7.4 Dredging Improvement

7.4.1 Improvement Measures

The typical dredging is by means of cutter suction dredge or hopper trailing suction. But, river dredging by the cutter suction dredge will hamper river navigation and possible wind and wave actions would easily make cutter suction dredging operation quite difficult.

In the case of the trailing suction hopper method, dredged spoils are loaded onto its hopper and transported to the designated areas for disposal. Because the channel along Boca Grande is 80 kilometers long and the average distance to the disposal site is located at about 40 kilometers away from the dredged area, a round trip to the disposal area would take 8 hours. This method is therefore inefficient and costly.

Therefore, the dredging method adopted to Orinoco is the trailing suction accompanied with dumping soils by the side casting immediately adjacent to the channel. In view of the above, the existing method appears to be appropriate. But, the improvements of dredging methods and equipment used at present will be required for effectiveness and efficiency of dredging works by the currently used dredges as described hereafter.

(1) Introduction of Precise Location System

Dredging operation is monitored by means of GPS at present. But accurate positioning of previously dredged area or remaining high spots is difficult due to the absence of such recording and storing devices as display indicator, plotter and others. At present, the unevenness of the dredged bottom of the channel is to an extent of about 3 meters. The precisely locating system of extremely uneven dredged bottom makes it possible to minimize the uneven bottom to be not more than 1.5 meters in Japan.

The drag head will be accurately positioned by the use of GPS and gyro for direction of dredging. Presently, the channel is provided with transmittal stations from which data are received through satellite to identify the location of the dredge. In order to complete the system, an integrated system equipment by track display, computer, drag head positioning system together with the gyro display software is recommended for dredges of Rio Orinoco and Guayana to precisely track depths and locations of shallow spots during dredging operation.

(2) Adoption of Dumping by Bottom Dumping Barge

Through the side casting pipe of 86m - 114m length which is shorter than the navigation channel width of 100m - 120m in Rio Grande, the dredged soil is discharged immediately adjacent to the

dredging routes in the channel. Therefore, the considerable return of disposed material into the channel is unavoidable. Especially, in Boca Grande, Rio Orinoco Dredge that is suitable in calm condition, is operated under the wind-whipped weather condition. The side casting pipe of the dredge can not be fully opened as the stability of the dredge under the reduced wind pressure should be maintained, and return ratio would increase. In the previous surveys, the return ratio in the outer channel is reported as 75% though it is only 25% for inland channel.

In order to eliminate a possible return of disposed material into the channel by the present method of side casting, the use of dumping barge is recommended for dredged materials disposal outside of the channel.

Two conveyors comprising of a barge of 3,500 cubic meter capacity and a 4,000PS pusher boat will be needed. Rio Orinoco is used for loading dredge materials onto the dumping barge and the dredged materials will be transported by dumping barge to the nearest suitable site outside the channel for disposal. Since the depths along the outside of the channel at Boca Grande range from 5 to 6 m, fully loaded barge of only 4 m draft can safely navigate along these areas.

By introducing the dumping barge system, it is expected to increase the dredging efficiency up to 80% - 100% by eliminating the return of soil, although the time efficiency may decrease up to 50% - 80% than the present side casting method. Based on the above improvement, the overall efficiency would be expected to increase at least by 1.6 times and, by simple calculation, the average dredging cost would decrease from 2.6 $ per m^3 to about 1.63 $ per m^3.

7.4.2 Other Improvement Measures

It is recommended to check the applicability of following dredging operations for dredging improvement.

(1) Deepening Tip of Drag for Fluff Dredging

At present, no previous study is available on the physical properties of the fluff. But, sounding data at Boca Grande shows a general profile of the bottom deposits clearly indicating a series of fluff deposits having different density. In general, it seems that as the fluff deposit get deeper, the unit weight of the deposit becomes heavier due to consolidation process by its own weight with time after being subjected to agitation.

