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UBLIQUE DU SENEGAL
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INISTERE DU DEVELOPPEMENT RURAL
ET DE L'HYDRAULIQUE

MISSION D'ETUDE ET D'AMENAGEMENT
DU CANAL DU CAYOR

CAYOR CHANNEL PROJECT

PRESENTATION NOTE

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SUMMARY

I - INTRODUCTION

This report is a presentation of the Cayor canal project, deriving from pre-project findings, relative to the constructions recommended, within the framework of a comprehensive treatment, as requested by the senegalese authorities.

The project which is of high priority in the economic and social development policy of Senegal, hopes to satisfy the portable water needs of the city of Dakar and its environs in a durable way. (up to the 2030'S) and enhance the improvement of 8500 hectares of agricultural plots in the four regions traversed by the canal.

Beyond these fundamental objectives, the Cayor canal is a multisectorial type operation, capable of making a significant contribution to current national pre-occupations, which are : - self sufficiency in food, creation of employment, the fight against desertification and the protection of the environment.

After a brief look at the history and justification of the project, the report recalls the objectives in relation to the needs that have to be satisfied and presents a detailled description of the project and its different components, accompanied by a cost estimate. It also presents an evaluation of its impact on the national economy and on the environment.

Lastly, the document presents the technical programme of activities to be undertaken, which will permit the completion of the project before the year 2000.

II - HISTORY AND PROJECT JUSTIFICATION

before 1971, water supply to the region of Dakar was assured exclusively by underground resources of the Cap Vert peninsula and the Thies region. A significant increase in population, resulting for a large part, from an abnomally high migration influx, as from 1992, doubled the population of Dakar between the 70's and 80's, bringing with it, a de facto increase in water consumption, as much for domestic usess as for collective activities, industrial and agricultural.

Moreover, the indadequacy of long term planning in water resources, due to lack of sufficiently viable datta and an imperfect knowledge of the effect of hydro-climatic phenomena on aquifers, resulted in a rupture between consumption and production, thus creating extremly precarious conditions in the area of distribution, particulartly in Dakar.

At the start of the 70's, even before the advent of the great sahellian drought, it was already clear, that even if managed scientifically, underground resources could never withstand the consequences of unlimited exploitation. To avoid a hydraulic dis-equilibrium, prejudical not only to Dakar but also to regions influenced by well pumpings, Government took the decision of relieving the burden on the aquifers, authorising SONEES to obtain supplementary volumes required for the water needs of the capital from the lake Guiers. The lake Guiers is a vast natural depression of 600 000 000 m^3 capacity, situated on the banks of the river Senegal, 250 km north east of Dakar.

A pumping and water treatment plant of a nominal capacity of 60 000 m^3/day was inaugurated in 1972 and was for 10 years quite efficient in responding to the water demands of Dakar. Since 1973, in spite of some additional re-inforcements, these installations no longer enable SONEES to regularly guarantee an adequate supply.

Today, the situation in Dakar is such that of an average demand of 210 000 m^3/day, SONEES can only provide, at the utmost, 172 000 m^3. This assumes of course, that all the installations are functioning at full capacity, that is, faultlessly. This, unfortunately, is not the case and most often users have to be satisfied with a supply of less than 150 000 m^3/day. And this deficit widens during the peak periods.

Consequently, faced by an ever increasing, water demand of 6% per year, SONEES had to resort to an increased rate of exploitation of the POUT and SEBIKHOTANE boreholes, at a high level of risk, - that is - increased pumping from aquifers already over exploited, notably those located in the palaeocene and in the Thies region. Various studies and mathematical models have long shown these aquifers to be fragile and precarious. Intensive pumping from aquifers, uncompensated by recharge from rain water have thus contributed to a decrease in the levels of the latter, resulting in an increase in salinity, perceptible in certain regions.

A decision therefore had to be made. The delivery system of water from the lake guiers had to be re-inforced urgently to avoid an ecological catastrophe ; and to meet the water demands of Dakar. To remedy the situation, the feasibility study carried out by a team of german consulting engineers, (RHEIN RUHR) in december 1983, recommmended the doubling of the water supply from the lake Guiers as from 1989, the tripling in 1994, quadrupling towards the year 2000 and so on ; without specifying how to end this eternal multiplication.

The study indicated a high recurrent investment cost, attaining 150 billion FCFA before the year 2000. It was therefore imperative to find a different approach that would resolve the problem in a more durable way, involving a lesser financial commitment, giving at the same time, a real impetus to the development of rural communities along the Louga-Dakar axis. The

Senegalese government then considered the possibility of transporting water by an open canal from the lake Guiers to the cape Vert peninsula in Dakar.

Other possibilities had earlier been considered, among which were:

- water supply from the Gambia, enabling the aquifers in the Thies region, (subject to excessive exploitation), to be put on reserve ;

- de-salinisation of sea water along the coast of Dakar ;

- utilisation of renewable energy (eolian and solar) ;

- water delivery by large diameter pipes.

None of these solutions produced more or as much interest as the canal solution, no matter how tempting some appeared to be. These reasons led the technical services of the Ministry of Water resources to propose in a memorandum dated 15th may 1984 and revised 15th july 1985, the study of transportation of water by a canal linking the lake Guiers to the Cape Vert peninsula. They also proposed the treatment of water upon arrival, in sufficient quatity for consumption in Dakar and injection of the residual discharge into the aquifers of the paleocene.

While preserving the principal objective of supplying potable water to the Dakar region, this solution, has multiple additional advantages which could be particularly benificial to the entire country : - recharge and conservation of underground water, development of agriculture, domestic farming, re-forestation and a general renaissance of plant life in the regions traversed.

That the newly completed Diama and Manantali dams would guarantee the quantity of water necessary, renders the project all the more credible. THe latter would also be the direct product of constructions on the river Senegal and would constitute a key element of the post-dam policy.

Considering the advantages that could be derived from the delivery of water by canal, the government of the Republic of Senegal judged it timely and necessary to have a factibility study of the project undertaken, englobing the provision of potable water for Dakar, irrigation of agricultural plots along the region traversed and recharge of aquifers.

The study undertaken by the Franco-Italian consulting group, BCEOM/ELECTRO-CONSULT/SOCIETE DES EAUX DE MARSEILLE/ARLAB/GEOLAB/ BOUETTE, was completed on 15th november 1988, with the financial assistance of the World Bank (900 million F.CFA).

The conclusions confirmed unequivocably, the soundness of the canal option and its economic superiority over all the other solutions.

Taking account of the scale of the operation, its multisectorial aspect and the necessity of demonstrating political will by constructing the canal within the shortest possible time, the Senegalese head of state decided by decree of 5th december 1988, to create a mission attached to the presidency. This mission named : "Mission d'Etude et d'Aménagement du Canal du Cayor" MEACC, (construction and consulting office of the canal of Cayor), is invested with extensive powers to seek financial credit and complete the studies.

In the same context, a survey contract was signed with a consulting group on august 1st 1991. This execution study of the Cayor Canal is recorded in a detailled pre-project report and its execution was awarded to the consulting group : SCET-TUNISIE with ELC-ELECTRO-CONSULT/COMPAGNIE NATIONALE DU RHONE/SONED AFRIQUE as contractor. The inauguration of the canal is scheduled for a date note far from the year 2000.

III/ OBJECTIVES OF THE PROJECT

The main aim of the project is to satisfy the water demand of the Dakar region and meet the water needs for irrigation of agricultural plots. These needs correspond to an overall maximum discharge of 17.25 m^3 in April 2030 ; 10.2 m^3 of which will be for the supply of potable water to the Thies reserve and 7.05 m^3 for irrigation.

3.1 Objective of potable water provision

The water needs that must be satisfied are :

- the needs of the Ngnith - Thies zone, comprising the towns of Louga and Thies ;
- the needs of the Thies-Dakar zone, comprising essentially the region of Dakar ;
- the needs of the Mbour-Petite Côte region ;
- the needs of the Canal's zone of influence (10 km on either side of its course).

