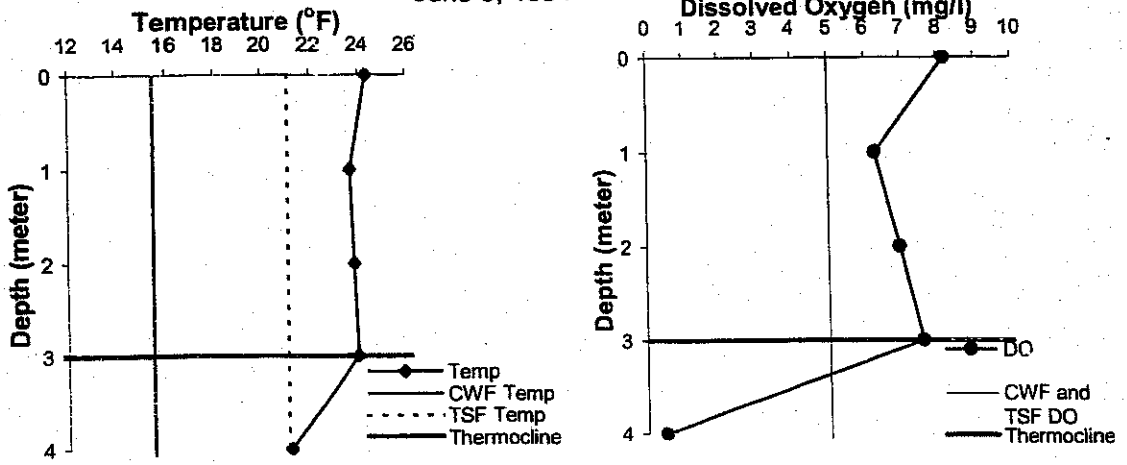
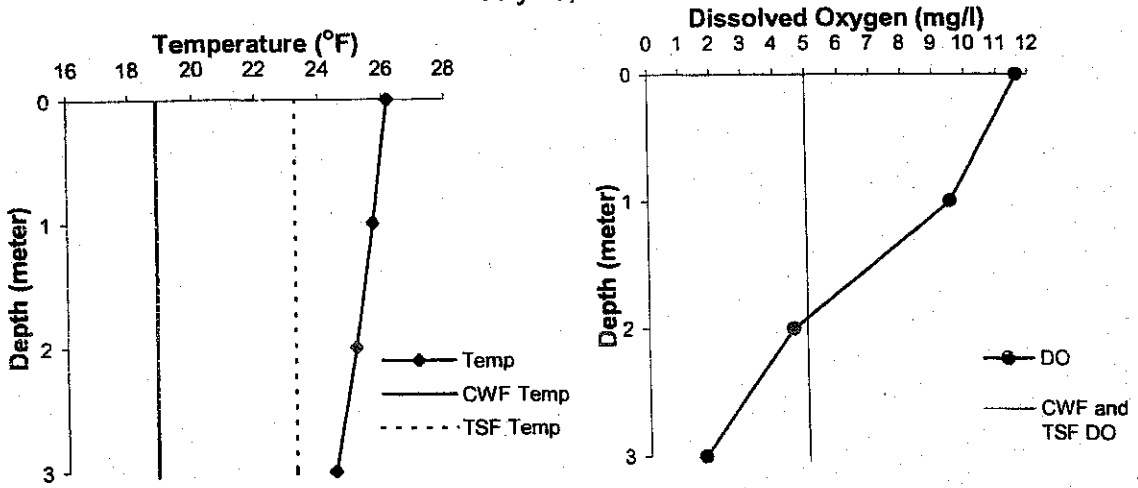


FIGURE 4.
LAKE LUXEMBOURG - WATER CHEMISTRY
Temperature and Dissolved Oxygen Profiles - Uplake Location
Coastal
Vertical lines depict parameter criteria.