It is recommended to dredge deeper layer of fluff deposits as possible in order to attain the designated channel depth of 13.2 meters for keeping safe navigable dredged depth. Dredging of deeper fluff layer will be facilitated by possible decrease of water with restraint of pump rotation. In addition, dredging should be carried out at suitable speed of movement to minimize the resistance of fluff deposits.

(2) Lowering the Position of the Discharge Pipe

In order to dispose dredged spoils far away as possible, the discharge pipe of dredge Rio Orinoco is positioned at 17 m above water level. But this positioning causes such ineffectiveness as frequent replacement of impeller or damage to the engine, unsteadiness of vessel, large fuel consumption and therefore the lowering the position of discharging pipe is recommended.

The following two (2) alternatives will be envisaged for lowering the position of the discharge pipe.

1) Use of rotational type at the tip of the discharge pipe so that pipe outlet could rotate 180 degrees for lowering its elevation by 5 meters

2) Lower the discharge pipe near the deck of the dredge

By these arrangements, the most efficient performance could be attained by minimizing probable replacement of impeller, proper adjustment of discharging volume, stabilization of the dredge, reducing fuel consumption, reduction of damages to the engine and prevention of severe abrasion to the impeller.

(3) Disposal Mode Shifting from Hopper to Side Casting for Guayana

Frequent occurrence of trouble is observed in the discharge system of Guayana particularly on its bottom closing and opening. It is therefore suggested to shift discharging mode from hopper to side cast method so that the dredging operation could increase from the present 600hr to 2,000 hr per annum.

(4) Finish Dredging at Boca Grande before Rainy Season

Survey result indicates that the water depth at Boca Grande is the shallowest along the channel when the Inland Channel has sufficient depth for navigation of larger size of vessel due to the rise of water level during rainy season. It is recommended that dredging at Boca Grande be completed before the beginning of rainy season.

(5) Provision of Bed Leveler to Drag Tip

Dredged bottom by trailing suction method tends to be extremely irregular and uneven. The remaining high spots should be removed or leveled for safe navigation. The device of bed leveler is quite effective to even irregular surface of dredged bottom so that the difference between the designated depth of channel and actual average depth of dredging could be reduced from 1.5 m to some 0.3 m.

7.4.3 Proposed Scheme of Investigation

(1) Survey on Properties of Fluff

To date, detailed study on properties of fluff deposits has not been conducted in Boca Grande. Echo sounding survey is not a tool for obtaining necessary physical properties of fluffs to determine effective method and program of dredging operation.

In view of the above, sufficient fluff samples from the channel should be taken for laboratory testing on such physical properties as natural water content, unit weight, grain size distribution, cohesion, etc. In particular, unit weights at different levels and time elapse of consolidation should be determined based on the result of consolidation analysis so that appropriate frequency of agitation could be formulated for dredging operation. Similarly, based on the result of the consolidation analysis, the most appropriate mode of dredging by means of agitation or removal or the combination thereof should be investigated.

(2) Examination of Dredging Method

In order to attain maximum output of dredging performance, the following items should be checked:

1) Discharge velocity

2) Size and revolution of impeller

3) Appropriate depth of drag head

(3) Checking of Orinoco Dredge

The dredge of Orinoco was constructed about twenty (20) years ago in August 1978. In order to improve its performance; the following aspects should be checked:

1) Listing of spare parts subjected to frequent replacements for the past twenty (20) years

2) Structural integrity of the dredge such as the steel frames, sheets and others for replacement if necessary

3) System of dredging, particularly the engine, power supply, pumps hydraulic systems and pipes and related equipment

4) Drag arm, ladder, winch and etc. for improvement as necessary

7.4.4 Costs of Proposed Improvement

The cost of the above scheme of improvement is estimated for the following cases.

1) The provision of positioning system for dredges of Orinoco and Guyana.

