2) Sea level canal

Case Number	Group	Size of ship	Number of Lift	Item 1) & 2)	Item 3)	Item 4) - 10)	
(Ratio to SQ)				Ratio of Items			
S -1	C	150	0	2.1	1.1	1.3	
2	C	150	0	2.1	1.1	1.3	
3	C	250	0	2.2	1.1	1.3	
4	C	250	0	2.2	1.1	1.3	
5	C	300	0	2.2	1.1	1.3	
6	C	300	0	2.2	1.1	1.3	
7	D	150	0	1.1	0.1	1.0	
8	D	150	0	1.1	0.1	1.0	
9	D	250	0	1.2	0.1	1.0	
10	D	250	0	1.2	0.1	1.0	
11	D	300	0	1.2	0.1	1.0	
12	D	300	0	1.2	0.1	1.0	
13	C	150	0	2.1	1.1	1.3	
14	C	150	0	2.1	1.1	1.3	
15	C	250	0	2.2	1.1	1.3	
16	D	250	0	1.2	0.1	1.0	
17	D	300	0	1.2	0.1	1.0	
18	D	300	0	1.2	0.1	1.0	
(O&M Cost: million US$ 1990)				Cost of Items			Total
SQ	A	65	3	123	54	213	390
S -1,2	C	150	0	258	59	277	594
3-6	C	250-300	0	271	59	277	607
7,8	D	150	0	135	5	213	353
9-12	D	250-300	0	148	5	213	366
13,14	C	150	0	258	59	277	594
15	C	250	0	271	59	277	607
16-18	D	250-300	0	148	5	213	366

II

PART II : COST ESTIMATES FOR PRESCREENING

PART - II COST ESTIMATES FOR PRESCREENING CONTENTS

CHAPTER 2 COST ESTIMATES

CHAPTER 1 - CONSTRUCTION

1.1 Construction Method for Canal Excavation

1.1.1 Lock Canal (High-Rise and Low-Rise)

(1) Zoning

In examining the excavation procedure for the canal, the total length is divided into five zones of different topographical features and methods of construction, as follows:

ZONE I	ATLANTIC ENTRANCE
ZONE II	GATUN LAKE
ZONE III	CULEBRA CUT
ZONE IV	MIRAFLORES LAKE
ZONE V	PACIFIC ENTRANCE

Excavation of the portion above water level at the Gatun Lake and along the canal or above sea level at canal entrance will in principle be carried out by land based method. That below water level will be done by marine based method. The volume of the earthworks entailed is extremely large, so excavation machineries and working vessels will be of the largest class that can possibly be procured at present.

(2) Dry Excavation

Prior to excavation work, temporary roads will be constructed in parallel with the canal. These will be on the east bank in the section from the Atlantic Entrance (near STA 0.00) to the Gatun Lake and on the west bank from the Culebra Cut westwards. These temporary roads are for the passage of off the road dump trucks to be employed, which are 20 m wide. In addition, further temporary roads will be provided to spoil-banks as a branches from these main temporary roads. The location of the spoil-banks is assumed to be at 3.5km of excavation areas.

Before excavation work is commenced, the land to be excavated will be cleared and grubbed. The top soil will in general be excavated using bulldozers (86 t class), loaded onto dump trucks (136 t class) using a shovel (18 m^3 class), transported to the spoil-banks, and spread. Excavation and loading will be also done by backhoes (15 m^3 class) concurrently.

Weathered rock will mainly be ripped using the bulldozer with ripper, loaded with the shovel, and transported to the spoil-banks using the dump trucks.

Hard rock will be excavated mainly by means of high face bench method of 15 m high. First, blast hole drills (600 HP) will be used for blasting. Large rocks resulting from blasting will be broken into smaller pieces, collected into piles using the bulldozer, loaded onto the dump trucks using the shovel, transported, and dumped as spoil.
Excavated areas will be vegetated after landscaping.
Spoil-banks will be compacted and landscaped.
The number of days for dry excavation working have been estimated based on 250 working days a year with 20 actual working hours a day in two shifts.

The excavation of ZONE IV (Miraflores Lake) will consist mainly of dry excavation, in other words, the canal in this section will be excavated from the land. The ground adjoining the Culebra Cut and the Miraflores Lake will be left untouched. After completion of the cofferdam between the Miraflores Lake and the new canal with the new lock, the canal will be filled with water, equalizing the water level of the Culebra Cut and the new canal. Then, the remaining natural ground will be excavated.

(3) Underwater Excavation

Marine based excavation can be roughly categorized into works in the sea portion and in the canal portion.

The muck from excavation of the lake portion (ZONES II, III, and IV) will be discarded in the Gatun Lake.

Ordinary soil and silt (mad) below the water level will be dredged using a trailer suction dredger (8,000 m^3 class). This dredger will draw the dredged material in through the hatch of the dredger, maneuver to the spoil-bank under its own power, and discharge the spoil using pumps. Muck from ZONE I (Atlantic Entrance), ZONE II (Gatun Lake), and ZONE V (Pacific Entrance) will be dumped into the lake or sea by transporting it at 2 km from the excavation point. Muck from ZONE III (Culebra Cut) will be transported to the Gatun Lake, where it is to be dumped to the bottom of the lake.

Soft rock below water level will be excavated using cutter suction dredgers (18,000 HP class). Dredged material from ZONE I (Atlantic Entrance), ZONE II

(Gatun Lake), and ZONE V (Pacific Entrance) will be dumped directly into the lake or sea at 2 km from the point of excavation through a sand-flushing pipe. Material from ZONE III (Culebra Cut) will be loaded onto a bottom-hopper barge (5,000 m^3 class) transported by a pusher boat (3,200 HP class) and dumped.

It is assumed that 70% of the rock below water level can be excavated using cutter suction dredger (18,000 HP class). The dredged material from dredger will be disposed of in the same manner as the soft rock. The remaining 30% should be excavated using a large grab dredger (50 m^3 class). Fifty percent of this hard rock is expected to require underwater blasting to be used as well. Drilling, explosive charging, and priming will be done from a drilling barge. Firing will be made by super-sonic method. The rock excavated by the large grab dredger will be loaded on a split barge (5,000 m^3 class), moved using the pusher boat, and dumped.

Dredged rock from ZONE I (Atlantic Entrance), ZONE II (Gatun Lake), and ZONE V (Pacific Entrance) will be dumped at 2 km from the point of excavation. Dredged rock from ZONE III (Culebra Cut) will be transported to the Gatun Lake for dumping.

The work of excavation by working vessel is assumed to take 240 days a year (10 months at 24 days a month) with actual working 16 hours per day for the large grab dredger and 22 hours per day for the cutter suction dredger and trailer suction dredger. Marine-based excavation of the sea portion and of ZONE II and ZONE III of the canal will be required close care as the work area is near existing navigation channel, and the navigation of ships may not be hindered.

In excavating the islands and the head of the peninsula within the Gatun Lake along ZONE II and ZONE IV, the muck will be dropped into water nearby and dredged by working vessels instead of transporting it to the spoil-bank onshore.

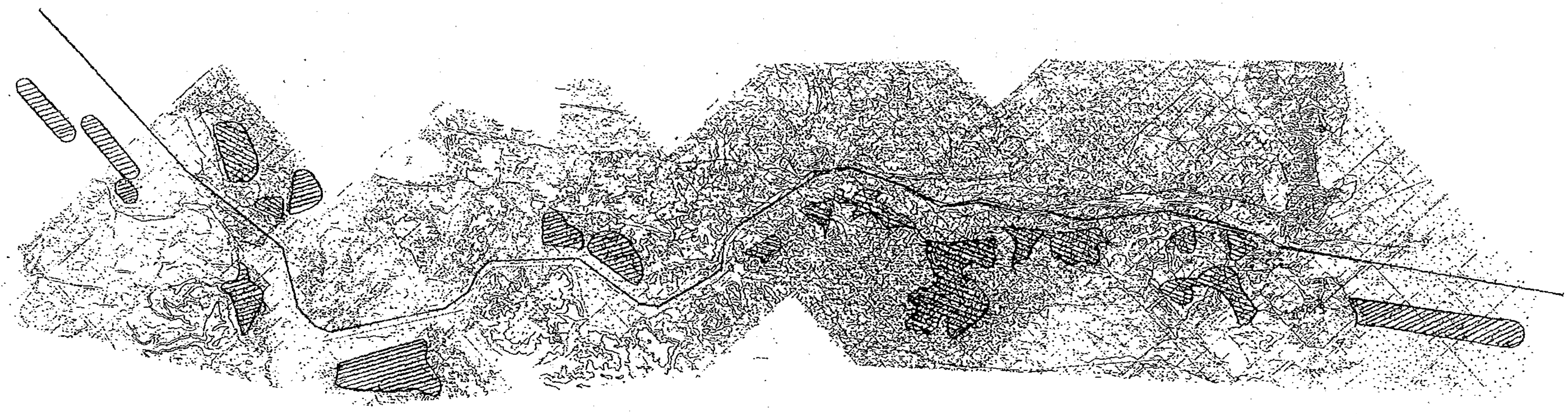
(4) Conversion Scheme

In the high-rise lock system, the cofferdam of the New Gatun Lock will be filled with water after completion, equalizing the water level outside and inside the cofferdam. The cofferdam will then be removed. At the New Miraflores Lock, the lock will be filled with water after completion of the new lock and the cofferdam separating Lock and Miraflores Lake on the north side. When the water level outside and inside the cofferdam has equalized, the cofferdam will be removed. The cofferdam on the Pacific Ocean side will also be dismantled similarly. The conversion in navigation channels will take place after completion of all structures and excavation of the canal. In this way, no hindrance to the navigation of ships through existing canal will result from the conversion.

In the low-rise lock system, it is necessary to reduce the level of Gatun Lake to 55' or 30'. The procedure will entail dismantling the cofferdam on the inland side after the water level has fallen sufficiently. While the water level is being lowered in the Gatun Lake and the cofferdam is being dismantled (a period expected to be 60-120 days), the navigation of ships will be closed entirely.

As for the cofferdam for the construction of the New Gatun Lock, the original ground can be used as it is. In this case, the section will be selected in consideration of safety during the construction of the Lock and the rate of progress of the dismantling work.

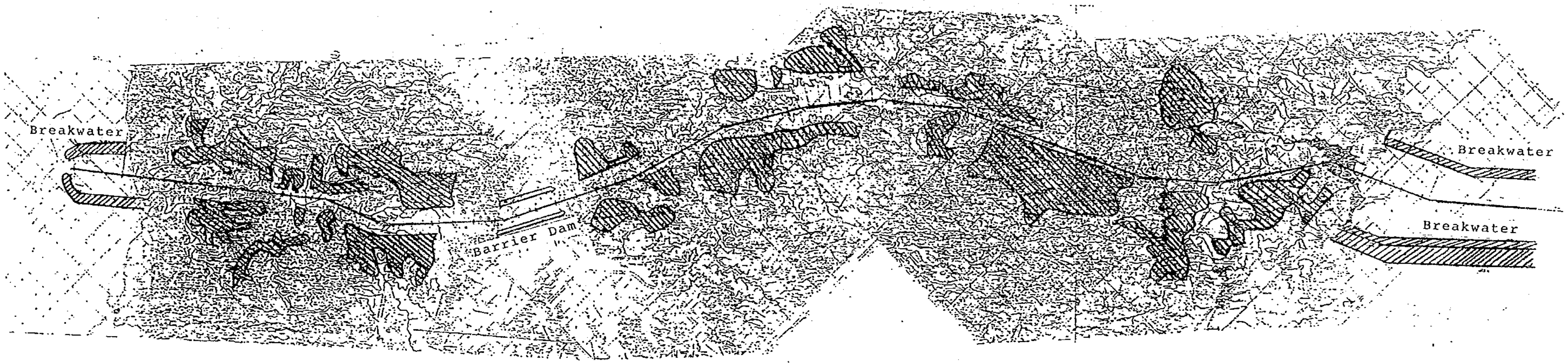
At the New Miraflores Lock, the cofferdam on the inland side will be constructed by reinforcing the original ground. On the Pacific Ocean side a completely new cofferdam will be constructed.



Legend Proposed Disposal Area (Lock Type)

Dry Excavation

Underwater Excavation



Legend Proposed Disposal Area (Route 10)

Dry Excavation

Underwater Excavation

1.1.2 Sea-level Canal (ROUTE 10)

(1) Zoning

The methods of excavation employed will be subject to restrictions due to topographic and geologic features. In consideration of this, the whole length of the canal is divided into 5 zones. The location and features of each zone are listed below.

ZONE I STA. -2.5 to 1.0 L = 3.5 km
Features: Atlantic Ocean to entrance of the canal (Lagarto). Underwater excavation by dredging.

ZONE II STA. 1.0 to 27.0 L = 26.0 km

Features: Lagarto-Escobal to Gatun Lake to Lagarterita. Land-based excavation will be carried out. Bedrock between Lagarto and Escobal is sandstone. Bottom of Gatun Lake is covered with thick sedimentary stratum.

ZONE III STA. 27.0 to 53.0 L = 26.0 km

Features: Lagarterita to Continental Divide to San Jose. Geology in the divide area is complex. There are alternating layers of basalt and clay shale, and the stability of the high slopes is considered questionable.

ZONE IV STA.53.0 to 58.0 L = 5.0 km

Features: The swamp on the Pacific Ocean side is covered with thick sedimentary layer.

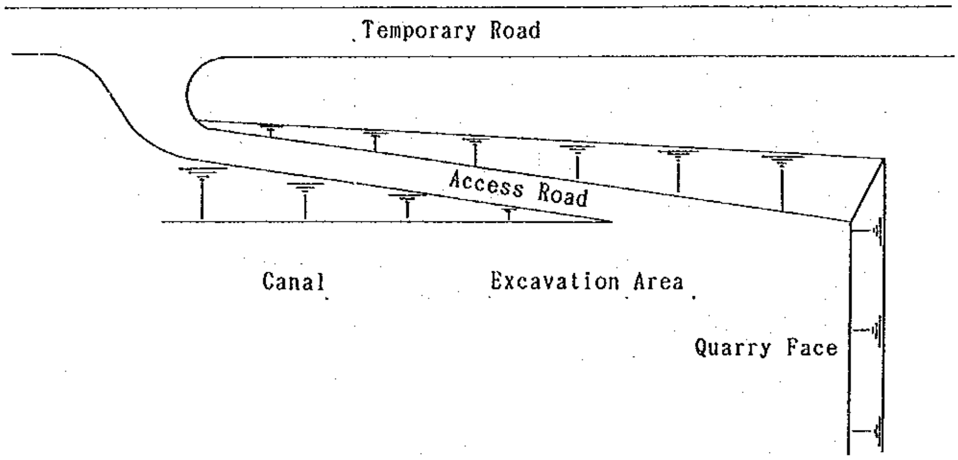
ZONE V, STA 58.0 to 83.7 L=25.7 km

Features: Estuary of Caimito River to Pacific Ocean. Underwater excavation by dredging will be carried out.

(2) Preparation Works

a) Temporary road

Temporary roads will be constructed in parallel with the east bank of the section running from near the entrance of the canal (STA 1.00) to the eastern end of the No.2 barrier dam (STA 38.00) and with the west bank of the section from STA 38.00 to the vicinity of the canal entrance on the Pacific Ocean side (STA 60.00). The muck will be transported to a nearby spoil-banks via these temporary roads. The roads will be 20 m in width and have a maximum gradient of 8% in consideration of their use by 136 t class dump trucks. Access roads to quarry faces will be provided every 2.5 km and the average hauling distance within the quarry faces will be 2.0 km. the average haulage outside work field is assumed to be 2.0 km. A plan of the temporary road and access road is shown below.



Access Road Plan

b) Temporary drainage

The inflow of water into the canal during excavation is expected to include rainfall, seepage water and water from streams that are cut off due to excavation of the canal. As this water will collect in the dry-excavated canal, it will be necessary to provide a drainage system at each face. Small and medium-size rivers will be diverted into the Gatun Lake. At the point in time when the Gatun Lake is divided by the Barrier Dam, water of southwest side of the Gatun Lake will instead be diverted into a previously constructed temporary spillway and be discharged into the Atlantic Ocean.

(3) Dry Excavation

The excavation areas and temporary road areas will be cleared and grubbed in two stages. First, the felling will be executed using a large chain pulled by two bulldozers, and this will be followed by grubbing of the remaining roots using a bulldozer. The collected materials will be piled up and burned.

Since the overburden is considered thin, at an average of about 4 m, the method of excavation of earth common will be such that after all quantity of common are cut using bulldozers, collected and loaded on dump trucks with a shovel, hauled and dumped. At the spoil-banks, the muck will be spread and compacted.

The methods of excavation for soft rock include ripping it using the bulldozers fitted with rippers, collecting the ripped material, and loading it on the dump trucks using the shovel. Another method is to carry out excavation directly using the shovel, loading the material onto the dump trucks. Hauling and spreading will be same as in the case of the earth common excavation.

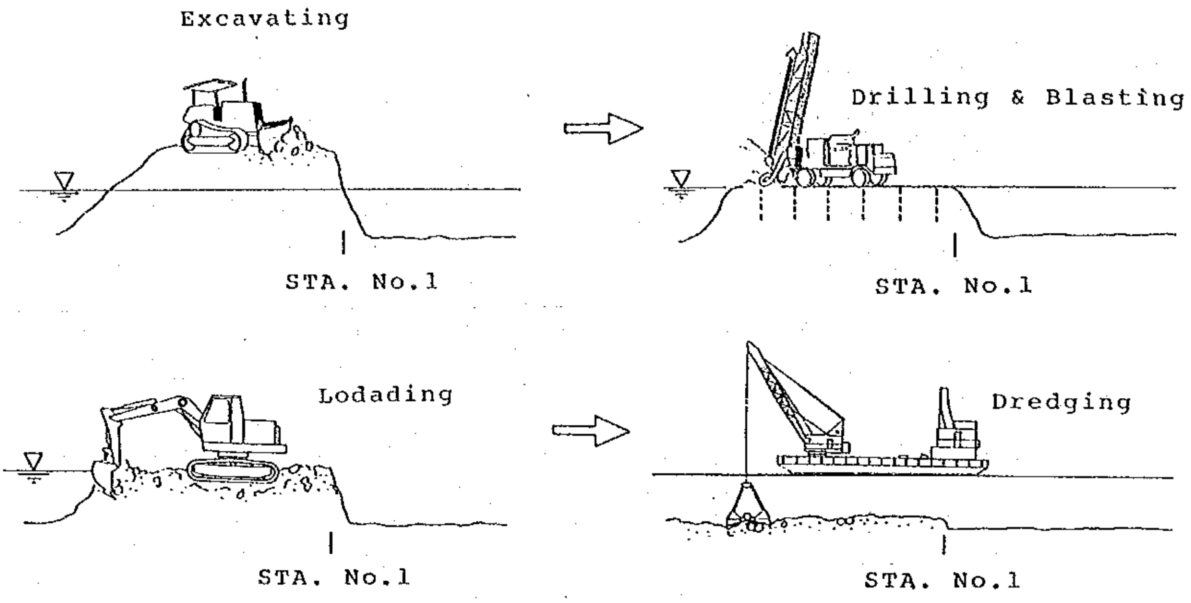
The average depth of hard rock excavation is about 30 m, so it will be carried out with blasting by means of the high-face bench cut method with a height of 15 m. Although the same combination of equipment will be used same as for earth common and weathered rock excavation, the bulldozer will be used as auxiliary machines for loading and finishing the bedrock.

