# Technical Analysis of the Deepening of the Pacific Entrance to Drafts of 41.5', 46', and 50'



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# TECHNICAL ANALYSIS DEEPENING OF THE PACIFIC ENTRANCE TO DRAFTS OF 41.5', 46', AND 50'

## GENERAL DESCRIPTION OF THE STUDY

Among major components of the Panama Canal Expansion Study are the deepening and widening of the Canal navigational channels, which include the Atlantic Entrance, Gatun Lake, Gaillard Cut, and Pacific Entrance. The deepening of the Canal navigational channels will allow the navigation of ships larger than the current Panamax size.

This study covers the technical analysis for deepening the Pacific Entrance navigation channel under three options as shown in the following table:

**PACIFIC ENTRANCE NAVIGATIONAL CHANNEL DEEPENING SCENARIOS**

| Draft | New Design Channel Bottom (PLD) | Water Depth (MLWS) |
|---|---|---|
| 41.5' | -54.1' | -46.5' |
| 46' | -58.6' | -51' |
| 50' | -62.6' | -55' |

Notes:
1. Actual navigation channel bottom elevation: -52.1 ft PLD.

The deepening to a draft of 41.5' consists of dredging the Pacific Entrance navigational channels from the south end of Miraflores locks to station 85K+920, close to the whistle buoy. Please refer to Appendix No. 1 for a sketch of the Panama Canal Pacific Entrance. On the other hand, the dredging for the deepening to drafts of 46' and 50' start about 2.8 kms south of Miraflores locks, station 71K+200, near the new locks excavation of 1939, and continues down to station 85K+920.

The deepening for a draft of 41.5' was originally intended for the existing canal, provided the sills in some of the Canal lock chambers, such as the south end of the Pedro Miguel locks and the north end of Gatun locks are lowered to obtain at least 1.5 ft under-keel clearance (UKC), required to accommodate ships with a draft of 41.5 ft. At present the sills in canal locks chambers provide a minimum of 1.5' UKC for Panamax ships with 39.5' draft; therefore, to allow ships with an increased draft of 41.5', the locks chamber sills must be cut to restore the minimum UKC. Please refer to Appendix No. 2, which shows the sill elevations in Panama Canal locks.

As of today, according to the studies performed by the Department of Maritime Operations, it is not technically feasible to increase canal maximum allowable draft of 39.5' to 41.5'. Field visits of canal lock chamber shown that not only the sills should be lowered but whole chamber floor. Therefore massive civil works would be required. ACP is analyzing the possibility to raise Miraflores Lake to allow the transit of ships with 40.5' draft, that is, one foot of draft increase as opposed to 2 feet for 41.5' draft scenario.

The deepening to 41.5' draft is now intended to allow deeper draft Panamax ships to Panamanian ports: Balboa and Cristobal ports that were given in concession by the Panamanian government to Hutchinson Ports.

Unlike the deepening for a draft of 41.5', the deepening for drafts of 46' and 50' is part of the Panama Canal Expansion Study. If the new locks are built, the bottoms of the Canal navigational channels will require dredging to allow the safe navigation of post-Panamax vessels.

## PACIFIC ENTRANCE TIDAL VARIATIONS

a. The Pacific Entrance has a wide tidal range as shown in the Panama Canal Clearance Diagram in Appendix No. 2. The extreme high- water tide is at +11.8 ft (3.6 m) PLD, and the extreme low-water tide is at –11.3 ft (-3.44 m), resulting in a 23.11 ft (7.04 m) of tidal variation.

b. The Panama Canal Clearance Diagram shows the locks chambers, lake, and tidal elevations referenced to precise level datum (PLD), which is a reference line used by ACP to measure all Canal elevations. This PLD is close to Pacific and Atlantic mean sea level.

c. Because of the wide tidal variation in the Pacific Entrance, the reaches of ACP dredges and drilling and blasting boat are limited at certain tide levels; therefore, their availability is limited as shown in the following table:

**DAILY AVAILABILITY OF REACH OF ACP DREDGES AND DRILLING & BLASTING (D&B) BARGES DUE TO VARIATION IN PACIFIC ENTRANCE TIDE LEVEL, SHOWN IN PERCENTAGE**

| DREDGE/D&B BARGE | 41.5' DRAFT | 46' DRAFT | 50' DRAFT |
|---|---|---|---|
| Dipper dredge RMC | 70% | 40% | 13% |
| Cutter-suction dredge MINDI | 100% | 100% | 90% |
| D&B barge THOR | 100% | 84%[1] | 70% |
| New D&B barge | 100% | 100% | 100% |

Notes:

1. The reach limitation of the THOR, at 46' draft, is dictated by the spuds; otherwise, its availability is 95%.

d. As shown in the previous table, the RMC (CHRISTENSEN) would be unable to operate adequately in the Pacific entrance deepening for drafts of 46', and 50'. The MINDI would be able to dredge 90% of the time under the 50' draft deepening scenario, while the THOR would be restricted 16% and 30% of time when dredging for drafts of 46' and 50', respectively; however, the reach capabilities of the MINDI and THOR are not as limited as those of the CHRISTENSEN.

e. If the drilling and blasting operation were executed by phase, the reach capability of the THOR to drill and blast for a draft of 46' from a channel bottom of 41.5' draft would be reduced from the 84% shown in the above table to 55%. On a channel bottom of 46' draft, the THOR's drilling capacity to 50' draft bottom would be further reduced from 70% to approximately 25%.

f. At a channel bottom of 46' draft, a ship with a draft of 50' would be able to navigate 79% of the time because of tidal variation.

g. Appendix No. 3 shows 3 tables, one for each draft depth, showing the dredging and drilling and blasting reaches required to obtain the desired design channel bottom, as well as the actual reaches of ACP dredges and barges.

# DREDGING VOLUMES

## DREDGING PARAMETERS

a. The parameters used to estimate the dredging volumes in deepening the Pacific Entrance for drafts of 41.5', 46', and 50', respectively, were the following:

**PACIFIC ENTRANCE DEEPENING PARAMETERS (all figures in feet)**

| Draft | Existing Design Channel Bottom (PLD) | Proposed New Design Channel Bottom (PLD) | Dredging Tolerance Elevation (PLD) |
|---|---|---|---|
| 41.5' | -52.1 | -54.1 | -56.1 |
| 46' | -52.1 | -58.6 | -60.6 |
| 50' | -52.1 | -62.6 | -64.6 |

Notes:

1. All elevations are referenced to Panama Canal Precise Level Datum (PLD), which is close to mean sea level.

b. To obtain the new design channel bottom, the ACP dredges require a minimum of 2' of dredging tolerance as shown in the above table.

c. For the Pacific entrance, the dredging volume includes an over-swing of about 50' outside of each navigational channel prism line up to dredging tolerance elevation, according to a meeting held on November 20, 2002, with the masters-in-charge of ACP dredges.

d. The Pacific entrance navigational channels require an over-swing of 50', as opposed to the 25' required in Gatun Lake and the Atlantic entrance, because of the high sedimentation rate and the bank erosion caused by the high tide fluctuations in the Pacific sector.

e. Please refer to Appendix No. 4 for Pacific entrance deepening cross sectional view of the deepening at the three levels.

## DREDGING VOLUME ESTIMATES

a. ACP Geo-technical Branch and Survey Branch estimated the dredging volumes by using the civil engineering application software INROADS, and HYPACK, respectively. Both ACP Branches used the digital bathymetry updated between November 2000 and June 2002 to compute dredging volumes. Please refer to Appendix No. 17 for bathymetric chart.

b. There are reliable historical records of ACP dredging performance, which are based on volume rather than area. Consequently, estimates of the duration and cost of the proposed dredging works are based on volume rather than progress by area, which is the methodology used for drilling and blasting production estimates.

c. The following table shows a summary of dredging volumes required at the Pacific Entrance for drafts of 41.5', 46', and 50'. For more details, please refer to Appendix No. 5.

**DREDGING VOLUME IN $m^3$**

| VOLUME | 41.5' Draft | 46' Draft | 50' Draft |
|---|---|---|---|
| Dredging | 2,098,892 | 4,391,508 | 8,464,436 |
| Dredging Tolerance | 1,314,944 | 1,968,363 | 2,381,871 |
| TOTAL | 3,413,836 | 6,359,871 | 10,846,307 |

1. Dredging to 41.5' draft starts at the south end of Miraflores locks
2. Dredging to drafts of 46' and 50' starts near the 1939 construction of third set of locks.
3. Dredging volume includes an over-swing of 50' outside the navigation channel prism lines.

d. Dredging volumes by phase, that is, from 41.5' to 46' draft, and 46' to 50' draft are as follows:

**DREDGING VOLUME IN $m^3$**

| VOLUME | 39.5' to 41.5' Draft | 41.5' to 46' Draft | 46' to 50' Draft |
|---|---|---|---|
| Dredging | 2,098,892 | 1,870,933 | 2,104,565 |
| Dredging Tolerance | 1,314,944 | 1,968,363 | 2,381,871 |
| TOTAL | 3,413,836 | 3,839,296 | 4,486,436 |

1. Dredging to 41.5' draft starts at the south end of Miraflores locks
2. Dredging to drafts of 46' and 50' starts near the 1939 construction of third set of locks.
3. Dredging volume includes an over-swing of 50' outside the navigation channel prism lines.

e. The deepening to 41.5' starts at the south end of Miraflores locks, and ends at station No. 85K+920. Dredging for the levels of 46' and 50' draft starts at 2.8km south of the south end of Miraflores locks and finishes at station No. 85K+920.

f. The above dredging volume contemplates an over-swing of 50' outside the prism line of each navigational channel; a tactic that delays the drifting of side slopes material into the deepest section of the channel and accomplishes the desired design channel bottom.

g. Appendix No. 5 reflects the dredging volume by a set of stations. The Pacific Entrance navigational channels were divided in this set of stations according to the geologic data obtained from the seismic profiles performed in November 1999 by the Coastal and Inland Marine Services, a subsidiary of the renowned BOSKALIS dredging company.

# DREDGING TIME FRAME

## GENERAL PARAMETERS

a. ACP has two dredges for Canal navigation channel maintenance and capital dredging: the cutter suction dredge MINDI and the dipper dredge RIALTO M. CHRISTENSEN (RMC or CHRISTENSEN). Nevertheless, as previously shown, owing to the wide tidal variation at the Pacific entrance, it is not recommended that the CHRISTENSEN perform the deepening under the 3 draft depths under study. Therefore, it is assumed that the MINDI and a new cutter suction similar to the MINDI will execute the Pacific entrance deepening at drafts 41.5', 46', and 50'.

b. The Canal Capacity Projects Division and the Dredging Division highly recommend the acquisition of a new dredge to accomplish the navigational channel improvement as part of the Panama Canal Expansion Study. Otherwise, the deepening could be too lengthy, and may not be ready for Post-Panamax vessels after construction of the new locks. Because it is versatile in its maneuvering and easier to acquire than a dipper dredge, the cutter suction dredge is preferred, despite its limited capability to dredge the Gaillard Cut and other hard material areas.

c. Because the navigational channels are relatively a long distance from the designated disposal sites in the Pacific Entrance, and the MINDI's maximum capacity to discharge the dredging material is 3 kms, a booster pump must be acquired to assist the MINDI.

d. The booster pump will discharge the dredging material from the end of the MINDI discharge line to the designated disposal site for an additional distance of 3 kms, that is, the total minimum discharging capacity of the MINDI and the booster pump, in tandem, would be 6 kms.

e. The MINDI's historical performance and the opinion of its master-in-charge concerning dredge productivity in the Pacific entrance were used to estimate the time required to accomplish the new proposed deepening of this entrance.

f. It is assumed that the new cutter suction dredge will have a dredging productivity similar to that of the MINDI, but a minimum discharging distance capacity of 6 kms. If such a cutter suction is unavailable, it must be equipped with a booster pump. For more details on minimum equipment characteristics, please refer to the section, "Acquisition of New Dredging Equipment for Future Channels Improvements."

g. The average time frame to execute a dredging task takes into account one month of preventive maintenance each year for each ACP dredge, and six months of dry dock overhaul every 5 years for each dredge. It is assumed that Gatun Lake and Gaillard Cut channel maintenance will be done by the CHRISTENSEN, freeing the MINDI and the new dredge from having to conduct maintenance dredging.

h. The Pacific entrance deepening will delay the required maintenance dredging cycle.

i. The Gantt Chart estimate of the time frame to execute the 3 deepening options assumes that the 6-month overhaul will be done after the Gatun Lake and Gaillard Cut deepening to 27.5' PLD, and before the Pacific entrance deepening. However, the overall Panama Canal navigational channels deepening takes into account the 6 months for overhauling all ACP dredges as well as drilling and blasting boats every 5 years.

j. Average productivity of ACP dredges includes out-of-service time such as emergency repairs.

k. The current work schedule for ACP dredges' is 24 hours a day, 7 days a week, and will continue as required for future dredging work. Effective working is around 16 hours per day.

l. Appendix No. 6 contains a summary of the MINDI historical performance. Following is a summary of the MINDI:

**ACP CUTTER SUCTION DREDGE "MINDI" PRODUCTION IN THE PACIFIC ENTRANCE FROM SEP '90 TO SEP '98**

| Production | Bank cubic meter per hour | Bank cubic meter per day | Bank cubic meter per week |
|---|---|---|---|
| Least | 306 | 4,590 | 32,130 |
| Average | 834 | 12,510 | 87,570 |
| Greatest | 2,272 | 34,080 | 238,560 |

## DREDGING TIME FRAME ESTIMATE

a. Based on historical records, the MINDI has an individual average productivity of 87,600 $m^3$ per week in the Pacific entrance. However, the MINDI will be dredging deeper design channel bottoms than it has dredged previously. Therefore, a meeting was held on November 20, 2002, with the masters-in-charge of the MINDI and CHRISTENSEN, and it was agreed that 24,000 $m^3$ per week for medium to hard material, and 60,000 $m^3$ per week for soft material would be better deepening productivity rates in estimating the time frame for dredging the Pacific entrance for drafts of 41.5', 46', and 50'. These rates also take into account the use of a booster pump used in tandem with the MINDI.

b. As stated previously, the new cutter suction will have, at a minimum, the same productivity as the MINDI but at a greater discharging distance of 6 kms; if not the new cutter suction will be connected with a booster pump to obtain the required discharge distance.

c. The MINDI and the new dredge will operate concurrently in the Pacific entrance navigation channels as shown in the Gantt Chart, Appendix No. 7. Using the aforementioned productivity rates, the deepening to drafts of 41.5', 46', and 50' draft could take 2.5, 2.5, and 4.5 years, respectively. As any other project, this dredging program might change to conform to ACP needs.

d. The time frame required to complete the three proposed dredging in the Pacific entrance, assuming its existing channel bottom as initial condition, may be summarized as follows:

**TOTAL DURATION ESTIMATE FOR DREDGING OPERATION**

| DRAFT | Dredging volume ($m^3$) | Dreges Quantity | Dredges average productiviy ($m^3$/week) | | Total duration (years) |
|---|---|---|---|---|---|
| | | | Medium to hard material | Soft material | |
| 41.5 ft | 3,413,836 | 2 | 24,000 | 60,000 | 2.50 |
| 46 ft | 6,359,871 | 2 | 24,000 | 60,000 | 2.50 |
| 50 ft | 10,846,307 | 2 | 24,000 | 60,000 | 4.50 |

Notes:

1. Both dredges are cutter suction type.
2. It is assumed that the new dredge will be operating by July 2005.
3. Estimated total duration includes overhaul, preventive maintenance, emergency repairs, crew relief, and dredge mobilization.
4. The 41.5' draft deepening starts at the south end of Miraflores locks; the 46' and 50' draft deepening start near the 1939 excavation for the third set of locks.

e. For more details, please refer to Appendixes Nos. 7 and 8. The Gantt Chart in Appendix No. 7 shows the dredges preventive maintenance schedules as well as their dredging activity for each of the dredging options. Appendix No. 8 contains in detail the time frame calculation. As stated, it is assumed that the MINDI has undergone a thorough overhaul before executing the Pacific entrance deepening. Also, the MINDI and the new dredge will not perform any maintenance dredging in the Gatun Lake and Gaillard Cut, as this task will be assigned to the CHRISTENSEN.

# DREDGING COSTS

## GENERAL PARAMETERS

a. The MINDI operation costs for fiscal years 1995, 1996, 1997 and 1998 were reviewed and are shown in Appendix No. 9. Included are operation costs for availability, labor, overhead, and auxiliary equipment support. Dredging Division overhead was estimated at 12%.

b. The yearly cost indexes for channels and canals, developed and revised on September 30, 2002, by the US Corps of Engineers (USACE), were used to convert to 2002 dollars the ACP dredges operation average cost of fiscal years 1995, 1996, 1997, and 1998, and may be seen in Appendix No. 10. As shown in this appendix, the average inflation rate for fiscal years 1995 through 2002 is 1.023.

c. The dredges' availability, fuel cost, and auxiliary support costs were converted to 2002 dollars using a conversion factor of 1.023. This conversion factor was not applied to ACP dredges' labor costs because labor costs were estimated at the maximum step for each employee wage-category effective on January 3, 1999, and have not been increased since.

d. The dredges' availability costs were averaged, based on 270 days of operation a year, to account for maintenance, overhaul, and emergency repairs.

e. It is assumed that the costs of the new dredge are similar to those of the MINDI plus the cost of the additional 3 kms discharge pumping distance, if required. It is estimated that the new dredge unit cost includes its depreciation cost, but not the initial acquisition cost. Also, the new dredge will not require as much maintenance as the MINDI; therefore, its unit cost (new dredge) will reflect more depreciation than maintenance cost.

## ACP DREDGES OPERATION AND UNIT COSTS

a. The following table shows a summary of the MINDI and booster estimated hourly costs for a maximum discharge pumping distance of 3 kms and another additional discharging distance of 3 kms, respectively. For more calculation details please refer to Appendixes Nos. 9 and 11.

## ACP CUTTER SUCTION DREDGE MINDI COST AND BOOSTER PUMP ESTIMATED COST

| | MINDI | BOOSTER PUMP |
|---|---|---|
| **Discharge Pumping Distance** | **3 kms** | **3 kms** |
| Availability cost ($ per hour) | 781 | 60 |
| Labor cost ($ per hour) | 624 | 78 |
| Indirect Cost ($ per hour) | 75 | 9 |
| Fuel cost ($ per hour) | 233 | 59 |
| Support equipment cost ($ per hour) | 439 | |
| **TOTAL COST ($ per hour)** | **2,153** | **206** |
| **TOTAL COST ($ per week)** | **351,866** | **32,197** |

b. For an average productivity of 24,000 and 60,000 m$^3$ per week for hard-to-medium and soft material, respectively, dredging unit costs are as follows:

**DREDGING UNIT COST**

| DREDGE | Cost per week ($) | Estimated production per week (m$^3$) | | Unit cost ($/m$^3$) | |
|---|---|---|---|---|---|
| | | Medium to hard material | Soft material | Medium to hard material | Soft material |
| **MINDI** | 351,866 | 24,000 | 60,000 | **14.66** | **5.86** |
| **BOOSTER PUMP** | 32,197 | 24,000 | 60,000 | **1.34** | **0.54** |
| **NEW DREDGE** | 351,866 | 24,000 | 60,000 | **14.66** | **5.86** |

Notes:

c. The above unit costs only reflect the dredges operational costs but not the cost of the initial investment for the new dredge and new booster pump. As stated, the MINDI unit cost reflects a high percentage for maintenance, but for the new dredge, the high cost will be that of its depreciation.

## TOTAL DREDGING COST FOR DRAFTS OF 41.5', 46', and 50'

a. Using the aforementioned unit cost, the dredging cost per set of stations is shown in Appendix No. 8, and the total cost for each of the 3 levels of dredging is as follows:

**PACIFIC ENTRANCE TOTAL DREDGING COST FOR EACH OF THE 3 LEVELS OF DREDGING**

| DRAFT | Dredging volume ($m^3$) | Unit cost including the dredge and booster pump ($/$m^3$) | | | | Total Dredging Cost ($) |
|---|---|---|---|---|---|---|
| | | Medium to hard material | | Soft material | | |
| | | Dredge | Booster | Dredge | Booster | |
| 41.5 feet | 3,413,836 | 14.66 | 1.34 | 5.86 | 0.54 | 47,698,111 |
| 46 feet | 6,359,871 | 14.66 | 1.34 | 5.86 | 0.54 | 85,141,776 |
| 50 feet | 10,846,307 | 14.66 | 1.34 | 6.40 | 0.54 | 141,532,899 |

Notes:

1. The total costs reflect the dredging operation, including the booster pump--if required.
2. The initial investment cost to acquire a new dredge, booster pump, and support equipment is not included.
3. The deepening for 41.5' draft starts at the south end of Miraflores locks, and the deepening for drafts of 46' and 51' start near the 1939 excavation for the third locks.

b. Dredging cost in phases is shown as follows:

**PACIFIC ENTRANCE TOTAL DREDGING COST IN PHASES FOR EACH OF THE 3 LEVELS OF DREDGING**

| DRAFT | Dredging volume ($m^3$) | Unit cost including the dredge and booster pump ($/$m^3$) | | | | Total Dredging Cost ($) |
|---|---|---|---|---|---|---|
| | | Medium to hard material | | Soft material | | |
| | | Dredge | Booster | Dredge | Booster | |
| 39.5 to 41.5 feet | 3,413,836 | 14.66 | 1.34 | 5.86 | 0.54 | 47,698,111 |
| 41.5 to 46 feet | 3,839,296 | 14.66 | 1.34 | 5.86 | 0.54 | 50,538,871 |
| 46 to 50 feet | 4,486,436 | 14.66 | 1.34 | 5.86 | 0.54 | 55,433,061 |

Notes:

1. The total costs reflect the dredging operation, including the booster pump--if required.
2. The initial investment cost to acquire a new dredge, booster pump, and support equipment is not included.
3. The deepening for 41.5' draft starts at the south end of Miraflores locks, and the deepening for drafts of 46' and 51' start near the 1939 excavation for the third locks.

## DRILLING & BLASTING (D&B) AREA AND VOLUME ESTIMATES

a. To estimate the D&B required to prepare the channel bottom material for effective dredging, the methodology used is "progress by area" (square meters) rather than "volume" (cubic meters).

b. The progress by area methodology was used because in November 2001 a time test was made for drilling at different borehole depths on the ACP D&B barge THOR; the test produced data for time by area. These time measurements were used to determine THOR's productivity and are shown in Appendix No. 12.

c. The Pacific entrance navigation channel area was estimated using the computer-aided design application program AUTOCAD.

d. For a draft of 41.5', D&B operation starts from the south end of Miraflores locks and ends at station 85K+920. Whereas for drafts of 46' and 50', the D&B operation starts at station 71K+200 and ends at station 85K+920.

e. Because of geologic conditions, certain areas of the Pacific entrance navigation channel require less D&B than others. Based on geologic records obtained from the geophysical investigation or seismic profiles performed by COASTAL AND INLAND MARINE SERVICES in November 1999, it is estimated that about 60% of the navigation channel in the Pacific entrance require D&B.

f. The Coastal and Inland Marine Services, which is a subsidiary of the renowned BOSKALIS dredging company, executed five seismic profiles from buoy 21 to the Pacific entrance whistle buoy: one at the navigational channel centerline, one at each prism line (two), and one on each lane halfway between the centerline and each prism line (two). The total length is 67.5 km (5 profiles x 13.5 km). These profiles indicate the top level of soft material, top level of weather rock, and top level of sound rock. Appendix No. 13 contains a percentage estimate of hard material found in the Pacific entrance navigational channel according to this geophysical investigation, and the report submitted by the Coastal and Inland Marine Services on the Pacific entrance seismic profiles.

g. Following is a table showing the D&B percentage for each of the three levels of dredging.