June 5, 1991



July 10, 1991



August 8, 1991

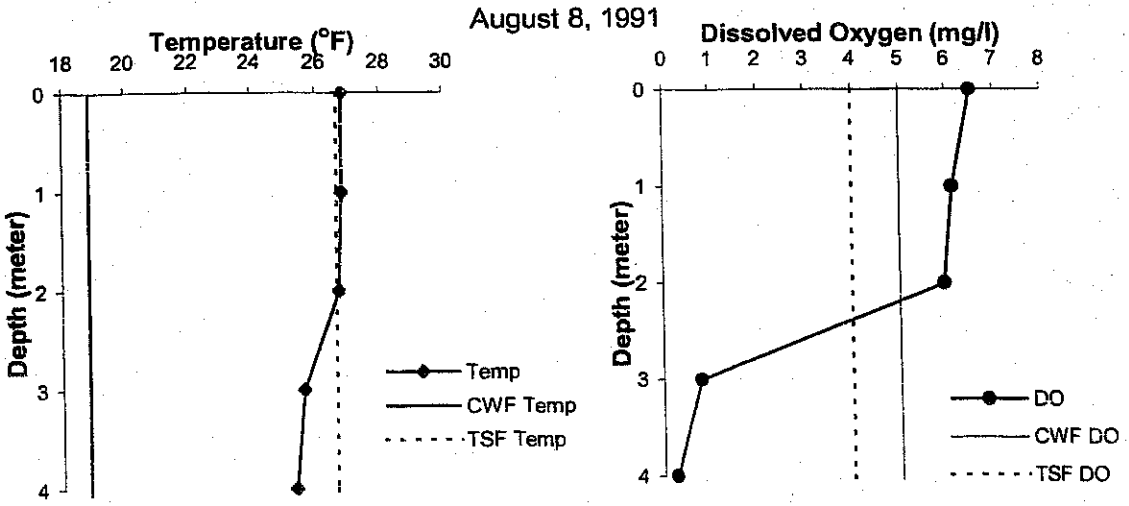
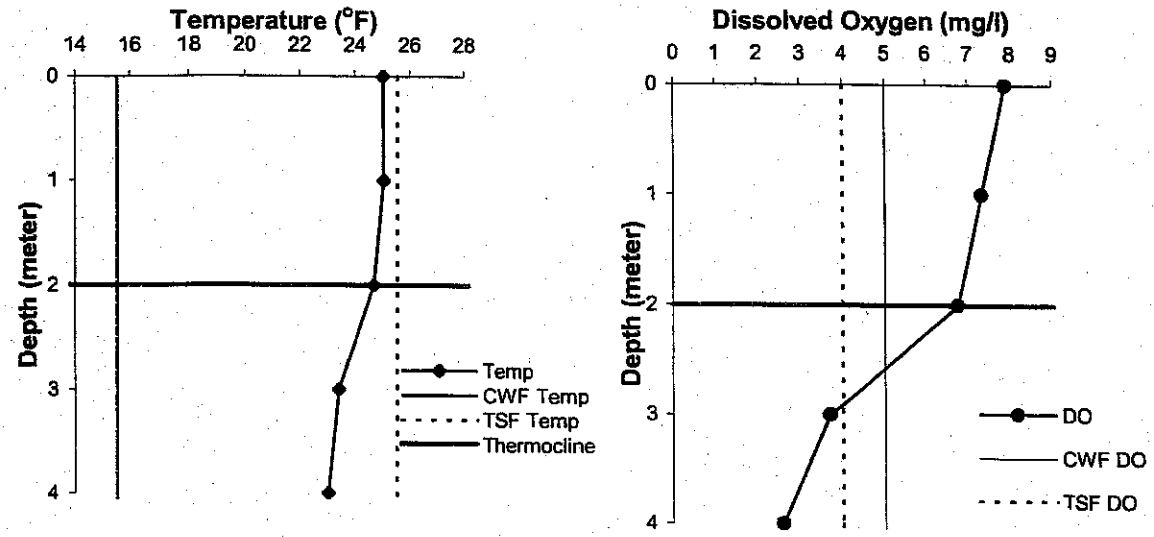
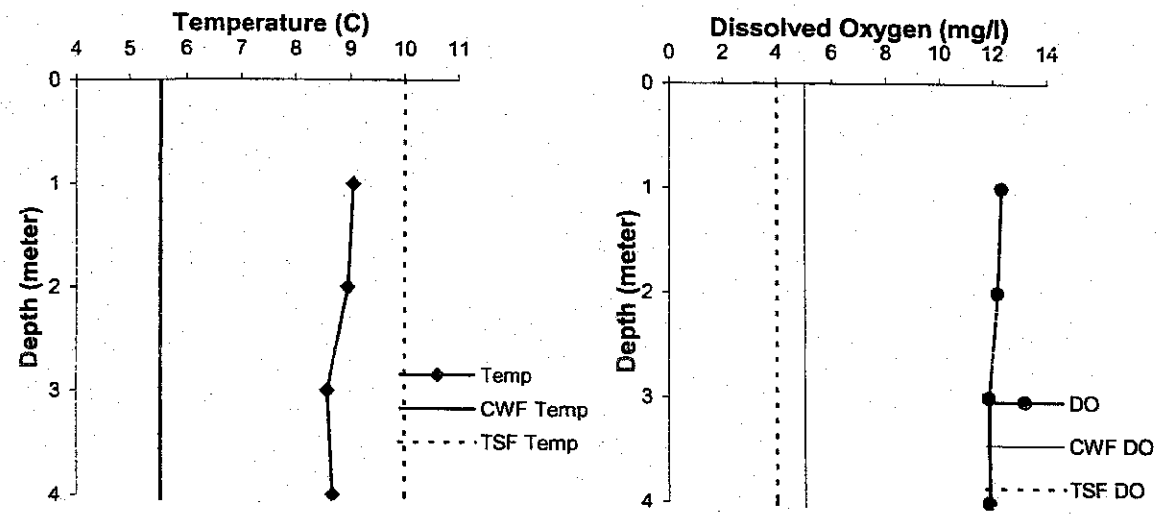