(4) Conversion Scheme

After excavation of the land section of the canal is completed leaving plugs on the Atlantic Ocean and the Pacific Ocean sides, these two Oceans are finally to be connected through the new canal. Since the tidal range is small on the Atlantic Ocean side, seawater will first be led into the canal from that side. Then the plug on the Pacific side will be excavated, connecting the Atlantic Ocean with the Pacific Ocean.

a) Excavation of canal entrance on Atlantic side

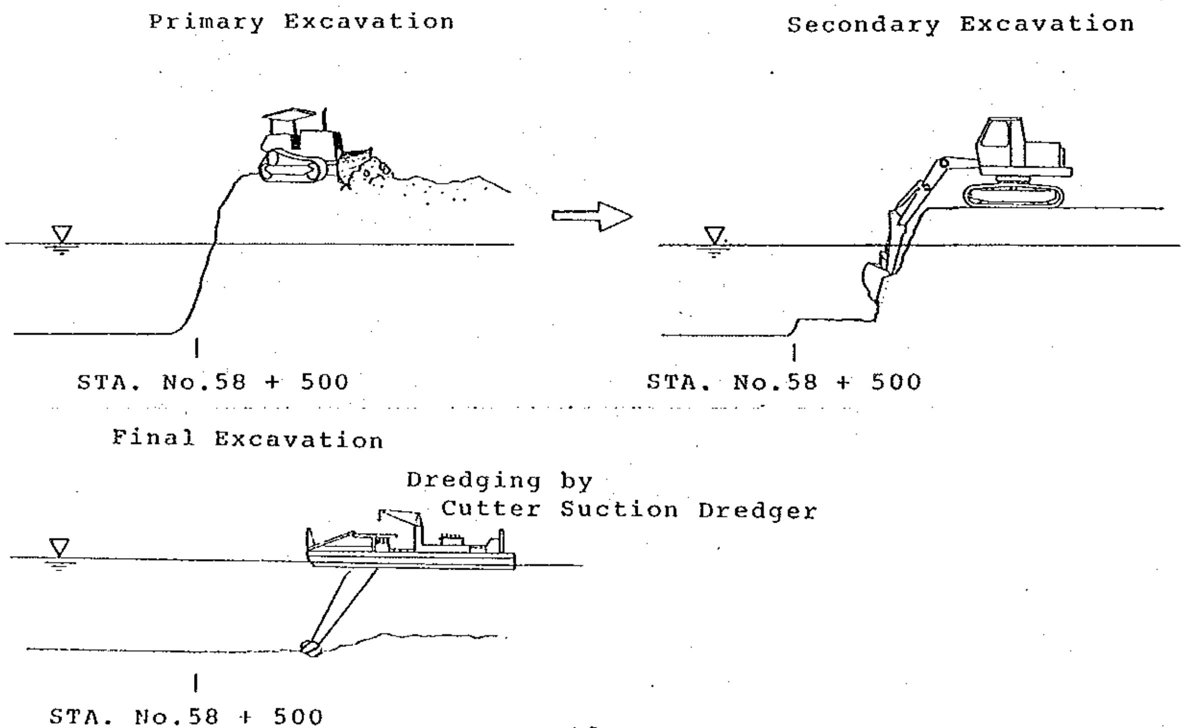
Initially, the canal will be completed to STA No.1 by dry excavation. After completing excavation of the common and weathered rock in the 500 m section from STA No.1 to the shore on the Atlantic Ocean side, the whole section will be blasted, loaded onto dump trucks, and hauled away using backhoes with dry excavation. The depth of the excavation will be about EL -10.00. After the canal will connect with the Atlantic Ocean, excavation below EL - 10.00 will be carried out using a large grab dredger. Dredged material will be loaded on a split barge, moved using a pusher boat, and disposed of in the designated disposal area. The final excavation of the canal will be carried out using a cutter suction dredger.



b) Excavation of Canal Entrance on Pacific Ocean side

First the canal is to be completed to STA No.58 + 500 by dry excavation. Primary excavation will be carried out to EL + 3.00 m above maximum sea level between STA No.58 + 500 and the Pacific shore. this will be followed by secondary excavation below sea level to depth of about 10 m, beginning from STA No.58 + 500, using backhoe, until the canal connects with the Pacific Ocean.

As the rock excavated around this area is assumed to be soft, the final excavation below sea level will be carried out using a cutter suction dredger. The muck will be disposed of in the designated disposal area.



(5) Equipment to be employed (excluding equipment for underwater excavation)

Equipment	Specification	Description
Bulldozer	86t-operating weight	Earth-excavating, ripping & dozing
Shovel	$18m^3$-heaped bucket capacity	Earth and weathered rock excavating & loading
Backhoe	$15m^3$-heaped bucket capacity	Underwater excavating and loading
Dump truck	136t-Max. Loading capacity	Hauling
Blast hole drill	165m/m dia. equ.	Rock drilling
Bulldozer	60t-operating weight	Spreading at disposal area and temporary works
Hydraulic drill	165m/m dia. equ.	Temporary works
Vibratory roller	15t-weight towed type	Compaction for fill dam & road maintenance
Motor grader	4.9m-blade	Road maintenance

1.1.3 Sea-level Canal (ROUTE 14S)

(1) Zoning

The length of the canal is divided into five zones as follows:

ZONE I	Atlantic Entrance
ZONE II	Gatun Lake
ZONE III	Gatun Lake Southeast Section and Inland Section
ZONE IV	Miraflores Lake
ZONE V	Pacific Entrance

The excavation of the canal will be by dry excavation for portions above sea level and lake level, as in the case of the lock canal plans, and working vessels will be used for work at lower levels. Excavation within Gatun Lake will be carried out without changing the existing lake water level. Prior to the excavation work, temporary roads will be constructed along the canal with the section from the Pacific entrance (near STA.54) to the Gatun Lake and near Darien and the Culebra Cut on the west side of the planned canal. In addition, temporary roads to the spoil-banks will branch out from these main temporary roads. It is assumed that spoil-banks will be located at 4 km of the point of excavation.

(2) Dry Excavation

Prior to excavation work, clearing and grubbing will be carried out in the areas.

The machinery used to excavate ordinary soil, soft rock and hard rock, and the method of implementation, will be the same for the Lock Canal in the preceding section.

The actual heavy equipments used for excavation will be as follows:

Ordinary soil
- Excavation & Piling: Bulldozer (86t class)
- Loading: Shovel Loader ($18m^3$ class)
- Haulage: Dump truck (136t class)
- Excavation and Loading: Backhoe ($15m^3$ class) will be used in combination.

Soft rock
- Excavation & Piling: Bulldozer with ripper
- Loading: Shovel loader
- Haulage: Dump truck

Hard rock for blasting
- Drilling: Blast hole drill
- Piling: Bulldozer
- Loading: Shovel loader
- Haulage: Dump truck

Excavated areas will be replanted with vegetation after suitable landscaping. The spoil-banks will be compacted and landscaped using bulldozers. Dry excavation operations are based on 250 working days per year with 20 actual working hours in two shifts per day. In order to maintain the water level in Gatun Lake, the ground will be left as it is near STA.5 and excavation will be carried out in front of and behind this portion (plug). The plug will be taken out after the other excavation is completed, lowering the water level of the Gatun Lake to sea level.

Upper portions from water level at islands and the peninsula within the Gatun Lake between STA.6 and STA.26 will be bulldozed into Gatun Lake and later dredged using a cutter suction dredger or grab dredger. The portion parallel to the Culebra Cut from STA.34 to Miraflores Lake will be excavated by dry excavation, and the section between plugs near STA.34 and STA.50 will also be excavated using dry excavation machinery. Both plugs will be removed after all other excavations for the canal have been completed and the level of the Gatun Lake has been lowered to sea level.

In ZONE V (Pacific Entrance), excavation between the Miraflores Lake near STA.51 + 500 and Third Locks will be plugged. The plug will be dismantled in the same way as other plugs.

(3) Underwater Excavation

Excavation below sea level and below lake water level will be carried out using working vessels.

The boat types to be used in excavating ordinary soil, weathered rock and rock, and the method of implementation, will be the same as for the lock canal excavation. In other words, ordinary soil and silt (mud) will be dredged using a drag suction dredger (8,000 m^3 class) and cutter suction dredger. The drag suction dredger stores up the dredged soil in its hatch, moves under its own power to the designated spot, and dumps it overboard. This method is for dredging at depths greater than 6 m, and dumping will take place in water deeper than 11 m. The excavation of ordinary soil in shallower water than this will be carried out using a cutter suction dredger.

Most of weathered rock and rock (estimated at 70%) will be excavated using a cutter suction dredger. Where the dredged soil can be dumped near the dredging point, as in the case of work within the Gatun Lake, piping will be laid at 2 km from the dredging point and the material dumped directly through this. On the other hand, where the dumping location is distant the excavated material will be loaded onto split barges (5,000 m^3 class) using a loading barge, moved using a pusher tug (3,200 HP class), and dumped.

About 30% of the rock will be dredged using a grab dredger, and 55% of this is expected to require the use of underwater blasting. A drilling barge will be used for drilling, and explosive charging. The muck, brought up using the grab dredger, will be loaded onto the split barges, moved using the pusher tug and dumped.

The muck from dredging in ZONE I (Atlantic Entrance) will be dumped outside the breakwater at the western end of the Limon Bay when use of the trailing suction dredger and the split barge are called for.

Muck excavated using a cutter suction dredger will be pumped for dumping at the western end of the Limon Bay. All muck from the excavation of STA.1 to

STA.5 will be dumped outside the Limon Bay.

Since dredging of the canal within the Gatun Lake will be carried out with the Gatun Lake at its present level, the dredging of rock shall take place at depths greater than 30m. Although this will be carried out using the grab dredger, efficiency will be extremely low because the rock is hard and ascent and descent of the grab will be time-consuming.

While it will be possible to dump muck from dredging ZONE II within the Gatun Lake in the immediate vicinity, muck from dredging the portion between STA.23 and STA.33 in ZONE III will have to be moved to the dumping point in the Gatun Lake.

Muck from dredging in ZONE V (Pacific Entrance) will be dumped at the designated point to the west of the navigation channel. This is to prevent silting of the navigation channel by the spoil as the result of the prevailing tidal current.

Excavation work using vessels is assumed to take place 240 days per year (10 months a year, 24 days a month), with 16 actual working hours per day for the grab dredger and 22 hours for the cutter suction dredger and trailing suction dredger. Since excavation of the new canal in the Gatun Lake will intersect with the existing canal at three points, it may be necessary to switch channels on a small scale several times as the crossing points are dredged. Careful consideration will be necessary to ensure that interference to the navigation channel is kept to a minimum.

Excavation at the site of the Barrier Dam will begin with the removal of mud and ordinary soil from the bottom of the lake. Good quality muck from the this excavation work will be reused for the construction of the dam itself. Although two possibilities might be considered for filling the dam --- working from vessels on the water or from dump trucks on land --- the vessel method will be used because access to the barrier dam site is not easy from the land. From the lake bed to -6 m level, the filling material will be dumped using the split barge. Thereafter, rock will be dumped from a deck barge (shallower than -6 m) using the grab and final layer of riprap material will be spread over the surface.

(4) Conversion Scheme

When excavation of the new canal in ZONE III between STA.34 and STA.50, paralleled to the Culebra Cut, is completed, this portion will be filled with water to level of the Gatun Lake and the plug near STA.34 will be removed. Switching to this channel will begin by lowering water level of the Gatun Lake, either by opening all the lock gates or using other methods. While this is being accomplished, dismantling operations on the remaining three plugs (near STA.5, STA.50, and STA.51) will be commenced.

Shutdown period of navigation is considered to be longest in the study cases because the huge quantity of plug material shall be removed. More than a half year may be supposed as the shutdown period of canal traffic.

1.2 Construction Method for Lock Structure

1.2.1 Excavation

Prior to commencement of excavation work, appropriate embankments and grouting works are to be carried out in order to prevent water inflow and seepage. Bench cut method will be applied same as the canal excavation. Bed-rock shall be arranged so as to be good foundation free from any disturbance of bed-rock using lights equipment, small scale blasting and handy tools. After excavation, bed-rock shall be cleaned and water tight mortar shall be placed, on which concrete will be placed.

Sequence of works is as follows:

Main Excavation	Excavation by heavy equipment
Finishing Excavation	Excavation by light equipment (Rock breaker, coal pick etc.)
Consolidation Grouting	
Clearance of Bed-rock	
Mortar Placing	

1.2.2 Concrete

(1) Material

Proportion of concrete is assumed to be same as that of dam concrete.

Cement content: 200 kg/m^3
Aggregates: Crushed stone and sand of which source is selected material from Canal Excavation

(2) Mixing, Transportation and Placing
Batching and Mixing plant is to be installed at adjacent location

of Rock. Mixed concrete will be transported to the placing site in concrete buckets on bogie carriages driven by diesel locomotive.

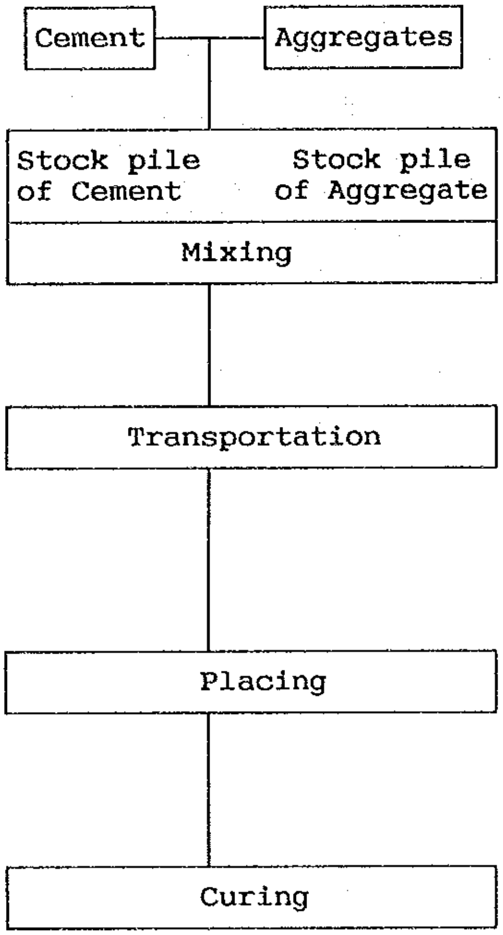
For concrete placing, traveling tower crane will be used and lift of concrete placing is supposed around 1.5m - 2.0m. After placing, concrete curing will be followed by means of water spray or water pond.

After green-cutting, joint mortar will be placed and mixed concrete placement will be succeeded. The tower crane will be concurrently utilized for installation of reinforcement and steel fabrics.

Sequence of works is as follows:

Study-Case 150,000 DWT
Lock Concrete 5,880,000m^3

(Atlantic Side)



Cement Silo 1,000 t x 3 sets
Conveyor for Aggregate 900mm x 150m
Batching/Mixing Plant 200m^3/h

200m^3/h Tracks 5 lane

Diesel Locomotive 5 sets
Bogie carriage 5 sets
Bucket 4.5m^3 10 sets

200m^3/h

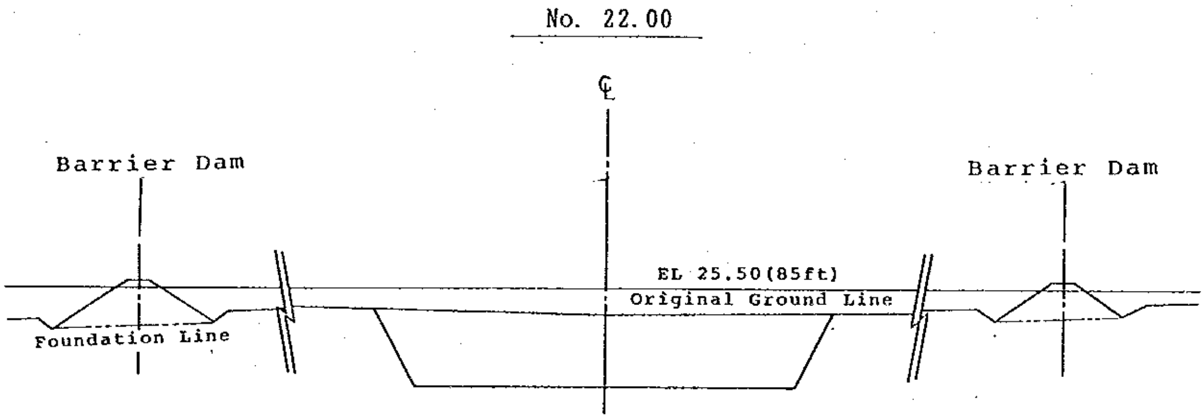
Traveling Tower Crane 4 sets
Vibro-dozer 4 sets
Concrete Vibrator 12 sets

$$\frac{588{,}000\ m^3}{250\ days/yr \times 20\ h/day \times 200\ m^3/h} = 6\ yrs$$

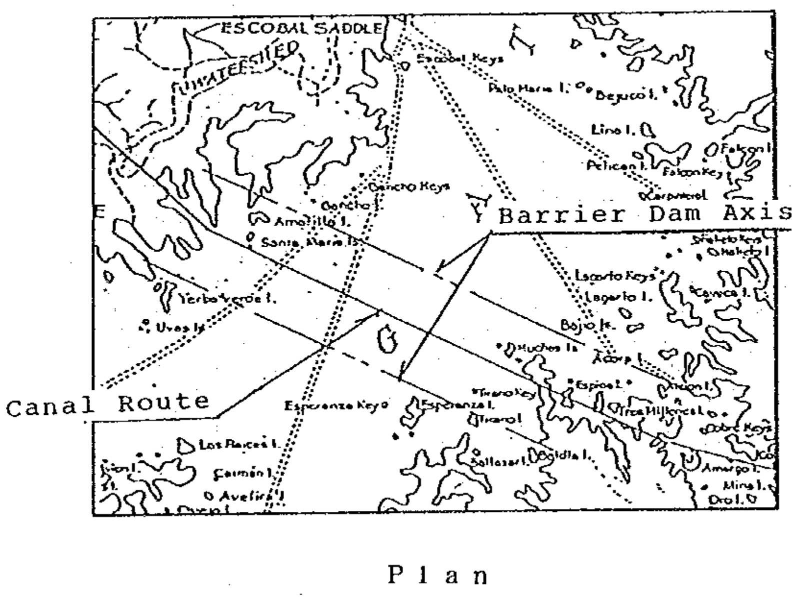
1.3 Construction Method for Barrier Dams (Case Route 10)

The barrier dam is a cofferdam constructed to allow canal excavation on the Gatun Lake under dry conditions. The barrier dam will be in two parts parallel to the left bank and right bank of the canal. In consideration of dam stability, it will be positioned sufficiently far away from the canal, while in an effort to reduce the volume of water needing dewatering as much as possible, it should not be placed too far away. A distance of about 500 m between the dam and the canal will be selected.

A plan and cross section of the dam and canal are shown below.



Cross Section



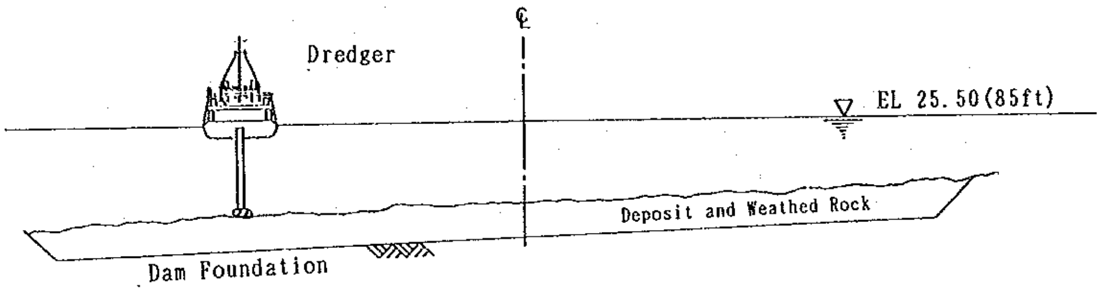
Plan

Construction Sequence is as follows:

- Dredging of Dam Foundation
- Embankment of Both Dams
- Construction of Impervious Zone
- Water Removal by Diversion channel between Gatun Lake and Atlantic Ocean
- Access road for Dry Excavation
- Canal Excavation

1.3.1 Dredging of Dam Foundations

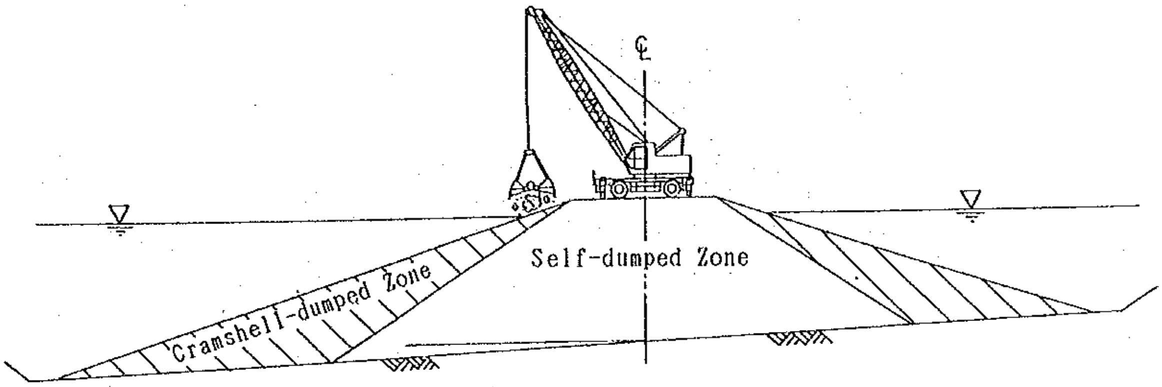
Prior to embankment, the sedimentary layer and soft rock in the area that is to form the foundation of the dams will be excavated using a cutter suction dredger. The muck will be brought ashore, stored, and selected material will be reused for embankment.



