CHAPTER 6. MASTER PLAN FOR CHANNEL IMPROVEMENT

6.1 Basis of Channel Improvement

Since the Rio Grande was opened for the waterway navigation in 1950s, enormous efforts have been made to maintain the navigation channel. Due to the heavy sediment discharges from the Orinoco River basin, sections of channels in the river delta are continuously required more than 8 million m^3 of annual dredging works in total. In addition, the long shore current along the coast transports and accumulates sediments in addition to the discharges from the Orinoco causing 10 million m^3 of dredging work annually in the navigation channel at the river mouth. The operation and maintenance of navigation channel specially dredging works has become a heavy burden to the development of the waterway transportation.

Therefore, sufficient channel improvement is desired to minimize the dredging activities and to guarantee the navigation safety as well. As for the channel improvement defined above, a combination of structural and non-structural measures must be employed along with an efficient method for dredging activity.

Table S.6.1 Concept of Channel Improvement

<table>
<tr><td>Subjective Channel</td><td colspan="3">Rio Grande Channel (L=339 km)</td></tr>
<tr><td>Present Problems</td><td colspan="3">Difficulty in huge amount of dredging work required and in provision of target depth for navigation</td></tr>
<tr><td rowspan="4">Concept for the Improvement</td><td>① Structural</td><td>② Non-structural</td><td>③ Improvement of Dredging methods</td></tr>
<tr><td colspan="2">Navigation channel improvement</td><td>Operation and Maintenance</td></tr>
<tr><td>Reduction of dredging volume with river structure</td><td>Reduction of dredging volume without river structure</td><td>Provision of required depth</td></tr>
<tr><td>- River structures to confine the flow to a narrow width and increase the discharge in the navigation channel.
- River structures to close the river branches</td><td>- Usage of deeper route for navigation</td><td>- Increase of dredging time
- Acquire a flat bed leveling the uneven channel bottom
- Prevent the return of disposed dredged materials into the channel</td></tr>
</table>

The Rio Grande channel was selected as the most suitable navigation route among all, such as Manamo and Macareo routes, taking into consideration of present and future cargo demands and efficient shipping systems as well as prevailing channel characteristics, improvement and maintenance costs for navigation. Therefore, channel improvement in this study is focused to Rio Grande route.

In addition, according to the forecast for future cargo handling requirement, size of the vessel needs to be used, would be the 65,000 DWT class of Panamax type same as the present allowable size.

Therefore, the depth to be maintained in the channel improvement is adopted to be the same with the present navigation criteria as follows:

- 10.2m (34 feet) below LWL(NAB) in Rio Grande (Inland channel).
- 13.2m (44 feet) below LWL(NAB) in Boca Grande (Outer channel).

In flood seasons, Panamax class vessels can navigate with full load (12.8 m draft) in the above channels. In dry seasons, however, since the water level goes down to LWL the smaller vessel types than Panamax and/or reduced load method, have to be selected.

6.2 Structural Measures

6.2.1 Dredging Sections

At present, in the Rio Grande channel, it can be identified that there are seven sections where dredging activities are required for the navigation of Panamax type of vessels. The total length of the 7 dredging sections is 128 km. Among them, 6 dredging sections are located in the inner channel and the total length is 50 km having the annual maintenance dredging volume of 8,400,000 m^3. The remaining section is located in the outer channel and the total length is 78 km having the annual maintenance dredging volume of 10,000,000 m^3 (see Table S.6.2). Annual budget of INC for the maintenance dredging amounts to US$ 32.85 million per year (Average from 1990 to 1995).

Table S.6.2 Present Dredging Sections

Section Name	Chainage (km)	Dredging Length (km) (Section Length in km)	Annual Dredging Volume (million m^3)
(1) San-Felix	330 - 339	8 (9)	1.61
(2) Aramaya	306 - 322	4 (16)	1.04
(3) Guarguapo-Barrancas-Ya-Ya	246 - 278	19 (32)	3.82
(4) Araguaito	222 - 246	1 (24)	0.10
(5) Sacupana-Guasina	182 - 207	16 (25)	1.51
(6) Curiapo	93 - 115	2 (22)	0.40
(7) Boca Grande	0 - 78	78 (78)	10.00
TOTAL			18.48

Note: The dredging volume represents the average dredging between 1965-1972.

