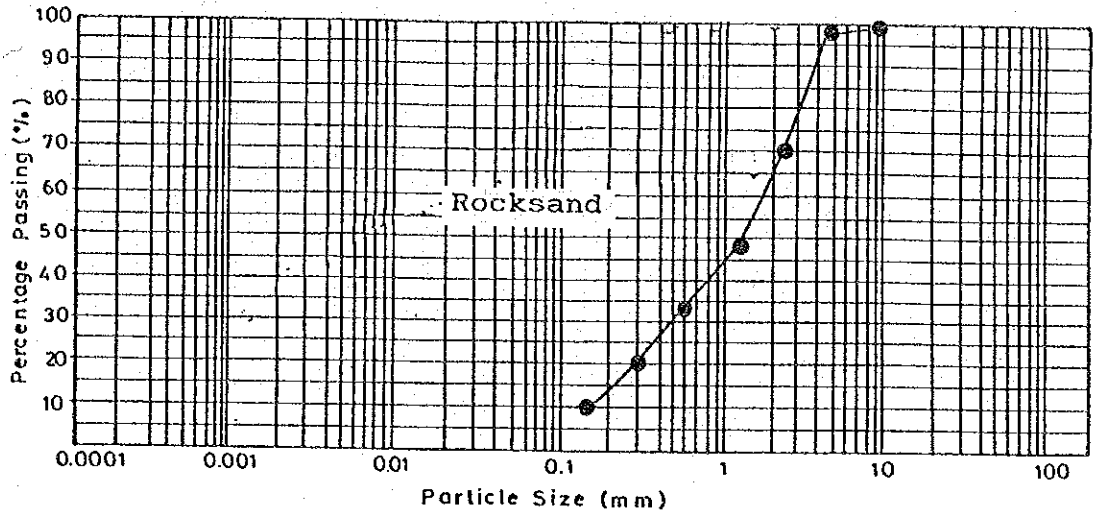
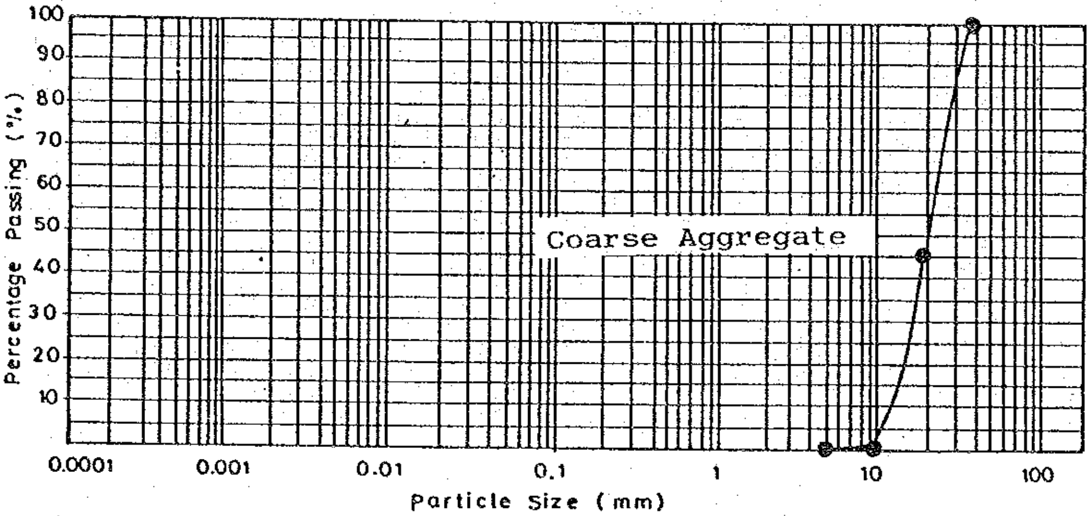
Fig. C.6





GRAIN SIZE ACCUMULATION CURVE OF ROCKSAND AND COARSE AGGREGATE PURCHASED FROM LOCAL SUPPLIER	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY

APPEDIX - D
COMPARATIVE STUDY ON ALTERNATIVE SCHEMES

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D.1 General

The optimum water supply plan is tried to be found through a comparative study on the conceivable alternative schemes. The comparative study consists of (i) selection of alternative water supply schemes for the comparative study, (ii) design and cost estimate on the alternative schemes to satisfy the water demand at the least cost, and (iii) comprehensive evaluation on the alternative schemes.

This Appendix-D presents all details of the above comparative study as well as recommendation for the selection of water supply plan.

D.2 Alternative Schemes for Water Source

D.2.1 Identification of Damsites

Various possible damsites are identified in the basin through the previous studies and reconnaissance by the JICA Study Team. Fig.D.2.1 indicates the location of all possible damsites identified so far. Table D.2.1 lists up the identified damsites and shows the approximate estimate of the elevations at the site, surface area of reservoir and possible storage capacity of reservoir for each damsite.

D.2.2 Selection of Alternative Damsites for Comparative Study

(1) General

The objective of the Project is to formulate the most suitable and economic water supply plan to meet the water demand of Port Louis City in the mid (2010) and long (2030) terms. The above most suitable and economic water supply plan is intended to be found out through a comparative study on the conceivable alternative plans as mentioned. Although numerous damsites are identified as mentioned in Section D.2.1 above, the following six (6) damsites are finally selected as the conceivable alternatives for the comparative study.

(i) G1 (Bocage-Guibies)

(ii) MO4 (Baptiste)

(iii) TRO

(iv) NWO

(v) TR9

(vi) CA2

The above six (6) damsites (schemes) for the comparative study are selected through the considerations and examinations as mentioned hereunder.

(2) Damsites with Small Storage Capacity

The examination on the water demand forecast and water balance in Port Louis City reveals that the required reservoir storage capacity to meet the water demand of Port Louis City in 2010 and 2030 will be 5 million m^3 and 6 million m^3 respectively.

Considering the application of small reservoir capacities as marked with * in Table D.2.1, numerous constructions of dams

(3) NW1, NW2, NW3, TRO and TR1 Sites

Five (5) damsites of NW1, NW2, NW3, TRO and TR1, those having an enough storage capacity for the demand, are the schemes based on the same idea: that is, those are the schemes to construct a large reservoir by utilizing the deep gorge near Soreze.

The careful reconnaissance and examinations on the topographical and geological conditions on the five sites select the site of TRO as most promising technically and economically as follows:

<u>NW1 and NW2:</u>

The river valley at NW1 and NW2 is relatively wider than other three (3) sites. The geological condition is also less attractive due to relatively high weathering and fractures in both abutments, resulting in higher construction cost.

NW3:

The present river valley at NW3 site seems to be slightly narrower as compared with NW2. However, this site has a thickly piled loose materials in the left abutment which was apparently caused by the collapse of left abutment, requiring its removal for dam construction and resulting in nearly same valley width as NW2. The geological condition at the left abutment of NW3 site will nearly be same as that at NW2 site.

TRO and TR1:

It was judged in the field reconnaissance that the geological condition at TRO and TR1 sites with relatively less weathering and fractures is much more favourable for dam construction, compared with NW1, NW2 and NW3 sites as mentioned. The valley width is also relatively narrower, resulting in reduction of dam volume and construction cost. In TR1 site, however, the right abutment is the land left between the Terre Rouge and Profonde rivers, forming the boundary between both river channels. Its thickness, which is estimated to be about 20 m at the top of land, is too thin and not suitable for the abutment of dam. Since TR1 site has such a technical problem as mentioned, TRO site is finally selected as most promising technically and economically out of five (5) damsites of NW1, NW2, NW3, TRO and TR1.

In this connection, an appropriate cost comparison is tried between NW3 and TRO sites for reference. As seen in Fig.D.2.2, TRO site will surely be more advantageous than NW3 site.

(4) G1 (Bocage-Guibies) and M04 (Baptiste)

G1 (Bocage-Guibies) and M04 (Baptiste), each having necessary storage capacity for the demand, are the schemes which have been taken up and examined in the past studies as one of the most promising schemes.

However, mainly due to insufficient investigations, the past studies have not yet clarified sufficiently various matters such as the detailed geological conditions, technical feasibility or construction cost, etc.

Therefore, it is required to confirm by clarifying the matters as mentioned above whether or not these two schemes can be the most suitable and economic one as the water supply plan for Port Louis City.

(5) NWO Site

NWO site which also has necessary storage capacity for the demand is identified as the damsite nearest to the Pailles treatment plant, making it possible to limit the cost of water transmission facilities to the minimum. The geological condition on both abutments of this site is not satisfactory with fractures, almost similar to NW1 site as mentioned. However, the site is considered possible to be one of the candidates in view of the cost saving in the transmission facilities.

(6) TR9 and CA2 Sites

These two sites will have rather small reservoir storage capacity of 1.5 to 2.5 million m^3 at maximum.
Thus, the water demand is not possible to be met with one of these schemes. However, the stage-wise construction of these smaller schemes to meet the growth of demand is considered to be one of the possible water supply plans to Port Louis City. Then, those should remain for examination.

D.3 Alternative Schemes for Water Transmission Facilities

D.3.1 General

In this Section, alternative plans of water transmission are presented and evaluated. This is for raw water transmission from the proposed dam sites to treatment plants; and each dam scheme will have some alternative transmission plans to be studied.

Water flow to be transmitted for treatment is tentatively estimated at 1.33 m^3/sec = 114,900 m^3/day.

In addition, a site for water treatment should be considered in connection with raw water transmission. Some transmission plans can place treatment facilities at new site, and others will limit the site of treatment into the existing Pailles Treatment Plant.

The four proposed dam schemes are outlined below:

Dam Scheme	River Impounded	Water (*) Level	Distance of Transmission
(A) Guibies Dam	Diversion from Moka River	HWL = +110 m LWL = + 95 m	3.5 km
(B) Baptiste Dam	Upstream of Moka River	HWL = +381 m LWL = +371 m	9 km
(C) Terre Rouge Dam	Terre Rouge River	HWL = +195 m LWL = +155 m	4 km
(D) Pailles Dam	Grand River North West	HWL = +107.5m LWL = + 75 m	1.5 km

(Note) - Ground elevation of the existing Pailles Treatment Plant = +70 m

- (*): Water Levels are tentatively assumed.

D.3.2 Alternative Plans (Drawings)

Alternative plans for water transmission from each dam site are shown in Fig.D.3.1 to D3.13 with drawings, and hydraulic profiles for transmission pipelines are given on representative alternatives. As seen in Fig.D.3.14 to D.3.17.

D.3.3 Description of Alternative Plans

Alternative plans for water transmission are described hereafter by each dam proposed and a comparison table is prepared at the tail of this section as a summary.

(A) Guibies Dam
(HWL=+110m, LWL=+95m)

This dam is located at the second nearest point and distance of water transmission is about 3.5 km. Water can be transmitted by gravity. Several ways of water transmission will be planned according to location of water treatment.

Case A-1

<Outline> (for A-1)

Transmission by gravity in condition of raw water up to the existing Pailles Treatment Plant from an intake tower at the dam, by way of a 900 mm diameter pipeline with distance of 3,400 m.

