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MULPOC - GISENYI

STUDY ON DREDGING REQUIREMENTS OF PORTS ON LAKE KIVU

ECA/GSY/MUL/CIE/III/12

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A. INTRODUCTION

1. The ad hoc working group of the "Comité permanent des responsables nationaux des transport sur le lac Kivu et Tanganyika" (COPTRALAC) which is also in charge of matters pertaining to dredging met in March 1992 to consider the report on the conduct of pre-dredging hydrographic surveys of CEPGL ports of lake Tanganyika.

2. One of the recommendations made by the ad hoc working group was to request ECA/MULPOC to undertake in respect of lake Kivu a study on dredging requirements similar to the one conducted on lake Tanganyika.

3. COPTRALAC endorsed the above recommendation which it submitted to the meeting of the Gisenyi MULPOC Follow-up Committee for consideration and adoption. The Committee requested MULPOC to include the study in its work programme and order of priorities for the 1994 - 1995 biennium and proposed that it be conducted in 1994.

4. The conduct in 1994 of a study on dredging requirements of the ports of lake Kivu was thus included in the 1994 - 1995 Gisenyi MULPOC work programme adopted by the second meeting of the inter-governmental experts held in Bujumbura in March 1993.

5. Following the socio-political troubles that rocked Rwanda at the beginning of 1994, the field mission connected with the conduct of the study could only take place in the first quarter of 1995 (24 January to 11 February 1995).

6. Since the study could not begin as originally planned, only part of the Rwandan zone of lake Kivu was covered: some berthing zones situated in localities with no easy access and where the security situation was very precarious could not be reached by the mission. Among these, mention will be made more particularly of the BRALIRWA, Kibuye and Kirambo port roadsteads.

7. As far as Rwanda is concerned, there are short comings in the study which need to be pointed out especially as the lake infrastructures, more particularly that of BRALIRWA on the Rwanda side of the lake, feature among the port infrastructures through which the largest percentage of Rwanda's lake traffic transits.

8. Furthermore, as mentioned earlier, a study on dredging requirements of CEPGL ports of lake Tanganyika was conducted by ECA/MULPOC. The document of that study (TRANSCOM/169) comprises chapters which will make it possible to have a better grasp of the fundamental notions relating among other things to:

- regulations on sedimentation of the coastal and port zones caused by waves and currents: littoral transit fed by coastal zones prone to erosion;

- regulations on the spread in the lake of sediments carried by rivers which empty themselves in the lake: solid flows of rivers under the combined effects of waves and currents.

9. Reference will be made, if necessary, to this document for possible additional information on these different factors.

10. Deterioration of depths of inland navigable waterways and port roadsteads which is corrected by conventional dredging operations is mainly caused by:

- Persistent fall in the water level over a relatively long period;

- Sedimentation sustained by permanent sources and hydrodynamic factors (waves, currents).

11. Any dredging programming requires a prior knowledge of these causes which constitute the first chapter of this document.

12. The second chapter deals with modalities for the execution of dredging operations.

13. Specific measures may be taken, especially after dredging, in order to prevent and avoid as much as possible, or at least to reduce, the deterioration of depths caused particularly by sediments. These measures will be examined in the third chapter.

14. The document therefore comprises three chapters, aside from the introductory part (A) and the part dealing with conclusions and recommendations (B).

CHAPTER ONE

1. DETERIORATION OF DEPTHS OF PORT ROADSTEADS OF LAKE KIVU

1.1. Lake Kivu and its economic role as a linkage among CEPGL countries

15. The filling basin of a volcanic pit of the Rift Valley with an area estimated at 2700 km^2 has given birth to lake Kivu which is the border between Rwanda in the East and Zaire in the West, the two countries that share one third and two thirds respectively of the waters of the lake.

16. Lake Kivu is situated in the southern hemisphere, not far from the Equator, between latitudes 1°35' and 2°30' south and longitudes 28°30' and 29°23' East. Its longitudinal axis is inclined North - North - East.

17. It is about 120km long and 40km wide. The average depth of lake Kivu is 240m as against a maximum depth of 480m. Its average water level is at an altitude of 1462m.

18. The edges of the lake are marked by volcanic rocks with very sharp slopes (almost vertical), except in few places suitable for the installation of berthing facilities.

19. The coastal gradients of the lake are generally steep.

20. The coastal features are very irregular with numerous small bays sheltered more or less from winds and waves coming from the lake.

21. Despite its profound depth, the lake is punctuated with many islands and islets, the biggest being the Ljwi island which rises in the middle of the lake and stretches southward, following the mean direction of the longitudinal axis of the lake.

22. The Ljwi island is situated in Zairean territorial waters.

23. Lake Kivu has only one outlet at its southern end. This outlet rises in the Ruzizi river which links it to lake Tanganyika whose northern end is about 100km south of the outlet.

24. The first thirty kilometers of the main waterway of Ruzizi are punctuated by a number of rapids which make it unnavigable.

25. Despite its relative remoteness, the lake constitutes an important inland waterway in that it opens up a large portion of the territory of the Economic Community of the Great Lakes States (CEPGL) composed of Burundi, Rwanda and Zaire. Indeed, it constitutes a vital link of:

- the north - south multimodal route serving the eastern region of Zaire and comprising: the road network of Northern Kivu, one of the main agricultural regions of Zaire; the Goma - Bukavu inland waterway on lake Kivu; the Bukavu - Kalundu link road between lake Kivu and lake Tanganyika; the Tanganyika inland waterway going in

the direction of Kalemie to rejoin the Zairean rail network in the South, linking this lake to the Shaba mining zone on the one hand and, on the other, in the direction of Kigoma (Tanzania) as a segment of the Central Corridor and towards Mpulungu (Zambia) as part of the southern route that opens up the CEPGL countries to the outside world;

- the bimodal route/lake/road including the Northern Kivu road network in the direction of Gisenyi using the lake Kivu waterway, and continuing by road towards Gisenyi and Bujumbura;

- the East - West transport system and vice versa, between Rwanda and Zaire.

26. This economic role of lake Kivu as a transport infrastructure which opens up the CEPGL has been discussed in detail in the study conducted by ECA/MULPOC and contained in a document entitled: Transport Development on lake Kivu. (Document ECA/MULPOC/Gisenyi/IX/27).

27. The same study also emphasizes that due to their bad condition as a result of the unfavorable relief, climate and ground which make their construction and maintenance very costly, the earth roads along the Eastern (Rwanda) and Western (Zaire) coasts of lake Kivu compete only poorly with the inland waterways which will continue to play the essential economic role referred to earlier.

28. This importance of transport on lake Kivu is also perceived through the efforts deployed by the two coastal states to improve safety. Indeed, under the impetus of the ECA/MULPOC, the buoyage operations and restoration of the minimum water level of the navigable waterways and landfalls of lake Kivu were fully financed by the two states to the tune of 90,000 units of account (90,000 u.a), of which 30,000 u.a was paid by Rwanda and 60,000 by Zaire. That relatively modest amount for operations of such a magnitude is attributable to the fact that the operations were carried out by the national services responsible for the maintenance of inland navigable waterways viz the "Régie des Voies Fluviales" (RVF) in Zaire and the "Direction des Transports Terrestres du Rwanda" in co-operation with and under the co-ordination of COPTRALAC ad hoc working group, and the supervision of CEPGL secretariat and MULPOC.

29. Cleaning of port roadsteads by dredging, which is the subject of this study, constitutes the second priority action of the programme for the improvement of the navigable infrastructures of lake Kivu adopted by COPTRALAC and as defined in its report on the execution and technical acceptance of buoyage operations and restoration of the minimum water level.

30. Thus, the present study satisfies the COPTRALAC second concern relating to navigation infrastructures. This concern was mainly motivated by the significant role that these infrastructures play as a linkage of a one of the economically important regions of the CEPGL territory composed of Burundi, Rwanda and Eastern Zaire.

1.2. Deterioration of depths of port roadsteads of lake Kivu

31. The two main factors responsible for the degradation of depths of port roadsteads are:

- persistent downward trend of the water level;
- sediments that develop in the vicinity of the port roadsteads.

1.2.1. Deterioration of depths of port roadsteads of lake Kivu due to variations of the water level

32. The water level of lake Kivu experiences different variations such as:

- short period diurnal variations with no impact on the depths;
- seasonal variations whose periods are modulated according to the seasons. In this category, definition is made of low water level (dry season) and high water level (rainy season). They only affect temporarily (low water level duration) the depths of the port roadsteads;
- long period variations (over five years) which are detected by analyzing the curves of the high and low water levels over man years. The downward trends observed on these curves correspond to the lapse of time during which the depths of port roadsteads have deteriorated.

33. Where the curve of the low water level reaches and continues to fall below a given threshold for each port, and is equal to the minimum draught required for its effective use, then action, especially dredging operation is necessary.

34. Floodmeters make it possible, among other things, to note down the different variations of the water level of the lake referred to earlier and plot the graphs accordingly, on the basis of which a decision is taken whether or not dredging operations should be carried out and how they should be scheduled.

35. The collection, analysis and processing of such data used in programming dredging operations form part of the activities aimed at restoring the floodmeters on lake Kivu, financed by the two coastal states and carried out by their national services in co-operation with and under the eagis of the CEPGL Permanent Executive Secretariat and of MULPOC.

