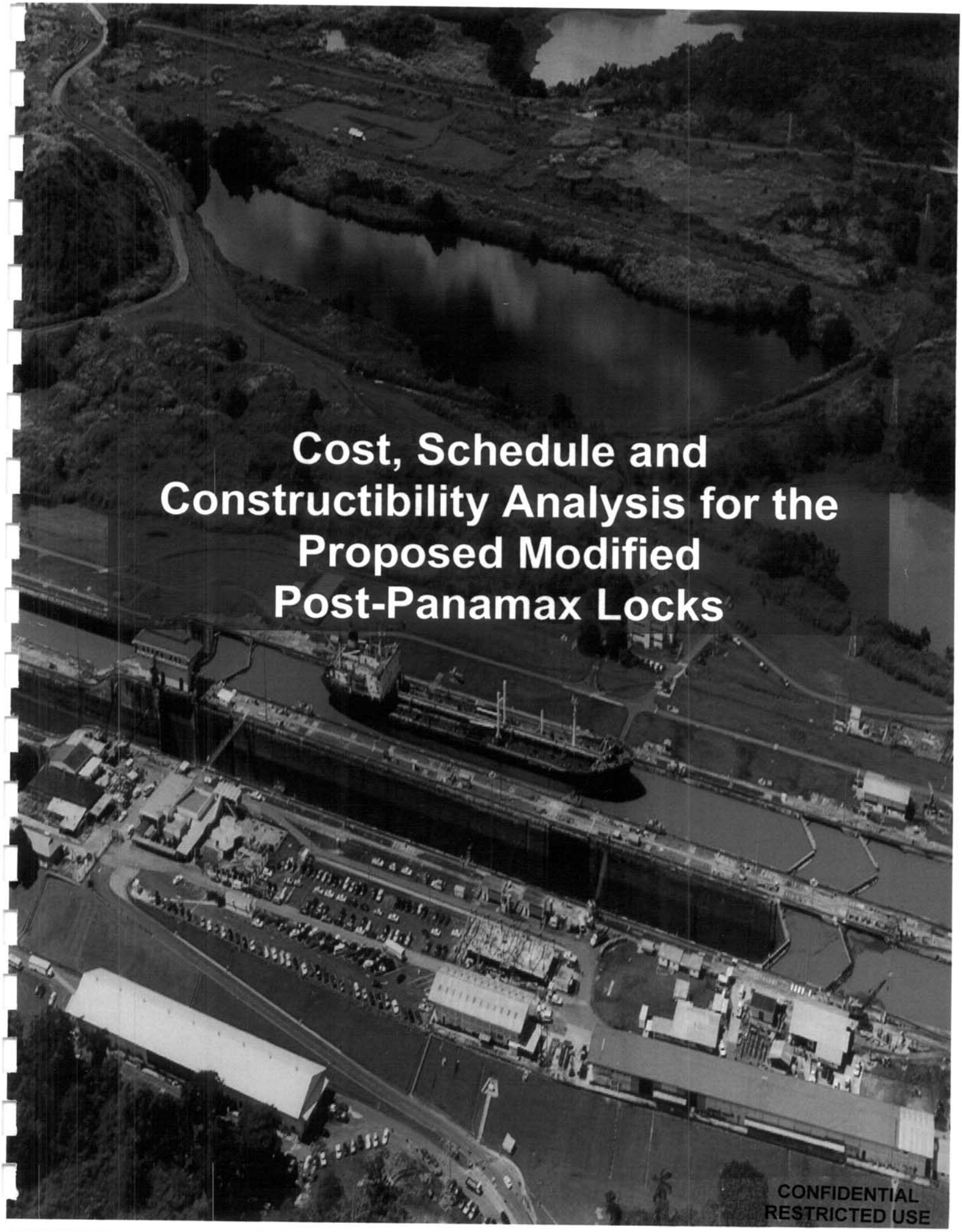
Cost, Schedule and Constructibility Analysis for the Proposed Modified Post-Panamax Locks

Costo, Establecimiento de horarios y Análisis de la constructibilidad de las Esclusas Pospanamax modificadas

Autoridad del Canal de Panamá

Agosto del 2004

Resumen Ejecutivo



Cost, Schedule and Constructibility Analysis for the Proposed Modified Post-Panamax Locks