The water needs for the group, (for the years 1995, 2001 and 2020) are shown overleaf on Table n° 1.

TABLE N° 1 ; POTABLE WATER NEEDS

	1995			2001			2020		
	M	P	C	M	P	C	M	P	C
NGNITH-THIES	44.280	54.590	37.400	66.090	81.640	55.710	110.880	137.160	93.360
THIES-DAKAR	311.600	368.400	261.700	415.000	514.600	348.600	762.000	944.900	640.000
MBOUR-PETITE COTE	12.000			17.500			31.000		
ZONE D'INFLUENCE DU CANAL DU CAYOR	19.000			19.000			19.000		
	386.880			517.590			922.880		

M : Average needs in m^3/d ; 7 months of year

P : Needs during peak periods in m^3/d ; 2 months of year (coefficient : 1.24)

C : Needs during low periods in m^3/d 3 months of the year (coefficient : 0.84)

Taking account of the supplementary resources, (besides the Canal), that must be mobilized during the temporary phase, (before the inauguration of the Canal) ; of the re-inforcement of the water supply - distribution network of the Dakar region ; and of the forseable evolution of the overall resources, (minus the canal) in the period 1995-2020 ; satisfying these needs could be accomplished as follows :

NGNITH - THIES ZONE

- station at Ngnith 64.000 m^3/d (nominal capacity)
- underground waters :

  * Aquifer of the nothern littoral : 45.000 m^3/d (average) ; 55.000 m^3/d (peak)

  * Aquifer of the Maestrichtian :
    (Thies region) : 10.000 m^3/d (average)
    : 20.000 m^3/d peak in 2020.

These resources exceed the needs of this zone and there even remains (in 2020, at peak periods), a surplus of 2000 m^3/d in the Thies - Dakar zone, for the reservoirs in Thies.

The Thies - Dakar zone

- surplus goes to the Thies reservoirs,

- underground waters :

  * Aquifers of the quaternary sands : 15.000 m^3/d
  * Maestrichtian - Paleocene system : 100.000 m^3/d

- Canal complement

The Mbour - Petite Cote zone

- underground waters of the Maestrichian-paleocene system
- eventually the canal could transport a complement but this would be negligible compared to the discharge of the Canal.

The Canal's zone of influence

The needs of this difuse zone of little importance will be covered by local underground water resources (limestone aquifers of the lutetian or terminal continental), a few villages will be covered by the A.L.G. delivery pipe.

Following the resources-needs chart of everything considered, the potable water Division of the Canal Project will, during the period 1995-2020, restrict itself, (in the delivery of treated water), to the water supply distribution network of the Dakar region as indicated below :

For 7 months :

1995....................................	1480 l/sec.
annual progression.........................	239 l/sec.
2020....................................	7395 l/sec.

For 2 months :

1995....................................	2270 l/sec.
annual progression.........................	293 l/sec.
2020....................................	9595 l/sec.

For 3 months :

1995....................................	830 l/sec.
Annual progression.........................	207 l/sec.
2020....................................	60051/sec.

The annual demand at cruising discharge is 234 mm^3/year.

3.2 Enhancement of Agriculture

The hydro-agricultural constructions are confined to two zones, situated along the length of the Canal, namely :

- the Cape-Vert zone : from the south-west of Thies hill to the terminal point of the Canal at Sebikhotane and

- The Cayor zone : between the lake guiers and Thies town.

The improvement programme envisages the supply of water to 8500 ha of agricultural plots, spread out as follows :

a) Cap-Vert

2 500 ha of vegetable gardening
500 ha of indegenous fruit farming

3 000 ha

b) Cayor

500 ha of indigenous fruit farming
2 500 ha of vegetable gardening
2 600 ha of vegetable gardening + fish farming
400 ha industrial usage + fish farming

5 500 ha

The 3 000 ha programme of the Cape-Vert zone includes irrigable land composed of rich soils, situated within the viscinity of the canal's course. This area includes sectors already irrigated, (but badly done due to lack of water), notably the Baobab plot of Senprim (900 ha ; 120 ha of which are irrigated) and FILFILI (700 ha ; 250 ha of which are irrigated).

This sectors would receive water from the Canal, thus permitting underground water resources which they presently utilise, to be conserved.

In the Cayor zone, the surface area to be irrigated would be divided into 27 plots, disposed in regular intervals (en echelon) along the whole length of the Canal. Their surface areas would be fixed in proportion to the active population living within the canal's zone of influence.

The guaranteed water supply, at cruising discharge would be the following :

- fruits : 15.000 t/year (2/3 agrumes and 1/3 mangoes)
- legumes 200.000 t/year ; 20.000 t/year of which will be for export
- Maize : 4.000 tonnes
- Sorghume : 3.500 tonnes
- groundnuts : grains or seedlings : 3 000 tonnes.

The determination of water demand for irrigation takes account of the four climatic zones of the project, which are ; starting from the catchment source : Louga, Kebemer, Thies and Cape-Vert.

At the head of the network (practically at canal's exit), and integrating water loss in the network and in the terrain, the net demand obtained is shown on tables n° 2 and 3, overleaf.

TABLE N° 2 : Annual water needs for irrigation (in m^3)

ZONES	1995	2001	2007	2010	2013 et au-delà
Cap-Vert	5.24	26.58	27.31	27.31	27.31
Louga	8.15	16.33	23.10	23.23	23.23
Kébémer		11.19	32.40	33.15	33.23
Thies		15.29	34.08	34.43	34.63
Total Cayor	8.15	42.81	89.58	90.82	91.09
Total Canal	13.60	69.49	116.89	118.13	118.40

TABLE N° 3 : Water needs for irrigation at peak periods (in m^3/sec.)

ZONES	1995	2001	2007	2010	2013 et au-delà
Cap-Vert (April)	0.399	1.925	1.959	1.959	1.959
Louga (March)	0.437	0.887	1.248	1.255	1.255
Kébémer (March)		0.573	1.660	1.693	1.696
Thies (March)		0.942	2.078	2.093	2.102
Total Cayor	0.437	2.402	4.986	5.041	5.053
Total Canal	0.836	4.327	6.945	7.000	7.012

The year 2007 coincides with the year in which the last surface areas would be supplied with water (2006), beyond that year, the needs only intersect moderately, up to cruising discharge.

3.3 Objective : recharge of aquifers

Only the aquifer of the paleocene limestones of the Pout area, (itself being a constituent of the upper aquifer of the Maestrichtien-paleocene system), posseses the characteristics favourable for the processes of recharge.

The latter could have a double objective :

- to conserve the water resources of the system ;
- to permit the use of the limestone substratum as a seasonal reservoir, so as to limit withdrawals from the canal during peak periods.

Among the 3 sites identified as potential recharge sites, two situated in the neighbourhood of the field of influence of Pout south, could ultimately permit the seasonal exploitation of the underground reservoir.

There are however some uncertainties concerning the application of such recharge - withdrawal processes ; which must be confirmed by earlier experimentations. The first experimentation programme aimed at testing the behaviour of the system under recharge conditions should have been executed earlier. This programme could not be carried out now, before the canal goes into service, since the financial resources available cannot be diverted from the provision of water for the Dakar region. Consequently, the programme could be treated as a parallel operation to be undertaken as soon as the possibilities of water provision allow.

3.4 The total needs to be met by the canal

The maximum discharge to be provided at the head of the canal is 18.4 m^3/s, which can be broken down as follows :

- an effective discharge of 17.25 m^3, 10.2 m^3/s of which is for the potable water supply of the Thies reserve and 7.05 m^3/s for irrigation ;

- a discharge of 1.15 m^3/s, representating the total water loss.

The discharge at the head of the Ferlo channel is about 26 m^3/s, comprising the discharge at the head of the canal (18.4 m^3/s), the water loss of the Diatmet delivery canal and of the channel, (estimated at 0.03 m^3/s and 5.33 m^3/s respectively) ; and a supplementary discharge of 2 m^3/s.

The evaluation of the overall water loss is given on Table n°4.