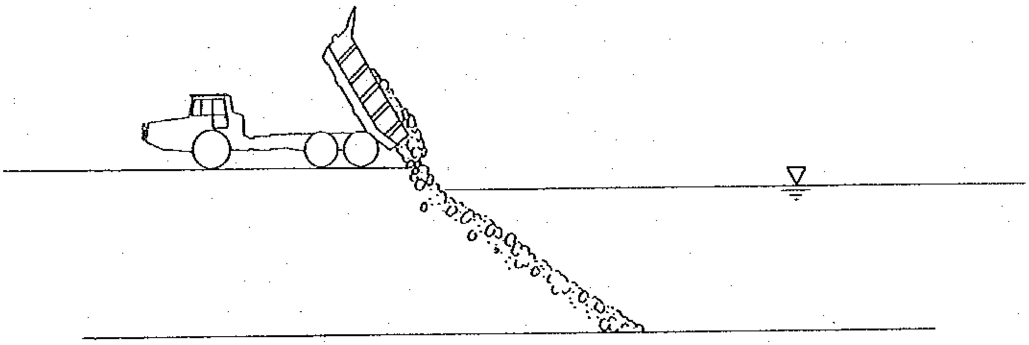
Plan

1.3.2 Embankment

The embankment will be formed by dumping material into the water from both left and right banks. Where the dumped material cannot be placed at the designed place, the work will be carried out using a clamshell bucket. A similar method will apply to riprap work. The material used for the banks will be obtained from canal excavation and dredging, which is to be temporarily stored as described previously. The embankment material above water will be compacted using a vibration roller.



Typical Cross Section



Longitudinal Section

1.3.3 Impervious Zone

The dam is of a homogeneous design that will be con structed by dumping random waste material. Accordingly, it will be difficult to construct an impervious zone during banking work. The zone will be constructed after banking has been completed. The following methods are possible for type of the impervious zone:

a Sheet pile: length = max. 20m
b Substitution of a core material
c Impervious wall of concrete diaphragm
d Impervious wall by grouting

Examination of these types resulted in the following conclusions:

In the case of the sheet pile method, it is thought that lumps and tree roots, etc., may be mixed in with the banking material, making it impossible to drive piles to form a continuous wall. Also, there is a risk of sheet piles corroding in the future, causing water leakage, because the piles are a permanent structure.

In the case of substitution of a core material, it is assumed that a large quantity of water would seep in during excavation for the core replacement, making it difficult to rewater and roller-compact the core material.

In the case of an impervious wall of concrete diaphragm, the excavation face would tend to collapse as the excavation is carried out, considerably extending the excavation time. Also, this method would cause the highest construction costs.

Lastly, in the case of an impervious wall by grouting, a grouting material based on cement is the main material used in the work. Some contractors have abundant experience in the construction of this type of impervious wall, and it is the most economical. Maintenance after construction would also be the most straightforward.

For these reasons, the grouting method will be adopted for construction of the impervious wall of the dam. Drilling will be carried out using a percussion drill with a double tube. This type of drill offers a faster drilling speed and it is provided with an outer tube to protect the collapse of borehole wall.

1.4 Construction Schedule

1.4.1 General

(1) Preparation Works and Finishing Clearances

It is supposed to be 0.5 year to prepare the commencement of the works, and 0.3 year to clean the project site after completion.

Preparation works are listed as follows:

- Mobilization of Equipment and Manpower
- Procurement of Equipment and Material
- Temporary Facilities
- Legal Procedures etc.

Finishing clearances are listed as follows:

- Demobilization of Equipment and Manpower
- Dismantlement of Temporary Facilities

(2) Canal Excavation

a) Dry Excavation

As for the dry excavation, the construction schedule is dominated by the hauling work. Hauling road will be arranged at interval of each 2.5 km, then,

$$\text{Ave. interval of trucks} = \frac{3.5\text{km} \times 2}{27 \text{ trucks}} = 0.26 \text{ km/truck}$$

average interval of truck will be approx. 250m. The interval of approx. 250m is considered the safety of traffic and scheduled velocity/cycle can be secured.

b) Underwater Excavation

Underwater excavation shall be executed not to hinder the navigation of ships in transit. Approx. 3.0km is thought to be min. interval of working vessels in order to secure the safe navigation. In case working site is far from the existing canal, no influence to the navigation of ships in transit is considered. In such area, working vessels will be allocated at intervals of approx. 1.0km.

(3) Installation of Gate Leaves

Installation of gate leaves is assumed to be completed by 1.0 year after completion of civil works at Lock Concrete Structure.

(4) Removal of Plugs at Route 14S

It is assumed that it takes 0.5 year to remove plugs after the completion of canal excavation and installation of gate leaves.

```
      Civil Work
   ______________
               Installation of gate leaves
                      |                    Plug removal
                      |                    |          |
                      |------ 1.0 yr ------|-- 0.5 yr -|
                      |------------ 1.5 yr ------------|
```

(5) Engineering, Design and Tender Preparation

Along the Route-15 and Route-14S, numerous investigations and studies having been carried out until now, the schedule of Engineering, Design and Tender preparation can be minimized up to 2.5 years, while at Route-10, further investigations and engineering being required, 3.5 years may be adequate for the period of Engineering, Design and Tender Preparation.

(6) Minimum Construction Schedule

Numerous gigantic heavy equipment will be used for the dry excavation. It is not clear at present whether such kind of equipment can be reused for same size projects in the near future. Then, minimum 7.5 years of actual construction period is considered for each cases from economical point of view in which more or less 90% of depreciation for book price of equipment will be probably attained.

1.4.2. High-rise Lock Canal

CONSC-1.WJ2

TYPE	WORKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
		YEARS																		
L-1	ENGINEERING, DESIGN & TENDER	====	====																	
	CONSTRUCTION			====	====	====	====	====	====	====	====									
L-2 (L-2')	ENGINEERING, DESIGN & TENDER	====	====																	
	CONSTRUCTION			====	====	====	====	====	====	====	====									
L-4	ENGINEERING, DESIGN & TENDER	====	====																	
	CONSTRUCTION			====	====	====	====	====	====	====	====									
L-5	ENGINEERING, DESIGN & TENDER	====	====																	
	CONSTRUCTION			====	====	====	====	====	====	====	====									
L-7	ENGINEERING, DESIGN & TENDER	====	====																	
	CONSTRUCTION			====	====	====	====	====	====	====	====	====								
L-8	ENGINEERING, DESIGN & TENDER	====	====																	
	CONSTRUCTION			====	====	====	====	====	====	====	====	====								
L-10	ENGINEERING, DESIGN & TENDER	====	====																	
	CONSTRUCTION			====	====	====	====	====	====	====	====									
L-13	ENGINEERING, DESIGN & TENDER	====	====																	
	CONSTRUCTION			====	====	====	====	====	====	====	====									
L-16	ENGINEERING, DESIGN & TENDER	====	====																	
	CONSTRUCTION			====	====	====	====	====	====	====	====	====	====	====	====	====	====			

1.4.3. Low-rise Lock Canal

CONSC-2.WJ2

TYPE	WORKS	YEARS																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
L-3	ENGINEERING, DESIGN & TENDER	===	===	=|																
	CONSTRUCTION			|=	===	===	===	===	===	===	===									
L-6	ENGINEERING, DESIGN & TENDER	===	===	=|																
	CONSTRUCTION			|=	===	===	===	===	===	===	===									
L-9	ENGINEERING, DESIGN & TENDER	===	===	=|																
	CONSTRUCTION			|=	===	===	===	===	===	===	===	===	===	===						
L-11	ENGINEERING, DESIGN & TENDER	===	===	=|																
	CONSTRUCTION			|=	===	===	===	===	===	===	===									
L-12	ENGINEERING, DESIGN & TENDER	===	===	=|																
	CONSTRUCTION			|=	===	===	===	===	===	===	===	===	===	===	===					
L-14	ENGINEERING, DESIGN & TENDER	===	===	=|																
	CONSTRUCTION			|=	===	===	===	===	===	===	===	===								
L-15	ENGINEERING, DESIGN & TENDER	===	===	=|																
	CONSTRUCTION			|=	===	===	===	===	===	===	===	===	===	===	===	===	===			
L-17	ENGINEERING, DESIGN & TENDER	===	===	=|																
	CONSTRUCTION			|=	===	===	===	===	===	===	===	===	===	===	===					
L-18	ENGINEERING, DESIGN & TENDER	===	===	=|																
	CONSTRUCTION			|=	===	===	===	===	===	===	===	===	===	===	===	===	===	===	===	

1.4.4. Sea-level Canal (Route 10)

CONSC-3.WJ2

TYPE	WORKS	YEARS																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
S-1	ENGINEERING, DESIGN & TENDER	===	===	===	==|															
	CONSTRUCTION				|=	===	===	===	===	===	===	===								
S-2	ENGINEERING, DESIGN & TENDER	===	===	===	==|															
	CONSTRUCTION				|=	===	===	===	===	===	===	===								
S-3	ENGINEERING, DESIGN & TENDER	===	===	===	==|															
	CONSTRUCTION				|=	===	===	===	===	===	===	===	===							
S-4	ENGINEERING, DESIGN & TENDER	===	===	===	==|															
	CONSTRUCTION				|=	===	===	===	===	===	===	===	===	===	===	===	===	===		
S-5	ENGINEERING, DESIGN & TENDER	===	===	===	==|															
	CONSTRUCTION				|=	===	===	===	===	===	===	===	===	===	===					
S-6	ENGINEERING, DESIGN & TENDER	===	===	===	==|															
	CONSTRUCTION				|=	===	===	===	===	===	===	===	===	===	===	===	===	===	===	===
S-13	ENGINEERING, DESIGN & TENDER	===	===	===	==|															
	CONSTRUCTION				|=	===	===	===	===	===	===	===	===	===	===	===				
S-14	ENGINEERING, DESIGN & TENDER	===	===	===	==|															
	CONSTRUCTION				|=	===	===	===	===	===	===	===	===	===	===	===	===			
S-15	ENGINEERING, DESIGN & TENDER	===	===	===	==|															
	CONSTRUCTION				|=	===	===	===	===	===	===	===	===	===	===	===	===	===		

1.4.5. Sea-level Canal (Route 14S)

CONSC-4.WJ2

TYPE	WORKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
S-7	ENGINEERING, DESIGN & TENDER	=	=	=																
	CONSTRUCTION			=	=	=	=	=	=	=	=									
S-8	ENGINEERING, DESIGN & TENDER	=	=	=																
	CONSTRUCTION			=	=	=	=	=	=	=	=	=	=	=						
S-9	ENGINEERING, DESIGN & TENDER	=	=	=																
	CONSTRUCTION			=	=	=	=	=	=	=	=									
S-10	ENGINEERING, DESIGN & TENDER	=	=	=																
	CONSTRUCTION			=	=	=	=	=	=	=	=	=	=	=	=	=				
S-11	ENGINEERING, DESIGN & TENDER	=	=	=																
	CONSTRUCTION			=	=	=	=	=	=	=	=	=	=	=	=					
S-12	ENGINEERING, DESIGN & TENDER	=	=	=																
	CONSTRUCTION			=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	
S-16	ENGINEERING, DESIGN & TENDER	=	=	=																
	CONSTRUCTION			=	=	=	=	=	=	=	=	=	=	=						
S-17	ENGINEERING, DESIGN & TENDER	=	=	=																
	CONSTRUCTION			=	=	=	=	=	=	=	=	=	=							
S-18	ENGINEERING, DESIGN & TENDER	=	=	=																
	CONSTRUCTION			=	=	=	=	=	=	=	=	=	=	=	=					

1.5 Impacts for Existing Canal Operations

1.5.1 High Rise Lock Canal

Navigation through the existing canal will be affected during construction of the high rise lock canal, at the following points:

(1) While widening and deepening the existing canal, it will be necessary to prevent hindrance to the navigation of ships such as by loosening the anchor cables on work boats, etc. Every time this has to be done, construction work will have to be interrupted. This will result in a considerable reduction in operating efficiency even if the operations of navigation and construction are planned systematically. Ships passing by will be forced to wait until work comes to a pause, reducing their efficiency. Even if priority is given to navigation, efficiency is still expected to be lowered by about 10% and impacts for the Canal Revenue will be considered. In particular, because navigation and construction work will be closely interlinked in the Culebra Cut, safety considerations will also be called for.

(2) There is no need to consider a temporary shutdown of the navigation channel when the new channel is completed and operation is to switch to the new channel.

(3) Comparing ROUTE-I and ROUTE-II, as work on ROUTE- I will be carried out away from the existing naviga tion channel in the Gatun Lake, the impact on existing traffic would be reduced.

However, the impact on existing traffic in the Culebra Cut will remain the same.

1.5.2 Low Rise Lock Canal

(1) The impact of construction work for the low-rise lock canal on existing canal operations will be much greater than in the case of constructing the high-rise lock canal. This is because the amount of excavation is larger and the excavation is deeper. In other words, the numbers of work boats will be greater and the construction period is longer.

It appears that navigation efficiency would be reduced to about 80%.

(2) In switching from the existing channel to the new one as the new canal is completed, a shutdown of

navigation for about 60-120 days will be necessary as mentioned in 1.1.2(4) Conversion Scheme.

1.5.3 Sea-level Canal (ROUTE 10)

Since ROUTE 10 will be constructed in parallel with existing ROUTE 15 and about 16-20 km away from it, there is no fear of hindrance to operations on the existing canal. But in the dry year of 10% probability (once ten years), the traffic at the existing canal may be restricted to 80 - 90% during/after construction period of new canal due to the shortage of lock water capacity which ought to be caused by dividing Gatun Lake with barrier dams decreasing catchment area.

1.5.4 Sea-level Canal (ROUTE 14S)

The great impact on the operations of the existing canal would be caused by construction of sea-level canal (ROUTE 14S). The total amount of excavation is largest, particularly the volume of deep-water dredging. As the some part of the route is adjacent to the existing canal, the loss of construction efficiency due to the passage of ships will be large. Ships will have to pass in the congested vicinity of many work boats, and therefore it is assumed that there will be many occasions when ships have to wait in order to guarantee safety.

With regard to convert channels, since the work involves the discharge of large volumes of water and considerable weird material must be removed, it will be necessary to have a navigational shutdown of about 180-270 days as mentioned in 1.1.3 (4).

1.6 Construction Feasibilities

1.6.1 Deep-Water Dredging Operations

For dredging ordinary soil (silt or sand), a drag suction dredger which can excavate to a depth of 60 m is available. Work at such a depth has already been carried out, and there are many records of experience. Since deep-water dredging in this study is to a maximum depth of 52.3 m, there should be no problems involved in the dredging of ordinary soil. However, the cutter suction dredger can only be used for work to a maximum depth of 30 m, so excavation of weathered rock and rock at deeper sites will have to depend on the use of a grab dredger.

With regard to the excavation of weathered rock and soft rock, it will be possible to use a grab dredger with a large bucket, but efficiency will be reduced. To excavate hard rock where blasting is required, a blasting barge or SEP will be the base for drilling and blasting. It will be equipped with a rock drill which can drill blasting holes 250 mm in diameter, and the muck will be loaded onto a split barge using a grab dredger, hauled to the designated location, and dumped.

This work can be done down to the necessary depth of about 60 m, but raising and lowering of the casing and rod will take time and the cycle time for ascent and descent of the grab will be increased. Thus, the efficiency will be reduced and the unit rate for excavation will be higher. The explosives used for underwater blasting will necessarily be a gelatinized waterproof explosive.

To sum up, although there will be no problems of feasibility as long as the water depth does not exceed about 60 m, the effects of deep water dredging operations on construction period and cost will be considerable.
The cost of Sea Level Canal (ROUTE 14S) is higher and its construction period is longer. The primary reason for this is caused by the deep water dredging operations.

1.6.2 Canal Excavation at/near Existing Canal

Since the Culebraa Cut section will be a two-lane channel as widening project starts in 1991-92, the study will take make full use of the wider channel. Work boats will occupy one lane out of two, and therefore when construction work is under way in the Culebra Cut, passing ships will have one lane available. Today, navigation is by one lane only, so operations with one lane will not cause great problems. The only concern is that the anchor cables used to moor the temporary constructional facilities in position, particularly the cutter section dredger, would hinder passing ships. When ships pass close to the cutter suction dredger, it will be necessary to loosen the anchor cables on the channel side to prevent such hindrance. While the anchor wires are loose, construction operations will naturally have to be suspended temporarily, greatly affecting the operational efficiency. When construction is underway using a trailer suction dredger, no anchor cables are used since the position of the dredger may be adjusted by means of the bow thruster and twin screws located at the bow of the dredger. In this case, therefore, construction need not be interrupted.

As the blast debris may disperse into the existing navigation channel after blasting, navigation must be stopped until the rock can be removed. The debris generated by blasting will be loaded onto a split barge, then an anchor cable will be necessary to secure the grab dredger in position. This will constitute a hindrance to passing ships. As already stated, where construction work is carried out at/near the existing canal, it can be assumed to have a great effect on passing ships, considerably reducing the efficiency of navigation. Operations would have to be suspended, particularly during dense fog.

Although it is difficult to quantify the reduction in operation efficiency, a judgment may be made to a certain degree based on coming experience with the Culebra Cut widening project.

1.6.3 Barrier Dam Construction

The barrier dams will be constructed using material from wet excavation for the low-rise lock canal and ROUTE-14S, while dry excavation for the sea-level canal (ROUTE-10). In either case, the muck will be dumped into the water, and effective compaction will be difficult. The technical difficulties are quite different depending on the character of material to be used for the embankment. In case the fine material will be used, it is necessary to reduce the excess pore-water pressure within the embankment, when the water level between the dams will be lowered, so as to prevent the slope from collapsing. Some kind of filter drain layers will be effective for reduction of pore-water pressure. If the coarse material will be used for the embankment, some kind of impervious zone or wall shall be specified to stop the seepage water.
Although the various methods may be considered to stop the water, the best one is probably to use the grouting method. However, as this is a new experience, it will be necessary to verify the relationship between specifications and effectiveness through experiments and testing. If satisfactory water-stopping effect cannot be obtained

using curtain grout, choice of the concrete water-stopping wall method using an underground continuous diaphragm may be preferred.

CHAPTER 2 - COST ESTIMATES

2.1 Estimate Basis and Assumptions

2.1.1 Type of Contract

Selection of contractors and type of contract shall be based on international competitive tender in accordance with the FIDIC 4th Edition, 1987.

2.1.2 Estimate Date and Currency

All estimate are based on data as of 1990 in US$. Cost increases during the construction period and cost increases in case of delays in commencement are excluded.

2.1.3 Payment

It is assumed that progressive payment will be made during construction such that no payment/receipt of interest is gained by contractors.

2.1.4 Taxes and Custom Duties

Both the taxes and duties are not considered in the cost estimate of case studies in phase 1.

2.1.5 Labor Costs

Overtime premiums and allowances for social benefits, amounting to 65%, are added to the man-day/hour cost in Panama as of 1990. (See Table 2.1.5)

SOCIAL BENEFITS AND OVERTIME PREMIUMS

TABLE 2.1.5

Depreciation	Rate per Salary (%)
Social Insurance	10.75
Retirement Fund	5.67
Educational Insurance	1.50
Bonus 1/	8.33
Vacation	11.48
National Holidays	7.29
Seniority Premium	0.06
Overtime	1.27
Interference by Rain	2.30
Due of Labor Relation	0.18
Non-Professional Accident	5.45
Retentions	0.66
Labor Union	0.26
Compensation for Layoff	8.52
Other Lending	1.28
Total	65.00

Note: 1/ Expressed as Thirteenth Month.

2.1.6 Operating Hours and Days

For land-based excavation, 250 operating days per year and 20 actual hours operation per day are assumed. Marine-based excavation will take place on 240 operating days per year (10 months per year and 24 days per month) and for 16 actual hours per day in the case of cutter suction dredgers or drag suction dredgers.

2.1.7 Loading and Unloading Facilities

Existing loading and unloading facilities are to be utilized as loading and unloading facilities used for construction works.

2.1.8 Hauling Distance of Dry Excavation

As for the hauling distance of dry excavation, it is difficult in the limited period of Phase-1 Study to define the disposal area without precise site surveys. Then, 3.5km for Lock Canal Excavation and 4.0km for Sea Level Canal Excavation were adopted as hauling distances by studying on map. If conditions are allowed in Phase-2 study, reconnaissance of the site would be done to identify the location of disposal area and to define the hauling distances.