In inner channels, river has several diversion branches that have been formed due to the development of large islands in the river channel. Therefore, discharge of the river is divided into all these branches, causing the flow intensity in the navigation channel less effective. Since huge bed-loads of 15.0 million m^3 per year are discharged in the Orinoco River, the dredged channel in the river section is completely filled at the end of every rainy season.

In the outer channel, the bed-shear-force of flow at the river estuary is drastically reduced due to the expanded flow width. Hence, the wash loads from the Orinoco River and sediment with the long shore currents from south coast are accumulated and the depth becomes shallow in this section. In the Boca Grande the annual deposition is noted at only of 1.0 m to 1.5 m height in the previously dredged channel.

6.2.2 Possible Measures and Selection of Sections for Structural Measures

Specific characteristics of the Rio Grande channel, which are of prime importance prior to undertake the structural measures, are verified by the one-dimensional (1-D) numerical analysis. A prominent characteristic of the Rio Grande channel is the longitudinal variation of channel bed elevation due to bed shear force as a consequent of channel width and/or discharge variations. Based on these characteristics of the river flow channels, structural measures are determined to acquire a larger water depth either by confining the flow to a narrow width or increasing flow discharge in the navigation channel.

Two types of measures, "point structural measures" targeting specific places and "longitudinal structural measures" along the channel can be envisaged.

Table S.6.3 Applicability of Structural Measures

Structural Measures	Features
① Point Measures	Measures to increase discharge in the navigation channel by point structure to close branch, and to increase the shear force in the channel (refer to Fig.S-7-2)
② Longitudinal Measures	Measures to confine the channel width by longitudinal structures along the channel such as groins and training dikes, and to increase the shear force in the channel.

As the Orinoco river is a huge river in terms of scale and discharge, large scale improvement measures along the longitudinal direction of the channel would not be economically feasible due to the lengthy dredging reaches. Hence, appropriate structural measures should be focused as point measures targeting specific places.

Based on the preliminary evaluations, 3-sections Aramaya, Guarguapo- Barrancas - Ya-Ya and Sacupana – Guasina are selected for structural measures by means of possible point measures. The environmental impacts and future maintenance requirements are also needed to be assessed.

6.2.3 Alternatives for Structural Measures

Owing to the existence of diversion channels at the 3-sections; Aramaya, Guarguapo-Barrancas-Ya-Ya, and Sacupana-Guasina which are selected for channel improvement, it is envisaged as the possible alternative measures (see Table S.6.4), to close certain diversion branches by dikes for improving flow intensity and lowering bed elevation in the branch of navigation channel.

Table S.6.4 Alternatives of Structural Measures

Section	Alternative	Main Facilities
Aramaya	A-0	No Facility (Maintain the present condition)
	A-1	Closing Dike; L=3,000 m
Guarguapo-Barrancas-Ya-Ya	B-0	No Facility (Maintain the present condition)
	B-1	Closing Dike; L=1,000 m and Revetment; L=2,000 m
	B-2	Closing Dike; L=2200 m and Revetment; L=2,000 m
	B-3	Closing Dike; L=1000 m and Revetment; L=2,000 m
Sacupana-Guasina	G-0	No Facility (Maintain the present condition)
	G-1	Closing Dike; L=1,700 m

In Aramaya section the river is very wide and shallow in this reach. As Alternative A-1, closing the diversion branch by constructing a closing dike was conceived in order to increase the discharge in the navigation channel.

In Guarguapo – Barrancas - Ya-Ya sections, three islands that exist in the river course, divert the discharge. In order to increase the discharge in the navigation channel, therefore, three alternatives were envisaged as Alternatives B-1, 2 and 3 by means of closing dike diversion channels. However, increasing discharge in the navigation channel by this measure may cause severe river bank erosion. Therefore, along with each alternative of closing dike, the revetment for bank protection is considered at the reach near Barrancas.