36. However, readings of the floodmeters which were put in place, some of which disappeared for want of monitoring and maintenance, were not done in Rwanda and were done only partially in Zaire, for various reasons including the socio-political troubles that had rocked these two countries. During the mission, the floodmeter installed at the Gisenyi fishing harbour quay in Rwanda was read. The water level was then at about 5cm below the zero mark on the floodmeter, which is the minimum gradient that can be reached by the water level of the lake. The normal water level estimated on the basis of marks left on the floodmeter support, varied between +60 and 80cm gradients, meaning that at that particular moment, the water level of lake Kivu had reached an exceptionally low level, i.e. 65cm

below the normal water level.

37. It is difficult to know whether this situation will persist, especially as there is no plotting of the graph of the water level for want of data, even right from the time the floodmeters were installed.

38. It should be pointed out that the situation persist, dredging operations connected with the variations of the water level would be necessary at the fishing harbour and probably at other port infrastructures of lake Kivu in order to avoid prolonged inaccessibility to its quay.

39. Berthing at the fishing harbour quay by Isambaza under the conditions described above is completely out of the question.

40. Owing to non-availability of hydrological data (readings of the floodmeters), it is not possible at the moment to take a decision as to whether it is necessary to dredge the port roadsteads of the lake as a result of the variations of the water level.

1.2.2. Deterioration of depths of port roadsteads of lake Kivu due to sediments

41. By their action on sediments, hydrodynamic factors (waves and currents) permanently shape the configurations of the beds of the lake and consequently modify the depths of roadsteads.

42. Investigation of the causes of the degradation of depths of port roadsteads due to sediments include:

- analyses of the hydrodynamic conditions in the immediate surroundings of these infrastructures;

- identification of the sources of the sediments including the definition of the nature and characteristics of these sediments;

- determination of the volume of water involved in the sedimentation process.

1.2.2.1. Hydrodynamic conditions

43. Waves and currents are the two main hydrodynamic factors which come into play in the sedimentation process that modifies the depths of roadsteads.

a) Waves

a-1 Generalities on lake waves

44. Waves are generated by winds. From the hydrodynamic viewpoint, they are characterized by:

- their 2H amplitude defined as the height between a crest (peak of the wave) and two

successive hollows;

- their 2T period which measures the time between two crests or two successive hollows (temporal representation of a wave train);
- their 2L wavelength which represents the distance between two crests or two successive hollows (spatial representation of a wave train);
- their propagation a direction in relation to the geographic north direction.

45. These sizes refer to random variables in respect of which representative values are determined. they are usually:

- average values relating to a stipulated period (daily, monthly, annual, decennial): 2HM, 2TM, 2LM, AM or dominant direction;
- significant values which represent the averages of one third higher than these variables in relation to a given period (daily, monthly, annual, decennial) 2H1/3, 2T1/3, 2L1/3, A1/3;
- maximum values recorded or expected for a given period (decennial, fiftieth, centenary waves) 2H10, 2H50, 2H100; 2L10, 2T50, 2L100.

46. With regard to the study on sedimentation generated by waves, littoral transit in particular, it is normal to refer to the significant values of these variables. The elements that come into play are, among others, amplitudes, wavelengths and propagation directions.

a-2 <u>Determination of the characteristics of waves of lake Kivu</u>

47. The determining sizes of 2H, 2T and 2L waves are calculated on the basis of observation data <u>in situ</u> when they are available: visual observation of amplitudes (on swell masts), periods, wavelengths and propagation directions and/or recording of these data by automatic stations.

48. When these observation data and/or <u>in situ</u> recording are lacking, as is the case of lake Kivu, use is made of empirical formula to predict waves on the basis of the characteristics of the winds that generate them.

49. In this connection, there are various formulae designed which take into account the factors that come into play in the generation of waves including in particular the characteristics of generating winds and the geographical configurations of the coasts.

<u>Characteristics of generating winds</u>

50. The wind elements which come into play in the formation of waves are: the direction of action, speed, T action time and D action distance or fetch.

51. Winds acting on lake Kivu come from three average directions namely the southern sector (140° - 200°), the western sector (220° - 280°) and the north eastern sector (0° - 40°).

Winds coming from the Souther sector

52. These are the dominant winds of lake Kivu. They blow on a permanent basis, sometimes with gales at a speed of 8m/s.

53. Recordings made at the Kamembe (Cyangugu) airport give the following indications:

* directions of origin: they vary between 140° and 200° with an average direction of 170° and a dominant direction of 160°;

* speed: the average speed is 3m/s, the significant speed being 4m/s and the maximum speed 8m/s;

* action time: these winds normally begin to blow from 8H and settle at around 15 or 16H. Sustained actions during 24H are possible but they are rare. The following can be retained as action time: average action time 6H, significant action time 12H and exceptional action time 24H;

* distance of action: it is counted form the southern end of the Ijwi island up to the surroundings of Gisenyi/Goma, corresponding to the lake distance without any obstacle. This D action distance is estimated at 100km.

Winds from the western sector

54. These are usually afternoon winds which rise from 14H. Surveys conducted at the Goma airport provide the following results:

* directions of origin: Western sector limited between 200° and 280°; average direction 250° and dominant direction 275°;

* speed: average speed 2m/s, significant speed 2.5m/s and maximum speed 5m/s;

* action time: winds from the western sector are less sustained and diminish before sunset. Their average action time is estimated at 3H and the significant action time at 4H. They can blow uninterruptedly for 6H in exceptional cases;

* action distance: the maximum action distance of these winds corresponds to the distance of the part of the lake situated North of the Ijwi island, which is about 40km. Regarding the area covered by the Ijwi island, the fetch is low; it is at less than 10km between the Zairean coasts and the Ijwi island and at 15km between the Ijwi island and the Rwandan coasts.

Winds from the North - Eastern sector

55. These are low intensity off-share breezes recorded from time to time in late afternoons. The observations made at the Goma airport provide the following elements:

* directions of origin: 0° to 40°, average direction 20°, dominant direction 30°;

* speed: the average speed is about 1m/s, the significant speed 1.7m/s and the maximum speed 4m/s;

* action time: the average action time is estimated at 2H, the significant action time at 3H and the maximum action time at 5H;

* action distance: the distance of action, counted form Goma right down to the Zairean coasts situated opposite the Northern end of the Ijwi island, is estimated at 50km.

ii) Geographical configurations of the coasts

56. In the southern part of the lake, the configurations of the Zairean coasts (very jagged) and the Rwandan coasts (moving eastward) are such that the existing port infrastructures of lake Kivu up to the Northern tip of the Ijwi island are sheltered from the effects of winds from the southern sector. The waves generated by these winds don not affect the depths of the port roadsteads of Cyangugu, Kirambo and Kibuye in Rwanda, and of Bukavu, Kaleche and Mukalele in Zaire. Similarly, the Gisenyi port of Kitraco (Rwanda and the port of Goma (Zaire) protected respectively by the advances of the Rubona cape and the projection of Mount Goma towards the lake, do not practically feel the effects of these winds. On the other hand, the Gisenyi passenger port and, to a lesser extent, the Gisenyi fishing harbour, are more directly exposed to these winds and, therefore, to the waves that they generate.

57. Concerning winds coming from the western sector, the effects on the port infrastructures of the Rwandan coasts situated in the North of Kibuye are mitigated by the presence of the Ijwi island and islets opposite Kibuye. On the other hand, the Gisenyi passenger port, the fishing harbour and the port of Goma are under the influence of these winds, but with a reduced action distance (15km at most), to the extent that the water level variations they cause around the port infrastructures are low and quickly absorbed.

58. Off shore breezes blowing from the North-Eastern sector and restrained by the presence of the Ijwi island are neither sufficiently intense nor sustained (2 to 3H action time only) to create serious disturbances on the western coasts of lake Kivu (Zairean coasts). Waves generated during the day by winds from the southern sector are quickly subdued by these breezes.

59. It can be inferred from the above that it is mostly the two port infrastructures of Gisenyi (passenger port and fishing harbour) which are exposed to the effects of the winds and that winds from the southern sector can generate around these sites, actions capable of giving rise to sedimentation.

a) Characteristics of winds generated at the right side of Gisenyi by winds from the Southern sector

60. Owing to lack of observation data, the 2H amplitudes and 2L wavelengths of waves reaching the outskirts of Gisenyi were calculated on the basis of projection formulae. Formulae with three variables, namely W (speed of the wind in metres per second), D(action distance of the wind or fetch in Km) and T (action time of the wind in hours) established for short distances (D less than 300km) and calculations from the coasts, seem to be most suited for lake Kivu. The following formulae satisfy these conditions:

2H amplitude:

$$2H = \frac{0.33W}{\left(1+\frac{0.7W}{D}\right)\left(1+\frac{1.86}{T}\right)}$$

2L wavelength

$$2L = \frac{12.34W}{\left(1+\frac{47.9W}{D}\right)\left(1+\frac{13.3}{T}\right)}$$

61. The presence of many islands and islets, reinforced by refraction, greatly diminishes the amplitudes of waves around the coasts. With a 0.0 absorption coefficient of wave amplitudes near the coasts, the calculation gives the following results:

	2H amplitudes (m)	2L Wavelength (m)
Average waves	0.70m	8m
Significant waves	0.90m	8m
Exceptional waves	1.80m	13m

b) Currents

62. The relatively small size of lake Kivu, the vast irregularity of its coasts and the existence of many impediments (islands and islets) neither allow for the formation of general currents of oceanic type nor currents generated by winds (Eckaman current).