TABLE N° 4 : EVALUATION OF WATER LOSS

CONSTRUCTION	WATER LOSS BY INFILTRATION	OBSERVATIONS
DIATMET Delivery Canal	30 $l/d/m^2$	No particular impermeable membrane
Principal Canal	8 $l/d/m^2$	Impermeable membrane present
Secondary Canal	60 $l/d/m^2$	No impermeable membrane
Thies Reserve	20,000 m^3	Preponderance of water loss by infiltration
Ferlo Channel	800 $l/d/m^2$	bed sub-merged
Treatment Plant	2% of vol. of water treated	

- The value obtained for the maximum water loss by evaporation is 3.56 m/year which is equal to 9.75 mm/d.

- The overage annual evaporation is the mean of the evaporation, measured along the length of the Canal, and is estimated at 2.68 m/year which is 7.35 mm/d.

The net total needs are presented on table n° 5 below. The gross water demand along the channel dug on the ancient bed of the Ferlo is presented on Table n° 6.

TABLE N° 5 : NET TOTAL NEEDS TO BE SATISFIED BY THE CANAL

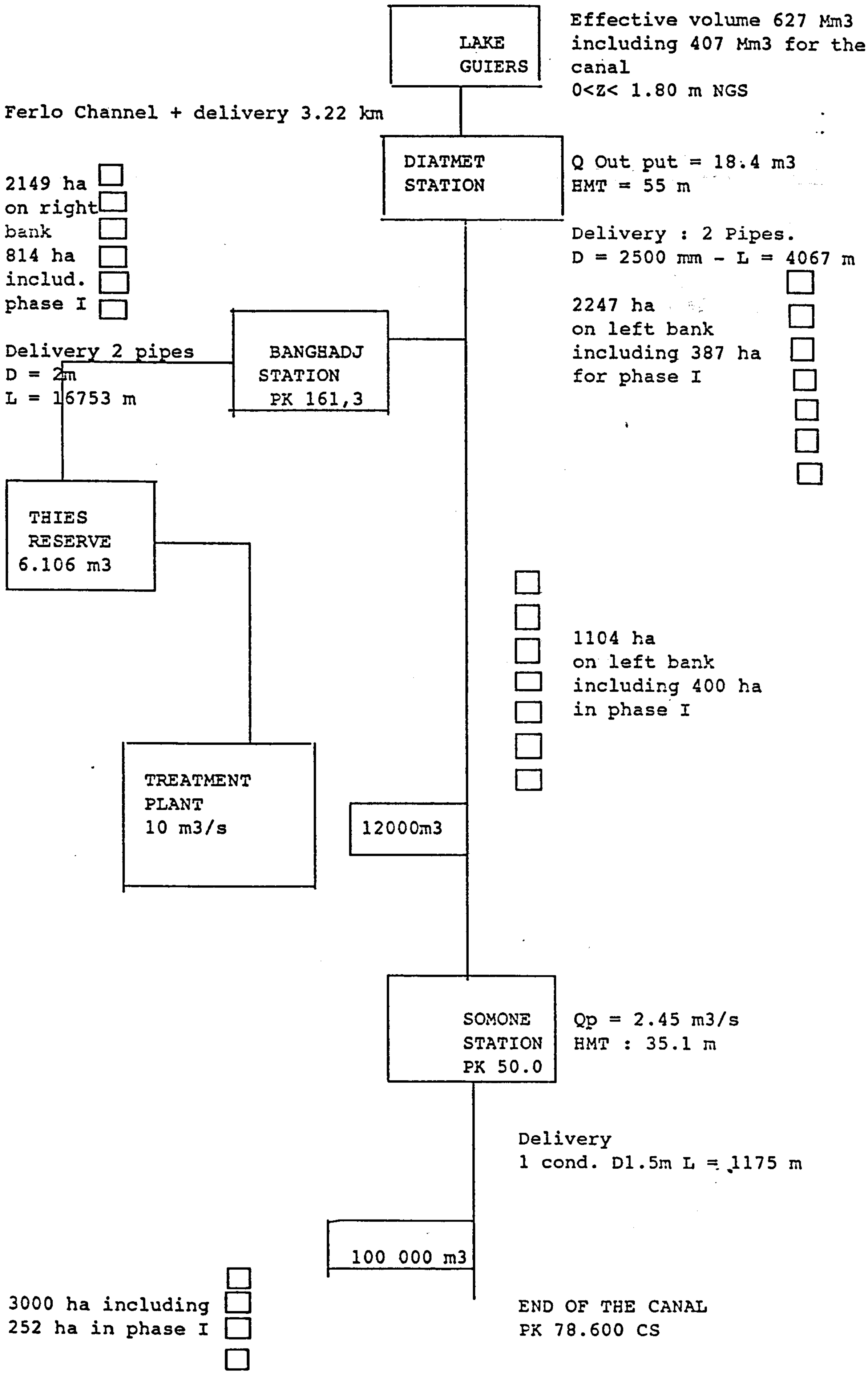
[illegible]ARS	MONTHLY NEEDS IN M^3/SEC/CONTINOUS												ANNUAL NEEDS M^3/YEARS
	1	2	3	4	5	6	7	8	9	10	11	12	
1995	2.12	2.17	3.20	3.07	1.98	1.73	0.96	1.00	1.00	1.53	1.66	1.88	57.54
2[illegible]	6.37	6.81	8.35	5.76	5.76	4.35	2.76	2.88	2.89	3.40	4.11	5.23	153.16
2007	10.32	10.89	12.76	12.14	8.81	6.74	4.63	5.07	5.07	5.41	6.61	8.43	251.09
2[illegible]0	11.04	11.64	13.63	13.02	9.53	7.46	5.25	5.69	5.69	6.12	7.33	9.15	273.58
2020	13.43	14.00	16.56	15.96	11.92	9.85	7.32	7.76	7.76	8.51	9.72	11.54	348.18

TABLE N° 6 : GROSS WATER NEEDS OF THE CANAL ZONE IN THE REGION OF THE ANCIENT BED OF FERLO

YEARS	MONTHLY NEEDS IN M^3/SEC/CONTINOUS												ANNUAL NEEDS M^3/YEARS
	1	2	3	4	5	6	7	8	9	10	11	12	
1995	3.68	3.73	4.84	4.80	3.52	3.24	2.30	2.35	2.35	3.02	3.17	3.41	104.72
2[illegible]	8.38	8.84	10.56	10.30	7.73	6.23	4.44	4.58	4.59	5.21	5.97	7.17	217.73
2[illegible]7	12.64	13.23	15.27	14.63	11.06	8.88	6.57	7.03	7.04	7.47	8.75	10.46	319.41
2010	13.43	14.02	16.23	15.60	11.85	9.69	7.28	7.74	7.75	8.28	9.55	11.46	344.42
2[illegible]0	16.06	15.65	19.42	18.79	14.49	12.34	9.61	10.07	10.07	10.95		12.21	427.06

Figure n° 1 of page 19 indicates the functional diagram of the Cayor Canal in relation to the total needs to be satisfied during the year 2030.

N°1 LONG TERM FUNCTIONAL DIAGRAM OF THE CAYOR CANAL



IV/. BRIEF PRESENTATION OF THE PROJECT

The project involves the construction of an open Canal, 240 km long, linking the lake guiers to the Thies region and having the capability of transporting annually, nearly 430 Million m^3 of water (at a discharge rate of about 20 m^3/s).

The lake guiers is situated on the north of Senegal, at the same latitude with the town of Saint-Louis and some 60 km into the interior. It trends north-south for about 50 km and is fed by flood waters of the river Senegal, to which it is connected by an existing canal, 17 km long (TAOUE CANAL).

4.1 Brief look at the Geology of the area

The project zone is located entirely within the interior of the sedimentation basin of Senegal.

Along the entire course of the Cayor Canal, the vast platform covering the northern part of Senegal, is composed of tertiary formations (limestones, muddy-limestones, sandstones and argilicious sandstones).