In Sacupana-Guasina sections also, the flow intensity in the navigation channel is lowered due to the distribution of discharge to several branches of channel formed by large islands in the river course. In order to increase the flow intensity in the navigation channel, the closing dikes as Alternatives G-1 and G-2 are conceived.

6.2.4 Proposed Structural Measures

In order to identify the effect of each alternative, the bed elevation change in the dredging section was simulated by utilizing one-dimensional (1-D) numerical model. As the result of simulation, the Alternative B-2 for Guarguapo - Barrancas - Ya-Ya section is confirmed as the most effective measure to lower the bed elevation of navigation channel, owing to the fact that currently 40 % of the

main stream discharge flowing in the Tortola channel is distributed to other channels and the discharge of the navigation channel increases almost twice.

For Aramaya and Sacupana-Guasina sections, alternatives A-1 and G-1 require large-scale structures. Hence the construction cost is high and it is not economical.

Regarding the structure type for the closing dike, the mound dike type is proposed in this study taking into the consideration construction and maintenance easiness, lower cost, etc.

6.2.5 Preliminary Costs for River Improvement

The preliminary project cost for the proposed structural measures Alternative B-2 is estimated at 58,793 million Bs (US $ 103.1 million). Operation and maintenance cost is assumed as 0.5 % of direct construction cost and estimated at 218 million Bs (US $ 0.38 million).

6.3 Non-structural Measures

In order to reduce the maintenance dredging volume, the non-structural measures as less expensive measures, can also be applied for channel improvement, ie., specifying the best route for navigation through the deepest area of the channel.

The seasonally deep water path in the channel subjects to move according to the changes in river flow. Therefore, by conducting regular bathymetrical surveys, the deeper area in the channel has to be defined and the navigation route realigned in viewpoint of reduction of the dredging volume, after careful evaluation.

6.4 Dredging Improvement

6.4.1 Brief Background

The navigation channel along Boca Grande and Rio Grande is about 339 kilometers long, comprising of 78 kilometers Outer Channel extended from the river mouth at Boca Grande towards offshore and 261 kilometers Inland Channel along Rio Grande. Due to shortage of water depth of the channel, some 78 and 50 kilometers long maintenance dredging along the Outer and Inland Channel respectively needs to be conducted to ensure safe navigation of vessels. Typical required cross-sections of the navigation channel are as follows.

- The Outer Channel : The Outer Channel is required to maintain to have a bottom width of not less than 400 feet and a depth of 44 feet below MLLW with side slope of 1: 6 in order to accommodate 65,000 ton Panamax vessels having a draft of 42 feet with an allowance of 2 feet for safety.

- The Inner Channel : The water levels in Inland Channel drastically rise in rainy season and fall to LWL in dry season. A depth of 34 feet below LWL and a bottom width of not less than 300 feet with side slope of 1:6 is required for the Inland Channel in dry season for accommodating vessels of 32 feet draft with an allowance of 2 feet.

The navigable depth in the Rio Grande Channel can be defined as the minimum depth of either the Inland Channel or the Outer Channel. In dry season, since the Inland Channel becomes shallower than the Outer Channel, the Inland Channel depth of 34 feet governs the navigational depth of the Channel while the navigational depth of Channel in rainy season becomes equal to the depth of the Outer Channel of 44 feet.

6.4.2 Present Status of Dredging Activities

The Institute Nacional de Canalization (INC) is the executing arm of the Government of Venezuela to implement the channel dredging to maintain navigable depth of water along the Outer and Inland Channel. The following are the relevant information on the present activities of maintenance dredging of the Channels.

- The bed of the Inland Channel consists of uniform fine sand ranging from 0.7 mm (700 microns) to 0.3 mm (300 microns) in diameter. At the river mouth where the flow velocity decelerates, suspended sediments in water tend to flocculate and settle into fluff with high void ratio. Therefore, the bed of the Outer Channel is deposited by fluff materials of very fine silts having a minute diameter of no more than 2.1 microns. Though the fluff settlement with high void ratio does not affect vessel navigation immediate after a process of flocculation, this fluff may become an obstruction to safe vessel navigation when the fluffs are compressed by its own weight as the void ratio of the fluff decrease with time.

