GCP/RAF/271/FIN-FM/07 (En) October 1993

FIELD MANUAL FOR LIMNOLOGICAL SAMPLING ON LAKE TANGANYIKA

by

Pierre-Denis Plisnier

FINNISH INTERNATIONAL DEVELOPMENT AGENCY

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS

Bujumbura, October 1993

PREFACE

The Research for the Management of the Fisheries on Lake Tanganyika project (Lake Tanganyika Research) became fully operational in January 1992. It is executed by the Food and Agriculture Organization of the United Nations (FAO) and funded by the Finnish International Development Agency (FINNIDA) and the Arab Gulf Programme for United Nations Development Organizations
(AGFUND).

This project aims at the determination of the biological basis for fish production on Lake Tanganyika, in order to permit the formulation of a coherent lake—wide fisheries management policy for the four riparian States (Burundi, Tanzania, Zaïre and Zambia).

Particular attention will be also given to the reinforcement of the skills and physical facilities of the fisheries research units in all four beneficiary countries as well as to the buildup of effective coordination mechanisms to ensure full collaboration between the Governments concerned.

Prof. O.V. LINDQVIST
Project Scientific Coordinator

Dr. George HANEK
Project Coordinator

LAKE TANGANYIKA RESEARCH
FAO
B.P. 1250
BUJUMBURA
BURUNDI

Telex: FOODAGRI BDI 5092

Tel.: (257) 229760

Fax.: (257) 229761

GCP/RAF/271/FIN PUBLICATIONS

Publications of the project are issued in two series:

* Series of **technical documents (GCP/RAF/271/FIN-TD)** related to meetings, missions and research organized by the project.

* Series of **field guides and manuals (GCP/RAF/271/FIN-FM)** related to training and field work activity conducted in the framework of the project.

For both series, reference is further made to the document number **(01)**, and the language in which the document is issued: English **(En)** and/or French **(Fr)**.

For bibliographic purposes this document should be cited as follows:

Plisnier, P.-D., 1993 Field Manual for Limnological Sampling on Lake Tanganyika. FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika. **GCP/RAF/271/FIN-FM/07 (En): 33 p.**

TABLE OF CONTENTS

1. Introduction

This field manual presents the procedures and the experimental plan for the limnology study and the way to sample, store and analyze in the field and in the laboratory. The detailed procedures for analyses are extensively dealt in the manuals provided with the water analysis kit and should be read carefully when performing analysis. Main analysis procedures are available in each station. References for the complete analysis manual are given in the last part of this document.

2. Definition and field of study

Limnology can be defined as the science studying the structural, functional and dynamic relations between the biotic environment and the abiotic parameters of freshwaters. As one can see, it is a very wide subject and covers many aspects of the study of aquatic environment. It is necessary to define more precisely here which fields of limnology are studied in this component of Lake Tanganyika Research (LTR) Project. In this project, the limnological component will process in two stages

First, it will start by studying those following parameters

- Dissolved oxygen (DO)
- pH
- Conductivity (C)
- Total phosphorus (P tot
- Orthophosphates ($P0_4$---)
- Ammonia (NH_3- N)
- Nitrites ($N0_2$--N)
- Nitrates (NO_3^--N)
- Turbidity
- Calcium (Ca^{++})
- Magnesium (Mg^{++})
- Alkalinity ($HC0_3^-$, $C0_3$--,OH^-)
- Chloride (Cl^-)
- Sulphate ($S04^{--}$)
- Silicate (Si02)

and an index of the abundance of the phytoplankton

- Chlorophyll *a* (Chl *a*)

At second stage, other aspect of limnology will be studied as well. It will deal with carbon and energy budget, including the study of dissolved organic carbon and microbiological aspects (bacteria ...) , etc.

This manual will deal only with the first stage of the limnological study involving regular, intensive and seasonal field work in the station.

3. Objective

The objective of the limnological study is to assess in space and time sequence the above listed parameters needed to better understand the chemical, physical and biological environment of the Lake Tanganyika on a regional basis during at least 2 complete annual cycles. Special emphasis will be given to the nutrients study (N, P) given their important role for the biological production of the lake.

Those information linked with other results of the Project's components (hydrodynamic, zooplankton,...) should enable us to reach the general objective of the Project : understand better the basis of the biological production of the lake Tanganyika to provide necessary information for an appropriate fisheries management.

4. Sampling and analysis in the field

Three different types of sampling will be done: regular weekly sampling, intensive sampling (24 H cycle every 6 weeks) and seasonal sampling (4 times/year). The location, the timing of sampling, the parameters to measure in the field and in the laboratory and the practical way to proceed are detailed here.

4.1. Weekly sample (type "A")

4.1.1 Time and location

The weekly sample will be performed every Tuesday at 9.00 a.m. (Burundi time) except during intensive sampling period. The precise schedule is available on a separate document. It will be performed at a defined site (recorded by GPS) not too far from the LTR station if possible where the depth of the lake will be > 120 meters for Bujumbura and Kigoma and 160 meters for Mpulungu. This site will be situated not less than 4 km away from the shore. It will be in the open lake (avoid bays and currents from affluent). The sampling will be done up to at least 100 meters in Bujumbura and Kigoma and 160 m in Mpulungu considering the deeper aerobic zone found in the South.

4.1.2 Parameters to measure

The following parameters will be measured during the weekly sampling:

- on the lake: transparency (SD), water temperature, dissolved oxygen, pH and conductivity.

- in the lab: P tot, $P0_4^{---}$ NH3-N, NO_2^-, $N0_3^-$, Chl *a* and turbidity

The sampling depth for T° , pH, conductivity, DO, turbidity and Chlorophyll *a* are every 10 meters up to 100 meters (110 and

120 meters depth can be added if possible). For Mpulungu, 120, 140 and 160 meters should be added (starting when electrical winch will be available).

The sampling depths for the measurement of other parameters (P tot, $P0_4^{---}$, $N0_3^-$, NO_2^-, NH_3-N) are every 20 meters

This means that a minimum of 11 bottles of 1 litres will be needed to keep water samples on the lake (0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 meters samples for Bujumbura and Kigoma and 0, 10, 20, 30, 40, 60, 80, 100, 120, 140 and 160 meters samples for Mpulungu).

The depth of the sampling and the measurements are summarised in Table 1. The corresponding form for the results is presented in Annex 1.

Depth	Station A		Weekly sample - each Tuesday -09 H (Burundi time)											
(m)	Zoopl. (100 um)	Hydr.	S.D. m	T° °C	pH	C. uS/cm	D.O. mg/l	Turb. NTU	Tot P mg/l	PO4- - - mg/l	NH4-N mg/l	NO3-N mg/l	NO2-N mg/l	Chl a ug/l
0		+	+	+	+	+	+	+	+	+	+	+	+	+
10		+		+	+	+	+	+	+	+	(+)	(+)	(+)	(+)
20		+		+	+	+	+	+	+	+	+	+	+	+
30		+		+	+	+	+	+	(+)	(+)	(+)	(+)	(+)	(+)
40		+		+	+	+	+	+	+	+	+	+	+	+
50		(+)		+	+	+	+	+	(+)	(+)	(+)	(+)	(+)	(+)
60		+		+	+	+	+	+	+	+	+	+	+	+
70		(+)		+	+	+	+	+	(+)	(+)	(+)	(+)	(+)	(+)
80		+		+	+	+	+	+	+	+	+	+	+	+
90		(+)		+	+	+	+	+	(+)	(+)	(+)	(+)	(+)	(+)
100		+		+	+	+	+	+	+	+	+	+	+	+
110		(+)		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
120		+ Mp		+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp
140		+ Mp		+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp
160		+ Mp		+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp	+ Mp
BOTTLES NAME:	Z/country code/A/date (to keep)							A/depth						

\+ : Minimal measurements
\+ and (+) : Optimal measurements
- - - : Field measurements
Mp : Mpulungu

S.D. = secchi disk (m)
C = conductivity (uS/cm),
D. O.= dissolved oxygen (mg/l)

Table 1 : Parameters to measure during sampling A and corresponding depth (m).

4.1.3 How to proceed ?

1. Get the boat ready (start preparation at least the day before going on the lake in order to avoid any delay due to a poor preparation of the boat).

— prepare fuel reserve, oil;
- check if engine is in good condition;
— life jackets must not be forgotten and should be used especially during bad weather condition to avoid any accident; and
— check the proper functioning of the tools such as the winch, etc...