The Canal and its constructions are located on quarternary formations, composed of a sandy and/or lateritic superficial cover ; the latter in the form of cuirases or fine gravel.

There still remains, thin stretches of tertiary rocks between Thies and lake guiers.

On the structural level, the main tectonic events took place during the tertiary and quartenary eras. The zone can be considered incactive, seismically.

4.2 Description of the project

Detailed pre-project studies permitted the improvement of the trajectory of the Cayor Canal, with precisions on the linear constructions.

From the catchment source towards the downstream end, successively, these constructions comprise the following sections:

1) An earthen channel, the Ferlo channel, 17 135 m long, running from the Keur Momar Sarr water catchment ;

2) A delivery canal, rectangular in form and cut into the rock. It is 3 219 m long, transporting water to the first pumping station at DIATMET.

   This station of a nominal capacity of 6 x 2 300 kw will be installed in (2) phases.

   The water will be delivered by (2) twin steel pipes ; each
   4 067 m long and 2 500 mm in diameter. One will be installed during the 1st phase.

This pumped water enters at the initial section of the principal canal.

3) The principal canal which is trapezoidal in form, has a coating of concrete, with a membrane sheath ; and is 157 207 m long. At the end of the Canal, the structure branches out. One branch, called the Banghadj branch, transports potable water to the reserve at Thies ; while the other branch transports the water of the Cape-Vert zone. This branch is also called the secondary canal.

4) The Banghadj branch comprises a delivery canal which feeds a second pumping station. This canal will be 4 025 m long, trapezoidal and built of re-inforced concrete, for 1 804 m of its lengh. From this point, right up to the pumping station, the section becomes rectangular and of re-inforced concrete, with a membrane.

Water delivery will be by means of two twin steel pipes, each of 16 753 m and 2 000 mm diameter. One of these will be installed during the second phase.

5) The delivery canal which runs to Thies, is coated with cement and is 2 195 m long.

6) The trapezoidal irrigation canal at the downstream end of the Somone pumping station, (length 78 600 m), comprises a section in the form of a steel delivery pipe, 1 175 m long and 1 500 mm in diameter.

A regulation reservoir of 12 000 m^3 capacity has been installed on the catchment end of the re-pumping station.

The Banghadj and Somone stations have outputs of 6 x 2 200 km and 3 x 400 km, respectively.

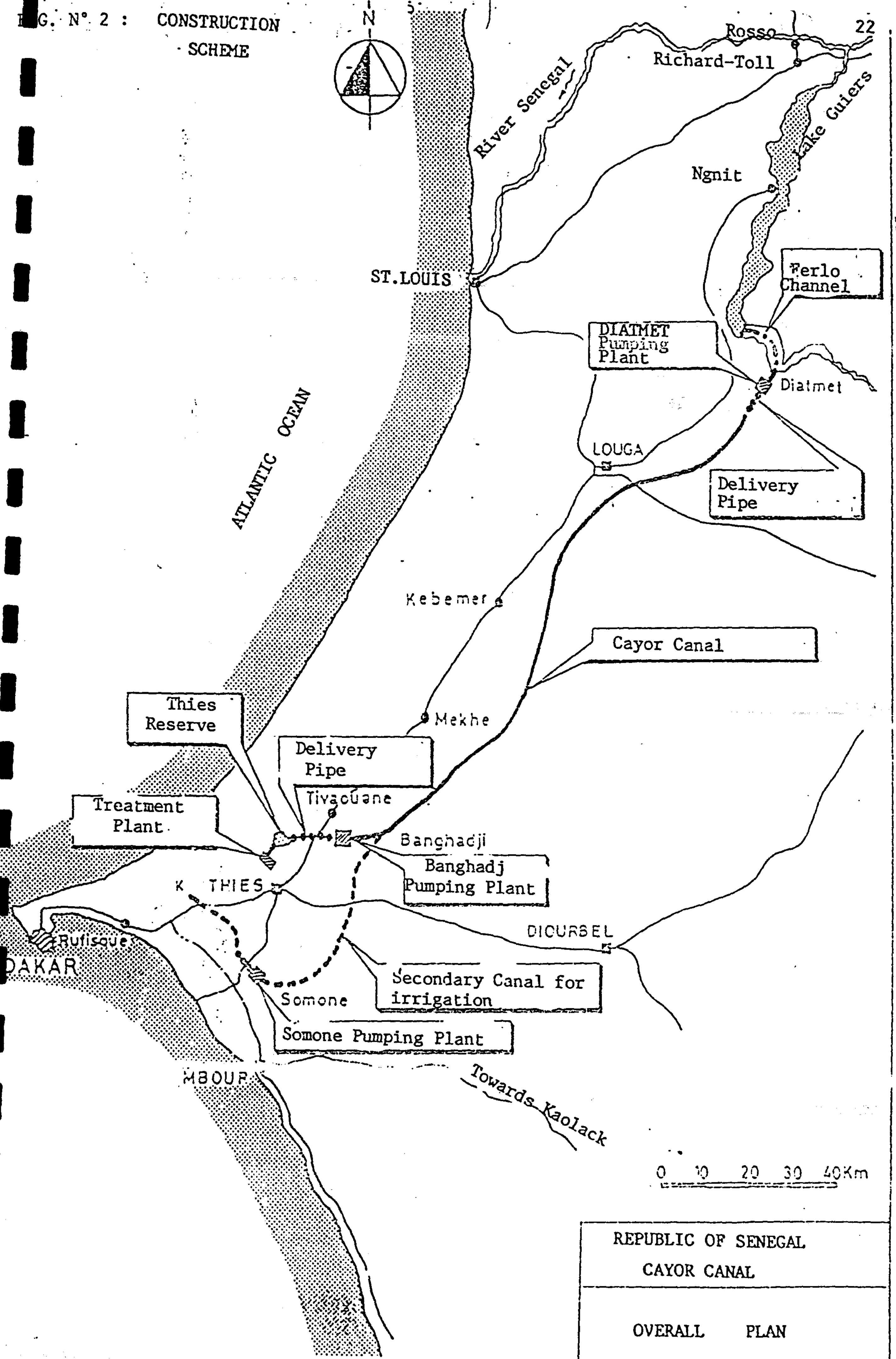
Throughout its course, the Canal tracing truncates, roads and packs of variable importance, in several places.

Table n° 7 presents a recapitulation of the final alignments, per section, for the entire project.

TABLE N° 7 : RECAPITULATION OF THE ALIGNMENTS OF THE CANAL TRACING

NAME OF SECTION	LENGTH (m)	NATURE	OBSERVATIONS
1. Ferlo Channel	17 135	Earthen, trapezoidal channel	
2. Diatmet delivery Canal	3 219	Rectangular canal built of cut stones	section cut into the rocks
3. Diatmet delivery pipe	4 067	2 of 2,500 mm	One to be installed in Phase 1
4. Principal canal common trunk	157 207	canal coated with concrete	With impermeable membrane
5. Banghadj delivery canal 5.1 5.2	 2 221 1 804	canal coated with concrete. canal built of re-inforced concrete	With membrane
6. Banghadj delivery pipe	16 753	2 pipes of 2 000 m	One to be installed during the first Phase
7. Thies Canal	2 195	canal of re-inforced concrete	
8. Secondary irrigation Canal	78 600	canal coated with concrete	Without impermeable membrane.

FIG. N° 2 : CONSTRUCTION SCHEME



REPUBLIC OF SENEGAL

CAYOR CANAL

OVERALL PLAN

The longitudinal section of the Canal is trapezoidal in form. It is rectangular and closed, for cylindrical sections connected with drainage ; or open rectangular, when the properties of the terrain require a more resistant structure (proximity to underground aquifers).