CONFIDENTIAL
RESTRICTED USE

Executive Summary

1. Introduction

The ACP Locks Cost Estimating Team (Cost Team) was established with the purpose of studying the constructibility and determining the costs of the concept level designs for the proposed third lane Pacific and Atlantic locks. With the assistance of consultants Parsons Brinkerhoff and Montgomery Watson Harza (PB/MWH), the cost team established a cost breakdown structure, calculated the quantities based on the cost breakdown structure, evaluated the methods and equipment required for constructing the Atlantic and Pacific locks as well as the Pacific access channel, and established the schedule for completing the project within a reasonable timeframe. The results of this effort can be reviewed in the Concept Level Design Estimates Report dated March 31, 2004

The ACP continued to evaluate alternatives for the locks configuration based on the results of the market study and the water requirements. The cost team estimated several configurations varying the width, depth and length of the conceptual designs in order to assess the impact of the lock size on the cost.

The estimates shown in this report reflect the costs based on the modifications made to the conceptual design of the Pacific Locks for the proposed third lane locks. This should be kept in mind when evaluating costs for the lock. A comparison of the parameters used in the conceptual design and those used in the proposed design can be seen in Table E-1 below.

	Conceptual Design		Proposed Design	
Site	Pacific	Atlantic	Pacific	Atlantic
Approach Wall	Yes	Yes	No	No
Chamber Width	61m	61m	55m	55m
Chamber Length	427m	427m	427m	427m
Chamber Depth	18.3m	18.3m	16.8m	16.8m
Max. Lake Operating Level	26.7m	26.7m	26.7m	26.7m
Min. Lake Operating level	23.9m	23.9m	23.9m	23.9m
No. of Water Saving Basins	3	2	3	3
Water Consumption w/o WSB	2.57	2.57	2.31	2.31
Water Consumption w/ WSB	1.03	1.29	.93	.93
Ship Beam	55m	55m	45.6m	45.6m
Ship Length	385m	385m	335m	335m
Ship Draft	15.2m	15.2m	13m	13m

Table E-1. Conceptual vs. proposed design - locks

A preliminary design for the Pacific and Atlantic locks that takes into account all of the items identified as necessary for the construction of the project is required to obtain a more reliable estimate of the total project cost.

The report is divided into three sections. The first section, General, describes items that are common to both locks and access channels. The second section, the Pacific Site, describes the activities in the Work Breakdown Structure for the lock and access channel on the Pacific side. The third section, the Atlantic Site, provides similar information for the Atlantic-side lock.

While the intent of this report is to provide a realistic cost estimate and schedule for the construction of the proposed locks, this schedule could be shortened with the addition of equipment and labor or lengthened with a reduction of both.

The excavation equipment assumed for the estimate is large mining equipment, although smaller equipment could be used to complete the job within a similar timeframe. The major impact of using smaller equipment would be an increase in costs because of the added labor required to operate it, and an increase in the operating and maintenance costs due to the amount of equipment. The area to be excavated is large and should not present a problem if the contractor chooses to use smaller equipment.

The estimate assumes that the contractor would prepare and place the concrete. The contractor would have the option of acquiring concrete from local suppliers to meet his requirements. He could also subcontract the concrete supply to one or both of the existing local concrete suppliers.

It is assumed that all the equipment to be used for the job would be new and most of it would be depreciated within the life span of the job. However, the contractor could bring used equipment, which would simply reduce the depreciation cost of the equipment.

1.1 Pacific Site

To accommodate the facilities required for the contractor's offices, shops, warehouses, and other operating infrastructure on the Pacific side, the ACP would need to acquire 23.2 hectares of land in Cocoli, including 89 existing buildings that are presently under concession to ESPANAM Iberoamerica, S.A. Although the ACP may not need to pay the concessionaire for this land, this study assumes purchase of the land at the market value. The requirements for these facilities are independent of the change in lock size.

The estimate for the Pacific locks was based on a modification of the Three-Lift Concept Level Study with three water saving basins per lift designed by the Consorcio Post Panamax (CPP), as well as other items identified as necessary for the successful execution of the project, such as the diversion of the Cocoli River, the construction of cofferdams at Miraflores Lake and Cocoli River, reinforcement of the northwest saddle dam at the existing Pedro Miguel Locks, construction of a saddle dam southwest of Pedro Miguel Locks, relocation of utilities, overhead and fees, and contingencies.