2. Prepare equipment: (get everything ready the day before going on the lake !)

- recording form (LIMNOlA) of the latest version (check the date);
— GPS + recorded position of sampling site;
- sampling tube of 2 litres + messenger (if the lake is rough, use 7 litres bottles to minimise the drift of the bottle);
— cable of appropriate length : prepare adequate marks every 10 meters and bigger every fifty meters, use preferably oil paint (but no knots!);
- protractor (desk type);
- Secchi disk : disk should be 20 cm in diameter, rope of 20 meters long should be marked every 10 cm + every meter and 5 m with different mark);
- 2 buckets of 20 litres capacity;
— 1 plastic becher of 500 ml;
— pH meter (calibrated) and conductivity meter;
- T°+ 0_2 probe (calibrated) with cable and stirrer (insure to have a spare battery);
— precision thermometer if probe is not available;
— 13 clean plastic bottles of 1 litre (cleaned with HCl of H_2S0_4 and rinsed carefully) + tag with “A /date/depth” (ex: A/20—08/0, A/20-08/10, etc....). A indicates the type of sampling (weekly sampling);
- 1 bottle with deionised water (to clean electrodes ...);
— 1 or 2 cool boxes with ice to keep samples (it is advised to produce some ice permanently in the freezer part of the fridge);

— equipment for zooplankton sampling

this sampling is done at the same time that the limnological sampling. Don’t forget the sampling net of 100 µm with some weight at the bottom for vertical sampling) with 100 meters rope, the formalin, the syringe, the sampling bottle with tag (Z/country code/A/date) etc... see field manual for more details. The bottle with this weekly sample will be kept after the counting as a reference.

3. Radio confirmation: It is very important that the sampling is done at the same time as in the other stations (every Tuesday at 9.00 a.m. Burundi time: start of the sampling at 0 m). If this is really not possible for your station, you should contact before the other stations to fix together another date of that week for the experiment.

4. Proceed to sampling site A with GPS:

- the first time, go to appropriate site (if possible, use echo-sounder to check depth). Then, use "EVENT" on GPS to record the position and store it (write the number used by GPS for further use). Record position on paper also and indicate it on appropriate form (Annex 1).

- in subsequent sampling, just use "GOTO" followed by the GPS number to reach the position of site A.

5. Make sure to reach the correct position in good time (9.00 a.m. Burundi time). Record time, names of data collectors, conditions of the lake... on the LIMNOlA-form.

6. Start with zooplankton net hauling from 100 meters depth. Proceed as indicated in zooplankton field manual. Pour in sampling bottle (with tag). Rinse and add formalin as specified for this component.

7. Measure Secchi disk transparency (average of three different measurements).

8. Measure T° and 0_2 if probe is available: immerse the probe at defined depth; start from the surface and continue towards the bottom. Allow a few seconds for 0_2 measurement until reading stabilises. If probe is not yet available, just measure T° with the thermometer inside the bottle or with the most accurate thermometer available. Do not use the thermometer provided with the pH-meter and conductivity meter as those have too low accuracy. Check carefully the shape of your temperature profile. Generally, besides possible surface cooling down by the effect of the wind and evaporation, the profile shows a decrease from the top water to the deeper waters. In case of particularities such as warm water below cold water (it is possible but quite rare) it is important to redo measurement to confirm your temperature profile.

9. Move the boat a few meters away (20—30 meters) as the water column has been disrupted by the zooplankton hauling.

10. Start sampling at 0 meters. The top of the 2 litres tube should be just under surface. Avoid any possible surface pollution from the boat's oils... (!) Pour water in a clean 500 ml becher (plastic). Then measure the following parameters:

A. conductivity (position 2 on conductivity meter)

B. pH

and record results on LIMNOlA-form (Annex 1)

11. Pour gently the water in the appropriate 1 litre plastic bottle. Check correct label on the bottle. Avoid mixing: place pipe in the bottom of bottle (the pipe might need to be extended). Keep in cooler box.

12. Repeat sampling for each depth (Table 1) and steps 10 and 11. If the lake is rough, it might be difficult to have a vertical hauling. In this case, either you can use a bottle with some weight added to it (when an electrical winch is available) either you measure the angle between the rope and the vertical line and using the Annex 9, you add appropriate length to reach the corresponding depth. Here is an example: you could measure an angle of 24° between vertical line and your rope and you want to reach the depth of 100 meters. From Annex 9, you see that you need to let go 109,5 m to reach that depth. A small protractor (desk type) is needed to measure that angle.

13. When the last depth is reached, record time on LIMNOlAform. The sampling shouldn’t take more than 1 to 1.30 hours.

14. Proceed back to the station (use “GOTO” + station number if position is recorded and NAV-1 or NAV-2 display).

15. On your way back, an horizontal transect between sampling A and the shore will be done to measure chlorophyll *a* and Secchi disk. Precise information and date for start of experiment will be sent on separate document.

16. Start laboratory analysis (see chapter 5) with the smallest possible delay

4.2. Intensive sampling (type “B”)

4.2.1 Time and location

It will be realised during a 24 H cycle of sampling. The hours of sampling will be: 12 a.m., 6 p.m., 12 p.m. and 06 a.m. (Burundi time). The dates of the sampling are chosen to alternate every 5 or 6 weeks a night with full moon and a night with no moon. The precise lunar calendar is shown in Annex 5 and the scheduled dates of experiments are provided on separate document.

The location of this sampling type “B” should be situated where the depth of the lake is superior to 320 meters in a pelagic area (not less than 5 km from shore).

It should not be too far away from the shore to allow the boat to go back in a reasonable time to a field station on a close shore point between sampling if needed (weather...). After a preliminary period the definite site will be chosen and then fixed (for January 1994). The sampling will be done up to 300 meters following the sampling plan shown in Table 2 (form in Annex 2).

4.2.2 Parameters to measure

The parameters to measure are the same as for the weekly sample

- on the lake: transparency (SD), water temperature, dissolved oxygen, conductivity and pH;
- in the lab: P tot, $P0_4^{---}$, NH_3-N, NO_2^-, NO_3^-, Chl. *a* and turbidity

The sampling depths are different. For all the parameters, the sampling will be done at every 20 meters up to 140 meters. Then, one sample should be taken at 200 meters and one at 300 meters (160, 180 and 250 m can be added for optimal measurement). The minimal number of sampling is 10 for each session (at 12 a.m., 6 p.m., 12 p.m. and 06 a.m.). This brings the total number of bottles to keep to at least 40. To handle such a number of samples, a good organisation is necessary.

The depth of the sampling and the measurements are summarised in Table 2. The corresponding form to record the results is presented in Annex 2.

Intensive sampling : 24 H cycle (12-18-24-06 H) Burundi time)															
Depth (m)	Zoopl. (50 um)	Hydr.	S.D. m	T° °C	pH	C. uS/cm	D.O. mg/l	Turb. NTU	Tot P mg/l	PO4- - - mg/l	NH4-N mg/l	NO3-N mg/l	NO2-N mg/l	Chl a ug/l	
0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
10	(+)	(+)		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
20	+	+		+	+	+	+	+	+	+	+	+	+	+	
30	(+)	(+)		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
40	+	+		+	+	+	+	+	+	+	+	+	+	+	
50	(+)	(+)		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
60	+	+		+	+	+	+	+	+	+	+	+	+	+	
70	(+)	(+)		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
80	+	+		+	+	+	+	+	+	+	+	+	+	+	
90	(+)	(+)		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
100	+	+		+	+	+	+	+	+	+	+	+	+	+	
110				(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
120	+	+		+	+	+	+	+	+	+	+	+	+	+	
130				(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
140	+	+		+	+	+	+	+	+	+	+	+	+	+	
150				(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
160		(+)		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
170															
180		(+)		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
190															
200		+		+	+	+	+	+	+	+	+	+	+	+	
250		(+)		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
300		+		+	+	+	+	+	+	+	+	+	+	+	
BOTTLES	Z/B/date/H/depth (2 sampling/depth)							B/H/depth							

\+ : Minimal measurements + and (+) : Optimal measurements S.D. = secchi disk (m) C = conductivity (uS/cm),
---- : Field measurements D. O.= dissolved oxygen (mg/l)

Table 2 : Parameters to measure during sampling B and corresponding depth (m).

4.2.3 How to proceed 7

1. Get the boat ready (start preparation at least the day before going on the lake):

—prepare fuel reserve, oil, life jackets...). Ensure that the winch is OK - be sure to have enough fuel for each trip to the lake. Check if lights on boat are working.

2. Prepare equipment

- GPS + recorded position of sampling site;
- 7,4 litres tube for zooplankton (taking a second tube of 7,4 litres as a reserve in case of problem is a good idea);
- rope 300 meters long (mark every 10 m);
- messengers for those gears;
- protractor (to measure angle with vertical and correct length of rope);
- Secchi disk with rope (good marks every 10 cm);
- 2 buckets of ± 15—20 litres capacity;
- 1 becher of 500 ml (plastic);
- pH meter (calibrated) and conductivity meter;
- oxygen and temperature probe + cable and agitator;
- 13*4 = 52 clean plastic 1 liter bottles (cleaned with HCl 10 % or H_2S0_4 2%) with tag indicating "B /date/ hour/ depth" B indicates the type of sampling. Prepare tags before sampling. Permanent writing could be done also with B/hour/depth;
- 1 bottle with deionised water (to clean electrodes ...)
- enough cool boxes with ice to keep sampling bottles (52 litres maximum
- equipment for zooplankton sampling

this sampling is done at the same time that the limnological sampling. Besides the 7,4 litres tube and rope), don't forget the sampling net of **50** µm (different from sampling A), the forinalin, the syringe, 52 (maximum) or 40 (minimum) sampling bottles with appropriates tag etc... (see Field Manual for more details).

- other equipment for 24 H cycle: clock, eventually camping material if a base must be installed on shore, flash light, food, drinks...