The longitudinal sections and capacity of the Canal are as follows :

<u>Principal Canal</u> : KP 0.1 to KP 161.3

	QP(m^3/s)	B(m)	b(m)	h(m)
Head Section	18.4	15.24	3.6	2.91
Final Section	11.8	14.74	2.3	3.11

<u>Secondary Canal</u> : KP 0.0 to KP 78.6

	QP(m^3/s)	B(m)	b(m)	h(m)
Head Section	4.3	9.5	2.9	1.65
Final Section	3.0	8.2	2.0	1.55

Longitudinal Section : Trapezoidal section
Q.P : discharge at head level of Canal
B : Width of Canal crest
b : Width of Canal floor
h : Total height of Canal

A few indicators give some idea of the extent of the project, which in time would necessitate the execution of :

- 15 million m^3 of embankment,
- 380.000 m^3 of concrete,
- 2.700.000 m^3 of impermeable membrane,
- 42 km of steel or cast-iron pipes of large diameter, (from 1 500 mm to 2 500 mm),

- 13 traverse sections through thalweg terrain, (4 for the principal canal and 9 for the secondary canal),

- 141 estetic works, whose distribution is as follows :

  * 29 bridges, 4 m wide (20 over the principal canal and 9 over the secondary canal)

  * 97 footbridges, 1.6 m wide (70 over the principal canal and 27 over the secondary canal)

  * 2 railway bridges (1 over the principal canal and 1 over the main highway)

  * 12 road works (crossings over the principal highway).

- 2 lateritic tarmacs, 7 m and 3 m wide by 240 km long, for maintenance and use,

- 3 pumping stations of a total output of 28.200 kw ,

- 1 water treatment plant of capacity 10 m^3/s,

- 2 tree-screen wind-breaks, 40 m wide, from either side of the canal and along its entire length,

- 5 exploitation centers, including the pumping stations.

V/. DESCRIPTION OF THE CONSTRUCTIONS

A more detailed description is given in this section, which also includes the technical characteristics of the most important constructions. The dimensions of the latter were obtained from detailed pre-project studies.

5.1 The head water constructions

a) The catchment construction across the Merinaguene dam will be fitted with two mobile sluice gates at the down-stream end ; three compartment - type shut off gates and four coffer dams (sheet piles).

Design discharge : 26 m^3/s
Minimum discharge : 0.1 m^3/s.

b) Ferlo Channel : Earthen Channel

* uncoated trapezoidal section

- length : 17.135 m
- width of ceiling : 53 m
- the ceiling level at head level passes from (-1.3) to (-3.01) at its down-stream extremity
- slope : 0.0001 m/m
- normal water level 1.20 taking into account sand level : 0.10 m
- max speed : 0.4 m/s
- slope of river bank : 5 H for IV.

c) Delivery Canal : (between the ancient ferlo river bed and the Diatmet station)

- length : 3 219 m
- width at ceiling : 12 m

- slope : 0.0001 m/m
- slope of rocky river bank : 3 H for IV
- dimensions of the canal floor : (-4.51) head of canal
  : (-4.83) end of canal
- max water surface level at Q = 0 : (-0.10)
- max water surface level at Qmax : at head of canal : (-1.81)
- max water surface level at Qmax : at end of canal : (-2.13)
- head water discharge : 18.43 m^3/s
- maximum speed : 0.59 m/s.

The berms of the dam, of widths 4 m and 3 m are included in the figures.

5.2 The Principal Canal

This is sub-divided into several sub-canals, regulated from the catchment source. The type of Canal section is trapezoidal, with a river bank slope of 2 H/IV (Zin I) and a general slope of 10 cm/m.

The hydraulic characteristics of each principal canal section type are summarised on table n° 8, taking into account, variations in discharge resulting from the non-continous nature of agricultural withdrawals. The characteristics were calculated from mathematical models. (manning-strickler's formula).

5.21 The principal canal coating

The choice of the canal coating is determinant for the success and cost of the project. Using APS data as base, general studies undertaken in the APD, permitted the comparison, (from a techno-economic view point), of concrete coatings, with those in which the impermeability is guaranteed by a membrane, protected by a concrete coating.

The choice of coating "with" membrane, has the advantage of substantially reducing water loss from the canal and hence reducing loss of discharge, commensurately.

The principal canal will therefore be surfaced with a layer of cement, (un-re-inforced), 8 cm thick, except for the first 500 metres, which are 14 cm thick. This concrete layer which protects the canal against vandalism and adverse climate, covers the impermeable "geo-membrane" and "geotexiles" complex.

At a higher level the geomembrane is protected from the charges transmitted by the concrete coating by a geotextile, which also has drainage properties.

At a lower level, in contact with the ground, another geotextile serves to protect the membrane from the ruggedness of the ground and drains water lost eventually from the geomembrane.

Impermeable membranes must be made of two types of materials: elastomers and plastomers.

The concrete is constructed partly from gravel, obtained from basalt quarries of the DIAK in the Thies region, (these quarries being the only ones in the neighbouring zone which can supply good quality, consistent material) ; and partly from sand obtained from well selected varieties fringing the coastal beaches.

TABLE N° 8 : THE HYDRAULIC CHARACTERISTICS OF THE PRINCIPAL CANAL

Q.P : Nominal discharge at head of Canal in (m^3/s)
B : Width of Canal floor in (m)
H : Total height of Canal in (m)
h 65 : Normal height of water, for K = 65
h 55 : Normal height of water, for K = 55
FB 65 : Compensation for ruggedness k = 65 in cm
FB 55 : Compensation for ruggedness k = 55 in cm

Kilometric Point (K.P)	QP m3/s	B m	H m	H65 m	H55 m	FB65 cm	B55 cm
0 -0.1*	18.4	9.0	2.90	2.37	2.76	58	19
0.1-55.5	18.4	3.6	2.91	2.53	2.76	38	15
55.5- 96.1	17.8	3.5	2.90	2.52	2.74	38	16
96.1-157.0	16.7	3.0	2.90	2.53	2.75	37	15
157.1-157.2*	16.7	8.35	2.90	2.53	2.75	37	15
canal d'amenée Banghadj							
157.2-161.3	16.7	2.30	3.11	2.28	2.48	80 $	60 $
canal d'amenée réserve Thies (µ)							
177.8-178.6µ	10.2	4.60	2.76	2.22	2.44	32	22
178.6-179.8@	10.2	4.60	2.60	2.10	2.27	50	33

* : Attention : section at fixed dimensions rectangled profile
$: Pumped discharge, Nil. FB65 and FB55 are only 0.15 m
µ : Attention : rectangular section
@ : Attention : fixed dimensions (rectangular)

Construction joints (transverse, longitudinal) and expansion joints are anticipated ; hence due allowance has been made for technical constraints, such as construction of the concrete, thermal variations and expansion of slabs.

5.22 Profile and protection of Canal

Protection of the Canal against "sanding" due mainly to eolian erosion, will consist of a classical tree-windbreak. The most current and certainly the most appropriate for the zone are :

- inert wind-breaks such as hedges of "salane"
- live wind-breaks such as trees and/or shrubs.

The emplacement of the salanes, immediatly after completion of the Canal, helps to stabilize the excavation untill the wind-breaks which preserve the canal from sand storms and runoff, can take over.

The complete protection of the canal by wind-breaks will cover at least 300 metres (150 m on both banks of the canal).