Modifications to the CPP design include:

- Elimination of the upper and lower approach walls
- Reduction of the width of the lock chamber by 6m
- Reduction of the depth of the chamber by 1.5m
- Reduction of the height of the wall by .5m and width of the top slab by 2m

The elimination of the upper and lower approach walls and the reduction of .5m in the height and 2m in the width of the top slab result from the use of tugs instead of locomotives for the vessel positioning system. The use of tugs was deemed as a viable option for the vessel positioning system at the proposed new locks after holding several workshops to discuss the use of tugs over locomotives. The need for the approach walls is inherent in the locomotive vessel positioning system but not for tugs. With the elimination of locomotives, the top slab could be reduced in width since part of the width was envisioned to accommodate the locomotive tow and return tracks. The reduction in the height of the wall responds to the elimination of the bridges required at the gate recesses to permit the passage of the locomotives.

The reduction of 6m in the width of the lock chamber is based on the reduction in size of the design vessel. The reduction in width of the lock chamber affected the excavation volume, the size of the water saving basins, and the size of the lock gates and gate recesses.

The reduction of 1.5m in the depth of the chamber is also based on the reduction in the size of the design vessel. The items affected by this reduction are the

excavation volume, the size of the lock walls, and the size of the lock gates and recesses.

The relocation of the utilities and the sequence of activities remain the same as for the conceptual design estimating exercise. Refer to Appendix I.1 for a summary of the utilities relocation. The schedule for completion of the lock construction was not significantly impacted by these changes. The elimination of the approach wall reduced the volume of concrete to be placed, but since this activity was not on the critical path the schedule was not affected. The reduction in the volume of concrete for the chamber and recess walls was not sufficient to have a discernible effect on the schedule.

The parameters for the access channel were also changed to reflect the changes made to the concept level designs. Table E-2 below shows the major changes between the concept level design and the proposed design.

	Conceptual Design	Proposed Design
Site	Pacific	Pacific
Channel Width	220m	218m
Channel Bottom Elevation	7.16m	10.4m
Max. Lake Operating Level	26.7m	26.7m
Min. Lake Operating level	23.9m	23.9m
Ship Beam	55m	45.6m
Ship Length	385m	335m
Ship Draft	15.2m	13m

Table E-2. Conceptual vs. proposed design - access channel

The changes shown in the table above resulted in a reduction of the excavation volume for the access channel. There was also a change in the excavation volume for the lock and access channel due to changes in the position of the intermediate dike (between the lock and access channel).

In addition to the above-mentioned changes, the total cost of the project was also affected by changes in the work schedule, labor rates, overhead, and the calculation of the owner's costs. The work schedule was changed from 2 – 10 hr shifts per day six days a week to 3 – 8 hr shifts per day six days week. This change resulted in a reduction of labor costs brought about by a reduction in overtime pay, but caused a workforce increase due to the addition of one shift per day. However, the additional shift reduced the total execution time. The activity that was most affected by the reduction in time was the lock and access channel excavation.

The change in the calculation of the factors that were applied to the base labor rates resulted in an increase in the hourly wages of the laborers. There was also an adjustment made to the social burden factor applied to the local employees

who receive a monthly salary, which resulted in an increase in the cost. These adjustments were also made to the conceptual design estimate and therefore are not considered as an increase in the cost.