3. Radio confirmation: get the confirmation of the experiment by radio. If radio contact is not possible and condition are OK for 24 H cycle, proceed for the experiment at the programmed date. If you can not go on the lake for some reason (very bad weather), proceed the next possible day for the experiment. It is very important that the experiment is done as much as possible at the same time by all stations. Any change that can be foreseen should be communicated as soon as possible using the radio in order for all the station to shift to the identical date.

4. Proceed to sampling site “B” with GPS:

—first time, go to appropriate site (use echo—sounder to check depth) and locate appropriate position. Then, use “EVENT” or “WAYPT” on GPS to record the position and store the position. Record position on paper with corresponding GPS number also and indicate it on appropriate form (Annex 2);

—on subsequent trips, just use “GOTO” followed by the corresponding GPS number to reach position of site B.

5. Be sure to reach position in time (12 a.m., 6 p.m., 12 p.m. and 06 a.m.)

6. Measure Secchi disk transparency during day time.

7. Measure T° and 0_2 if probe is available: immerse the probe at defined depth; start from the surface to the bottom. Allow a few seconds for 0_2 measurement until reading stabilises. If probe is not yet available, just measure T° with the thermometer inside the bottle.

8. Start sampling from 0 m and then proceed to deeper samplings. Use 7,4 litres tube to sample.

9. Take 1 litre for sample bottle (with pipe). Check tag B/date/hour/ depth. Keep in cooler box. Take 0,4 litres in a becher for conductivity and pH measurements.

10. Filter the rest of the tube in 50 µm net . Proceed as indicated in Zooplankton field manual. When the electrical winch is available, two bottles of 7,4 liters will be needed to be sampled at each depth down to 140 meters. The total volume water filtered will be 13,4 liters (14,8 liters less 1 liter for limnology sample bottle and 0,4 liter in becher for analysis on the boat).

11. Use the becher containing 0,4 litres of water (point 8) to measure

A. Conductivity (position 2 on conductivity meter

B. pH

and record results on LIMNOlB-form (Annex 2)

12. Repeat sampling for each depth (Table 2) (steps 8 to 11)

13. When the last depth is reached, record time on LIMNOlB-form (Annex 2).

14. Proceed back to the shore base or to your station at the end of the experiment.

15. After the cycle, as soon as you are back, make a plan

on which sample a “fresh” team can analyze directly. Then determine what you can analyze before the next 24 H, before the next 48 H and after 48 H ... Use the priority list given under laboratory analysis. Then, you or preferably the “fresh team” should go on by preserving the samples that need to be and by analysing the sample that can be done directly. Don’t forget that some samples taken at the beginning of the cycle have already been conserved for 24 H ! Those samples must naturally be analyzed in priority. Start directly with tot P and if possible $P0_4^{---}$. Especially Tot P should be analyzed as soon as reaching the laboratory. The samples for the rest (Ammonia, $N0_2^-$, $N0_3^-$, CHl *a*, turbidity and eventually $P04^{---}$, if not done the first day, will be analyzed after appropriate conservation in the time that you can manage). Even if the maximum time for conservation of water for several parameters is 28 days, it is strongly advised to not wait to long for the analyses of the samples and to avoid accumulation of bottles. This will allow also time for a proper cleaning of those bottles before the next samplings.

4.3. Seasonal sample (type “C”)

4.3.1 Time and location

The site for this experiment will be the same that the site for sampling of type “B” (24 H cycles). The sampling will also be done down to 300 meter depth following the sampling plan shown in Table 3 (form in Annex 3). Four experiment will be done each year: in January, April, July and October around 12 a.m.

4.3.2 Parameters to measure

No measurement will need to be done on the lake. But if the lake is calm, part or all of analysis can be performed on the boat during the 24 H cycle. Water should be sampled every 50 meters down to 300 meters (minimum): 0, 50, 100, 150, 200, 250 and 300 m (Table 3). The analysis of Ca^{++} hardness, total hardness, alkalinity, Cl^-, $S0_4^{--}$ and $Si0_2$ will be done by each team. A sample of 200 ml for each depth will need to be conserved (Table 4 b) and sent for external analysis for Na^+ and K^+ trough Bujumbura headquarters (see 5.2).

4.3.3 How to proceed ?

You need 7 bottles of <u>two</u> litres with appropriate tags (“C/date/depth/hour”), a tube of 7,4 litres (heavy for vertical haul) , 300 meters of cable, the messenger, For the rest, follow instruction given under “how to proceed” (sampling type B) and record results on form LIMNOlC-frin (Annex 3).

Station B. Seasonal sampling C (October, January, April, July at the beginning of 24 H cycle)										
Depth	Hydr.	Na +	K+	Tot Hardness	Ca++	P. Alkal.	Tot. Alkal.	Cl-	SO4- -	SiO2
(m)		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
0	+	send	send	+	+	+	+	+	+	+
50	+	send	send	+	+	+	+	+	+	+
100	+	send	send	+	+	+	+	+	+	+
150	+	send	send	+	+	+	+	+	+	+
200	+	send	send	+	+	+	+	+	+	+
250	+	send	send	+	+	+	+	+	+	+
300	+	send	send	+	+	+	+	+	+	+
BOTTLE	country/C/date/H/depth + coordinates						C/date/H/depth			

Table 3 : Parameters to measure during sampling C and corresponding depth (m).

5. Analysis in the Laboratory

Information concerning the order to follow for the analysis is provided below. Reference for detailed procedures of the Hach Manual are given here. It should be mentioned also that with appropriate number of glassware and good organisation, a same analysis for several samples can be performed at once. After dissolution of chemicals, timer can be run once and proper shift between zero sampling measurement and sample measurement can be done in a sequence of analysis. A considerable amount of time can be gained doing so with no lost of precision providing that maximum time for reaction should in any case be respected.

5.1 Analysis for sampling of types A and B

After sampling on the lake and coming back to the laboratory, one team should start the analysis with the spectrophotometric methods in the following order. The general principle is to take note of the results as the spectrophotometer gives it without transformation (exception if you have been diluting and for titration methods (sampling c) if multiplication factor must be used).

1. P total

(analyze should be done directly, if not possible you can store at ≤ 4° C up to 24 H after collection. Given the number of samples to be analyzed fast after an intensive cycle of 24 H, the “lab team” might need to work overtime to complete the work as analysis of P total can not be delayed in any way. Two set of glassware would allow you to start another “set” of analyses while the previous one cools down or is analyzed.

Try to use 3 (or 4 ml) of acid and neutralise with 3 (or 4) ml of 5.0 N Sodium hydroxide. The objective is to get a better “digestion” and extract the phosphorus contained in the organic forms. Keep on boiling gently

method: n° 8190 (page 427) of Hach manual

2. PO_4^{---}

Analyze should be done directly ideally. If this is not possible, sample can be stored at ≤ 4°C up to 24 H and longer with addition of mercuric acid solution, see table 4). Even if preserved, it is advised anyway to perform the analysis as soon as possible.

The method low range n° 8048 (phosver 3) should be used for 0 to 2,5 mg/l of PO_4^{---}. If concentration is higher, the method high range (molybdovanate) n° 8114 should be use. Dilution should be done if higher

concentration are reached with appropriate correction.

method : low range n° 8048 (page 419) of Hach manual
high range n° 8114 (page 415) of Hach manual

3. NH_3-N

(analyze should be done directly, acidification allow storage at ≤ 4°C up to 28 days, see table 4

method: n° 8038 (page 319) of Hach manual

4. $N0_3^-$

(storage at ≤ 4°C up to 24-48 H, acidification is needed for preservation up to 28 days, see table 4

method : n° 8192 (page 291) of Hach manual

5. NO_2^-

(storage at ≤ 4°C up to 24 H, addition of Mercuric Chloride solution is needed for storage up to 28 days, see table 4)

method : n° 8507 (page 309) of Hach manual

6. Chl *a*

Information is provided on particular instruction sheet.

When you have to wait for reaction or digestion for previous analysis, you can perform the turbidity measurement in between:

7. Turbidity

(storage is possible at ≤ 4°C up to 48 Hours). Remember the extreme care to have in handling the measuring cell (see instruction in 6.5)

If you can't analyze the samples directly, more details on the preservation of samples are given in chapter 7. Nevertheless, it is necessary to analyze P tot and PO_4^{---} especially as soon as possible.

It is advised for the analysis of sampling type B (24 h cycle) to keep a "fresh" team (2–3 persons if possible) which was not working the preceding night in order to start the analysis as soon as the boat comes back from the 24 h cycle).

After performing analyses, before discarding the remaining water of the sample, it is very important that the team and the responsible of limnology in your station check the results to decide if one or several measures that might show "abnormal" (at first sight) value should be repeated. Drawing a fast profile of the results will help you to find those "out of trend"

measures. Look also at absolute values of the whole profile to detect any bias. Write results that you can't trust for some reason in brackets when recording them and give eventual comments on the side of the form. In any case, it is good to be critical about your own work in order to find ways to improve the quality and the reliability of the results.

5.2 Analysis for sampling of types C

The analysis of sampling C should be performed in the following order. Sample for alkalinity can't be kept for more than 24 H and should be analyzed in priority.