**PACIFIC ENTRANCE NAVIGATION CHANNEL DRILLING AND BLASTING REQUIRED AREAS IN m2**

| DRAFT | Total Area | Estimated percentage of areas that require D&B according to the seismic profiles test | Net areas that require D&B |
|---|---|---|---|
| 41.5 ft | 4,252,661 | 61% | 2,597,273 |
| 46 ft | 3,740,711 | 56% | 2,085,323 |
| 50 ft | 3,740,711 | 57% | 2,133,824 |

1. The D&B for a draft of 41.5' starts at the south end of Miraflores locks.
2. The D&B for drafts of 46' and 50' starts near 1939 excavation for the third locks.
combined

# D&B TIME FRAME ESTIMATES

## GENERAL PARAMETERS TO MEASURE THE PRODUCTIVITY OF THE THOR AND THE NEW DRILLBOAT

a. It is assumed that ACP D&B barge THOR and a new drill-boat would perform the blasting of Pacific entrance navigational channel bottoms for the proposed deepening to 41.5', 46', and 50' PLD. ACP is planning to acquire by August 2004 a new drill-boat with 4 towers, similar to the THOR.

b. To obtain a design channel bottom for the 3 levels of deepening, D&B will be required at 8' below the new design channel bottom or 6' below the over-dredge elevations as follows. Please refer to Appendix No. 4 for a schematic.

**PACIFIC ENTRANCE DEEPENING PARAMETERS (all figures in feet)**

| Draft | Existing Design Channel Bottom (PLD) | Proposed New Design Channel Bottom (PLD) | Dredging Tolerance Elevation (PLD) | D&B Elevation (PLD) |
|---|---|---|---|---|
| 41.5 | -52.1 | -54.1 | -56.1 | -62.1 |
| 46 | -52.1 | -58.6 | -60.6 | -66.6 |
| 50 | -52.1 | -62.6 | -64.6 | -70.6 |

Notes:
1. All elevations are referenced to Panama Canal Precise Level Datum (PLD)

c. In 2002, the THOR received hydraulic system improvements that could increase its productivity to a minimum of 13%, as estimated by the ACP Mechanical Branch (IPIM). This 13% productivity increase has been included in the THOR productivity estimate.

d. The THOR and the new barge will perform the deepening on a round-the-clock schedule, 7 days a week, unlike the previous schedule of the THOR for the Gaillard Cut Widening Project of 16 hours a day, 5 days a week.

e. The average time frame to execute the drilling and blasting takes into account preventive maintenance, crew relief, and emergency repairs. Therefore the THOR and new barge effective working time per day would be 18 hours.

f. An average pattern of 100' x 52' was used to estimate the productivity of the THOR and of the new drill barge. Each pattern would have 12.5' of spacing and 13' of burden, resulting in 4 lines of 8 boreholes each, for a total of 32 boreholes. Each borehole has a 6.5" diameter. The pattern size might change to fulfill dredging operation needs and according to the type of material found in the channel bottom. For instance, the pattern spacing and burden should be smaller for hard material.

g. Time measurements taken on board the THOR in November 2001 were used as the baseline to estimate THOR productivity, with the projected 13% efficiency increase included. Appendix No. 12 shows the measurement taken for each D&B activity.

h. ACP has recorded the historical performances of the TAMROCK drill towers on land as shown in Appendix No. 8, which can be used to estimate the new drill-boat performance with drills similar to those of the TAMROCK; however, it is estimated that the new drill-boat could achieve at least 25% productivity increase over the THOR because drilling underwater is quite different from drilling on land. The mobilization and blasting time were assumed to be the same for both barges (THOR and new drill-boat).

i. The THOR productivity estimate includes the use of cartridge explosives; some experts say that the use of bulk explosives could boost D&B efficiency. However, data on bulk explosive use is not available and therefore was not considered in the estimate. The estimated blasting time is based on cartridge explosive information, despite the fact that the new barge could possibly use bulk explosives for blasting.

*j.* *Blasting Analysis International* (BAI) evaluated the cartridge and proposed bulk explosive systems for the submarine blasting in May 2002. According to BAI, ACP should test and prove the proposed bulk system in the submarine environment before acquiring it, and re-evaluate the borehole loading procedures, reliability and safety for both cartridge and bulk systems. A copy of this report is included in Appendix No. 14.

k. Appendix No. 8 shows in detail the calculations used to estimate THOR and the new drill-boat activity. Following is a table that summarizes the productivity of the THOR and the new 4-tower drill-boat:

**THOR AND NEW DRILLBOAT DRILLING & BLASTING ESTIMATED PERFORMANCE FOR A PATTERN OF 100' x 52'**

| | 41.5' Draft | | 46' Draft | | 50' Draft | |
|---|---|---|---|---|---|---|
| | THOR | NEW BARGE | THOR | NEW BARGE | THOR | NEW BARGE |
| Total estimated time to complete one pattern (hours) | 7.64 | 5.11 | 9.53 | 5.56 | 11.21 | 5.96 |
| Number of patterns per week | **16** | **20** | **13** | **16** | **11** | **14** |
| Progress by area ($m^2$ per week) | 7,732 | 9,665 | 6,283 | 7,732 | 5,316 | 6,766 |
| D&B volume ($m^3$ per week) | 23,576 | 29,470 | 27,776 | 34,185 | 29,986 | 38,164 |

Notes:

1. THOR (number of patterns per week) = Effective working time per week / time required to perform a pattern
2. New drill-boat = 1.25 x THOR productivity

## D&B TIME FRAME ESTIMATE

a. Based on an average theoretical productivity for drafts of 41.5', 46', and 50' shown in the previous table with patterns measuring 100' x 52' per week, the D&B may be accomplished in a maximum of 4 years, as shown in Appendixes No. 7 (Gantt Chart), and No. 8.

b. The following table summarizes the duration of D&B for each of the three dredging levels:

**PACIFIC ENTRANCE DRILLING AND BLASTING ESTIMATED TIME FRAME**

| DRAFT (ft) | Net areas that will require D&B ($m^2$) | Drillboats quantity | D&B average productivity ($m^2$ per week) | D&B total duration (years) |
|---|---|---|---|---|
| **41.5** | **2,597,273** | **2** | 8,699 | **3.20** |
| **46** | **2,085,323** | **2** | 7,008 | **3.25** |
| **50** | **2,133,824** | **2** | 6,041 | **4.00** |

Notes:

1. D&B for a draft of 41.5' starts at the south end of Miraflores locks.
2. D&B for drafts of 46' and 50' starts near the 1939 excavation for the third locks.
3. D&B estimated time frame includes 1 month of annual preventive maintenance, 6-month overhaul every 5 years, emergency repair, crew relief, and equipment mobilization.

## UNCERTAIN DRILLING AND BLASTING FACTORS

The above THOR and new drill-boat productivity estimates are subject to several variables or factors that could affect their performance to greater or lesser degrees:

a. The exact productivity of the new drill-boat is uncertain; however, the specifications for the acquisition of a new drill-boat state that technical requirements such as pull-down, drilling rate, torque, automatic bit changer, automatic bar changer, etc. shall be higher than those of the THOR. Consequently, the new drill-boat should have a higher drilling production than the THOR. It is assumed that the new drill-boat could have at least a 25% productivity increase over the THOR.

b. The THOR has never operated in the 24-hour mode, i.e. 3-watch / 7-day. Therefore, no historical records are available to confirm the THOR estimated productivity under such a schedule.

c. Drilling and blasting data information is available only for Gaillard Cut widening projects; there are no available data for the deepening.

d. Geologic information and hard material percentage estimates of Pacific entrance navigation channel were based on the seismic profiles performed by COASTAL AND INLAND MARINE SERVICES. The THOR and new drill-boat performances are expected to vary according to the type of material found.

e. Canal vessel traffic is the greatest interruption or impediment to obtaining an effective D&B performance. Very precise coordination with ACP Marine Traffic Control Branch is required to efficiently carry out the navigational channel D&B for the channel deepening. The traffic of vessels through the Canal has precedence over all dredging and D&B operations.

f. The drill barges will require an average of 10 hours to complete and blast one pattern. However, the only time permitted for detonation or blasting is between 06:00 to 18:00 hrs **and** when transiting ships are at a minimum 500 m distance from the blasting area. This distance will be increased to 610 m for ships carrying dangerous cargo.

# DRILLING & BLASTING COST ESTIMATES

## COST ESTIMATES FOR D&B FOR DRAFTS OF 41.5', 46', AND 50' DRAFT

a. D&B historical cost records were used to estimate the future D&B operation costs.

b. The D&B barge THOR had an average cost of $1,087,195 per month in the year 2001 when executing the Gaillard Cut Widening Program (to 630'). The weekly cost was $251,084.33, which included the cost for explosives.

c. It is assumed that the new D&B barge average operational cost is estimated at the same rate as that of the THOR, $251,084.33 a week because the new barge will have 4 towers, the same as the THOR.

d. Appendix No. 15 details the costs for the crew and operation of the THOR.

e. Appendix No. 8 shows the cost of D&B by station for each deepening option. The D&B total cost does not reflect the initial investment to acquire a new drill boat.

f. The following table summarizes the cost of each level of the Pacific entrance deepening assuming initial condition of 39.5' draft:

**PACIFIC ENTRANCE NAVIGATION CHANNEL DRILLING & BLASTING COST ESTIMATE**

| DRAFT (ft) | Net areas that require D&B ($m^2$) | Time frame estimate (years) | Cost ($/week) | Total cost ($) |
|---|---|---|---|---|
| 41.5 | 2,597,273 | 3.20 | 251,084 | 75,104,193 |
| 46 | 2,085,323 | 3.25 | 251,084 | 75,082,264 |
| 50 | 2,133,824 | 4.00 | 251,084 | 89,463,930 |

Notes:

1. D&B for a draft of 41.5' starts at the south end of Miraflores locks.
2. D&B for drafts of 46' and 50' starts near the 1939 excavation for the third locks.
3. The total cost does not reflect the acquisiton of a new drilling & blasting barge.

## THREE PHASE DRILLING AND BLASTING

a. If ACP decides to drill and blast initially for 41.5' draft, then 46' draft, and later perform the drilling and blasting for 50' draft, the total cost for drilling and blasting in one phase versus three phases would be as follows:

**1 PHASE VERSUS 3 PHASE DRILLING & BLASTING COMPARISON**

| Previous Draft Condition (ft) | Proposed Draft Condition (ft) | Borehole depth (ft) | Duration with 2 drillboats (years) | Total Cost ($) |
|---|---|---|---|---|
| 39.5 | 41.5 | 10 | 3.25 | 75,104,193 |
| 41.5 | 46 | 10.5 | 3 | 60,556,994 |
| 46 | 50 | 10 | 3.5 | 62,025,320 |
| **Total 3 Phase** | | **30.5** | | **197,686,507** |
| 39.5 | 50 | 18.5 | 4 | 89,463,930 |
| **Total 1 Phase** | | **18.5** | | **89,463,930** |
| **DIFFERENCE** | | | | **108,222,577** |
| **DIFFERENCE IN %** | | | | **121%** |

b. The cost to perform the drilling and blasting in two phases is substantially greater than in one phase, that is, 121% more. For more calculation details, see Appendix No. 8.

c. If it is decided to drill and blast in 2 phases, then the cost would be as follows:

**1 PHASE VERSUS 2 PHASE DRILLING & BLASTING COMPARISON**

| Previous Draft Condition (ft) | Proposed Draft Condition (ft) | Borehole depth (ft) | Duration with 2 drillboats (years) | Total Cost ($) |
|---|---|---|---|---|
| 39.5 | 46 | 14.5 | 3.25 | 75,082,264 |
| 46 | 50 | 10 | 3.5 | 62,025,320 |
| **Total 2 Phase** | | **24.5** | **6.5** | **137,107,584** |
| 39.5 | 50 | 18.5 | 4 | 89,463,930 |
| **Total 1 Phase** | | **18.5** | **4** | **89,463,930** |
| **DIFFERENCE** | | | **2.5** | **47,643,654** |
| **DIFFERENCE IN %** | | | **63%** | **53%** |

d. The drilling and blasting cost to 41.5' draft is higher than to 46' draft because material fragmentation is required from Miraflores locks south end, meanwhile for 46' draft, fragmentation starts 2.8 kms south of Miraflores locks.

## COST COMPARISON BETWEEN PRODUCTION BY AREA AND BY VOLUME

a. To validate the previous estimated cost of $75.1 million each for D&B of "progress by area" for drafts of 41.5' and 46', and $89.5 million for a draft of 50', a comparison of the cost was made with D&B productivity cost in terms of volume for each level of deepening.

b. The THOR D&B unit cost is based on its operation cost, as shown in Appendix No. 15. Following is a summary of the hourly operation cost of the THOR, converted to 2002 dollars:

**ACP DRILLING & BLASTING BARGE THOR OPERATION COST**

| | Hourly Cost ($) |
|---|---|
| Availability cost | 163 |
| Labor cost | 517 |
| Overhead cost | 62 |
| Fuel cost | 54 |
| Auxiliary equipment cost | 216 |
| **TOTAL HOURLY COST** | **$1,012** |

c. The D&B unit cost for the THOR under each deepening scenario is summarized in the following table.

**DRILLING & BLASTING UNIT COST FOR DRILLBOAT THOR**

| Deepening scenarios (draft) | Cost per hour ($) | Cost per week ($) | Estimated production per week ($m^3$) | Unit cost ($\$/m^3$) | Explosives unit cost ($\$/m^3$) | Total unit cost ($\$/m^3$) |
|---|---|---|---|---|---|---|
| **41.5'** | 1,013 | 167,894 | 23,576 | 7.12 | 2.00 | **9.12** |
| **46'** | 1,013 | 167,894 | 27,776 | 6.04 | 2.00 | **8.04** |
| **50'** | 1,013 | 167,894 | 29,986 | 5.60 | 2.00 | **7.60** |

d. To obtain the D&B volume, the D&B net area for each level of deepening was multiplied by the borehole depth; that is 10' for 41.5' draft; 14.5' for 46' draft; and 18.5' for 50' draft.

e. Using the estimated volumes, historical cost per week, and unit cost, the following results were obtained:

**DRILLING & BLASTING BARGE "THOR" COST COMPARISON BETWEEN AREA AND VOLUME METHODOLOGY**

| DRAFT (ft) | Progress by area calculation methodology | | | Calculation methodology by volume | | |
|---|---|---|---|---|---|---|
| | Net area that require D&B ($m^2$) | Cost per week ($) | Total D&B cost by progress area ($) | Volume = area x dredging depth ($m^3$) | Unit cost ($/$m^3$) | Total D&B cost by volume ($) |
| **41.5** | 2,597,273 | 251,084 | **$ 75,104,193** | 7,916,102 | 9.12 | **$ 72,206,019** |
| **46** | 2,085,323 | 251,084 | **$ 75,082,264** | 9,215,844 | 8.04 | **$ 74,137,638** |
| **50** | 2,133,824 | 251,084 | **$ 89,463,930** | 12,031,620 | 7.60 | **$ 91,429,391** |

f. The above table shows that there is a of 3.9%, 1.3%, and 2.1% difference between estimated costs by area and geometrically estimated volume for deepening for drafts of 41.5', 46', and 50'. The slight differences among these show that the cost estimate of "progress by area" is reasonable.

# DISPOSAL SITES FOR DREDGING MATERIAL

## GENERAL PARAMETERS

a. The Pacific entrance navigation channel deepening, including the 2' of over-dredging and 50' of over-swing, will require disposal of the following dredging volumes:

- Deepening for 41.5' draft: 3.4 M $m^3$
- Deepening for 46' draft: 6.4 M $m^3$
- Deepening for 50' draft: 10.8 M $m^3$

b. The current capacities of the disposal site at the Pacific entrance to receive material are estimated for a maximum of 2' of freeboard for the land sites, and at mean low water springs for the water sites. Following is a table showing the designated disposal sites and corresponding capacities. For more details, please refer to Appendix No. 16.

**PACIFIC ENTRANCE DESIGNATED DISPOSAL SITES**

| Disposal sites | Type | Remaining capacity ($m^3$) | Additional capacity ($m^3$) | Total capacity due to bulking factor (bank $m^3$) | Additional cost ($) |
|---|---|---|---|---|---|
| Victoria | Terrestrial | 505,734 | | **404,587** | |
| Velasquez | Terrestrial | 1,758,410 | | **1,406,728** | |
| Roseau | Terrestrial | 611,621 | | **489,297** | 1,041,303 |
| Farfan | Terrestrial | 3,058,104 | 4,346,950 | **5,924,043** | 1,877,564 |
| **TOTAL CAPACITY FOR TERRESTRIAL SITES** | | | | **8,224,655** | **2,918,867** |
| Tortolita | Aquatic | 11,700,000 | | **9,360,000** | |
| Tortolita South | Aquatic | 12,500,000 | | **10,000,000** | |
| **TOTAL CAPACITY FOR AQUATIC SITES** | | | | **19,360,000** | |

Notes:

1. Farfan additional capacity includes the disposal extension to the west and raising the height of the dike.

2. Rosseau is a new disposal and requires the construction of dike, drainage system, and spillway.

c. As shown in Appendix No. 1, the dredging material from station 71K+200 to 76K+000, is estimated at around 4.4 M $m^3$ under the most critical scenario, 50' draft. These 4.4 M $m^3$ can be deposited at disposal sites

Victoria, Velasquez, Rosseau, and Farfan, which can hold a maximum of 8.2 M bank $m^3$.

d. The Pacific entrance deepening, especially under the most critical scenario, 50' of draft, will substantially reduce the land disposal sites to approximately 2.9 M bank $m^3$ of remaining capacity, which could not be enough for future channel maintenance dredging. Therefore, it is strongly recommended to relocate a great part of the dredging material from the deepening to another site.

e. For the remaining stations, 76K+000 to 85K+920, the dredging material from the deepening may be dumped in the water disposal sites of Tortolita and Tortolita South, which have sufficient remaining capacity of 9.36 and 10 M bank $m^3$. However, as mentioned previously, because of the relative long distance, more than 3 kms, between the navigation channels and the designated water disposal sites, a booster pump is required to discharge the dredging material.

f. The use of a booster pump might be eliminated if the dredging material could be discharged at the south end of the disposal site at Farfan; however, this scheme is not feasible because the type of dredging material found in the Pacific entrance requires a long drainage path to allow sedimentation, which could not be accomplished by depositing the material at the south section of Farfan because the drainage path is too short. Under existing conditions, the dredging material is discharged at the north end of Farfan. In this way, the dredging material tends to deposit its sediment in the north section of Farfan, allowing clear water to flow slowly to the south and finally exit through the spillway at the south end of Farfan.

## Acquisition of New Dredging Equipment for Future Channels Improvements

a. This report is not an in-depth analysis of new dredging equipment and cost estimate, just general recommendations of basic requirements to fulfill the Panama Canal expansion program.

b. As of today, the ACP is in the process of acquiring a new drilling and blasting barge with 4 towers, similar to the THOR but with greater productivity, at least 25% more, with more drilling reach and deeper spuds capacity.

c. The THOR maximum drilling reach is 75' underwater, and 58' for the spuds, which are not sufficient to perform the Pacific entrance deepening for 50' draft at high tide. ACP has requested that the new drill-boat have a minimum drilling capacity of 85' underwater, and spuds reach of 80', which complies with future drilling requirements to deepen the Pacific entrance for the Canal expansion plan. Please refer to Appendix No. 3 for drill-boat and dredge requirements for the Pacific entrance deepening.

d. As for a new cutter suction dredge, it should be similar to the MINDI but offering greater output, capacity to dredge harder material, and greater dredging material discharge distance. It is convenient that the new dredge dimensions be similar to those of the MINDI for ease in maneuvering within a restricted channel like the Gaillard Cut. A rough estimate of a new cutter suction dredge similar to the MINDI but with greater output could be around $40 million. If the new cutter suction dredge with a minimum discharging capacity of 6 kms is not available on the market, it is recommended to get a booster pump to comply with discharging minimum reach in the Pacific entrance.

e. As mentioned previously, the new cutter suction dredge will assist the MINDI in completing the channel deepening on time to allow the traffic of Post-Panamax vessels after the construction of new locks. The MINDI meets dredging requirement for Pacific entrance deepening, except at high tide, where it can dredge 90% of the time for the 50' draft scenario. However, the MINDI can still be upgraded by replacing the existing engines with more powerful ones, extending the ladder, and automating the dredge to lower manpower requirements. Thus, the MINDI can become more efficient and dredging costs could be less than the estimated deepening cost.

f. For the Pacific entrance deepening, it is highly recommended to acquire a booster pump to assist the MINDI because of the remoteness of the disposal sites. It is estimated that capacity of the new booster pump shall be similar to that of the MINDI pump, that is, 3600 hp. A rough estimate of the acquisition cost of a new booster pump is around $8 million including 2 kms of "wavifloats", which are open sea discharge pipes. The $8 million includes $6 million for the new booster, and $2 million for the discharge pipe accessories with "wavifloat" technology.