63. Very localized currents may however exist. They are:

- residual currents of rivers emptying themselves in the lake. Depending on the size of these rivers and the initial speed of the currents they generate around their months, such currents are felt at variable distances of the coasts and are responsible for the sedimentation of the zones situated opposite the mouth of the river (sublacustrine bars) or on either side of the mouth (sediment zone).

- suction current around the outlets. They are often responsible for the erosion of the surrounding coasts.

64. No study on these currents was conducted in the case of lake Kivu, especially in regard to residual currents which cause sedimentation of the mouth zones, and consequently the port road steads in these zones.

65. Thus, when there are sources of sediments in the vicinity of the port infrastructures, the hydrodynamic conditions (waves, currents) which prevail there act on these sediments and permanently shape the depths of the port roadsteads. Port sedimentation is caused by the combined action of hydrodynamic factors of waves and currents on sediments. Lack of knowledge about hydrodynamic factors around these infrastructures on account of inaccurate measurements and careless observation (measurement of currents, observation of waves) does not make sediment movement forecasts (calculation of cubatures involved) any easier. It however emerged from previous considerations regarding hydrodynamic factors acting on lake Kivu that:

- only the zone around Gisenyi is exposed to the serious effects of waves;

- the months of rivers are affected by residual currents sustained by these rivers;

- the port infrastructures in these two categories of places are exposed to modifications in the depths of their roadsteads only if there are sedimentation sources likely to be activated by the hydrodynamic factors referred to above.

1.2.2.2. <u>Identification of sedimentary sources in the vicinity of port infrastructures of lake Kivu</u>

66. Lake Kivu is of volcanic origin. Its coasts cannot constitute sources of sediments because they are rocky and steep. Because of its profound depth, sediments deposited in the bed of the lake cannot move towards the coasts.

67. Sediments that are responsible for the deterioration of depths in some coastal zones of the lake come from sources external to the lake. These are especially solid flows from rivers emptying themselves in the lake and which constitute the main sources of sediments that settle there. The port infrastructures located around these months especially roadsteads, can face problems of sedimentation.

a) <u>Case of port infrastructures on the Rwanda side of lake Kivu</u>

i) <u>The port of Cyangugu</u>

68. The port of Cyangugu is situated at the southern end of the eastern coast of lake Kivu, in a protected bay where no river empties itself. The deterioration of depths at the port of Cyangugu is not caused by sediments. The dumping of wastes from the quays, compiled with the exceptional of wastes fall in the water level, is the only factor that may explain the need for dredging operations in the port.

ii) **The ports of Kirambó, Kibuye and Bralirwà**

69. The mission was not able to visit these ports for reasons mentioned earlier. Consequently, it has not been possible to establish the existence of sedimentary source likely to modify the depths of the roadsteads of these infrastructures.

iii) **The Kitraco port of Gisenyi**

70. This port is located at the end of the bay where a stream, the Kilimby, empties itself, flowing down from the neighbouring mountains and carrying alluvium (mud, silt), sand and gravel. The relatively strong residual currents of this stream, especially during the rainy season, are capable of propelling sediments, not only along the quays (which are very rudimentary), but also within the bay which gets silted up gradually. At the time of the mission, the average depth of the port of kitraco was 0.20m, corresponding when the water is at its lowest level, to a draught of 0.20 + 0.50 = 0.70m. Owing to the exceptionally low water level, no boat could berth at the port of Kitraco without going aground.

71. The restoration of the normal water level does not however seem to resolve the problem. The 0.70m depth when the water level is normal doest not allow for the berthing of units draught ranges between 0.50 and 0.55m with a safety margin of 0.20 to 0.15m.

72. Due to the persistent sediment problem posed by the Kitsimby stream, the guaranteed draught at the port of Kitraco with a safety margin of 0.15m is currently 0.55m when the water level is normal and 0.05 when it is exceptionally low.

iv) **The Gisenyi fishing harbour**

73. Situated at about 1km north of the port of Kitraco, the fishing harbour is outside the operational zone of the Kitsimby stream. It is however located between the drainage zone of the Gisenyi power station (200m south) and the month of Sebega river.

74. Depending on nautical conditions, the roadstead of this port is fed alternately by weak solid flows drained by the pipes of the power station (waves from the south/south/eastern sector refracted in the vicinity of the port) and by large sediments carried by the Sebeya river (waves from the south/west/western sector refracted as they approach the coasts).

75. Under the effects of this double littoral transit, the roadstead of the port undergoes a more or less rapid sedimentation. At the time of the mission the quay had a 0.05m vertical sand bank, offering under normal circumstances a depth of about 0.55m and a guaranteed draught of 0.35m (a minimum safety margin of 0.20m is required as the roadstead is not sheltered). This draught no longer makes it possible for the Isambaza with a 0.90m draught to berth. For some time now, the quays of this port have become unoperational.

v) **The Gisenyi passenger port**

76. This port was constructed at about 200m north of the mouth of the Sebeya river. It comprises a two compartment anchorage basin parallel to the bank line: 40 X 20m

compartment and another of 60 X 35m which is bordered in the North by a quay on piers used as landing stage by the units.

77. A masonry protection grain parallel to the bank with its end slightly bent towards the lake (pierhead) serves at the same time as the lake side wall of this double basin. The 30 or 50 metre aperture between the end of this groin and the landing stage constitutes the fairway (vide annex 1).

78. The waves from the southern sector reach almost consistently the groin without any hindrance, a littoral transit sustained by solid flows from the Sebeya river. Through refraction around the pierhead of the protection grain, the moving sediments penetrate the basin and settle there. The small basin and two thirds of the big basin are at the moment silted. Only the end of the landing stage 20m long (instead of 35m) provides an adequate depth to accommodate boats of the Office National des Transports en Commun (ONATRACOM) of Rwanda which uses this infrastructure. Since the basins have become completely unusable, the two units belonging to ONATRACOM no longer have a protected anchorage basin at the Gisenyi passenger port. This explains the premature decrepitude of their hulls.

79. The draught of these units is around 1.00m which means that the draught within the basin was less than 1.20m.

80. A project for the renewal of these passenger vessels was envisaged by ONATRACOM. The dredging of the two basins to guarantee safe anchorage constitutes one of the prerequisites for this renewal.

b) <u>Case of port infrastructures on the Zairean side of lake Kivu</u>

81. The two main Zairean port installations on lake Kivu are located at Bukavu at the Southern end of the lake (opposite Cyangugu) and at Goma on the Northern coasts, slightly north of the Gisenyi installations.

i) The Port of Bukavu

82. The port of Bukavu managed by the "Société des Chemins de Fer de l'Est" (SFE) is established in a bay protected from the waves. It does not experience the problems posed by littoral transit.

83. The Kawa river flows into this bay, running directly along the souther edges of the port. The solid flows of this river constitute a permanent source of sediments whose spread around the port roadstead, activated by residual currents, affects the depths of the roadsteads.

84. The port of Bukavu has three quays almost inclined south-north.

85. Quay no. 3 which is further south is contiguous to the mouth of the Kawa river. The access roadstead to this quay is under the direct influence of sedimentation sustained by solid flows from the river. The guaranteed draught along this quay varies, according to a pre-

dredging hydrodynamic survey conducted in May 1994 by the "Régie des Voies Fluviales" (RVF), between 0.20m and 0.30m. The quay is unoperational at the moment.

86. Quay no. 2 of the port of Bukavu is slightly projected towards the lake, compared to quays no. 3 and no. 1. This gives it a more comfortable depth despite the onslaught of materials carried by the Kawa river. The draught varies between 1.20m and 2.00m from the southern end to the northern end of the quay, which precludes, when the water level is normal, berthing of SFE units with a minimum draught of 1.28m.

87. Quay no. 1, further north, was constructed on the same line as quay no. 3 and, as such, does not have the same depth as quay no. 2. However, by virtue of its position, its basin is less exposed to sedimentation than the basins of the two other quays. The guaranteed draught is inadequate but better than that of quay no. 3 and varies between 1.00m in the part sheltered by the projection of quay no. 2 and 0.50m going northward.

88. Sedimentation of the roadstead of the port of Bukavu sustained by particles carried by the Kawa river is such that two of the three quays of the port don not provide permanent easy access. Besides, berthing at quay no. 2 becomes dangerous when the water level is low.

89. This critical situation implies that dredging is urgently needed in this port, the biggest of the lake Kivu, as evidenced by the traffic it handles annually (60,000 to 70,000 tons.

ii) <u>Port of Goma</u>

90. The port of Goma is the second Zairean port of lake Kivu by virtue of its importance. It was built at about 5km north of the Gisenyi passenger port, in a bay formed by the extension of Mount Goma towards the lake.

91. No affluent of lake Kivu flows into the surroundings of the port of Goma. This port therefore has no problem of sedimentation caused by rivers.

92. The bay has four berthing zones:

- Two private ways belonging o "Société Bisengimana" and " Société B. Israel" respectively;

- Two quays managed by SFE: the Bralima quay 13.50m long, which is no longer operational; the main quay of the port of Goma, 80m long, which handles 80% of the annual traffic of the entire port, estimated at about 50,000 tons.

93. The main quay has three berths. The exceptionally low water level observed during the mission, about 60cm below the average water level, has made it impossible for units to have access to the two extreme berths of the quay.

94. The possible depths are as follows:

- Western berth: 1.75m to 2.10m. Some loaded units could berth but with great risk;
- Eastern berth: 2.00m to 0.50m. Off loaded barges were berthing there with the front of the barges running aground.
- "General MULUMBA" owned by the Bisengimana company could not berth at the Bisengimana quay.