- INC Report dated January 1996 indicated that the annual average volume of dredging at the Outer and Inland Channels amounted to 10 million and 8.4 million cubic meters respectively for a period from 1965 to 1972. However, according to the recent INC record from January 1 ,1995 to December 31 in 1998, the navigable depth is 2-3 meters less than the required channel depth.

- The water level in the Inland Channel starts to rise in April, thus increasing water depth along the navigable channel. As a result, the water depth in Outer Channel becomes comparatively shallower. The water level in the Inland Channel however starts to fall in September, making the Inland Channel shallower than the Outer Channel. Therefore, the Inland Channel is being dredged from September to March during the dry season while the Outer Channel is being dredged from March to August during the rainy season.

- According to pre and post dredging survey taken along the longitudinal section of the Outer Channel in April and September 1997, the Channel was dredged to an average depth of 13.2 meters below MLLW so as to satisfy the required depth from average of 11.7 m below MLLW prior to dredging. However, the survey result also shows an unevenly dredged bed channel in some places indicating the highest spot to have navigable depth of about 7.0 meters only below MLLW.

- Based on the INC's depth bulletin, it is observed that the maintenance dredging of the Outer Channel is much higher than the Inland Channel during the rainy season in particular when the River becomes deeper than the Outer Channel. This deepening for the Outer Channel is estimated to involve a total volume of about 25 million cubic meters of spoils. As regard the Inner Channel based on the recently obtained graph by INC Bulletin on channel depth along Boca Grande and Pt. Ordaz covering the period January to December 1988, depth of the Inner Channel from November to April or about 6 months period is more or less than 10 meters below MLLW. This is about the same depth as of Boca Grande, which satisfies the required depth of 10.2 meters during the receding water line period. As water level rises from May to October, the depth along almost all the Inner Channel becomes more than 13.2 meters.

- Prior to the start of dredging operation, water depth sounding survey is being conducted at the stretches of deposits. 24 kHz and 200 kHz echo sounder is used for the Outer and the Inland Channel. Since the bed material in Inland Channel consists of sand, both the 24 kHz or 200 kHz will detect the same depth. In case of the Outer Channel, however, the 200 kHz echo sounder would measure only extremely shallow depth of the high spots composed of the uncompressed fluffs. The 24 kHz echo sounder, on the one hand, may detect the deeper surface of denser stratum which would indicate the level of obstruction for safe navigation.

- INC publishes a daily bulletin on the depth of the Channel. Based on the shallowest depth from the data, the shipping operators are required to subtract two (2) feet of the vessel's draft to ensure safe navigation of vessels. In the case of the Outer Channel, when the captain considers that passage is hazardous due to occurrence of fishtailes or squat, INC is notified to adjust the published depth accordingly.

6.4.3 Dredge Fleet

INC owns a fleet of three (3) dredges, namely: Rio Orinoco, Icoa and Guayana, all of which are trailing suction side discharge type of dredges except for Guryana of Hopper type. But among the three dredges, Icoa is no longer operational. At present, the Channel is maintained by three (3) dredges including Hang Jun 6001 Dredge contracted with China Harbor. Particulars of these dredges are shown in the Table below.