<Facilities to be Constructed> (for A-1)

- Pipeline	:	Ø 900 mm x L = 3,400 m
- River crossing	:	2 points
(- St. Louis Stream	:	Ø 900 x L = 25 m)
(- Mt. Ory Stream	:	Ø 900 x L = 15 m)
- Intake tower	:	1

<Brief Comments> (for A-1)

- Construction cost is estimated at the lowest.
  (Almost same as Case A-2, A-3, or D-1)

- Construction work is ordinary pipelaying work and will not give particular difficulty to construction.
  (Same as Case A-2 or A-3)

Case A-2 or Case A-3

<Outline> (for A-2, 3)

Water is to be treated at a new treatment plant nearby the dam.

The treated water will be transmitted by Ø 900 mm x L = 3,000 m pipeline and connected to existing treated water transmission mains at the foot of Pailles Hill.

Site of a new treatment plant is proposed on sugar cane field (Outgoing water level = + 70 m) located just nearby the dam (Case A-2), or on the hill (Outgoing water level = + 75 m) near Les Guibies Branch Road (Case A-3).

<Facilities to be Constructed> (for A-2, 3)

- Pipeline	:	Ø 900 mm x L = 3,000 m for treated water, and Ø 800 mm x L = 400 m for raw water
- River crossing (St. Louis Stream No. 2	:	1 point Ø 900 x L = 30 m)
- New treatment plant	:	Q = 1.33 m^3/sec

<Brief Comments> (for A-2, 3)

- Lowest construction cost.
  (Almost same as Case A-1 or D-1)

- No special difficulty in construction work.
  (Same as Case A-1)

- Possibility of new sites for water treatment other than the existing Pailles Treatment Plant.

(B) Baptiste Dam
(HWL = +381 m, LWL = +371 m)

This dam is located at the farthest point, and distance of water transmission is about 9 km. Impounded water level is highest among four dams schemes at HWL==381 m and LWL=+317 m, by which water can be gravitated with enough pressure. (As water pressure is too high in the case of a direct transmission pipeline, construction of break-pressure tanks is needed in order to reduce the high pressure).

Case B-1

<Outline> (for B-1)

Long distance transmission pipeline Ø 800 mm x L = 9 km) from the dam by direct intake through an intake tower to be installed at the dam, by way of gravity flow.

The route will take Bois Cheri Road and Montagne Ory Road towards west, and meet the Highway; and going northwards being along the Highway. Then, raw water will arrive at a new treatment plant site proposed on present sugar cane field nearby Pailles Conjunction Road.

The raw water is to be treated there with process of rapid sand filtration. Treated water will be transmitted to the existing reservoirs. (About a half quantity will be led to the existing reservoirs in Pailles T. Plant, and the remaining to the existing mains nearby Pailles Hill).

<Facilities to be Constructed> (for B-1)

- Pipeline	:	Ø 800 mm x L = 8,400 m for raw water, and Ø 600 mm x L = 2,100 m for treated water
- Break-pressure tank	:	4 places (RC made)
- River Crossing	:	5 points
(- Moka River	:	Ø 800 x L = 40 m)
(- Moka River	:	Ø 800 x L = 60 m)
(- St. Louis Stream	:	Ø 600 x L = 25 m)
(- St. Louis Stream No.2	:	Ø 600 x L = 30 m)
(- Mt. Ory Stream	:	Ø 600 x L = 15 m)
- Intake tower	:	1 point
- New treatment plant	:	Q = 1.33 m^3/sec

(or augmentation of the existing Pailles T. Plant)

<Brief Comments> (for B-1)

- Longest distance of transmission.
- Highest construction costs.
- Highest water pressure.
- No special difficulty in construction work.
- Construction period will take the longest; however it can be within the period of dam construction.
- As water pressure in the pipeline is very high (about 200 m),

break-pressure tanks should be installed at 4 points on the way.

- Treatment plant can be located on a new site (present sugarcane field) along the Highway, or on the existing Pailles Treatment Plant.)

Case B-2

<Outline> (for B-2)

Impounded water will be released from the dam reservoir into original Moka River, and flow down to Grand River North West. Intake will be made at the existing Municipal Dyke and raw water will be transmitted to the Pailles Treatment Plant by gravity through a new pipeline of Ø 1,100 mm x L = 2,000 m which will be installed in parallel with the existing Municipal Pipelines.

<Facilities to be Constructed> (for B-2)

- Pipeline : Ø 1,100 mm x L = 2,000 m

<Brief Comments> (for B-2)

- Construction cost is higher than Case A or D, however much lower than Case B-1 or B-3.

- Although a pipeline will be forced to be installed along/in the rocky valley, a route of the existing pipelines will be utilised for installation of the proposed pipeline.

- Location of water treatment will be limited to the Pailles Treatment Plant.

- As the released water will be mixed with other river flows, raw water for treatment would have higher turbidity in heavy rainy days. This problem however can be solved by employment of rapid sand filtration process of treatment.

- It may, or may not, happen to some extent that the released water will be leaked through river bed and/or taken for other purposes on the way to the Municipal Dyke.

- Existing transmission pipelines (Municipal Pipelines) of 27"/19"/18" linking Municipal Dyke and Pailles Treatment Plant will be unused after a new pipeline's installation, because they have been already deriorated and give much leakage currently.

Case B-3

<Outline> (for B-3)

This plan is categorized between Case B-1 and Case B-2. Impounded water will be released firstly into original Moka River flow. The water will be taken by a pipeline at some middle point between Municipal Dyke and Baptiste Dam, on the Moka River. The pipeline of 800 mm diameter with gravity flow will take a route along slope of Moka River Valley for about 2 km upto near Soreze Fall; then go up to the Highway. thereafter it will take some routes Case B-1.

<Facilities to be Constructed> (for B-3)

- Pipeline	:	Ø 800 mm x L - 4,300 m for raw water, and Ø 600 mm x L = 2,100 for treated water
- Break-pressure tank	:	2 places
- Intake dyke	:	1
- River crossing	:	3 points
(-St. Louis Stream	:	Ø 600 x L = 25 m)
(-St. Louis Stream No. 2	:	Ø 600 x L = 30 m)
(-Mr. Ory Stream	:	Ø 600 x L = 15 m)

<Brief Comments> (for B-3)

- Construction cost ranges between Case B-1 and B-2

- Installation work of the pipeline between intake dyke and the Highway, about 2 km, will be rather difficult, because it is to be on slope of Moka River Valley. (There exists an open concrete channel, 0.42 m wide and 0.45 m deep, on the proposed route).

- Water loss and deterioration of quality will be minor, even if any.

- Location and ground elevation of a new treatment plant will be at choice.

(C) Terre Rouge Dam
(HWL=+195 m, LWL=+155 m)

This dam is located at the second farthest site making transmission distance about 4 km; and its water level takes the second highest (HWL=+195m, LWL=+155m). Regarding water transmission, a pumping-up method (Case C-1) will be planned as well as the gravity flow method (Case C-2 or C-3).

Case C-1

<Outline> (for C-1)

Pumping-up method.
Impounded water will be lifted up firstly by way of intake pumps and a rising main (Ø 1,000 mm) to a receiving tank to be located on present sugar cane field nearby the right bank of the proposed Terre Rouge Dam.

From the receiving tank with water level of +245 m, water is transmitted by gravity through a pipeline (Ø 800 mm) along the Highway, taking same way as Case B-1 of Baptiste Scheme.

<Facilities to be Constructed> (for C-1)

- Pipeline : Ø 1,000 mm x L = 400 m for rising main, Ø 800 mm x L = 3,300 m for raw water, and Ø 600 mm x L = 2,100 m for treated water.

- Intake pumps : 600 KW x 4units (including one unit for standby)

- Pumping house and electrical facility for the pumps: 1 lot

- Intake tower : 1 (RC made)

- Receiving tank : 1 place (RC made)

- B tank : 2 places (RC made)

- Valley/river crossing : 4 points
  (- Valley of Moka River : Ø 800 x L = 120 m)
  (- St. Louis Stream : Ø 600 x L = 25 m)
  (- St. Louis Stream No.2: Ø 600 x L = 30 m)
  (- Mt. Ory Stream : Ø 600 x L = 15 m)

- New treatment plant : Q = 1.33 m^3/sec
  (or augmentation of existing Pailles T. Plant)

<Brief Comments> (for C-1)

- Construction cost will take the second highest ranked next to Case B-1.

- Transmission pipeline requires construction of break-pressure tanks at 2 points on the way, since water head is much high as 150 m.

- Running power load of intake pumps will be as large as 1,800 kwh, and capacity and facility of the power supply will have difficulty to some extent.

- Power cost of pump operation will be extremely high, resulting in higher water cost.

- The power of electric energy for pumping-up could be considered a kind of wastage from a certain standpoint.

- The pumps will be apt to have technical problem of water hammer due to the steep hydraulic gradient profile of the rising main and high lifting head as about 100 m.

- Construction of pipe bridge crossing deep valley of Moka River, Ø 800mm x L = 120 m, will be comparatively difficult.

- Location and ground elevation of a new treatment plant will be at choice. (Either the existing Pailles T. Plant or sugar cane field nearby the Highway).

<u>Case C-2</u>

<Outline> (for C-2)

Water impounded in Terre Rouge Dam reservoir will be released into Terre Rouge River and flow down to be mixed with other rivers forming Grand River North West. Then, at the Municipal Dyke, water will be taken by a new pipeline 1,100 mm and led to the existing Pailles Treatment Plant by gravity. (This plan is same as Case B-2).

<Facilities to be Constructed> (for C-2)

- Pipeline : Ø 1,100 mm x L = 2,000 m
  (Same as Case B-2)

<Brief Comments> (for C-2)
(Same as Case B-2)

Case C-3

<Outline> (for C-3)
Direct intake/transmission of impounded water by a transmission pipeline Ø 800 mm x L = 4,200 m to Pailles Treatment Plant via Municipal Dyke.
The pipeline route should be on/along deep valleys of Terre Rouge River and Grand River North West.

<Facilities to be Constructed> (for C-3)

- Pipeline : Ø 800 mm x L = 4,200 m
- Break-pressure tank : 1 place (RC made)
- Intake tower : 1 (RC made)

<Brief Comments> (for C-3)

- Construction cost will be lower than Case C-1, but more than double of Case C-2.

- Water will not be lost and water quality will not be changed, because of an exclusive transmission pipeline.

- Installation of the pipeline to be forced to be on/along rocky valley bed will have difficulty, particularly about 2,200 m distance from the dam site to the Municipal Dyke.

- Location of treatment plant will not be limited to the existing Pailles Treatment Plant, since the transmission pipeline will retain enough pressure which can transmit the raw water to a farther place.

(D) Pailles Dam
(HWL=+107.5 m, LWL=+75 m)

The dam located nearest from Pailles Treatment Plant, is proposed on the main stream of Grand River North West, near Pailles. A way of water transmission will be following one.