FIGURE 4. (cont.)
WATER CHEMISTRY - Temperature and Dissolved Oxygen Profiles

September 18, 1991



November 21, 1991



March 5, 1992

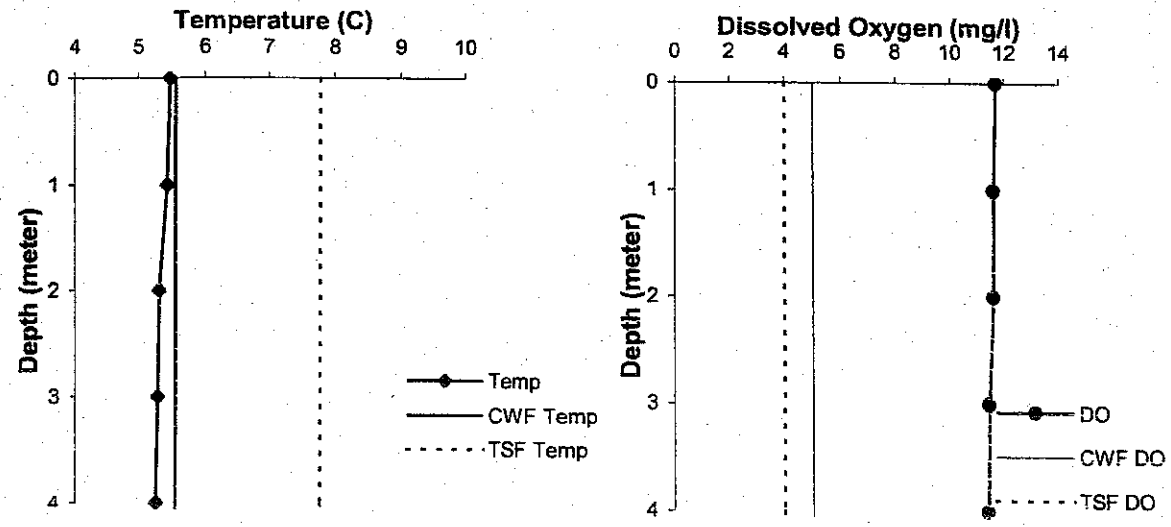


FIGURE 4. (cont.)
WATER CHEMISTRY - Temperature and Dissolved Oxygen Profiles

May 4, 1992

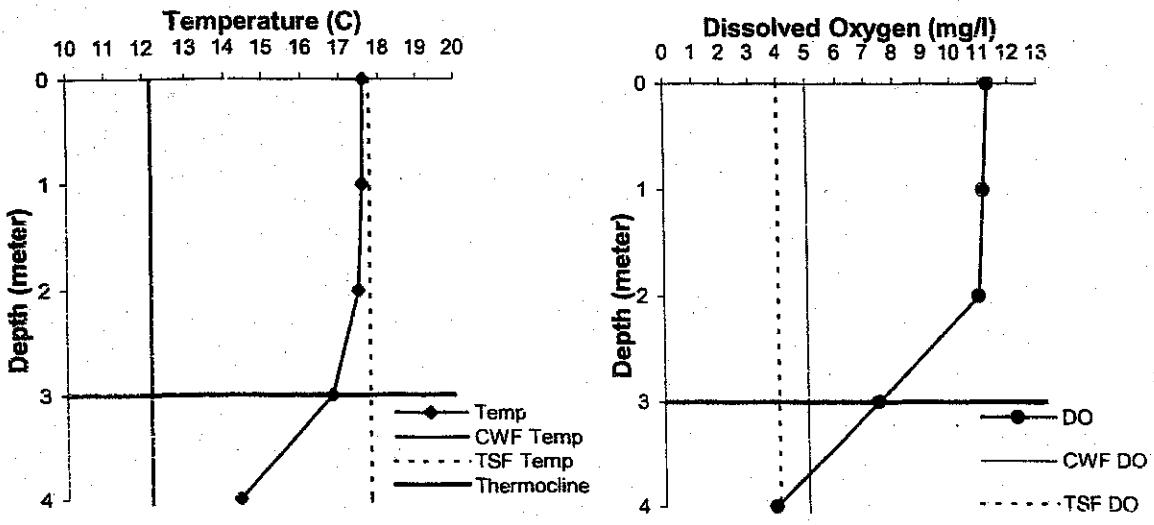
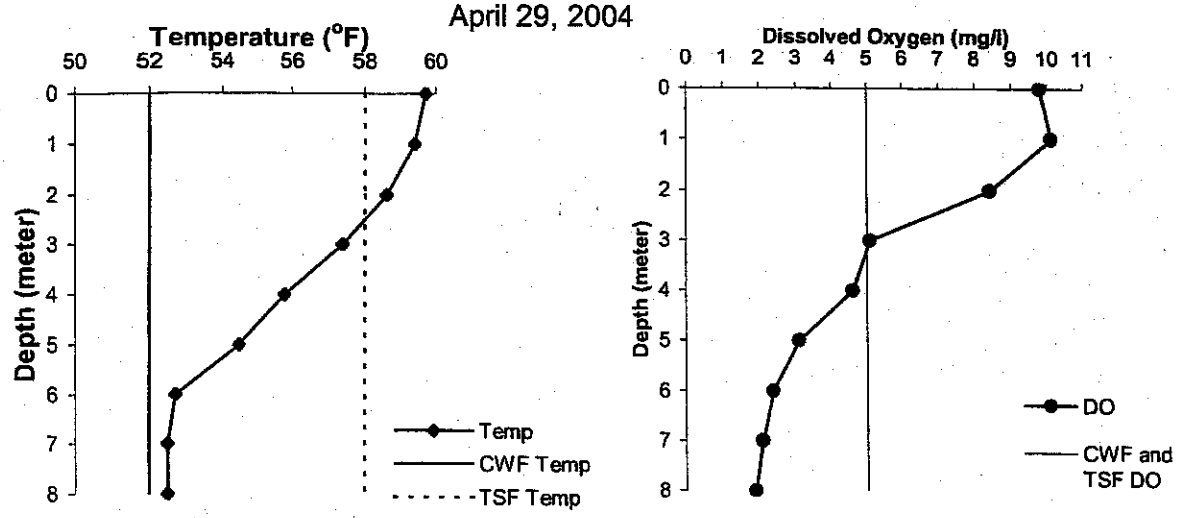