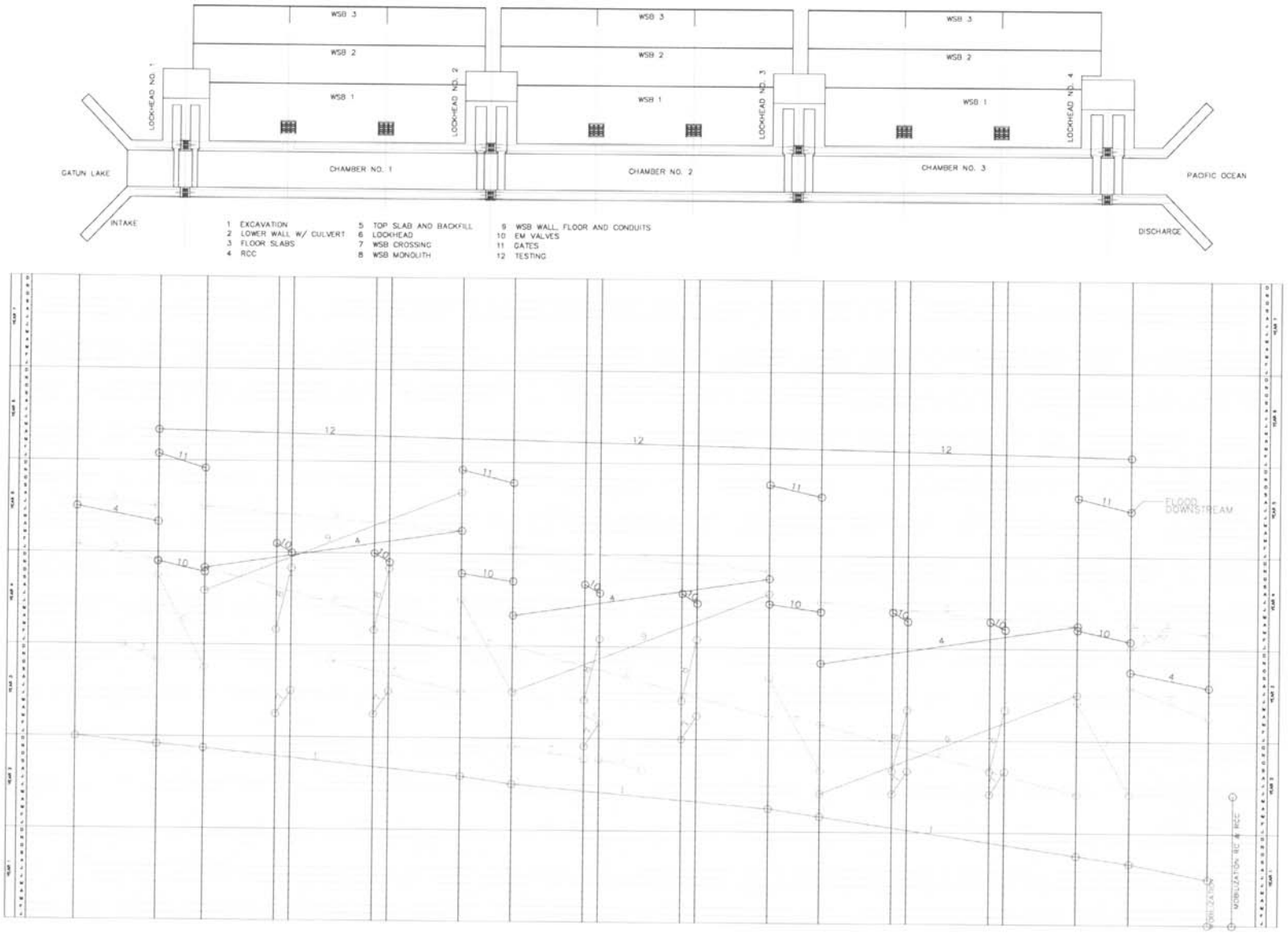
In the conceptual design estimate, the owner costs were calculated as a percentage of the total cost. This method resulted in an increase in owner costs if the project costs increased and decreased with a decrease in project cost. Since the owner costs are mostly fixed costs that do not vary greatly with changes in the total cost, the use of percentages for these calculations was not considered appropriate. The present estimate calculates owner costs based on estimated requirements and is considered a more reliable method for obtaining these costs. This method for calculating owner costs resulted in a substantial reduction in owner costs.

Table E-3 presents a summary of costs for the Pacific lock and access channel. Figure E1 presents the schedule for the Pacific lock with the sequence of activities that have the greatest effect on the cost and completion of the project.

DESCRIPTION		TOTAL ($ 000)
CIVIL WORK - LOCKS		711,400
MECHANICAL - ELECTRICAL - ARCHITECTURAL		239,573
TOTAL - LOCKS		**950,974**
CIVIL WORK - ACCESS CHANNEL		362,932
DREDGING WORK (SUBCONTRACTED)		-
TOTAL - ACCESS CHANNEL		**362,932**
TOTAL COST PACIFIC SIDE (EXCL CONTINGENCY)		**1,313,905**
CONTINGENCY ALLOWANCE		
CIVIL WORK - LOCKS	15%	106,710
MECH/ELECTR/ARCH	10%	23,957
TOTAL CONTINGENCY - LOCKS		**130,667**
CIVIL WORK - ACCESS CHANNEL	20%	72,586
DREDGING WORK	25%	-
TOTAL CONTINGENCY - ACC CHANNEL		**72,586**
TOTAL CONTINGENCY ALLOWANCE		**203,254**
TOTAL COST LOCKS (INCL CONT ALLOWANCE)		**1,081,641**
TOTAL COST ACC CHAN (INCL CONT ALLOW)		**435,518**
TOTAL COST (INCL CONTINGENCY ALLOWANCE)		**1,517,159**
OWNER's COST		
ADMINISTRATION	1.0%	9,769
ENGINEERING	1.0%	30,326
CONSTRUCTION MANAGEMENT	1.0%	25,851
RIGHT OF WAY	1	232
ENVIRONMENTAL MITIGATION	1	16,825
Total Owner's Cost - Locks	7.7%	**83,002**
ADMINISTRATION	1.0%	2,171
ENGINEERING	1.0%	6,518
CONSTRUCTION MANAGEMENT	1.0%	1,728
RIGHT OF WAY	1	-
ENVIRONMENTAL MITIGATION	1	6,025
Total Owner's Cost - Access Channel	3.8%	**16,442**
TOTAL OWNER's COST	6.6%	**99,444**
TOTAL PACIFIC LOCKS COST		**1,164,643**
TOTAL PACIFIC ACCESS CHANNEL COST		**451,960**
TOTAL PACIFIC SIDE PROJECT COST		**1,616,603**