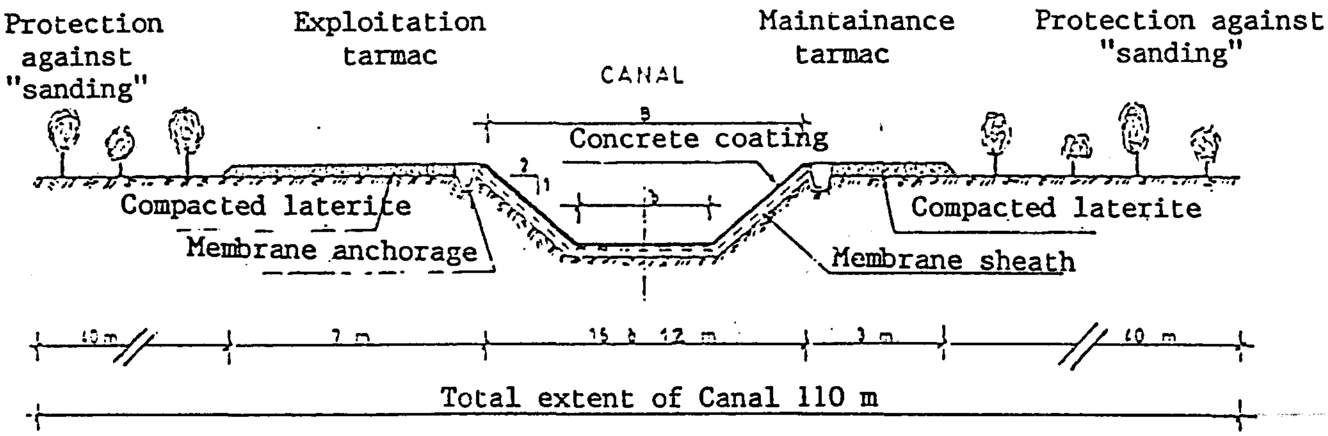
The transverse profile across the canal will comprise :

- on the east bank, an exploitation and maintenance tarmac 4.0 m wide

- on the other bank, (west bank), an exploitation and maintenance tarmac 8.0 m wide.

These tarmacs will be situated on the upper slopes of the canal.

FIG. N° 3 : TRANSVERSE SECTION OF THE CANAL



5.3 The Secondary irrigation Canal

The whole length of the irrigation canal is regulated at the downstream end, where there are (q) canal bays.

- 5 primary canal bays at the catchment end of the somone station

- 4 other bays at the downstream end of the Somone delivery pipe.

The secondary canal which lacks a membrane, has a coating of un-reinforced concrete slabs, 10 cm thick. Allowance has been made for contraction and expansion joints.

The section type is trapezoidal, the general slope being 10 cm / 1 cm. Exploitation and maintenance tarmacs, 4 m and 8 m wide are constructed along the canal.

The characteristics of the running section of the irrigation canal from KP 0.0 to PK 78.6 are recorded on stable n° 9, below.

TABLE N° 9 : HYDRAULIC CHARACTERISTICS OF THE SECONDARY CANAL

Kilometric Point (K.P)	OP m3/s	B m	H m	H65 m	H55 m	FB65 cm	B55 cm
Somone canal, catchment end							
00.0 - 8.9	4.3	2.90	1.65	1.34	1.49	31	16
8.9 - 17.6	4.3	2.90	1.65	1.34	1.49	31	16
17.6 - 30.1	3.5	2.00	1.65	1.35	1.49	30	16
30.1 - 36.3	3.5	2.00	1.65	1.35	1.49	30	16
36.3 - 50.0	3.5	2.00	1.65	1.35	1.49	30	16
Somone canal, downstream end							
51.6 - 51.7*	3.0	4.80	1.55	1.15	1.39	40	16
51.7 - 58.6	3.0	2.00	1.55	1.25	1.39	30	16
58.6 - 65.1	3.0	2.00	1.55	1.25	1.39	30	16
65.1 - 73.3	3.0	2.00	1.55	1.25	1.39	30	16
73.3 - 78.6	3.0	2.00	1.55	1.25	1.39	30	16

* : Attention : section according to fixed dimensions.
Rectangular profile.

5.4 The pumping stations

The project comprises three pumping stations which guarantee the collection of all water entering the cylindrical section of the pre-ceeding canal :

- the DIATMET station collects all the water of the project, it is located on the down-stream end of the DIATMET Canal,

- the BANGHADJ station, at the summit of Thies hill, distributes water meant for the supply - distribution network of the Dakar region. It is situated at the bifurcation of the BANGHADJ (at KP 16/317, about 4 km after the bifurcation),

- The SOMONE station distributes water for irrigation in the Cape-Vert region. It is situated on the secondary canal, at KP 50.

The pumping stations are constructed on the same model ; consisting of a principal structure, rectangular in form, lying perpendicular to the canal section at the catchment end ; and perpendicular to the delivery pipes at the downstream end. Throughout its entire surface, the principal structure carries an elevated ceiling, on which the pump heads and bases of the motors are fixed. This forms underground, on only one half of the width, the suction tank of the pumps. The tank overflows towards the canal side of the principal structure, thus forming a rectangular open air basin.

The delivery pipes, will in principle be of steel, protected internally and externally ; considering their large diameters. The cast iron material used, (ductile), can be selected for the Banghadj delivery pipes (2 ϕ 2000) and those of the Somone (1 ϕ 1500).

The two pipes serving the same stations (Diatmet and Banghadj), will be emplaced at sufficient distances to avoid any pertubation with the first pipe.

<u>TABLE 10</u> : BELOW SUMMARISES THE TECHNICAL CHARACTERISTICS OF THE PUMPING STATIONS.

	DIATMET	BANGHADJ	SOMONE
Installed capacity (kw)	13 800	13 200	1 200
Number of final groups	6 + 2	6 + 2	3 + 1
Number of 1st phase group	3 + 1	3 + 1	3 + 1
Nominal discharge (m^3/s)	3.07	1.7	0.82
HMT (m)	56	88	33.5
Project discharge (m^3/s)	18.4	10.2	2.46
Normal water level (m)	40	89	49
Width of delivery pipe (mm)	2 x 2500	2 x 2000	1 x 1500
Length (m)	4 010	16 600	1 230
Nature	steel	steel	steel
Rotation speed (t/m)	740	980	980
Nominal absorbed capacity (kw)	2 060	1 730	340
Maximum aborped capacity (kw)	2 175	2 050	365
Out-put %	>or= 82	>or= 85	>or= 79
Optimal immersion (Q and HMT given)	<or= 1.5	<or= 1.5	<or= 1.5m
Electric motor			
Type			
Nominal capacity (kw)	2 300	2 200	400
Start	direct at fut vol-tage.	id	id

The pumps will be of the centrifugal type, submerged in the suction tank, with distribution at a higher level, equal to that of the delivery pipes.

In principle, Pressure - discharge relationships for the different systems can come into play, depending on the number of groups functioning. the output of the pumps should remain at least equal to 80 %.

The motors will be the tropicalised, vertical axis type, of 5.5 kw voltage ; and direct starting mechanism. They are fixed at the top of the pumps and mounted on bases, which are fixed on to the upper ceiling of the stations.

The motors and pumps will be placed in a closed compartment, considering the sand-winds blowing regularly in the region.

However, some solutions, involving out-door motors, with re-inforced protection of type IP55 could be considered.

The re-inforced protection, ("anti-belier"), for the Diatmet station comprises :

- 5 air/water acculators in series, having a total volume of 400 m^3, including 200 m^3 of air under normal functioning conditions,

- an equilibrium shaft, 30 m high and 6 m wide (interior diameter), is constructed at an elevated point on the pipes
  (+ 26 000 m), approximately mid-way along the tracing.

For the Banghadj station

- 5 air/water accumulators in series, having a total volume of 700 m^3, including 350 m^3 of air, under normal functioning conditions,

- air inlet valves, with doubled sonic cleansers, constructed on the pipes at an elevated point, (level 82), about 200 m from the end of the tracing and which could also be located in a depression.

For the Somone station

- an arrangement of 3 air/water accumulators, having a total volume of 75 m^3, including 35 m^3 of air under normal functioning conditions, identical with that of the Diatmet station.

5.5 Storage of crude (un-treated) water

The un-treated water reservoir is located in the immediate surroundings of Thies, some 3 km west of the Ecole Polytechnique de Thies. It will occupy, at maximum storage, a surface area of 65 ha.

The storage site was selected on the basis of its geology and morphology, which proved adequate for the retention of a volume of 6 million m^3 of water.

The reserve has two objectives :

- to contribute to the permanent regulation of discharge from the combined storage - water treatment plant of the Canal,

- to serve as a loose security in the provision of potable water for Dakar region, in case the project ends abrubtly.

The first objective requires an effective volume of 500.000 m^3, while the second will require a storage of crude water equivalent to 7 days consumption, having a total capacity of 6 million m^3, including the 500.000 m^3 reserved for regulation.