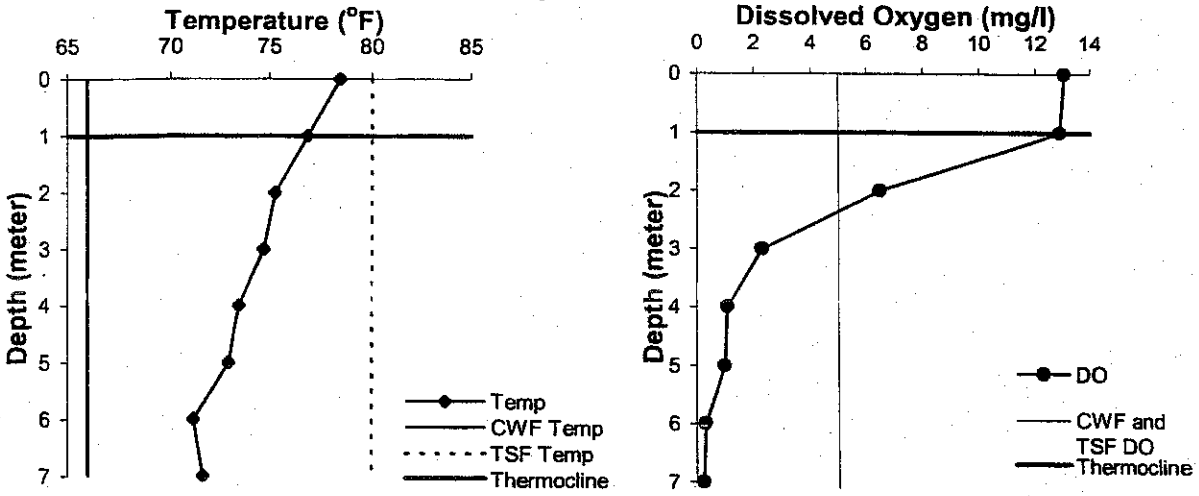
FIGURE 5.
LAKE LUXEMBOURG - WATER CHEMISTRY
Temperature and Dissolved Oxygen Profiles - Dam Location
DEP

Vertical lines depict parameter criteria.