Table S.6.5 Particulars of the Dredge Equipment

Dredge	**Río Orinoco**	**Hang Jun 6001**	**Icoa**	**Guayana**
Owners	INC	CHINA HARBOR	INC	INC
Year Constructed	1979	1979	1961	1991
Length	116m	153m	147m	141m
Width	28m	29m	28,5m	23m
Gross Weight (GT)	8,750	14,328		
Propulsion	Self-propelled	Self-propelled	Self-propelled	Self-propelled
Type	Trailing Suction Discharge Arm	Trailing Suction Discharge Arm Hopper	Trailing Suction Discharge Arm Hopper	Trailing Suction Hopper
Arn Length from the center of hull	86m	114m	108m	-
Arm Height from Water Level	17m	17m	20m	-
Hopper Capacity	-	6,300m^3	2,350m^3	7,500m^3
Number of Pump	4 pumps	4 pumps	4 pumps	2 pumps
Pumping capacity per pump	12,000m^3/h	10,500m^3/h	10,000m^3/h	15,000m^3/h

6.4.4 Evaluation of the Current Dredging Activities

(1) Soil Disposal dredged at the Outer Channel

Dumping of dredged soils is carried out by the side casting method except for Guayana dredge. The discharging arm is constructed to rotate at an angle of 90 degrees in horizon from the longitudinal axis of vessel to ensure discharge to the outside of dredged Channel. However, discharging arm is limited to rotate about 15 degrees only to ensure vessel stability against strong wind or wave actions in the Outer Channel. Therefore, the dredged materials are being disposed inside the Channel, resulting in the dredged deposits being transferred from one place to another within the Channel. This agitation of bed materials would be effective for vessel navigation to some extent because of loosening channel bed materials to the state of fluff.

(2) Soil Disposal dredged at the Inland Channel

In the case of dredging at the Inland Channel, the discharge arm of the dredge is workable to rotate in horizon at 90 degrees perpendicularly to the axis of the vessel. But the shortage of discharge pipe length would only permit the disposal of the dredged spoils either into the Channel or immediately adjacent to the Channel.

(3) Extremely Uneven Dredged Channel Bottom

A sample of the Channel dredged section by a trailer suction dredge shows that the dredged channel bottom is extremely irregular and contains many peaks and valleys. Considering safe passage of the vessels, the navigable depth of the Channel should be measured from the highest peak of the dredged bottom to the water level. In such case, the differences between the average depths and the highest peak of the dredged bottoms in April and September 1997 for instance are 4.0 m and 3.2 m, respectively. It is very important to minimize the differences between the average depths and the highest peak of the dredged bottoms in order to obtain the maximum depth by minimizing the volume to be dredged.

(4) Operating Hours

According to the annual operation dredging record of the three (3) dredges in recent years, Rio Orinoco and Hang Jun 6001 have been in operation on an average of six (6) and ten (10) hours per day only, respectively. Among others, Guayana yields minimal output of dredging and Icoa is no longer operational. The low performance ranging from about 30% to 50% of the planning volume is stemmed out from the low operating time of the dredging.

Discussions with INC's representatives revealed the following reasons for a low operating time of dredges:

1) The crew is tasked basically to operate the dredge only. Maintenance and/or repair of the dredge fleet is contracted to other party;
2) For every three (3) weeks of operation, five (5) days are spent on maintenance of the dredge.
3) The Guayana dredge is continuously in trouble, hence is almost non operational. The discharge system of the hopper is also in trouble particularly on the closing and opening system of the hopper bottom cover which discharges the dredged spoils. In addition, the Rio Orinoco dredge has stability problem.
4) The procurement of spare parts sometimes takes more than six (6) months.
5) The impeller is being subject to rapid severe abrasion particularly at its inner side because of rotation in pump filled with sand soils; and
6) Spare parts are being damaged due to the exhaust gas of high temperature.

6.5 Institution and Organization Study

6.5.1 Institutions Related with the Study

At present the main institutions related with transportation in the Orinoco axis are the General Sectorial Directorate for the Orinoco-Apure Program (DG-PROA), MINFRA (MTC prior to August 1999), National Institute of Canalization (INC) and Port Captaincy. These institutions are basically responsible for planning, development and operation of the channel navigation and its facilities. The Venezuelan Corporation of Guayana (CVG) and CVG enterprises are the main users of the navigation facilities. It is noted that recent ministerial reform of August 1999 has altered some of the relevant responsible ministries as also noted above. These relevant institutions are briefed below.