The reserve is supplied from the Banghadj pumping station, through a distribution pipe and at the last cylindrical section, through an open canal 1.9 km long.

The following constructions are included in the programme of the downstream end construction of the canal, for water storage :

The principal confining dam ; a secondary dam ; a spill way ; and a water tower, for water supply to the treatment plant.

5.51 <u>The principal and secondary confining dams</u>

The principal dam closes the valley, using the two hills as abutments. It will be an earth-type dam, with the central core composed of fine grained laterite ; and the outer core of a more coarse grained laterite.

A sand filter will be used on the down-stream end ; while the catchment facing will be protected by cut stones and rocks. Its characteristics are :

- crest elevation : 90 m
- length of crest : 360 m
- maximum height : 29 m
- catchment slope : IV for 3H (1 in 3)
- downstream end slope : IV for 2.5 H (1 in 2.5)

- maximum width at ground level : 160 m.

At the base of the dam is an outlet, composed of a 1.5 m diameter pipe.

The neck of the spillway, (approved by the APS), was located at a level lower than the maximum height of the reservoir. It was therefore decided to seal the neck by a secondary dam and re-locate the spillway.

The secondary dam is a zoned-dam, with a central core of low permeability. It is composed of compacted laterite ; with a downstream end filter and a catchment facing, protected by cut stones and rocks. Its characteristics are :

- crest elevation level : 90 m
- length of crest : 55 m
- maximum height : 305 m
- catchment end and downstrream end slopes : IV for 1H (1 in 1)
- width : 4 m.

Materials for the construction of the dams are derived on the one hand, from burrowed zones ; (natural materials such as laterites and beach sand), and on the other hand from the processing of quarried blocks of rocks by crushing.

5.52 <u>The spillway</u>

The water reservoir is situated below a small catchment basin. It is equiped with a security spillway in the secondary canal and the two canal locks.

The construction is a water evacuator whose shelf-threshold level coincides with a channel. The axis of the channel is perpendicular to the shelf (frontal funnelling). The spillway will permit the evacuation of :

- flood waters, when the treatment plant has stoped treating water for 24 hrs. The evacuator must then get rid of excess water and the discharge of 10 m^3/s brought in by the canal,

- the millenary flood-water, when the treatment plant is functioning.

The "too full" level is at an elevation of 88 m, which is the maximum water level in the reservoir. The width of spillway recommended is 15 m. The height of water above the maximum water level of the reservoir, will attain 0.77 m, hence a level of 88.77 m.

The flood water evacuator consists of a delivery canal and a restoration canal.

The delivery canal has two sections, one serving to direct the water flow towards the evacuator and the second towards the shelf of the spillway. The floor level of the second canal must not exceed 87 m.

5.53 **The water tower**

The water tower is installed in the water reservoir. It serves as a transition structure between the water reserve and the junction canal, which conducts water to the treatment plant. Its cylindrical concrete structure has a height of 39 m and an exterior diameter of 19 m.

In order to obtain the best circulation of water in the reserve, 9 openings at 3 diffetrent levels ; (at the bottom of the tower = + 65 m, at +72 m and at +79.5 m), each 2 m by 4 m, permit the entry of water at one or different depths in the reserve.

Water leaves the tower through a collecting channel constructed in the interior of the tower, close to the junction canal. For gravitational water distribution, the channel is equiped with gates.

Exceptionnally, when the level of water in the reservoir no longer permits gravitational distribution, the pumps are then used to pump water into the collecting channels.

Six identical pumps, with vertical axis will be employed, (discharge = 1.66 m^2/s and HMT = 15 m). Three will be installed during phase 1, two during phase 2, and another during phase 3.

The hydraulic constructions

The hydraulic constructions connected with the reservoir include, the out-let canal, the delivery canals, which bring water into the reservoir, the by-pass canal and the junction canal between the water tower and its intersection with the by-pass canal.

The out-let canal is an open canal, with a trapezoidal section, which can transport the discharge of phase 3 (10 m^3/s). This branches after 2 km, into two delivery canals which can transport the total discharge of the out-let canal.

The by-pass canal is an open canal, with a trapezoidal section, built to transport the discharge (10 m^3/s), of the outlet canal ; into the junction canal. When the by-pass canal is being used, the discharge provided by the Banghadj pumping station must correspond with the discharge required at the treatment plant.

The geometrical characteristics of the canals are presented in the following table.

TABLE 11 : GEOMETRICAL CHARACTERISTICS OF THE CANALS

	Out-let canal	Delivery Canal	By-pass Canal	Junction Canal
Trapezoidal section				
- width (m)	1.5	1.00	1.5	-
- slope of wall V/H	1/1.5	1/1.5	1/1.5	
- slope of canal (%)	0.01	0.01	0.03	
Rectangular section				
- width	4.5	3.00	4.5	4.5
- slope (%)	0.01	0.01	0.03	0.03

5.6 Miscellaneous constructions

These constructions are either incorporated in the longitudinal section of the canal, which they intersperse, (out-let, drainage and sectioning constructions, traverses across thalweg terrain, water supply constructions for irrigation) ; or are assembled, leaving the rectangular canal section free, though eventually modified. (crossing above the latter) ; (road bridges, footbridges, railway bridges). Due to their importance, the thalwegs will be traversed by a section of the canal (rectangular), installed on an embankment or on a canal bridge.

In the first case, water is channelled by means of tubes across the embankment. In the second case, the initial section of the thalweg is preserved and the flow is not modified. In both cases, necessary precautions must be taken to guarantee a lengthy service life.

The Somone station will be traversed by a buried section of the canal, without discrupting the catchment and downstream end sections and leaving the river bed free. The railway crossings, (three in all), will be constructed, leaving the existing, leaving the existing line intact and without modifying the profile.

5.7 <u>The water treatment plant</u>

The water treatment plant which is connected to the reservoir by the by-pass canal, is situated less than 2 km south east of the reservoir, exactly to the north of road N° 2 and the Dakar-Thies railway line.

The treatment plant will occupy a surface area of 23.5 ha. The following 3 zones are envisaged :

- the Administrative zone and that which handles chemical products (occupying 24.000 m^2),

- the treatment-chain zone, which will be developed in 3 phases at the rate of 22.000 m^2/phase, giving 66.000 m^2 at the final phase,

- the mud-treatment zone, also planned at the rate of 48.300 m^2/phase, giving a total of 145.000 m^2.

The surface area is larger than that estimated by the A.P.S studies, which did not take into consideration the area required for mud treatment.

The foundation dimensions for the structure of the treatment plant, including those for the junction canal, are determined by considering the vertical overburden pressure due to an quifer situated at the ground surface.

The choice and number of equipments are determined on the basis of three essential constraints, namely the reduction :

- of the number of equipments,
- the dead spaces within the site,
- the effect produced by break down of an equipment.

Eight chains were therefore planned, offering an equilibrium between the number of equipments and their capacities to whithstand overloading.

5.71 Scheme explaining treatment procedure and principle

The treatment chain, whose main set-up is similar to the Ngnith plant, consits of the following processes : deflocculation, fine sieving, pre-oxydation with potassuim permanganate, decantation by elimination, rapid filtration and lastly, disinfection and water distribution.

The eight treatment chains envisaged will safeguard proper functioning. In case there is stoppage on one of the chains, the adjacent equipments can take an overload of 12 % without posing any serious threat to the operation and maintaining a water quality, consistent with the standard required.

The functioning of the station is semi-automatic, with central supervision of operations and decentralised controll of equipments.

The different phases of the treatment process are as follows:

a) Pre-treatment

1) Deflocculation :

To prevent floating debris from entring the plant and hampering the functioning of the downstream equipments, an automatic system of deflocculation cleansing will be installed. Meshes composed of galvanised steel bars, spaced at 20 mm, are installed in the junction canal of the station.

The residus collected are then transported to a sanitary disposal site.

2) Sieving

Micro-sieving will be employed to reduce the heavy load of matter in suspension ; to preserve the pre-oxydation equipments and decanters ; and to minimise consumption of chemicals.