## SUMMARY

a. In summary, the total drilling and blasting areas, dredging volume, required dredging equipment, time frame, and costs of deepening the Pacific entrance navigation channels for the 3 options **without any contingency factor** and assuming that the Pacific entrance channel bottom is at –52.1 PLD are as follows:

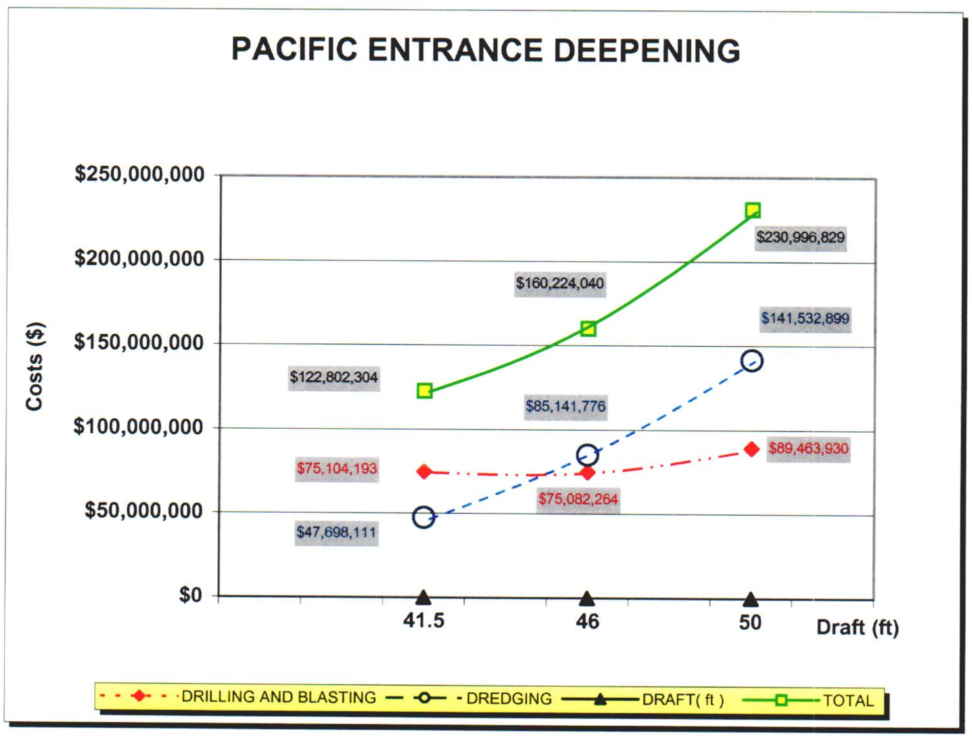
**SUMMARY OF VOLUME, AREAS, DURATION, EQUIPMENT, AND COST TO DEEPENING THE PACIFIC ENTRANCE NAVIGATION CHANNELS**

| DRAFT | D&B areas ($m^2$) | Dredging volume ($m^3$) | No. of Drillboats | No. of dredges | Total duration (years) | D&B cost ($) | Dredging cost ($) | Total Cost ($) |
|---|---|---|---|---|---|---|---|---|
| **41.5 ft** | 2,597,273 | 3,413,836 | 2 | 2 | 3.25 | 75,104,193 | 47,698,111 | **122,802,304** |
| **46 ft** | 2,085,323 | 6,359,871 | 2 | 2 | 4.00 | 75,082,264 | 85,141,776 | **160,224,040** |
| **50 ft** | 2,133,824 | 10,846,307 | 2 | 2 | 5.50 | 89,463,930 | 141,532,899 | **230,996,829** |

Notes:

1. The deepening for 41.5' draft initiates at Miraflores locks south end.
2. The deepening for 46' and 50' draft initiates near 1939 third set of locks excavation.

b. The following graph shows the cost relationship between dredging and drilling & blasting for the 3 drafts depths. For drilling and blasting, the efficiency increases at deeper boreholes, as opposed to dredging, in which the costs are directly proportional to the dredging volume.



c. Deepening cost in phases assuming one-phase drilling and blasting would be as follows:

**SUMMARY OF VOLUME, AREAS, DURATION, EQUIPMENT, AND COST TO DEEPENING THE PACIFIC ENTRANCE NAVIGATION CHANNELS**

| DRAFT | Dredging volume ($m^3$) | No. of Drillboats | No. of dredges | D&B cost ($) | Dredging cost ($) | Total Cost ($) |
|---|---|---|---|---|---|---|
| **39.5 to 41.5 feet** | 3,413,836 | 2 | 2 | 75,104,193 | 47,698,111 | **122,802,304** |
| **41.5 to 46 feet** | 3,839,296 | 2 | 2 | 32,236,561 | 50,538,871 | **82,775,432** |
| **46 to 50 feet** | 4,486,436 | | 2 | | 55,433,061 | **55,433,061** |

Notes:

1. The deepening for 41.5' draft initiates at Miraflores locks south end.
2. The deepening for 46' and 50' draft initiates near 1939 third set of locks excavation.

d. If the decision is to drill and blast initially for a 46'-draft channel bottom instead of going directly for a 50' draft, the total deepening cost could increase up to 21%, as shown in the following table:

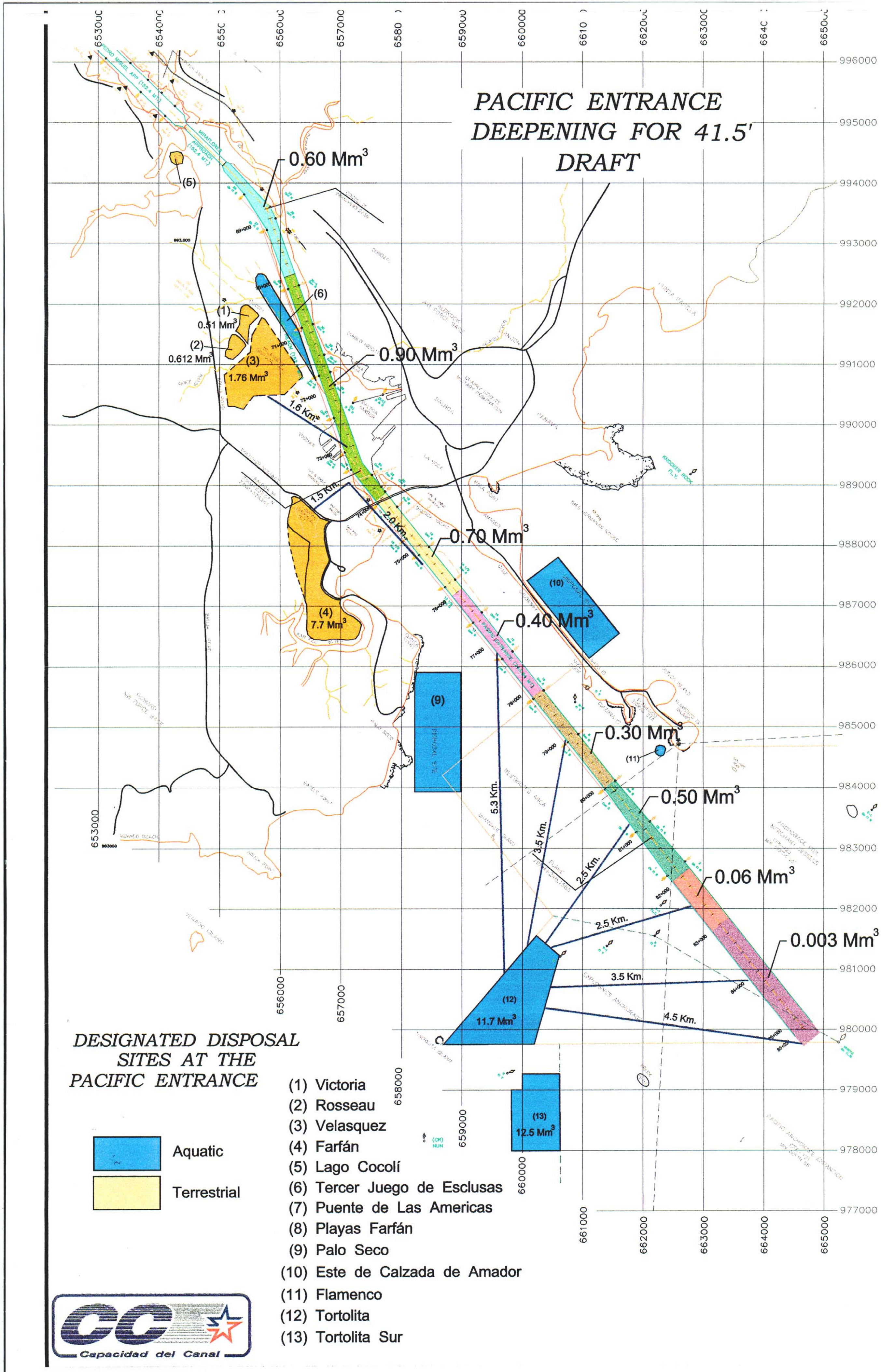
**COMPARISON BETWEEN DRILLING AND BLASTING FOR 46' versus 50' DRAFT IN ONE PHASE AND TWO PHASES**

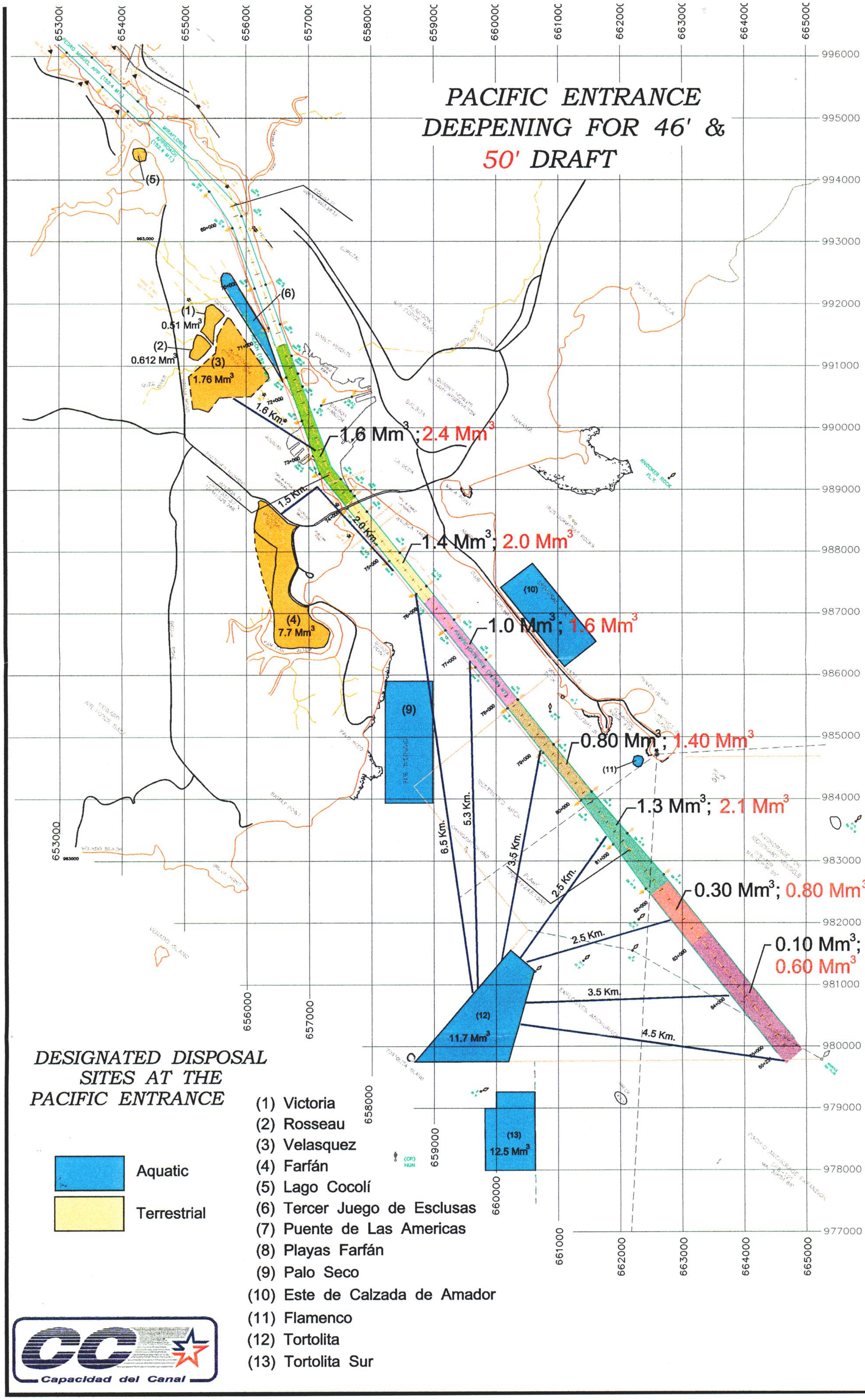
| Design Channel Bottom | 46' draft | 50' draft | TOTAL |
|---|---|---|---|
| Dredging Volume (m3) | 6,359,871 | 4,486,436 | 10,846,307 |
| Drilling & Blasting areas (m2) | 2,085,323 | 2,133,824 | 4,219,147 |
| Duration with 2 dredges and 2 drillboats (years) | 4 | 5.5 | 7.25 |
| **TOTAL COST, ONE - PHASE D&B ($)** | **160,224,040** | **70,772,789** | **230,996,829** |
| **TOTAL COST, TWO - PHASE D&B ($)** | **160,224,040** | **118,416,443** | **278,640,483** |

e. The previous table does not contemplate any contingency factor.

# APPENDIX No. 1

## Panama Canal Pacific Entrance


PACIFIC ENTRANCE
DEEPENING FOR 41.5'
DRAFT
0.60 Mm3
0.90 Mm3
0.70 Mm3
0.40 Mm3
0.30 Mm3
0.50 Mm3
0.06 Mm3
0.003 Mm3
(1) 0.51 Mm3
(2) 0.612 Mm3
(3) 1.76 Mm3
(4) 7.7 Mm3
(5)
(6)
(9)
(10)
(11)
(12) 11.7 Mm3
(13) 12.5 Mm3
1.6 Km.
1.5 Km.
2.0 Km.
5.3 Km.
3.5 Km.
2.5 Km.
2.5 Km.
3.5 Km.
4.5 Km.
DESIGNATED DISPOSAL
SITES AT THE
PACIFIC ENTRANCE
Aquatic
Terrestrial
(1) Victoria
(2) Rosseau
(3) Velasquez
(4) Farfán
(5) Lago Cocolí
(6) Tercer Juego de Esclusas
(7) Puente de Las Americas
(8) Playas Farfán
(9) Palo Seco
(10) Este de Calzada de Amador
(11) Flamenco
(12) Tortolita
(13) Tortolita Sur
Capacidad del Canal


PACIFIC ENTRANCE
DEEPENING FOR 46' &
50' DRAFT
(1)
0.51 Mm3
(2)
0.612 Mm3
(3)
1.76 Mm3
(4)
7.7 Mm3
(5)
(6)
(9)
(10)
(11)
(12)
11.7 Mm3
(13)
12.5 Mm3
1.6 Km.
1.5 Km.
2.0 Km.
6.5 Km.
5.3 Km.
3.5 Km.
2.5 Km.
2.5 Km.
3.5 Km.
4.5 Km.
1.6 Mm3; 2.4 Mm3
1.4 Mm3; 2.0 Mm3
1.0 Mm3; 1.6 Mm3
0.80 Mm3; 1.40 Mm3
1.3 Mm3; 2.1 Mm3
0.30 Mm3; 0.80 Mm3
0.10 Mm3;
0.60 Mm3
653000
654000
655000
656000
657000
658000
659000
660000
661000
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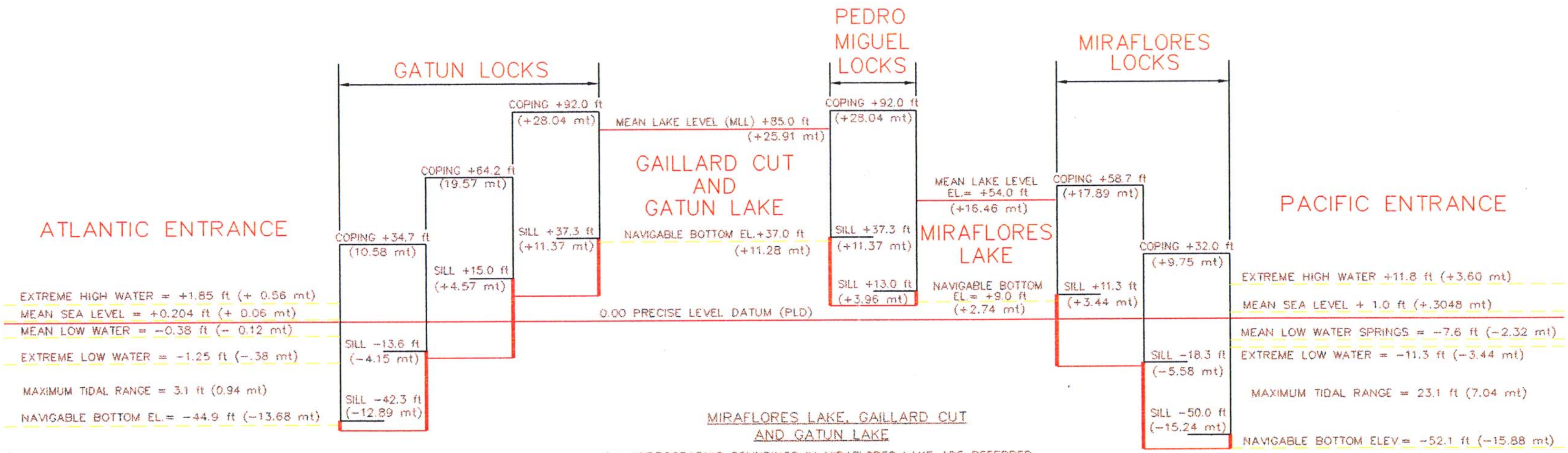
663000
664000
665000
996000
995000
994000
993000
992000
991000
990000
989000
988000
987000
986000
985000
984000
983000
982000
981000
980000
979000
978000
977000
DESIGNATED DISPOSAL
SITES AT THE
PACIFIC ENTRANCE
Aquatic
Terrestrial
(1) Victoria
(2) Rosseau
(3) Velasquez
(4) Farfán
(5) Lago Cocolí
(6) Tercer Juego de Esclusas
(7) Puente de Las Americas
(8) Playas Farfán
(9) Palo Seco
(10) Este de Calzada de Amador
(11) Flamenco
(12) Tortolita
(13) Tortolita Sur
Capacidad del Canal

# APPENDIX No. 2

## Panama Canal Clearance Diagram




MIRAFLORES LAKE, GAILLARD CUT AND GATUN LAKE

1.- HYDROGRAPHIC SOUNDINGS IN MIRAFLORES LAKE ARE REFERRED TO "MEAN LAKE LEVEL" WHICH IS +54.0 ft (+16.46 mt) PLD

2.- HYDROGRAPHIC SOUNDINGS IN GAILLARD CUT AND GATUN LAKE ARE REFERRED TO "MEAN LAKE LEVEL" WHICH IS +85.0 ft (+25.91 mt) PLD

3.- MAXIMUM NAVIGABLE DEPTH IS CONTROLLED BY DEPTH OF WATER OVER SILL AT SOUTH END OF PEDRO MIGUEL LOCKS

ATLANTIC ENTRANCE

1.- THE DATUM FOR TIDAL ELEVATIONS AND HYDROGRAPHIC CHARTS AT ATLANTIC ENTRANCE IS "MEAN LOW WATER" WHICH IS -0.38 ft (-0.12 mt) PLD

2.- "MEAN LOW WATER" IS THE AVERAGE OF ALL LOW TIDE

NOTE:

1.- TIDAL DATA IS BASED ON HYDROGRAPHIC RECORDS FROM 1902 TO 1972

2.- CLEAR NAVIGABLE DEPTH WILL BE MAINTAINED TO NAVIGABLE BOTTOM ELEVATIONS BY MAINTENANCE DREDGING

3.- ALL ELEVATIONS ARE REFERRED TO PRECISE LEVEL DATUM (PLD)

PACIFIC ENTRANCE

1.- THE DATUM FOR TIDAL ELEVATIONS AND HYDROGRAPHIC CHARTS AT PACIFIC ENTRANCE IS "MEAN LOW WATER SPRINGS" WHICH IS -7.6 ft (-2.32 mt) PLD

2.- "MEAN LOW WATER SPRINGS" IS THE AVERAGE OF LOW WATERS AT TIME OF SPRING TIDE

JOB SAFETY DEPENDS ON YOU

| REV | DATE | DESCRIPTION | BY | CHKD | REVWD | APPVD |
|---|---|---|---|---|---|---|
| MC | 7/99 | NAVIGABLE BOTTOMS | RC | | | |
| AC | 7-05-95 | NOTES POSSITIONS | RC | J.R | R.S.F | |

PANAMA CANAL COMMISSION

ENGINEERING AND INDUSTRIAL SERVICES
ENGINEERING DIVISION
BALBOA HEIGHTS, REPUBLIC OF PANAMA

THE PANAMA CANAL CLEARANCE DIAGRAM

SCALE: NOT TO SCALE | DATE: JULY 26, 1999

DRAWN: M. R. CARRIZO, CARTOGRAPHIC SECTION
CHECKED: R. CASTILLO, SUPERVISOR, CARTOGRAPHIC SECTION
SUBMITTED: MANAGER, SURVEYS BRANCH
APPROVED: MANAGER, ENGINEERING DIVISION

NOTE:
THIS DRAWING SUPERSEDES DWG. No. 6120-30A AND DWG. No.6120-30B

M 6120- 30 C

# APPENDIX No. 3

## Panama Canal dredges and drilling & blasting barges reaches

## ACP DREDGES UNDERWATER REACH FOR PACIFIC ENTRANCE DEEPENING TO 41.5' DRAFT

| REACH | High Tide | | Mean Sea Level | | Mean Low Water Springs | |
|---|---|---|---|---|---|---|
| | feet | meters | feet | meters | feet | meters |
| Required for 41.5' draft | 67.9 | 20.69 | 57.1 | 17.40 | 48.5 | 14.78 |
| Dipper dredge RMC | 60 | 18.29 | 60 | 18.29 | 60 | 18.29 |
| Cutter suction MINDI | 72 | 21.94 | 72 | 21.94 | 72 | 21.94 |
| MINDI spuds | 83 | 25.30 | 83 | 25.30 | 83 | 25.30 |
| D&B barge THOR | 75 | 22.86 | 75 | 22.86 | 75 | 22.86 |
| D&B barge THOR spuds | 58 | 17.68 | 58 | 17.68 | 58 | 17.68 |
| New D&B barge | 85 | 25.91 | 85 | 25.91 | 85 | 25.91 |
| New D&B barge spuds | 80 | 24.38 | 80 | 24.38 | 80 | 24.38 |

Notes:

1. Figures in red indicate that the equipment does not meet the required reach.
2. As of Dec. 2002, ACP is in process to acquire a new drilling and blasting barge

**ACP DREDGES UNDERWATER REACH FOR PACIFIC ENTRANCE DEEPENING TO 46' DRAFT**

| REACH | High Tide | | Mean Sea Level | | Mean Low Water Springs | |
|---|---|---|---|---|---|---|
| | feet | meters | feet | meters | feet | meters |
| Required for 46' draft | 72.4 | 22.07 | 61.6 | 18.77 | 53 | 16.15 |
| Dipper dredge RMC | 60 | 18.29 | 60 | 18.29 | 60 | 18.29 |
| Cutter suction MINDI | 72 | 21.94 | 72 | 21.94 | 72 | 21.94 |
| MINDI spuds | 83 | 25.30 | 83 | 25.30 | 83 | 25.30 |
| D&B barge THOR | 75 | 22.86 | 75 | 22.86 | 75 | 22.86 |
| D&B barge THOR spuds | 58 | 17.68 | 58 | 17.68 | 58 | 17.68 |
| New D&B barge | 85 | 25.91 | 85 | 25.91 | 85 | 25.91 |
| New D&B barge spuds | 80 | 24.38 | 80 | 24.38 | 80 | 80 |

Notes:

1. Figures in red indicate that the equipment does not meet the required reach.
2. As of Dec. 2002, ACP is in process to acquire a new drilling and blasting barge