(1) General Sectorial Directorate for the Orinoco-Apure Program (DG-PROA), Ministry of Environment and Natural Resources (MARN)

DG-PROA is a Directorate of the Ministry of Environment and Natural Resources (MARN). It is one of the key agencies for the development of the Study Area. The specific aims of DG-PROA are:

- To direct and conduct studies and research as well as to formulate development programs and projects in the Orinoco-Apure river basin;
- To promote the exploitation of the existing potential of the Orinoco and Apure rivers and its adjacent areas;
- To promote the social and economic development of these regions; and
- To formulate a system of urban centers within the framework of the National Plan for the Territorial Organization.

In order to achieve these goals, DG-PROA is:

- Developing projects in the Orinoco river basin with due consideration of the environment;
- Encouraging the fluvial navigation; and
- Carrying out studies and research.

(2) Ministry of Infrastructure (MINFRA)

The MINFRA, recently formed following the reformation with the combination of the Ministry of Transportation and Communications (MTC) and the Ministry of Urban Development (MINDUR) is the foremost central governmental organization responsible for the planning and execution of the

Executive policies of infrastructure development including transportation and communication as well as the regulation and control of navigation.

The main attributions of MINFRA regarding water transportation are:

- Planning, construction, operation and maintenance of the ports, berths, quays, navigation channels and other related facilities as well as the related services to the ships entering the ports;
- Regulation of the shipping policies and control of the navigation and water transportation;
- Establishment of the rates and freights for services; and
- Provision and regulation of the services of water transportation.

Currently, the functions of MINFRA in Orinoco Axis have mainly been oriented to the design of an institutional and regulatory organization focused in the provision of water transportation services.

(3) Port Captaincy

The Port Captaincies are departments within the organization of MINFRA. They are in charge of control and surveillance of the territorial and interior waters, coasts, ports and related facilities providing safety to the navigation activities. For this purpose, Venezuela has been divided into 12 regions. The Port Captaincy within the Study Area is located in Puerto Ordaz and its area of influence extends from Boca Grande to 215 miles upstream of the Orinoco River. Its main activities are:

- To guard and control the territorial waters, coasts and related facilities;
- To acknowledge any significant activity by the vessels, such as: entrance and leaving from the port, fuel and water supply, and shipyards use among others;
- Surveillance of the quays, waterfronts, berths, shipyards, oil or other combustible storage facilities; and
- To organize navigation activities in order to make them proceed safely and smoothly.

Port Captaincy provides navigation pilot service from Boca Grande to Puerto Ordaz and vice versa.

(4) National Institute of Canalization (INC)

The INC is an institute affiliated to MINFRA. Currently, INC's main functions are:

- Study, financing, construction, maintenance, inspection, improvement and management of the navigation routes, especially those having access of large draft ships to the Orinoco route;

- Development of auxiliary facilities required for the construction, use, service and maintenance of the above mentioned routes;
- Dredging of the navigable river beds, directly or in association with private, public, local or foreign organization; and
- Acquisition of shares or participation on governmental, private or joined (governmental & private) companies that contribute directly to the execution and improvement of the dredging related works.

At present, INC's activities in the Study Area are related to the assurance of the navigability of large vessels through Rio Grande canal by conducting necessary dredging operations, the appropriate signaling and provision of navigation aids. INC's budget is supported by tariffs paid by the users of the navigation channels.

(5) Venezuelan Corporation of Guayana (CVG)

The Venezuelan Corporation of Guayana is an autonomous institution. In the past, the development programs of CVG encompassed a variety of activities as diverse as hydro-electric power generation, direct exploitation of iron ore and other cargo for export via the Orinoco river using its own berths.

At present, most of the cargo handling activities has been delegated to CVG subsidiaries, namely CVG enterprises. This has resulted in independent ownership of the berths and absence of an integrated Port Authority. The only port still under CVG's direct operation is San Felix Port as a general cargo terminal for public use.