95. Thus, due to the exceptionally low water level, about 75% of the berthing facilities at the port of Kigoma (private quays and SFE) have become useless. The two newly restored floodmeters in the roadsteads were destroyed for want of monitoring and maintenance. As a result, it is not possible to monitor the variations of the water level and make a well grounded opinion as to the persistence or otherwise of the minimum water level situation. However, should the situation persist, it will be necessary to programme dredging operations at the port of Goma to avoid the repeated and prolonged idleness of the berthing infrastructures.

96. Two main causes are responsible for the degradation of the depths which currently affects the roadsteads of the ports of lake Kivu, especially at the right side of the berthing facilities:

- The exceptionally low water level noticed during the mission: floodmeters were put back in place in all the ports in order to monitor the variations of the water level of lake Kivu. The data collected will make it possible to analyse the variations of the water level of the lake and establish a forecast of the coasts where the water level is likely to be low. A downward trend of the water level at such coasts compared to the water level situation observed during the mission implies urgent programming of dredging operations in all the ports of lake Kivu. If, on the other hand, there is an upward trend, it would not be necessary to carry out dredging operations at the ports of Cyangugu and Goma which are not exposed to sedimentation from sources fed by rivers emptying themselves in the lake;
- The silting of the port roadsteads installed in the influence zones of the sources of solid flows from the affluents of the lake which, either under the action of the residual currents of these affluents (case of the Kitraco port in Gisenyi and the port of Bukavu or the combined effects of these currents and waves (case of the passenger port and the fishing harbour of Gisenyi) come to settle in the roadsteads. The prevailing situation in these ports is such that access to and especially berthing at their quays is no longer possible, except at quay no. 2 at the port of Bukavu which is accessible only when the water level is not low. Urgent measures should be taken to clean up the depths of these infrastructures through dredging.

CHAPTER TWO

2. MODALITIES FOR THE DREDGING OF THE PORTS OF LAKE KIVU

2.1. Required draught

97. Draught Te is the minimum depth required for the safety of boats in navigation or manoeuvering in a port.

It has two components:

- Maximum draught E of a loaded and moving vessel: the technical specifications of the vessel, particularly the measurements as indicated on the hull in accordance with the regulations, provide the data related thereto;

- Safety margin that takes into account the forward suction effect and ramming caused by the waves. The M margin is estimated at 0.30m with respect to lake Kivu.

98. Annexes 2(a) and 2(b) provide the list of Rwandan and Zairean vessels currently operating on lake Kivu.

99. Data on draught E are not indicated in the list of Rwandan vessels. One should refer to the Zairean units with similar characteristics to estimate the maximum value E to be taken into account regarding the port infrastructures of Rwanda.

100. The Tambo barge with a capacity of 110 tons represents the biggest unit operating in the Rwandan waters.

101. It is to a very large extent equivalent to the Zairean barge of D1 type, with a total capacity of 105 tons. Draught E with a full load of this unit is estimated at 2.20m (Draught of D1 barge).

102. The maximum draught required in Rwandan port roadsteads is thus estimated at: Te=E+M=2.20+0.20=2.50m.

103. With regard to Zairean units, the maximum draught recorded corresponds to the draught of Potopato (currently General Mulamba) which, with a capacity of 218 tons, requires a draught of 2.70m.

104. The minimum draught to be guaranteed in the Zairean port roadsteads should therefore be: Te = 2.70+0.30 = 3.00m.

105. The draught required in the Zairean ports is 0.50m higher than that required for the Rwandan ports.

106. From the point of view of regionalization of the transport services of Lake Kivu within the framework of CEPGL, it would be advisable that efforts be initiated now to

standardize the various norms governing access to the berthing facilities of lake Kivu. In this connection, the adoption of 3.00m draught for all the port manoeuvering zones of lake Kivu should be envisaged and a decision taken accordingly. The opinion of COPTRALAC on this specific point is useful when formulating a proposal to be submitted to CEPGL Authorities for consideration.

2.2. Volume and nature of materials to be dredged

2.2.1. Volume of materials to be dredged

107. The precise dredging cubature is determined on the basis of the data deriving from a regular and recent survey conducted at an appropriate scale (1/500 to 1/2000 depending on the size of the lake).

108. Apart from the port of Bukavu which was the subject of a hydrographic survey conducted in May 1994 by RVF, no hydrographic document was available on the other ports. The calculation of the following dredging cubatures based on the estimation of the current average depth provide the order of importance of these cubatures.

a) Port of Cyangugu

109. Dredging would be necessary only if the low water level observed during the mission persisted.

110. The average depth was estimated at 1.10m up to about 30m below the quays. Beyond that the depth of 2.50m should be observed everywhere. The manoeuvering zone of the vessels covers a length of about 300m (quays included).

111. The average thickness of sediments to be dredged is therefore 2.50m (required draught) - 1.10m (current average depth) = 1.40m.

112. This corresponds to a dredging cubature estimated at: 300m X 1.40m = $420m^3$ rounded up to $500m^3$.

b) Kitraco port in Gisenyi

113. The roadstead is subjected to sedimentation sustained permanently by the Kitsimby river.

114. The current average depth is estimated at 0.50m up to 50m below the quays.

115. The swinging area of the units has a total territory of about 400m including the quays.

116. The volume of materials to be dredged thus represents: 400m X (2.50 - 0.50)m X 50m = $400m^3$.

c) **Fishing harbour**

117. Under the combined action of residual currents and waves, the fishing harbour is subjected to double sedimentation sustained by draining canals of the Gisenyi hydroelectric power station and, above all, by the Sebeya river.

118. The average depth up to 40m below the quay is estimated at 0.40m. The coastal territory of the installations of the fishing harbour is about 300m.

119. The approximate cubature of materials to be dredged would thus be:

300m X (2.50 - 0.40)m X 50m = 3150 m^3 rounded up to 3500 m^3.

d) **Gisenyi passenger port**

120. The sedimentation sustained by residual currents of the Sebeya river and by waves is fed by relatively solid flows from that river.

121. The entire small basin and about two thirds of the big anchorage basin are silted.

122. The thickness of materials to be dredged is 2.50m.

123. The volume to be dredged is estimated at:

- small basin: 40m X 20m X 2.50m = 2000m^3
- big basin: 2/3 X 60m X 35m X 2.50 = 1750m^3

Total	3750m^3
Rounded up to	4000m^3

e) **Port of Goma**

124. The deterioration of the depths is linked to an exceptionally low water level detected during the mission. Dredging would be necessary if the situation persisted.

125. The dredging zones are broken down as follows:

- Western berth: 20m long plus a manoeuvering coastal territory of 50m, with an average depth of 1.20m up to 10m below the quay. This would correspond to a dredging cubature of: 70m X 10m X (3.00 X 1.20m) = 1260m^3;

- Central berth: 40m long with an average depth of 2.00m up to 10m below the quay, i.e. a dredging cubature of:

  40m X 10m X (3.00 - 2.00)m = 400m^3

- Eastern beth: 20m long with a manoeuvering coastal territory of 50m and an average

depth of 0.80m up to 10m below the quay, i.e. a dredging cubature of:

$70m \times 10m \times (3.00 - 0,80)m = 1540m^3$

126. The total dredging volume to be envisaged at the port of Goma would thus be: $3200m^2$.

f) Port of Bukavu

127. At the request of SFE and given the critical situation it faces regarding the berthing of its units (two of the three quays are permanently inaccessible, the third quay is inaccessible when the water level is at its lowest), RVF conducted in May 1994 a hydrographic survey of the roadstead of the port of Bukavu.

128. The hydrographic plan resulting therefrom is attached hereto as annexes 3(a) and 3(b).

129. The survey was conducted at 1/1000 scale and the depths were expressed in decimeter (annex 3(a)), which means that one centimetre on the plan is equivalent to 10m in the field, and that the length of quay no. 2 should therefore be about 20m. This however does not seem to be the case. The error might be due to the scale used.

130. The data of this plan were nonetheless used to estimate the dredging cubature to be envisaged at the port of Bukavu. The total volume to be dredged is estimated at $2000m^3$ (see detailed calculation in annex 4a, b and c).

131. The total dredging requirements of the ports of lake Kivu are estimated at $15,500m^3$.

2.2.2. Nature of materials to be dredged

132. Regarding dredging operations, the nature of the materials is determined on the basis of gramulometric graphs. This implies the collection of samples of these materials followed by gramulometric analysis in the laboratory.

133. No such study was conducted on any of the port infrastructures of lake Kivu.

134. However, based on the identified sources of port sedimentation, it will be possible to make a qualitative description of the materials involved:

i) Kitraco port in Gisenyi: Before emptying itself in lake Kivu, the Kitsimby river runs through a steep volcanic soil and a small alluvial plane. The materials thus carried comprise a high percentage of volcanic sand and a little percentage of muddy/clayey sand;

ii) Gisenyi passenger and fishing ports: The Sebeya river receives the drained materials from the reservoir of the Gisenyi hydroelectric power station. These materials are mainly composed of average sand with a very low percentage of mud;

iii) Port of Bukavu: The Kawa river also serves as an outlet for the drainage of waste waters of a large part of the town of Bukavu. The river passes through a zone whose soil is essentially composed of muddy sand with a higher percentage of sand. Thus, particles settling in the port roadstead of Bukavu are composed of sand, mud and various organic materials.