2) Loading dredged soils onto bottom dumping barge and disposing dredged spoils to the designated site outside the channel

Table S.7.3 Dredging Improvement Cost

Cost Item	Cost
Track Recorder for Orinoco and Guyana (Display and computer software including installation	US$ 191,000
Procurement of Bottom Dumping Barge/Pusher Barge And Installation of Discharging Pipes for Orinoco	US$ 21,900,000
Operation, Maintenance & Administration Charge	US$ 343,000
Total Cost	US$ 22,434,000

7.5 Implementing Agency

INC (National Institute of Canalization) annexed to the MINFRA (Ministry of Infrastructure) is proposed as the implementing agency to execute the projects conceived by the feasibility study, at least in the immediate short-term.

The feasibility projects are grouped into two (2) categories of dredging works and channel improvement works

7.5.1 Dredging Works

It is noted that despite the problems associated with ensuring the design navigation depth, INC still remains as the only institution having experience in conducting dredging works in the Orinoco river channel. Accordingly it will continue to carry out the similar but improved river channel dredging works as conceived in the feasibility study. Hence, the organization set-up of INC, as far as the conduct of dredging work is concerned, would basically be the same as that exists at present. This section of INC is referred to as the Canal Management Section, which is basically the existing Canal Orinoco Division of INC.

The Canal Management Section will continue to be responsible for river channel dredging operation and the related maintenance works including the conduct of required bathymetric surveys for improved river channel dredging works.

7.5.2 Channel Improvement Works

The addition of the Project Implementation Unit within the existing Canal Orinoco Division of INC is proposed to be newly established to manage, in overall sense, the execution of the civil and structural works of the project of the feasibility study on river navigation improvement other than dredging works.

The Project Implementation Unit (PIU) would utilize external expertise to design and execute the civil work project. Accordingly, Consultant to design, assist in tendering and professional supervision of construction works would initially be employed by the PIU. Also with tendering of design works a Contractor to carry out the civil construction works will be selected.

Based on the above, the PIU will be responsible for the overall project management including the provision of necessary information and guidance and approval as required for the Consultant, and for quality control, schedule and budget of the project execution based on the professional advice provided by the Consultant. In principle this organizational set-up of PIU will last until the civil construction works are designed and constructed with the assistance of external expertise of Consultant and Contractor organizations.

7.5.3 Organizational Set-up

It is noted that the core of PIU will have a project manager and the relevant administrative staffs as direct employees of INC. Also the PIU will have the necessary means to deal with land acquisition and compensation issues related to the execution of the civil and structural works. The required technical expertise for planning, surveying, designing and construction supervision including environmental management could be provided by the Consultant employed by the PIU.

The supervisory system of INC will remain the same as present. MINFRA will be the direct supervisory institution. PROA of MARN will remain as the coordinating agency. Accordingly the Steering Committee comprising members from all these organizations of MINFRA, MARN/PROA and INC may be established to oversee the execution of the project and hence to ensure its smooth implementation.

7.6 Environmental Impact assessment (EIA)

Based on the IEE results, in order to establish the integrated environmental protection program in the Feasibility Study for the project, detailed environmental study of the present situation and examination of mitigation and/or elimination of the negative impacts was carried out.

7.6.1 Existing Environmental Study

(1) Quality of Water, Sediment and Analysis of Benthic Animals and Planktons

- The measured values are considered as normal comparing to the standards on water qualities in Venezuela (Decree N° 883 - Waters type 2, 4 and 6; agriculture, recreation and navigation).
- The composition of the bottom material is essentially sand with insignificant organic components.
- Biological activity is very poor.
- No macroinvertebrate organisms associated to the bottom were found.

(2) Aquatic life and fisheries

- Commercial fisheries are performed seasonally in the dry season (November to April).
- Most important fishing locations are: Mariche and the Tórtola channel.
- Fishing activity is the main source of income of riverside communities.