## ACP DREDGES UNDERWATER REACH FOR PACIFIC ENTRANCE DEEPENING TO 50' DRAFT

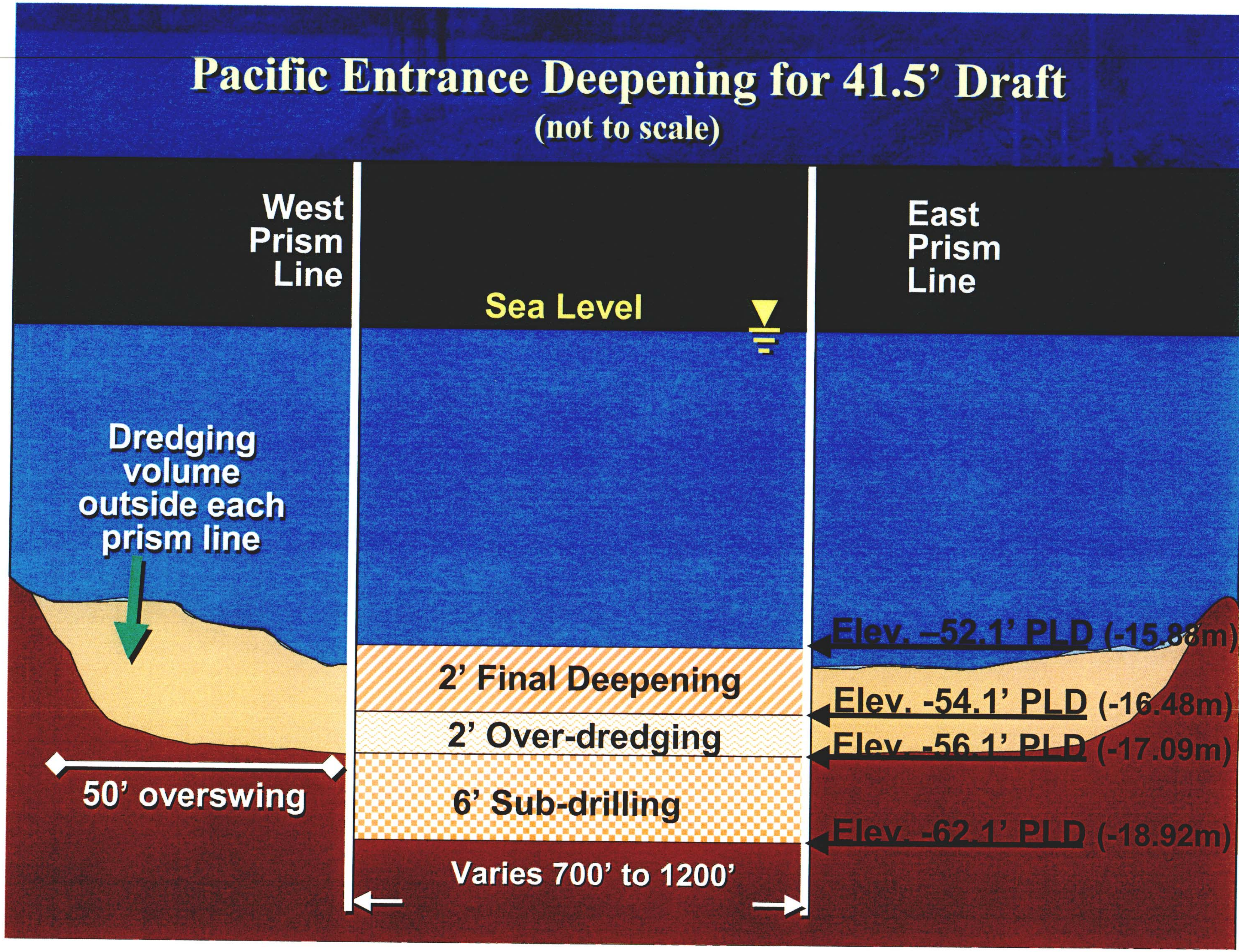
| REACH | High Tide | | Mean Sea Level | | Mean Low Water Springs | |
|---|---|---|---|---|---|---|
| | feet | meter | feet | meter | feet | meter |
| Required for 50' draft | 76.4 | 23.29 | 65.6 | 19.99 | 57 | 17.37 |
| Dipper dredge RMC | 60 | 18.29 | 60 | 18.29 | 60 | 18.29 |
| Cutter suction MINDI | 72 | 21.94 | 72 | 21.94 | 72 | 21.94 |
| MINDI spuds | 83 | 25.30 | 83 | 25.30 | 83 | 25.30 |
| D&B barge THOR | 75 | 22.86 | 75 | 22.86 | 75 | 22.86 |
| D&B barge THOR spuds | 58 | 17.68 | 58 | 17.68 | 58 | 17.68 |
| New D&B barge | 85 | 25.91 | 85 | 25.91 | 85 | 25.91 |
| New D&B barge spuds | 80 | 24.38 | 80 | 24.38 | 80 | 24.38 |

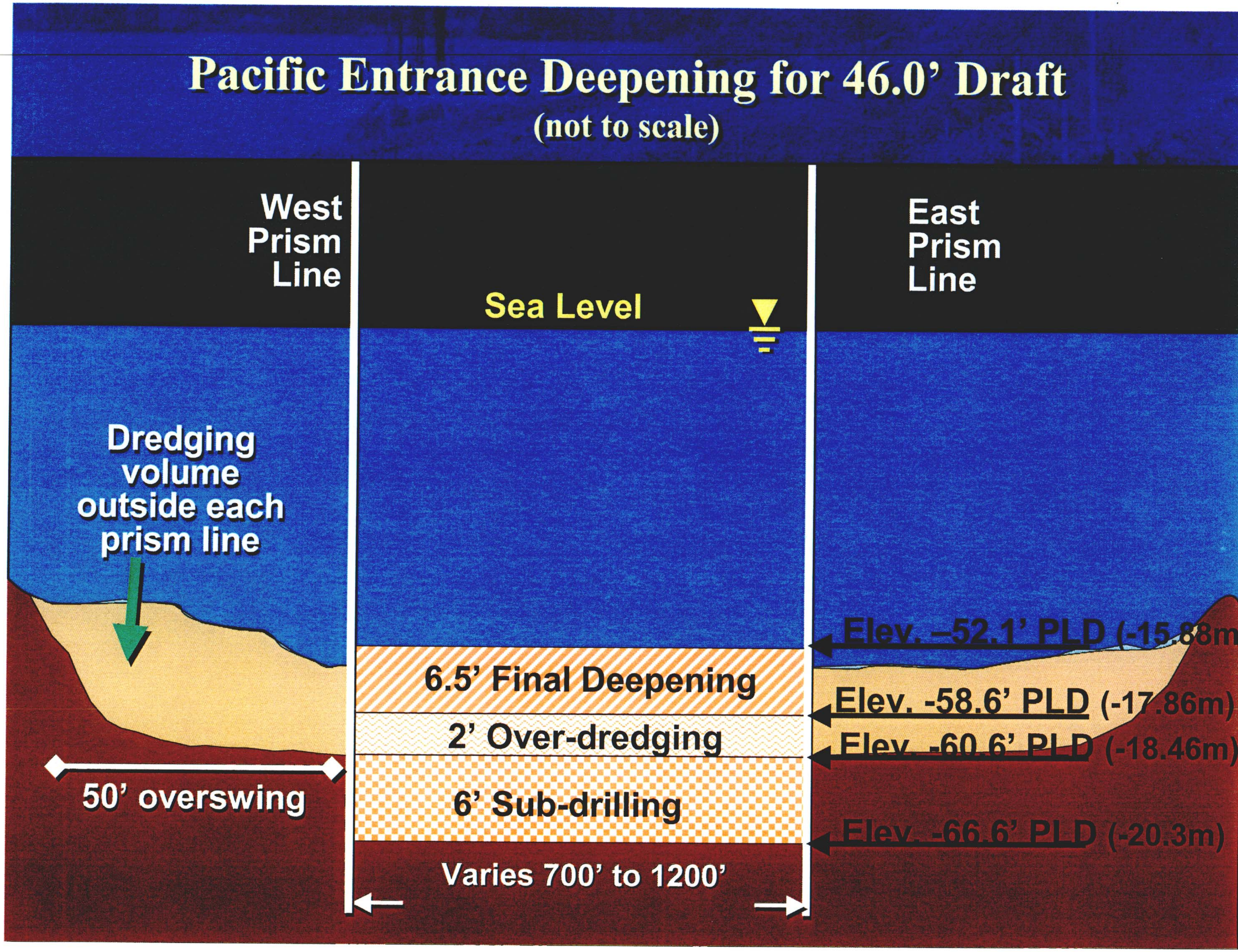
Notes:

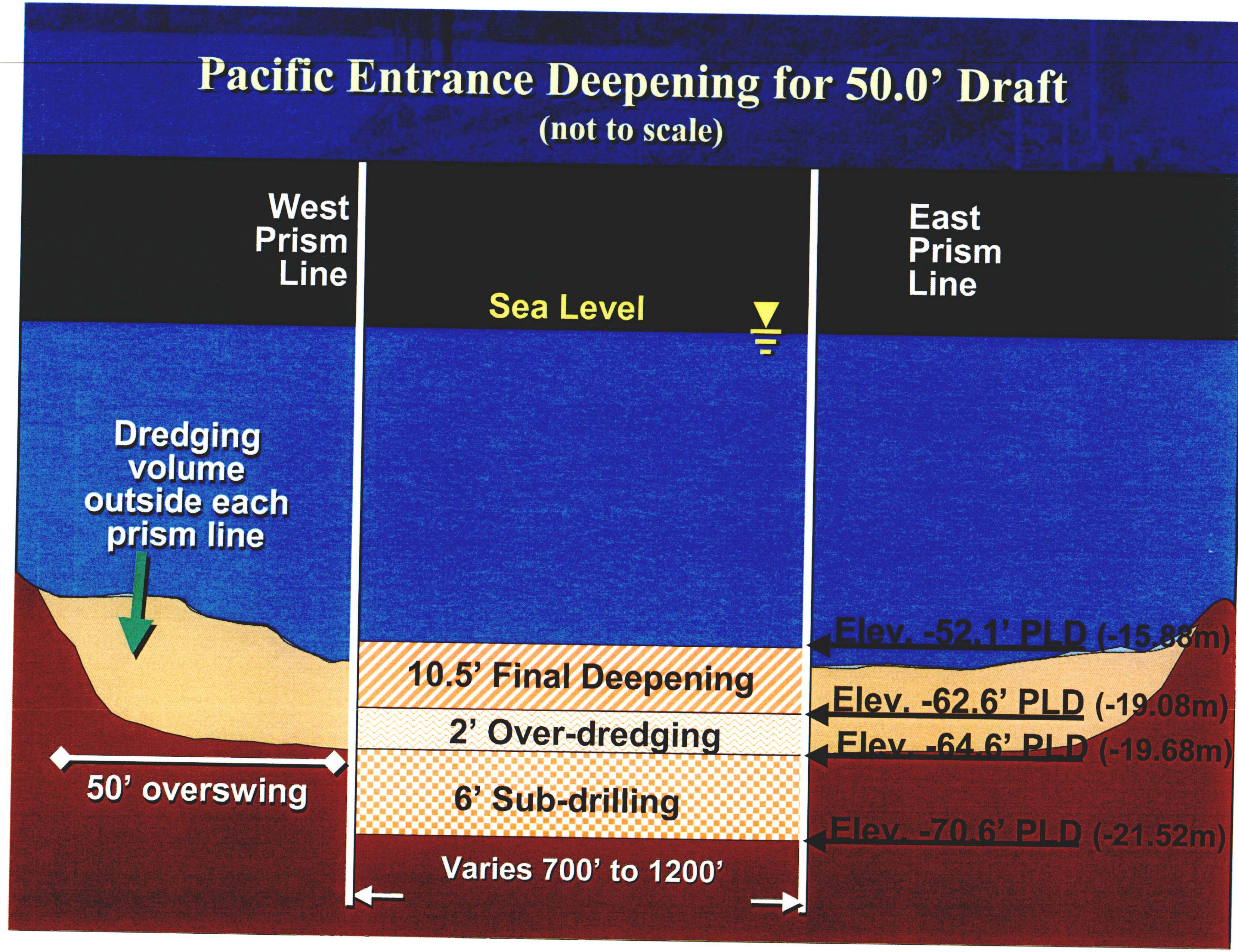
1. Figures in red indicate that the equipment does not meet the required reach.
2. As of Dec. 2002, ACP is in process to acquire a new drilling and blasting barge

# APPENDIX No. 4

## Pacific Entrance Cross Sectional Views for the Three Deepening Scenarios


Pacific Entrance Deepening for 41.5' Draft
(not to scale)
West Prism Line
East Prism Line
Sea Level
Dredging volume outside each prism line
Elev. –52.1' PLD (-15.88m)
2' Final Deepening
Elev. -54.1' PLD (-16.48m)
2' Over-dredging
Elev. -56.1' PLD (-17.09m)
6' Sub-drilling
Elev. -62.1' PLD (-18.92m)
50' overswing
Varies 700' to 1200'


Pacific Entrance Deepening for 46.0' Draft
(not to scale)
West Prism Line
East Prism Line
Sea Level
Dredging volume outside each prism line
Elev. -52.1' PLD (-15.88m)
6.5' Final Deepening
Elev. -58.6' PLD (-17.86m)
2' Over-dredging
Elev. -60.6' PLD (-18.46m)
6' Sub-drilling
Elev. -66.6' PLD (-20.3m)
50' overswing
Varies 700' to 1200'


Pacific Entrance Deepening for 50.0' Draft
(not to scale)
West Prism Line
East Prism Line
Sea Level
Dredging volume outside each prism line
10.5' Final Deepening
2' Over-dredging
6' Sub-drilling
50' overswing
Varies 700' to 1200'
Elev. -52.1' PLD (-15.88m)
Elev. -62.6' PLD (-19.08m)
Elev. -64.6' PLD (-19.68m)
Elev. -70.6' PLD (-21.52m)

# APPENDIX No. 5

## Pacific Entrance Dredging Volumes for 41.5', 46', and 50' draft

Appendix No. 5

## PACIFIC ENTRANCE DREDGING VOLUME FOR 41.5' DRAFT

| STATIONS | Dredging Volume from -52.1' to -54.1' PLD ($m^3$) | Overdredge Volume from -54.1' to -56.1' PLD ($m^3$) | Total Dredging Volume from -52.1' to -56.1' PLD ($m^3$) |
|---|---|---|---|
| STA( 68K+415 @ 70K+000 ) | 408,134 | 203,720 | 611,854 |
| STA( 70K+000 @ 74K+000 ) | 576,075 | 361,947 | 938,022 |
| STA( 74K+000 @ 76K+000 ) | 452,291 | 249,408 | 701,699 |
| STA( 76K+000 @ 78K+000 ) | 158,012 | 179,735 | 337,747 |
| STA( 78K+000 @ 80K+000 ) | 200,718 | 58,536 | 259,254 |
| STA( 80K+000 @ 82K+000 ) | 298,098 | 207,059 | 505,157 |
| STA( 82K+000 @ 83K+000 ) | 5,564 | 54,250 | 59,814 |
| STA( 83K+000 @ 85K+920 ) | 0 | 289 | 289 |
| **TOTAL** | **2,098,892** | **1,314,944** | **3,413,836** |

## PACIFIC ENTRANCE DREDGING VOLUME FOR 46' DRAFT

| STATIONS | Dredging Volume from -52.1' to -58.6' PLD ($m^3$) | Overdredge Volume from -58.6' to -60.6' PLD ($m^3$) | Total Dredging Volume from -52.1' to -60.6' PLD ($m^3$) |
|---|---|---|---|
| STA( 71K+200 @ 74K+000 ) | 1,129,205 | 435,121 | 1,564,326 |
| STA( 74K+000 @ 76K+000 ) | 1,071,232 | 299,849 | 1,371,081 |
| STA( 76K+000 @ 78K+000 ) | 691,987 | 298,920 | 990,907 |
| STA( 78K+000 @ 80K+000 ) | 479,297 | 281,568 | 760,865 |
| STA( 80K+000 @ 82K+000 ) | 834,118 | 443,572 | 1,277,690 |
| STA( 82K+000 @ 83K+000 ) | 134,534 | 150,810 | 285,344 |
| STA( 83K+000 @ 85K+920 ) | 51,135 | 58,523 | 109,658 |
| **TOTAL** | **4,391,508** | **1,968,363** | **6,359,871** |

## PACIFIC ENTRANCE DREDGING VOLUME FOR 50' DRAFT

| STATIONS | Dredging Volume from -52.1' to -62.6' PLD ($m^3$) | Overdredge Volume from -62.6' to -64.6' PLD ($m^3$) | Total Dredging Volume from -52.1' to -64.6' PLD ($m^3$) |
|---|---|---|---|
| STA( 71+200 @ 74+000 ) | 1,908,139 | 463,203 | 2,371,342 |
| STA( 74+000 @ 76+000 ) | 1,669,953 | 299,362 | 1,969,315 |
| STA( 76+000 @ 78+000 ) | 1,288,852 | 298,431 | 1,587,283 |
| STA( 78+000 @ 80+000 ) | 1,090,381 | 307,203 | 1,397,584 |
| STA( 80+000 @ 82+000 ) | 1,692,906 | 416,141 | 2,109,047 |
| STA( 82+000 @ 83+000 ) | 531,991 | 241,656 | 773,647 |
| STA( 83+000 @ 85+920 ) | 282,214 | 355,875 | 638,089 |
| **TOTAL** | **8,464,436** | **2,381,871** | **10,846,307** |

# APPENDIX No. 6

## ACP cutter suction dredge MINDI historical performance

## MINDI

### PACIFIC ENTRANCE

| DATE | RUN TIME IN HOURS | ADVANCE IN FEET | VOLUME IN $YD^3$ | VOLUME IN $M^3$ | AVERAGE PIPELINE | AVERAGE $YD^3$/HR. | AVERAGE $M^3$/HR. | EQUIMENT USED |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Jan-89 | 9.17 | 245 | 9,037.78 | 7,469.24 | 5,600.00 | 985.58 | 814.53 | MINDI |
| Feb-89 | 402.29 | 9345 | 512,637.40 | 423,667.27 | 5,965.00 | 1,274.30 | 1,053.14 | MINDI |
| Mar-89 | 406.61 | 8800 | 406,506.10 | 335,955.45 | 5,487.00 | 999.74 | 826.24 | MINDI |
| Apr-89 | 347.48 | 6074 | 256,636.10 | 212,095.95 | 4,137.50 | 738.56 | 610.38 | MINDI |
| May-89 | 201.42 | 1300 | 241,099.00 | 199,255.37 | 3,500.00 | 1,197.00 | 989.25 | MINDI |
| | | | | | | | | |
| Feb-90 | 337.69 | 4340 | 739,620.10 | 611,256.28 | 5,041.66 | 2,190.23 | 1,810.11 | MINDI |
| Mar-90 | 429.29 | 7165 | 1,180,301.43 | 975,455.73 | 4,693.05 | 2,749.43 | 2,272.25 | MINDI |
| Apr-90 | 318.77 | 8395 | 802,858.51 | 663,519.43 | 4,626.56 | 2,518.61 | 2,081.50 | MINDI |
| May-90 | 202.87 | 6550 | 319,757.10 | 264,262.07 | 3,593.75 | 1,576.17 | 1,302.62 | MINDI |
| Jun-90 | 196.99 | 3325 | 213,163.72 | 176,168.36 | 3,636.84 | 1,082.10 | 894.30 | MINDI |
| Jul-90 | 157.77 | 1555 | 120,437.94 | 99,535.49 | 3,682.14 | 763.38 | 630.89 | MINDI |
| Aug-90 | 186.82 | 2215 | 134,375.64 | 111,054.25 | 4,004.34 | 719.28 | 594.45 | MINDI |
| Sep-90 | 223.04 | 1870 | 94,574.82 | 78,161.01 | 3,093.47 | 424.03 | 350.43 | MINDI |
| Oct-90 | 228.48 | 4520 | 199,017.46 | 164,477.24 | 3,919.04 | 871.05 | 719.88 | MINDI |
| Nov-90 | 127.64 | 1230 | 129,831.14 | 107,298.46 | 4,479.41 | 1,017.17 | 840.63 | MINDI |
| | | | | | | | | |
| Feb-92 | 398.29 | 2585 | 315,986.29 | 261,145.69 | 6,350.89 | 793.36 | 655.67 | MINDI |
| Mar-92 | 355.44 | 1430 | 297,678.98 | 246,015.69 | 4,677.88 | 837.49 | 692.14 | MINDI |
| Apr-92 | 379.67 | 1190 | 190,136.11 | 157,137.28 | 4,462.75 | 500.79 | 413.88 | MINDI |
| May-92 | 354.1 | 2640 | 307,532.85 | 254,159.38 | 4,645.45 | 868.49 | 717.76 | MINDI |
| Jun-92 | 407.46 | 1375 | 236,750.46 | 195,661.54 | 3,732.25 | 581.04 | 480.20 | MINDI |
| Jul-92 | 370.16 | 5010 | 259,599.85 | 214,545.33 | 4,061.90 | 701.32 | 579.60 | MINDI |
| Aug-92 | 369.85 | 1230 | 238,739.87 | 197,305.68 | 4,095.74 | 645.50 | 533.47 | MINDI |
| Sep-92 | 371.32 | 1280 | 292,040.16 | 241,355.50 | 4,435.00 | 786.49 | 649.99 | MINDI |
| Oct-92 | 433.54 | 700 | 197,307.31 | 163,063.89 | 5,261.53 | 455.11 | 376.12 | MINDI |
| Nov-92 | 205.11 | 1025 | 149,367.18 | 123,443.95 | 5,222.71 | 728.23 | 601.84 | MINDI |
| Dec-92 | 64.24 | 4725 | 86,049.33 | 71,115.15 | 4,743.95 | 1,339.50 | 1,107.02 | MINDI |
| | | | | | | | | |
| May-93 | 411.78 | 1570 | 159,238.11 | 131,601.74 | 5,040.38 | 386.71 | 319.59 | MINDI |
| Jun-93 | 409.84 | 1525 | 151,752.74 | 125,415.49 | 6,080.00 | 370.27 | 306.01 | MINDI |
| Jul-93 | 292.94 | 2490 | 172,819.17 | 142,825.76 | 5,826.08 | 589.95 | 487.56 | MINDI |
| | | | | | | | | |
| Sep-94 | 151.12 | 1715 | 192,308.20 | 158,932.40 | 4,046.15 | 1,272.55 | 1,051.70 | MINDI |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sep-98 | 49.7 | 328 | 38,931.02 | 32,174.40 | 3,525.00 | 783.32 | 647.37 | MINDI |
| Oct-98 | 352.86 | 3590 | 438,445.00 | 362,351.24 | 3,975.00 | 1,242.55 | 1,026.90 | MINDI |
| Nov-98 | 353.3 | 3695 | 464,716.90 | 384,063.55 | 5,212.00 | 1,315.36 | 1,087.07 | MINDI |
| Dec-98 | 243.42 | 5015 | 248,489.00 | 205,362.81 | 5,505.00 | 1,020.82 | 843.66 | MINDI |

| | |
|---|---|
| AVERAGE OF "MINDI" MONTHLY ADVANCE IN FEET: | 3236.68 FEET |
| | 980.81 METERS |

| | | | |
|---|---|---|---|
| LEAST PRODUCTIVITY | 306 $M^3$/HR | 4590 $M^3$/DIA | 32130 $M^3$/SEMANA |
| AVERAGE PRODUCTIVITY | 834.36 $M^3$/HR | 12515.4 $M^3$/DIA | 87607.8 $M^3$/SEMANA |
| GREATEST PRODUCTIVITY | 2272.25 $M^3$/HR | 34083.75 $M^3$/DIA | 238586.25 $M^3$/SEMANA |

# APPENDIX No. 7

## Pacific Entrance Deepening for 41.5', 46', and 50' Draft Gantt Chart

Alternativas-Profundización de entrada del Pacifico(rev.22)
Cash Flow - Draft 41.5'