135. The table below summarizes the dredging requirements

Table 1: Definition of dredging requirements of the ports of Lake Kivu

Port infrastructures	Sedimentation source	Hydrodynamic factors in Play	Nature of materials	Method of calculating the cubatures	Cubatures (m³)
Cyangungu	-	Extreme low water level	-	-	500
Kitrco Port	River Kitsimby	Residual currents	Mud/clay volcanic sand	estimation	4000
Port Project	Gisenyi power station outlet Sebeya river	Residual currents	Sank with little mud	estimation	3500
Gisenyi Passenger port	River Sebeya	Residual currents and waves	Sand with little mud	estimation	4000
Bukavu port	River Kawa	Residual currents	Sand with mud and organic materials	Pre-dredging hydrographic survey	2000
Goma port	-	Extreme low water level	-	estimation	3200

Source: ECA — Total 15,200m³
Rounded up to 15,500m³

2.3. Precise estimation of dredging cubatures

136. It emerges from the above table that subject to the observation made on the accuracy of the pre-dredging hydrographic plan prepared by RVF for the port of Bukavu, no definite estimation of cubatures to be dredged has been made due to lack of the relevant hydrographic data.

137. The conduct of pre-dredging hydrographic surveys is conditional upon the availability of accurate estimation of cubatures to be dredged in each port.

138. These plans constitute at the same time vital working tools for the drawing up of dredging programmes including particularly the demarcation of the operation zones.

139. As in the case of CEPGL ports of lake Tanganyika, consideration should be given to the joint conduct of these pre-dredging hydrographic surveys. This will involve RVF, the Rwanda Land Transport Division, the permanent CEPGL Executive Secretariat (SEP/CEPGL) and ECA. The modalities thereof will be defined within the framework of COPTRALAC which will set up an ad hoc working group on the dredging of lakes Kivu and Tanganyika, while strengthening the existing working group on lake Tanganyika. The recommendations of this working group will be submitted through COPTRALAC to the concerned CEPGL officials for consideration. COPTRALAC will have to be reactivated. The cost involved in the joint conduct of these hydrographic surveys is estimated at US$ 10,000.

2.4. Required dredging equipment

2.4.1. Mechanical shovel

140. No dredger is available at the moment as far as lake Kivu is concerned.

141. The only existing civil engineering equipment in the immediate vicinity of the lake and which can be used for dredging purposes are mechanical shovels used on rental basis. the Ministry of Public Works of Rwanda, the Zaire Road Authority and civil engineering enterprises operating in the region have this material.

142. To be able to sweep the entire zone to be dredged in each roadstead, the shovel should be carried on a pontoon.

143. SFE has a pontoon with the following characteristics:

- Floating material made up of two barges of B5 - B6 type, each with a capacity of 35T, i.e. a loading capacity of 70 tons;
- A platform 19.10m long and 3.65m wide;
- load draught of 1.28m.

144. This pontoon is in good condition and can lift any type of mechanical shovel.

145. The dredging depth is 3.00m from the lowest point of the water level (zero level); dredging activities are programmed when the water level is normal, i.e. about 0.50m above the zero level; the freeboard of the pontoon loaded with the shovel and its accessories is 0.50m; a 0.50m margin of the crane deflection is necessary to enable the crane to function properly. Under these circumstances the shovel should have a minimum deflection of:

3.00m + 0.50m + 0.50m + 0.50m = 4.50m.

146. The drawback of the mechanical shovel is its low output as far as under-water operations are concerned. It is not easy to make an accurate assessment of this output. An approximate value of $10m^3$ per hour may be retained based on the following work hypotheses: capacity of the scoop (0.50m); 50% filling and manoeuvering loss, i.e. $0.25m^3$ of materials dredged by scoop, at a rate of 1 scoop every 90 minutes (1 minute 30 seconds)

i.e. 40 scoops per hour.

147. This corresponds to a dredging volume of $100m^3$ at the rate of 10 hours of effective work daily, i.e. approximately 150 working days to carry out dredging operations at the ports of lake Kivu concerned by this study.

2.4.2. Use of dredger line (C45 Lima crane) of RVF

148. The RVF agency in Kalemie has a tracked Lima crane with accessories for dredge line operations with an output of 30 to 40 m^3 per hour. Its use on SFE pontoon does not pose any special problem. Its rental as proposed by RVF is currently US$ 90 per hour of operation. Dredging per m^3 will cost between US$3 and 2.25. The rate normally charged for small dredging operations like those concerning the ports of lake Kivu ranges between US$ 3 and 4 per m^3.

149. This equipment which is best suited for dredging operations will help carry out activities on lake Kivu for a little over three months (instead of nine months, i.e. a period of at least three years corresponding to three minimum water levels using mechanical shovels).

150. In so far as the Lima dredger can dredge a depth that exceeds by far 5m, the idea of operating only when the water level is low, as in the case of mechanical shovel, does not arise. This has a dual advantage:

- possibility to adopt a continuous operational programme, thereby avoiding additional costs involved in sending equipment to the site back and forth;

- possibility to decide when to carry out the operation, preferably during the calm season, especially in the unsheltered zones such as the roadsteads of the Gisenyi passenger and fishing ports. This reduces considerably the idle period and consequently, the operation time frame and cost.

2.4.3. Use of ONATOUR dredger

151. The joint utilization of this dredger for dredging operations concerning CEPGL ports of lake Tanganyika was agreed upon within the framework of COPTRALAC. In that connection, it was proposed that ONATOUR reassign the dredger to the Navigable Waterway Authority of Burundi. As a matter of fact, the dredger belongs to the "Office National Burundias des Tourbes" (ONATOUR). In view of the fact that it is not suitable for peat bog operations in Burundi, the dredger is not used by ONATOUR. Since its acquisition in 1987, the dredger has been lying idle at the container quay at the port of Bujumbura. It is however perfectly suited for average scale operations in such ports as the CEPGL ports of lake Tanganyika.

152. Its relatively higher output (more than $100m^3$/hour) does not make it suitable for operations on lake Kivu, more so as its transportation by road on tracked vehicle from Bujumbura to lake Kivu entails prohibitive dismantling and reassembling costs.

153. The advantage of this dredger is that it does not require the use of a pontoon. Besides, it is preferred to a mechanical shovel if the Lima crane is not available. It is only under such circumstances that its use should be envisaged.

2.5. Joint dredging operations on lake Kivu

154. As was the case regarding the buoyage of the navigable waterways and resetting of the floodmeters of lake Kivu, as well as the dredging of CEPGL ports of lake Tanganyika, concerted efforts should be made to dredge the ports of lake Kivu. This operation envisaged within the framework of COPTRALAC will involve RVF, the Rwand Lank Transport Division, SEP/CEPGL and ECA. It will also comprise various operational phases, namely search for funding and joint conduct of pre-dredging hydrographic surveys; search for funding and dredging operations proper. This presupposes the reactivation of COPTRALAC as was previously suggested.

CHAPTER THREE

3. PROPOSED MEASURES TO PRESERVE THE DEPTHS AFTER DREDGING OPERATIONS

155. The information contained in table one (1) shows that the two main causes of degradation of the depths of port roadsteads of lake Kivu are:

- the extremely low water level and/or
- solid flows brought by affluents flowing into the lake

156. After dredging operations, appropriate measures should be taken to limit the negative impact of these factors on the depth.

3.1. Extremely low water level

157. Where it is not possible to limit the effects of the low water level on the depth, it is possible, nevertheless, to forecast its variations so that a decision can be taken whether or not there is need for dredging operation.

158. However, this forecast is possible only if observation data on the waterlevel variations are available. These data provide the necessary elements that make it possible to determine the evolutionary trend of the water level. An exceptionally low water level over a number of years implies dredging operation in order to avoid more or less frequent and long periods of inaccessibility to the berthing facilities by vessels.

159. These data are derived from constant recordings of the water level variations with limnigraphs or at least by observation, at well defined and unbroken periods of time (every six hours), using floodmeters properly installed on the coast.

160. In the case of lake Kivu, the floodmeters that were recently restored have almost disappeared for want of monitoring and control. Even on those that are still in place, the readings are done erratically or not at all.

161. Due to lack of data, it is not possible as was stated earlier, to know whether the exceptionally low water level noticed on lake Kivu during the field mission will persist, in which case dredging of the roadsteads of the ports of Cyangugu and Goma will have to be programmed.

162. One of the urgent measures to be taken after dredging will consist in restoring the floodmeters on the lake, resume or begin limnimetric recordings and ensure proper monitoring and maintenance of these floodmeters.

163. One has to refer to the report on the implementation of activities relating to the buoyage and resetting of flood meters on lake Kivu to be able to make an accurate assessment of the dredging operation cost. The global amount will not exceed US$ 10,000. This is a very modest sum in so far as effective use of both the port infrastructures and

transport unit (loading rate adapted to the draught in the vicinity of the ports) requires knowledge of the readings on these floodmeters.

3.2. Sedimentation of port roadsteads caused by solid flows brought by the lake affluents

164. Out of the six port infrastructures of lake Kivu visited during the mission, four are established in the immediate vicinity of the outlets of the affluents. In view of the rather steep nature of the lake coast, these sediment discharge zones provide sites where the depths tady with more appropriate port construction techniques and costs. This explains the choice of these sites for the establishment of port infrastructures on the lake.

165. If sedimentation developing around these sites is unavoidable, it is nevertheless possible to limit the frequency and intensity through appropriate roadstead protection devices.