April 29, 2004



July 21, 2004



August 17, 2004

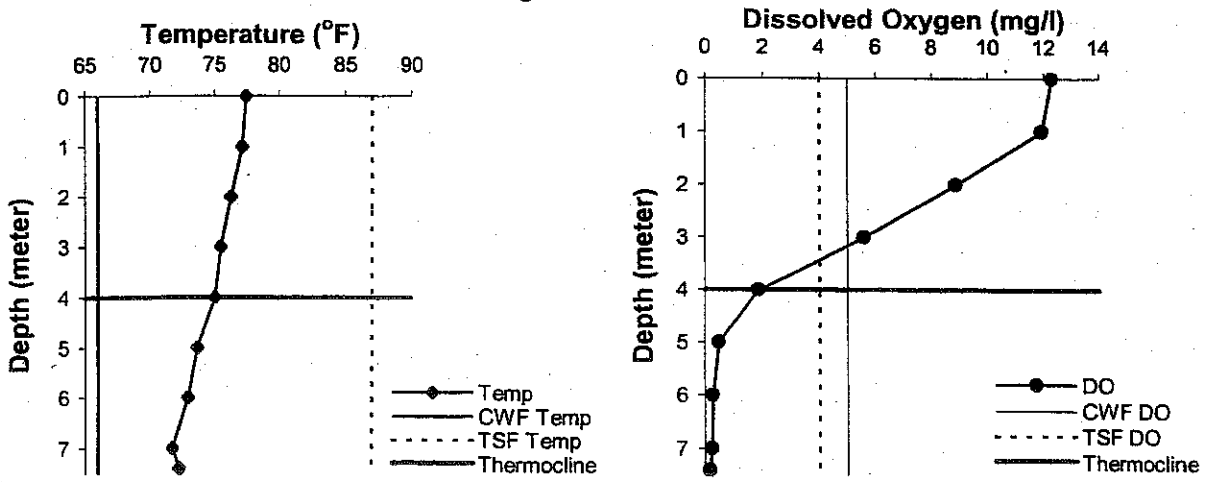


FIGURE 5. (cont.)
WATER CHEMISTRY - Temperature and Dissolved Oxygen Profiles