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
|---|---|---|---|---|---|---|---|
| ALTERNATIVAS-PROFUNDIZACIÓN ENTRADA DEL PACÍFICO | | | | | | | |
| Profundización-Entrada del Pacifico ( Calado 41.5' ) | | | | | | | |
| Perforación y Voladura de -52.1' @ -62.1' PLD | | | | | | | |
| Sta.( 68+415 @ 70+000 )-Nva. Perf. | B/. 6,062,919.40 | B/. 7,236,298.60 | | | | | B/. 13,299,218.00 |
| Sta.( 70+000 @ 74+000 )-Thor | B/. 6,242,749.14 | B/. 12,451,384.90 | B/. 730,594.96 | | | | B/. 19,424,729.00 |
| Sta.( 74+000 @ 76+000 )-Nva. Perf. | | B/. 4,815,485.13 | B/. 6,334,867.87 | | | | B/. 11,150,353.00 |
| Sta.( 76+000 @ 78+000 )-Thor | | | B/. 11,262,051.52 | B/. 1,240,109.48 | | | B/. 12,502,161.00 |
| Sta.( 78+000 @ 80+000 )-Nva. Perf. | | | B/. 5,518,009.38 | B/. 3,757,908.62 | | | B/. 9,275,918.00 |
| Sta.( 80+000 @ 82+000 )-Thor | | | | B/. 6,239,907.00 | | | B/. 6,239,907.00 |
| Sta.( 82+000 @ 83+000 )-Nva. Perf. | | | | B/. 3,211,908.00 | | | B/. 3,211,908.00 |
| Sta.( 83+000 @ 85+920 ) | | | | | | | |
| Dragado de -52.1' @ -54.1' PLD, con 2' de tolerancia de dragado | | | | | | | |
| Sta.( 68+415 @ 70+000 )-Nva. Draga | | B/. 8,969,780.00 | | | | | B/. 8,969,780.00 |
| Sta.( 70+000 @ 74+000 )-Nva. Draga | | | B/. 13,751,403.00 | | | | B/. 13,751,403.00 |
| Sta.( 74+000 @ 76+000 )-Mindi + Booster | | | B/. 9,521,905.64 | B/. 1,705,278.36 | | | B/. 11,227,184.00 |
| Sta.( 76+000 @ 78+000 )-Mindi + Booster | | | | B/. 4,885,173.00 | | | B/. 4,885,173.00 |
| Sta.( 78+000 @ 80+000 )-Mindi + Booster | | | | B/. 3,824,515.00 | | | B/. 3,824,515.00 |
| Sta.( 80+000 @ 82+000 )-Nva. Draga | | | | B/. 4,471,650.00 | | | B/. 4,471,650.00 |
| Sta.( 82+000 @ 83+000 )-Mindi + Booster | | | | B/. 568,408.00 | | | B/. 568,408.00 |
| Sta.( 83+000 @ 85+920 ) | | | | | | | |
| Profundización-Entrada del Pacifico ( Calado 46' ) | | | | | | | |
| Profundización-Entrada del Pacifico ( Calado 50' ) | | | | | | | |
| Total | B/. 12,305,668.54 | B/. 33,472,948.63 | B/. 47,118,832.37 | B/. 29,904,857.46 | | | B/. 122,802,307.00 |

Alternativas-Profundización de entrada del Pacifico(rev.22)
Cash Flow - Draft 46'

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
|---|---|---|---|---|---|---|---|
| ALTERNATIVAS-PROFUNDIZACIÓN ENTRADA DEL PACIFICO | | | | | | | |
| Profundización-Entrada del Pacifico ( Calado 41.5' ) | | | | | | | |
| Profundización-Entrada del Pacifico ( Calado 46' ) | | | | | | | |
| Perforación y Voladura de -52.1' @ -66.6' PLD | | | | | | | |
| Sta.( 71+200 @ 74+000 )-Thor | B/. 6,024,160.43 | B/. 12,015,401.96 | B/. 5,867,795.61 | | | | B/. 23,907,358.00 |
| Sta.( 74+000 @ 76+000 )-Nva. Perf. | B/. 6,038,216.30 | B/. 7,899,724.70 | | | | | B/. 13,937,941.00 |
| Sta.( 76+000 @ 78+000 )-Thor | | | B/. 6,276,462.19 | B/. 9,110,812.81 | | | B/. 15,387,275.00 |
| Sta.( 78+000 @ 80+000 )-Nva. Perf. | | B/. 4,126,950.82 | B/. 7,467,946.18 | | | | B/. 11,594,897.00 |
| Sta.( 80+000 @ 82+000 )-Nva. Perf. | | | B/. 4,911,698.22 | B/. 1,328,208.78 | | | B/. 6,239,907.00 |
| Sta.( 82+000 @ 83+000 )-Nva. Perf. | | | | B/. 4,014,886.00 | | | B/. 4,014,886.00 |
| Sta.( 83+000 @ 85+920 ) | | | | | | | |
| Dragado de -52.1' @ -58.6' PLD, con 2' de tolerancia de dragado | | | | | | | |
| Sta.( 71+200 @ 74+000 )-Nva. Draga | | | B/. 13,086,584.58 | B/. 9,846,434.42 | | | B/. 22,933,019.00 |
| Sta.( 74+000 @ 76+000 )-Mindi + Booster | | B/. 2,296,653.71 | B/. 18,628,413.43 | B/. 1,012,228.86 | | | B/. 21,937,296.00 |
| Sta.( 76+000 @ 78+000 )-Mindi + Booster | | | | B/. 14,332,479.00 | | | B/. 14,332,479.00 |
| Sta.( 78+000 @ 80+000 )-Mindi + Booster | | | | B/. 3,217,813.94 | B/. 8,006,466.06 | | B/. 11,224,280.00 |
| Sta.( 80+000 @ 82+000 )-Nva. Draga | | | | B/. 7,956,630.13 | B/. 3,353,481.87 | | B/. 11,310,112.00 |
| Sta.( 82+000 @ 83+000 )-Nva + Booster | | | | | B/. 2,702,778.00 | | B/. 2,702,778.00 |
| Sta.( 83+000 @ 85+920 )-Nva. + Booster | | | | | B/. 701,811.00 | | B/. 701,811.00 |
| Profundización-Entrada del Pacifico ( Calado 50' ) | | | | | | | |
| Total | B/. 12,062,376.73 | B/. 26,338,731..19 | B/. 56,238,900.21 | B/. 50,819,493.94 | B/. 14,764,536.93 | | B/. 160,224,039.00 |

Alternativas-Profundización de entrada del Pacífico(rev.22)
Cash Flow - Draft 50'

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
|---|---|---|---|---|---|---|---|
| ALTERNATIVAS-PROFUNDIZACIÓN ENTRADA DEL PACÍFICO | | | | | | | |
| Profundización-Entrada del Pacifico ( Calado 41.5' ) | | | | | | | |
| Profundización-Entrada del Pacifico ( Calado 46' ) | | | | | | | |
| Profundización-Entrada del Pacifico ( Calado 50' ) | | | | | | | |
| Perforación y Voladura de -52.1' @ -70.6' PLD | | | | | | | |
| Sta.( 71+200 @ 74+000 )-Thor | B/. 6,069,860.65 | B/. 12,106,552.67 | B/. 10,077,737.68 | | | | B/. 28,254,151.00 |
| Sta.( 74+000 @ 76+000 )-Nva. Perf. | B/. 6,183,533.45 | B/. 9,745,541.55 | | | | | B/. 15,929,075.00 |
| Sta.( 76+000 @ 78+000 )-Thor | | | B/. 1,985,728.44 | B/. 11,881,906.43 | B/. 5,832,739.13 | | B/. 19,700,374.00 |
| Sta.( 78+000 @ 80+000 )-Nva. Perf. | | B/. 2,555,237.93 | B/. 11,305,329.07 | | | | B/. 13,860,567.00 |
| Sta.( 80+000 @ 82+000 )-Nva. Perf. | | | B/. 824,157.20 | B/. 6,307,164.80 | | | B/. 7,131,322.00 |
| Sta.( 82+000 @ 83+000 )-Nva. Perf. | | | | B/. 4,588,441.00 | | | B/. 4,588,441.00 |
| Sta.( 83+000 @ 85+920 ) | | | | | | | |
| Dragado de -52.1' @ -62.6' PLD, con 2' de tolerancia de dragado | | | | | | | |
| Sta.( 71+200 @ 74+000 )-Nva. Draga | | B/. 2,774,653.66 | B/. 16,832,386.48 | B/. 15,156,833.86 | | | B/. 34,763,874.00 |
| Sta.( 74+000 @ 76+000 )-Mindi + Booster | | B/. 7,275,453.05 | B/. 18,116,250.35 | B/. 6,117,336.59 | | | B/. 31,509,039.99 |
| Sta.( 76+000 @ 78+000 )-Mindi + Booster | | | | B/. 10,095,299.03 | B/. 13,929,815.97 | | B/. 24,025,115.00 |
| Sta.( 78+000 @ 80+000 )-Mindi + Booster | | | | | B/. 4,650,872.37 | B/. 16,502,958.63 | B/. 21,153,831.00 |
| Sta.( 80+000 @ 82+000 )-Nva. Draga | | | | B/. 1,734,516.64 | B/. 16,934,767.36 | | B/. 18,669,284.00 |
| Sta.( 82+000 @ 83+000 )-Nva. Draga + Booster | | | | | B/. 22,421.16 | B/. 7,305,562.84 | B/. 7,327,984.00 |
| Sta.( 83+000 @ 85+920 )-Nva. + Booster | | | | | | B/. 4,083,770.00 | B/. 4,083,770.00 |
| Total | B/. 12,253,394.10 | B/. 34,457,438.86 | B/. 59,141,589.22 | B/. 55,881,498.35 | B/. 41,370,615.99 | B/. 27,892,291.47 | B/. 230,996,827.99 |

**Profundización de entrada del Pacífico, calado de 46' a 50'(rev.22)**
**Cash Flow**

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| PROFUNDIZACIÓN ENTRADA DEL PACÍFICO 46' A 50', EN DOS FASES. | | | | | | | | | | |
| DrillBoat THOR mayor maintenance | | | | | | | | | | |
| New Drillbarge mayor maintenance | | | | | | | | | | |
| MINDI mayor maintenance | | | | | | | | | | |
| New Dredge mayor maintenance | | | | | | | | | | |
| Profundización-Entrada del Pacífico ( Calado 46' ) | | | | | | | | | | |
| Perforación y Voladura de -52.1' @ -66.6' PLD | | | | | | | | | | |
| Sta.( 71+200 @ 74+000 )-Thor | B/. 6,024,160.43 | B/. 12,016,401.96 | B/. 5,887,795.81 | | | | | | | B/. 23,907,358.00 |
| Sta.( 74+000 @ 76+000 )-Nva. Perf. | B/. 6,038,216.50 | B/. 7,899,724.70 | | | | | | | | B/. 13,937,941.00 |
| Sta.( 76+000 @ 78+000 )-Thor | | | B/. 6,276,462.19 | B/. 9,110,812.81 | | | | | | B/. 15,387,275.00 |
| Sta.( 78+000 @ 80+000 )-Nva. Perf. | | B/. 4,126,950.82 | B/. 7,467,946.18 | | | | | | | B/. 11,594,897.00 |
| Sta.( 80+000 @ 82+000 )-Nva. Perf. | | | B/. 4,911,699.22 | B/. 1,328,208.78 | | | | | | B/. 6,239,907.00 |
| Sta.( 82+000 @ 83+000 )-Nva. Perf. | | | | B/. 4,014,886.00 | | | | | | B/. 4,014,888.00 |
| Sta.( 83+000 @ 85+920 ) | | | | | | | | | | |
| Dragado de -52.1' @ -58.6' PLD, con 2' de tolerancia de dragado | | | | | | | | | | |
| Sta.( 71+200 @ 74+000 )-Nva. Draga | | | | B/. 13,181,072.55 | B/. 9,751,946.45 | | | | | B/. 22,933,019.00 |
| Sta.( 74+000 @ 76+000 )-Mindi + Booster | | | | B/. 14,239,253.01 | B/. 7,698,042.99 | | | | | B/. 21,937,296.00 |
| Sta.( 76+000 @ 78+000 )-Mindi + Booster | | | | | B/. 10,835,741.11 | B/. 3,496,737.89 | | | | B/. 14,332,479.00 |
| Sta.( 78+000 @ 80+000 )-Mindi + Booster | | | | | | B/. 11,224,280.00 | | | | B/. 11,224,280.00 |
| Sta.( 80+000 @ 82+000 )-Nva. Draga | | | | | B/. 8,007,121.70 | B/. 3,302,990.30 | | | | B/. 11,310,112.00 |
| Sta.( 82+000 @ 83+000 )-Nva + Booster | | | | | | B/. 2,702,778.00 | | | | B/. 2,702,778.00 |
| Sta.( 83+000 @ 85+920 )-Nva. + Booster | | | | | | B/. 701,811.00 | | | | B/. 701,811.00 |
| Profundización-Entrada del Pacífico ( Calado 50' ) | | | | | | | | | | |
| Perforación y Voladura de -52.1' @ -70.6' PLD | | | | | | | | | | |
| Sta.( 71+200 @ 74+000 )-Thor | | | | B/. 3,069,047.90 | B/. 11,801,957.99 | B/. 4,553,723.40 | | | | B/. 19,424,729.99 |
| Sta.( 74+000 @ 76+000 )-Nva. Perf. | | | | B/. 6,108,144.78 | B/. 5,041,208.22 | | | | | B/. 11,150,353.00 |
| Sta.( 76+000 @ 78+000 )-Thor | | | | | | B/. 1,507,537.95 | B/. 12,036,469.05 | | | B/. 13,544,007.00 |
| Sta.( 78+000 @ 80+000 )-Nva. Perf. | | | | | B/. 1,051,389.17 | B/. 8,651,007.83 | | | | B/. 9,702,397.00 |
| Sta.( 80+000 @ 82+000 )-Nva. Perf. | | | | | | B/. 4,322,384.91 | B/. 669,540.09 | | | B/. 4,991,925.00 |
| Sta.( 82+000 @ 83+000 )-Nva. Perf. | | | | | | | B/. 3,211,908.00 | | | B/. 3,211,908.00 |
| Sta.( 83+000 @ 85+920 ) | | | | | | | | | | |
| Dragado de -52.1' @ -82.6' PLD, con 2' de tolerancia de dragado | | | | | | | | | | |
| Sta.( 71+200 @ 74+000 )-Nva. Draga | | | | | | B/. 10,452,102.18 | B/. 1,378,752.82 | | | B/. 11,830,855.00 |
| Sta.( 74+000 @ 76+000 )-Mindi + Booster | | | | | | | B/. 8,571,744.00 | | | B/. 8,571,744.00 |
| Sta.( 76+000 @ 78+000 )-Mindi + Booster | | | | | | | B/. 8,252,130.32 | B/. 774,616.68 | | B/. 9,026,747.00 |
| Sta.( 78+000 @ 80+000 )-Mindi + Booster | | | | | | | | B/. 8,637,379.00 | | B/. 8,637,379.00 |
| Sta.( 80+000 @ 82+000 )-Nva. Draga | | | | | | | B/. 7,359,172.00 | | | B/. 7,359,172.00 |
| Sta.( 82+000 @ 83+000 )-Nva. Draga + Booster | | | | | | | B/. 4,625,206.00 | | | B/. 4,625,206.00 |
| Sta.( 83+000 @ 85+920 )-Nva. + Booster | | | | | | | B/. 3,381,958.00 | | | B/. 3,381,958.00 |
| Total | B/. 12,062,376.73 | B/. 24,042,077.49 | B/. 24,628,902.20 | B/. 51,052,426.98 | B/. 54,187,407.33 | B/. 50,816,353.46 | B/. 50,466,980.28 | B/. 10,411,996.66 | | B/. 277,882,419.99 |

# APPENDIX No. 8

## Pacific Entrance Deepening for 41.5', 46', and 50' Draft Calculations

# Pacific Entrance Deepening for 41.5' Draft Calculation

# DRILLING BLASTING DURATION BY REACH
# PACIFIC ENTRANCE
# DRAFT 41.5'
# (REV.-22)

| | | | |
|---|---|---|---|
| 1 | B | C | D |
| 2 | **DRILLING AND BLASTING AREA WITH NO RESTRICTIONS - 41.5' DRAFT** | | |
| 3 | **DESCRIPTION** | **THOR** | **New Drill Barge** |
| 4 | Drilling level | PLD-62.1' | PLD-62.1' |
| 5 | **Drilling Grid (feet); Spacing=12.5'; Burden=13'.** | **12.5' x 13'** | **12.5' x 13'** |
| 6 | **Actual pattern area (feet)** | **100' x 52'** | **100' x 52'** |
| 7 | Drilling spacing ( feet ) | 12.5 | 12.5 |
| 8 | Spacing between drilling rows ( feet ) | 13 | 13 |
| 9 | Pattern length (feet) | **100** | **100** |
| 10 | Pattern width (feet) | **52** | **52** |
| 11 | Volume per pattern ( cubic meters) | 1474 | 1474 |
| 12 | Number of patterns | 1 | 1 |
| 13 | Number of rows | 4 | 4 |
| 14 | Drill depth (feet) | 10 | 10 |
| 15 | Number of passes | N / A | N / A |
| 16 | Average time to connect additional drill pipe (minutes) | N / A | N / A |
| 17 | Average time to drill a blasting hole (minutes)-(1) | 14.26 | 12.50 |
| 18 | Install Casing | | 1 |
| 19 | Lower tri-cone column | | 2 |
| 20 | Drill to required depth | | 7.50 |
| 21 | Raise rods, change drill bit for shoe | | n/a |
| 22 | Straighten borehole, sounding and load borehole | | n/a |
| 23 | Remove rods and casing | | 2 |
| 24 | Number of drillholes per line | 8 | 8 |
| 25 | Average time required to drill an 8-hole line (hours) | 1.05 | 0.42 |
| 26 | Rate of perforation per line, per drill tower (feet per minute) | 0.32 | 0.80 |
| 27 | **Average time required to drill a pattern of 4 lines of 8 boreholes each line (in hours)** | **4.20** | **1.67** |
| 28 | Estimated time to move the towers per line (minutes) | 3 | 3 |
| 29 | Moving time for the drillboat barge (minutes) | 17 | 17 |
| 30 | Time for setting explosives per bore hole (minutes) | 6.67 | 6.67 |
| 31 | Total time for setting a line of 8 bore holes (minutes) | 13.34 | 13.34 |
| 32 | Preparation time for blasting one pattern (minutes) | 116.36 | 116.36 |
| 33 | **Preparation time for blasting one pattern (hours)** | **1.94** | **1.94** |
| 34 | **Total time for activities in addition to drilling (hours)** | **1.50** | **1.50** |
| 35 | **Total drilling and blasting time for one pattern (hours)** | **7.64** | **5.11** |
| 36 | **High Tide drilling production factor** | **1.00** | **1.00** |
| 37 | **Number of patterns per week** | **16** | **20** |
| 38 | **Area of progress per week (square meters per week)** | **7,732** | **9,665** |
| 39 | Weekly volume (cubic meters) | **23,576** | **29,470** |
| 40 | Production percentage ratio | 44 | 56 |
| 41 | Rate of perforation per pattern, estimated for one tower in feet per minute. | **0.169** | **0.159** |
| 42 | **Notes:** | | |
| 43 | (1) A 13% increase in the productivity of the drillboat THOR was assumed for the times calculated for the THOR. | | |
| 44 | | | |

# DRILLING BLASTING DURATION BY REACH
# PACIFIC ENTRANCE
# DRAFT 41.5'
# (REV.-22)

**Cell:** C3
**Comment:** All times used to define the THOR productivity were obtained from drilling tests made by Dredging Division to different depths in November 2001.

**Cell:** D3
**Comment:** All times used to define the New Drill Barge productivity were obtained from land based drilling logs provided by Dredging Division.

**Cell:** C11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** D11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** C17
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** C25
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** D25
**Comment:** Total time in cell No. 17 was multiplied by the number of drill holes per line, and then divided by 4 because 4 towers will be installed in the new drill barge.

**Cell:** C31
**Comment:** Total loading time has been divided by four, assuming that the four THOR towers are working simultaneously.

**Cell:** D31
**Comment:** Total loading time has been divided by four because the 4 towers will work simultaneously.

**Cell:** C32
**Comment:** To calculate the THOR blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** D32
**Comment:** To calculate the New Drill barge blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** C34
**Comment:** Time estimate based on the experience of underwater drilling personnel.

# DRILLING BLASTING DURATION BY REACH
# PACIFIC ENTRANCE
# DRAFT 41.5'
# (REV.-22)

**Cell:** D34
**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** C37
**Comment:** Assuming an effective working hours of 18 per day (2 hours of maintenance and relay for each watch).
18 hours times 7 days per week divided by the total drilling and blasting time for one pattern

**Cell:** D37
**Comment:** Assuming an efficiency increase of 25% more than the THOR

**Cell:** C38
**Comment:** Area of progress per week equals the number of patterns per week multiplied by the area of a pattern.

**Cell:** C39
**Comment:** Volume of progress per week equals the number of patterns per week multiplied by the volume of one pattern.

**DRILLING BLASTING DURATION BY REACH**
**PACIFIC ENTRANCE**
**DRAFT 41.5'**
**(REV.-22)**

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | **AREA AND VOLUME - DRAFT 41.5'** | | | | |
| 3 | | Dredging Volume from -52.1' to -54.1' PLD (mts3) | Overdredge Volume from -54.1' to -56.1' PLD (mts3) | D&B from -52.1 to -62.1 PLD($mts^2$) | % Drilling & Blasting Required | Net Area for D&B -52.1'to -62.1' PLD (mts2) |
| 4 | **Pacific Entrance Deepening** | | | | | |
| 5 | **STA( 68+415 @ 70+000 )** | 408,134 | 203,720 | 511,950 | 100% | 511,950 |
| 6 | **STA( 70+000 @ 74+000 )** | 576,075 | 361,947 | 598,200 | 100% | 598,200 |
| 7 | **STA( 74+000 @ 76+000 )** | 452,291 | 249,408 | 429,230 | 100% | 429,230 |
| 8 | **STA( 76+000 @ 78+000 )** | 158,012 | 179,735 | 458,350 | 84% | 385,014 |
| 9 | **STA( 78+000 @ 80+000 )** | 200,718 | 58,536 | 410,430 | 87% | 357,074 |
| 10 | **STA( 80+000 @ 82+000 )** | 298,098 | 207,059 | 565,185 | 34% | 192,163 |
| 11 | **STA( 82+000 @ 83+000 )** | 5,564 | 54,250 | 386,380 | 32% | 123,642 |
| 12 | **STA( 83+000 @ 85+920 )** | 0 | 289 | 892,936 | 0% | 0 |
| 13 | **TOTAL** | 2,098,892 | 1,314,944.00 | 4,252,661.00 | | 2,597,273 |

# DRILLING BLASTING DURATION BY REACH
# PACIFIC ENTRANCE
# DRAFT 41.5'
# (REV.-22)

**Cell:** C3
**Comment:** The dredging volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** D3
**Comment:** The overdredge volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** E3
**Comment:** Reach area is calculated using AUTOCAD software.

**Cell:** F3
**Comment:** Percentages based on seismic profiles data of November 1999, performed by Coastal and Inland Marine Services.

**Cell:** G3
**Comment:** Drilling and Blasting net area for each reach was calculated by multiplying the area of each reach (Col. E) by the percentage of hard material, according to the seismic profiles( Col. F ).

**DRILLING BLASTING DURATION BY REACH**
**PACIFIC ENTRANCE**
**DRAFT 41.5'**
**(REV.-22)**

| 1 | B | C | D | E | F |
|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Areas ( $m^3$)** | AVAILABLE DRILLBOATS | DRILLBOAT PRODUCTIVITY | Duration (weeks) |
| 3 | | D&B from -52.1' to -62.1' PLD | | $Mts^2$/ week | Total duration per reach |
| 4 | **PACIFIC ENTRANCE** | | | | |
| 5 | STA( 68+415 @ 70+000 ) | 511,950 | New Drill Boat | 9,665 | 53 |
| 6 | STA( 70+000 @ 74+000 ) | 598,200 | Thor | 7,732 | 77 |
| 7 | STA( 74+000 @ 76+000 ) | 429,230 | New Drill Boat | 9,665 | 44 |
| 8 | STA( 76+000 @ 78+000 ) | 385,014 | Thor | 7,732 | 50 |
| 9 | STA( 78+000 @ 80+000 ) | 357,074 | New Drill Boat | 9,665 | 37 |
| 10 | STA( 80+000 @ 82+000 ) | 192,163 | Thor | 7,732 | 25 |
| 11 | STA( 82+000 @ 83+000 ) | 123,642 | New Drill Boat | 9,665 | 13 |
| 12 | STA( 83+000 @ 85+920 ) | 0 | | | |
| 13 | **TOTAL** | 2,597,273 | | | 299 |
| 14 | | | | | |
| 15 | | | | | |

## DRILLING BLASTING DURATION BY REACH
## PACIFIC ENTRANCE
## DRAFT 41.5'
## (REV.-22)

**Cell:** E2
**Comment:** Output values correspond to the equipment productivity by areas of progress determined in Spreadsheet No. 1, comparative table of drilling times for the THOR and the new drillboat with four towers.