(3) Socio-economic environment

- The socioeconomic dynamic relies upon around the river, mainly at the rural communities, where the river is the only communications.
- In the case of Barrancas the economy turns around the agricultural and live stock activities, and the public sector. In the case of the remaining communities, there is a clear agricultural and fishing orientation. In both cases, the dependency of the economic activity on the river is very high.

7.6.2 Impact assessment

(1) Potential hydraulic-fluvial effects

1) Erosion effects

Erosion effect will not only take place in the vertical direction of the riverbed but in its hydraulic perimeter, which means that there will also be erosion at the river banks, although it will be in a much lower proportion than the bottom erosion.

2) Sedimentation Effects

The sediment conveyed from the upper stream of the Rio Grande will be deposited at upstream of Tórtola channel due to the closure of the channel. The sedimentation will fill-up the water body area. It will lead the loss of habitat of aquatic life including aquatic vegetation. The local transportation route from Mariche to Barrancas will be affected as well.

(2) Impacts on the aquatic life and fishing

The special locations for fishing of Mariches and Tórtola would disappear with the total or partial closure of Tórtola channel. This will adversely affect the local inhabitants who depend on the fishing activity as main living and employment source.

(3) Impacts on the socioeconomic environment

Consequent to the closing of water passage by the dike, the vessels passage is hindered. This would mean interruption of communication of communities in the West of Tórtola channel with major population centers such as Barrancas and Piacoa. The population that inhabits the bank of the river almost exclusively depends on fishing activity for both income and self-consumption. Thus, the closure of the canal would alter their daily lives.

7.6.3 Mitigation plan

1) It is desirable to introduce appropriate structural facilities and allow the required water flow through the Tortola channel in order to maintain the fluvial environment in lotic condition. Several measures can be envisaged such as submerged dike or dike with culvert/silt openings ensuring the flow discharge through the Tortola channel, while maintaining the required discharge in the Rio Grande channel to satisfy the navigation depth requirement.

2) A measure to ensure no interruption to local navigation even in dry season with the provision of a small navigation lock along with the dike closure.

3) There will be a possibility of erosion at the left bank of Rio Grande in the sector of Barrancas. The necessary revetment for protection of the river bank subjected to erosion is designed.

It is considered that even if the structure of submerged dike or dike with culvert/slit openings is adopted as the mitigation measure, the fill-up of the water body could not be avoided in the long term. Consequently resettlement of river bank population would be required. Table S.7.4 shows the information on the related villages affected by the channel closure.

Table S.7.4 The information on the Relating Villages

Village name	No. of Family	No. of people
Caratal de Tortola	9	21
Manacal de Tortola	16	98
Tortola Abajo	33	198
Tortola arriba	7	20
Mariche	4	17
Total	70	354

7.7 Economic and Financial Evaluation

7.7.1 General

The subject plans for evaluation are the Structural Measure and the Dredging Improvement Plan. The former has two alternatives involving a complete closing dyke and a submerged dyke respectively while the latter has two alternatives designed for step-by-step improvement involving additional GPSs and new type dredging boats respectively.

In the case of the Structural Measure, each alternative is independently evaluated. In the case of the Dredging Improvement Plan, the additional GPS alternative alone and the combined implementation of the GPS alternative and the new type dredging boat alternative are evaluated.

In addition, various indirect effects which cannot be quantified are analyzed for each of these two plans for comprehensive evaluation.

7.7.2 Economic Evaluation

(1) Structural Measure

The following evaluation results suggest that neither alternative of the Structural Measure has economic viability.

Table S.7.5 Economic Evaluation of Structural Measure

	Alternative I (Complete Closing Dyke)	Alternative II (Submerged Dyke)
Project Cost (economic price)	US$ 61,029,000	US$ 77,936,000
O/M cost (economic price)	US$ 305,000/year	US$ 389,000 /year
Benefit (economic price)	US$ 8,939,000 (benefit from reduced dredging cost)	US$ 8,939,000 (benefit from reduced dredging cost)
B/C	0.95	0.74
EIRR	-	-
Economical Feasibility	×	×

(2) Dredging Improvement Plan

The following evaluation results suggest that both alternatives of the Dredging Improvement Plan have clear economic viability.