Alkalinity ($HC0_3^-$, $C0_3^{--}$, OH^-) (sample volume 100 ml, fill completely the bottle, storage at ≤ 4°C up to 24H)

method : Titrimetric method, page 34, Digital Titrator Manual (try range 100 - 400 mg/l as $CaCO_3$)

Ca $^{++}$ hardness (sample volume 100 ml, direct analyze or acidification and storage at ≤ 4°C up to 7 days, see table 4)

method: Titrimetric method, page 79, Digital Titrator Manual.
(try range 10 - 40 mg/l as $CaCO_3$)

Total Hardness (sample volume 100 ml, direct analyze or acidification and storage at ≤ 4°C up to 7 days, see table 4)

method: Measure of Total Hardness, titrimetric method, page 72, Digital Titrator Manual. (try range 100- 400 mg/l as $CaCO_3$)

Mg $^{++}$ First, perform Total Hardness then subtract Ca $^{++}$ hardness from it.

mg/L Mg^{++} Hardness = mg/L Total Hardness - mg/L Ca^{++} Hardness as $CaCO_3$ as $CaCO_3$ as $CaCO_3$

mg/ L $MgCO_3$ = mg/L Hardness as $CaCO_3$ x 0,842 mg/L Mg = mg/L $MgCO_3$ x 0,29

$S0_4^{--}$ (sample volume 25 ml, storage at ≤ 4°C up to 7 days)
method : n° 8051 (page 509) of Hach manual

$Si0_2$ Low range (0 to 1,6 mg/l)

Generally this method will be used for water sampled between 0 and 100 meters.
(sample volume 50 ml, storage at ≤ 4°C up to 7 days)

method: n° 8186 (page 479) of Hach manual

SiO_2 High range (0 to 100 mg/l) Generally this method will be used for water sampled below 100 meters. (sample volume 25 ml, storage at ≤ 4°C up to 7 days)
method: n° 8185 (page 485) of Hach manual

Cl - (sample volume 100 ml, storage up to 7 days)

method: Titrimetric (silver nitrate) method, page 51, Digital Titrator Manual (try range 10 - 40 mg/l as Cl)

Na^+ and K^+ For the analysis of Na^+ and K^+, you should keep at least 200 ml of water for each sampling depth in a polyethylene bottle. Add 0,1 ml / of concentrated HCl by 100 ml of sample. Tag it properly (country, station, coordinates, date, hour and depth + instruction "for Na^+ and K^+ analysis"). Send it the same month to Bujumbura.

6. Remarks concerning the apparatus

You will need, at the beginning, to use 5 kinds of methodology associated with a corresponding apparatus. Here are a few things to keep in mind concerning each of those apparatuses. More details will naturally be found in the corresponding manuals and it is advised that a few persons at least go through those manuals at each station.

6.1. Spectrophotometer:

The detailed information can be found in 2 manuals

- HACH - DR/2000 Spectrophotometer. Instrument manual.
- HACH - DR/2000 Spectrophotometer Handbook - Procedure Manual

Note particularly the following:

When you turn the wavelength control knob, it is important to remember to always approach the desired wavelength from the high side to get a better accuracy and repeatability.

If the display flashes, this means that the recommended wavelength was not set properly.

When a pre measured reagent has been added to the sample, you should respect the time indicated in the procedure as these allow full development of the colour (due to the reaction between the reagent and the substance to measured).

Batt/l key can be used to check the condition of the battery (used with shift key).

It is of first necessity to keep the sampling cells very dry and clean as this affects the measurement in a very important way. Measurement of volumes should be done by using a calibrated pipette to insure accuracy. Considering that several parameters show very low concentration, this will help you to keep bias and measurement errors at their lowest possible level.

6.2 - Digital titrator

The use of the digital titrator and the analysis are described step by step in “HACH - Digital titrator - Model 16900-01 – Manual “.

It is advised to keep a specific delivery tube for each particular solution. Keep a tag about 1 cm from one end of the delivery tube and indicate to which product is this delivery tube corresponding.

Turn the knob of the digital titrator very slowly at the end as some reactions are slow and you might loose the precision by going to fast. When accuracy checks ampoules (known concentration) will be available, check carefully the change of colour of each test as this will help you to assess more precisely the change of colour to expect during the future titration.

6.3 - pH-meter

The pH-meter should be calibrated every week and particularly before an important experiment.

For calibration, proceed as follow:

1. Open a pH 4.01 (red) Hach powder pillow. Dissolve in 50 ml of deionized water. Use the electrode to stir the solution and rinse the electrode afterward.

2. Prepare another solution by opening a pH 7 (yellow) powder pillow and dissolve as above.

3. Press **I/O** button of pH-meter.

4. Press **pH**

5. Press **Auto/manual**

6. Place the electrode into the pH 4.01 Hach Powder Pillow Buffer and press the dispenser button until it clicks. Wait for 30 seconds. Press **Standard** and wait until the pH indicators stop flashing.

7. Rinse the electrode with deionized water and repeat step 6 with pH 7 solution.

8. Press **pH**. Rinse the electrode. The calibration is completed and your pH—meter measure now the pH

To measure an unknown sample (routine measurement) : Place the clean electrode into sample. Press the dispenser button until it clicks. Read pH after the stability indicator stop flashing. In case of wide and aberrant variation of pH, a probable air bull should be removed by shaking the probe as a thermometer and by pressing several times the dispenser. Sometimes, the primary knob must be turned (toward the left) to eject drops of KCl and air bulls.

6.4 - Conductivity meter

After starting the conductivity meter, press CND and use range n^0 2. Express the results in µS/cm. Rinse the probe thoroughly with demineralised water after each measurement. Calibration of the conductivity meter is needed every three month normally. The use of the standard 1.99 µS/cm and the cal control screw are explained in the manual of the conductivity meter page 14 and 15.

6.5 - Turbidimeter

1. Warm up the turbidimeter in 0-1000 NTU range for 30 minutes before performing analyses.

2. The sample cells should be very clean (no finger prints, scratches...) especially when measuring low turbidity as it is often the case for lake Tanganyika.

3. Rinse cell with small amount of sample water.

4. Fill approximately with 25 ml of test sample (between 24 and 26 ml).

5. Dry the exterior part of the cell with clean, lint free cloth of tissue. The bottom should especially be clean and dry.

6. Try to use always the same cell in the same direction (small mark on the top to show facing side).

7. If 0-1000 NTU of 0-100 NTU range is used, don’t forget to place the cell riser.

8. Standardisation should be performed with secondary standard (GELEX) before each measurement in a given range. Primary standardisation should be done every 3 month with formalin following instruction in the turbidimeter manual page 11

(paragraph 4.6.2).

9. Cover with light shield.

10. Read (eyes above meter scale, the reflection of the needle shouldn’t be seen).

11. In standby, don’t shut the instrument off but remove cell and put on 0-100 range.

12. Shut down only when all the measurement of the day are done.

7. Conservation of samples

The bottles and sample cells should be cleaned with H_2S0_4 (2 *%)* or HCl (10%) when tot P and $P0_4^{---}$ must be analyzed (it is the case most of the time) and rinsed with demineralized water. No detergent should be used as the phosphate content of those will contaminate the sample).

When other tests than $P0_4^{---}$ and tot P are performed, sample cells should be washed with soap, rinsed several times with tap water than rinsed with demineralized water.

The analysis should preferably be done as soon as possible. The weekly samples A should normally be analyzed in less than 48 H while the 24 H cycle samples B should be analyzed in the next two weeks (after proper preservation of water).

For several analyses, it is possible to keep the samples at ≤ 4°C in the dark for less than 24 H-48H. Before analysing, you should let it warm to the temperature of the room.

The samples that you will not be able to analyze in the next 48 H should be carefully preserved following the instruction of table 4.

TABLE 4 (A) : Procedure and time of preservation when direct analysis is not possible. Quantity of necessary sample is indicated also (including sample for blanks). (sampling types A and B)

To analyse...	ml	Procedure	Time
P total	25	refrigerate at ≤ 4°C	24 H
P04---	50	A.- refrigerate the sample at ≤ 4°C	24 H
		A. For longer storage, add 4.0 ml of mercuric chloride solution by 1 litre of sample and mix.	> 24 H
		B..- refrigerate the sample at ≤ 4°C	
		C. - Prevent mercuric interference by adding 0,1 g sodium chloride/ litre of solution.	
Nitrogen Ammonia	50	A.- If Cl_2 is present, add 0.1 N sodium thiosulfate (1 drop /0,3 mg/l Cl_2)	28 days
(NH_3-N)		B. - adjust sample pH to 2 or less with H_2SO_4 (ACS) (> 2 ml of H_2SO_4 /litre of sample)	
		C. - refrigerate the sample	
		D.- before testing, warm to room temperature	
		E.- neutralise with 5.O N NAOH solution	
		F.- correct the test results for volume addition (*)	
Nitrite (NO_2^--N)	50	A. Storage at ≤ 4 °C	24 H
		A. - add 4 ml of Mercuric Chloride solution / liter of sample and mix	28 days
		B. - refrigerate the sample	
		C.- before testing, warm to room temperature (*)	
Nitrate (NO_3^--N)	55	A. Storage at ≤ 4 °C	24-48 H
		A.- adjust sample pH to 2 or less with 2 ml of H_2SO_4 *(ACS)* by litre of sample.	28 days
		B.- refrigerate the sample	
		C.- before testing, warm to room temperature	
		D.- neutralise with 5.O N NAOH solution	
		E.- correct the test results for volume addition (*)	
Turbidity	40	A. storage at 4° C	48 H
TOTAL quantity	270		

TABLE 4 (B) : Procedure and time of preservation when direct analysis is not possible. (Sampling of type C) Quantity of necessary sample is indicated also (including sample for blanks).