166. These infrastructures are aimed at directing the solid flows in a way as to avoid their spread in the lake under the effects of residual currents and/or waves, and around the port manoeuvering zones.

167. A carefully designed draining and stabilization system of the affluent waterway around the mouth zone will provide satisfactory answer to this problem.

168. The Kawa armco pipe constructed at the time, in the immediate south of the port of Bukavu had played a protective role as far as the roadstead of this port is concerned. The pipe was dislocated for want of maintenance. In order to replace it, SFE is currently constructing a reinforced movable concrete slabs in order to facilitate the maintenance thereof.

169. The design of similar devices for the port infrastructures exposed to sedimentation problems and the construction of these devices immediately after dredging are necessary, if not to preserve these infrastructures against rapid deterioration of the depths in the roadsteads, at least to slow down considerably this deterioration.

170. The device used by SFE to protect the port of Bukavu against sedimentation can serve as a model. Exchange of experience in the area of design and construction of this type of structure forms part of the actions to be promoted within the framework of COPTRALAC and included in any dredging programme of the ports of lake Kivu under the influence of solid flows carried by its affluents.

B. CONCLUSION AND RECOMMENDATIONS

171. Lake Kivu as an inland waterway transport infrastructure plays a vital role first as a linkage among CEPGL countries and second as an instrument that opens up an economically important region of the territory of the Economic Community of the Great Lakes States to the outside world.

172. By virtue of its volcanic origin, the lake has edges with very rugged relief, unstable soil and a rather humid climate (two rainy seasons yearly), meaning that all the condition underlying any road construction project exist.

173. This makes inland water navigation operations more attractive.

174. The effective use of the inland waterway services is however hindered by problems such as the deterioration of the depth of the port roadsteads, compounded by the exceptionally low water level and/or sedimentation sustained by solid flows from rivers flowing into the immediate surroundings of these ports.

175. The situation seriously affects accessibility to the port facilities of the lake, so much so that at the moment, berthing at some of the quays is not possible.

176. Dredging is necessary in order to clean up the roadsteads of these ports, all of which were not visited during the mission. Some of the ports such as the ports of Kibuye and Kirambo in Rwanda were at the time of the mission in zones of insecurity and could therefore not be visited.

177. The global dredging cubature to be envisaged is estimated at 15,500 m^3. Owing to non availability of data for an accurate calculation of this cubature, namely pre-dredging hydrographic survey plans, estimations had to be made, with the exception of the port of Bukavu in respect of which a survey was recently conducted by the "Régie des Voies Fluviales" (RVF).

178. The volume thus determined makes it possible to measure the magnitude of the work to be envisaged, bearing in mind the need to conduct jointly and as rarely as possible, the hydrographic surveys that are lacking.

179. In this connection, it is recommended that the formula adopted which facilitated similar operations concerning CEPGL ports of lake Tanganyika should be retained. This implies the reactivation of COPTRALAC without delay.

180. The dredging sites to be programmed for each of the infrastructures examined are relatively small and do not require the use of high output dredger such as the one belonging to ONATOUR. The use of RVF Lima crane constitutes the most appropriate solution. The joint utilization of this equipment to dredge the ports of lake Kivu should be examined by the COPTRALAC ad hoc working group.

181. It is recommended in this connection that the ad hoc working group draw up a concrete programme of action to be endorsed by COPTRALAC which will in turn submit it to the concerned CEPGL Authorities to seek the necessary funding for the implementation of the dredging operations.

182. Measures should be taken, if not to preserve the depths of port infrastructures against deterioration, at least to slow down considerably such deterioration.

183. These measures include the restoration of the floodmeters, their monitoring and maintenance, careful limniter readings, the design and construction of waterway drainage and stabilization facilities at the mouth zones.

184. It is recommended that members of the COPTRALAC ad hoc working group be designated to undertake missions to inspect the various port infrastructures of lake Kivu with the aim of:

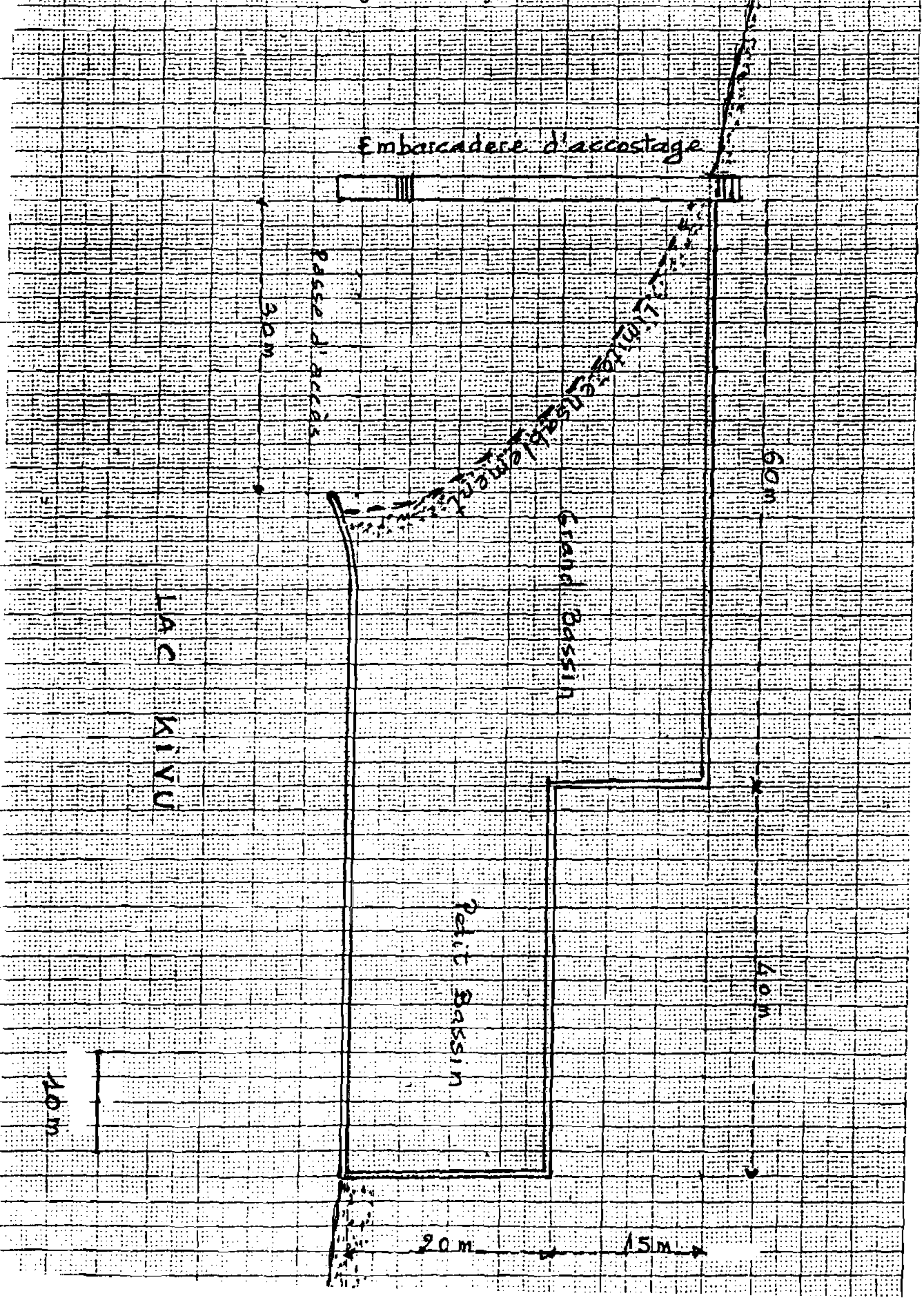
i) drawing up the list of floodmeters to be maintained and/or renewed, as well as preparing the estimated cost related thereto;

ii) designing devices to protect the roadsteads of port infrastructures exposed to sedimentation. This design will include the drawing up of the implementation programme of these devices as well as the preparation of the estimate of quantities and costs involved.

185. The documents thus prepared will be considered by COPTRALAC and submitted to CEPGL Authorities for approval and for the necessary funding to be sought.