October 13, 2004

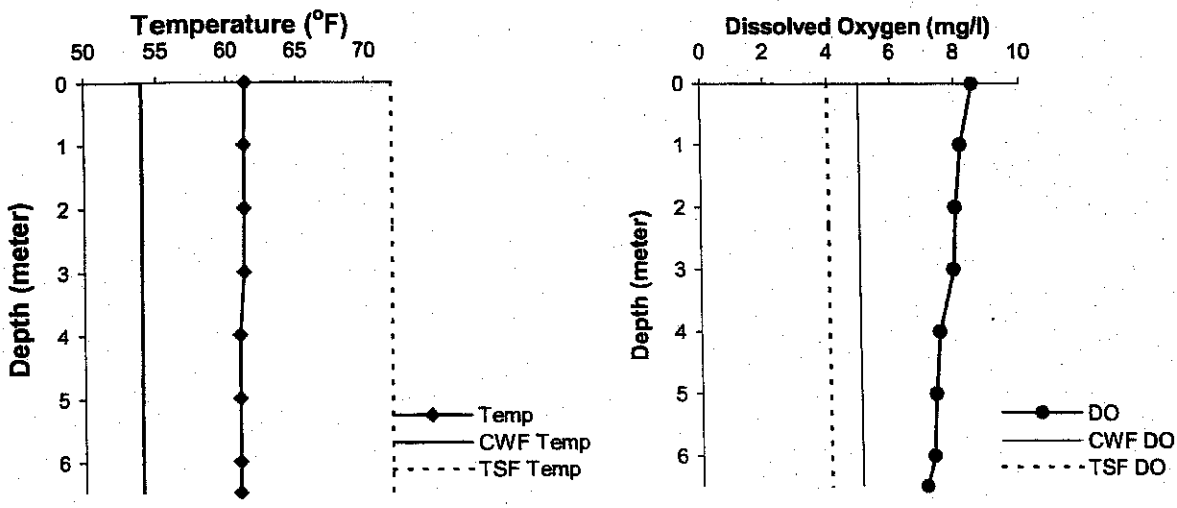
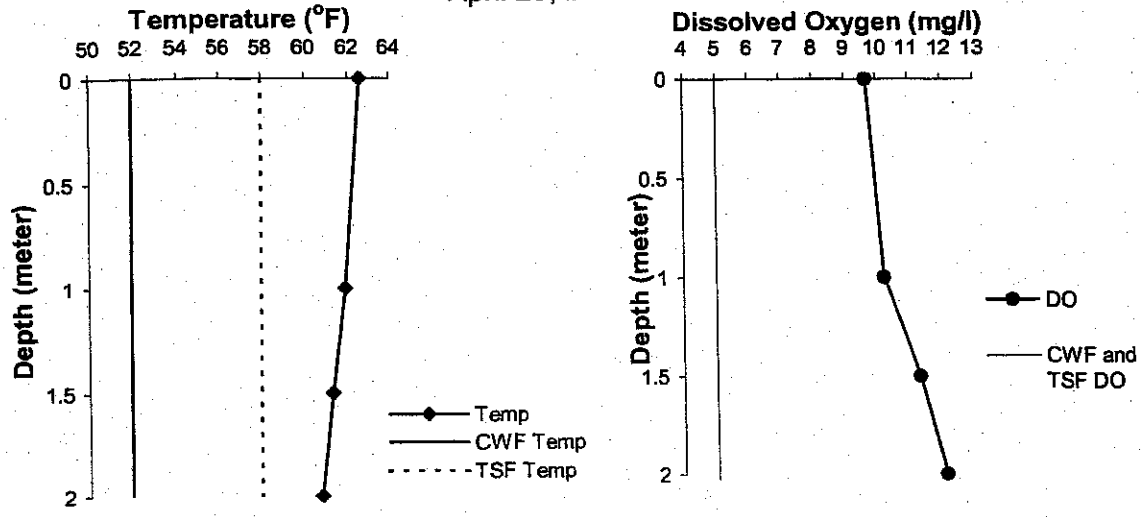
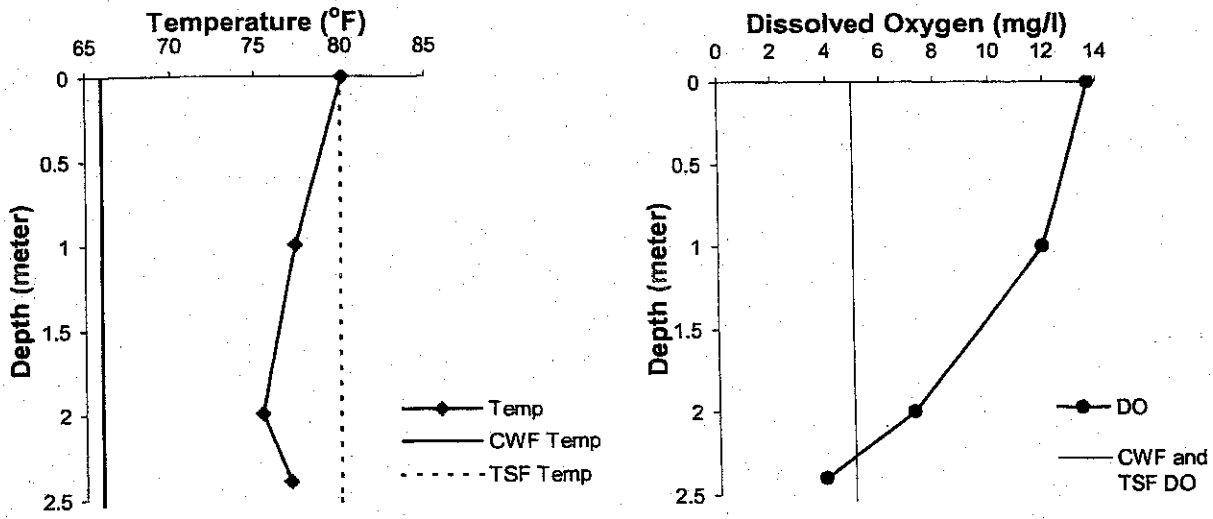