To analyse...	ml	Procedure	Time
Alkalinity	100	A. storage at ≤ 4 ° C	24 H
Ca^{++}	100	A.- Add 1.5 ml Nitric Acid per litre sample **B.**- refrigerate the sample **C.**- neutralise to pH 7 with NaOH before testing	7 days
Total Hardness	100	A.- adjust sample pH to 2 or less with concentrated nitric acid or sulphuric acid. **B.**- refrigerate the sample at 4°C **C.**- neutralise to pH 7 with Ammonium hydroxide before testing	7 days
$SO4^{--}$	25	A. storage at ≤ 4 ° C	7 days
$Si0_2$ (LR)	50	A. storage at ≤ 4 ° C	7 days
$Si0_2$ (HR)	100	A. storage at ≤ 4 ° C	7 days
Cl^-	100	A. no refrigeration necessary	7 days
Na^+	100	A. add 0,1 ml of concentrated HCL	6 month
K^+	100	A. add 0,1 ml of concentrated HCL	6 month
TOTAL quantity	775		

(*) correction of test results for volume addition:

1. Determine the total volume of initial sample, acid added and base added.

2. Divide the total volume by the initial volume

3. Multiply the test result by this factor.

8. Management of the stock of chemicals

It is advised to keep a list of reagent that you have in your stock to perform each analyse. You can use the lists provided in appendice 6, 7, and 8. From this stock, you can take what is needed for the work to perform in the next two months and place

this in the laboratory under the appropriate tags corresponding to each analyse. Be sure to ask more chemicals when you see that you will run out of it (at least 3 month in advance). You should send a list of your stock of chemicals once every two months to the Limnologist of the Project or earlier if there is a need.

9. Limnological Database

Appendices 1, 2 and 3 are the forms to use for the result on paper and in the computer (file called LIMNO1A-frm, LIMNO1B-frm and LIMNO1C-frm) in EXCEL spreadsheet.

First, it is very important to avoid the input of data that you think are unreliable (because of eventual problems during experiment...). This is why, before entering data's on computer, they should be checked by the person in charge of limnology in your station.

After each week sampling and validation by the responsible of limnology in the station, enter the data that have been validated on the appropriate worksheet (it takes 15 minutes maximum for a sampling A). If problems are suspected, it is better in such case to let parts of the forms blank or to put data in brackets with some comments. If results have been performed more than once for the same depth, you can input them by separating them with slashes on the computer. Maybe, because of this, you will not be able to print all but it will be seen on the computer.

The form LIMNO1A-frm for sampling A, LIMNOlB-frm for sampling B and LIMNO1C-frm for sampling C should be left blanks to be used each time.

As soon as you have been opening those forms, use the command "SAVE AS..." to give an appropriate name following this procedure:

First letter:
A, B or C (for each type of sampling)

This letter is followed by the date of the sampling (always the first day for a 24 H cycle): ex: 930803 = 1993 August 3 (format YYMMDD as this allows an automatic classification by the computer).

Second letter:
Country code (Burundi = A, Tanzania = B, Zambia C, Zaire = D)

The 8 characters long file name is followed by two characters long file extension:

The first character is **L**. It indicates the subcomponent : **L** for limnology

The second character is **0** in case of sampling of type A and C. It is used only for sampling of type B. Then **1**

indicates the sampling at 12 H, **2** the sampling at 18 H, **3** the sampling at 24 H and **4** the sampling at 06 H.

The possibility of a third character for the file name extension is not used.

Example: B930803A.L4 is the limnology data file for a sampling of type B started the 3rd of August 1993 in Burundi and performed at 06 H.

At the end of each month, a diskette containing copy of the forms for sampling of type A and eventual sampling of type B and C performed during this month should be sent at the address of the FAO's limnologist in Mpulungu. This diskette will be sent to you back with data's for other coordinators of the Project's components. A copy of the file on paper should also be sent with the diskette (form A, B, C printout after input data on computer). For security, you should keep a duplicate of each form on diskette and in paper in your station.
24

10. References

HACH - Portable Hach One pH meter Model 438-00

HACH - Model 44600- Conductivity/TDS meter

HACH - DRI2000 Spectrophotometer. Instrument manual. For use with software version 3.

HACH - DRI2000 Spectrophotometer Handbook - Procedure Manual

HACH - Digital titrator - Model 16900-01 - Manual

HACH - Instrument manual. Laboratory turbidimeter. Model 2100A

11. Appendices

1. Form to use for recording results of sampling A (LIMNO1A-frm)
2. Form to use for recording results of sampling B (LIMNOlB-frm)
3. Form to use for recording results of sampling C (LIMNO1C-frm)
4. Map showing approximate positions of sampling A, B and C for each station
5. Moon schedule
6. Chemical stock list by method
7. Chemical stock list by reference number
8. Chemical stock list by alphabetic order
9. Length of rope corrected for angle due to drift

LAKE TANGANYIKA RESEARCH PROJECT - LIMNOLOGY (A)

Country :		GPS record n° :	
Team sampling :		Latitude :	
Team analysing :		Longitude :	
Date :		Hour begining :	
Lake condition :		Hour ending	
Remarks			

Depth	Station A		Weekly sample - each Tuesday 09 H (Burundi time)													Bottle
(m)	Zoopl. (100 um)	Hydr.	S.D. m	T° °C	pH	C. uS/cm	D.O. mg/l	Turb. NTU	Tot P mg/l	PO4- - - mg/l	NH4-N mg/l	NO3-N mg/l	NO2-N mg/l	Chl a ug/l		
0		+														
10		+														
20		+														
30		+														
40		+														
50		(+)														
60		+														
70		(+)														
80		+														
90		(+)														
100		+														
110		(+)														
120		+ Mp														
140		+ Mp														
160		+ Mp														

BOTTL NAME:	Z/country code/A/date (to keep)
	A/depth

\+ : Minimal measurements
\+ and (+) : Optimal measurements
- - - - : Field measurements
Mp : Mpulungu

S.D. = secchi disk (m)
C = conductivity (uS/cm),
D. O.= dissolved oxygen (mg/l)

LIMNO1A-form 1/10/93

LAKE TANGANYIKA RESEARCH PROJECT - LIMNOLOGY (B) LIMNO1B.FRM

Country :		GPS record n° :	
Team sampling :		Lattitude :	
Team analysing :		Longitude :	
Date :		Hour begining :	
Lake condition :		Hour ending	
Moon (time +clarty)			
Remarks			

Intensive sampling : 24 H cycle (12-18-24-06 H) Burundi time)

Depth (m)	Zoopl. (50 um)	Hydr.	S.D. m	T° °C	pH	C. uS/cm	D.O. mg/l	Turb. NTU	Tot P mg/l	PO4- - - mg/l	NH4-N mg/l	NO3-N mg/l	NO2-N mg/l	Chl a ug/l		Bottle
0	+	+														
10	(+)	(+)														
20	+	+														
30	(+)	(+)														
40	+	+														
50	(+)	(+)														
60	+	+														
70	(+)	(+)														
80	+	+														
90	(+)	(+)														
100	+	+														
110																
120	+	+														
130																
140	+	+														
150																
160		(+)														
170																
180		(+)														
190																
200		+														
250		(+)														
300		+														

BOTTLES Z/B/date/H/depth (2 samplings/depth) B/H/depth

\+ : Minimal measurements + and (+) : Optimal measurement: S.D. = secchi disk (m) C = conductivity (uS/cm),

. . . . : Field measurements D. O.= dissolved oxygen (mg/l) LIMNO1B-form 1/10/93

LAKE TANGANYIKA RESEARCH PROJECT - LIMNOLOGY (C)