2.1.9 Gate Leaves and Related Facilities

The study period of Phase-1 is too limited to obtain the firm quotation of Gate Leaves and Related Facilities from outside Japan. So, the estimates for them are based on the assumption; manufactured in Japan, transported from Japan to Panama and installed in Panama.
In the study of Phase-2, estimates would be made based on the quotations through the worldwide aspects.

2.1.10 General Conditions

Panama Canal alternative project will be divided to 10 - 20 work blocks. Size of one contract will be more or less US$ 500 million. Considering the scale of projects, General Conditions of the project are assumed as 15% of direct costs.

Items of General Conditions considered are as follows:

(1) Field Office Expenses

- Salaries/Wages of Managers, Engineers, Technicians, Clerks, Watchman, Safety Personnel and Others.
- Office Facilities and Engineering Supplies.
- Utilities* (Water, Power, etc.) * consumption
- Communications (Telephone, etc.)
- Traveling Expenses and Crew Transportations
- Welfare Expenses
- Reports and Photos
- Legal Expenses
- Insurance (Construction, Third Party and Equipment)
- Bonds (Performance and Advance Payment)
- Vehicles

(2) Home Office Expenses

- Overhead for Headquarter
- Risk and Profit
- Subcontracting

2.1.11 Supporting Construction

In order to carry out construction works, many supporting works and facilities are required during construction period. the costs of supporting works and facilities are estimated 5.6% of direct cost by trial calculation. Items included in Supporting Construction are as follows:

(1) Mobilization and Demobilization
- Ocean freight
- Stevedoring
- In-land transportation
- Packing and lashing
- Air freight etc.

(2) Area Sanitation and Health
- Medical office and hospital
- Preventive medicine
- Medical support

(3) Support Facilities
- Office
- Housing (Family quarters, Bachelor quarters)
- Public service (Mess, School, Police, Fire, Postal etc.)
- Utilities (Water, Sewerage, Power, Telephone System, Garbage, etc.)
- Warehouse
- Repair shops
- Motor pools
- Temporary jetties
- Laboratories (Soil, Concrete etc.)

2.1.12 Indirect Costs

Indirect costs shall be managed by client which are categorized as follows:

(1) Administrative Costs

Client costs for Salaries, Travel, and Expenses in support of engineering and construction activities.

(2) Headquarters Costs

Engineering, Design, and Headquarters Support, Including salaries, travel, and expenses of all home office assigned personnel.

(3) Construction Supervision

Salaries, Travel and Expenses in Support of Construction Management Activities.

(4) Land Acquisition and Land Rights

(5) Compensation Costs

To include costs for relocation of existing facilities and structures as well as resettlement of current inhabitants.

(6) Contingency

Physical Contingency allowing for uncertainties in scooping, quantities, and pricing.

(7) Other Indirect Costs

2.2 Unit Cost Analysis for Main Works

2.2.1 Canal Excavation

(1) Dry Excavation

a) General Condition

Shift	2 Shifts
Working hours per day	12 hours x 2 shifts = 24 hours
Equipment operating hours per day	10 hours x 2 shifts = 20 hours
Output (m^3/h)	Based on loading equipment (Shovel)

b) Combination of Set

Combination of one set is as follows: (Ref. Table 2.2.1-(7))

Table 2.2.1-(1)

Description		Common	Weathered Rock	Hard Rock *1
Bulldozer 86t-eq.	(Nos.)	1,480/540 2.74	1,190/240 4.96	(1,050/385)x0.33 0.91
Blast hole drill 165 m/m	(Nos.)	-	-	1,050/280 3.75
Shovel $18m^3$-eq.	(Nos.)	1.00	1.00	1.00
Dump Truck 136t-eq.	(Nos.)	9.00	9.00	9.00
Bulldozer 60t-eq. *2	(Nos.)	(1,480/520)x0.33 0.95	(1.190/420)x0.33 0.94	(1,050/370)x0.33 0.93
Output	(m^3/h)	1,480	1,190	1,050

*1 One third of blasted rocks will be gathered by bulldozer 86t-eq. at rock face.

*2 One third of disposed material will be spreaded by bulldozer 60t-eq. at disposal area.

c) Break down of Unit cost

COMMON

Table 2.2.1-(2)

Description	(A) Equipment Cost/Unit ($/h)	(B) Number of Equipment (Each)	(C) Total Equipment cost (AxB) ($/h)	(D) Output (m^3/h)	(E) Unit cost (C/D) ($/m^3$)
Blasting					
Excavating	189	2.74	517.86	1,480	0.35
Loading	441	1.00	441	1,480	0.30
Hauling	247	9.00	2,223	1,480	1.50
Disposing	100	0.95	95.0	1,480	0.06
			Composite Unit Rate ($/m^3$)		2.21

WEATHERED ROCK

Table 2.2.1-(3)

Description	(A) Equipment Cost/Unit ($/h)	(B) Number of Equipment (Each)	(C) Total Equipment cost (AxB) ($/h)	(D) Output (m^3/h)	(E) Unit cost (C/D) ($/m^3$)
Blasting					
Excavating	189	4.96	937.44	1,190	0.79
Loading	441	1.00	441	1,190	0.37
Hauling	247	9.00	2,223	1,190	1.87
Disposing	100	0.93	93.0	1,190	0.08
			Composite Unit Rate ($/m^3$)		3.11

ROCK

Table 2.2.1-(4)

Description	(A) Equipment Cost/Unit ($/h)	(B) Number of Equipment (Each)	(C) Total Equipment cost (AxB) ($/h)	(D) Output (m^3/h)	(E) Unit cost (C/D) ($/m^3$)
Blasting	507	3.75	1,901.25	1,050	1.81
Excavating	189	0.91	171.99	1,050	0.16
Loading	441	1.00	441	1,050	0.42
Hauling	247	9.00	2,223	1,050	2.12
Disposing	100	0.93	93	1,050	0.09
			Composite Unit Rate ($/m^3$)		4.60

Note: 1) Hauling distance L = 3km

2) Unit Costs include Operating and Maintenance.

d) Hourly Cost of heavy Equipment

Table 2.2.1-(5)

Description	Unit	Bulldozer 86t Equiv.	Bulldozer 60t Equiv.	Shovel $15m^3$ Equiv.	Dump Truck 136t Equiv.	Blast Hole Drill 165 m/m Equiv.
Purchase Price	$	1,143,000	643,000	4,071,000	1,407,000	$943,000
Final Depreciation rate		0.9	0.9	0.9	0.9	0.9
Durable years	year	6	6	6	6	5
Annual Depr. rate	per year	0.15	0.15	0.15	0.15	0.18
Annual Charge rate	per year	0.07	0.07	0.07	0.07	0.07
Maintenance & Repair Rate		1.70	1.20	0.70	1.40	0.80
Annual Maintenance & Repair Rate	per year	0.283	0.200	0.117	0.233	0.160
Annual Operating Hour	h	4,000	4,000	4,000	4,000	4,000
Hourly Equipment Rate	per hour	0.000126	0.000105	0.000085	0.000113	0.000103
Total Equipment Cost	$/h	144.00	67.50	346.00	159.00	97.10
Fuel Oil	$/h	95 ltr 27.60	64 ltr 18.60	217 ltr 62.90	92 ltr 26.70	85 ltr 24.70
Lubricating Oil	$/h	0.92 ltr 1.70	0.56 ltr 1.00	3.56 ltr 6.60	1.55 ltr 2.90	0.83 ltr 1.50
Consumable Materials	$/h	7.30	4.90	17.20	7.40	Bit. Lot. etc. 85.70
Tire Consumption	$/h				0.0004 Sets 45.00	0.0004 Sets 5.10
						12.6kg 78.10
Anfo	$/h					71.4kg 107.10
Detonator	$/h					2 nos 6.50
Detonating Cord	$/h					20 m 72.00
Total Material Cost	$/h	36.60	24.50	86.70	82.00	380.70
Foreman	$/h	0.20 nos 1.30	0.20 nos 1.30	0.20 nos 1.30	0.20 nos 1.30	0.20 nos 1.30
Driver/Operator	$/h	1 nos 5.70	1 nos 5.70	1 nos 5.70	1 nos 3.10	2 nos 6.20
Unskilled Labor	$/h	0.33 nos 1.20	0.33 nos 1.20	0.33 nos 1.20	0.33 nos 1.20	6 nos 21.60
Total Labor Cost	$/h	8.20	8.20	8.20	5.60	29.10
Total Hourly Cost	$/hour	189.00	100.00	441.00	247.00	507.00

Equipment Hourly Cost of Heavy Equipment

Table 2.2.1-(6)

Description	Unit	Crawler Drill 75 m/m		Compactor (Tamping Type) 30.8t 314HP		Tire Roller 20t 2.3mw 100HP		Motor Grader 4.9m 280HP 29t		Vibratory Roller 2.4m wide 177HP	
Purchase price	$		243,000		425,000		59,000		325,000		115,000
Depreciation rate	year		0.9		0.9		0.9		0.9		0.9
Durable years	year		5		6		8		7		6
Annual Depr. Rate	Per year		0.18		0.15		0.11		0.13		0.15
Annual Charge Rate	Per year		0.07		0.07		0.07		0.07		0.07
Maintenance & Repair Rate			0.40		0.80		0.70		0.70		0.80
Annual Mainte-nance & Repair Rate	Per year		0.08		0.13		0.09		0.10		0.13
Annual Opera-ting Hour	h		2,000		2,000		2,000		2,000		2,000
Hourly Equip-ment Rate	Per hour		0.000165		0.000177		0.000135		0.000249		0.000177
Total Equipment Cost	$/h		40.10		75.20		8.00		48.40		20.40
Fuel Oil	$/h	22 ltr	6.30	34 ltr	9.90	7 ltr	2.00	20 ltr	5.80	19 ltr	5.50
Lubricating oil	$/h	0.8 ltr	1.50	0.5 ltr	0.90	0.2 ltr	0.40	0.5 ltr	0.90	0.3 ltr	0.60
Consumable Materials	$/h		57.90*1				28.80*2				
Dynamite	$/h	6.9kg	42.80								
Anfo	$/h	3.9kg	58.50								
Detonating Cord	$/h	0.386m	1.40								
Detonator	$/h	2.861 pcs	9.20								
Total Material Cost	$/h		117.60		10.80		2.40		35.50		6.10
Foreman	s/h	1/3 nos	2.20	1/5 nos	1.30	1/5 nos	1.30	1/5 nos	1.30	1/5 nos	1.30
Operator	$/h	1 nos	4.80	1 nos	5.70	1 nos	5.70	1 nos	5.70	1 nos	5.70
Unskilled Labor	$/h	1 nos	3.60	1/3 nos	1.20	1/3 nos	1.20	1/3 nos	1.20	1/3 nos	1.20
Total Labor Cost	$/h		10.60		8.20		8.20		8.20		8.20
Total Hourly Cost	$/hour		228.00		74.00		19.00		92.00		35.00

*1

Bit	75 m/m dia	0.06 pcs	20.80
Rod	45 m/m dia	0.03 pcs	12.70
Shank Rod		0.02 pcs	4.70
Sleeve		0.049 pcs	4.40
Others			15.30
Total			$57.90

*2

Cutting Edge	0.03 pcs	19.20
End Bit	0.015 pcs	4.80
Tire	0.004 sets	4.80
Total		$28.80

e) Capacities of Heavy Equipment

Table 2.2.1-(7)

Description	Spec. & Working Substance	q [m³]	L (m)	Cm (min)	E	A (m²)	K	t1 (min)	t2 (min)	t3 (min)	v (km/h)	n (nos)	Formula	Q1 m³/h	f	Qn m³/h	
Bulldozer	86t-equiv. Dozing	20.8	30	1.34	0.7								$\frac{60xqxE}{cm}$	652	0.83 0.67 0.59	540 440 385	Earth Common Weathered Rock Hard Rock
Bulldozer	86t-equiv. Ripping		30	1.49	0.5	0.84							$\frac{60xAxLxE}{cm}$			510	
Bulldozer	86t-equiv. Ripping & Dozing		Ripping Capacity Q1=440 Dozing Capacity Q2=510										$\frac{Q1xQ2}{Q1 + Q2}$ *1			240	
Bulldozer	60t-equiv. Spreading	14.3	20	0.96	0.7								$\frac{60xqxE}{cm}$	626	0.83 0.67 0.59	520 420 370	Earth Common Weathered Rock Hard Rock
Shovel	$15m^3$-equiv. Loading	15		0.5	0.9		1.1						$\frac{60xqxKxE}{cm}$	1,782	0.83 0.69 0.59	1,480 1,190 1,050	Earth Common Weathered Rock Hard Rock
Dump Truck	136t-equiv. Hauling	82.5	3,000	22 *4	0.9			18 *2	2.5 *3	1.5	20	8.8 *5	$\frac{60xqtxnxE}{cm}$	1,782	0.83 0.67 0.59	1,480 1,190 1,050	Earth Common Weathered Rock Hard Rock
Blast Hole	165m/m-equiv. Drilling												$\frac{DxWxV}{1.1x1.05}$ *6			280	Hard Rock

Abbreviation

- q: Bowl capacity for blade, bucket, vessel and etc. $[m^3]$ at struck loading
- L: Hauling distance [m]
- Cm: Cycle time [min]
- t_1: Hauling time [min]
- t_2: Loading time [min]
- t_3: Dumping time [min]
- n: Number of dump truck [nos]
- A: Ripping Area $[m^2]$
- K: Heaped factor for struck loading
- V: Ave. Hauling speed [km/h]
- E: Working efficiency
- Ql: Capacity of heavy equipment $[m^3/h$: loose]
- f: Loading factor
- Qn: Capacity of heavy equipment $[m^3/h$: compacted]

Note:

*1 *Composite Capacity*

*2 t1 : Hauling time

$$t1 = \frac{0.12 \times L}{V} = \frac{0.12 \times 3,000}{20} = 18 \text{ [min]}$$

*3 t2 : Loading time

$$t2 = \frac{qt \times Cms}{qs \times K} = \frac{82.5 \times 0.5}{15 \times 1.1} = 2.5 \text{ [min]}$$

qt: Bowl Capacity of Dump truck
qs: Bucket Capacity of Shovel
Cms: Cycle time of Shovel

*4 Cm : Cycle time of Dump truck
Cm = t1 + t2 + t3 = 18 + 2.5 + 1.5 = 22 [min]

*5 N : Number of Dump truck

$$N = \frac{t1 + t3}{t2} + 1 = \frac{18 + 2.5}{2.5} + 1 = 8.8 \text{ [nos]}$$

*6

H:	Height of Bench-Cut	15	[m]
D:	Drilling Hole Spacing	6.5	[m]
W:	Overburden	5	[m]
V:	Drilling Speed	10	[m/h]
t:	Drilling time [h]		

$$t = \frac{1.1 \times H}{V}$$

Drilling lengths 1.1 x H

Q: Capacity of Drilling $[m^3/h]$

$$Q = \frac{D \times W \times H}{t} = \frac{DWH}{\left(\frac{1.1 \times H}{V}\right)} \times \frac{1}{1.05}$$

$$= \frac{D \times W \times V}{1.1 \times 1.05}$$

Working factor 1.05

f) Transportation Cost Table - Dry Excavation

Table 2.2.1-(8)

Distance (km)	Cycle Time (min) T1	T2	T3	cm	Kind of Material	Output (m^3/h)	Cost ($\$/m^3$)
1.0	6	2.5	1.5	10	Common Weathered Rock	378 305 269	0.67 0.83 0.94
1.5	9	2.5	1.5	13	Common Weathered Rock	284 230 202	0.89 1.11 1.25
2.0	12	2.5	1.5	16	Common Weathered Rock	231 187 164	1.09 1.36 1.54
2.5	15	2.5	1.5	19	Common Weathered Rock	195 157 138	1.29 1.61 1.83
3.0	18	2.5	1.5	22	Common Weathered Rock	160 136 120	1.50 1.87 2.12
3.5	21	2.5	1.5	25	Common Weathered Rock	147 119 105	1.70 2.13 2.41
4.0	24	2.5	1.5	28	Common Weathered Rock	132 107 94	1.90 2.37 2.67
5.0	30	2.5	1.5	34	Common Weathered Rock	109 88 77	2.31 2.88 3.26
10.0	60	2.5	1.5	64	Common Weathered Rock	58 47 41	4.41 5.50 6.24

Note (1) Combination of dump trucks (136t) and shovel loader (15 cu.m) is considered. Ave. velocity of dump truck is assumed to be 20 km/h.

Note (2) t1 Hauling hour (min)
t2 Loading hour (min)
t3 Dumping hour (min)

UNIT COST OF CANAL DRY EXCAVATION

Table 2.2.1-(9)

Case	Route	Average Hauling Distance	Description	Excavation ($/m^3)					Total Unit Cost
				Blasting	Excavating	Loading	Hauling	Disposal	
Lock Canal L-1 L-2 L-3 L-4 L-5 L-6 L-7 L-8 L-9	15 + Third L.	3.5 km	Earth Common Weathered Rock Hard Rock	- - 1.81	0.35 0.79 0.16	0.30 0.37 0.42	1.70 2.13 2.41	0.06 0.08 0.09	2.41 3.37 4.89
Lock Canal L-10 L-11 L-12 L-13 L-14 L-15 L-16 L-17 L-18	15 + Gatun + Third L.	3.5 km	Earth Common Weathered Rock Hard Rock	- - 1.81	0.35 0.79 0.16	0.30 0.37 0.42	1.70 2.13 2.41	0.06 0.08 0.09	2.41 3.37 4.89
Sea Level Canal S-1 S-13 S-2 S-14 S-3 S-15 S-4 S-5 S-6	10	4.0 km	Earth Common Weathered Rock Hard Rock	- - 1.81	0.35 0.79 0.16	0.30 0.37 0.42	1.90 2.37 2.67	0.06 0.08 0.09	2.61 3.61 5.15
Sea Level Canal S-7 S-16 S-8 S-17 S-9 S-18 S-10 S-11 S-12	14 S	4.0 km	Earth Common Weathered Rock Hard Rock	- - 1.81	0.35 0.79 0.16	0.30 0.37 0.42	1.90 2.37 2.67	0.06 0.08 0.09	2.61 3.61 5.15

(2) Underwater Excavation

a) General Condition

Shift 2 shifts	
Working hours per day	12 h x 2 shifts = 24 hours
Equipment operating hours per day	10 h x 2 shifts = 20 hours

b) Organization, Output & Unit

Table 2.2.1-(10)

Description		Organizations	out-put m^3 per year	unit cost $\$/m^3$
Rock	Blasting	Blasting barge,	218,700	60.38
Rock	Grab dredging	Grab dredger,	1,360,000	7.05
Rock	Cutter suction dredging	Cutter suction & split barge	2,477,200	8.43
Weathered Rock	Cutter suction dredging	Cutter suction dredger & split barge	5,346,000	4.47
Common	Cutter suction dredging	Cutter suction dredger & split barge	9,900,000	1.71
Common	Drag suction dredging	Drag suction Dredger	(L=2km) 12,183,000	2.11
Deep water (below -30m) Hard rock Soft Rock	Grab dredging	Grab dredger	1,000,000	9.09

c) Breakdown of Unit Cost

Table 2.2.1-(11)

	Blasting barge drill 10 nos, 300HP	Anchor boat 240HP
Kind of work	Rock blasting	
Number of vessels	1	3
Book price (brand new)	$3,059,000	$821,429,000
Depreciation period	5 years	16 years
Monthly operation	350 hours	200 hours
Months in operation per year	10 months	10 months
Out-put per year	218,700m^3	

Equipment cost per year

		Amount $		Amount $	
Equipment		4,926,540		225,060	
Depreciation		3,233,350		64,170	
Maintenance and repair		1,693,190		160,890	
Lubricating and fuel oil		730,800		22,410	
Manpower		2,389,520		163,180	
Skilled sea-man	19	1,302,860	2	137,140	
Common sea-man	36	468,720	2	26,040	
Diver	12	617,940			
Material		3,604,090		107,140	
Explosives		3,175,520			
Miscellaneous		428,570		107,140	
Total		11,650,950		517,790	
Unit cost		53.27		2.37 x 3 = 7.11	$60.38/m^3

Table 2.2.1-(12)

Working vessel	Grab dredger $50m^3$, 3000HP	Anchor boat 600HP
Kind of work	Rock grab dredging	
Book price (brand new)	$11,214,286,000	$1,785,714,000
Depreciation Period	8 years	14 years
Monthly operation	400 hours	250 hours
Months in operation per year	10 months	10 months
Out-put per year	$1,360,000m^3$	