(6) Committee on the Authority of the Orinoco River (CEARO)

The CEARO was constituted in 1986 as an attempt to create an integrated Port Authority in the Study Area. It was entrusted with management of the ports and navigation. Its budget was provided by the MTC, however its administrative offices were located in CVG. Nevertheless, in 1992, its activities have been suspended. At present, these related facilities are under self-control of CVG and its enterprises.

6.5.2 Management Institution

The Venezuelan government ministries have been reformed in August 1999. Still the establishment of a legal and institutional framework that allows the sustained consolidation of the Orinoco River axis remains an important issue to be resolved. With the recent Venezuelan government ministerial reformation change toward decentralization and delegation of public functions to the regions is expected to be expedited.

The significant institutional and management issues concerned to the port management and river (Rio Grande) navigation in the Study area and the respective institutional improvement measures are identified below.

(1) Overall Port Management

Prior to the delegation and formation of CVG enterprises, CVG was responsible for overall port management. However, at present, the formation of various independent subsidiary companies of CVG and their independent berth ownership has led to an institutional vacuum concerned to the overall port management. Accordingly, it is recommended to establish a Port Authority similar to the ones exist in other regions of the country. The Port Authority may be established as an organ of the MINFRA and responsible for the co-ordination of the port berth operation as well as the development of future port expansion to achieve a sustainable economic growth in the Orinoco river basin.

(2) Dredging in the Navigation Channel.

In order to increase the efficiency of dredging works and to follow the government policy of decentralization, a scheme of private companies to carry out the dredging works under the planning, management and supervision of INC is recommended to be considered. Under this system, INC will play the role of planner and regulator, leaving the actual execution role to third parties in the form of "outsourcing".

(3) Long-term Institutional Improvement

The recent government ministerial reformation has given the momentum for subsequent institutional reformation at state and municipal levels. Accordingly, the institutional reformation of responsible organizations managing the navigation axis of the Orinoco River, in particular INC, need to be studied. It is recommended to establish an ad-hoc institutional reformation committee to study and determine the appropriate modality of modern institutions within a set (definite) time frame (2 - 3 years).

6. 6 Environmental Study

This Environmental Study is divided into two bodies, that are, Initial Environmental Examination (IEE) and Environmental Impact Assessment(EIA). In the phase of the Master Plan of the Project, the Initial Environmental Examination(IEE) was carried out with the review, analysis and assessment of the previous studies and field reconnaissance survey results, together with the studies on the environmental administration systems in the Venezuela . And then this study was followed by a detailed field survey of the Environmental Impact Assessment (EIA) for the Feasibility study for the Project.

6.6.1 Procedures on Environmental Impact Assessment(EIA) in Venezuela

In Venezuela, all the promoters who intend to establish any project have to submit Intention Document to DGSCA of MARNR. The document refers to the project description, objectives , impacts to be expected after implementation of the project. The DGSCA shall establish the methodology among the following three methodologies depending on the magnitude of the projects. They are "Environmental Impact Study", "Specific Environmental Evaluation" and "Presenting additional information for evaluation of the impacts caused by the project". The promoter will acquire the authorization of land use and natural resource use through the examination of the study report by the DGSCA.

6.6.2 Present Condition of Environment of Study Area

(1) Natural Environment

The Orinoco Delta presents a humid tropical climate with high temperatures and a short dry season in which there is still considerable precipitation. The vegetation of the Delta is characterized by the marshy plains of the Orinoco Delta. It is said that Venezuela is one of the most important 10 regions in the world for bio-diversity. In the Orinoco Delta, due to the uniformity of the climatic condition derived from topographical characteristic of flat plain in the area, the fauna in the area is also evenly distributed. The Mariusa National Park, 265,000 ha, is located in the State of Delta Amacuro between the Macareo canal and the Mariusa canal. Also there is Orinoco Delta biosphere reservation in the area located between Macareo canal and Rio Grande.

(2) Social Environment

The main economic activities of the state of Amacuro Delta are fishery, agriculture, forestry and mining. As for the infrastructure of roads and communications in the State, the transportation in the area is poorly developed due to its geographical location and its delta condition. There is a limited interrelation between the rural area and populated areas because of the lack of network of the fluvial, maritime, land and air communication. According to the 1990 Census conducted by OCEI, the population of the state was 84,564. Regarding the indigenous People, the predominant ethnic group in the State of Delta Amacuro is the Warao, whose total population is estimated at some 29,000.