**Cell:** E3
**Comment:** Output is the number of drilling patterns per week multiplied by the area of a pattern of 100' by 52'.

# DRILLING BLASTING DURATION BY REACH
## PACIFIC ENTRANCE
## DRAFT 41.5'
## (REV.-22)

| 1 | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | REACHES | VOLUME - DRAFT 41.5' ( $m^3$ ) | | | Hard & Medium Material Estimated Percentage | Hard and medium material volume ($mts^3$) | Soft material volume ($mts^3$) | AVAILABLE DREDGES | DREDGE PRODUCVITY ($M^3$/WEEK) | | Duration (weeks) | | TOTAL DURATION (weeks) |
| 3 | | Dredging Volume from -52.1' to -54.1' PLD (mts3) | Overdredge Volume from -54.1' to -56.1' PLD (mts3) | Dredging Total Volume ($mts^3$) | | | | | Hard and Medium Material | Soft Material | Hard and Medium Material | Soft Material | |
| 4 | **PACIFIC ENTRANCE** | | | | | | | | | | | | |
| 5 | STA( 68+415 @ 70+000 ) | 408,134 | 203,720 | 611,854 | 100% | 611,854 | 0 | New Dredge | 24,000 | 60,000 | 25 | 0 | 25 |
| 6 | STA( 70+000 @ 74+000 ) | 576,075 | 361,947 | 938,022 | 100% | 938,022 | 0 | New Dredge | 24,000 | 60,000 | 39 | 0 | 39 |
| 7 | STA( 74+000 @ 76+000 ) | 452,291 | 249,408 | 701,699 | 100% | 701,699 | 0 | Mindi | 24,000 | 60,000 | 29 | 0 | 29 |
| 8 | STA( 76+000 @ 78+000 ) | 158,012 | 179,735 | 337,747 | 84% | 283,707 | 54,040 | Mindi | 24,000 | 60,000 | 12 | 1 | 13 |
| 9 | STA( 78+000 @ 80+000 ) | 200,718 | 58,536 | 259,254 | 87% | 225,551 | 33,703 | Mindi | 24,000 | 60,000 | 9 | 1 | 10 |
| 10 | STA( 80+000 @ 82+000 ) | 298,098 | 207,059 | 505,157 | 34% | 171,753 | 333,404 | New Dredge | 24,000 | 60,000 | 7 | 6 | 13 |
| 11 | STA( 82+000 @ 83+000 ) | 5,564 | 54,250 | 59,814 | 32% | 19,140 | 40,674 | Mindi | 24,000 | 60,000 | 1 | 1 | 1 |
| 12 | STA( 83+000 @ 85+920 ) | 0 | 289 | 289 | 0% | 0 | 289 | Mindi | 24,000 | 60,000 | 0 | 0 | 0 |
| 13 | **TOTAL** | **2,098,892** | **1,314,944** | **3,413,836** | | **2,951,727** | **462,109** | | | | 123 | 8 | **131** |

# DRILLING BLASTING DURATION BY REACH
# PACIFIC ENTRANCE
# DRAFT 41.5'
# (REV.-22)

**Cell:** F2
**Comment:** Percentages based on seismic profiles data of November 1999, performed by Coastal and Inland Marine Services.

**Cell:** G2
**Comment:** Hard and medium material volume was estimated by multipling column E by column F.

**Cell:** H2
**Comment:** Soft material volume was estimated by the difference of column E minus column G.

**Cell:** J2
**Comment:** Average historical value provided by Operations Branch of Dredging Division.

**Cell:** L2
**Comment:** Duration was calculated by dividing the volume of hard or soft material by the corresponding productivity.

**Cell:** N2
**Comment:** Total duration is the sum of column L plus column M.

**Cell:** C3
**Comment:** Value imported from spreadsheet 2, column C; corresponding to the dredging volume calculated by the Geothechnical Section .

**Cell:** D3
**Comment:** Value imported from spreadsheet 2, column D; corresponding to the dredging volume calculated by the Geothechnical Section .

**Cell:** E3
**Comment:** The Total dredging volume is the sum of column C plus column D.

**DRILLING BLASTING DURATION BY REACH**
**PACIFIC ENTRANCE**
**DRAFT 41.5'**
**(REV.-22)**

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | | Available Drillboat | DURATION (WEEKS) | Cost ($ per week) | Drilling & Blasting Cost ($) |
| 3 | | D&B from -52.1' to -62.1' PLD | | | | |
| 4 | **Pacific Entrance** | | | | | |
| 5 | STA( 68+415 @ 70+000 ) | 511,950 | New Drillboat (4 Towers) | 53 | $251,084 | $13,299,218 |
| 6 | STA( 70+000 @ 74+000 ) | 598,200 | Thor | 77 | $251,084 | $19,424,729 |
| 7 | STA( 74+000 @ 76+000 ) | 429,230 | New Drillboat (4 Towers) | 44 | $251,084 | $11,150,353 |
| 8 | STA( 76+000 @ 78+000 ) | 385,014 | Thor | 50 | $251,084 | $12,502,161 |
| 9 | STA( 78+000 @ 80+000 ) | 357,074 | New Drillboat (4 Towers) | 37 | $251,084 | $9,275,918 |
| 10 | STA( 80+000 @ 82+000 ) | 192,163 | Thor | 25 | $251,084 | $6,239,907 |
| 11 | STA( 82+000 @ 83+000 ) | 123,642 | New Drillboat (4 Towers) | 13 | $251,084 | $3,211,908 |
| 12 | STA( 83+000 @ 85+920 ) | 0 | | | | |
| 13 | **TOTAL** | 2,597,273 | | 299 | | **$75,104,193** |
| 14 | | | | | | |

# DRILLING BLASTING DURATION BY REACH
# PACIFIC ENTRANCE
# DRAFT 41.5'
# (REV.-22)

**Cell:** E2
**Comment:** Value imported from Spreadsheet 3, Column F.

**Cell:** F2
**Comment:** THOR operating costs per week were calculated by dividing the average monthly operation cost ($1,087,195) by 4.33 weeks per month. To calculate operating cost of a new drillboat with four towers, the THOR cost was used as a reference.

**Cell:** G2
**Comment:** The cost per reach is equal to the total duration per reach in weeks (E) multiplied by the operation cost per week (F), including explosives.

**Cell:** C3
**Comment:** Value imported from Spreadsheet 2, Column G.

## DRILLING BLASTING DURATION BY REACH
## PACIFIC ENTRANCE
## DRAFT 41.5'
## (REV.-22)

| 1 | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | REACHES | VOLUME - DRAFT 41.5' ( $m^3$ ) | | | Available Dredge | Hard and medium material volume | Soft material volume | DREDGIGN UNIT COST | | TOTAL COST BY REACH |
| 3 | | Dredging Volume from -52.1' to -54.1' PLD (mts3) | Overdredge Volume from -54.1' to -56.1' PLD (mts3) | Dredging Total Volume ($m^3$) | | | | Hard and Medium Material | Soft material | |
| 4 | Pacific Entrance | | | | | | | | | |
| 5 | STA( 68+415 @ 70+000 ) | 408,134 | 203,720 | 611,854 | New Dredge | 611,854 | 0 | $14.66 | $5.86 | $8,969,780 |
| 6 | STA( 70+000 @ 74+000 ) | 576,075 | 361,947 | 938,022 | New Dredge | 938,022 | 0 | $14.66 | $5.86 | $13,751,403 |
| 7 | STA( 74+000 @ 76+000 ) | 452,291 | 249,408 | 701,699 | Mindi + Booster | 701,699 | 0 | $16.00 | $6.40 | $11,227,184 |
| 8 | STA( 76+000 @ 78+000 ) | 158,012 | 179,735 | 337,747 | Mindi + Booster | 283,707 | 54,040 | $16.00 | $6.40 | $4,885,173 |
| 9 | STA( 78+000 @ 80+000 ) | 200,718 | 58,536 | 259,254 | Mindi + Booster | 225,551 | 33,703 | $16.00 | $6.40 | $3,824,515 |
| 10 | STA( 80+000 @ 82+000 ) | 298,098 | 207,059 | 505,157 | New Dredge | 171,753 | 333,404 | $14.66 | $5.86 | $4,471,650 |
| 11 | STA( 82+000 @ 83+000 ) | 5,564 | 54,250 | 59,814 | Mindi + Booster | 19,140 | 40,674 | $16.00 | $6.40 | $566,558 |
| 12 | STA( 83+000 @ 85+920 ) | 0 | 289 | 289 | Mindi + Booster | 0 | 289 | $16.00 | $6.40 | $1,850 |
| 13 | TOTAL | 2,098,892 | 1,314,944 | 3,413,836 | | | | | | $47,698,111 |
| 14 | | | | | | | | | | |
| 15 | DREDGING UNIT COST | | | | | | | | | |
| 16 | DESCRIPTION | HARD MATERIAL | SOFT MATERIAL | | | | | | | |
| 17 | PRODUCTION ($m^3$/wk) | 24,000 | 60,000 | | | | | | | |
| 18 | MINDI or NEW DREDGE COST ( $/$m^3$ ) | $14.66 | $5.86 | | | | | | | |
| 19 | BOOSTER COST ( $/$m^3$ ) | $1.34 | $0.54 | | | | | | | |
| 20 | MINDI + BOOSTER COST ( $/$m^3$ ) | $16.00 | $6.40 | | | | | | | |

# DRILLING BLASTING DURATION BY REACH
# PACIFIC ENTRANCE
# DRAFT 41.5'
# (REV.-22)

**Cell:** G2
**Comment:** Value imported from spreadsheet 4, column G.

**Cell:** H2
**Comment:** Value imported from spreadsheet 4, column H.

**Cell:** I2
**Comment:** Dredging unit costs were estimated based on equipment production related to the submarine soil geologic condition, and the addition of a Booster pump based on the distance from the reach to the dispossal site.

**Cell:** K2
**Comment:** Total cost by reach is equal to the product of the volume of hard or soft material by the corresponding unit price, considering or not the use of a booster pump. Therfore the formula used was equal to=( Col G*Col.I + Col.H*Col.J).

**Cell:** C3
**Comment:** Value imported from spreadsheet 2, column C.

**Cell:** D3
**Comment:** Value imported from spreadsheet 2, column D.

**Cell:** E3
**Comment:** The Total dredging volume is the sum of column C plus column D.

**Cell:** I3
**Comment:** Unit cost imported from table at the lower left corner.

**Cell:** J3
**Comment:** Unit cost imported from table at the lower left corner.

# Pacific Entrance Deepening for 46'Draft Calculation

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 46'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

| 1 | B | C | D |
|---|---|---|---|
| 2 | **DRILLING AND BLASTING AREA WITH NO RESTRICTIONS - 46' DRAFT** | | |
| 3 | **DESCRIPTION** | **THOR** | **4-TOWER** |
| 4 | Drilling level | PLD-66.6' | PLD-66.6' |
| 5 | **Drilling Grid (feet); Spacing=12.5'; Burden=13'.** | **12.5' x 13'** | **12.5' x 13'** |
| 6 | **Actual pattern area (feet)** | **100' x 52'** | **100' x 52'** |
| 7 | Drilling spacing ( feet ) | 12.5 | 12.5 |
| 8 | Spacing between drilling rows ( feet ) | 13 | 13 |
| 9 | Pattern length (feet) | **100** | **100** |
| 10 | Pattern width (feet) | **52** | **52** |
| 11 | Volume per pattern ( cubic meters) | 2137 | 2137 |
| 12 | Number of patterns | 1 | 1 |
| 13 | Number of rows | 4 | 4 |
| 14 | Drill depth (feet) | 14.5 | 14.5 |
| 15 | Number of passes | N / A | N / A |
| 16 | Average time to connect additional drill pipe (minutes) | N / A | N / A |
| 17 | Average time to drill a blasting hole (minutes)-(1) | 20.67 | 15.88 |
| 18 | Install Casing | | 1 |
| 19 | Lower tri-cone column | | 2 |
| 20 | Drill to required depth | | 10.88 |
| 21 | Raise rods, change drill bit for shoe | | n/a |
| 22 | Straighten borehole, sounding and load borehole | | n/a |
| 23 | Remove rods and casing | | 2 |
| 24 | Number of drillholes per line | 8 | 8 |
| 25 | Average time required to drill an 8-hole line (hours) | 1.52 | 0.53 |
| 26 | Rate of perforation per line, per drill tower (feet per minute) | 0.32 | 0.91 |
| 27 | **Average time required to drill a pattern of 4 lines of 8 boreholes each line (in hours)** | **6.09** | **2.12** |
| 28 | Estimated time to move the towers per line (minutes) | 3 | 3 |
| 29 | Moving time for the drillboat barge (minutes) | 17 | 17 |
| 30 | Time for setting explosives per bore hole (minutes) | 6.67 | 6.67 |
| 31 | Total time for setting a line of 8 bore holes (minutes) | 13.34 | 13.34 |
| 32 | Preparation time for blasting one pattern (minutes) | 116.36 | 116.36 |
| 33 | **Preparation time for blasting one pattern (hours)** | **1.94** | **1.94** |
| 34 | **Total time for activities in addition to drilling (hours)** | **1.50** | **1.50** |
| 35 | **Total drilling and blasting time for one pattern (hours)** | **9.53** | **5.56** |
| 36 | **High Tide drilling production factor** | **1.00** | **1.00** |
| 37 | **Number of patterns per week** | **13** | **16** |
| 38 | **Area of progress per week (square meters per week)** | **6,283** | **7,732** |
| 39 | Weekly volume (cubic meters) | **27,776** | **34,185** |
| 40 | Production percentage ratio | 45 | 55 |
| 41 | Rate of perforation per pattern, estimated for one tower in feet per minute. | **0.199** | **0.246** |
| 42 | **Notes:** | | |
| 43 | (1) A 13% increase in the productivity of the drillboat THOR was assumed for the times calculated for the THOR. | | |

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 46'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

**Cell:** C3
**Comment:** All times used to define the THOR productivity were obtained from drilling tests made by Dredging Division to different depths in November 2001.

**Cell:** D3
**Comment:** All times used to define the New Drill Barge productivity were obtained from land based drilling logs provided by Dredging Division.

**Cell:** C11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** D11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** C17
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** C25
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** D25
**Comment:** Total time in cell No. 17 was multiplied by the number of drill holes per line, and then divided by 4 because 4 towers will be installed in the new drill barge.

**Cell:** C31
**Comment:** Total loading time has been divided by four, assuming that the four THOR towers are working sinultaneously.

**Cell:** D31
**Comment:** Total loading time has been divided by four because the 4 towers will work simultaneously.

**Cell:** C32
**Comment:** To calculate the THOR blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** D32
**Comment:** To calculate the Tamrocks blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 46'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

**Cell:** C34
**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** D34
**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** C37
**Comment:** Assuming an effective working hours of 18 per day (2 hours of maintenance and relay for each watch). 18 hours times 7 days per week divided by the total drilling and blasting time for one pattern

**Cell:** D37
**Comment:** Assuming an efficiency increase of 25% more than the THOR

**Cell:** C38
**Comment:** Area of progress per week equals the number of patterns per week multiplied by the area of a pattern.

**Cell:** C39
**Comment:** Volume of progress per week equals the number of patterns per week multiplied by the volume of one pattern.

STUDY ELEMENT
DEEPENING PACIFIC ENTRANCE - 46'DRAFT
COMPARATIVE TABLE OF DRILLING TIMES
(REVISION No. 22)

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | **AREA AND VOLUME - DRAFT 46'** | | | | |
| 3 | | Dredging Volume from -52.1' to -58.6' PLD (mts3) | Overdredge Volume from -58.6' to -60.6' PLD (mts3) | D&B from -52.1 to -66.6(mts$^2$) | % Drilling & Blasting Required | Net Area for D&B -52.1´to -66.6' PLD (mts2) |
| 4 | **Pacific Entrance Deepening** | | | | | |
| 5 | **STA( 71+200 @ 74+000 )** | 1,129,205 | 435,121 | 598,200 | 100% | 598,200 |
| 6 | **STA( 74+000 @ 76+000 )** | 1,071,232 | 299,849 | 429,230 | 100% | 429,230 |
| 7 | **STA( 76+000 @ 78+000 )** | 691,987 | 298,920 | 458,350 | 84% | 385,014 |
| 8 | **STA( 78+000 @ 80+000 )** | 479,297 | 281,568 | 410,430 | 87% | 357,074 |
| 9 | **STA( 80+000 @ 82+000 )** | 834,118 | 443,572 | 565,185 | 34% | 192,163 |
| 10 | **STA( 82+000 @ 83+000 )** | 134,534 | 150,810 | 386,380 | 32% | 123,642 |
| 11 | **STA( 83+000 @ 85+920 )** | 51,135 | 58,523 | 892,936 | 0% | 0 |
| 12 | **TOTAL** | 4,391,508 | 1,968,363 | 3,740,711 | | 2,085,323 |

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 46'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

**Cell:** C3
**Comment:** The dredging volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** D3
**Comment:** The overdredge volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** E3
**Comment:** Reach area is calculated using AUTOCAD software.

**Cell:** F3
**Comment:** Percentages based on seismic profiles data of November 1999, performed by Coastal and Inland Marine Services.

**Cell:** G3
**Comment:** Drilling and Blasting net area for each reach was calculated by multiplying the area of each reach (Col. E) by the percentage of hard material, according to the seismic profiles( Col. F ).

STUDY ELEMENT
DEEPENING PACIFIC ENTRANCE - 46'DRAFT
COMPARATIVE TABLE OF DRILLING TIMES
(REVISION No. 22)

| B | C | D | E | F |
|---|---|---|---|---|
| REACHES | Net Areas ($m^3$) | AVAILABLE DRILLBOATS | DRILLBOAT PRODUCTIVITY | Duration (weeks) |
| | D&B from -52.1' to -66.6' PLD | | $Mts^2$ / week | Total duration per reach |
| Pacific Entrance | | | | |
| STA( 71+200 @ 74+000 ) | 598,200 | Thor | 6,283 | 95 |
| STA( 74+000 @ 76+000 ) | 429,230 | New Barge(4 towers) | 7,732 | 56 |
| STA( 76+000 @ 78+000 ) | 385,014 | Thor | 6,283 | 61 |
| STA( 78+000 @ 80+000 ) | 357,074 | New Barge(4 towers) | 7,732 | 46 |
| STA( 80+000 @ 82+000 ) | 192,163 | New Barge(4 towers) | 7,732 | 25 |
| STA( 82+000 @ 83+000 ) | 123,642 | New Barge(4 towers) | 7,732 | 16 |
| STA( 83+000 @ 85+920 ) | 0 | | | |
| TOTAL | 2,085,323 | | | 299 |

**Notas:**

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 46'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

**Cell:** E2
**Comment:** Output values correspond to the equipment productivity by areas of progress determined in Spreadsheet No. 1, comparative table of drilling times for the THOR and the new drillboat with four towers.

**Cell:** E3
**Comment:** Output is the number of drilling patterns per week multiplied by the area of a pattern of 100' by 52'.

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 46'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

| 1 | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | **REACHES** | **VOLUME - DRAFT 46' ( $m^3$ )** | | | Hard and Medium Material Estimated Percentage | Hard and medium material volume ($m^3$) | Soft material volume ($m^3$) | AVAILABLE DREDGES | DREDGE PRODUCVITY ($M^3$/ WEEK) | | Duration (weeks) | | TOTAL DURATION (weeks) |
| 3 | | Dredging Volume from -52.1' to -58.6' PLD (mts3) | Overdredge Volume from -58.6' to -60.6' PLD (mts3) | Dredging Total Volume ($mts^3$) | | | | | Hard and Medium Material | Soft Material | Hard and Medium Material | Soft Material | |
| 4 | **Pacific Entrance** | | | | | | | | | | | | |
| 5 | STA( 71+200 @ 74+000 ) | 1,129,205 | 435,121 | 1,564,326 | 100% | 1,564,326 | 0 | New Dredge | 24000 | 60,000 | 65 | 0 | 65 |
| 6 | STA( 74+000 @ 76+000 ) | 1,071,232 | 299,849 | 1,371,081 | 100% | 1,371,081 | 0 | Mindi+Booster | 24000 | 60,000 | 57 | 0 | 57 |
| 7 | STA( 76+000 @ 78+000 ) | 691,987 | 298,920 | 990,907 | 84% | 832,362 | 158,545 | Mindi+Booster | 24000 | 60,000 | 35 | 3 | 37 |
| 8 | STA( 78+000 @ 80+000 ) | 479,297 | 281,568 | 760,865 | 87% | 661,953 | 98,912 | Mindi+Booster | 24000 | 60,000 | 28 | 2 | 29 |
| 9 | STA( 80+000 @ 82+000 ) | 834,118 | 443,572 | 1,277,690 | 34% | 434,415 | 843,275 | New Dredge | 24000 | 60,000 | 18 | 14 | 32 |
| 10 | STA( 82+000 @ 83+000 ) | 134,534 | 150,810 | 285,344 | 32% | 91,310 | 194,034 | Dredge + Booster | 24000 | 60,000 | 4 | 3 | 7 |
| 11 | STA( 83+000 @ 85+920 ) | 51,135 | 58,523 | 109,658 | 0% | 0 | 109,658 | Dredge + Booster | 24000 | 60,000 | 0 | 2 | 2 |
| 12 | **TOTAL** | **4,391,508** | **1,968,363** | **6,359,871** | | **4,955,446** | **1,404,425** | | | | | | |

**Cell:** F2
**Comment:** Percentages based on seismic profiles data of November 1999, performed by Coastal and Inland Marine Services.

**Cell:** G2
**Comment:** Hard and medium material volume was estimated by multipling column E by column F.

**Cell:** H2
**Comment:** Soft material volume was estimated by the difference of column E minus column G.

**Cell:** J2
**Comment:** Average historical value provided by Operations Branch of Dredging Division.

**Cell:** L2
**Comment:** Duration was calculated by dividing the volume of hard or soft material by the corresponding productivity.

**Cell:** N2
**Comment:** Total duration is the sum of column L plus column M.

**Cell:** C3
**Comment:** Value imported from spreadsheet 2, column C; corresponding to the dredging volume calculated by the Geothechnical Section .

**Cell:** D3
**Comment:** Value imported from spreadsheet 2, column D; corresponding to the dredging volume calculated by the Geothechnical Section .

**Cell:** E3
**Comment:** The Total dredging volume is the sum of column C plus column D.

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 46'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Area ($m^3$)** | Available Drillboat | DURATION (WEEKS) | Cost ($ per week) | Drilling & Blasting Cost ($) |
| 3 | | D&B from -52.1' to -66.6' PLD | | | | |
| 4 | **Pacific Entrance** | | | | | |
| 5 | **STA( 71+200 @ 74+000 )** | 598,200 | Thor | 95 | $251,084 | $23,907,358 |
| 6 | **STA( 74+000 @ 76+000 )** | 429,230 | New Barge(4 towers) | 56 | $251,084 | $13,937,941 |
| 7 | **STA( 76+000 @ 78+000 )** | 385,014 | Thor | 61 | $251,084 | $15,387,275 |
| 8 | **STA( 78+000 @ 80+000 )** | 357,074 | New Barge(4 towers) | 46 | $251,084 | $11,594,897 |
| 9 | **STA( 80+000 @ 82+000 )** | 192,163 | New Barge(4 towers) | 25 | $251,084 | $6,239,907 |
| 10 | **STA( 82+000 @ 83+000 )** | 123,642 | New Barge(4 towers) | 16 | $251,084 | $4,014,886 |
| 11 | **STA( 83+000 @ 85+920 )** | 0 | | | | |
| 12 | **TOTAL** | 2,085,323 | | | | **$75,082,264** |
| 13 | | | | | | |
| 14 | | | | | | |

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 46'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

**Cell:** E2
**Comment:** Value imported from Spreadsheet 3, Column F.

**Cell:** F2
**Comment:** THOR operating costs per week were calculated by dividing the average monthly operation cost ($1,087,195) by 4.33 weeks per month. To calculate operating cost of a new drillboat with four towers, the THOR cost was used as a reference.