Equipment cost per year

		Amount $		Amount $	
Equipment		5,748,230		473,770	
Depreciation period		2,831,890		199,300	
Maintenance and repair		2,916,340		274,470	
Lubricating and fuel oil		560,280		70,040	
Manpower		678,770		163,180	
Skilled sea-man	8	548,570	2	137,140	
Common sea-man	10	130,200	2	26,040	
Material		1,757,520		142,000	
Total		8,744,860		848,990	
Unit cost		6.43		0.62	$\$7.05/m^3$

Table 2.2.1-(13)

Working vessel	Cutter suction dredger 18,000 HP	Anchor boat 600 HP	Loading barge 500 HP
Kind of work	Cutter suction dredging (rock)		
Book price (brand new)	$25,286,000	$1,786,000	$714,000
Depreciation period	8 years	14 years	12 years
Monthly operation	400 hours	250 hours	400 hours
Months in operation per year	11 months	11 months	11 months
Out-put per year	2,477,200m^3		

Equipment cost per year

		Amount $		Amount $		Amount $	
Equipment		9,723,430		508,650		268,450	
Depreciation		4,544,820		219,230		163,690	
Maintenance and repair		5,178,610		289,420		104,760	
Lubricating and fuel oil		3,697,850		77,040		102,718	
Manpower		972,150		163,180		189,220	
Skilled sea-man	10	685,710	2	137,140	2	137,140	
Common sea-man	22	286,440	2	26,040	4	52,080	
Material		4,897,760		142,860		142,860	
Total		19,291,190		891,730		703,248	
Unit cost		7.79		0.36		0.28	$8.43/m^3

Cutter Suction Dredging (Weathered Rock)

Table 2.2.1-(14)

Working vessel	Cutter suction dredger 18,000HP	Anchor boat 600HP	Loading barge 500HP
Kind of work	Cutter suction dredging (weathered rock)		
Book price (brand new)	$25,286,000	$1,786,000	$714,000
Depreciation Period	8 years	14 years	12 years
Monthly operation	450 hours	250 hours	450 hours
Months in operation per year	11 months	11 months	11 months
Out-put per year	5,346,000m^3		

Equipment cost per year

		Amount $		Amount $		Amount $	
Equipment		10,737,280		508,650		288,910	
Depreciation		5,112,920		219,230		184,150	
Maintenance and repair		5,624,340		289,420		104,760	
Lubricating and fuel oil		4,160,080		77,040		115,560	
Manpower		972,150		163,180		189,220	
Skilled sea-man	10	685,710	2	137,140	2	137,140	
Common sea-man	22	286,440	2	26,040	4	52,080	
Material		6,423,310		142,860		142,860	
Total		22,292,820		891,730		736,550	
Unit cost		4.17		0.16		0.14	$4.47/m^3

Table 2.2.1-(15)

Working vessel	Cutter suction dredger pump 10,000PS, cutter 2,500 HP	Anchor boat 600 HP	Loading barge 500 HP
Kind of work	Cutter suction dredging (earth common)		
Book price (brand new)	$25,286,000	$1,786,000	$714,000
Depreciation Period	12 years	14 years	12 years
Monthly operation	500 hours	250 hours	500 hours
Months in operation per year	11 months	11 months	11 months
Out-put per year	9,900,000m^3		

Equipment cost per year

		Amount $		Amount $		Amount $	
Equipment		8,316,020		508,650		309,370	
Depreciation		3,787,350		219,230		204,610	
Maintenance and repair		4,528,670		289,420		104,760	
Lubricating and fuel oil		4,622,310		77,040		128,400	
Manpower		972,150		163,180		189,220	
Skilled sea-man	10	685,710	2	137,140	2	137,140	
Common sea-man	22	286,440	2	26,040	4	52,080	
Material		1,335,520		142,860		142,860	
Total		15,246,000		891,730		769,850	
Unit cost		1.54		0.09		0.08	$1.71/m^3

Table 2.2.1-(16)

Working vessel		Drag suction dredger pump 7,800 HP		Survey boat 750 HP	
Kind of work		Common dredging (less than 2 km of hauling distance)			
Book price (brand new)		$48,000,000		$461,000	
Depreciation period		14 years		12 years	
Monthly operation		616 hours		300 hours	
Months in operation per year		11 months		11 months	
Out-put per year		12,183,050m^3			

Equipment cost per year

		Amount $		Amount $	
Equipment		17,584,320		170,830	
Depreciation		7,592,160		79,190	
Maintenance and repair		9,992,160		91,640	
Lubricating and fuel oil		4,112,830		115,560	
Manpower		1,634,430		163,180	
Skilled sea-man	17	1,165,710	2	137,140	
Common sea-man	36	468,720	2	26,040	
Material		1,782,240		142,860	
Total		25,113,820		592,430	
Unit cost		2.06		0.05	$2.11/m^3

Table 2.2.1-(17)

Working vessel		Grab dredger 50 m^3 3,000 HP		Anchor boat 600 HP	
Kind of work		Grab dredging (deep water, below -30m)			
Book price (brand new)		$11,214,000		$1,786,000	
Depreciation period		7 years		14 years	
Monthly operation		400 hours		250 hours	
Months in operation per year		10 months		10 months	
Out-put per year		1,000,000m^3			

Equipment cost per year

		Amount $		Amount $	
Equipment		5,748,630		473,770	
Depreciation		2,833,190		199,300	
Maintenance and repair		2,915,440		274,470	
Lubricating and fuel oil		560,280		70,040	
Manpower		678,770		163,180	
Skilled sea-man	8	548,570	2	137,140	
Common sea-man	10	130,200	2	26,040	
Material		1,252,320		142,860	
Total		8,240,000		849,850	
Unit cost		8.24		0.85	$9.09/$m^3$

d) Unit Cost of Transportation (Underwater excavation)

Unit costs of transportation are shown in Table 2.2.1-(19). Average hauling distances of each case are shown in Table 2.2.1-(18).

Table 2.2.1-(18)

	Z-I	Z-II	Z-III	Z-IV	Z-V
High-rise	3.6	9.0	34.9	41.9	9.9
Low-rise	3.6	9.0	34.9	21.5	9.9
Route-14S	3.6	2.2	18.4	18.4	9.9
Route-10	3.6	-	-	-	3.6

(km)

Unit Cost of Transportation

Table 2.2.1-(19)
unit cost $/m^3

Distance (km)	Hard Rock Below -30m deep	Hard Rock Above -30m deep	Weathered Rock Below -30m deep	Weathered Rock Above -30m deep	Common
2.2	1.80	1.00	1.80	0.58	0.46
2.4	1.81	1.01	1.81	0.59	0.47
3.5	1.87		1.87		
3.6	1.87	1.07	1.87	0.66	0.53
4.0	1.0			0.68	
6.0					0.67
6.3				0.80	
7.7		1.30			
8.1	2.12	1.32	2.12	0.90	
9.0		1.37		0.95	6.85
9.9	2.20	1.40	2.20		0.90
10.0		1.42			
12.5		1.56			
13.9			1.22		
18.4	2.68	1.88	2.68	1.46	1.35
18.5					
18.9	2.71		2.71		
19.1					1.38
20.8				1.66	
21.3		20.30			
21.5	2.05	2.04	2.05	2.81	1.49
34.9		3.01		2.22	2.15
41.9		3.33		2.69	2.45

e) Combined Unit Cost of Wet Excavation

Assumptions of case study are as follows:

In case of lock canal, 15% of rock will be excavated by blasting.

In case of sea-level canal;

deep water dredging operation (-30m - -53m) will be carried out.

55% of rock will be excavated by blasting.

45% of weathered rock will be excavated by blasting.

Unit costs of each case are shown in Table 2.2.1-(20) to (23).

Assumed proportion for wet excavation

Hard Rock
100% -30 m Above — 70% Cutter Suction Dredging
30% Grub Dredging — 15% Blasting
15% Non-Blasting

Weathered Rock
100% -30 m Above — 100% Cutter Suction Dredging — 100% Non-Blasting

DREDGING UNIT COST (Case of High-rise)
For Depths up to -30 meters

Unit cost in dollars Table 2.2.1-(20)

Material to be Excavated	Type of Equipment	Dredging Loading Cost: Soil ratio %	Unit Cost	Weighted Average ($/m^3)	Transportation Disposal Haul Distance: Z-I 3.6	Z-II 9.0	Z-III 34.9	Z-IV 41.9	Z-V 9.9	Total Dredging Unit Costs: Z-I	Z-II	Z-III	Z-IV	Z-V
Hard Rock	Cutter suction dredging	70	8.43	5.90										
	Grub dredging	30	7.05	2.12										
	Blasting (grub dredging)	15	60.38	9.06										
	Cost per m^3			17.08	1.07	1.37	3.01	3.33	1.43	18.15	18.45	20.09	20.41	18.51
Weathered Rock	Cutter suction dredging	100												
	Cost per m^3			4.47	0.66	0.95	2.22	2.69	1.00	5.13	5.42	6.69	7.16	5.47
Common	Cutter suction dredging	100												
	Cost per m^3			1.71	0.53	0.86	2.15	2.45	0.90	2.24	2.57	3.86	4.16	2.61

Note: 1) Transportation Costs, Refer to Table 2.2.1-(19).
2) Total Dredging Unit Costs equal 'Dredging Loading Cost and Transportation'.

DREDGING UNIT COST (Case of Low-rise)
For Depths up to -30 meters

Unit cost in dollars Table 2.2.1-(21)

Material to be Excavated	Type of Equipment	Dredging Loading Cost: Soil ratio %	Dredging Loading Cost: Unit Cost	Dredging Loading Cost: Weighted Average ($/m^3)	Transportation Disposal Haul Distance: Z-I 3.6	Z-II 9.0	Z-III 34.9	Z-IV 21.9	Z-V 9.9	Total Dredging Unit Costs: Z-I	Z-II	Z-III	Z-IV	Z-V
Hard Rock	Cutter suction dredging	70	8.43	5.90										
	Grub dredging	30	7.05	2.12										
	Blasting (grub dredging)	15	60.38	9.06										
	Cost per m^3			17.08	1.07	1.37	3.01	2.04	1.43	18.15	18.45	20.09	19.12	18.51
Weathered Rock	Cutter suction dredging	100												
	Cost per m^3			4.47	0.66	0.95	2.22	2.81	1.00	5.13	5.42	6.69	7.28	5.47
Common	Cutter suction dredging	100												
	Cost per m^3			1.71	0.53	0.85	2.15	1.49	0.90	2.24	2.56	3.86	3.20	2.61

Assumed proportion for wet excavation

Hard Rock

100% -30 m Above
- 70% Cutter Suction Dredging
- 30% Grub Dredging
  - 15% Blasting
  - 15% Non-Blasting

Weathered Rock

100% -30 m Above — 100% Cutter Suction Dredging — 100% Non-Blasting

DREDGING UNIT COST (Route - 14S Sea Level)
For Depths below -30 meters

Unit cost in dollars Table 2.2.1-(22)

Material to be Excavated	Type of Equipment	Dredging Loading Cost: Soil ratio %	Unit Cost	Weighted Average ($/m^3)	Transportation Disposal Haul Distance: Z-I 3.6	Z-II 2.2	Z-III 18.4	Z-IV 18.4	Z-V 9.9	Total Dredging Unit Costs: Z-I	Z-II	Z-III	Z-IV	Z-V
Hard Rock	Cutter suction dredging	10	17.08	1.71										
	Grub dredging	90	9.09	8.18										
	Blasting (grub dredging)	55	60.38	33.21										
	Cost per m^3			43.10	1.87	1.80	2.65	2.65	2.20	44.97	44.90	45.75	45.75	45.30
Weathered Rock	Cutter suction dredging	10	4.47	0.45										
	Grub dredging	90	9.09	8.18										
	Blasting (grub dredging)	45	60.38	27.17										
	Cost per m^3			35.80	1.87	1.80	2.65	2.65	2.20	37.67	37.60	38.45	38.45	38.00
Common	Cutter suction dredging	100												
	Cost per m^3			1.71	0.53	0.46	1.35	1.35	0.90	2.24	2.17	3.06	3.06	2.61

Assumed proportion for wet excavation

Hard Rock

- 10% -30 m Above
  - 7% Cutter Suction Dredging
  - 3% Grub Dredging
    - 1.5% Blasting
    - 1.5% Non-Blasting
- 90% -30 m Below
  - 90% Grub Dredging
    - 55% Blasting
    - 35% Non-Blasting

Weathered Rock

- 10% -30 m Above
  - 10% Cutter Suction Dredging
- 90% -30 m Below
  - 90% Grub Dredging
    - 45% Blasting
    - 45% Non-Blasting

DREDGING UNIT COST (Route-10 Sea Level)
For Depths up to -30 meters

Unit cost in dollars Table 2.2.1-(23)

Material to be Excavated	Type of Equipment	Dredging Loading Cost: Soil ratio %	Dredging Loading Cost: Unit Cost	Dredging Loading Cost: Weighted Average ($/m^3)	Transportation Disposal Haul Distance: Z-I 3.6	Z-II –	Z-III –	Z-IV –	Z-V 3.6	Total Dredging Unit Costs: Z-I	Z-II	Z-III	Z-IV	Z-V
Hard Rock	Cutter suction dredging	70	8.43	5.90										
	Grub dredging	30	7.05	2.12										
	Blasting (grub dredging)	15	60.38	9.06										
	Cost per m^3			17.08	1.07	–	–	–	1.07	18.15	–	–	–	18.15
Weathered Rock	Cutter suction dredging	100												
	Cost per m^3			4.47	0.66	–	–	–	0.66	5.13	–	–	–	5.13
Common	Cutter suction dredging	100												
	Cost per m^3			1.71	0.53	–	–	–	0.53	2.24	–	–	–	2.24

Assumed proportion for wet excavation

Hard Rock

100% -30 m Above → 70% Cutter Suction Dredging

→ 30% Grub Dredging → 15% Blasting

→ 15% Non-Blasting

Weathered Rock

100% -30 m Above → 100% Cutter Suction Dredging → 100% Non-Blasting

(3) Miscellaneous Works

a) Haul road construction (Route 10)

a. Route 10

- Plan of Haul Road

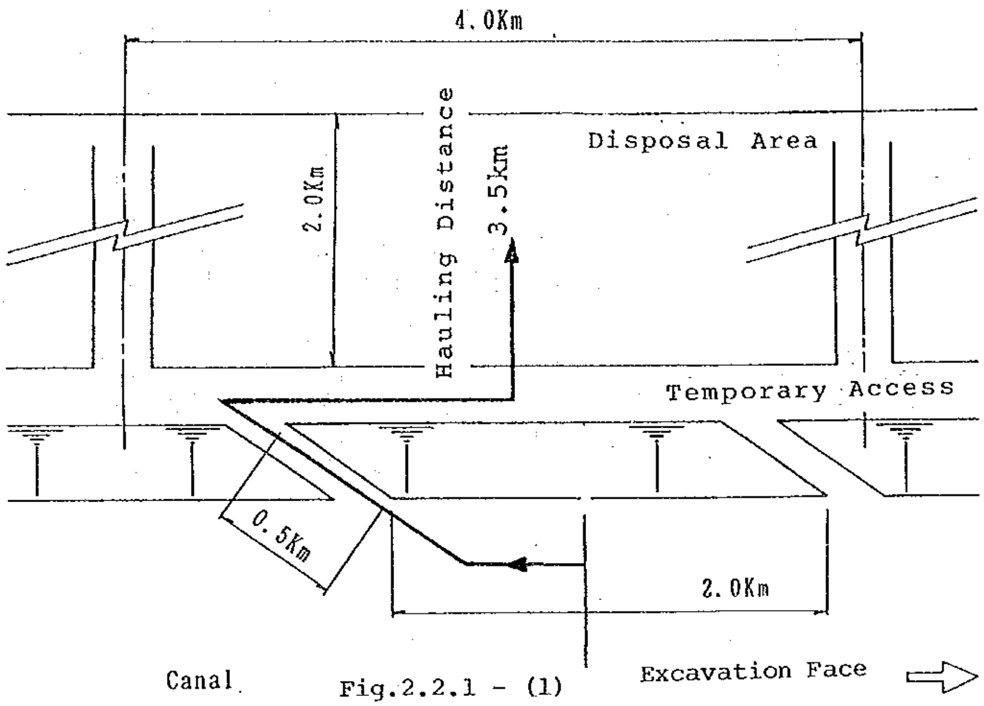


Fig.2.2.1 - (1)

Average hauling distance

	km	Ave.
Excavation face - Inclined drive	0 - 2.0	1.0
Inclined drive	0 - 1.0	0.5
Inclined drive - disposal area	0 - 4.0	2.0
Total		3.5 km

Haul Road Length (km)

Lagarto - Escobal	16
Lagarterita - 2nd Barrier Dam	5
STA No.38 - Puerto Caimito	22
Sub-total	43 km

Inclined drive Ave. 0.5 x 30 Spots =	15 km
Total	58 km

- Quantities (Assumed)

Common excavation	90,000 x 30 x 0.40	= 1,080,000 m^3
Weathered rock	36 x 43,000	= 1,548,000
	90,000 x 30 x 0.60	= 1,620,000
	Subtotal	= 3,168,000 m^3
Hard rock	150,000*1 x 30	= 4,500,000 m^3
Pavement (Water Tightened Macadam)	58,000 x 20	= 1,160,000 m^2
Temporary bridge*2		24 nos

- Estimate

	Q'ty	Unit cost ($)	Amount (million dollars)
Common	1,080,000	2.21	2.39
Weathered rock	3,168,000	3.11	9.85
Hard rock	4,500,000	4.92	22.14
Pavement	1,160,000	6.00	6.96
Temporary bridge	24	200,000.00	4.80
			$46.14

- Unit cost

$46,160,000 / 58,000m = 795.9 = $796.00/m

*1 150,000 cubic meters of excavation volume is assumed as per spot.