Case D-1

<Outline> (for D-1)

Raw water will be directly transmitted to the existing Pailles Treatment Plant from an intake tower to be constructed in the dam by way of a pipeline of Ø 1,000 mm x L = 1,400 m with gravity flow.

<Facilities to be Constructed> (for D-1)

- Pipeline : Ø 1,000 mm x L = 1,400 m
- intake tower : 1 (RC made)

<Brief Comments> (for D-1)

- Lowest construction cost, nearly equal to Case A-1, A-2 or A-3.

- Water quantity can be assured because of direct intake.

- The pipeline route will take along the existing Municipal Pipelines.

- Location of treatment will be limited only to the Pailles Treatment Plant.

D.3.4 Conclusion

From a standpoint of water transmission from dam sites proposed, the following conclusion can be provisionally given.

(1) Among the four proposed dam schemes, Guibies Scheme (Case A) is most preferable, because of the lowest construction cost and non-difficulty of construction cost and non-difficulty of construction work for water transmission.

(In addition, Guibies Scheme has an advantage that a treatment plant can be placed at a new site nearby the dam, other than the existing Pailles Treatment Plant).

(2) In the next place, Pailles Scheme (Case D) is preferable because of low construction cost.

(3) In the case of Terre Rouge Scheme (Case C), Case C-2 is recommendable.

(4) In the case of Baptiste Scheme (Case B), Case B-2 is recommendable.

D.4 Preliminary Design of Alternative Schemes

D.4.1 Dam Height

(1) General

Determination of dam height requires (i) the required storage capacity to meet the water demand, (ii) assessment of sedimentation in the reservoir, (iii) estimate of evaporation loss from the reservoir surface, (iv) determination of free board, etc.

Followings discuss about such factors as the sedimentation, evaporation and free board etc., which are necessary for determining the dam height.

(2) Sedimentation in the Reservoir

Very few data for assessing the sedimentation are available at this stage: that is, only data of suspended load for small discharges are available while the data for some big discharges are essential for estimating the sedimentation.

Since the data for exactly assessing the sedimentation are not sufficient as mentioned the sedimentation is approximately estimated with a formula which empirically gives an approximate amount of sedimentation based on the flood inflow volume, catchment area, of devastated land, and riverbed slope.

The above-mentioned formula gives a denudation rate of 0.3 mm/year for GRNW river basin, which is judged reasonable referring to the sedimentation measured in other basins with basin conditions similar GRNW river basin. Then, the sedimentation at each damsite is estimated based on the above denudation rate of 0.3 mm/year and respective catchment area. Table D.4.1 presents the estimated sedimentation at end damsite.

(3) Evaporation Loss from Reservoir Surface

The evaporation loss from reservoir surface, which should be taken into account in the necessary storage volume of reservoir, is assessed based on the average evaporation rate of 1,700 mm/year measured in Mauritius and the reservoir surface area.

The evaporation loss which should be counted for the necessary storage volume is assumed to be the evaporation for 100 days during which Port Louis City will require the water supply from the reservoir.

The evaporation loss calculated at each damsite are also shown in Table D.4.1.

(4) Free Board

The design criteria specify the free board above the design flood water level should consider the height of wave due to wind (or the height of wave due to earthquake), rise of water level due to unexpected accident in operating spillway gates and addition of allowance according to type and importance of dams.

The larger value of either the height of wave due to wind or the height of wave due to earthquake is applied, since there is rate probability that the design flood and earthquake occur simultaneously.

Besides the above, the design criteria also specify that the height of the free board shall not be less than the following values in consideration of uncertainties involved in the estimation of various factors and importance depending on the dam height and the reservoir capacity.

Height of Dam	Free Board (m) Concrete Dam	Fill Dam
Less than 50 m	1.0	2.0
50 m - 100 m	2.0	3.0
Over 100 m	2.5	2.5

The height of wave due to wind is calculated at around 0.5 m assuming the wind velocity of 30 m/S (ten minutes average) and fetch of 1,000 m. The height of wave due to earthquake in Mauritius is considered negligible or much less than the height of wave due to wind because mauritius has no record of earthquake or very small seismic coefficient of 0.05 or less is applicable for Mauritius.

The rise of water level due to unexpected accident of spillway gates is considered to be in proportion to the flood discharge and duration of the accident and to be in inverse proportion to the surface area of the reservoir and number of gates. But it is impossible to predict a specific value and also there exists an economical limit for the free board. Thus, its value is estimated by judgement taking into account the significance of the above factors. Its standard value is taken as about 0.5 m.

In the design of dam for Port Louis Water Supply Project, however, the installation of spillway gates will not be considered in principle in consideration of the difficulty of frequent and prompt operations of spillway gates and the safety of dam: that is, the dam is, in principle, designed with nongated spillway.

Thus, the rise of water level due to unexpected accident of spillway gates is not necessary to be taken in the free board.

The allowance of 1.0 m is given in addition to the above if the dam is of fill type. On the other hand, no allowance is considered for the concrete dam since the concrete dam will not be subject to so serious damage due to overtoping.

As discussed above, the sum of all the factors which should be taken into account for the free board, is less than the minimum values specified in the design criteria, resulting in the free board determined on the basis of the minimum values specified in the design criteria.

(5) Determination of Dam Height

Fig.D.4.1 to D.4.8 illustrate the determination of dam height at respective alternative damsites, applying the estimated sedimentation in the reservoir, necessary effective storage capacity for meeting the water demand, allowance for evaporation loss and necessary free board on the storage capacity curve.

As seen in the Figures, the respective alternative schemes should be provided with the following dam heights:

Alternative Schemes		Dam Type	Elevation of Riverbed (m)	Dam Crest Elevation (m)	Dam Height (m)
- GI(Bocage-Guibies)	:	Rockfill	70.1	109.0	38.9
- MO4(Baptiste)	:	Earthfill	360.0	383.0	23.0
- TRO	:	Rockfill	120.0	199.2	79.2
		Conc.	120.0	198.2	78.2
- NWO (Pailles)	:	Rockfill	45.7	117.2	71.5
		Conc.	45.7	116.2	70.5
- TR9 (2.3 MCM)	:	Earthfill	365.0	390.0	25.0
- TR9 (4.0 MCM)	:	Earthfill	360.0	390.0	30.0
- CA2	:	Earthfill	354.0	380.0	26.0

Notes: (i) As for the dam type, reference is made to section D.4.2.

(ii) The dam height at TR9 and CA2 sites is determined at topographically maximum scale.

D.4.2 Dam type and Dimensions

(1) Dam Type

Two types of the fill type dam (Rockfill dam with center core of Earthfill dam) and concrete gravity dam are taken into consideration as conceivable dam types for the Project.

At the damsites where the geological and topographic conditions allow the construction of concrete gravity dam, both types of the fill type dam and concrete gravity dam are examined in the comparative study.

However, at the sites where the construction of concrete gravity dam is considered difficult evidently in view of the geological or topographic condition, the examination is limited to the fill type dam.

The sites where the construction of concrete gravity dam is judged possible technically are two sites of TRO and NWO.

Selection of the rockfill type or earthfill type depends on the dam height, geology of foundation and cost of dam.

Dam types selected at the respective damsites for the comparative study are as follows:

Sites	Selected Dam Types
G1 (Bocage-Guibies) :	
Bocage	Concrete Weir
Guibies	Rockfill Dam
MO4 (Baptiste)	Earthfill Dam
TRO	Rockfill and Concrete Gravity Dam
NWO (Pailles)	Gravity Dam
TR9	Earthfill Dam
CA2	Earthfill Dam

(2) Dimensions of Dam

The determination of detailed dam dimensions requires the detailed property tests on dam materials, further detailed investigations on the geology of foundation, and dam stability analyses for various cases of conceivable loading conditions, etc.

On the one hand, an empirical determination of approximate dimensions is possible based on general investigations on the available dam materials and conditions of dam foundation. In view that a comparative study on the basis of such dimensions determined empirically will give a satisfactory answer for selecting an optimum scheme, the dam dimensions are determined based on the engineering judgement as follows:

Rockfill Dam

The hard old lava which is extensively distributed in the project area will be used for the rock material of rockfill dam. Assuming the above use of old lava for the rock material, the upstream and downstream slopes of rockfill dam are determined at 1:2.5 and 1:2.0 respectively, which usually ensure the necessary stability of dam for conceivable loading conditions.

The impervious core is designed as the center core type which is the most desirable from the aspect of safety.

The impervious core should usually have its thickness more than one-third of water depth and should be founded on the foundation rock. With the upstream and downstream slopes of 1:0.25 having its thickness of 5 m at the top, and is founded on the foundation rock investigated through the core borings and seismic explorations carried out in Phase I field investigation.

The filter is provided at both upstream and downstream sides of the impervious core. The filter is provided with the slope of 1:0.35 with the thickness of 1 m at its top in accordance with the usual design practice.

Earthfill Dam

The clayey earth materials spread widely on the sugarcane lands are considered to be used for the earthfill dam material. The dam is the uniform earthfill dam which is usually provided with the dam upstream slope of 1:3.0 to 1:3.5 and the downstream slope of 1:2.5 to 1:3.0. Taking into consideration the properties of available earth materials in the project area, the dam is assumed to require the upstream slope of 1:3.2 and downstream slope of 1:3.0.

The damsites where the construction of earthfill dam is envisaged are covered by loose materials with 3 to 5 m in thickness, requiring its removal so as to eliminate harmful materials and avoid damages of dam due to consolidation.

The geological investigation reveals that the weathered rock is situated at around 15 m depth from the ground surface above which clayey materials with relatively higher permeability overlie. Then, the cut-off trench for water stop is excavated down to about 15 m depth.

Concrete Gravity Dam

The concrete gravity dam should be founded on a firm foundation base rock. Its dimensions depend mainly on the shear strength of the based rock.

In the case that the dam is possible to be founded on the old lava which has an enough shearing strength more than 20 kg/cm2, the dam can be designed with the usual section of concrete gravity dam. Then, the dam is provided with the usual dam section of vertical upstream slope and downstream slope of 1:0.75.

The geological investigation reveals that the dam is forced to be founded on the new lava in both abutments, since the old lava is distributed with a nearly horizontal layer. A high shearing strength is not expected for the new lava, estimated at about 8-10 kg/cm2. Then, a concrete mat is provided in the based of dam to ensure the necessary sliding safety factor for which the dam design criteria specify the factor more than 4.0 should be kept.

D.4.3 Spillway

The spillway is designed to have the capacity to pas the spillway design flood without considering the regulation by the reservoir. The spillway design flood at the comparative study stage is taken at 1.2 times of 200-year recurrence flood peak for the fill type dam and 100-

year recurrence flood peak for the concrete dam in compliance with the design standard in Japan.