6.6.3 Initial Environmental Examination(IEE)

(1) Objectives and procedure of IEE

In order to reveal the present environmental condition in the Area and to focus the elements which have relevance to the Project, Initial Environmental Examination(IEE) was carried out.

(2) The results of the IEE

Overall negative environmental impacts by the channel improvement project was evaluated as significant. The reason for this conclusion of the environmental evaluation is as follows;

With regard to impacts on environment, there is no sensitive area such as national parks in the project sites. The impact to local navigation and tourism due to dredging activities is also evaluated as insignificant, because the activities have already been carried out for long periods and no new route for the dredging is included in the Master Plan.

However, closing channels is evaluated as significant with respect to the social impacts, because of the loss of aquatic life such as fish. It affects the life of the people living in the downstream area of the closing dike directly. It might cause involuntarily resettlement because of the loss of their main subsistence fishery.

In addition, the deterioration of water quality due to closing channels is considered as significant. It might affect aquatic life consequently. Moreover, the change of water flow condition derived from closing channel might lead to erosion of the river bank at Barrancas city.

Therefore, the devise on closing the dike should consider securing the water movement at downstream of the closed channel and for protection of river bank from erosion at the Barrancas river section.

(3) Investigation items of the environmental factors

Based on the IEE results, investigation items of the environmental factors, which are identified for further detailed environmental study in the feasibility Study, are given below.

- Water quality including analysis of Sediment and Benthic life
- Aquatic life and fishery
- Social environment

6.7 Economic and Financial Evaluation

6.7.1 General

The five proposed alternatives for the structural measures are evaluated from the viewpoint of the national economy, for changes between the pre-project conditions (without the Project) and post-project conditions (with the Project).

The quantitative elements for evaluation are the project cost (cost) and decreased dredging cost after project implementation (benefit).

The financial evaluation of those alternatives having economic viability is then conducted to examine the suitability of project implementation from the financial point of view.

Based on the economic and financial evaluation results, comprehensive evaluation is conducted for the final selection of priority projects.

6.7.2 Economic Evaluation

The five alternatives in question are one for the Aramaya Section, three for the Barrancas Section and one for the Guasina Section. As the first step of the evaluation, the project cost of each alternative was compared with the dredging cost without the project, i.e. current dredging cost, at the relevant section based on the net present value in the cash flow over a period of 30 years. The viability of the alternative was then accepted if the net present value of the project cost was lower than the net present value of the current dredging cost.

Only Alternative B2 for the Barrancas Section is judged to be economically viable. (see Table S.6.6)

Table S.6.6 Economic Cost and Economic Benefit for Alternative B2

Economic Cost	Alternative B2 : net present value of project cost	US$ 83,370,000
Economic Benefit	net present value of dredging cost at Barrancas Section	US$ 87,305,000

The calculated EIRR for Alternative B2 based on comparison between the dredging cost at the Barrancas Section without the Project and the project cost plus the O/M cost (including the dredging cost) is 11%.

As the opportunity cost ratio for project investment in Venezuela is approximately 12%, the economic viability of Alternative B2 is fairly low unless a large indirect benefit is assumed.

6.7.3 Financial Evaluation

The financial viability of Alternative B2, having economic viability was examined using the FIRR to judge whether or not the project cost could be repaid in 30 years with revenue from the future navigation charge on the presumed cargo transportation. The resulting FIRR of 3% denies the financial viability of Alternative B2.

However, when the use of the public works budget is assumed to cover the project cost, negating the need for repayment, resulted in an FIRR of 13% idicating the financial viability of Alternative B2.

6.7.4 Comprehensive Evaluation

In general, the economic and financial evaluation results indicate not very significant economic and financial viability for the structural measures. Still, Alternative B2 may be feasible and should be selected as a priority project for further detailed analysis.