*2 Specification of assumed bridge is as follows:

Temporary Bridge
Specification

Proposed Vehicle	Dump truck	136t
Ave. Span		6m
Width		20m
Structure	Steel plate Girder	
	Steel weight	67t

Cost

Steel Fabrication			
Material	67t	725/t	$ 48,575.00
Processing	67t	1,000/t	$ 67,000.00
Sub-total			$115,575.00
Foundation	1 L.S.		$ 17,425.00
Installation/ Removal	67t	1,000/t	$ 67,000.00
Total Cost			$200,000.00

b. Route 14S

- Road Length

Temporary access road			31 km
Access road to excavation face	31 / 2 = 15.5	=	16
	16 spots x 0.5	=	8 km
	Total	=	39 km

- Quantities

Common excavation	90,000 x 16 x 0.4	=	576,000 m^3
Weathered rock	90,000 x 16 x 0.6	=	864,000
	36 x 31,000	=	1,116,000
	Sub-total		1,980,000 m^3
Hard rock	150,000 x 16	=	2,400,000 m^3
Pavement	(31,000 + 16 x 500) x 20	=	780,000 m^2
Temporary bridge	31/43 x 24	=	18 nos

- Estimates

	Q'ty	Unit cost ($)	Amount (million dollars)
Common	576,000	2.21	1.27
Weathered rock	1,980,000	3.11	6.16
Hard rock	2,400,000	4.92	11.81
Pavement	780,000	6.00	4.68
Temporary bridge	18	200,000.00	3.60
Total			$27.52

- Unit Cost

$27,520,000 / 39,000 = 705.6 = $705.09/m

c. Lock Type Canal

- Road Length

Gamboa - Miraflores	18 km
Limon Bay - Gatun	5
Access road to quarry face 23 / 2 x 0.5	6
Total	29 km

- Quantities

Common excavation	90,000 x 12 x 0.4	=	432,000 m^3
Weathered rock	90,000 x 12 x 0.6	=	648,000
	36 x 18,000	=	648,000
	Sub-total	=	1,296,000 m^3
Hard rock	150,000 x 12	=	1,800,000 m^3
Pavement	29,000 x 20	=	580,000 m^2
Temporary bridge		=	8 nos

- Estimate

	Q'ty	Unit cost ($)	Amount (million dollars)
Common	432,000	2.21	0.95
Weathered rock	1,296,000	3.11	4.03
Hard rock	1,800,000	4.92	8.86
Pavement	580,000	6.00	3.48
Temporary bridge	8	200,000.00	1.66
Total			$18.92

- Unit Cost

$18,920,000 / 29,000 = 652.4 = $652.00/m

b) Clearing and grubbing

	Q'ty (h)	Unit cost ($)	Amount (per ha)
(Equipment cost)			
Bulldozer 86t-eq.	10	187.00	1,870.00
(Labor cost)	nos.		
Foreman	1	34.40	34.40
Unskilled	20	18.80	376.00
		Total	$2,280.40/ha

Unit price $2,280.40 / 10,000 = 0.228 = $0.23/m^2

c) Vegetation $0.70/m^2 (from actual data)

2.2.2 LOCK CONCRETE STRUCTURE

(1) Estimate Basis

a) Study case

Concrete of 150,000 DWT lock, volume of concrete 5,880,000m^3

b) Material and proportioning

Materials are to be procured and mixed at concrete plants.
proportioning: dam concrete specification

(2) Summary of Execution

a) Capacity of concrete placing

150,000 DWT lock (Pacific side) concrete volume 5,880,000m^3

construction period: 6 years
total working hours 6 yrs x 250 days / yr.
x (10h / day x 2 shifts) = 30,000 h

capacity per hour $\frac{5,880,000m^3}{30,000h}$ = 196 m^3/h

b) Flow of concrete placing

196m^3/h

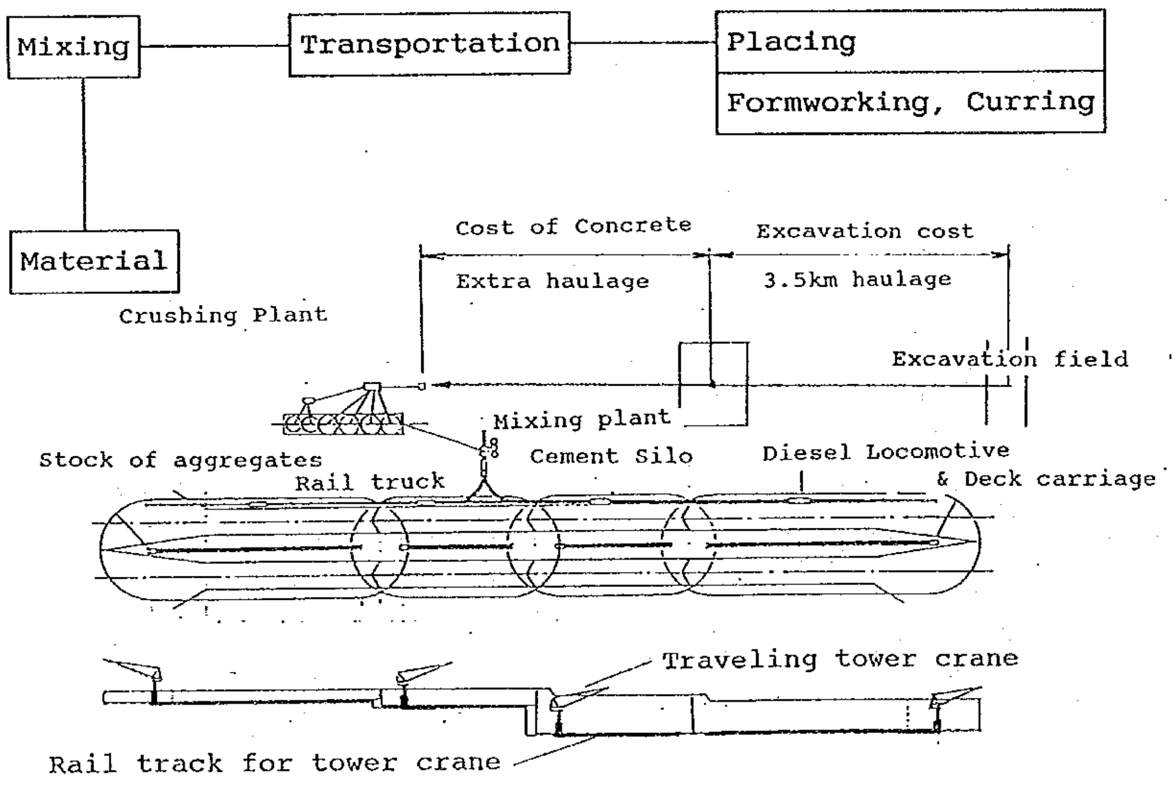


Fig. 2. 2. 2－(1)

Concept of concrete work

c) Cycle time and placing capacity

Table 2.2.2-(1)

	Mixing	Transportation	Placing
cycle time (min)	concrete mixer $3m^3$ x 3 nos 2.5 min	method $4.5m^3$ Distance av. 1.1km av. velocity 15km/h 1.1/15+t1+t2=12.4min t1: loading 1.0 min t2: unloading 3.5 min x 2	cycle of placing $4.5m^3$ bucket 3.5 min
capacity per hour	60min/2.5minx$3m^3$x 3 nos = 216 m^3/h	60min/12.4minx(4.5m^3x 2 nos) = 43.5 m^3/h	60min/3.5minx4.5m^3 x0.8=61.7m^3/h efficiency: 0.8
equipment per 196m^3/h placing	196/216=0.91set	196/43.5=4.5set	196/61.7=3.2set
arrangement of main equipment	mixing plant 1 ($3m^3$mixer x 3sets)	diesel locomotive (12t) 5 deck carriage 5 ($4.5m^3$ bucket 2 sets on board) concrete bucket $4.5m^3$ 10 track 2.3km x 5 lane	traveling tower crane 4 concrete vibro dozer 4

(3) Unit Cost of Concrete

a)	material	\$33.91/m^3
b)	mixing	1.53/m^3
c)	transportation	0.85/m^3
d)	placing	6.57/m^3
e)	form work and curing	3.81/m^3

unit cost of concrete \$46.67/m^3

(4) Calculation for Unit Cost of Concrete

	Contents	Unit Cost ($)	Cost ($/m^3)
a) Material			
cement	0.2t/m^3	106.00/t	21.20
coarse aggregate	0.85m^3	9.20/m^3*1	7.82
fine aggregate	0.46m^3	8.30/m^3*2	3.82
additives	0.0006t/m^3	1,786.00/t	1.07
unit cost of material			$33.91/m^3
b) Cost of Mixing			
- installation and demolition of concrete plant L.S.	$213,000.00		$0.04/m^3
- mixing			
plant operation	1 hour		157.00
operation for aggregate feeding conveyor	1 hour		26.00
operation for coment storage	3 hours	$12.00/h	36.00
operation for coment feeding conveyor	3 hours	$4.00/h	12.00
wheel loader operation for aggregate stock yard	1 hour		26.00
generation operation for mixing plant	1 hour		36.00
Total	196 m^3/h		$293.00/h
unit cost of mixing			$1.49/m^3
unit cost of concrete mixing 0.04 + 1.49 =			$1.53/m^3

*1 Coarse aggregate

(Disposal Area) — Loading $0.42/m^3 — Hauling (5.0 km) $3.20/m^3 — (Crushing Plant) Crushing & Sieving $5.52/m^3 — (Stock pile) Coarse aggregates $9.20/m^3

*2 Fine aggregate

(Disposal Area) — Loading $0.42/m^3 — Hauling $3.20/m^3 — (Crushing Plant & Rod Mill) Crushing, Milling & Washing $4.62/m^3 — (Stock pile) Fine aggregates $8.30/m^3

	Contents	Unit Cost	Cost
c) Transportation			
- installation and demolition of rail truck for concrete transportation L.S.	$752,000.00		$0.13/m^3$
- cost of transportation			
operation of diesel locomotive	4.5 hours	$17.00/h	76.50
operation of deck carriage	4.5 hours	$5.00/h	22.50
operation of concrete bucket	2x4.5 hours	$1.00/h	9.00
labor cost			
foreman	0.2/hours	$6.70/h	1.30
un-skilled labor	9.0/hours	$3.60/h	32.40
Total	196 m^3/h		$141.70/h
Transportation Cost			$0.72/m^3$
Concrete Transportation Cost 0.13 + 0.72 =			$0.85/m^3$

	Contents	Unit Cost	Cost
d) Placing			
- installation and demolition of traveling tower crane L.S.	$756,000.00		$0.13/m^3$
- concrete placing			
operation of tower crane	4 hours	$205.00/h	820.00
operation of generation	4 hours	$23.00/h	92.00
vibro-dozer	4 hours	$43.00/h	172.00
concrete vibrator	3x4 hours	$1.00/h	12.00
miscellaneous (pump etc.)	10x4 hours	$1.00/h	40.00
concrete gang			
foreman	4x1 man-hours	$6.70/h	26.80
skilled labor	4x3 man-hours	$3.90/h	46.80
unskilled labor	4x2 man-hours	$3.60/h	28.80
carpenter	4x1 man-hours	$3.90/h	15.60
electrician	4x0.5 man-hours	$3.90/h	7.80
mechanic	4x0.5 man-hours	$4.80/h	9.60
Total	$196m^3/h$		$1,261.40/h
unit cost of placing			$6.44/m^3$

unit cost of concrete placing
0.13 + 6.44 = $6.57/m^3$

e) Form work and Curing
- form work ($0.2m^2/m^3$)
$18.00/m^2 x 0.2m^2/m^3 = $3.6/m^3$

- green cut and curing
output
per block 1.5m x 15m x 30m = 675m³ (1 lift: 1.5m)
2 block/day 675m³ x 2 block/day = 1,350m³/day

labor cost			
foreman	1 men-day	$53.30/day	53.30
skilled labor	2 men-day	$31.00/day	62.00
unskilled labor	6 men-day	$29.10/day	174.60
Total			$289.90/day

unit cost of green cut and curing $0.21/m^3$

unit cost of form work and curing
3.60 + 0.21 = $3.81 /m^3$

(5) Unit Cost (per hour) of Equipment for Concrete Works

HOURY COST OF EQUIPMENT

Table 2.2.2-(2)

Description	Unit	Mixing plant $200m^3/H$ $3m^3$x3 nos.	Belt conveyor 900mm 150m	Cement Silo 1,000t	Screw Conveyor & Bucket Elevator 40t/H	Generator 440HP 300KVA
Purchase price	$	1,030,000	286,000	144,000	37,000	69,000
Depreciation rate		0.9	0.9	0.9	0.9	0.9
Duarable years	year	8	8	8	8	9
Annual depr. rate	per year	0.11	0.11	0.11	0.11	0.10
Annual charge rate	per year	0.07	0.05	0.05	0.05	0.05
Maintenance & repair rate		0.40	0.20	0.05	0.40	0.80
Annual maintenance & repair rate	per year	0.05	0.03	0	0.05	0.09
Annual operating hour	h	4,000	4,000	4,000	4,000	4,000
Hourly equipment rate	per hour	0.000058	0.000052	0.000042	0.000047	0.000060
Total Equipment Cost	$/h	59.70	14.90	6.00	1.70	4.10
Fuel oil						52 ltr 15.10
Lubricating oil		98 ltr 1.50				0.31 ltr 0.60
Consumable materials		70.00				
Total Material cost	$/h	71.50	*1	*1	*1	15.70
Forman	$/h	1nos. 6.70	0.33nos. 2.20	0.33nos. 2.20	0.33nos. 2.20	0.2nos. 1.30
Operator	$/h	2nos. 11.40	1nos. 5.70			
Unskilled labourer	$/h	2nos. 7.20	1nos. 3.60	1nos. 3.60		0.5nos. 1.80
Total labour cost	$/h	25.30	11.50	5.80	2.20	3.10
Total Hourly Cost	$/hour	157.00	26.00	12.00	4.00	23.00

*1 Including in Total Equipment cost

HOURLY COST OF EQUIPMENT

Table 2.2.2-(3)

Description	Unit	Diesel Locomotive 10t 110HP	Concrete Bucket $4.5m^3$ (for Dam)	Deck Carriage (Bogie Type) $4.5m^3$x2 nos.	Travelling Tower Crane 1,000t-m 300kw 424t
Purchase price	$	105,000	29,000	49,000	3,540,000
Depreciation rate		0.9	0.9	0.9	0.9
Duarable years	year	7	5	7	8
Annual Depr. rate	per year	0.13	0.18	0.13	0.11
Annual charage rate	per year	0.05	0.05	0.05	0.07
Maintenance & repair rate		0.7	0.9	0.9	0.20
Annual maintenance & repair rate	per year	0.10	0.18	0.14	0.03
Annual operating hour	h	4,000	4,000	4,000	4,000
Hourly equipment rate	per year	0.000070	0.000103	0.000077	0.000052
Total equipment cost	$/h	7.40	3.00	3.80	184.10
Fuel oil	$/h	4 ltr 1.20			
Lubricating oil	$/h	0.1 ltr 0.20		0.1 ltr 0.20	0.5 ltr 0.90
Wire rope	$/h				Wire rope 500m/1,000h 5.30
Total Material cost	$/h	1.40		0.20	6.20
Forman	$/h	0.20nos. 1.30		0.20nos. 1.30	0.20nos. 1.30
Operator	$/h	1 nos. 5.70			1 nos. 5.70
Unskilled Laborer	$/h	0.33nos. 1.20			2 nos. 7.20
Total Labour cost	$/h	8.20		1.30	14.20
Total Hourly cost	$/h	17.00	3.00	5.00	205.00

HOURLY COST OF EQUIPMENT

Table 2.2.2-(4)

Description	Unit	Vibro Dozer 57ps 8t	Concrete Vabrator 1.5kW x 135 dia.	Generator 300kVA 440ps 6t
Purchase price	$	93,000	18,000	69,000
Depreciation rate		0.9	0.9	0.9
Durable years	year	4.5	4.5	9
Annual depr. rate	per year	0.20	0.20	0.10
Annual charge rate	per year	0.07	0.07	0.05
Maintenance & repair rate		2.00	2.00	0.80
Annual maintenance & repair rate	per year	0.44	0.44	0.09
Annual operating hour	h	2,000	2,000	4,000
Hourly equipment rate	per hour	0.000357	0.000357	0.000060
Total equipment cost	$/h	33.20	0.60	4.10
Fuel oil	$/h	6 ltr 1.70		52 ltr 15.10
Lubricating oil		0.1 ltr 0.20		0.31 ltr 0.60
Consumable materials			0.40	
Total Material cost	$/h	1.90	0.40	15.70
Foreman	$/h	0.2nos. 1.30		0.2nos. 1.30
Operator	$/h	1 nos. 5.70		
Unskilled laborer	$/h	0.33nos.1.20		0.50nos.1.80
Total Labor cost	$/h	8.20		3.10
Total Hourly Cost	$/h	43.00	1.00	23.00

HOURLY COST OF EQUIPMENT

Table 2.2.2-(5)

Description	Unit	Wheel Loader 14t 2.3m^3 160HP	Truck Crane 28HP 31.5t 30t
Purchase price	$	109,000	244,000
Depreciation rate		0.9	0.9
Durable years	year	6	8
Annual depr. rate	per year	0.15	0.11
Annual charge rate	per year	0.07	0.07
Maintenance & repair rate		0.80	0.30
Annual maintenance & repair rate	per year	0.13	0.05
Annual operating hour	h	2,000	2,000
Hourly equipment cost	per hour	0.000117	0.000110
Total equipment cost	$/h	19.30	26.80
Fuel oil	$/h	19 ltr 5.50	10 ltr 2.90
Lubricating oil	$/h	0.3 ltr 0.60	0.3 ltr 0.60
Tire	$/h	0.005 set 2.80	
Wire rope	$/h		150m/200h 1.50
Total material cost		8.90	5.00
Foreman	$/h	0.2nos. 1.30	0.2nos. 1.30
Operator	$/h	1nos. 5.70	1nos. 5.70
Unskilled laborer	$/h	0.33nos. 1.20	1nos. 3.60
Total labor cost	$/h	8.20	10.60
Total Hourly Cost	$/h	36.00	42.00

(6) Unit Cost of Other Works

a) Rock excavation

	Ratio (%)	Unit cost ($/m^3)	Composite Unit Cost ($/m^3)
Common	6.9	2.11	0.146
Weathered rock	71.3	3.11	2.217
Hard rock	21.8	4.92	1.073
Total			$3.44/m^3

b) Backfill (weathered rock)

	Out put (m^3/h)	Unit price ($/h)	Composite Unit Cost ($/m^3)
Spreading	440	100.00	0.227
Compaction	1,000	74.00	0.07
Hauling			1.87
Loading			0.37
Total			$2.54/m^3

c) Re-bar fabrication

	($/ton)
Material	675.00
fabrication	67.00
Total	$742.00/ton

2.2.3 Other Works

(1) Barrier Dam

Barrier Dam Estimation

a) Quantities — Dam length = 10,130 m

a. Dredging — $V = 120x5x10,130=6,078,000m^3$

b. Clamshell dumped Embankment

$V = 2x1/2x20x20x10,130=4,052,000m^3$

c. Compaction — Compaction area = $1/2x(20+35)x10,130x4=1,114,300m^2$

d. Impervious grouting

$S=20x10,130=202,600m^2$

e. Drilling & Grouting

L = (dam height + 20) x dam length x 1.05/1.5 =
(20.0 + 20.0) x 10.13 x 1.05/1.5 = 283,640 = 284,000 m

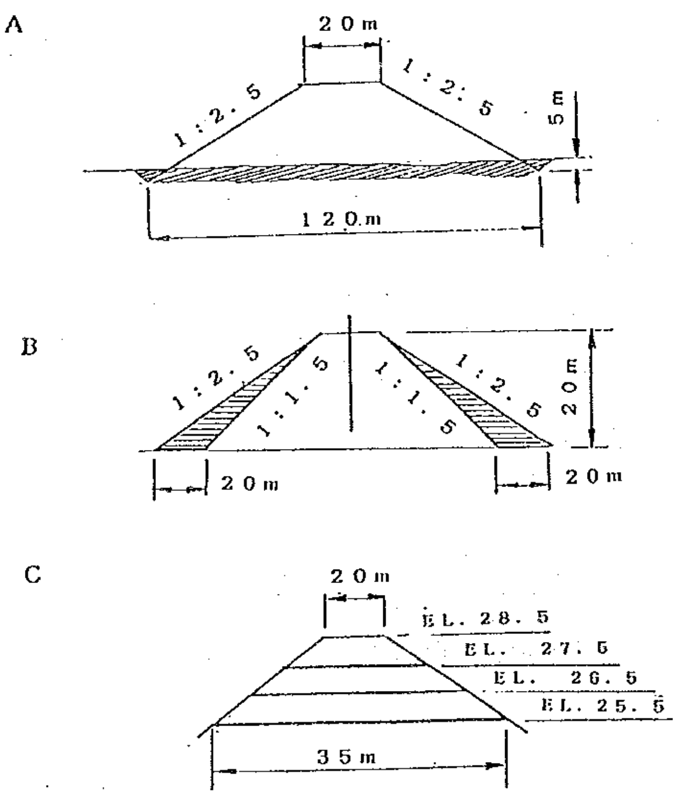


Fig. 2. 2. 3 (1)

b) Unit Cost

a. Dredging

Cutter suction type, direct discharge
$4.70 per m^3 (estimation from wet Excavation)

b. Additional Cost of Hauling Distance Adjustment

Hauling distance of land excavation (L = 3.5km)

Hauling distance = 3.5 + 2.3 = 5.8 km = 5,800 m

Hauling hour t1 = $\frac{0.12 \times 5,800}{24}$ = 29'

(loading hour 2.5', dumping hour 1.5')

Nos of Dump Truck = $\frac{29 + 1.5}{2.5}$ + 1 = 13.2 = 14 nos

Additional unit cost per hour (for weathered rock)

(14 - 9) x $247.00 / 1,194 = $1.03/$m^3$

c. Clamshell Dumped Embankment

Output of clamshell (7,450)=20m^3x30 times/hx0.9=540m^3/h
Equipment cost 420/570 x 439 = $323.47

Unit cost $323.47 / 540 = $0.60/$m^3$

d. Impervious Grouting

Unit cost $214.00/$m^2$

e. Compaction

Output of compactor 2,400 m/h *1 x 2 m / 5 = 960 m^2/h
Unit cost = $74.00 / 960 = $0.08 / m^2

f. Drilling & Grouting

$75.00/m *2 for percussion drill.