The followings are the spillway design floods applied for the respective damsites:

Damsite	Dam Type	Spillway Design Flood ($m/^3S$)
G1:		
(Bocage)	Concrete Weir	454
(Guibies)	Rockfill	181
M04 (Baptiste)	Earthfill	539
TRO:	Rockfill	1,536
	Concrete Gravity	834
NWO:	Rockfill	1,796
	Crete Gravity	1,325
TR9:	Earthfill	420
CA2:	"	498

In principle, the spillway is designed as the non-gated spillway, regarding the safety of dam as important. Thus, the spillway has its overflow crest elevation at the high water level of reservoir.

The determination of overflow depth of flood, i.e. the difference between the flood water level and the high water level, largely effects on the project cost.

The larger overflow depth makes the spillway width less, reducing the cost of spillway. The higher dam, however, becomes necessary, resulting in more expensive dam cost. Then, the overflow depth should be determined to minimize the total project cost. A preliminary examination indicates:

(i) For the dam which has a long dam crest, the overflow depth should be limited to as small as 1.0 m. the above requires

(ii) For the dam with an usual dam crest length, which constructed at the damsite having relatively steep abutment the overflow depth should be increased to about 3.0 m. The reduced scale of spillway minimizes the total project cost.

Then, the spillway is designed with the above consideration without spillway gates.

D.4.4 River Diversion System

The river diversion system during the construction is designed in accordance with the usual design practice as follows:

In the case of the fill type dam, the diversion design flood is taken at the recorded maximum flood so that the dam will not be subject to any overtoping during construction.
On the other hand, the river diversion system for the concrete dam is designed for the recorded maximum flood in the dry season, allowing the overtoping over the dam under construction during the rainy season to minimize the project cost.

The river diversion system is usually composed of the diversion tunnel and cofferdams. The system, however, is forced to consist of the diversion open channel with a culvert in it and cofferdams in the case that the topographic conditions do not allow the construction of tunnel mainly due to insufficient coverage over the tunnel.

D.4.5 Preliminary Design Drawings

Fig.D.4.9 to D.4.23 show the preliminary designs of respective alternative schemes which have been made based on the considerations and criteria as mentioned above.

The comparative study on the alternative schemes is made on the basis of the above design drawings.

The comparative study on the alternative schemes is made on the basis of the above design drawings.

D.5 Cost Estimate

D.5.1 General

The project cost of respective alternative scheme is estimated for selecting the optimum water supply scheme for Port Louis City.

The project cost is estimated by the economic cost and is composed of (i) the construction cost, (ii) engineering service fee, (iii) government administration cost, and (iv) physical contingency.

The construction cost includes the costs for the preparatory works, civil works, metal works, electrical works, and compensation, etc. necessary for constructing the dam and reservoir, water transmission facilities and water treatment plants, and is estimated based on the unit construction cost established for each work item and the work quantity assessed on the basis of the prelimianry design as stated in the previous Section D.4.

The engineering service fee is the cost necessary for the engineering services such as the detailed design of the project and supervision on the construction work, etc., and is estimated at 10% of the construction cost based on the past examples of the similar projects.

The implementation of the project also requires the administration by the government of which cost is estimated at 2.5% of the construction cost.

The physical contingency is an allowance to be prepared in consideration of the accuracy in the cost estimate, and is taken at 10% of the sum of the construction cost, engineering service fee and government administration cost, taking into account the accuracy in cost estimate at this stage.

This section presents in detail the result of cost estimate made as mentioned hereunder.

D.5.2 Unit Construction Cost

The unit construction cost for each work item is established at 1988 price level in due consideration of the actual results of past similar construction work in Mauritius.

The project is assumed to be implemented under an international competitive bidding. Thus, the recent results of similar international competitive biddings are duly reviewed, making proper adjustments on the respective unit construction costs.

The established unit construction costs are as shown in Table D.5.1 to D.5.4.

D.5.3 Project Cost

(1) Water Source

This section presents the project cost estimated for each alternative scheme.

Fig.D.5.1 shows the relation among the project cost, effective storage volume of reservoir and dam height for all of six alternative schemes.

Table D.5.5 to D.5.14 give the breakdown of project cost necessry for acquiring the effective storage capacity of 6.0 MCM to meet the water demand in 2030. (It is noted that the project cost at TR9 and CA2 sites shows the cost for effective storage which is considered topographically maximum.)

The project cost for each alternative scheme is summarized below:

Comparison of Project Cost

(Water Source)

Alternative Schemes	Project Cost (10^3 US$)
1. G1 (Bocage-Guibies)	88,370
Bocage	(8,870)
Guibies	(79,500)
2. MO4 (Baptist) Site	60,313
3. TRO Site	
Rockfill Dam Scheme	58,433
Conc. Gravity Dam Scheme	71,012
4. NWO Site	
Rockfill Dam Scheme	67,327
Conc. Gravity Dam Scheme	75,695
5. TR9 Site (2.3 MCM)	51,213
TR9 Site (4.0 MCM)	53,304
6. CA2 Site (1.2 MCM)	28,533

(2) Water Transmission Facilities

Table D.5.15 to D.5.27 give the estimated cost for the alternative plans of water transmission facilities.

Table D.5.15 summarizes the estimated project cost. Table D.5.16 to D.5.27 show the breakdown of construction cost.

The result is as follows:

Comparison of Project Cost

(Water Transmission Facilities)

Alternative Schemes	Project Cost (10^3 US$)
G1 (Bocage-Guibies)	
Case A-1	3,655
" A-2	3,551
" A-3	3,649
M04 (Baptiste)	
Case B-1	9,928
" B-2	3,932
" B-3	6,264
TRO	
Case C-1	11,150
" C-2	3,932
" C-3	4,696
NWO	
Case D-1	2,676
TR9	
Case E-1	3,932
CA2	
Case F-1	3,932

D.5.4 Cost Comparison

The cost comparison of alternative schemes is made in terms of the present worth which is defined as the sum of investment cost discounted to a base year.

Table D.5.28 shows the cash flow of project cost for working out the present worth for each alternative scheme.

The cash flow is prepared with the following considerations:

(i) The investment of project cost is made in accordance with the conceivable implementation schedule to meet the growth of water demand.

Fig.D.5.2 shows the assumed implementation schedule of each alternative scheme in comparison with the growth of water demand.

(ii) Relatively large scale of dam construction such as G1 (Bocage-Guibies), M04 (Baptiste), TRO and NWO schemes is assumed to take 4 years. On the other hand, TRa9 and CA2 schemes, which are comparatively of smaller scale, are assumed to take 3 years for its completion.

(iii) In the case of TR9 and CA2 schemes, some additional storage capacity is required to acquire the storage capacity of 6.0 MCM in total. For this requirement, a small scheme at TRO or M04 (Baptiste) site is taken into consideration, and a stepwise construction of these schemes in accordance with the growth of water demand is applied.

(iv) The project requires some operation and maintenance cost in addition to the investment cost for construction.

The annual operation and maintenance cost is taken at 0.5% of the investment cost, dusly referring to the past similar project.

(v) The reasonable opportunity cost in Mauritius is considered to be around 8%. Then, the discount rate to work out the present worth is taken at 8%.

(vi) As for the cost of water transmission facilities, the cheapest plan in ach scheme is applied.

Table D.5.28 also indicates the total cost in terms of the present worth for respective scheme. Those are shown below:

Cost Comparison in Terms of Present Worth

Alternative Schemes	Project Cost (10^3 US$)
G1 (Bocage-Guibies)	75,493
M04 (Baptiste)	52,605
TRO (Rockfill Dam)	51,053
NWO (Rockfill Dam)	55,311
TR9 (2.3 MCM)+CA2(1.2 MCM) + small TRO(2.5MCM)	96,382
TR9 (4.0 MCM)+Baptiste(2.0 MCM)	

D.5.5 Evaluation and Recommendation for Selection

(1) Evaluation

(a) G1 (Bocage-Guibies) Scheme

This scheme shows relatively higher project cost, indicating the amount of US$75,493 X 10^3 in terms of the present worth agains US$51,933 X 10^3 in M04 (Baptiste) scheme.

The above higher project cost results from the necessary of a tunnel from Bocage and the thick pervious scree deposits with talus deposits in the right bank of Guibies damsite, which require the costly foundation treatment in a large scale.

As for the foundation treatment for the above thick deposits, a cut-off concrete wall is adopted in view of its least cost as well as high technical reliability due to recent remarkable technical development for the underground concrete wall.

Despite such an arrangement to reduce the cost, the considerably higher project cost seems to be inevitable for this scheme due to the mentioned unfavourable geological condition in the foundation.

Besides the above, this scheme involves some technical uncertainties: that is, the future reservoir area tends to cause landslides as reported in the previous investigation reports, requiring further detailed investigation and examination.
The above is a factor to further augment the project cost for the countermeasure if necessry.

(b) M04 (Baptiste) Scheme

This scheme shows a favourable low project cost, indicating the present worth of US$52,484 X 10^3 which corrresponds to the second lowest project cost.

The scheme has no special technical difficulties. It, however, involves relatively severe social constraing: that is, the reservoir area consists of fertile sugarcane lands which will be submerged in a large scale.

Besides that, the following is another factor to make this scheme less attractive: that is, this scheme forms a wide and shallow reservoir in which the progress of eutrophication in the reservoir will be remarkable more than others, causing the water quality problem in future.

(c) TRO Scheme

TRO scheme has resulted in the least cost one as seen, indicating the present worth of US$51,053 X 10^3, although the cost difference from the second least cost scheme is as small as 3%.

Furthermore, the following makes this scheme more attractive:

that is, (i) the scheme does not have any social constraint such a submergence of sugarcane lands and residential houses as M04 (Baptiste) scheme. The reservoir will have a sufficient water depth in which the eutrophication of reservoir and deterioration of water quality will be limited to the minimum.

The scheme, which is situated in relatively favourable geological conditions of dam foundation, does not involve any special technical difficulty. Although the dam in both abutments is forced to be founded on the new lava with relatively higher permeability. However, the geological investigation reveals that the new lava has the permeability coefficient of about 10^{-4} cm/s which is possible to be improved to the order of 10^{-5} cm/s without any difficulty.

(d) NWO Scheme

This scheme is located at the most downstream reaches, having the largest spillway design flood. furthermore, the topography at the damsite makes the arrangement of spillway structure difficult, resulting in the project cost higher than TRO or M04 (Baptiste) ated nearest to the Pailles treatment plant mission facilities.

The geological investigation clarifies that the damsite of this scheme is subject to a severe weathering extensively. As such, this scheme is found less attractive also from the technical aspect compared with TRO scheme.

(e) Stepwise Construction of Small Schemes.

The stepwise construction of small schemes has been examined in view of its convenience in the financing arrangement.
However, it is found that such a plan requiring the construction of several dams will not be effective and

advantageous economically, indicating the most expensive project cost as seen.

(2) Recommendation for Selection

As discussed in 91) Evaluation above, G1 (Bocage-Guibies) scheme will not be possible to be the optimum scheme because of its costly project cost mainly due to unfavourable geological conditions in the dam foundation, although this scheme has been taken up in the past studies as one of the most promising schemes.