FIGURE 6.
LAKE LUXEMBOURG - WATER CHEMISTRY
Temperature and Dissolved Oxygen Profiles - Uplake Location
DEP
Vertical lines depict parameter criteria.

April 29, 2004



July 21, 2004



August, 17, 2004

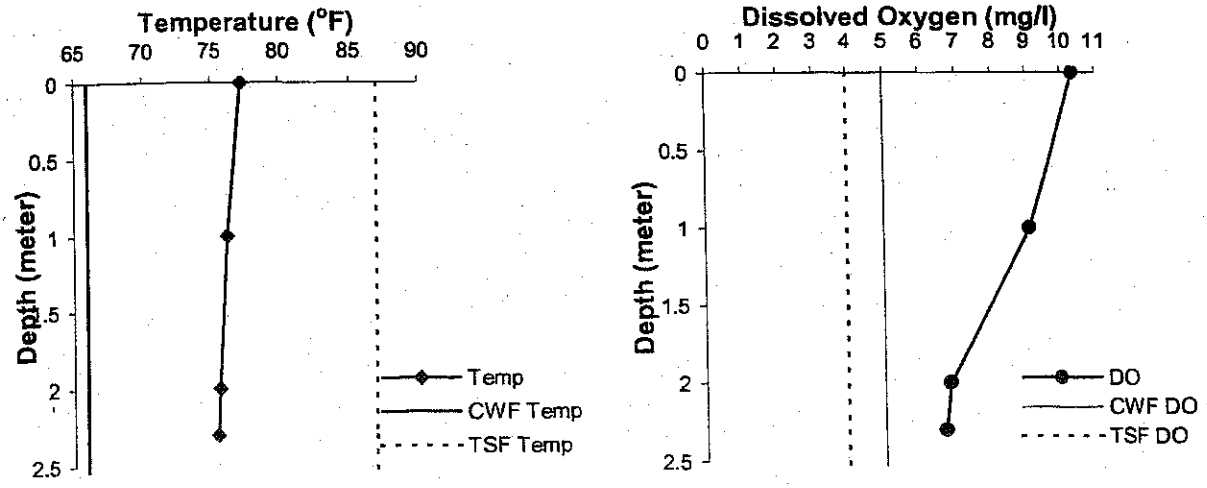


FIGURE 6. (cont.)
WATER CHEMISTRY - Temperature and Dissolved Oxygen Profiles

October 13, 2004