Table E-3 Summary of Costs for Pacific Side

Figure E1. Pacific Locks Construction Schedule



1.2 Atlantic Site

The requirements for the facilities for the contractor's offices, shops, warehouses, and other operating infrastructure were not affected by the change in lock size or design.

The estimate for the Atlantic Locks was based on a modification of the Pacific Three-Lift Concept Level Study with three water saving basins per lift designed for the Pacific site by CPP, as well as items identified as necessary for the successful execution of this project, such as all costs associated with the transportation of aggregate from the Pacific to the Atlantic site. In evaluating the results of the cost estimate it must be clear that the estimate is based on a modification of a design for the Pacific site and must be validated with a conceptual or preliminary design for the Atlantic site.

Modifications to the CPP design include:

- Elimination of the upper and lower approach walls
- Reduction in the width of the lock chamber by 6m
- Reduction in the depth of the chamber by 1.5m
- Reduction in the height of the wall by .5m and in the width of the top slab by 2m
- The use of a modification to the design used for the area with La Boca formation at the Pacific site for the entire lock at the Atlantic site

The elimination of the upper and lower approach walls, 6m reduction in chamber width, 1.5m reduction in chamber depth and the modifications to account for the elimination of the locomotive as the vessel positioning system are similar to those described for the Pacific site. The decision was made to base the estimate on the CPP design with rolling gates for both lock sites. This permitted the evaluation of the difference in cost for the locks based on the site conditions. Since there was no design for the Atlantic site, the Pacific design was modified. The Gatun formation has properties that are similar to La Boca formation at the Pacific site and therefore the CPP design for this area was modified and applied to the Atlantic. The modification consisted of increasing the base of the lock walls to account for the increased seismic risk at the Atlantic site.

The gate sizes for the Atlantic are similar to those on the Pacific site, so the same gate sizes were assumed except for the lower level. The tidal variation on the Atlantic side is much smaller than at the Pacific and this permitted the use of the same gates at the middle and lower levels.

Table E-4 shows the estimated cost of the Atlantic site lock using the modified CPP design.

DESCRIPTION		TOTAL ($ 000)
CIVIL WORK - LOCKS		799,441
MECHANICAL - ELECTRICAL - ARCHITECTURAL		239,127
TOTAL - LOCKS		**1,038,568**
TOTAL COST ATLANTIC SIDE (EXCL CONTINGENCY)		**1,038,568**
CONTINGENCY ALLOWANCE		
CIVIL WORK - LOCKS	15%	119,916
MECH/ELECTR/ARCH	10%	23,913
TOTAL CONTINGENCY - LOCKS		**143,829**
TOTAL CONTINGENCY ALLOWANCE		**143,829**
TOTAL COST LOCKS (INCL CONT ALLOWANCE)		**1,182,397**
TOTAL COST (INCL CONTINGENCY ALLOWANCE)		**1,182,397**
OWNER's COST		
ADMINISTRATION	1.0%	9,769
ENGINEERING	1.0%	30,326
CONSTRUCTION MANAGEMENT	1.0%	25,851
RIGHT OF WAY	1.0%	21,024
ENVIRONMENTAL MITIGATION	1.0%	19,011
TOTAL OWNER's COST	9.0%	**105,980**
TOTAL ATLANTIC SIDE PROJECT COST		**1,288,377**

Table E-4. **Total Cost Atlantic Side**

Table E-5 summarizes the cost for the Atlantic lock, Pacific lock and the Pacific access channel.