NWO scheme or the staged construction of several small schemes will not be more advantageous economically as compared with TRO or MO4 (Baptiste) schemes. Besides, these schemes do not have any particular advantage from the technical or other aspects. Thus, these schemes are also impossible to be the optimum scheme.

MO4 (Baptiste) and TRO schemes are comparable with each other from the economic aspect, indicating the least project cost. It is also difficult to point out the superiority or inferiority from the technical aspect between both schemes. However, MO4 (Baptiste) scheme of which reservoir will submerge the sugarcane lands in a large scale is accompanied with the necessary solution on the severe social constraint. MO4 (Baptiste) scheme is also anticipated to be subject to the eutrophication of reservoir, also requiring the solution for deterioration of water quality.

On the other hand, TRO scheme does not have any social constraint as mentioned.

The degree of eutrophication in the reservoir will also be much less than MO4 (Baptiste) scheme. As such, it is concluded and recommended that TRO scheme should be selected as the optimum water supply scheme for further detailed investigations and studies.

D.6 Optionary Study in Case of 4 MCM

D.6.1 General

Preliminary design for the effective storage volume of 4 MCM is carried out as a case of different dependability of water supply under the request of CWA. The methodology of design, construction plan and cost estimate is same as those for the effective storage volume of 6 MCM.

The design drawings of dam and related facilities are presented in Figs. D.6.1 to D.6.5. The reservoir area map is as shown in Fig. D.6.6.

The Terre Rouge dam for the effective storage volume of 4 MCM is designed as rockfill type with center core, 65 m in height and 210 m in crest length. Embankment volume of the dam is 1.0 MXCM. The Spillway is sidechannel type with crest length of 80 m. The diversion tunnel is aligned in the left abutment in 6.4 m diameter and 440 m length. The intake is constructed at right abutment and connected to the diversion tunnel for water supply.

D.6.2 Cost Estimate

The bill of quantity of the construction cost is presented in Table D.6.1. The summary for dam construction, water transmission facilities and treatment plant works is tabulated in Table D.6.2.

TABLES

Table D.2.1 : IDENTIFIED DAMSITES AND ITS CHARACTERISTICS

Damsite No.		Elevation(m) Min.	Elevation(m) Max.	Reservoir Surface (10^3m^2)	Storage Capacity (10^6m^3)	Remarks
1.	NW0	48.8	120.0	300	10.0	0
2.	NW1	91.4	175.3	630	23.0	
3.	NW2 (Soreze)	106.7	205.7	820	35.0	
4.	NW3	121.9	221.0	750	32.0	
5.	PW1	251.5	259.1	38	0.18	*
6.	TR0	130.0	230.0	600	20.0	0
7.	TR1	167.6	251.5	325	12.0	
8.	TR2	275.8	292.6	140	0.90	*
9.	TR3	275.8	295.7	190	1.30	*
10.	TR4	280.4	295.7	150	0.09	*
11.	TR5	300.2	310.9	42	0.18	*
12.	TR6	312.4	324.6	80	0.45	*
13.	TR7	334.0	360.0	-	1.75	*
14.	TR8	357.0	380.0	-	2.10	
15.	TR9	362.0	390.0	-	3.70	0
16.	TR10 (Hermitage-1)	-	-	-	0.76	*
17.	TR11 (" -2)	-	-	-	0.09	*
18.	CA1	310.9	329.2	120	0.95	*
19.	CA2	353.6	380.0	-	2.10	0
20.	CA3 (Cote D'or -1)	-	-	-	0.51	*
21.	CA4 (" D'or -2)	-	-	-	0.96	*
22.	PR1	350.5	359.7	68	0.26	*
23.	PR2	353.6	361.3	50	0.17	*
24.	PR3	362.7	370.3	22	0.07	*
25.	MO1	205.7	228.6	57	0.70	*
26.	MO2	317.0	327.7	63	0.30	*
27.	MO3	320.0	327.7	49	0.16	*
28.	MO4 (Baptiste)	360.0	382.5	1,600	10.0	0
29.	G1(Bocage-Baptiste)	70.0	112.0	600	13.0	0

Remarks: *: Not selected for comparative study due to too small storage capacity.

0: Selected for comparatve study.

Table D.3.1 WATER TRANSMISSION ALTERNATIVES
(Comparison Table)

Dam Scheme	Case (Alter-native)	Const-ruction Cost *	Difficulty of Construction Work	Period of Const-ruction Work	Opera-tion Cost	Proposal Site of Treatment	Energy of Water Transmis-sion	Certainty of Intake Quantity	Water Quality	Evaluation (Tentative)
A Guibies	A-1	Lowest	--	Shortest	--	Pailles Plant (Existing)	Gravity	Sure	Original water	OK
	A-2	Lowest	--	Shortest	--	New site near Dam	Gravity	Sure	Original water	OK
	A-3	Lowest	--	Shortest	--	New site near Dam	Gravity	Sure	Original water	OK
B Baptiste	B-1	Highest	(--)	Longest	--	New site along Highway, or Pailles Plant	Gravity	Sure	Original water	Very high Construction cost
	B-2	Low	(--)	Shortest	--	Pailles Plant (Existing)	Gravity	Fear of loss (?)	Mixture with other river-flows	OK
	B-3	High	-Pipeline instal-lation along Moka River valley(ø800 x 2000 m)	Long	--	New site along Highway, or Pailles Plant	Gravity	Sure	Slightly-Mixed water	Difficult in Pipelaying work
C Terre Rouge	C-1	Second highest	-Pumping station Valley bed -Moka River valley pipe bridge (ø800)	Second longest	very expen-sive	New site along Highway, or Pailles Plant	Pump up	Sure	Original water	Very high operation (power) cost
	C-2	Low	(--)	Short	--	Pailles Plant (Existing)	Gravity	Fear of loss (?)	Mixture with other river-flows	OK
	C-3	High	-Pipeline instal-lation along deep valley (ø 800x2200m)	Long	--	New site along Highway, or Pailles Plant	Gravity	Mirror loss, if any	Almost original water	Difficult in pipelaying work
D Pailles	D-1	Lowest	(--)	Shorter	--	Pailles Plant (Existing)	Gravity	Sure	Original water	OK

* : Not including treatment facilities

Table D.4.1 ESTIMATE OF EVAPORATION AND SEDIMENT (Comparison Table)

Sites	EVAPORATION				SEDIMENT				
	Annual Average Evaporation (mm)	100 days Evaporation (mm)	Reservoir Surface Area (m^2)	100 Days Evaporation (m^3)	Estimated Denudation Rate (mm/year)	Catchment Basin Area (km^2)	40-Year Sediment Product (m^3)	Estimated Trap Ratio (%)	40-Year Sediment Volume (m^3)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Bocage-Guibies	1,700	466	400,000	186,000	0.3	23	276,000	70	193,000
Baptiste (M04)	1,700	466	1,350,000	629,000	0.3	19	228,000	70	160,000
TRO	1,700	466	300,000	140,000	0.3	55	660,000	70	462,000
NWO	1,700	466	230,000	107,000	0.3	114	1,368,000	70	958,000
TR9	1,700	466	400,000	186,000	0.3	13	156,000	70	109,000
CA2	1,700	466	125,000	58,000	0.3	17	204,000	70	143,000

NOTE: (2) = (1) x 100/365
(4) = (2) x (3)
(7) = (5) x (6) x 40
(9) = (7) x 0.7

Table D.5.1 : UNIT CONSTRUCTION COSTS (DAM CONSTRUCTION WORK)

Unit Construction

Work Items	Unit	Cost (US$)
1. Excavation:		
Earth	m^3	4.0
Weather rock	"	5.0
Hard rock	"	10.0
2. Backfilling:	"	5.0
3. Dam Embankment:		
Earth	"	10.0
Filter	"	12.0
Rockfill	"	15.0
4. Concreting;		
Mass concrete	"	95.0
Structural concrete	"	130.0
5. Grouting:		
Curtain grout	m	180.0
Consolidation grout (Blanket grout)	"	140.0
6. Tunnel:		
Excavation	m^3	200.0
Lining concrete	"	130.0
7. Cut-off Concrete Wall:	m^2	420.0
8. Reinforcement Bar:	ton	800.0
9. Spillway Gate:	ton	4,000.0
10. Compensation:		
Sugarcane land	km^2	2,000,000.0

Table D.5.2 UNIT CONSTRUCTION COSTS
(TRANSMISSION PIPE WORK)

(Rupees per Meter : Rs./m)

unit : Rs/m

Item		φ 600mm	φ 700mm	φ 800mm	φ 900mm	φ 1000mm	φ 1100mm	φ 1200mm
Supply of Pipes(DIP)								
① CIF (*1)		3,450	4,190	5,300	6,530	7,910	9,400	10,980
② Inland cost (*2)		276	335	424	522	633	752	878
Supply of Fittings & Valves (*3)								
③ CIF (*1)		690	838	1,060	1,306	1,582	1,880	2,196
④ Inland cost (*2)		55	67	85	104	127	150	176
Sub Total (①~④)		4,471	5,430	6,869	8,462	10,252	12,182	14,230
Pipe Laying Work								
⑤ Transport/deliver		39	50	63	77	93	111	129
⑥ Trench earth work		863	989	1,130	1,276	1,427	1,595	1,764
⑦ Pipe laying work		126	152	180	234	252	306	360
⑧ Miscellaneous work(*4)		206	238	275	317	354	402	451
Sub Total (⑤~⑧)		1,234	1,429	1,648	1,904	2,126	2,414	2,704
Sub Total (①~⑧)		5,705	6,859	8,519	10,366	12,378	14,596	16,934
Reinstatement								
⑨ Reinstatement of paved road		420	450	480	510	540	570	600
Total (①~⑨)		(447) 6,125	(534) 7,309	(657) 8,977	(794) 10,876	(943) 12,918	(1,107) 15,166	(1,280) 17,534
Breakdown	F/C portion	4,140	5,028	6,360	7,836	9,492	11,280	13,176
	L/C portion	1,985	2,281	2,637	3,040	3,426	3,886	4,358

Note: (*1) = Foreign currency portion

(*2) = 8 % of CIF

(*3) = Assumed 20 % of pipes

(*4) = Anchor blocks, valve chambers, installation of valves/fittings etc; assumed 20 % of (⑤+⑥+⑦)