ANNEXE 1

Plan Approximatif du Port à Passagers de Gisenyi



Annex 2(a)

List of Rwandan units operating on lake Kivu

Inventory of Rwandan goods transport units operating on lake Kivu

No.	Description	Owner	Capacity		Usual berthing place	Type of boat
			Cases	Tonnes		
1.	Tembo	TRAFIPRO		110	Kibuye	Tow
2.	Buda	"		60	"	"
3.	Dominique	"		50	"	"
4.	Jeannette	"		60	"	"
5.	Chantal	"		25	"	Tugboat
6.	Gitamara	"		10.5	"	"
7.	Karonni	"		-	"	Self propelled barge
8.	Walungu	Nzamurambaho	200	3.4	Mugonero	Tow
9.	Izeligana	Ngwijabarezi	300	5.1	Kirambo	"
10.	Munimba	"	110	2	"	Self propelled barge
11.	Imvubu	Mzabakirana	3000	51	"	Tugboat
12.	Rambira	Nyilinkwaya	2500	42	Shara	Tow
13.	Muramba	Kanyamashyo	200	5.4	Kinunu	"
14.	Karona	Kayihura	2000	34	Kibuye	"
15.	-	Ntagize	100	1.7	Nkombo	Zodiac
16.	Umwambi	Banzi	520	9	Gisenyi	Self propelled barge
17.	Nyamirere	Minani	700	12	Cyangugu	Tugboat
18.	Migogo	Kanyandege	900	15	"	Tow
19.	Marie-Françoise	Sibuli	2300	39.1	Shangi	"
20.	Gihohohoho	"	60	1	"	"
21.	Umulimo	"	720	12	"	Self propelled barge
22.	Ramba	Abdulatif	-		Cyangugu	Tugboat
23.	Rwanda	"	2500	25	"	Tow
24.	Jijuka	"	1000	17	"	Tugboat
25.	Amahoro	"	1000	17	"	Tow
26.	Mudende	Kanyamuhanda	3500	59.5	"	Self propelled barge

No.	Description	Owner	Capacity		Usual berthing place	Type of boat
			Cases	Tonnes		
27.	Leya	Kanyamdege	1200	20.4	"	"
28.	Kirambo	Semanyenzi	3000	51	Kirambo	Tow
29.	Kirambo	"	200	3.4	"	Tugboat
30.	Kabambali	Mugambira	-	-	Kilimbi	Self propelled barge
31.	Jacaud *	COLI	-	25	-	"
32.	Cooperative Impala	Cooperative Impala	-	2.5	-	"
33.	Cooperative Impala	Cooperative Impala		20	-	"
34.	Rurangwa	Rurangwa		15	-	"
35.	Rurangwa	"		7	-	"
36.	Kimbitigiti	Abdulatif	1200	20.4	Cyangugu	"
37.	Kamabere	"	1200	20.4	"	"
38.	Vedette no 1	ONATRACOM	50P		Gisenyi	"
39.	Vedette no 2	"	50P		"	"

ANNEX 2(B)
LIST OF ZAIREAN UNITS OPERATING ON LAKE KIVU

Unites	Years of service commissioning	Tonnage capacity	Length (m)	Width (m)	Draught (m)	Date of last carrenage
1. Passenger Boat						
Ruzizi	1954	45P	23.24	4.20	1.80	1975
Rutoburu	1954	45P	23.24	4.20	1.80	1975
Mbandaka	1973	115P	32.50	5.20	2.25	1978
Matadi	1973	115P	32.50	5.20	2.25	1976
2. Self propelled units						
Karisimbi	1952	130t	35.00	5.52	2.30	1976
Mikeno	1952	130t	35.00	5.52	2.30	1980
Albatros	1954	9t	12.67	2.45	1.33	1975
Potopoto	1932	218t	40.20	7.20	2.70	1962

* Data relating to Nos. 33 to 39 come from MINITRANSCO (1979) but were not recorded by BUNEP mission. It is likely that the boats mentioned are either no longer operational or are known under different names.

Unites	Years of service commissioning	Tonnage capacity	Length (m)	Width (m)	Draught (m)	Date of last carrenage
3. Tugboats						
Kibati	1941	23t	19.29	3.55	1.55	1977
Kirambo	1948	14t	15.16	3.37	1.45	1978
Kalehe	1948	14t	15.16	3.37	1.45	1981
Katutu	1957	6.50t	15.00	3.62	1.60	1975
Katana	1955	6.50t	15.00	3.62	1.60	1978
Ishara	1948	14.50t	15.16	3.57	1.45	1981

INVENTORY OF ZAIREAN FLEET BARGES

Type	Commissioning	Tonnage (tonnes)	Length (m)	Width (m)	Draught (m)	Date of last careenage
Type B						
B1	1948	34,875	19.10	3.68	1.28	1979
B2	1948	34,875	19.10	3.68	1.28	1977
B4	1948	34,875	19.10	3.68	1.28	1978
B7	1949	34,875	19.10	3.68	1.28	1978
B8	1950	34,875	19.10	3.68	1.28	1980
B9	1950	34,875	19.10	3.68	1.28	
Type C						
C1	1958	70.5	18.16	4.50	1.85	1980
C2	1958	70.5	18.16	4.50	1.85	1981
C3	1958	76.5	22.71	3.50	1.82	1981
C4	1954	76.5	22.71	3.50	1.82	1978
C5	1954	76.5	22.71	3.50	1.82	1979
C7	1954	76.5	22.75	3.50	1.80	1981
C8	1957	77.7	22.21	3.51	1.80	1981
C9	1957	77.7	22.21	3.51	1.80	1981
C10	1957	77.7	22.21	3.51	1.80	1981
C11	1957	77.7	22.21	3.51	1.80	1981
Type D						
D1	1931	105.0	25.75	5.00	2.20	1976
D2	1931	105.0	25.75	5.00	2.20	1981
D3	1954	129.5	27.50	5.00	2.20	1976
D4	1958	158.0	30.66	6.01	2.21	1977
D5	1958	158.0	30.66	6.01	2.21	1975
Type G						
G81	1958	79.3	24.47	3.50	1.80	1980
G82	1958	79.3	24.47	3.50	1.80	1980
G83	1958	79.3	24.47	3.50	1.80	1976
G84	1958	79.3	24.47	3.50	1.80	1976

Type	Commissioning	Tonnage (tonnes)	Length (m)	Width (m)	Draught (m)	Date of last careenage
Ponton						
B5-B6	1949	35.0	19.10	3.68	1.28	1977
X1	1926	54.4	22.15	3.55	1.30	1980
X2	1934	54.4	22.15	3.55	1.30	1980
XH-1	1938	62.0	23.65	3.55	1.50	1976
XH-2	1938	62.0	23.65	3.55	1.50	1980

Source: S.N.C.Z. Bukavu

…UL/CIE/III/12

…nexe 3(a)

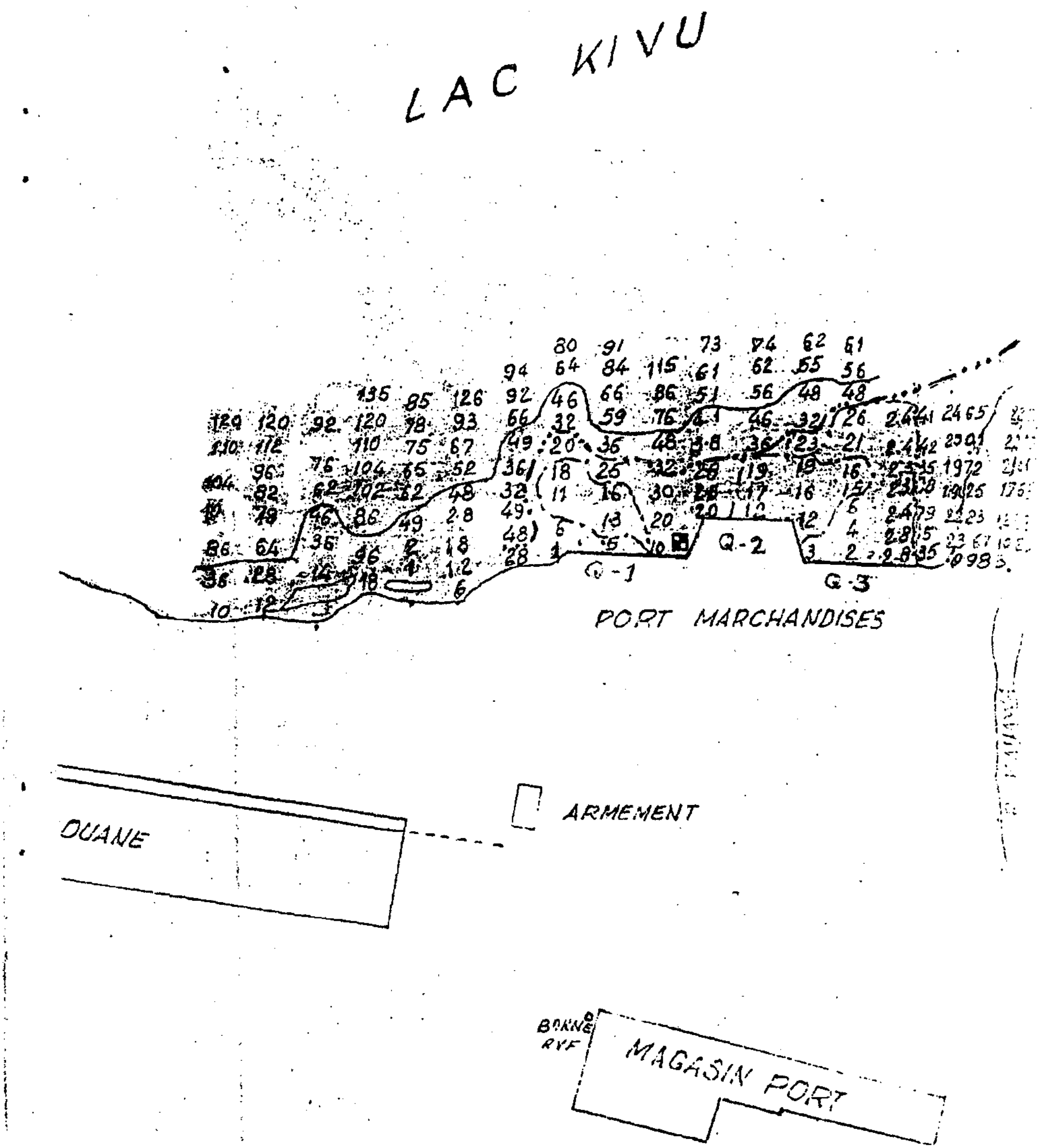
REPUBLIQUE DU ZAIRE
REGIE DES VOIES FLUVIALES
ETABLISSEMENT PUBLIC BIEF SUPERIEUR