Table S.7.6 Economic Evaluation of Dredging Improvement Plan

	Alternative I (Additional GPSs)	Alternative II (Additional GPSs + New Type Dredging Boats)
Project Cost (economic price)	US$ 177,000	US$ 20,544,000
O/M Cost (economic price)	US$ 465/year	US$ 319,000/year
Benefit (economic price)	US$ 874,500 (benefit from reduced transportation cost)	US$ 11,250,700 (benefit from reduced transportation cost and dredging cost)
B/C	43.76	4.36
EIRR	493%	53%
Economical Feasibility	feasible	Feasible

7.7.3 Financial Evaluation

(1) Structural Measures

The economic evaluation results clearly indicate that both alternatives lack economic viability. Consequently, it is judged that financial evaluation of the structural measures is meaningless.

(2) Dredging Improvement Plan

1) Alternative I (Additional GPSs)

As the INC (Institute National de Canalization), the implementing agency of the Project, cannot expect any increase of its revenue following the implementation of this alternative, exploration of the financial viability is difficult. However, the transportation cost of iron ore will be reduced by US$ 874,500 a year with the implementation of this alternative and it should be possible for consignors of iron ore to pay some 10% of the above savings to the INC as an additional charge. Such payment is also rational from the economic point of view.

Assuming that such upward revision of the charge is feasible, the revenue of the INC will increase by US$ 87,450 (US$ 874,500 x 0.1) a year (this will represent an increase of US$ 0.0219/ton or approximately a 1.6% increase of the present charge).

Based on this assumption, the FIRR of 46 % is calculated for this alternative of additional GPSs.

2) Alternative II (Introduction of Barge Disposal System)

The implementation of the dredging improvement plan will not directly increase the revenue of the INC, a reduction of the dredging cost can be anticipated. When this cost reduction (US$ 9,700,000) is considered to be the financial profit, the financial analysis produces an FIRR of 42%, suggesting that the dredging improvement plan is financially feasible.

The FIRR is still 40% for the case in which the procurement cost of the barge disposal system is assumed to be met by a foreign loan (JBIC case), illustrating the financial feasibility of this alternative.

Assuming the continuation of the present situation under which the annual budget of the INC is insufficient to allocate sufficient funds to completely conduct the necessary amount of dredging, some type of government subsidy will be required to cover part of the project cost. To be more precise, a government subsidy for the introduction cost of the barge disposal system (US$ 21,900,000) and an increase of the present iron toll charge by 7% (US$ 0.0945779/ton) will be required. This toll charge increment is only some 25% of the reduction of transportation cost of US$ 0.387675/ton (= US$ 1,550,700/4,000,000 tons) due to the implementation of this alternative. The FIRR of this case is 18% making the alternative financially viable.

7.7.4 Comprehensive Evaluation

The comprehensive evaluation results of the structural measures and the Dredging Improvement Plan, both of which are proposed as priority projects, are described below based on the economic evaluation as well as the financial evaluation results for these plans.

(1) Structural Measures

Both the Complete Closing Dike Project and the Submerged Closing Dike Project indicate that the benefit arising from the investment cost fails to show feasibility from the viewpoint of the national economy. Needless to say, the financial feasibility of both projects is judged to be difficult. The implementation of these projects should, therefore, be suspended.

(2) Dredging Improvement Plan

Both the additional GPS plan and the barge disposal system introduction plan clearly show economic feasibility due to the improved precision and efficiency of dredging work. As the project implementation body, therefore, the INC should urgently install dredges with additional GPS units. The barge disposal system should be implemented if it is found necessary to solve the financial problems based on a national consensus.