F/C = Foreign Currency

L/C = Local Currency

Figures in bracket indicate the unit construction cost in U.S.$

Table D.5.3 UNIT CONSTRUCTION COSTS
(TRANSMISSION PIPE WORK ALONG/IN RIVERBED)
(Rupees per Meter : Rs./m)

unit : Rs/m

Item		φ 600mm	φ 700mm	φ 800mm	φ 900mm	φ 1000mm	φ 1100mm	φ 1200mm
Supply of Pipes(DIP)								
① CIF (*1)		3,450	4,190	5,300	6,530	7,910	9,400	10,980
② Inland cost (*2)		276	335	424	522	633	752	878
Supply of Fittings & Valves (*3)								
③ CIF (*1)		690	838	1,060	1,306	1,582	1,880	2,196
④ Inland cost (*2)		55	67	85	104	127	150	176
Sub Total (①~④)		4,471	5,430	6,869	8,462	10,252	12,182	14,230
Pipe Laying Work								
⑤ Transport/deliver		78	100	126	154	186	222	258
⑥ Rock excavation and disposal		424	512	612	716	832	952	1,084
⑦ Pipe laying work		189	228	270	351	378	459	540
⑧ Concrete work		1,389	1,602	1,833	2,047	2,296	2,545	2,812
Sub Total (⑤~⑧)		2,079	2,442	2,841	3,268	3,692	4,178	4,694
⑨ Miscellaneous work (*4)		2,079	2,442	2,841	3,268	3,692	4,178	4,694
Sub Total (⑤~⑨)		4,158	4,884	5,682	6,536	7,384	8,356	9,388
Total (①~⑨)		(630) 8,629	(753) 10,314	(916) 12,551	(1,095) 14,998	(1,287) 17,636	(1,499) 20,538	(1,724) 23,618
Breakdown	F/C portion	4,140	5,028	6,360	7,836	9,492	11,280	13,176
	L/C portion	4,489	5,286	6,191	7,192	8,144	9,258	10,442

Note: (*1) = Foreign currency portion

(*2) = 8 % of CIF

(*3) = Assumed 20 % of pipes

(*4) = Preparatory work, site clearance/cleaning, water shuttering, temporary work, valve chambers, installation of valves/fittings etc; assumed 100 % of (⑤+⑥+⑦+⑧)

F/C = Foreign Currency

L/C = Local Currency

Figures in bracket indicate the unit construction cost in U.S.$

Table D.5.4 UNIT CONSTRUCTION COSTS (BREAK PRESSURE TANK OF RECEIVING TANK)

unit : Rs/tank

Item	Unit	Quantity	Unit Price (Rs)	Amount (Rs)
① Concrete for structure				
- Base concrete	m^3	70.3	1,780-	125,134-
- Wall concrete	m^3	134.9	1,780-	240,122-
- Slab concrete	m^3	12.8	1,780-	22,784-
② Steel bars reinforcement for the aboves (Deformed bars)	ton	26.2	15,750-	412,650-
③ Formwork for concrete-shuttering work	m^2	821.3	300-	246,390-
④ Stone foundation	m^3	45.1	190-	8,569-
⑤ Leveling concrete	m^3	15.1	1,600-	24,160-
⑥ Earth work				
- Excavation(Soil)	m^3	337.4	100	33,740-
- Excavation(Rock)	m^3	337.4	250-	84,350-
- Backfill(Soil)	m^3	239.4	75-	17,955-
- Disposal(Soil)	m^3	98.0	100-	9,800-
- Disposal(Rock)	m^3	337.4	100-	33,740-
⑦ Handrail work, Steel pipe made, H=1.0m	m	27.4	1,050-	28,770-
⑧ Boundary fence work, wire mesh, H=1.8m	m	77.0	1,000-	77,000-
⑨ Miscellaneous work (10%)		1 Lot		136,836-
Total (①~⑨)				(109,635) 1,502,000-

(L/C portion)

Note: Figure in bracket show the unit construction cost in U.S.$

Table D.5.5 COST ESTIMATE FOR ALTERNATIVE DAMSITE
(NWO : CONCRETE GRAVITY, 6.0 MCM)

	Construction Cost for NW0 Gravity Dam Scheme					6 MCM
				Quantity		Amount
			Unit	(x1,000)	Unit Price	($1,000)
1	PREPARATORY WORKS		20%	of (2+3+4)		10,190
	Access & Service Road					
	Yards					
	Buildings					
2	DIVERSION					(9,812)
	Open Cut	Common	m3	1	4	4
		Weathered Rock	m3	1	5	5
		Fresh Rock	m3	1.65	10	17
		Reinfrocement Bar	t	0.42	800	336
	Tunnel	Excavation	m3	37.35	200	7,470
		Lining	m3	14	130	1,820
	Gate		t	0.04	4,000	160
3	DAM					(37,638)
	Excavation	Common	m3	62	4	248
		Weathered Rock	m3	66	5	330
		Fresh Rock	m3	223	10	2,230
	Embankment					
		Mass Concrete	m3	307	95	29,165
		Mat Concrete	m3	48	95	4,560
	Grout	Curtain	m	5	180	971
		Consolidation	m	1	140	134
4	SPILLWAY					(3,525)
	Concrere					
		Structural	m3	19.4	130	2,522
	Reinfrocement Bar		t	0.58	800	466
	Gate		t	0.13	4,000	538
	Direct Cost					**61,165**
5	Compensation		km2			
6	Engineering &	10% *	(1~4)			7,650
	Administration	2.5% *	(1~5)			
7	Physical Contingency					6,880
		10% *	(1~7)			
8	Price Contingency					
9	**Grand Total**					**75,695**

Table D.5.6 COST ESTIMATE FOR ALTERNATIVE DAMSITE
(NWO : ROCKFILL, 6.0 MCM)

		Construction Cost for NW0 Dam Scheme				6 MCM
				Quantity		Amount
			Unit	(x1,000)	Unit Price	($1,000)
1	PREPARATORY WORKS		20%	of (2+3+4)		9,070
	Access & Service Road					
	Yards					
	Buildings					
2	DIVERSION					(9,812)
	Open Cut	Common	m3	1	4	4
		Weathered Rock	m3	1	5	5
		Fresh Rock	m3	1.65	10	17
	Embankment	Earth	m3	0	6	0
		Mass Concrete	m3	0	95	0
		Reinfrocement Bar	t	0.42	800	336
	Tunnel	Excavation	m3	37.35	200	7,470
		Lining	m3	14	130	1,820
	Grout	Consolidation	m		140	0
	Backfill		m3		5	0
	Gate		t	0.04	4,000	160
3	DAM					(23,412)
	Excavation	Common	m3	147	4	588
		Weathered Rock	m3	91	5	455
		Fresh Rock	m3	231	10	2,310
	Embankment	Core	m3	250	10	2,500
		Filter	m3	95	18	1,710
		Rockfill	m3	982	15	14,730
	Grout	Curtain	m	5.5	180	985
		Brangket	m	1	140	134
4	SPILLWAY					(12,113)
	Excavation	Common	m3	29	4	116
		Weathered Rock	m3	111	5	555
		Fresh Rock	m3	358	10	3,580
	Backfill		m3		5	0
	Concrere	Mass	m3	16	95	1,520
		Structural	m3	39	130	5,070
	Reinfrocement Bar		t	1.17	800	936
	Grout	Curtain	m		180	0
	Gate		t	0.084	4,000	336
	Direct Cost					**54,407**
5	Compensation					
6	Engineering &	10% *	(1~4)			6,800
	Administration	2.5% *	(1~5)			
7	Physical Contingency					6,120
		10% *	(1~7)			
8	Price Contingency					
9	**Grand Total**					**67,327**

Table D.5.7 COST ESTIMATE FOR ALTERNATIVE DAMSITE (TRO : CONCRETE GRAVITY, 6.0 MCM)

		Construction Cost for TR0 Dam Scheme				El.198.2
				Quantity		Amount
			Unit	(x1,000)	Unit Price	($1,000)
1	PREPARATORY WORKS		20% of (2+3+4)			9,560
	Access & Service Road					
	Yards					
	Buildings					
2	DIVERSION					(8,103)
	Open Cut	Common	m3	6	4	24
		Weathered Rock	m3	8	5	40
		Fresh Rock	m3	2.29	10	23
	Embankment	Earth	m3	0	6	0
		Mass Concrete	m3	0	95	0
		Reinfrocement Bar	t	0.33	800	264
	Tunnel	Excavation	m3	30.71	200	6,142
		Lining	m3	11	130	1,430
	Grout	Consolidation	m		140	0
	Backfill		m3		5	0
	Gate		t	0.045	4,000	180
3	DAM					(35,192)
	Excavation	Common	m3	25.7	4	103
		Weathered Rock	m3	41	5	205
		Fresh Rock	m3	99	10	990
	Embankment					
		Mass Concrete	m3	266	95	25,270
		Mat Concrete	m3	67.5	95	6,409
	Grout	Curtain	m	11	180	1,978
		Consolidation	m	2	140	236
4	SPILLWAY					(4,528)
	Concrere					
		Structural	m3	29	130	3,822
	Reinfrocement Bar		t	0.88	800	706
	Grout	Curtain	m		180	0
	Gate		t	0	4,000	0
	Direct Cost					**57,382**
5	Compensation		km2			
6	Engineering &	10% * (1~4)				7,170
	Administration	2.5% * (1~5)				
7	Physical Contingency					6,460
		10% * (1~7)				
8	Price Contingency					
9	**Grand Total**					**71,012**

Table D.5.8 COST ESTIMATE FOR ALTERNATIVE DAMSITE (TR0 : ROCKFILL, 6.0 MCM)

		Construction Cost for TR0 Dam Scheme				6 MCM
				Quantity		Amount
			Unit	(x1,000)	Unit Price	($1,000)
1	PREPARATORY WORKS		20%	of (2+3+4)		7,870
	Access & Service Road					
	Yards					
	Buildings					
2	DIVERSION					(8,103)
	Open Cut	Common	m3	6	4	24
		Weathered Rock	m3	8	5	40
		Fresh Rock	m3	2.29	10	23
	Embankment	Earth	m3	0	6	0
		Mass Concrete	m3	0	95	0
		Reinfrocement Bar	t	0.33	800	264
	Tunnel	Excavation	m3	30.71	200	6,142
		Lining	m3	11	130	1,430
	Grout	Consolidation	m		140	0
	Backfill		m3		5	0
	Gate		t	0.045	4,000	180
3	DAM					(22,728)
	Excavation	Common	m3	84	4	336
		Weathered Rock	m3	30	5	150
		Fresh Rock	m3	13	10	130
	Embankment	Core	m3	233	10	2,330
		Filter	m3	89	18	1,602
		Rockfill	m3	1063	15	15,945
	Grout	Curtain	m	11	180	1,999
		Brangket	m	2	140	236
4	SPILLWAY					(8,523)
	Excavation	Common	m3	65	4	260
		Weathered Rock	m3	101	5	505
		Fresh Rock	m3	371	10	3,710
	Backfill		m3	0	5	0
	Concrere	Mass	m3	9.7	95	922
		Structural	m3	20	130	2,639
	Reinfrocement Bar		t	0.61	800	487
	Grout	Curtain	m		180	0
	Gate		t	0	4,000	0
	Direct Cost					47,223
5	Compensation		km2			
6	Engineering &	10% *	(1~4)			5,900
	Administration	2.5% *	(1~5)			
7	Physical Contingency					5,310
		10% *	(1~7)			
8	Price Contingency					
9	**Grand Total**					58,433

Table D.5.9 COST ESTIMATE FOR ALTERNATIVE DAMSITE
(NW3 : ROCKFILL, 6.0 CMC)