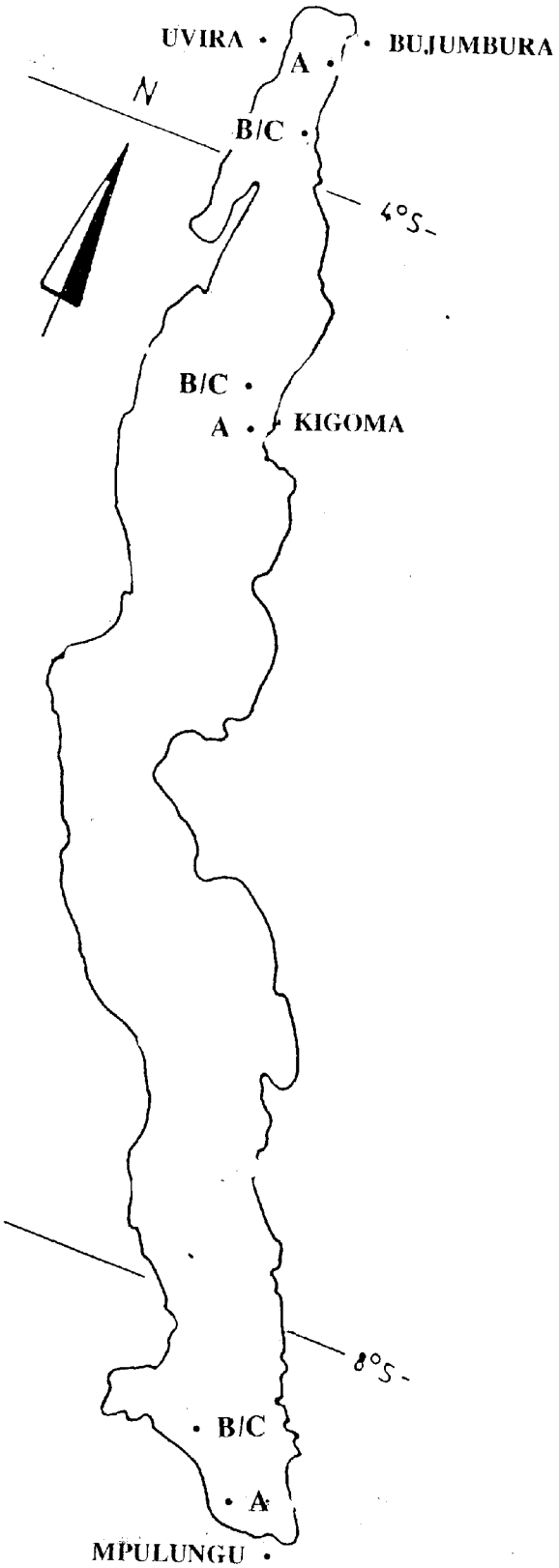
Country :		GPS record n°:	
Team sampling :		Latitude :	
Team analysing :		Longitude :	
Date :		Hour beginning :	
Lake condition :		Hour ending	
Remarks			

Station B. Seasonal sampling C (October, January, April, July at the beginning of 24 H cycle)										
Depth (m)	Hydr.	Na + mg/l	K+ mg/l	Tot Hardness mg/l	Ca++ mg/l	P. Alkal. mg/l	Tot. Alkal. mg/l	Cl- mg/l	SO4- - mg/l	SiO2 mg/l
0	+	send	send							
50	+	send	send							
100	+	send	send							
150	+	send	send							
200	+	send	send							
250	+	send	send							
300	+	send	send							
BOTTLE	country/C/date/H/depth + coordinates						C/date/H/depth			

Results of Ca++, tot hardness, P. alk. and tot alk. should be expressed as CaCO3 (no transformation after the test)

NB: for analysis of Na+ and K+: preserve sample following field manual instruction an send to Project HQ before the end of the month.

LIMNO1C-form 1/9/93


UVIRA
BUJUMBURA
A
N
B/C
4°S
B/C
A
KIGOMA
8°S
B/C
A
MPULUNGU

PHASES OF THE MOON

NEW MOON				FIRST QUARTER				FULL MOON				LAST QUARTER			
	D	H	M		D	H	M		D	H	M		D	H	M
1993															
				JAN.	1	03	39	JAN.	8	12	38	JAN.	15	04	02
JAN.	22	18	28	JAN.	30	23	20	FEB.	6	23	56	FEB.	13	14	58
FEB.	21	13	06	MAR.	1	15	47	MAR.	8	09	47	MAR.	15	04	17
MAR.	23	07	16	MAR.	31	04	11	APR.	6	18	45	APR.	13	19	39
APR.	21	23	49	APR.	29	12	42	MAY	6	03	35	MAY	13	12	20
MAY	21	14	08	MAY	28	18	22	JUNE	4	13	03	JUNE	12	05	37
JUNE	20	01	54	JUNE	26	22	45	JULY	3	23	46	JULY	11	22	50
JULY	19	11	25	JULY	26	03	26	AUG.	2	12	11	AUG.	10	15	20
AUG.	17	19	29	AUG.	24	09	59	SEPT.	1	02	34	SEPT.	9	06	27
SEPT.	16	03	12	SEPT.	22	19	33	SEPT.	30	18	54	OCT.	8	19	37
OCT.	15	11	37	OCT.	22	08	53	OCT.	30	12	38	NOV.	7	06	37
NOV.	13	21	35	NOV.	21	02	04	NOV.	29	06	32	DEC.	6	15	50
DEC.	13	09	28	DEC.	20	22	26	DEC.	28	23	07				
1994															
												JAN.	5	00	01
JAN.	11	23	11	JAN.	19	20	27	JAN.	27	13	24	FEB.	3	08	07
FEB.	10	14	31	FEB.	18	17	49	FEB.	26	01	16	MAR.	4	16	55
MAR.	12	07	06	MAR.	20	12	15	MAR.	27	11	11	APR.	3	02	55
APR.	11	00	18	APR.	19	02	35	APR.	25	19	46	MAY	2	14	33
MAY	10	17	08	MAY	18	12	51	MAY	25	03	40	JUNE	1	04	03
JUNE	9	08	28	JUNE	16	19	57	JUNE	23	11	34	JUNE	30	19	31
JULY	8	21	39	JULY	16	01	13	JULY	22	20	17	JULY	30	12	41
AUG.	7	08	46	AUG.	14	05	58	AUG.	21	06	48	AUG.	29	06	41
SEPT.	5	18	34	SEPT.	12	11	35	SEPT.	19	20	02	SEPT.	28	00	24
OCT.	5	03	56	OCT.	11	19	18	OCT.	19	12	19	OCT.	27	16	45
NOV.	3	13	37	NOV.	10	06	15	NOV.	18	06	58	NOV.	26	07	05
DEC.	2	23	55	DEC.	9	21	08	DEC.	18	02	18	DEC.	25	19	08
1995															
JAN.	1	10	57	JAN.	8	15	47	JAN.	16	20	27	JAN.	24	04	59
JAN.	30	22	48	FEB.	7	12	55	FEB.	15	12	16	FEB.	22	13	05
MAR.	1	11	49	MAR.	9	10	15	MAR.	17	01	26	MAR.	23	20	11
MAR.	31	02	09	APR.	8	05	36	APR.	15	12	09	APR.	22	03	19
APR.	29	17	37	MAY	7	21	45	MAY	14	20	49	MAY	21	11	36
MAY	29	09	28	JUNE	6	10	27	JUNE	13	04	04	JUNE	19	22	02
JUNE	28	00	51	JULY	5	20	04	JULY	12	10	50	JULY	19	11	11
JULY	27	15	15	AUG.	4	03	17	AUG.	10	18	17	AUG.	18	03	04
AUG.	26	04	33	SEPT.	2	09	04	SEPT.	9	03	38	SEPT.	16	21	10
SEPT.	24	16	56	OCT.	1	14	36	OCT.	8	15	53	OCT.	16	16	27
OCT.	24	04	37	OCT.	30	21	18	NOV.	7	07	21	NOV.	15	11	41
NOV.	22	15	44	NOV.	29	06	29	DEC.	7	01	28	DEC.	15	05	33
DEC.	22	02	24	DEC.	28	19	07								

Method		Product Name	N°	STOCK Aoû-93		STOCK		STOCK
chl a	analysis	Adapter, 1 cm cuvette	44895-00					
		Sample cells (1 cm matched pair)	20951-00					
		Filtre super gelman 0,45 mm, diam 25 mm	3060172					
		Filter holder Delvin, diam 25 mm	3001109					
		NN Dimethil formamide DMF extra pur	4161063					
D.O.	analysis	Dissolved O2 1 Reagent Powder Pillow	981-99					
		Dissolved O2 2 Reagent Powder Pillow	982-99					
		Dissolved O2 3 Reagent Powder Pillow	987-68					
		Sodium thiosulfate titration cartridge	22675-01					
		BOTTLE BOD 60 ml	1909-2					
		Erlenmeyer 125 ml	505-43					
Iodine	analysis	DPD- total chlorine	14064-99					
NO3 (LR)	analysis	Nitriver 3	14065-66					
		Nitraver 6	14119-66					
		cylinder 50 ml	1896-41					
		stopper	14480-01					
		sample bottle	20950-00					
	conservation	sulfuric acid ACS 500 ml	979-49					
		bromine water	2211-20					
		phenol solution	2112-20					
		sodium hydroxyde standard sol 5.0 N	2450-26					
NO2 (LR)	analysis	Nitriver 3	14065-66					
		stopper hollow polyethylene	14480-01					
	conservation	Mercuric chloride solution	14994-14					
NH3-N	analysis	cylinder graduated, mixing, tall form 25 ml	21190-40					
		Nessler Reagent	21194-49					
		Mineral Stabilizer	23766-26					
		Polyvinil Alcohol dispersing agent	23765-26					
	conservation	sodium thiosulfate	323-37					
		sodium hydroxide	2450-37					
		sulfuric acid ACS-500 ml	979-49					
Tot P	analysis	Potassium persulfate powder pillow	2451-66					
		Sulfuric acid solution 5.25 N (2 ml)	2449-37					
		Sodium hydroxyde sol 5 N (2 ml)	2450-37					
		erlenmeyer 50 ml	505-41					
PO4-P (molyb. meth)	analysis	Molybdovanate reagent (2 ml)	20760-37					
		cylinder graduated 25 ml	508-40					
	conservation	Mercuric chloride solution	14994-14					
		Sodium chloride ACS	182-01					
PO4-P (asc. meth.)		Phosver 3	2125-99					
Tot hardness	analysis	Buffer sol hardness 1	424-37					
		Man-ver 2 hardness indic.	851-99					
		EDTA 0,08 M	14364-01					
		EDTA 0,8 M	14399-01					
	conservation	concentrated nitric acid	2540-11					
		amonium hydroxide	14736-37					
Ca++	analysis	EDTA 0,08	14364-01					
		potassium hydroxyde standard sol 8.0 N	282-37					
		calver 2 calcium indicator pillow	852-99					
		cylinder 100 ml	508-42					
	conservation	Nitric acid	2540-11					
		Amonium hydroxyde	14736-37					
Alcalinity	analysis	Bromcresol green-methyl red powder pill.	943-99					
		Phenophtalein powder pillow	942-99					
		Sulfuric acid titr. cartr. 1.6	14389-01					
		Sulfuric acid titr. cartr. 0.16	14388-01					
		delivery tube	17205-00					
Cl-	analysis	Chloride 2 indic powder pill.	1057-66					
		Silver nitrate 0.2255 N	14396-01					
		Silver nitrate 1.128	14397-01					
SO4	analysis	Sulfaver 4 reagent powder pill.	12065-66					
Sio2 LR	analysis	amino acid F reagent	22538-69					
		citric acid powder pill	14548-99					
		molybdate 3 reagent	1995-37					
SiO2 HR	analysis	Molybdate reagent powder pillow	1041-66					
		acid reagent powder pillow	1042-66					
		bottle square mixing 25 ml	17042-00					
		cap, bottle	21667-06					
		holmium trichloride powder pillow	23432-67					
		citric acid powder pillow	14548-99					
Misc.		HCL concentrated 37 %	4140303					
		NaOH pastillen	4117373					
		H2SO4 99-100%	4111023					
		pipet tensette 0,1 to 1 ml	19700-01					
		pipet tips	21856-96					