**Cell:** G2
**Comment:** The cost per reach is equal to the total duration per reach in weeks (E) multiplied by the operation cost per week (F), including explosives.

**Cell:** C3
**Comment:** Value imported from Spreadsheet 2, Column G.

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 46'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

| 1 | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | **REACHES** | **VOLUME - DRAFT 46' ( $m^3$ )** | | | Available Dredge | Hard and medium hard material volume | Soft material volume | DREDGIGN UNIT COST | | TOTAL COST BY REACH |
| 3 | | Dredging Volume from 52.1' to -58.6' PLD (mts3) | Overdredge Volume from -58.6' to -60.6' PLD (mts3) | Dredging Total Volume ($m^3$) | | | | Hard and Medium Hard Material | Soft material | |
| 4 | **Pacific Entrance** | | | | | | | | | |
| 5 | STA( 71+200 @ 74+000 ) | 1,129,205 | 435,121 | 1,564,326 | New Dredge | 1,564,326 | 0 | $14.66 | $5.86 | $22,933,019 |
| 6 | STA( 74+000 @ 76+000 ) | 1,071,232 | 299,849 | 1,371,081 | Mindi + Booster | 1,371,081 | 0 | $16.00 | $6.40 | $21,937,296 |
| 7 | STA( 76+000 @ 78+000 ) | 691,987 | 298,920 | 990,907 | Mindi + Booster | 832,362 | 158,545 | $16.00 | $6.40 | $14,332,479 |
| 8 | STA( 78+000 @ 80+000 ) | 479,297 | 281,568 | 760,865 | Mindi + Booster | 661,953 | 98,912 | $16.00 | $6.40 | $11,224,280 |
| 9 | STA( 80+000 @ 82+000 ) | 834,118 | 443,572 | 1,277,690 | New Dredge | 434,415 | 843,275 | $14.66 | $5.86 | $11,310,112 |
| 10 | STA( 82+000 @ 83+000 ) | 134,534 | 150,810 | 285,344 | Dredge + Booster | 91,310 | 194,034 | $16.00 | $6.40 | $2,702,778 |
| 11 | STA( 83+000 @ 85+920 ) | 51,135 | 58,523 | 109,658 | Dredge + Booster | 0 | 109,658 | $16.00 | $6.40 | $701,811 |
| 12 | **TOTAL** | **4,391,508** | **1,968,363** | **6,359,871** | | | | | | **$85,141,776** |
| 13 | | | | | | | | | | |
| 14 | **DREDGING UNIT COST** | | | | | | | | | |
| 15 | **DESCRIPTION** | **HARD MATERIAL** | **SOFT MATERIAL** | | | | | | | |
| 16 | PRODUCTION ($m^3$/wk) | 24,000 | 60,000 | | | | | | | |
| 17 | MINDI COST ( $/$m^3$ ) | $14.66 | $5.86 | | | | | | | |
| 18 | BOOSTER COST ( $/$m^3$ ) | $1.34 | $0.54 | | | | | | | |
| 19 | MINDI + BOOSTER COST ( $/$m^3$ ) | $16.00 | $6.40 | | | | | | | |

**Cell:** G2
**Comment:** Value imported from spreadsheet 4, column G.

**Cell:** H2
**Comment:** Value imported from spreadsheet 4, column H.

**Cell:** I2
**Comment:** Dredging unit costs were estimated based on equipment production related to the submarine soil geologic condition, and the addition of a Booster pump based on the distance from the reach to the dispossal site.

**Cell:** K2
**Comment:** Total cost by reach is equal to the product of the volume of hard or soft material by the corresponding unit price, considering or not the use of a booster pump. Therfore the formula used was equal to=( Col G*Col.I + Col.H*Col.J).

**Cell:** C3
**Comment:** Value imported from spreadsheet 2, column C.

**Cell:** D3
**Comment:** Value imported from spreadsheet 2, column D.

**Cell:** E3
**Comment:** The Total dredging volume is the sum of column C plus column D.

**Cell:** I3
**Comment:** Unit cost imported from table at the lower left corner.

**Cell:** J3
**Comment:** Unit cost imported from table at the lower left corner.

# Pacific Entrance Deepening for 50' Draft Calculation

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 50'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

| | | | |
|---|---|---|---|
| 1 | B | C | D |
| 2 | **DRILLING AND BLASTING AREA WITH NO RESTRICTIONS - 50' DRAFT** | | |
| 3 | **DESCRIPTION** | **THOR** | **4-TOWER** |
| 4 | Drilling level | PLD-70.6' | PLD-70.6' |
| 5 | **Drilling Grid (feet); Spacing=12.5'; Burden=13'.** | **12.5' x 13'** | **12.5' x 13'** |
| 6 | **Actual pattern area (feet)** | **100' x 52'** | **100' x 52'** |
| 7 | Drilling spacing ( feet ) | 12.5 | 12.5 |
| 8 | Spacing between drilling rows ( feet ) | 13 | 13 |
| 9 | Pattern length (feet) | **100** | **100** |
| 10 | Pattern width (feet) | **52** | **52** |
| 11 | Volume per pattern ( cubic meters) | 2726 | 2726 |
| 12 | Number of patterns | 1 | 1 |
| 13 | Number of rows | 4 | 4 |
| 14 | Drill depth (feet) | 18.5 | 18.5 |
| 15 | Number of passes | N / A | N / A |
| 16 | Average time to connect additional drill pipe (minutes) | N / A | N / A |
| 17 | Average time to drill a blasting hole (minutes)-(1) | 26.37 | 18.88 |
| 18 | Install Casing | | 1 |
| 19 | Lower tri-cone column | | 2 |
| 20 | Drill to required depth | | 13.88 |
| 21 | Raise rods, change drill bit for shoe | | n/a |
| 22 | Straighten borehole, sounding and load borehole | | n/a |
| 23 | Remove rods and casing | | 2 |
| 24 | Number of drillholes per line | 8 | 8 |
| 25 | Average time required to drill an 8-hole line (hours) | 1.94 | 0.63 |
| 26 | Rate of perforation per line, per drill tower (feet per minute) | 0.32 | 0.98 |
| 27 | **Average time required to drill a pattern of 4 lines of 8 boreholes each line (in hours)** | **7.77** | **2.52** |
| 28 | Estimated time to move the towers per line (minutes) | 3 | 3 |
| 29 | Moving time for the drillboat barge (minutes) | 17 | 17 |
| 30 | Time for setting explosives per bore hole (minutes) | 6.67 | 6.67 |
| 31 | Total time for setting a line of 8 bore holes (minutes) | 13.34 | 13.34 |
| 32 | Preparation time for blasting one pattern (minutes) | 116.36 | 116.36 |
| 33 | **Preparation time for blasting one pattern (hours)** | **1.94** | **1.94** |
| 34 | **Total time for activities in addition to drilling (hours)** | **1.50** | **1.50** |
| 35 | **Total drilling and blasting time for one pattern (hours)** | **11.21** | **5.96** |
| 36 | **High Tide drilling production factor** | **1.00** | **1.00** |
| 37 | **Number of patterns per week** | **11** | **14** |
| 38 | **Area of progress per week (square meters per week)** | **5,316** | **6,766** |
| 39 | Weekly volume (cubic meters) | **29,986** | **38,164** |
| 40 | Production percentage ratio | 44 | 56 |
| 41 | Rate of perforation per pattern, estimated for one tower in feet per minute. | **0.215** | **0.274** |
| 42 | **Notes:** | | |
| 43 | (1) A 13% increase in the productivity of the drillboat THOR was assumed for the times calculated for the THOR. | | |

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 50'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

**Cell:** C3
**Comment:** All times used to define the THOR productivity were obtained from drilling tests made by Dredging Division to different depths in November 2001.

**Cell:** D3
**Comment:** All times used to define the Tamrock productivity were obtained from land based drilling logs provided by Dredging Division.

**Cell:** C11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** D11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** C17
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** C25
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** D25
**Comment:** Total time in cell No. 17 was multiplied by the number of drill holes per line, and then divided by 4 because 4 towers will be installed in the new drill barge.

**Cell:** C31
**Comment:** Total loading time has been divided by four, assuming that the four THOR towers are working sinultaneously.

**Cell:** D31
**Comment:** Total loading time has been divided by four because the 4 towers will work simultaneously.

**Cell:** C32
**Comment:** To calculate the THOR blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** D32
**Comment:** To calculate the Tamrocks blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** C34
**Comment:** Time estimate based on the experience of underwater drilling personnel.

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 50'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

**Cell:** D34
**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** C37
**Comment:** Assuming an effective working hours of 18 per day (2 hours of maintenance and relay for each watch).
18 hours times 7 days per week divided by the total drilling and blasting time for one pattern

**Cell:** D37
**Comment:** Assuming an efficiency increase of 25% more than the THOR

**Cell:** C38
**Comment:** Area of progress per week equals the number of patterns per week multiplied by the area of a pattern.

**Cell:** C39
**Comment:** Volume of progress per week equals the number of patterns per week multiplied by the volume of one pattern.

STUDY ELEMENT
DEEPENING PACIFIC ENTRANCE - 50'DRAFT
COMPARATIVE TABLE OF DRILLING TIMES
(REVISION No. 22)

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | **AREA AND VOLUME - DRAFT 50'** | | | | |
| 3 | | Dredging Volume from -52.1' to -62.6' PLD (mts3) | Overdredge Volume from -62.6' to -64.6' PLD (mts3) | D&B from -52.1 to -70.6(mts$^2$) | % Drilling & Blasting Required | Net Area for D&B 52.1´to 70.6' PLD (mts2) |
| 4 | **Pacific Entrance Deepening** | | | | | |
| 5 | STA( 71+200 @ 74+000 ) | 1,908,139 | 463,203 | 598,200 | 100% | 598,200 |
| 6 | STA( 74+000 @ 76+000 ) | 1,669,953 | 299,362 | 429,230 | 100% | 429,230 |
| 7 | STA( 76+000 @ 78+000 ) | 1,288,852 | 298,431 | 458,350 | 91% | 417,099 |
| 8 | STA( 78+000 @ 80+000 ) | 1,090,381 | 307,203 | 410,430 | 91% | 373,491 |
| 9 | STA( 80+000 @ 82+000 ) | 1,692,906 | 416,141 | 565,185 | 34% | 192,163 |
| 10 | STA( 82+000 @ 83+000 ) | 531,991 | 241,656 | 386,380 | 32% | 123,642 |
| 11 | STA( 83+000 @ 85+920 ) | 282,214 | 355,875 | 892,936 | 0% | 0 |
| 12 | **TOTAL** | 8,464,436 | 2,381,871 | 3,740,711 | | 2,133,824 |

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 50'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

**Cell:** C3
**Comment:** The dredging volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** D3
**mment:** The overdredge volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** E3
**mment:** Reach area is calculated using AUTOCAD software.

**Cell:** F3
**mment:** Percentages based on seismic profiles data of November 1999, performed by Coastal and Inland Marine Services.

**Cell:** G3
**Comment:** Drilling and Blasting net area for each reach was calculated by multiplying the area of each reach (Col. E) by the percentage of hard material, according to the seismic profiles( Col. F ).

STUDY ELEMENT
DEEPENING PACIFIC ENTRANCE - 50'DRAFT
COMPARATIVE TABLE OF DRILLING TIMES
(REVISION No. 22)

| 1 | B | C | D | E | F |
|---|---|---|---|---|---|
| 2 | REACHES | Net Areas ( $m^3$ ) | AVAILABLE DRILLBOATS | DRILLBOAT PRODUCTIVITY | Duration (weeks) |
| 3 | | D&B from -52.1' to -70.6' PLD | | $Mts^2$ / week | Total duration per reach |
| 4 | Pacific Entrance Deepening | | | | |
| 5 | STA( 71+200 @ 74+000 ) | 598,200 | Thor | 5,316 | 113 |
| 6 | STA( 74+000 @ 76+000 ) | 429,230 | New Barge(4 towers) | 6,766 | 63 |
| 7 | STA( 76+000 @ 78+000 ) | 417,099 | Thor | 5,316 | 78 |
| 8 | STA( 78+000 @ 80+000 ) | 373,491 | New Barge(4 towers) | 6,766 | 55 |
| 9 | STA( 80+000 @ 82+000 ) | 192,163 | New Barge(4 towers) | 6,766 | 28 |
| 10 | STA( 82+000 @ 83+000 ) | 123,642 | New Barge(4 towers) | 6,766 | 18 |
| 11 | STA( 83+000 @ 85+920 ) | 0 | | | |
| 12 | TOTAL | 2,133,824 | | | 356 |
| 13 | | | | | |
| 14 | | | | | |

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 50'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

**Cell:** E2
**Comment:** Output values correspond to the equipment productivity by areas of progress determined in Spreadsheet No. 1, comparative table of drilling times for the THOR and the new drillboat with four towers.

**Cell:** E3
**Comment:** Output is the number of drilling patterns per week multiplied by the area of a pattern of 100' by 52'.

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 50'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

**Cell:** E2
**Comment:** Output values correspond to the equipment productivity by areas of progress determined in Spreadsheet No. 1, comparative table of drilling times for the THOR and the new drillboat with four towers.

**Cell:** E3
**Comment:** Output is the number of drilling patterns per week multiplied by the area of a pattern of 100' by 52'.

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 50'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

| 1 | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | **REACHES** | **VOLUME - DRAFT 50' ( $m^3$ )** | | | Hard Material Estimated Percentage | Hard and medium material volume | Soft material volume | AVAILABLE DREDGES | DREDGE PRODUCVITY ($M^3$/ WEEK) | | Duration (weeks) | | TOTAL DURATION (weeks) |
| 3 | | Dredging Volume from -52.1' to -62.6' PLD (mts3) | Overdredge Volume from -62.6' to -64.6' PLD (mts3) | Dredging Total Volume ($mts^3$) | | | | | Hard and Medium Material | Soft Material | Hard and Medium Material | Soft Material | |
| 4 | **Pacific Entrance** | | | | | | | | | | | | |
| 5 | STA( 71+200 @ 74+000 ) | 1,908,139 | 463,203 | 2,371,342 | 100% | 2,371,342 | 0 | New Dredge | 24,000 | 60,000 | 99 | 0 | 99 |
| 6 | STA( 74+000 @ 76+000 ) | 1,669,953 | 299,362 | 1,969,315 | 100% | 1,969,315 | 0 | Mindi+Booster | 24,000 | 60,000 | 82 | 0 | 82 |
| 7 | STA( 76+000 @ 78+000 ) | 1,288,852 | 298,431 | 1,587,283 | 91% | 1,444,428 | 142,855 | Mindi+Booster | 24,000 | 60,000 | 60 | 2 | 63 |
| 8 | STA( 78+000 @ 80+000 ) | 1,090,381 | 307,203 | 1,397,584 | 91% | 1,271,801 | 125,783 | Mindi+Booster | 24,000 | 60,000 | 53 | 2 | 55 |
| 9 | STA( 80+000 @ 82+000 ) | 1,692,906 | 416,141 | 2,109,047 | 34% | 717,076 | 1,391,971 | New Dredge | 24,000 | 60,000 | 30 | 23 | 53 |
| 10 | STA( 82+000 @ 83+000 ) | 531,991 | 241,656 | 773,647 | 32% | 247,567 | 526,080 | Dredge+Booster | 24,000 | 60,000 | 10 | 9 | 19 |
| 11 | STA( 83+000 @ 85+920 ) | 282,214 | 355,875 | 638,089 | 0% | 0 | 638,089 | Dredge+Booster | 24,000 | 60,000 | 0 | 11 | 11 |
| 12 | **TOTAL** | **8,464,436** | **2,381,871** | **10,846,307** | | **8,021,529** | **2,824,778** | | | | 334 | 47 | **381** |

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 50'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

**Cell:** F2
**Comment:** Percentages based on seismic profiles data of November 1999, performed by Coastal and Inland Marine Services.

**Cell:** G2
**Comment:** Hard and medium material volume was estimated by multipling column E by column F.

**Cell:** H2
**Comment:** Soft material volume was estimated by the difference of column E minus column G.

**Cell:** J2
**Comment:** Average historical value provided by Operations Branch of Dredging Division.

**Cell:** L2
**Comment:** Duration was calculated by dividing the volume of hard or soft material by the corresponding productivity.

**Cell:** N2
**Comment:** Total duration is the sum of column L plus column M.

**Cell:** C3
**Comment:** Value imported from spreadsheet 2, column C; corresponding to the dredging volume calculated by the Geothechnical Section .

**Cell:** D3
**Comment:** Value imported from spreadsheet 2, column D; corresponding to the dredging volume calculated by the Geothechnical Section .

**Cell:** E3
**Comment:** The Total dredging volume is the sum of column C plus column D.

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 50'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Area (m3)** | Available Drillboat | DURATION (WEEKS) | Cost ($ per week) | Drilling & Blasting Cost ($) |
| 3 | | D&B from -52.1' to -70.6' PLD | | | | |
| 4 | **Pacific Entrance** | | | | | |
| 5 | **STA( 71+200 @ 74+000 )** | 598,200 | Thor | 113 | $251,084 | $28,254,151 |
| 6 | **STA( 74+000 @ 76+000 )** | 429,230 | New Barge(4 towers) | 63 | $251,084 | $15,929,075 |
| 7 | **STA( 76+000 @ 78+000 )** | 417,099 | Thor | 78 | $251,084 | $19,700,374 |
| 8 | **STA( 78+000 @ 80+000 )** | 373,491 | New Barge(4 towers) | 55 | $251,084 | $13,860,567 |
| 9 | **STA( 80+000 @ 82+000 )** | 192,163 | New Barge(4 towers) | 28 | $251,084 | $7,131,322 |
| 10 | **STA( 82+000 @ 83+000 )** | 123,642 | New Barge(4 towers) | 18 | $251,084 | $4,588,441 |
| 11 | **STA( 83+000 @ 85+920 )** | 0 | | | | |
| 12 | **TOTAL** | 2,133,824 | | | | **$89,463,930** |
| 13 | | | | | | |
| 14 | **Notas:** | | | | | |
| 15 | | | | | | |

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 50'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

**Cell:** E2
**Comment:** Value imported from Spreadsheet 3, Column F.

**Cell:** F2
**Comment:** THOR operating costs per week were calculated by dividing the average monthly operation cost ($1,087,195) by 4.33 weeks per month. To calculate operating cost of a new drillboat with four towers, the THOR cost was used as a reference.

**Cell:** G2
**Comment:** The cost per reach is equal to the total duration per reach in weeks (E) multiplied by the operation cost per week (F), including explosives.

**Cell:** C3
**Comment:** Value imported from Spreadsheet 2, Column G.

**STUDY ELEMENT**
**DEEPENING PACIFIC ENTRANCE - 50'DRAFT**
**COMPARATIVE TABLE OF DRILLING TIMES**
**(REVISION No. 22)**

| 1 | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | **REACHES** | **VOLUME - DRAFT 50' ( $m^3$ )** | | | Available Dredge | Hard and medium material volume | Soft material volume | DREDGIGN UNIT COST | | TOTAL COST BY REACH |
| 3 | | Dredging Volume from 52.1' to -62.6' PLD (mts3) | Overdredge Volume from -62.6' to -64.6' PLD (mts3) | Dredging Total Volume ($m^3$) | | | | Hard and Medium Material | Soft material | |
| 4 | **Pacific Entrance** | | | | | | | | | |
| 5 | STA( 71+200 @ 74+000 ) | 1,908,139 | 463,203 | 2,371,342 | New Dredge | 2,371,342 | 0 | $14.66 | $5.86 | $34,763,874 |
| 6 | STA( 74+000 @ 76+000 ) | 1,669,953 | 299,362 | 1,969,315 | Mindi + Booster | 1,969,315 | 0 | $16.00 | $6.40 | $31,509,040 |
| 7 | STA( 76+000 @ 78+000 ) | 1,288,852 | 298,431 | 1,587,283 | Mindi + Booster | 1,444,428 | 142,855 | $16.00 | $6.40 | $24,025,115 |
| 8 | STA( 78+000 @ 80+000 ) | 1,090,381 | 307,203 | 1,397,584 | Mindi + Booster | 1,271,801 | 125,783 | $16.00 | $6.40 | $21,153,831 |
| 9 | STA( 80+000 @ 82+000 ) | 1,692,906 | 416,141 | 2,109,047 | New Dredge | 717,076 | 1,391,971 | $14.66 | $5.86 | $18,669,284 |
| 10 | STA( 82+000 @ 83+000 ) | 531,991 | 241,656 | 773,647 | Dredge+Booster | 247,567 | 526,080 | $16.00 | $6.40 | $7,327,984 |
| 11 | STA( 83+000 @ 85+920 ) | 282,214 | 355,875 | 638,089 | Dredge+Booster | 0 | 638,089 | $16.00 | $6.40 | $4,083,770 |
| 12 | **TOTAL** | **8,464,436** | **2,381,871** | **10,846,307** | | | | | | **$141,532,899** |
| 13 | | | | | | | | | | |

| | | | |
|---|---|---|---|
| 14 | **DREDGING UNIT COST** | | |
| 15 | **DESCRIPTION** | **HARD MATERIAL** | **SOFT MATERIAL** |
| 16 | PRODUCTION ($m^3$/wk) | 24,000 | 60,000 |
| 17 | MINDI COST ( \$/$m^3$ ) | $14.66 | $5.86 |
| 18 | BOOSTER COST ( \$/$m^3$ ) | $1.34 | $0.54 |
| 19 | MINDI + BOOSTER COST ( \$/$m^3$ ) | $16.00 | $6.40 |

**Cell:** G2
**Comment:** Value imported from spreadsheet 4, column G.

**Cell:** H2
**Comment:** Value imported from spreadsheet 4, column H.

**Cell:** I2
**Comment:** Dredging unit costs were estimated based on equipment production related to the submarine soil geologic condition, and the addition of a Booster pump based on the distance from the reach to the dispossal site.

**Cell:** K2
**Comment:** Total cost by reach is equal to the product of the volume of hard or soft material by the corresponding unit price, considering or not the use of a booster pump. Therfore the formula used was equal to=( Col G*Col.I + Col.H*Col.J).