	Construction Cost for NW3 Dam Scheme					6 MCM
				Quantity		Amount
			Unit	(x1,000)	Unit Price	($1,000)
1	PREPARATORY WORKS		20%	of (2+3+4)		9,770
	Access & Service Road					
	Yards					
	Buildings					
2	DIVERSION					(10,636)
	Open Cut	Common	m3	5	4	20
		Weathered Rock	m3	6	5	30
		Fresh Rock	m3	1.50	10	15
	Embankment	Earth	m3	0	6	0
		Mass Concrete	m3	0	95	0
		Reinfrocement Bar	t	0.45	800	360
	Tunnel	Excavation	m3	40.50	200	8,101
		Lining	m3	15	130	1,950
	Grout	Consolidation	m		140	0
	Backfill		m3		5	0
	Gate		t	0.04	4,000	160
3	DAM					(26,721)
	Excavation	Common	m3	274.4	4	1,098
		Weathered Rock	m3	146.6	5	733
		Fresh Rock	m3	67.3	10	673
	Embankment	Core	m3	283	10	2,830
		Filter	m3	107.4	18	1,933
		Rockfill	m3	1171	15	17,565
	Grout	Curtain	m	9	180	1,686
		Brangket	m	1	140	203
4	SPILLWAY					(11,514)
	Excavation	Earth	m3	105	4	420
		Weathered Rock	m3	226	5	1,130
		Hard Rock	m3	491	10	4,910
	Backfill		m3		5	0
	Concrere	Mass	m3	11.70	95	1,112
		Structural	m3	25.60	130	3,328
	Reinfrocement Bar		t	0.77	800	614
	Grout	Curtain	m		180	0
	Gate		t	0	4000	0
	Direct Cost					**58,641**
5	Compensation	(Land)	km2	0	2,000,000	0
6	Engineering &	10% *	(1~4)			7,330
	Administration	2.5% *	(1~5)			
7	Physical Contingency					6,600
		10% *	(1~7)			
8	Price Contingency					
9	**Grand Total**					**72,571**

Table D.5.10 (1) COST ESTIMATE FOR ALTERNATIVE DAMSITE (1/2)
(GUIBIES : ROCKFILL, 6.0 MCM)

	Construction Cost for Guibies Dam Scheme					6 MCM
				Quantity		Amount
			Unit	(x1,000)	Unit Price	($1,000)
1	PREPARATORY WORKS		20% of (2+3+4)			10,710
	Access & Service Road					
	Yards					
	Buildings					
2	DIVERSION					(963)
	Open Cut	Common	m3	12	4	48
		Weathered Rock	m3	11	5	55
		Fresh Rock	m3	2.39	10	24
	Embankment	Earth	m3	0	6	0
		Mass Concrete	m3	0	95	0
		Reinfrocement Bar	t	0.03	800	24
	Tunnel	Excavation	m3	2.61	200	522
		Lining	m3	1	130	130
	Grout	Consolidation	m		140	0
	Backfill		m3		5	0
	Gate		t	0.04	4,000	160
3	DAM					(50,877)
	Excavation	Common	m3	1860	4	7,440
		Weathered Rock	m3	1.00	5	5
		Fresh Rock	m3	0.10	10	1
	Embankment	Core	m3	241	10	2,410
		Filter	m3	90	18	1,620
		Rockfill	m3	891	15	13,365
	Cut-off Concrete		m2	48.4	450	21,780
	Grout	Curtain	m	20	180	3,571
		Brangket	m	5	140	685
4	SPILLWAY					(1,690)
	Excavation	Earth	m3	29.7	4	119
		Weathered Rock	m3	65.3	5	327
		Hard Rock	m3	61.5	10	615
	Backfill		m3		5	0
	Concrere	Mass	m3	1.60	95	152
		Structural	m3	3.10	130	403
	Reinfrocement Bar		t	0.09	800	74
	Grout	Curtain	m		180	0
	Gate		t	0	4,000	0
	Direct Cost					**64,240**
5	Compensation	(Land)	km2	0	2,000,000	0
6	Engineering &	10% *	(1~4)			8,030
	Administration	2.5% *	(1~5)			
7	Physical Contingency					7,230
		10% *	(1~7)			
8	Price Contingency					
9	**Grand Total**					**79,500**

Table D.5.10 (2) COST ESTIMATE FOR ALTERNATIVE DAMSITE (1/2)
(BOCAGE : CONCRETE WEIR, 6.0 MCM)

	Construction Cost for Bocage Weir Scheme		Unit	Quantity (x1,000)	Unit Price	Amount ($1,000)
1	PREPARATORY WORKS		20%	of (2.+3.+4.)		770
	Access & Service Road					
	Yards					
	Buildings					
2	DIVERSION					(80)
	Open Cut	Common	m3	0	4	0
		Weathered Rock	m3	0	5	0
		Fresh Rock	m3	0	10	0
	Embankment	Common	m3	0	6	0
		Mass Concrete	m3	0	95	0
		Reinfrocement Bar	t	0	800	0
	Tunnel	Excavation	m3	0	200	0
	Culvert		m3	0	130	0
	Sand Flush Gate		t	0.02	4,000	80
3	Weir					(356)
	Excavation	Common	m3	9	4	36
		Weathered Rock	m3	3	5	15
		Fresh Rock	m3	0	10	0
	Concrete	Mass	m3	1	95	95
		Wall	m3	1	130	130
		0	m3	0	0	0
	Grout	Curtain	m	0.31	180	55
		Consolidation	m	0.18	140	25
4	DIVERSION TUNNEL					(3,404)
	Tunnel	Excavation	m3	12	200	2,400
		Lining	m3	6	130	780
	Backfill		m3	0	5	0
	Concrere	Mass	m3	0	95	0
		Wall	m3		130	0
	Reinfrocement Bar		t	0.18	800	144
	Grout	Curtain	m		180	0
	Gate		t	0.02	4,000	80
	Direct Cost					**4,610**
5	Compensation	(Land)	km2	0.0014	2,000,000	2,800
6	Engineering &	10% *	(1~4)			650
	Administration	2.5% *	(1~5)			
7	Physical Contingency					810
		10% *	(1~7)			
8	Price Contingency					
9	**Grand Total**					**8,870**

Table D.5.11 COST ESTIMATE FOR ALTERNATIVE DAMSITE (BAPTISTE : EARTHFILL, 6.0 MCM)

		Construction Cost for Baptiste Dam Scheme				
				Quantity		Amount
			Unit	(x1,000)	Unit Price	($1,000)
1	PREPARATORY WORKS		20%	of (2.+3.+4.)		7,700
	Access & Service Road					
	Yards					
	Buildings					
2	DIVERSION					(1,762)
	Open Cut	Common	m3	33	4	132
		Weathered Rock	m3	17	5	85
		Fresh Rock	m3	0	10	0
	Embankment	Common	m3	9	6	54
		Mass Concrete	m3	9	95	855
		Reinfrocement Bar	t	0.27	800	216
	Tunnel	Excavation	m3	0	200	0
	Culvert		m3	2	130	260
	0	0	m		0	0
	0		m3		0	0
	Gate		t	0.04	4,000	160
3	DAM					(26,750)
	Excavation	Common	m3	893	4	3,572
		Weathered Rock	m3	151	5	755
		Fresh Rock	m3		10	0
	Embankment	Common	m3	1819	10	18,190
		0	m3	0	0	0
		0	m3	0	0	0
	Grout	Curtain	m	17	180	3,011
		Consolidation	m	9	140	1,222
4	SPILLWAY					(9,981)
	Excavation	Common	m3	261	4	1,044
		Weathered Rock	m3	345	5	1,725
		Fresh Rock	m3	120	10	1,200
	Backfill		m3	15	5	75
	Concrere	Mass	m3	9	95	855
		Wall	m3	33	130	4,290
	Reinfrocement Bar		t	0.99	800	792
	Grout	Curtain	m		180	0
	Gate		t	0	4,000	0
	Direct Cost					**46,193**
5	Compensation	(Land)	km2	0.0014	2,000,000	2,800
6	Engineering &	10% *	(1~4)			5,840
	Administration	2.5% *	(1~5)			
7	Physical Contingency					5,480
		10% *	(1~7)			
8	Price Contingency					
9	**Grand Total**					**60,313**

Table D.5.12 COST ESTIMATE FOR ALTERNATIVE DAMSITE (CA2 : ROCKFILL, 1.2 MCM)

		Construction Cost for CA2 Dam Scheme				Amount
				Quantity		
			Unit	(x1,000)	Unit Price	($1,000)
1	PREPARATORY WORKS		20%	of (2+3+4)		3,840
	Access & Service Road					
	Yards					
	Buildings					
2	DIVERSION					(3,199)
	Open Cut	Common	m3	55	4	220
		Weathered Rock	m3	51	5	255
		Fresh Rock	m3	12	10	120
	Embankment	Common	m3	0	6	0
		Mass Concrete	m3	16	95	1,520
		Reinfrocement Bar	t	0.48	800	384
	Tunnel	Excavation	m3	0	200	0
	Culvert		m3	4	130	520
	Gate		t	0.045	4,000	180
3	DAM					(10,914)
	Excavation	Common	m3	326	4	1,304
		Weathered Rock	m3	101	5	505
		Fresh Rock	m3		10	0
	Embankment	Common	m3	648	10	6,480
	Grout	Curtain	m	11	180	1,931
		Consolidation	m	5	140	693
4	SPILLWAY					(5,110)
	Excavation	Common	m3	146	4	584
		Weathered Rock	m3	131	5	655
		Fresh Rock	m3	48	10	480
	Backfill		m3	0	5	0
	Concrere	Mass	m3	13	95	1,235
		Wall	m3	14	130	1,820
	Reinfrocement Bar		t	0.42	800	336
	Grout	Curtain	m		180	0
	Gate		t		4,000	0
	Direct Cost					**23,063**
5	Compensation		km2			
6	Engineering &	10% *	(1~4)			2,880
	Administration	2.5% *	(1~5)			
7	Physical Contingency					2,590
		10% *	(1~7)			
8	Price Contingency					
9	**Grand Total**					**28,533**

Table D.5.13 COST ESTIMATE FOR ALTERNATIVE DAMSITE (TR9 : EARTHFILL, 2.3 MCM)