*1 Velocity of Compactor

*2

Drilling	75 m/m	$36.12/m
Cement Milk Mixing		6.55
Grouting	7 kg/cm^2	24.62
Material		
Cement	0.07 t/m	7.42
Miscellaneous	L.S.	0.29
Total Cost		$75.00/m

c) Estimation (per V = 10,700,000)

Description	Unit	Q'ty ($x10^6$)	Unit cost ($)	Amount (million dollars)
Dredging	m^3	6.1	4.70	28.67
Hauling	m^3	10.7	1.03	11.02
Dumped Embankment	m^3	4.05	0.60	2.43
Compaction	m^2	1.11	0.08	0.09
Spreading	m^3	10.70	0.11	1.177
Impervious gone	m^2	0.202	214.00	43.23
Drilling & Grouting	m	0.284	75.00	21.30
		Sub-total		$107.915
Others *1	$107,915,000 x 0.40			43.166
		Total		$151.08

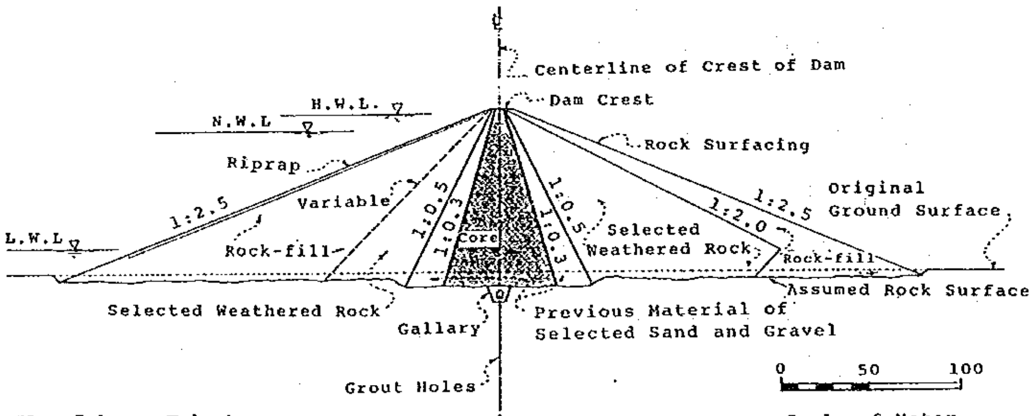
Unit cost (per m^3) = 151.08 / 10.7 = $14.12/$m^3$

*1 Diversion Tunnel, spillway and other works are included in others.

(2) New Dam

a) General Condition

a. Typical Section of Dam



b. Hauling Distance

Dam Site to disposal area = 3.5 km
Quarry site to disposal area = 3.5 km
Quarry site to dam site = 3.5 km

c. Item List

1.	Clearing and Grubbing	7.	Rock Embankment
2.	Spoiled Dump at Quarry	8.	Riprap Embankment
3.	Common Excavation	9.	Drilling & Grouting
4.	Rock Excavation	10.	Diversion Tunnel
5.	Core Embankment	11.	Spillway
6.	Filter Embankment	12.	Others

b) quantities

	Ciri	Trinidad (1)	Trinidad (2)
a. Clearing & Grubbing	$1.5x10^6m^3$	$2.5x10^6m^3$	$4.0x10^6m^3$
Quarry site	0.84	1.17	1.50
Dam site	0.08	0.17	0.24
Disposal area	0.28	0.39	0.50
Others	0.11	0.16	0.20
Total (million m^2)	1.31	1.89	2.44
b. Spoiled Dump at Quarry			
Average 0.5m x Quarry Area (million m^3)	0.35	0.59	0.75
c. Common Excavation			
Clearing & grubbing x 0.2 (million m^3)	0.26	0.38	0.49
d. Rock Excavation			
Common excavation x 0.25 (million m^3)	0.07	0.10	0.12

e. Respective Zone Embankment

Core zone	0.122
Filter zone	0.085
Rock zone	0.770
Riprap	0.023
Total zone	1,000

Zone (Ratio)		Ciri $1.5x10^6m^3$	Trinidad (1) $2.5x10^6m^3$	Trinidad (2) $4.0x10^6m^3$
Core	0.122	183,000	305,000	488,000
Filter	0.085	127,500	212,500	340,000
Rock	0.770	1,155,000	1,925,000	3,080,000
Rioprap	0.023	34,500	57,500	92,000
Total (m^3)		1,500,000	2,500,000	4,000,000

f. Drilling and Grouting

a. Ciri Dam (1.5 x 10^6m^3)
L = Dam volume x 1/100 = 15,000 m

b. Trinidad Dam (1) (2.5 x 10^6m^3)
L = (1/3xdam height+35)xDam lengthx1/1.5= 21,300 m

c. Trinidad Dam (2) (4.0 x 10^6m^3)
L = (1/3x dam height+35)xDam lengthx1/1.5= 26,400 m

c) Unit Cost

a. Clearing & Grubbing
Unit cost: $0.48/m^2$ (Assumed 2 times of Canal Excavation)

b. Spoiled Dump
Unit cost: $2.43/m^3$ (unit cost of common exc.x1.15)

c. Common Exc.: Aver. of common and weathered
(2.11 + 3.11) / 2 = $2.61
2.61 x 1.15 = $3.00/m^3$

d. Rock embankment

i. 5.39 *1 x 1.15 = $26.20/m^3$
6.20 x 0.792 *2 = $4.91/m^3$

ii. Compaction cost	$0.08/m^3$
Unit cost of Rock Embankment	$4.99/m^3$

e. Core Embankment

Rock embankment x 3 = 4.99 x 3 =	$14.97/m^3$

f. Filter Embankment

Rock embankment x 1.5 = 4.99 x 1.5 =	$7.485/m^3$

g. Riprap

Rock Embankment x 2.0 = 4.99 x 2 =	$9.98/m^3$

h. Drilling & Grouting

Unit cost =	$145.00/m *3

*1 Ref. Rock Excavation at Canal

*2 Load factor

*3 Unit Cost

Drilling	75 m/m	$72.24/m
Cement Milk Mixing		$6.55
Grouting	15 kg/cm^2	$49.24
Material		
Cement	0.15 t/m	$15.90
Miscellaneous	1 L.S.	$1.07
Total		$145.00/m

d) Cost Estimation

a. Ciri Dam ($1.5 \times 10^6 m^3$)

Depreciation	Unit	Q'ty ($x10^6$)	Unit cost ($)	Cost (million dollars)
Clearing & Grubbing	m^2	1.31	0.48	0.6288
Spoiled Dump	m^3	0.35	2.43	0.8505
Common Exc.	m^3	0.26	3.00	0.7800
Rock Exc.	m^3	0.07	5.85	0.4095
Core Embankment	m^3	0.183	14.99	2.7395
Filter Embankment	m^3	0.1275	7.485	0.9543
Rock Embankment	m^3	1.155	4.99	5.7635
Riprap	m^3	0.0345	9.98	0.3443
Drilling & Grouting	m	0.015	145.00	2.175
			Sub-Total	14.6454
Others *1	$14,645,400 x 0.50			7.3227
			Total	$21.9681

Unit cost (per m^3) = $21,968,100 / 1.5 = $14.65/$m^3$

*1 Diversion tunnel, spillway & other works are included in others

b. Trinidad (1) ($V = 2.5 \times 10^6 m^3$)

Depreciation	Unit	Q'ty ($\times 10^6$)	Unit cost ($)	Cost (million dollars)
Clearing & Grubbing	m^2	1.89	0.48	0.9072
Spoiled Dump	m^3	0.59	2.43	1.4337
Common Excavation	m^3	0.38	3.00	1.1400
Rock Excavation	m^3	0.10	5.85	0.585
Core Embankment	m^3	0.305	14.97	4.5659
Filter Embankment	m^3	0.2125	7.485	1.5906
Rock Embankment	m^3	1.925	4.99	9.6058
Riprap	m^3	0.0575	9.98	0.5739
Drilling & Grouting	m	0.0213	145.00	3.0885
			Sub-total	23.4904
Others	$23,490,400 x 0.45			10.5707
			Total	$34.0611
Unit Cost (per m^3)	$34,061,100 / 2.5			$13.62/$m^3$

c. Trinidad (2) ($V = 4.0 \times 10^6 m^3$)

Depreciation	Unit	Q'ty ($\times 10^6$)	Unit cost ($)	Cost (million dollars)
Clearing & Grubbing	m^2	1.50	0.48	0.72
Spoiled Dump	m^3	0.75	2.43	1.8225
Common Excavation	m^3	0.49	3.00	1.47
Rock Excavation	m^3	0.12	5.85	0.702
Core Embankment	m^3	0.488	14.97	7.3054
Filter Embankment	m^3	0.34	7.485	2.5449
Rock Embankment	m^3	3.08	4.99	15.3692
Riprap	m^3	0.092	9.98	0.9182
Drilling & Grouting	m^3	0.0264	145.00	3.828
			Sub-total	34.6801
Others	$34,680,100 x 0.40			13.8720
			Total	$48.5521
Unit cost (per m^3)	$48,551,100 / 4.0			$12.14/$m^3$

(3) Flood Control System

Excavation volume per linear meter is small. Then, excavated material will be disposed at near area.

Assume the hauling distance is ave. 500 m, Unit costs of Excavation are as follows:

Earth Common	$0.96/m^3$
Rock Weathered	$1.55/m^3$
Rock	$2.83/m^3$

Depth of excavation is comparatively shallow. Assume the proportion of each material as follows:

Earth Common	50%
Rock Weathered	45%
Rock	5%

Combined Unit Cost is:

$$0.96 \times 0.50 + 1.55 \times 0.45 + 2.83 \times 0.05 = \$1.32/m^3$$

(4) Partition Wall

TABLE2.2.2-(6)

Case	Work Items	Steel Pipe Pile	Steel Joint	Excavation	Concrete Fill	Mortar Fill	Coping Concrete	Total Unit Cost of Partition Wall million dollar/ per 1.0km
	Unit Cost	819.60($/t)	761.30($/t)	16.40($/m3)	42.35($/m3)	48.15($/m3)	271.77($/m3)	
S-2	Quantity per meter	14.5(t)	0.5(t)	23.5(m3)	23.5(m3)	0.4(m3)	15.0(m3)	
	Cost per meter ($)	11,884.20	380.65	385.40	995.23	19.26	4,076.55	17.74
S-4	Quantity per meter	17.6(t)	0.72(t)	28.4(m3)	28.4(m3)	0.47(m3)	15.0(m3)	
	Cost per meter ($)	14,424.96	548.14	465.76	1,202.74	22.63	4,076.55	20.74
S-6	Quantity per meter	20.7(t)	0.85(t)	33.5(m3)	33.5(m3)	0.55(m3)	15.0(m3)	
	Cost per meter ($)	16,965.72	647.11	549.40	1,418.73	26.48	4,076.55	23.68
S-8	Quantity per meter	14.5(t)	0.51(t)	23.5(m3)	23.5(m3)	0.4(m3)	15.0(m3)	
	Cost per meter ($)	11,884.20	388.26	385.40	995.23	19.26	4,076.55	17.75
S-10	Quantity per meter	17.6(t)	0.72(t)	28.4(m3)	28.4(m3)	0.47(m3)	15.0(m3)	
	Cost per meter ($)	14,424.96	548.14	465.76	1,202.74	22.63	4,076.55	20.74
S-12	Quantity per meter	20.7(t)	0.85(t)	33.5(m3)	33.5(m3)	0.55(m3)	15.0(m3)	
	Cost per meter ($)	16,965.72	647.11	549.40	1,418.73	26.48	4,076.55	23.68

2.2.4 Unit Price Applied

Data Sources:
- CAPAC
- AOKI Corp. Panama
- Office of Canal Improvements Culebra Cut Feasibility Study
- ESSO Japan
- Instituto de Recursos Hidraulicos Y Electrificacion (IRHE)

(1) Unit Wage Rate (U.S. dollars)
Present day 1990

	Hourly Rate $/Hr	Daily Rate $/Day	Monthly Rate $/Month
Engineer	9.80	78.10	2,031.10
General foreman	8.20	65.70	1,708.70
Foreman	6.70	53.30	1,386.30
Earth worker	3.60	29.10	728.50
Carpenter	3.90	31.00	775.00
Bar bender	3.90	31.00	775.00
Rigger	4.80	38.40	961.00
Plasterer	3.90	31.00	775.00
Mechanic	4.80	38.40	961.00
Operator (winch, engine)	3.90	31.00	775.00
Operator (heavy eq.)	5.70	45.90	1,147.00
Welder	4.10	32.90	821.50
Electrician	3.90	31.00	775.00
Plumber	3.90	31.00	775.00
Ductworker	5.50	44.00	1,100.50
Driver (heavy dump)	4.80	38.40	961.00
Driver (light vehicle)	3.90	31.00	775.00
Unskilled labor	3.60	29.10	728.50

Note: 1) Social charges and overtime payment are included.
2) Based on Panamanian Labor Rates

(2) Unit Price of Main Material (U.S. dollars)
Present day 1990

	Items	Unit	Price ($)
a)	Fuel and lubricating oil		
	Gasoline	litter	0.47
	Diesel gas oil	litter	0.29
	Kerosene	litter	0.35
	Lubricating oil	litter	1.84
	Gear oil	litter	1.94
	Asphalt	ton	43.00
	Heavy oil	litter	0.29
b)	Concrete material		
	cement (941bs sack)	ton	106.00
	Reinforcing bar	ton	675.00
	Steel fabrics	ton	725.00
	Gravel	m^3	9.20
	Sand	m^3	8.30
	Riprap	m^3	8.50
c)	Timber		
	Log (local)	m^3	185.00
	Square timber (imported)	m^3	185.00
d)	Dynamite	kg	6.20
	AN-FO	kg	1.50
	Detonator	nos	3.25
	Detonating cord	m	3.60

2.3 Construction Costs

2.3.1 Project Cost Summary

unit : million dollar

CASE	CONSTRUCTION COST	INDIRECT COST						TOTAL	REMARKS	
		ADMINIS. COST	HEADQUATERS COST	CONSTRUCTION SUPERVISION	LAND ACQ. & RIGHT COST	COMPENSATION	CONTINGENCY		ROUTE	RISE ft.
L-1 (100,000 DWT)	4,888.92	63.56	122.22	107.56	8.82	105.00	488.89	5,784.97	15	90
L-2 (100,000 DWT)	5,163.53	67.13	129.09	113.60	8.82	105.00	516.35	6,103.52	15	85
L-2' (100,000 DWT)	5,423.33	70.50	135.58	119.31	8.82	105.00	542.33	6,404.87	15	85
L-3 (100,000 DWT)	7,154.98	93.01	178.87	157.41	8.82	105.00	715.50	8,413.59	15	55
L-4 (150,000 DWT)	6,722.67	87.39	168.07	147.90	8.82	105.00	672.27	7,912.12	15	90
L-5 (150,000 DWT)	6,950.02	90.35	173.75	152.90	8.82	105.00	695.00	8,175.84	15	85
L-6 (150,000 DWT)	9,458.45	122.96	236.46	208.09	8.82	105.00	945.85	11,085.63	15	55
L-7 (250,000 DWT)	10,966.13	142.56	274.15	241.25	8.82	105.00	1,096.61	12,834.52	15	90
L-8 (250,000 DWT)	11,314.61	147.09	282.87	248.92	8.82	105.00	1,131.46	13,238.77	15	85
L-9 (250,000 DWT)	13,106.42	170.38	327.66	288.34	8.82	105.00	1,310.64	15,317.26	15	55
L-10 (100,000 DWT)	6,894.46	89.63	172.36	151.68	8.82	105.00	689.45	8,111.40	15+G	85
L-11 (100,000 DWT)	7,862.45	102.21	196.56	172.97	8.82	105.00	786.25	9,234.26	15+G	55
L-12 (100,000 DWT)	9,729.91	126.49	243.25	214.06	8.82	105.00	972.99	11,400.52	15+G	30
L-13 (150,000 DWT)	8,879.38	115.43	221.98	195.35	8.82	105.00	887.94	10,413.90	15+G	85
L-14 (150,000 DWT)	10,011.51	130.15	250.29	220.25	8.82	105.00	1,001.15	11,727.17	15+G	55
L-15 (150,000 DWT)	12,314.48	160.09	307.86	270.92	8.82	105.00	1,231.45	14,398.62	15+G	30
L-16 (250,000 DWT)	13,812.46	179.56	345.31	303.87	8.82	105.00	1,381.25	16,136.27	15+G	85
L-17 (250,000 DWT)	13,227.57	171.96	330.69	291.01	8.82	105.00	1,322.76	15,457.81	15+G	55
L-18 (250,000 DWT)	16,900.43	219.71	422.51	371.81	8.82	105.00	1,690.04	19,718.32	15+G	30
									ROUTE	LANE
S-1 (150,000 DWT)	5,760.12	74.88	144.00	126.72	101.22	21.00	576.01	6,803.95	10	1
S-2 (150,000 DWT)	9,940.70	129.23	248.52	218.70	101.22	21.00	994.07	11,653.44	10	2
S-3 (250,000 DWT)	6,284.59	81.70	157.11	138.26	101.22	21.00	628.46	7,412.34	10	1
S-4 (250,000 DWT)	11,256.09	146.33	281.40	247.63	101.22	21.00	1,125.61	13,179.28	10	2
S-5 (300,000 DWT)	7,182.14	93.37	179.55	158.01	101.22	21.00	718.21	8,453.50	10	1
S-6 (300,000 DWT)	13,204.95	171.66	330.12	290.51	101.22	21.00	1,320.49	15,439.95	10	2
S-7 (150,000 DWT)	13,789.07	179.26	344.73	303.36	8.82	105.00	1,378.91	16,109.15	14S	1
S-8 (150,000 DWT)	26,332.64	342.32	658.32	579.32	8.82	105.00	2,633.26	30,659.68	14S	2
S-9 (250,000 DWT)	17,804.58	231.46	445.11	391.70	8.82	105.00	1,780.46	20,767.13	14S	1
S-10 (250,000 DWT)	35,430.83	460.60	885.77	779.48	8.82	105.00	3,543.08	41,213.58	14S	2
S-11 (300,000 DWT)	19,680.44	255.85	492.01	432.97	8.82	105.00	1,968.04	22,943.13	14S	1
S-12 (300,000 DWT)	38,559.93	501.28	964.00	848.32	8.82	105.00	3,855.99	44,843.34	14S	2
S-13 (150,000 DWT)	7,663.42	99.62	191.59	168.60	101.22	21.00	766.34	9,011.79	10	1.5
S-14 (250,000 DWT)	8,709.78	113.23	217.74	191.62	101.22	21.00	870.98	10,225.57	10	1.5
S-15 (300,000 DWT)	9,882.44	128.47	247.06	217.41	101.22	21.00	988.24	11,585.84	10	1.5
S-16 (150,000 DWT)	21,156.88	275.04	528.92	465.45	8.82	105.00	2,115.69	24,655.80	14S	1.5
S-17 (250,000 DWT)	28,843.36	374.96	721.08	634.55	8.82	105.00	2,884.34	33,572.11	14S	1.5
S-18 (300,000 DWT)	31,363.71	407.73	784.09	690.00	8.82	105.00	3,136.37	36,495.72	14S	1.5
S.Q. (65,000 DWT)	4,405.36	57.27	110.13	96.92	0	105.00	440.54	5,215.22	15	1~2
	100.0%	1.3%	2.5%	2.2%			10.0%			

General Note:Project Costs of Lock Canal are studied in case of 35,000 Transits per year.(15,000 Transits at Existing Canal and 20,000 Transit at New Canal)