Appendice 6 : Chemical stock list by method

N°	Product name	Method			Stock			
			(Date)					
non Hach								
3001109	filter holder Delvin, diam 25 mm	chl a -DMF						
3060172	filtre super gelman 0,45 mm, diam 25 mm	chl a -DMF						
4111023	H2SO4 99-100%	Misc.						
4117373	NaOH pastillen	Misc.						
4140303	HCL concentrated 37 %	Misc.						
4161063	NN Dimethil formamide DMF extra pur	chl a -DMF						
Hach								
1041-66	molybdate reagent powder pillow	SiO2 HR						
1042-66	acid reagent powder pillow	SiO2 HR						
1057-66	chloride 2 indic powder pill.	Cl-						
12065-66	sulfaver 4 reagent powder pill.	SO4						
14064-99	DPD- total chlorine	Iodine						
14065-66	nitriver 3	NO2 (LR)/NO3 (LR)						
14119-66	nitraver 6	NO3 (LR)						
14364-01	EDTA 0,08	Ca++						
14364-01	EDTA 0,08 M	Tot hardness						
14388-01	sulfuric acid titr. cartr. 0.16	Alkalinity						
14389-01	sulfuric acid titr. cartr. 1.6	Alkalinity						
14396-01	silver nitrate 0.2255 N	Cl-						
14397-01	silver nitrate 1.128	Cl-						
14399-01	EDTA 0,8 M	Tot hardness						
14480-01	stopper	NO3 (LR)						
14480-01	stopper hollow polyethylene	NO2 (LR)						
14548-99	citric acid powder pill	Sio2 LR/SiO2 HR						
14736-37	amonium hydroxide	Tot hardness/Ca++						
14994-14	mercuric chloride solution	NO2 (LR)/PO4-P (molyb)						
17042-00	bottle square mixing 25 ml	SiO2 HR						
17205-00	delivery tube	Alkalinity						
182-01	sodium chloride ACS	PO4-P (molyb)						
1896-41	cylinder 50 ml	NO3 (LR)						
1909-2	bottle BOD 60 ml	D.O.						
19700-01	pipet tensette 0,1 to 1 ml	Misc.						
1995-37	molybdate 3 reagent	Sio2 LR						
20760-37	molybdovanate reagent (2 ml)	PO4-P (molyb)						
20950-00	sample bottle	NO3 (LR)						
20951-00	sample cells (1 cm matched pair)	chl a -DMF						
2112-20	phenol solution	NO3 (LR)						
21190-40	cylinder graduated, mixing, tall form 25 ml	NH3-N						
21194-49	nessler Reagent	NH3-N						
2125-99	phosver 3	PO4-P (asc.)						
21667-06	cap, bottle	SiO2 HR						
21856-96	pipet tips	Misc.						
2211-20	bromine water	NO3 (LR)						
22538-69	amino acid F reagent	Sio2 LR						
22675-01	sodium thiosulfate titration cartridge	D.O.						
23432-67	holmium trichloride powder pillow	SiO2 HR						
23765-26	polyvinil Alcohol dispersing agent	NH3-N						
23766-26	mineral Stabilizer	NH3-N						
2449-37	sulfuric acid solution 5.25 N (2 ml)	Tot P						
2450-26	sodium hydroxyde standard sol 5.0 N	NO3 (LR)						
2450-37	sodium hydroxide	NH3-N /Tot P						
2451-66	potassium persulfate powder pillow	Tot P						
2540-11	concentrated nitric acid	Tot hardness						
2540-11	nitric acid	Ca++						
282-37	potassium hydroxyde standard sol 8.0 N	Ca++						
323-37	sodium thiosulfate	NH3-N						
424-37	buffer sol hardness 1	Tot hardness						
44895-00	adapter, 1 cm cuvette	chl a -DMF						
505-41	erlenmeyer 50 ml	Tot P						
505-43	erlenmeyer 125 ml	D.O.						
508-40	cylinder graduated 25 ml	PO4-P (molyb)						
508-42	cylinder 100 ml	Ca++						
851-99	man-ver 2 hardness indic.	Tot hardness						
852-99	calver 2 calcium indicator pillow	Ca++						
942-99	phenophtalein powder pillow	Alkalinity						
943-99	bromcresol green-methyl red powder pill.	Alkalinity						
979-49	sulfuric acid ACS-500 ml	NH3-N /NO3 (LR)						
981-99	dissolved O2 1 Reagent Powder Pillow	D.O.						
982-99	dissolved O2 2 Reagent Powder Pillow	D.O.						
987-68	dissolved O2 3 Reagent Powder Pillow	D.O.						
	Appendice 7 : Chemical stock list by reference number							

Product name	Method	N°			Stock			
			(Date)					
acid reagent powder pillow	SiO2 HR	1042-66						
adapter, 1 cm cuvette	chl a -DMF	44895-00						
amino acid F reagent	Sio2 LR	22538-69						
amonium hydroxide	Tot hardness/Ca++	14736-37						
bottle BOD 60 ml	D.O.	1909-2						
bottle square mixing 25 ml	SiO2 HR	17042-00						
bromcresol green-methyl red powder pill.	Alkalinity	943-99						
bromine water	NO3 (LR)	2211-20						
buffer sol hardness 1	Tot hardness	424-37						
calver 2 calcium indicator pillow	Ca++	852-99						
cap, bottle	SiO2 HR	21667-06						
chloride 2 indic powder pill.	Cl-	1057-66						
citric acid powder pill	Sio2 LR/SiO2 HR	14548-99						
concentrated nitric acid	Tot hardness	2540-11						
cylinder 100 ml	Ca++	508-42						
cylinder 50 ml	NO3 (LR)	1896-41						
cylinder graduated 25 ml	PO4-P (molyb)	508-40						
cylinder graduated, mixing, tall form 25 ml	NH3-N	21190-40						
delivery tube	Alkalinity	17205-00						
dissolved O2 1 Reagent Powder Pillow	D.O.	981-99						
dissolved O2 2 Reagent Powder Pillow	D.O.	982-99						
dissolved O2 3 Reagent Powder Pillow	D.O.	987-68						
DPD- total chlorine	Iodine	14064-99						
EDTA 0,08	Ca++	14364-01						
EDTA 0,08 M	Tot hardness	14364-01						
EDTA 0,8 M	Tot hardness	14399-01						
erlenmeyer 125 ml	D.O.	505-43						
erlenmeyer 50 ml	Tot P	505-41						
filter holder Delvin, diam 25 mm	chl a -DMF	3001109						
filtre super gelman 0,45 mm, diam 25 mm	chl a -DMF	3060172						
H2SO4 99-100%	Misc.	4111023						
HCL concentrated 37 %	Misc.	4140303						
holmium trichloride powder pillow	SiO2 HR	23432-67						
man-ver 2 hardness indic.	Tot hardness	851-99						
mercuric chloride solution	NO2 (LR)/PO4-P (molyb)	14994-14						
mineral Stabilizer	NH3-N	23766-26						
molybdate 3 reagent	Sio2 LR	1995-37						
molybdate reagent powder pillow	SiO2 HR	1041-66						
molybdovanate reagent (2 ml)	PO4-P (molyb)	20760-37						
NaOH pastillen	Misc.	4117373						
nessler Reagent	NH3-N	21194-49						
nitraver 6	NO3 (LR)	14119-66						
nitric acid	Ca++	2540-11						
nitriver 3	NO2 (LR)/NO3 (LR)	14065-66						
NN Dimethil formamide DMF extra pur	chl a -DMF	4161063						
phenol solution	NO3 (LR)	2112-20						
phenophtalein powder pillow	Alkalinity	942-99						
phosver 3	PO4-P (asc.)	2125-99						
pipet tensette 0,1 to 1 ml	Misc.	19700-01						
pipet tips	Misc.	21856-96						
polyvinil Alcohol dispersing agent	NH3-N	23765-26						
potassium hydroxyde standard sol 8.0 N	Ca++	282-37						
potassium persulfate powder pillow	Tot P	2451-66						
sample bottle	NO3 (LR)	20950-00						
sample cells (1 cm matched pair)	chl a -DMF	20951-00						
silver nitrate 0.2255 N	Cl-	14396-01						
silver nitrate 1.128	Cl-	14397-01						
sodium chloride ACS	PO4-P (molyb)	182-01						
sodium hydroxide	NH3-N /Tot P	2450-37						
sodium hydroxyde standard sol 5.0 N	NO3 (LR)	2450-26						
sodium thiosulfate	NH3-N	323-37						
sodium thiosulfate titration cartridge	D.O.	22675-01						
stopper	NO3 (LR)	14480-01						
stopper hollow polyethylene	NO2 (LR)	14480-01						
sulfaver 4 reagent powder pill.	SO4	12065-66						
sulfuric acid ACS-500 ml	NH3-N /NO3 (LR)	979-49						
sulfuric acid solution 5.25 N (2 ml)	Tot P	2449-37						
sulfuric acid titr. cartr. 0.16	Alkalinity	14388-01						
sulfuric acid titr. cartr. 1.6	Alkalinity	14389-01						
Appendice 8 : Chemical stock list by alphabetical order								