		Construction Cost for TR9 Dam Scheme				
				Quantity		Amount
			Unit	(x1,000)	Unit Price	($1,000)
1	PREPARATORY WORKS		20% of (2+3+4)			6,900
	Access & Service Road					
	Yards					
	Buildings					
2	DIVERSION					(2,372)
	Open Cut	Common	m3	77	4	308
		Weathered Rock	m3	41	5	205
		Fresh Rock	m3	0	10	0
	Embankment	Common	m3	0	6	0
		Mass Concrete	m3	11	95	1,045
		Reinfrocement Bar	t	0.33	800	264
	Tunnel	Excavation	m3	0	200	0
	Culvert		m3	3	130	390
	0	0	m		0	0
	0		m3		0	0
	Gate		t	0.04	4,000	160
3	DAM					(20,906)
	Excavation	Common	m3	578	4	2,312
		Weathered Rock	m3	121	5	605
		Fresh Rock	m3		10	0
	Embankment	Common	m3	1424	10	14,240
		0	m3	0	0	0
		0	m3	0	0	0
	Grout	Curtain	m	15	180	2,730
		Consolidation	m	7	140	1,019
4	SPILLWAY					(11,205)
	Excavation	Common	m3	542	4	2,169
		Weathered Rock	m3	625	5	3,125
		Fresh Rock	m3	0	10	0
	Backfill		m3		5	0
	Concrere	Mass	m3	9	95	829
		Wall	m3	33	130	4,290
	Reinfrocement Bar		t	0.99	800	792
	Grout	Curtain	m		180	0
	Gate		t	0	4,000	0
	Direct Cost					**41,383**
5	Compensation					
6	Engineering &	10% *	(1~4)			5,170
	Administration	2.5% *	(1~5)			
7	Physical Contingency					4,660
		10% *	(1~7)			
8	Price Contingency					
	Grand Total					**51,213**

Table D.5.14 **COST ESTIMATE FOR ALTERNATIVE DAMSITE (TR9 : EARTHFILL, 4.0 MCM)**

			Quantity	Unit	Amount
		Unit(x1,000)		Price	($1,000)
1 PREPARATORY WORKS		20% of (2+3+4)			7,180
Access & Service Road					
Yards					
Buildings					
2 DIVERSION					(2,372)
Open Cut	Common	m3	77	4	308
	Weathered Rock	m3	41	5	205
	Fresh Rock	m3	0	10	0
Embankment	Common	m3	0	6	0
	Mass Concrete	m3	11	95	1,045
	Reinfrocement Bar	t	0.33	800	264
Tunnel	Excavation	m3	0	200	0
Culvert		m3	3	130	390
Gate		t	0.04	4,000	160
3 DAM					(21,042)
Excavation	Common	m3	360	4	1,440
	Weathered Rock	m3		5	0
	Fresh Rock	m3		10	0
Embankment	Common	m3	1559	10	15,590
Grout	Curtain	m	17	180	3,060
	Consolidation	m	7	140	952
4 SPILLWAY					(12,480)
Excavation	Common	m3	332	4	1,328
	Weathered Rock	m3	0	5	0
	Fresh Rock	m3	0	10	0
Backfill		m3		5	0
Concrere	Mass	m3	72	95	6,840
	Stractural	m3	28	130	3,640
Reinfrocement Bar		t	0.84	800	672
Grout	Curtain	m		180	0
Gate		t	0	4,000	0
Direct Cost					43,074
5 Compensation		ha		20,000	0
6 Engineering & Administration	10% * (1~4) 2.5% * (1~5)				5,380
7 Physical Contingency		10% * (1~6)			4,850
8 Price Contingency					
Grand Total					53,304

Table D.5.15 IMPLEMENTATION COST OF TRANSMISSION PIPELINES FACILITIES

Scheme	Case	① Construction Cost	② Engineering Fees =①×10%	③ Administration Cost =①×2.5%	④ Contingency =(①+②+③)×10%	⑤ Total Implementation Cost =①+②+③+④
		Rs.	Rs.	Rs.	Rs.	Rs.
(A) Guibies Dam	A-1	40,468,000-	4,047,000-	1,012,000-	4,553,000-	50,080,000-
	A-2	39,316,000-	3,932,000-	983,000-	4,423,000-	48,654,000-
	A-3	40,396,000-	4,040,000-	1,010,000-	4,545,000-	49,991,000-
(B) Baptiste Dam	B-1	109,914,000-	10,991,000-	2,748,000-	12,365,000-	136,018,000-
	B-2	43,526,000-	4,353,000-	1,088,000-	4,897,000-	53,864,000-
	B-3	69,347,000-	6,935,000-	1,734,000-	7,802,000-	85,818,000-
(C) Terre Rouge Dam	C-1	123,439,000-	12,344,000-	3,086,000-	13,887,000-	152,756,000-
	C-2	43,526,000-	4,353,000-	1,088,000-	4,897,000-	53,864,000-
	C-3	51,983,000-	5,198,000-	1,300,000-	5,848,000-	64,329,000-
(D) Pailles Dam	D-1	29,628,000-	2,963,000-	741,000-	3,333,000-	36,665,000-
(E) TR-9 Dam	E-1	43,526,000-	4,353,000-	1,088,000-	4,897,000-	53,864,000-
(F) CA-2 Dam	F-1	43,526,000-	4,353,000-	1,088,000-	4,897,000-	53,864,000-

Table D.5.16 COST ESTIMATE OF TRANSMISSION FACILITIES

(Case A-1)

Item	Unit	Quantity	Unit Cost (Rs.)	Amount (Rs.)
(1) Transmission pipeline φ 800mm (DIP)	m	3,400	8,997-	30,590,000-
(2) Pipe bridge for river crossing:				
- St. Louis Stream (φ 800mm × L=25m)		1 Lot		2,084,000-
- Pitot Stream (φ 800mm × L=15m)		1 Lot		1,040,000-
Sub Total {(1)~(2)}				33,723,000-
(3) Overhead and others (20%) including preparatory work, mobilization, site cleaning, temporary work, right of way, traffic control cost, insurance, fee, profit, tax, etc.		1 Lot		6,745,000-
Total {(1)~(3)}			Case A-1 =	Rs 40,468,000-
Breakdown: Foreign currency portion				22,364,000-
Breakdown: Local currency portion				18,104,000-

Table D.5.17 COST ESTIMATE OF TRANSMISSION FACILITIES

(Case A-2)

Item		Unit	Quantity	Unit Cost (Rs.)	Amount (Rs.)
(1) Transmission pipeline for treated water, φ800mm (DIP)		m	3,000	8,997-	26,991,000-
(2) Transmission pipeline for raw water, φ800mm (DIP)		m	400	8,997-	3,599,000-
(3) Pipe bridge for river crossing: - St. Louis Stream No.2 (φ800mm×L=30m)			1 Lot		2,173,000-
Sub Total {(1)~(3)}					32,763,000-
(4) Overhead and others (20%) including preparatory work, mobilization, site cleaning, temporary work, right of way, traffic control cost, insurance, fee, profit, tax, etc.			1 Lot		6,533,000-
Total {(1)~(4)}				Case A-2 =	Rs 39,316,000-
Breakdown	Foreign currency portion				22,033,000-
	Local currency portion				17,283,000-

Table D.5.18 **COST ESTIMATE OF TRANSMISSION FACILITIES**

(Case A-3)

Item		Unit	Quantity	Unit Cost (Rs.)	Amount (Rs.)
(1) Transmission pipeline for treated water, ϕ 800mm (DIP)		m	2,500	8,997-	22,453,000-
(2) Transmission pipeline for raw water, ϕ 800mm (DIP)		m	1,000	8,997-	8,997,000-
(3) Pipe bridge for river crossing: - St. Louis Stream No.2 (ϕ 800mm × L=30m)			1 Lot		2,173,000-
Sub Total {(1)~(3)}					33,663,000-
(4) Overhead and others (20%) including preparatory work, mobilization, site cleaning, temporary work, right of way, traffic control cost, insurance, fee, profit, tax, etc.			1 Lot		6,733,000-
Total {(1)~(4)}		Case A-3 =			Rs 40,396,000-
Breakdown	Foreign currency portion				22,669,000-
	Local currency portion				17,727,000-

Table D.5.19 COST ESTIMATE OF TRANSMISSION FACILITIES

(Case B-1)

Item		Unit	Quantity	Unit Cost (Rs.)	Amount (Rs.)
(1) Transmission pipeline for raw water, φ700mm (DIP)		m	8,400	7,309-	61,396,000-
(2) Transmission pipeline for treated water, φ600mm (DIP)		m	2,100	6,125-	12,863,000-
(3) Pipe bridge for river crossing:					
- Moka River (φ700mm×L=40m)			1 Lot		3,874,000-
- Moka River (φ700mm×L=60m)			1 Lot		4,171,000-
- St. Louis Stream (φ600mm×L=25m)			1 Lot		1,282,000-
- St. Louis Stream No.2(φ600mm×L=30m)			1 Lot		1,336,000-
- Pitot Stream (φ600mm×L=15m)			1 Lot		665,000-
(4) Break-pressure tank		Tank	4	1,502,000-	6,008,000-
Sub Total {(1)~(4)}					91,595,000-
(5) Overhead and others (20%) including preparatory work, mobilization, site cleaning, temporary work, right of way, traffic control cost, insurance, fee, profit, tax, etc.			1 Lot		18,319,000-
Total {(1)~(5)}				Case B-1 =	109,914,000-
Breakdown	Foreign currency portion				52,488,000-
	Local currency portion				57,426,000-

Table D.5.20 COST ESTIMATE OF TRANSMISSION FACILITIES

(Case B-2)

Item		Unit	Quantity	Unit Cost (Rs.)	Amount (Rs.)
(1) Transmission pipeline, in the valley, φ1,000mm (DIP)		m	2,000	17,636-	35,272,000-
(2) Intake chamber at Municipal Dyke			1 Lot		1,000,000-
Sub Total {(1)~(2)}					36,272,000-
(3) Overhead and others (20%) including preparatory work, mobilization, site cleaning, temporary work, right of way, traffic control cost, insurance, fee, profit, tax, etc.			1 Lot		7,254,000-
Total {(1)~(3)}				Case B-2 =	Rs 43,526,000-
Breakdown	Foreign currency portion				18,984,000-
	Local currency portion				24,542,000-

Table D.5.21 COST ESTIMATE OF TRANSMISSION FACILITIES

(Case B-3)

Item	Unit	Quantity	Unit Cost (Rs.)	Amount (Rs.)
(1) Transmission pipeline for raw water, in the valley, φ700mm (DIP)	m	2,000	10,314-	20,628,000-
(2) Transmission pipeline for raw water, on the road, φ700mm (DIP)	m	2,300	7,309-	16,811,000-
(3) Transmission pipeline for treated water, φ600mm (DIP)	m	2,100	6,125-	12,863,000-
(4) Pipe bridge for river crossing:				
- St. Louis Stream (φ600mm×L=25m)		1 Lot		1,282,000-
- St. Louis Stream No.2(φ600mm×L=30m)		1 Lot		1,336,000-
- Pitot Stream (φ600mm×L=15m)		1 Lot		665,000-
(5) Dyke for raw water intake on Moka River		1 Lot		1,200,000-
(6) Break-pressure tank	Tank	2	1,502,000-	3,004,000-
Sub Total {(1)~(6)}				57,789,000-
(7) Overhead and others (20%) including preparatory work, mobilization, site cleaning, temporary work, right of way, traffic control cost, insurance, fee, profit, tax, etc.		1 Lot		11,558,000-
Total {(1)~(7)}			Case B-3 =	Rs 69,347,000-
Breakdown: Foreign currency portion				31,110,000-
Breakdown: Local currency portion				38,237,000-