LAC KIVU (BAIE DE LA [illegible]
PORT DE BUKAVU
SITUATION MAI 1994

LEVE ET DESSINE PAR BULUNGULE	CALQUE PAR ABEDI FUNDI
N° KALEMIE le 19-5-94	APPROUVE PAR LE REPRESENTANT ai MBAYUMOYA PL

- LES SONDAGES EXECUTES AU PLOMB POISSON SONT EXPRIMES EN DECIMETRES
- DU 3e AU 5e PROFIL VERS LA RIVIERE KAHAWA LES SONDAGES SONT EXPRIMES EN METRES EN PARTANT DE LA BORNE RVF COTE HYDROGRAPHIQUE 3,30 m
- PENDANT LE LEVE LE NIVEAU DU LAC KIVU INDIQUAIT –0.82 A L'ECHELLE PRINCIPALE DU PORT
- LES DESSINS DU BATIMENTS ET AUTRES SONT REPRIS DU PLAN SFE N° SP/602 DU 31-10-84
- LA COURBE DE 1m EST CELLE DE — · — · —
  " 2m " " " — ·· — ·· —
  " 5m " " " ————

ECHELLE: 1/1000e

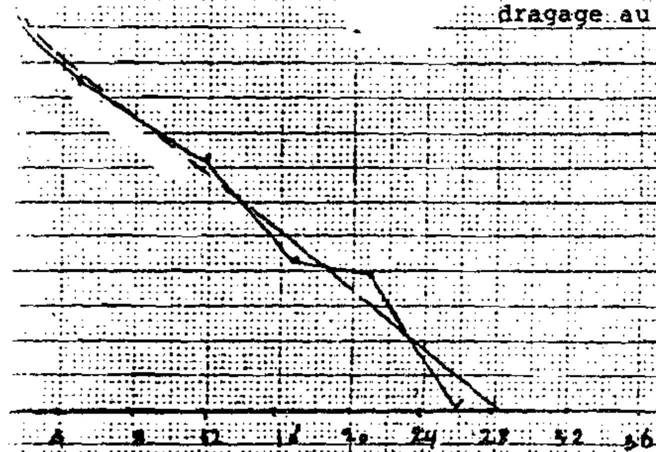

LAC KIVU
Q-1
Q-2
Q-3
PORT MARCHANDISES
OUANE
ARMEMENT
MAGASIN PORT

ANNEXE 4 (a)

Evaluation de la cubature de dragage au port de BUKAVU

d = 5m

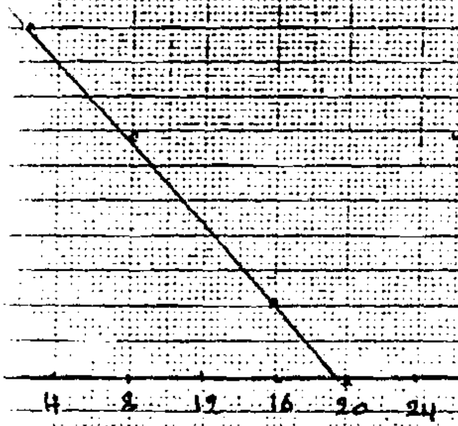
$$q_1 = \frac{5 \times 28 \times 3}{2} = 210\ m^3$$



P 1

d = 10 m

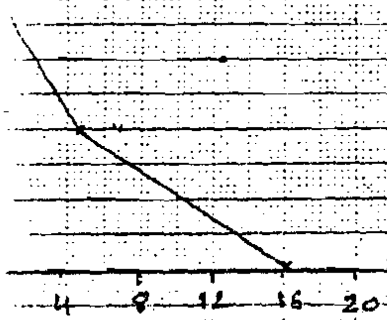
$$q_2 = \frac{10 \times 20 \times 2.75}{2} = 275\ m^3 \approx 300\ m^3$$



P 2

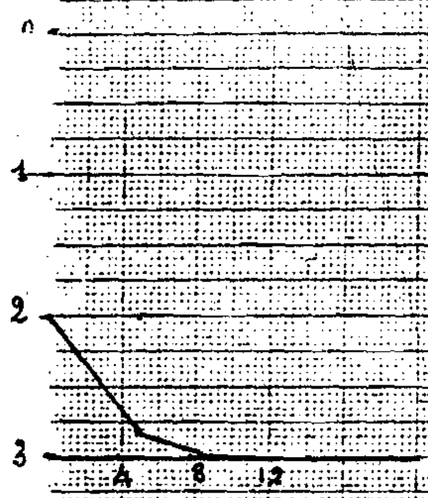
d = 10 m

$$q_3 = 125\ m^3 \approx 150\ m^3$$



P 3

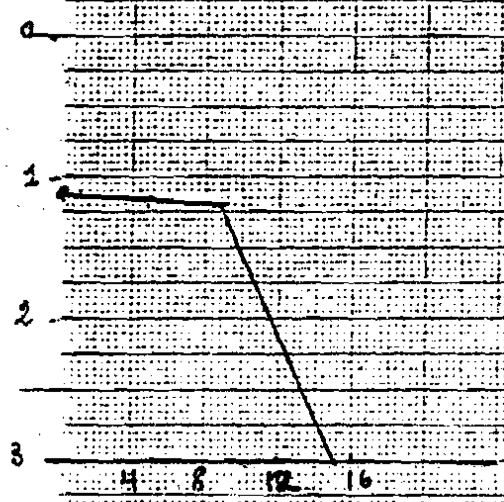
Evaluation de la cubature de
dragage au port de BUKAVU (Suite)



$d = 5\,m$

$$q = \frac{1 + 0{,}20}{2} \times 5 + \frac{0{,}2 \times 5}{2} \times 5 \simeq 20\,m^3$$

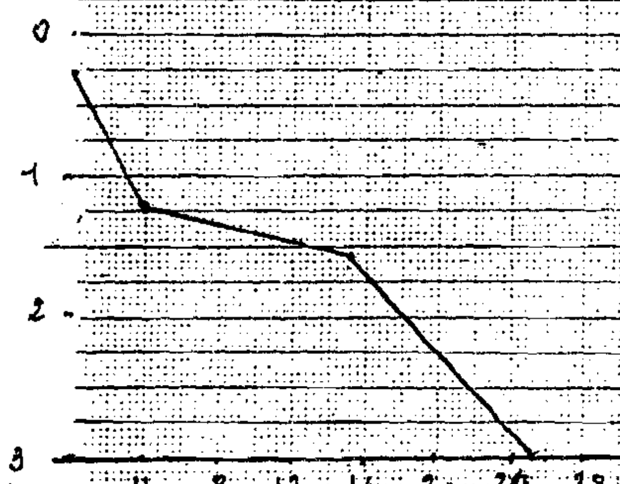
P4



$d = 10\,m$

$$q = \frac{(1{,}90 + 1{,}80) \times 10}{2} \times 10 + \frac{1{,}80 \times 5}{2} \times 10 = 230\,m^3$$

P5



$d = 10\,m$

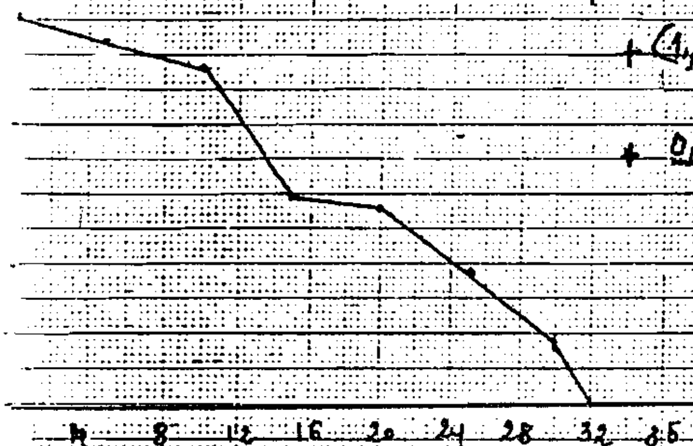
$$q = \frac{(2{,}70 + 1{,}80) \times 5}{2} \times 10 + \frac{(1{,}80 + 1{,}40) \times 10}{2} \times 10 + \frac{1{,}40 \times 10}{2} \times 10 \simeq 350\,m^3$$

P6

Evaluation de la cubature de dragage au port de BUKAVU (Fin)

$d = 10\,m$

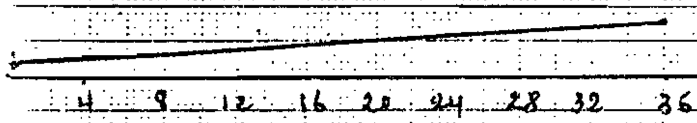
$$q = \frac{(2{,}80 + 2{,}60)}{2} \times 10 \times 10 + \frac{(2{,}60 + 1{,}50)}{2} \times 5 \times 10 + \frac{(1{,}50 + 1{,}40)}{2} \times 5 \times 5 + \frac{(1{,}40 + 0{,}40)}{2} \times 10 \times 10 + \frac{0{,}40 \times 2}{2} \times 10 = 540\,m^3$$



P7

$d = 10\,m$

$$q = \frac{(0{,}2 + 0{,}6)}{2} \times 36 \times 10 = 150\,m^3$$



P 8

$$Q = 210 + 300 + 150 + 20 + 230 + 350 + 540 + 150 = 1900\,m^3$$

arrondi à $2000\,m^3$