Lenght of rope to use for angle correction

Sampling	Angle with vertical																					
Depth (m)	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°
10	10,1	10,1	10,2	10,2	10,3	10,4	10,5	10,6	10,8	10,9	11,1	11,3	11,5	11,8	12,1	12,4	12,7	13,1	13,5	13,9	14,4	14,9	15,6
20	20,1	20,2	20,3	20,4	20,6	20,8	21,0	21,3	21,6	21,9	22,3	22,7	23,1	23,6	24,1	24,7	25,4	26,1	26,9	27,8	28,8	29,9	31,1
30	30,2	30,3	30,5	30,7	30,9	31,2	31,5	31,9	32,4	32,8	33,4	34,0	34,6	35,4	36,2	37,1	38,1	39,2	40,4	41,7	43,2	44,8	46,7
40	40,2	40,4	40,6	40,9	41,2	41,6	42,1	42,6	43,1	43,8	44,5	45,3	46,2	47,2	48,2	49,4	50,8	52,2	53,8	55,6	57,6	59,8	62,2
50	50,3	50,5	50,8	51,1	51,5	52,0	52,6	53,2	53,9	54,7	55,6	56,6	57,7	59,0	60,3	61,8	63,5	65,3	67,3	69,5	72,0	74,7	77,8
60	60,3	60,6	60,9	61,3	61,8	62,4	63,1	63,9	64,7	65,7	66,8	68,0	69,3	70,8	72,4	74,2	76,1	78,3	80,7	83,4	86,4	89,7	93,3
70	70,4	70,7	71,1	71,6	72,1	72,8	73,6	74,5	75,5	76,6	77,9	79,3	80,8	82,5	84,4	86,5	88,8	91,4	94,2	97,3	100,8	104,6	108,9
80	80,4	80,8	81,2	81,8	82,4	83,2	84,1	85,1	86,3	87,6	89,0	90,6	92,4	94,3	96,5	98,9	101,5	104,4	107,7	111,2	115,2	119,6	124,5
90	90,5	90,9	91,4	92,0	92,8	93,6	94,6	95,8	97,1	98,5	100,1	101,9	103,9	106,1	108,6	111,2	114,2	117,5	121,1	125,1	129,6	134,5	140,0
100	100,6	101,0	101,5	102,2	103,1	104,0	105,1	106,4	107,9	109,5	111,3	113,3	115,5	117,9	120,6	123,6	126,9	130,5	134,6	139,0	144,0	149,4	155,6
110	110,6	111,1	111,7	112,5	113,4	114,4	115,7	117,1	118,6	120,4	122,4	124,6	127,0	129,7	132,7	136,0	139,6	143,6	148,0	152,9	158,4	164,4	171,1
120	120,7	121,2	121,9	122,7	123,7	124,8	126,2	127,7	129,4	131,4	133,5	135,9	138,6	141,5	144,7	148,3	152,3	156,6	161,5	166,8	172,7	179,3	186,7
130	130,7	131,3	132,0	132,9	134,0	135,2	136,7	138,3	140,2	142,3	144,6	147,2	150,1	153,3	156,8	160,7	165,0	169,7	174,9	180,7	187,1	194,3	202,2
140	140,8	141,4	142,2	143,1	144,3	145,6	147,2	149,0	151,0	153,2	155,8	158,6	161,7	165,1	168,9	173,0	177,7	182,8	188,4	194,6	201,5	209,2	217,8
150	150,8	151,5	152,3	153,4	154,6	156,0	157,7	159,6	161,8	164,2	166,9	169,9	173,2	176,9	180,9	185,4	190,4	195,8	201,8	208,5	215,9	224,2	233,4
160	160,9	161,6	162,5	163,6	164,9	166,4	168,2	170,3	172,6	175,1	178,0	181,2	184,8	188,7	193,0	197,8	203,0	208,9	215,3	222,4	230,3	239,1	248,9
170	170,9	171,7	172,6	173,8	175,2	176,9	178,7	180,9	183,4	186,1	189,1	192,5	196,3	200,5	205,1	210,1	215,7	221,9	228,8	236,3	244,7	254,1	264,5
180	181,0	181,8	182,8	184,0	185,5	187,3	189,3	191,6	194,1	197,0	200,3	203,9	207,8	212,3	217,1	222,5	228,4	235,0	242,2	250,2	259,1	269,0	280,0
190	191,0	191,9	192,9	194,2	195,8	197,7	199,8	202,2	204,9	208,0	211,4	215,2	219,4	224,0	229,2	234,9	241,1	248,0	255,7	264,1	273,5	284,0	295,6
200	201,1	202,0	203,1	204,5	206,1	208,1	210,3	212,8	215,7	218,9	222,5	226,5	230,9	235,8	241,2	247,2	253,8	261,1	269,1	278,0	287,9	298,9	311,1
210	211,2	212,1	213,2	214,7	216,4	218,5	220,8	223,5	226,5	229,9	233,6	237,8	242,5	247,6	253,3	259,6	266,5	274,1	282,6	291,9	302,3	313,8	326,7
220	221,2	222,2	223,4	224,9	226,7	228,9	231,3	234,1	237,3	240,8	244,8	249,2	254,0	259,4	265,4	271,9	279,2	287,2	296,0	305,8	316,7	328,8	342,3
230	231,3	232,3	233,5	235,1	237,0	239,3	241,8	244,8	248,1	251,8	255,9	260,5	265,6	271,2	277,4	284,3	291,9	300,2	309,5	319,7	331,1	343,7	357,8
240	241,3	242,4	243,7	245,4	247,3	249,7	252,4	255,4	258,8	262,7	267,0	271,8	277,1	283,0	289,5	296,7	304,6	313,3	323,0	333,6	345,5	358,7	373,4
250	251,4	252,5	253,9	255,6	257,7	260,1	262,9	266,0	269,6	273,7	278,2	283,1	288,7	294,8	301,6	309,0	317,3	326,4	336,4	347,5	359,9	373,6	388,9
260	261,4	262,6	264,0	265,8	268,0	270,5	273,4	276,7	280,4	284,6	289,3	294,5	300,2	306,6	313,6	321,4	329,9	339,4	349,9	361,4	374,3	388,6	404,5
270	271,5	272,7	274,2	276,0	278,3	280,9	283,9	287,3	291,2	295,6	300,4	305,8	311,8	318,4	325,7	333,7	342,6	352,5	363,3	375,3	388,7	403,5	420,0
280	281,5	282,8	284,3	286,3	288,6	291,3	294,4	298,0	302,0	306,5	311,5	317,1	323,3	330,2	337,7	346,1	355,3	365,5	376,8	389,2	403,1	418,5	435,6
290	291,6	292,8	294,5	296,5	298,9	301,7	304,9	308,6	312,8	317,4	322,7	328,4	334,9	342,0	349,8	358,5	368,0	378,6	390,2	403,1	417,5	433,4	451,2
300	301,7	302,9	304,6	306,7	309,2	312,1	315,4	319,3	323,6	328,4	333,8	339,8	346,4	353,8	361,9	370,8	380,7	391,6	403,7	417,0	431,9	448,3	466,7

Appendice 9 : Lenght of rope (m) to use in fonction of angle (between vertical and actual rope) to reach a particular depth when vertical hauling is not possible