2.3.2 Construction Cost Summary

SUMMARY-1.WJ2

unit : million dollar

CASE	DIRECT CONSTRUCTION COST	GENERAL CONDITIONS	SUPPORTING CONDITIONS	TOTAL CONSTRUCTION COST	REMARKS	
					ROUTE	RISE ft.
L-1 (100,000 DWT)	4,053.83	608.08	227.01	4,888.92	15	90
L-2 (100,000 DWT)	4,281.53	642.23	239.77	5,163.53	15	85
L-2' (100,000 DWT)	4,496.96	674.54	251.83	5,423.33	15	85
L-3 (100,000 DWT)	5,932.82	889.92	332.24	7,154.98	15	55
L-4 (150,000 DWT)	5,574.35	836.15	312.16	6,722.67	15	90
L-5 (150,000 DWT)	5,762.87	864.43	322.72	6,950.02	15	85
L-6 (150,000 DWT)	7,842.83	1,176.42	439.20	9,458.45	15	55
L-7 (250,000 DWT)	9,092.98	1,363.95	509.21	10,966.13	15	90
L-8 (250,000 DWT)	9,381.93	1,407.29	525.39	11,314.61	15	85
L-9 (250,000 DWT)	10,867.68	1,630.15	608.59	13,106.42	15	55
L-10 (100,000 DWT)	5,716.80	857.52	320.14	6,894.46	15+G	85
L-11 (100,000 DWT)	6,519.45	977.92	365.09	7,862.45	15+G	55
L-12 (100,000 DWT)	8,067.92	1,210.19	451.80	9,729.91	15+G	30
L-13 (150,000 DWT)	7,362.67	1,104.40	412.31	8,879.38	15+G	85
L-14 (150,000 DWT)	8,301.42	1,245.21	464.88	10,011.51	15+G	55
L-15 (150,000 DWT)	10,211.01	1,531.65	571.82	12,314.48	15+G	30
L-16 (250,000 DWT)	11,453.11	1,717.97	641.37	13,812.46	15+G	85
L-17 (250,000 DWT)	10,968.13	1,645.22	614.22	13,227.57	15+G	55
L-18 (250,000 DWT)	14,013.62	2,102.04	784.76	16,900.43	15+G	30
					ROUTE	LANE
S-1 (150,000 DWT)	4,776.22	716.43	267.47	5,760.12	10	1
S-2 (150,000 DWT)	8,242.70	1,236.41	461.59	9,940.70	10	2
S-3 (250,000 DWT)	5,211.10	781.66	291.82	6,284.59	10	1
S-4 (250,000 DWT)	9,333.41	1,400.01	522.67	11,256.09	10	2
S-5 (300,000 DWT)	5,955.34	893.30	333.50	7,182.14	10	1
S-6 (300,000 DWT)	10,949.38	1,642.41	613.17	13,204.95	10	2
S-7 (150,000 DWT)	11,433.72	1,715.06	640.29	13,789.07	14S	1
S-8 (150,000 DWT)	21,834.69	3,275.20	1,222.74	26,332.64	14S	2
S-9 (250,000 DWT)	14,763.33	2,214.50	826.75	17,804.58	14S	1
S-10 (250,000 DWT)	29,378.80	4,406.82	1,645.21	35,430.83	14S	2
S-11 (300,000 DWT)	16,318.77	2,447.82	913.85	19,680.44	14S	1
S-12 (300,000 DWT)	31,973.40	4,796.01	1,790.51	38,559.93	14S	2
S-13 (150,000 DWT)	6,354.41	953.16	355.85	7,663.42	10	1.5
S-14 (250,000 DWT)	7,222.04	1,083.31	404.43	8,709.78	10	1.5
S-15 (300,000 DWT)	8,194.39	1,229.16	458.89	9,882.44	10	1.5
S-16 (150,000 DWT)	17,543.02	2,631.45	982.41	21,156.88	14S	1.5
S-17 (250,000 DWT)	23,916.55	3,587.48	1,339.33	28,843.36	14S	1.5
S-18 (300,000 DWT)	26,006.40	3,900.96	1,456.36	31,363.71	14S	1.5
S.Q. (65,000 DWT)	3,652.86	547.93	204.56	4,405.36	15	1~2

CASE L-1

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	AMOUNT	REMARKS
A.CANAL EXCAVATION	LS	1		2,609.92	SEE SUM-1.WJ2
B.LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		346.03	SEE SUM1-10.WJ2
ATLANTIC SIDE	LS	1		346.03	
SUBTOTAL				692.06	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		1,264.54	SEE SUM2-1.WJ2
F.NEW DAMS	LS	1		67.57	SEE SUM5-1.WJ2
G.PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	3	84.94	254.83	SEE SUM6.WJ2
TOTAL				4,888.92	

CASE L-2

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A.CANAL EXCAVATION	LS	1		2,892.38	SEE SUM-2.WJ2
B.LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		346.03	SEE SUM1-10.WJ2
ATLANTIC SIDE	LS	1		346.03	
SUBTOTAL				692.06	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		1,239.18	SEE SUM2-2.WJ2
F.NEW DAMS	LS	1		85.07	SEE SUM5-2.WJ2
G.PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	3	84.94	254.83	SEE SUM6.WJ2
TOTAL				5,163.53	

CASE L-2'

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		2,892.38	SEE SUM-2'.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		346.03	SEE SUM1-10'.WJ2
ATLANTIC SIDE	LS	1		346.03	
SUBTOTAL				692.06	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,159.21	SEE SUM2-2'.WJ2
F. NEW DAMS	LS	1		85.07	SEE SUM5-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	7	84.94	594.61	SEE SUM6.WJ2
TOTAL				5,423.33	

CASE L-3

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		4,828.78	SEE SUM-3.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		287.65	SEE SUM1-13.WJ2
ATLANTIC SIDE	LS	1		287.65	
SUBTOTAL				575.31	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,065.44	SEE SUM2-3.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	4	84.94	339.78	SEE SUM6.WJ2
TOTAL				7,154.98	

CASE L-4

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		3,686.81	SEE SUM-4.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		437.69	SEE SUM1-11.WJ2
ATLANTIC SIDE	LS	1		437.69	
SUBTOTAL				875.38	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,668.20	SEE SUM2-4.WJ2
F. NEW DAMS	LS	1		67.57	SEE SUM5-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	5	84.94	424.72	SEE SUM6.WJ2
TOTAL				6,722.67	

CASE L-5

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		4,035.38	SEE SUM-5.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		437.69	SEE SUM1-11.WJ2
ATLANTIC SIDE	LS	1		437.69	
SUBTOTAL				875.38	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,631.92	SEE SUM2-5.WJ2
F. NEW DAMS	LS	1		67.57	SEE SUM5-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	4	84.94	339.78	SEE SUM6.WJ2
TOTAL				6,950.02	

CASE L-6

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		6,552.22	SEE SUM-6.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		329.13	SEE SUM1-14.WJ2
ATLANTIC SIDE	LS	1		329.13	
SUBTOTAL				658.26	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,392.62	SEE SUM2-6.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	6	84.94	509.67	SEE SUM6.WJ2
TOTAL				9,458.45	

CASE L-7

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A.CANAL EXCAVATION	LS	1		6,536.00	SEE SUM-7.WJ2
B.LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		606.20	SEE SUM1-12.WJ2
ATLANTIC SIDE	LS	1		606.20	
SUBTOTAL				1,212.39	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		2,555.57	SEE SUM2-7.WJ2
F.NEW DAMS	LS	1		67.57	SEE SUM5-1.WJ2
G.PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	7	84.94	594.61	SEE SUM6.WJ2
TOTAL				10,966.13	

CASE L-8

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A.CANAL EXCAVATION	LS	1		7,011.27	SEE SUM-8.WJ2
B.LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		606.20	SEE SUM1-12.WJ2
ATLANTIC SIDE	LS	1		606.20	
SUBTOTAL				1,212.39	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		2,496.22	SEE SUM2-8.WJ2
F.NEW DAMS	LS	1		85.07	SEE SUM5-2.WJ2
G.PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	6	84.94	509.67	SEE SUM6.WJ2
TOTAL				11,314.61	

CASE L-9

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		9,223.32	SEE SUM-9.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		411.19	SEE SUM1-15.WJ2
ATLANTIC SIDE	LS	1		411.19	
SUBTOTAL				822.38	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,950.55	SEE SUM2-9
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	9	84.94	764.50	SEE SUM6.WJ2
TOTAL				13,106.42	

CASE L-10

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		4,623.32	SEE SUM-10.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		346.03	SEE SUM1-10.WJ2
ATLANTIC SIDE	LS	1		346.03	
SUBTOTAL				692.06	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,239.18	SEE SUM2-10.WJ2
F. NEW DAMS	LS	1		85.07	SEE SUM5-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	3	84.94	254.83	SEE SUM6.WJ2
TOTAL				6,894.46	

CASE L-11

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A.CANAL EXCAVATION	LS	1		5,536.25	SEE SUM-11.WJ2
B.LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		287.65	SEE SUM1-13.WJ2
ATLANTIC SIDE	LS	1		287.65	
SUBTOTAL				575.31	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		1,065.44	SEE SUM2-11.WJ2
D.BARRIER DAMS	LS	1		345.68	SEE SUM3-1.WJ2
G.PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	4	84.94	339.78	SEE SUM6.WJ2
TOTAL				7,862.45	

CASE L-12

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		7,718.96	SEE SUM-12.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		279.77	SEE SUM1-23.WJ2
ATLANTIC SIDE	LS	1		279.77	
SUBTOTAL				559.55	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		935.84	SEE SUM2-12.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	2	84.94	169.89	SEE SUM6.WJ2
TOTAL				9,729.91	

CASE L-13

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		5,964.73	SEE SUM-13.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		437.69	SEE SUM1-11.WJ2
ATLANTIC SIDE	LS	1		437.69	
SUBTOTAL				875.38	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,631.92	SEE SUM2-13.WJ2
F. NEW DAMS	LS	1		67.57	SEE SUM5-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	4	84.94	339.78	SEE SUM6.WJ2
TOTAL				8,879.38	

CASE L-14

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A.CANAL EXCAVATION	LS	1		7,105.28	SEE SUM-14.WJ2
B.LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		329.13	SEE SUM1-14.WJ2
ATLANTIC SIDE	LS	1		329.13	
/ SUBTOTAL				658.26	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		1,392.62	SEE SUM2-14.WJ2
D.BARRIER DAMS	LS	1		345.68	SEE SUM3-1.WJ2
G.PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	6	84.94	509.67	SEE SUM6.WJ2
/ TOTAL				10,011.51	

CASE L-15

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		9,875.01	SEE SUM-15.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		315.65	SEE SUM1-24.WJ2
ATLANTIC SIDE	LS	1		315.65	
SUBTOTAL				631.30	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,207.65	SEE SUM2-15.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	3	84.94	254.83	SEE SUM6.WJ2
TOTAL				12,314.48	

CASE L-16

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		9,509.12	SEE SUM-16.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		606.20	SEE SUM1-12.WJ2
ATLANTIC SIDE	LS	1		606.20	
SUBTOTAL				1,212.39	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		2,496.22	SEE SUM2-16.WJ2
F. NEW DAMS	LS	1		85.07	SEE SUM5-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	6	84.94	509.67	SEE SUM6.WJ2
TOTAL				13,812.46	

CASE L-17

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		9,344.46	SEE SUM-17.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		411.19	SEE SUM1-15.WJ2
ATLANTIC SIDE	LS	1		411.19	
SUBTOTAL				822.38	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,950.55	SEE SUM2-17.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-1.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	9	84.94	764.50	SEE SUM6.WJ2
TOTAL				13,227.57	

CASE I-18

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		13,768.36	SEE SUM-18.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		394.56	SEE SUM1-25.WJ2
ATLANTIC SIDE	LS	1		394.56	
SUBTOTAL				789.12	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,657.49	SEE SUM2-18.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-2.WJ2
G. PUMPING STATION					
PUMPING STATION & FACILITIES	LOT	4	84.94	339.78	SEE SUM6.WJ2
TOTAL				16,900.43	

CASE S-1

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		5,096.59	SEE SUM-19.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		107.89	SEE SUM1-16.WJ2
ATLANTIC SIDE	LS	1		107.89	
SUBTOTAL				215.77	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		207.69	SEE SUM2-19.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ22
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAK WATER					
NO. 1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO. 2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
TOTAL				5,760.12	

CASE S-2

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		8,647.27	SEE SUM-20.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		128.39	SEE SUM1-17.WJ2
ATLANTIC SIDE	LS	1		128.39	
/ SUBTOTAL				256.78	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		240.28	SEE SUM2-20.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAK WATER					
NO. 1 (PACIFIC SIDE)	LS	1		30.22	SEE SUM8.WJ2
NO. 2 (ATLANTIC SIDE)	LS	1		30.22	
/ SUBTOTAL				45.13	
I. PARTITION WALL	LS	1		556.30	SEE SUM7.WJ2
/ TOTAL				9,940.70	

CASE S-3

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		5,500.87	SEE SUM-21.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		127.07	SEE SUM1-18.WJ2
ATLANTIC SIDE	LS	1		127.07	
SUBTOTAL				254.15	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		289.50	SEE SUM2-21.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAK WATER					
NO.1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO.2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
TOTAL				6,284.59	

CASE S-4

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		9,728.73	SEE SUM-22.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		151.01	SEE SUM1-19.WJ2
ATLANTIC SIDE	LS	1		151.01	
/ SUBTOTAL				302.03	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		334.92	SEE SUM2-22.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAK WATER					
NO.1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO.2 (ATLANTIC SIDE)	LS	1		30.22	
/ SUBTOTAL				45.13	
I. PARTITION WALL	LS	1		650.35	SEE SUM7.WJ2
/ TOTAL				11,256.09	

CASE S-5

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		6,322.04	SEE SUM-23.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		146.14	SEE SUM1-20.WJ2
ATLANTIC SIDE	LS	1		146.14	
SUBTOTAL				292.28	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		327.74	SEE SUM2-23.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAK WATER					
NO.1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO.2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
TOTAL				7,182.14	

CASE S-6

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A.CANAL EXCAVATION	LS	1		11,494.77	SEE SUM-24.WJ2
B.TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		174.15	SEE SUM1-21.WJ2
ATLANTIC SIDE	LS	1		174.15	
SUBTOTAL				348.30	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		379.17	SEE SUM2-24.WJ2
D.BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E.FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H.BREAK WATER					
NO.1(PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO.2(ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
I.PARTITION WALL	LS	1		742.64	SEE SUM7.WJ2
TOTAL				13,204.95	

CASE S-7

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		13,019.93	SEE SUM-25.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		107.89	SEE SUM1-16.WJ2
ATLANTIC SIDE	LS	1		107.89	
SUBTOTAL				215.77	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		207.69	SEE SUM2-25.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
TOTAL				13,789.07	

CASE S-8

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A.CANAL EXCAVATION	LS	1		24,911.95	SEE SUM-26.WJ2
B.TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		128.39	SEE SUM1-17.WJ2
ATLANTIC SIDE	LS	1		128.39	
SUBTOTAL				256.78	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		240.28	SEE SUM2-26.WJ2
D.BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
I.PARTITION WALL	LS	1		577.94	SEE SUM7.WJ2
TOTAL				26,332.64	

CASE S-9

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A.CANAL EXCAVATION	LS	1		16,915.25	SEE SUM-27.WJ2
B.TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		127.07	SEE SUM1-18.WJ2
ATLANTIC SIDE	LS	1		127.07	
SUBTOTAL				254.15	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		289.50	SEE SUM2-27.WJ2
D.BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
TOTAL				17,804.58	

CASE S-10

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		33,772.84	SEE SUM-28.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		151.01	SEE SUM1-19.WJ2
ATLANTIC SIDE	LS	1		151.01	
SUBTOTAL				302.03	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		334.92	SEE SUM2-28.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
I. PARTITION WALL	LS	1		675.36	SEE SUM7.WJ2
TOTAL				35,430.83	

CASE S-11

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		18,714.73	SEE SUM-29.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		146.14	SEE SUM1-20.WJ2
ATLANTIC SIDE	LS	1		146.14	
SUBTOTAL				292.28	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		327.74	SEE SUM2-29.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
TOTAL				19,680.44	

CASE S-12

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		36,715.58	SEE SUM-30.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		174.15	SEE SUM1-21.WJ2
ATLANTIC SIDE	LS	1		174.15	
SUBTOTAL				348.30	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		379.17	SEE SUM2-30.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
I. PARTITION WALL	LS	1		771.20	SEE SUM7.WJ2
TOTAL				38,559.93	

CASE S-13

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		6,999.89	SEE SUM-31.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		107.89	SEE SUM1-16.WJ2
ATLANTIC SIDE	LS	1		107.89	
SUBTOTAL				215.77	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		207.69	SEE SUM2-31.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAK WATER					
NO.1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO.2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
TOTAL				7,663.42	

CASE S-14

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	million dollar AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		7,926.06	SEE SUM-32.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		127.07	SEE SUM1-18.WJ2
ATLANTIC SIDE	LS	1		127.07	
SUBTOTAL				254.15	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		289.50	SEE SUM2-32.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAK WATER					
NO.1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO.2 (ATLANTIC SIDE)	LS	1		30.22	
SUBTOTAL				45.13	
TOTAL				8,709.78	

CASE S-15

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		9,022.34	SEE SUM-33.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		146.14	SEE SUM1-20.WJ2
ATLANTIC SIDE	LS	1		146.14	
/ SUBTOTAL				292.28	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		327.74	SEE SUM2-33.WJ2
D. BARRIER DAMS	LS	1		182.21	SEE SUM3-4.WJ2
E. FLOOD CONTROL SYSTEM	LS	1		12.74	SEE SUM4.WJ2
H. BREAK WATER					
NO. 1 (PACIFIC SIDE)	LS	1		14.91	SEE SUM8.WJ2
NO. 2 (ATLANTIC SIDE)	LS	1		30.22	
/ SUBTOTAL				45.13	
/ TOTAL				9,882.44	

CASE S-16

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A.CANAL EXCAVATION	LS	1		20,387.74	SEE SUM-34.WJ2
B.TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		107.89	SEE SUM1-16.WJ2
ATLANTIC SIDE	LS	1		107.89	
SUBTOTAL				215.77	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		207.69	SEE SUM2-34.WJ2
D.BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
TOTAL				21,156.88	

CASE S-17

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A. CANAL EXCAVATION	LS	1		27,954.04	SEE SUM-35.WJ2
B. TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		127.07	SEE SUM1-18.WJ2
ATLANTIC SIDE	LS	1		127.07	
/ SUBTOTAL				254.15	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		289.50	SEE SUM2-35.WJ2
D. BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
/ TOTAL				28,843.36	

CASE S-18

DESCRIPTION	UNIT	QUANTITY	million dollar		REMARKS
			UNIT PRICE	AMOUNT	
A.CANAL EXCAVATION	LS	1		30,398.00	SEE SUM-36.WJ2
B.TIDAL GATE CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		146.14	SEE SUM1-20.WJ2
ATLANTIC SIDE	LS	1		146.14	
SUBTOTAL				292.28	
C.GATE LEAVES AND RELATED FACILITIES	LS	1		327.74	SEE SUM2-36.WJ2
D.BARRIER DAMS	LS	1		345.68	SEE SUM3-3.WJ2
TOTAL				31,363.71	

CASE 'STATUS QUO'

DESCRIPTION	UNIT	QUANTITY	million dollar UNIT PRICE	AMOUNT	REMARKS
A. CANAL EXCAVATION	LS	1		2,516.74	SEE SUM-37.WJ2
B. LOCK CONCRETE STRUCTURE					
PACIFIC SIDE	LS	1		168.02	SEE SUM1-22.WJ2
ATLANTIC SIDE	LS	1		168.02	
SUBTOTAL				336.05	
C. GATE LEAVES AND RELATED FACILITIES	LS	1		1,552.57	SEE SUM2-37.WJ2
TOTAL				4,405.36	

2.3.3 Breakdown of Canal Excavation

SUM-1.WJ2

QUANTITY : 1,000 m3
UNIT COST : dollar
AMOUNT : million dol.

(1) CASE L-1

a) EXCAVATION

DESCRIPTION		ZONE I	ZONE II	ZONE III	ZONE IV	ZONE V	TOTAL
EARTH, COMMON	QUANTITY	0	6,060	24,514	10,275	0	40,849
	UNIT PRICE		2.41	2.41	2.41		
	AMOUNT		14.61	59.08	24.76		98.45
ROCK, WEATHERED	QUANTITY	2,240	59,269	57,830	33,245	0	152,584
	UNIT PRICE	3.37	3.37	3.37	3.37		
	AMOUNT	7.55	199.74	194.89	112.04		514.21
ROCK	QUANTITY	0	16,670	42,993	63,445	0	123,108
	UNIT PRICE		4.89	4.89	4.89		
	AMOUNT		81.52	210.24	310.25		602.00
DREDGING,	QUANTITY	5,492	3,848	23	0	7,665	17,028
	UNIT PRICE	2.24	2.57	3.86		2.61	
LOOSE MATERIAL	AMOUNT	12.30	9.89	0.09		20.01	42.29
DREDGING, WEATHERED	QUANTITY	10,377	14,251	4,039	0	9,577	38,244
	UNIT PRICE	5.13	5.42	6.69		5.47	
SOFT ROCK	AMOUNT	53.23	77.24	27.02		52.39	209.88
ROCK UNDERWATER	QUANTITY	940	14,299	5,805	705	6,793	28,542
	UNIT PRICE	18.15	18.45	20.09	20.41	18.51	
	AMOUNT	17.06	263.82	116.62	14.39	125.74	537.63
DREDGING,	QUANTITY	5,532	0	0	0	10,260	15,792
	UNIT PRICE	2.24				2.61	
CLAYEY MATERIAL	AMOUNT	12.39				26.78	39.17
TOTAL	QUANTITY	24,581	114,397	135,204	107,670	34,295	416,147
	AMOUNT	102.54	646.80	607.93	461.43	224.91	2,043.62

b) HAUL ROAD CONSTRUCTION	29,000 m	652.00 $/m	18.91
c) CLEARING	12,900,000 m²	0.23 $/m²	2.97
d) VEGETATION	4,500,000 m²	0.70 $/m²	3.15
e) DEWATERING	ls		95.47
SUBTOTAL			2,164.11
SUPPORTING CONSTRUCTION			121.19
GENERAL CONDITIONS			324.62
TOTAL			2,609.92