Figures in thousands of dollars

	Pacific - Locks (3L + 3WSB)	Pacific Channel	Atlantic Locks (3L + 3WSB)
Direct Costs	950,974	362,932	1,038,568
Contingency	130,667	72,586	143,829
Owner Costs	83,002	16,442	105,980
Total	**$ 1,164,643**	**$ 451,960**	**$ 1,288,377**

Table E-5. **Summary**

Figure E2 shows the schedule for completion of the Atlantic lock.

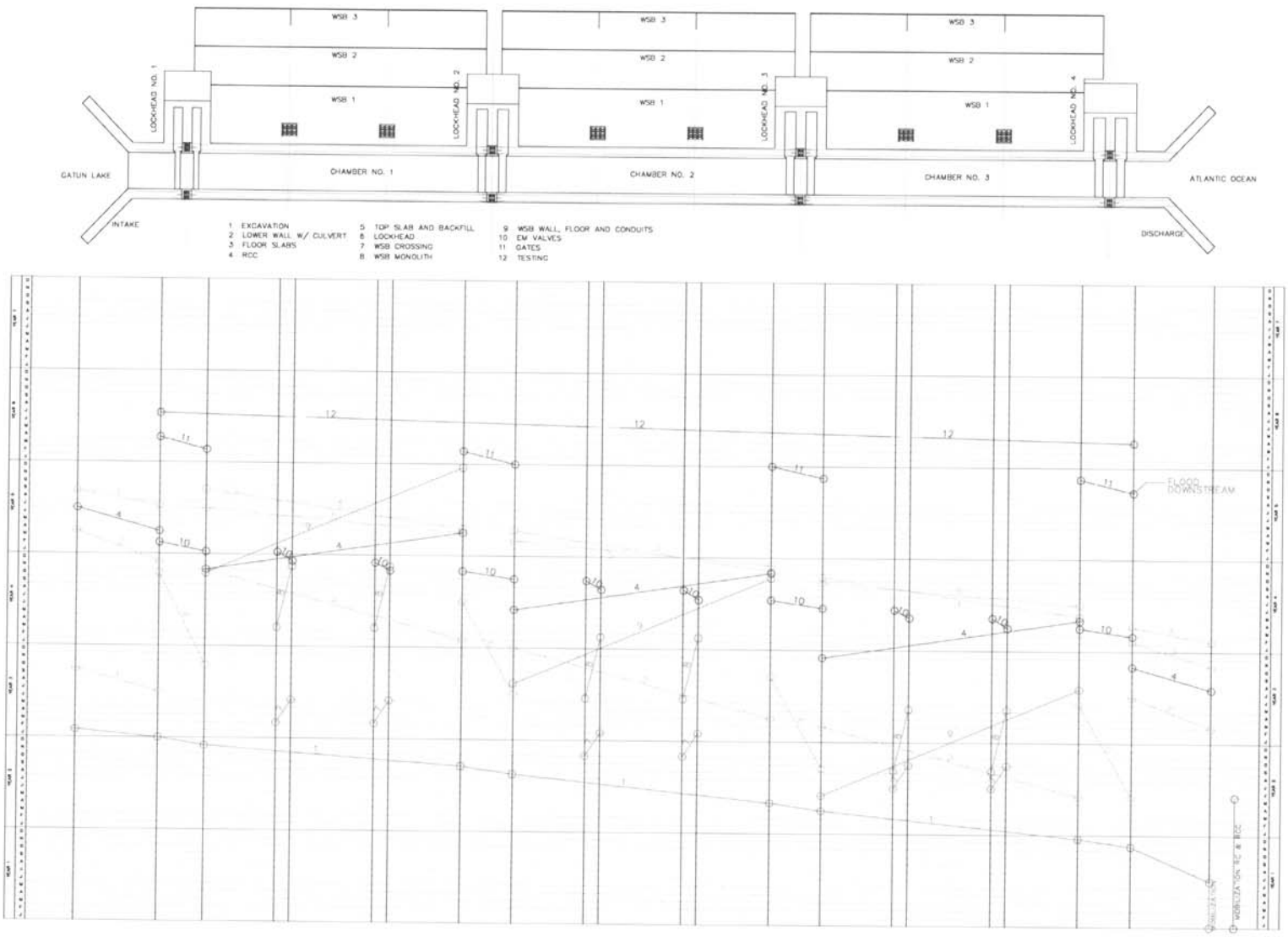



Figure E-2 Atlantic Locks Construction Schedule