The water passes through sieves made of inoxydable steel wire mesh having a mesh size of 180 microns. The sieves have an automatic washing system.

The design output of each deflocculator and sieve is 3.33 m^3. The maximum out-put is 5 m^3/s. three deflocculators and three sieves will be provided.

The installation of a sheet-pile (coffer dam), at the catchment end of each deflocculator and at the down-stream end of each sieve, will help isolate all the deflocculator and sieves for maintainance etc. The sheet pile (coffer dam), will be installed as from PhaseI.

To guarantee uptimal dosage of chemicals necessary for the water treatment during each Phase I, a pershall canal is integrated into the delivery canal, conveying deflocculated and sieved water to the potassium permanganate contact basins.

b) Pre-oxydation

The use of potassium permanganate for the pre-oxydation was recommended by surveys. This choice makes the use of contact bassins, unecessary for the water coming from lake guiers. A contact basin is neverthless planned to counteract any eventual degradation of the water during its transportation and storage in the reservoir.

The potassium permanganate is introduced at a nominal dosage of 2 mg/l through the mouth of the contact basins, which will have a volume of 6.400 m^3 in Phase I and 19.200 m^3 in Phase III. The nominal contact time is 30 minutes.

The dosage rate will be 1.6 m^3/h in Phase I and 4.8 m^3/h in Phase III.

Each contact basin system has an effective volume of 800 m^3 and is divided into two basins so that it can be drained, without bringing the treatment chain to a complete stop.

c) Decantation

The equipments to be used include the rapid mixer and the centrifuge.

Eight (8) rapid mixers with a unitary volume of 28 m^3 will be employed. Each mixer unit has a helical agitator of 7.5 kw power.

For the formation of flocs, 8 modules, having a unitary volume of 400 m^3 and a centrifugal power of between 150 and 1 400 kw are installed.

Each module is compartmentalised into 3 chambers, arranged in series, to limit hydraulic short circuiting.

The water is centrifuged in order to eliminate particles in suspension by permitting their decantation.

The study approved the choice of a mud-contact decanter, which has the advantage of attaining increasingly high speeds and obtaining a reduced surface of decantation; A flux of 3 $m^3/h/m^2$ can be used for a total surface area of 4 255 m^2 (Phase I).

d) <u>Filtration</u>

A rapid system of filtration is envisaged. This system based on a single layer of sand, has a flux of 7.7 $m^3/n/m^3$. The filters are washed periodically by simultaneous injection of air and water.

e) <u>Disinfection</u>

Between filtration and distribution, the water is chlorinated to destroy all bacteria and to remove all taste, odour and residual colour. The chlorination approved is chlorine dioxyde, which remains active, even after a long stay in the tubing.

The rate of solution is 19.2 m^3/n in Phase I and 57.6 m^3/n in Phase III. The volume of a contact basin is 6 495 m^3.

f) <u>Storage of treated water</u>

The water thus treated is stored in reservoirs, having a capacity of 24.000 m^3. One reservoir is constructed for each of the phases; Water is conveyed to Dakar either by gravily, (departure level : 79 m) or by pumping ; (36.000 m^3/h in Phase III) ; with a supply pressure corresponding to a departure level of 105 m. The latter type of equipment comprises six groups of generators, (2 per phase), an emergency electrical network and an automatic starter system.

g) Mud-treatment

The treatment plant generates mud and solides. The detritus can be buried directly, while the mud, (1 % solid and 99 % liquid), is condensed to a consistency of 3 % in four condensers ; built for the process. The condensers have a diameter of 33 m, a height of 4 m ; giving a unitary volume of 3421 m^3.

The condensed mud is dehydrated by evaporation, untill a layer 400 m thick is formed. It is then transported to the disposal site.

5.8 Provision of electric energy

Considering the important electrical demand of the pumping stations of the project, the Cayor Canal Project will in time, become one of the most important, if not the only important consumer of energy in Senegal . The installed output of the principal pumping stations at cruising periods, will be in the order of 25 megawatts and its annual consumption of energy will be 30 G.WH.

Under such conditions, the energy needs of the project must be incorporated into the country's national policy on the subject, which is characterised by the future generation of hydro-electric power from the Manantali dam (in Mali), to the areas of consumption. The electrical power at Senegal's desposal, could, at least in the short term, exceed its needs. Hence, the pumping stations could be supplied from the H.T. network projected for Senegal. The following solutions are presented :

a) Within the general framework of electrification of the country, Senegal electrifies a large area in the north on 225 kw, with a splitting-up post at Sakal, (or a near-by site), at about 20 km to the north-west of Louga.

b) From the station, lines of 90 kw will then supply Louga and the pumping station of the Cayor Canal at Diatmet. This line, as well as the transformer station at the extremity, would be under the project's controll. However, considering the likely delay in the installation of this new line, the first phase of the Diatmet station could be equiped with a thermal station as a temporary substitute of an electrical station at sakal ; the construction having been structured from the start, to be served by the SENELEC network.

c) The Banghadj pumping station could be supplied from the existing 90 kw Thies-Taïba line.

d) The Somone pumping station could be supplied from the existing MT 30 KW Thies - Sindia line, which passes near-by.

e) The water treatment plant and accompanying pumping station in the reservoir, could be supplied from the existing MT 30 kw lines which pass near-by.

5.9 The irrigation network

The different types of irrigation networks, corresponding to the different modes of irrigation imaginable, were considered during the pre-project studies under - "short term" or the first set of hydro-agricultural constructions envisaged for the project.

This first set consists of 5 plots disposed "en echelon", in the Cayor zone, (Nguer Malal, Gueoul,, Pekesse, Pire Gouyeye, Noto), over a surface area of 1,504 ha ; and in the Cape-Vert Zone, (Thiambokh), over a surface areea of 296 ha net (area occupied by "la petite propriété" and exploited by a serere group).

This area is considered representative of the different soil qualities and other constraints connected with irrigation.

Soils recognised as being apt for irrigation, (Cayor region), largely belong to the general sandy group, exemplified by attenuated dune sands ; ("dior-soils"), which are poor chemically and suitable only for small scale irrigation or sprinkling.

Soils in depressions and valleys, which were also encountered to the north and south of the region - "deck soils" or "deck-dior", in the local language, having a more or less sandy - clay texture, are slightly richer than the "Dior soils", but are subject to plugging and are only rarely homogenous, with no regular micro-relief. Gravitational irrigation should not however be ruled out for these soils.

In the Cape-Vert zone are argilicious soils, quite suitable for vegetable gardening, but are subject to localised erosions on slopes or in ravines. The irrigation modes considered are :

- mode localised by means of flexible or traditional tubings (improved gandiolais)

- classical sprinkling,
- pivot,
- drop - by - drop system.

The above irrigation modes are well known, with the exception of the localised flexible tubing or improved gandiolais. This mode is similar to irrigation by sprinkling that is widely practised in Senegal, but rendered easier, since no water transportation is involved. The area to be irrigated is divided into elimentary plots of 2 500 m^2 (50 m x 50 m) gross ; or 2 000 m^2 net, grouped in 1 ha sectors, (4 elimentary plots) and irrigation blocks - (40 sectors).

Each elimentary plot is served at its centre, by a sprinkler, (from which water is supplied at low pressure ; and from which it is irrigated by flexible tubing(s) of maximum length 35 m and having a discharge of 0.4 l/sec. Peak demands can be met by use of 4 flexible tubings, operating in one or more of the 4 elementary plots, which from a sector. The head discharge of each sector is limited at 1.6 l/sec.

Irrespective of the mode of irrigation employed, water is transported by pipes under pressure. It is therefore necessary to maintain a pressure head in the network, at the immediate exit of the Canal. The stations concerned with maintaining pressure, will be equiped, in a general way, with motorised pumps (between 3 to 5), consisting of diesel motors.

The regulation of pressure sources, will be achieved by changing the water level in an elevated reservoir, connected to the distribution pipes. This mode of regulation is the simplest and also the most burdensome. Others exist, which could be examined in detail under the framework of project execution./.