**Cell:** C3
**Comment:** Value imported from spreadsheet 2, column C.

**Cell:** D3
**Comment:** Value imported from spreadsheet 2, column D.

**Cell:** E3
**Comment:** The Total dredging volume is the sum of column C plus column D.

**Cell:** I3
**Comment:** Unit cost imported from table at the lower left corner.

**Cell:** J3
**Comment:** Unit cost imported from table at the lower left corner.

# DRILLING AND BLASTING COST ESTIMATE

## 3 PHASES:

## 39.5' Draft to 41.5' Draft

## 41.5' Draft to 46' Draft

## 46' Draft to 50' Draft

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 39.5'@ 41.5'
# (REV.-22)

| 1 | B | C | D |
|---|---|---|---|
| 2 | **DRILLING AND BLASTING AREA WITH NO RESTRICTIONS - 41.5' DRAFT ( Phase 1 )** | | |
| 3 | **DESCRIPTION** | **THOR** | **4-TOWER** |
| 4 | Drilling level | PLD-62.1' | PLD-62.1' |
| 5 | **Drilling Grid (feet); Spacing=12.5'; Burden=13'.** | **12.5' x 13'** | **12.5' x 13'** |
| 6 | **Actual pattern area (feet)** | **100' x 52'** | **100' x 52'** |
| 7 | Drilling spacing ( feet ) | 12.5 | 12.5 |
| 8 | Spacing between drilling rows ( feet ) | 13 | 13 |
| 9 | Pattern length (feet) | 100 | 100 |
| 10 | Pattern width (feet) | 52 | 52 |
| 11 | Volume per pattern ( cubic meters) | 1474 | 1474 |
| 12 | Number of patterns | 1 | 1 |
| 13 | Number of rows | 4 | 4 |
| 14 | Drill depth (feet) | **10** | **10** |
| 15 | Number of passes | N / A | N / A |
| 16 | Average time to connect additional drill pipe (minutes) | N / A | N / A |
| 17 | Average time to drill a blasting hole (minutes)-(1) | 14.26 | 12.50 |
| 18 | Install Casing | | 1 |
| 19 | Lower tri-cone column | | 2 |
| 20 | Drill to required depth | | 7.50 |
| 21 | Raise rods, change drill bit for shoe | | n/a |
| 22 | Straighten borehole, sounding and load borehole | | n/a |
| 23 | Remove rods and casing | | 2 |
| 24 | Number of drillholes per line | 8 | 8 |
| 25 | Average time required to drill an 8-hole line (hours) | 1.05 | 0.42 |
| 26 | Rate of perforation per line, per drill tower (feet per minute) | 0.32 | 0.80 |
| 27 | **Average time required to drill a pattern of 4 lines of 8 boreholes each line (in hours)** | **4.20** | **1.67** |
| 28 | Estimated time to move the towers per line (minutes) | 3 | 3 |
| 29 | Moving time for the drillboat barge (minutes) | 17 | 17 |
| 30 | Time for setting explosives per bore hole (minutes) | 6.67 | 6.67 |
| 31 | Total time for setting a line of 8 bore holes (minutes) | 13.34 | 13.34 |
| 32 | Preparation time for blasting one pattern (minutes) | 116.36 | 116.36 |
| 33 | **Preparation time for blasting one pattern (hours)** | **1.94** | **1.94** |
| 34 | **Total time for activities in addition to drilling (hours)** | **1.50** | **1.50** |
| 35 | **Total drilling and blasting time for one pattern (hours)** | **7.64** | **5.11** |
| 36 | **High Tide drilling production factor** | **1.00** | **1.00** |
| 37 | **Number of patterns per week** | **16** | **20** |
| 38 | **Area of progress per week (square meters per week)** | **7,732** | **9,665** |
| 39 | Weekly volume (cubic meters) | **23,576** | **29,470** |
| 40 | Production percentage ratio | 44 | 56 |
| 41 | Rate of perforation per pattern, estimated for one tower in feet per minute. | **0.169** | **0.212** |
| 42 | **Notes:** | | |
| 43 | (1) A 13% increase in the productivity of the drillboat THOR was assumed for the times calculated for the THOR. | | |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 39.5'@ 41.5'
# (REV.-22)

**Cell:** C3
**Comment:** All times used to define the THOR productivity were obtained from drilling tests made by Dredging Division to different depths in November 2001.

**Cell:** D3
**Comment:** All times used to define the New Drill Barge productivity were obtained from land based drilling logs provided by Dredging Division.

**Cell:** C11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** D11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** C17
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** C25
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** D25
**Comment:** Total time in cell No. 17 was multiplied by the number of drill holes per line, and then divided by 4 because 4 towers will be installed in the new drill barge.

**Cell:** C31
**Comment:** Total loading time has been divided by four, assuming that the four THOR towers are working sinultaneously.

**Cell:** D31
**Comment:** Total loading time has been divided by four because the 4 towers will work simultaneously.

**Cell:** C32
**Comment:** To calculate the THOR blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** D32
**Comment:** To calculate the Tamrocks blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 39.5'@ 41.5'
# (REV.-22)

**Cell:** C34
**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** D34
**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** C37
**Comment:** Assuming an effective working hours of 18 per day (2 hours of maintenance and relay for each watch).
18 hours times 7 days per week divided by the total drilling and blasting time for one pattern

**Cell:** D37
**Comment:** Assuming an efficiency increase of 25% more than the THOR

**Cell:** C38
**Comment:** Area of progress per week equals the number of patterns per week multiplied by the area of a pattern.

**Cell:** C39
**Comment:** Volume of progress per week equals the number of patterns per week multiplied by the volume of one pattern.

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 39.5'@ 41.5'
# (REV.-22)

| 1 | B | E | F | G |
|---|---|---|---|---|
| 2 | REACHES | AREA AND VOLUME - DRAFT 41.5' ( Phase 1 ) | | |
| 3 | | D&B from -52.1 to -62.1 PLD(mts$^2$) | % Drilling & Blasting Required | Net Area for D&B -52.1´to -62.1' PLD (mts2) |
| 4 | Pacific Entrance Deepening | | | |
| 5 | STA( 68+415 @ 70+000 ) | 511,950 | 100% | 511,950 |
| 6 | STA( 70+000 @ 74+000 ) | 598,200 | 100% | 598,200 |
| 7 | STA( 74+000 @ 76+000 ) | 429,230 | 100% | 429,230 |
| 8 | STA( 76+000 @ 78+000 ) | 458,350 | 84% | 385,014 |
| 9 | STA( 78+000 @ 80+000 ) | 410,430 | 87% | 357,074 |
| 10 | STA( 80+000 @ 82+000 ) | 565,185 | 34% | 192,163 |
| 11 | STA( 82+000 @ 83+000 ) | 386,380 | 32% | 123,642 |
| 12 | STA( 83+000 @ 85+920 ) | 892,936 | 0% | 0 |
| 13 | TOTAL | 3,740,711 | 69% | 2,597,273 |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 39.5'@ 41.5'
# (REV.-22)

**Cell:** C3
**Comment:** The dredging volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** D3
**Comment:** The overdredge volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** E3
**Comment:** Reach area is calculated using AUTOCAD software.

**Cell:** F3
**Comment:** Percentages based on seismic profiles data of November 1999, performed by Coastal and Inland Marine Services.

**Cell:** G3
**Comment:** Drilling and Blasting net area for each reach was calculated by multiplying the area of each reach (Col. E) by the percentage of hard material, according to the seismic profiles( Col. F ).

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 39.5'@ 41.5'**
**(REV.-22)**

| 1 | B | C | D | E | F |
|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Areas ($m^3$)** | AVAILABLE DRILLBOATS | DRILLBOAT PRODUCTIVITY | Duration (weeks) |
| 3 | | D&B from -52.1' to -62.1' PLD | | $Mts^2$ / week | Total duration per reach |
| 4 | **Pacific Entrance** | Phase 1 | | | |
| 5 | STA( 68+415 @ 70+000 ) | 511,950 | New Barge(4 towers) | 9,665 | 53 |
| 6 | STA( 70+000 @ 74+000 ) | 598,200 | Thor | 7,732 | 77 |
| 7 | STA( 74+000 @ 76+000 ) | 429,230 | New Barge(4 towers) | 9,665 | 44 |
| 8 | STA( 76+000 @ 78+000 ) | 385,014 | Thor | 7,732 | 50 |
| 9 | STA( 78+000 @ 80+000 ) | 357,074 | New Barge(4 towers) | 9,665 | 37 |
| 10 | STA( 80+000 @ 82+000 ) | 192,163 | Thor | 7,732 | 25 |
| 11 | STA( 82+000 @ 83+000 ) | 123,642 | New Barge(4 towers) | 9,665 | 13 |
| 12 | STA( 83+000 @ 85+920 ) | 0 | | | |
| 13 | **TOTAL** | 2,597,273 | | | 299 |
| 14 | | | | | |
| 15 | **Notas:** | | | | |
| 16 | | | | | |

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 39.5'@ 41.5'**
**(REV.-22)**

**Cell:** E2
**Comment:** Output values correspond to the equipment productivity by areas of progress determined in Spreadsheet No. 1, comparative table of drilling times for the THOR and the new drillboat with four towers.

**Cell:** E3
**Comment:** Output is the number of drilling patterns per week multiplied by the area of a pattern of 100' by 52'.

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 39.5'@ 46'**
**(REV.-22)**

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Area (m$^3$)** | Available Drillboat | DURATION (WEEKS) | Cost ($ per week) | Drilling & Blasting Cost ($) |
| 3 | | D&B from -52.1' to -62.1' PLD | | | | |
| 4 | **Pacific Entrance** | Phase 1 | | | | |
| 5 | **STA( 68+415 @ 70+000 )** | 511,950 | New Barge(4 towers) | 53 | $251,084 | $13,299,218 |
| 5 | **STA( 70+000 @ 74+000 )** | 598,200 | Thor | 77 | $251,084 | $19,424,729 |
| 6 | **STA( 74+000 @ 76+000 )** | 429,230 | New Barge(4 towers) | 44 | $251,084 | $11,150,353 |
| 7 | **STA( 76+000 @ 78+000 )** | 385,014 | Thor | 50 | $251,084 | $12,502,161 |
| 8 | **STA( 78+000 @ 80+000 )** | 357,074 | New Barge(4 towers) | 37 | $251,084 | $9,275,918 |
| 9 | **STA( 80+000 @ 82+000 )** | 192,163 | Thor | 25 | $251,084 | $6,239,907 |
| 10 | **STA( 82+000 @ 83+000 )** | 123,642 | New Barge(4 towers) | 13 | $251,084 | $3,211,908 |
| 11 | **STA( 83+000 @ 85+920 )** | 0 | | | | |
| 12 | **TOTAL** | 2,597,273 | | 299 | | **$75,104,193** |
| 13 | | | | | | |
| 14 | | | | | | |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 39.5'@ 46'
# (REV.-22)

**Cell:** E2
**Comment:** Value imported from Spreadsheet 3, Column F.

**Cell:** F2
**Comment:** THOR operating costs per week were calculated by dividing the average monthly operation cost ($1,087,195) by 4.33 weeks per month. To calculate operating cost of a new drillboat with four towers, the THOR cost was used as a reference.

**Cell:** G2
**Comment:** The cost per reach is equal to the total duration per reach in weeks (E) multiplied by the operation cost per week (F), including explosives.

**Cell:** C3
**Comment:** Value imported from Spreadsheet 2, Column G.

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 41.5'@ 46'
# (REV.-22)

| 1 | B | C | D |
|---|---|---|---|
| 2 | **DRILLING AND BLASTING AREA WITH NO RESTRICTIONS 41.5' - 46' DRAFT (FROM -56.1' TO -66.6' PLD)-Phase 2** | | |
| 3 | **DESCRIPTION** | **THOR** | **4-TOWER** |
| 4 | Drilling level | PLD-66.6' | PLD-66.6' |
| 5 | **Drilling Grid (feet); Spacing=12.5'; Burden=13'.** | **12.5' x 13'** | **12.5' x 13'** |
| 6 | **Actual pattern area (feet)** | **100' x 52'** | **100' x 52'** |
| 7 | Drilling spacing ( feet ) | 12.5 | 12.5 |
| 8 | Spacing between drilling rows ( feet ) | 13 | 13 |
| 9 | Pattern length (feet) | 100 | 100 |
| 10 | Pattern width (feet) | 52 | 52 |
| 11 | Volume per pattern ( cubic meters) | 1547 | 1547 |
| 12 | Number of patterns | 1 | 1 |
| 13 | Number of rows | 4 | 4 |
| 14 | Drill depth (feet) | **10.5** | **10.5** |
| 15 | Number of passes | N / A | N / A |
| 16 | Average time to connect additional drill pipe (minutes) | N / A | N / A |
| 17 | Average time to drill a blasting hole (minutes)-(1) | 14.97 | 12.88 |
| 18 | Install Casing | | 1 |
| 19 | Lower tri-cone column | | 2 |
| 20 | Drill to required depth | | 7.87 |
| 21 | Raise rods, change drill bit for shoe | | n/a |
| 22 | Straighten borehole, sounding and load borehole | | n/a |
| 23 | Remove rods and casing | | 2 |
| 24 | Number of drillholes per line | 8 | 8 |
| 25 | Average time required to drill an 8-hole line (hours) | 1.10 | 0.43 |
| 26 | Rate of perforation per line, per drill tower (feet per minute) | 0.32 | 0.82 |
| 27 | **Average time required to drill a pattern of 4 lines of 8 boreholes each line (in hours)** | **4.41** | **1.72** |
| 28 | Estimated time to move the towers per line (minutes) | 3 | 3 |
| 29 | Moving time for the drillboat barge (minutes) | 17 | 17 |
| 30 | Time for setting explosives per bore hole (minutes) | 6.67 | 6.67 |
| 31 | Total time for setting a line of 8 bore holes (minutes) | 13.34 | 13.34 |
| 32 | Preparation time for blasting one pattern (minutes) | 116.36 | 116.36 |
| 33 | **Preparation time for blasting one pattern (hours)** | **1.94** | **1.94** |
| 34 | **Total time for activities in addition to drilling (hours)** | **1.50** | **1.50** |
| 35 | **Total drilling and blasting time for one pattern (hours)** | **7.85** | **5.16** |
| 36 | **High Tide drilling production factor** | **1.00** | **1.00** |
| 37 | **Number of patterns per week** | **16** | **20** |
| 38 | **Area of progress per week (square meters per week)** | **7,732** | **9,665** |
| 39 | Weekly volume (cubic meters) | **24,755** | **30,944** |
| 40 | Production percentage ratio | 44 | 56 |
| 41 | Rate of perforation per pattern, estimated for one tower in feet per minute. | **0.178** | **0.222** |
| 42 | **Notes:** | | |
| 43 | (1) A 13% increase in the productivity of the drillboat THOR was assumed for the times calculated for the THOR. | | |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 41.5'@ 46'
# (REV.-22)

**Cell:** C3
**omment:** All times used to define the THOR productivity were obtained from drilling tests made by Dredging Division to different depths in November 2001.

**Cell:** D3
**omment:** All times used to define the Tamrock productivity were obtained from land based drilling logs provided by Dredging Division.

**Cell:** C11
**omment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** D11
**omment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** C17
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** C25
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** D25
**Comment:** Total time in cell No. 17 was multiplied by the number of drill holes per line, and then divided by 4 because 4 towers will be installed in the new drill barge.

**Cell:** C31
**Comment:** Total loading time has been divided by four, assuming that the four THOR towers are working sinultaneously.

**Cell:** D31
**Comment:** Total loading time has been divided by four because the 4 towers will work simultaneously.

**Cell:** C32
**Comment:** To calculate the THOR blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** D32
**Comment:** To calculate the Tamrocks blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** C34
**omment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** D34

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 41.5'@ 46'
# (REV.-22)

**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** C37
**Comment:** Assuming an effective working hours of 18 per day (2 hours of maintenance and relay for each watch).
18 hours times 7 days per week divided by the total drilling and blasting time for one pattern

**Cell:** D37
**omment:** Assuming an efficiency increase of 25% more than the THOR

**Cell:** C38
**omment:** Area of progress per week equals the number of patterns per week multiplied by the area of a pattern.

**Cell:** C39
**Comment:** Volume of progress per week equals the number of patterns per week multiplied by the volume of one pattern.

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 41.5'@ 46'**
**(REV.-22)**

| 1 | B | E | F | G |
|---|---|---|---|---|
| 2 | **REACHES** | **\REA AND VOLUME - DRAFT 41.5' @ 46' ( Phase 2** | | |
| 3 | | D&B from -56.1 to -66.6(mts$^2$) | % Drilling & Blasting Required | Net Area for D&B -58.6´to -66.6' PLD (mts2) |
| 4 | Pacific Entrance Deepening | | | |
| 5 | STA( 71+200 @ 74+000 ) | 598,200 | 100% | 598,200 |
| 6 | STA( 74+000 @ 76+000 ) | 429,230 | 100% | 429,230 |
| 7 | STA( 76+000 @ 78+000 ) | 458,350 | 84% | 385,014 |
| 8 | STA( 78+000 @ 80+000 ) | 410,430 | 87% | 357,074 |
| 9 | STA( 80+000 @ 82+000 ) | 565,185 | 34% | 192,163 |
| 10 | STA( 82+000 @ 83+000 ) | 386,380 | 32% | 123,642 |
| 11 | STA( 83+000 @ 85+920 ) | 892,936 | 0% | 0 |
| 12 | **TOTAL** | 3,740,711 | 56% | 2,085,323 |

## DRILLING BLASTING AREA AND DURATION
## PACIFIC ENTRANCE
## DRAFT 41.5'@ 46'
## (REV.-22)

**Cell:** C3
**Comment:** The dredging volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** D3
**Comment:** The overdredge volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** E3
**Comment:** Reach area is calculated using AUTOCAD software.

**Cell:** F3
**Comment:** Percentages based on seismic profiles data of November 1999, performed by Coastal and Inland Marine Services.

**Cell:** G3
**Comment:** Drilling and Blasting net area for each reach was calculated by multiplying the area of each reach (Col. E) by the percentage of hard material, according to the seismic profiles( Col. F ).

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 41.5'@ 46'**
**(REV.-22)**

| 1 | B | C | D | E | F |
|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Areas ( $m^3$ )** | AVAILABLE DRILLBOATS | DRILLBOAT PRODUCTIVITY | Duration (weeks) |
| 3 | | D&B from -56.1' to -66.6' PLD | | $Mts^2$ / week | Total duration per reach |
| 4 | Pacific Entrance Deepening | Phase 2 | | | |
| 5 | STA( 71+200 @ 74+000 ) | 598,200 | Thor | 7,732 | 77 |
| 6 | STA( 74+000 @ 76+000 ) | 429,230 | New Barge(4 towers) | 9,665 | 44 |
| 7 | STA( 76+000 @ 78+000 ) | 385,014 | Thor | 7,732 | 50 |
| 8 | STA( 78+000 @ 80+000 ) | 357,074 | New Barge(4 towers) | 9,665 | 37 |
| 9 | STA( 80+000 @ 82+000 ) | 192,163 | New Barge(4 towers) | 9,665 | 20 |
| 10 | STA( 82+000 @ 83+000 ) | 123,642 | New Barge(4 towers) | 9,665 | 13 |
| 11 | STA( 83+000 @ 85+920 ) | 0 | | | |
| 12 | **TOTAL** | 2,085,323 | | | 241 |
| 13 | | | | | |
| 14 | | | | | |

## DRILLING BLASTING AREA AND DURATION
## PACIFIC ENTRANCE
## DRAFT 41.5'@ 46'
## (REV.-22)

**Cell:** E2
**Comment:** Output values correspond to the equipment productivity by areas of progress determined in Spreadsheet No. 1, comparative table of drilling times for the THOR and the new drillboat with four towers.

**Cell:** E3
**Comment:** Output is the number of drilling patterns per week multiplied by the area of a pattern of 100' by 52'.

## DRILLING BLASTING AREA AND DURATION
## PACIFIC ENTRANCE
## DRAFT 41.5'@ 46'
## (REV.-22)

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Area (m3)** | Available Drillboat | DURATION (WEEKS) | Cost ($ per week) | Drilling & Blasting Cost ($) |
| 3 | | D&B from -56.1' to -60.6' PLD | | | | |
| 4 | Pacific Entrance | Phase 2 | | | | |
| 5 | STA( 71+200 @ 74+000 ) | 598,200 | Thor | 77 | $251,084 | $19,424,729 |
| 6 | STA( 74+000 @ 76+000 ) | 429,230 | New Barge(4 towers) | 44 | $251,084 | $11,150,353 |
| 7 | STA( 76+000 @ 78+000 ) | 385,014 | Thor | 50 | $251,084 | $12,502,161 |
| 8 | STA( 78+000 @ 80+000 ) | 357,074 | New Barge(4 towers) | 37 | $251,084 | $9,275,918 |
| 9 | STA( 80+000 @ 82+000 ) | 192,163 | New Barge(4 towers) | 20 | $251,084 | $4,991,925 |
| 10 | STA( 82+000 @ 83+000 ) | 123,642 | New Barge(4 towers) | 13 | $251,084 | $3,211,908 |
| 11 | STA( 83+000 @ 85+920 ) | 0 | | 0 | | |
| 12 | **TOTAL** | 2,085,323 | | 241 | | **$60,556,994** |
| 13 | | | | | | |
| 14 | **Notas:** | | | | | |
| 15 | | | | | | |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 41.5'@ 46'
# (REV.-22)

**Cell:** E2
**Comment:** Value imported from Spreadsheet 3, Column F.

**Cell:** F2
**Comment:** THOR operating costs per week were calculated by dividing the average monthly operation cost ($1,087,195) by 4.33 weeks per month. To calculate operating cost of a new drillboat with four towers, the THOR cost was used as a reference.

**Cell:** G2
**Comment:** The cost per reach is equal to the total duration per reach in weeks (E) multiplied by the operation cost per week (F), including explosives.

**Cell:** C3
**Comment:** Value imported from Spreadsheet 2, Column G.

## DRILLING BLASTING AREA AND DURATION
## PACIFIC ENTRANCE
## DRAFT 46'@ 50'
## (REV.-22)

| 1 | B | C | D |
|---|---|---|---|
| 2 | DRILLING AND BLASTING AREA WITH NO RESTRICTIONS - 50' DRAFT (FROM -60.6' TO -70.6' PLD)-Phase 3 | | |
| 3 | **DESCRIPTION** | **THOR** | **4-TOWER** |
| 4 | Drilling level | PLD-70.6' | PLD-70.6' |
| 5 | **Drilling Grid (feet); Spacing=12.5'; Burden=13'.** | **12.5' x 13'** | **12.5' x 13'** |
| 6 | **Actual pattern area (feet)** | **100' x 52'** | **100' x 52'** |
| 7 | Drilling spacing ( feet ) | 12.5 | 12.5 |
| 8 | Spacing between drilling rows ( feet ) | 13 | 13 |
| 9 | Pattern length (feet) | 100 | 100 |
| 10 | Pattern width (feet) | 52 | 52 |
| 11 | Volume per pattern ( cubic meters) | 1474 | 1474 |
| 12 | Number of patterns | 1 | 1 |
| 13 | Number of rows | 4 | 4 |
| 14 | Drill depth (feet) | **10** | **10** |
| 15 | Number of passes | N / A | N / A |
| 16 | Average time to connect additional drill pipe (minutes) | N / A | N / A |
| 17 | Average time to drill a blasting hole (minutes)-(1) | 14.26 | 12.50 |
| 18 | Install Casing | | 1 |
| 19 | Lower tri-cone column | | 2 |
| 20 | Drill to required depth | | 7.50 |
| 21 | Raise rods, change drill bit for shoe | | n/a |
| 22 | Straighten borehole, sounding and load borehole | | n/a |
| 23 | Remove rods and casing | | 2 |
| 24 | Number of drillholes per line | 8 | 8 |
| 25 | Average time required to drill an 8-hole line (hours) | 1.05 | 0.42 |
| 26 | Rate of perforation per line, per drill tower (feet per minute) | 0.32 | 0.80 |
| 27 | **Average time required to drill a pattern of 4 lines of 8 boreholes each line (in hours)** | **4.20** | **1.67** |
| 28 | Estimated time to move the towers per line (minutes) | 3 | 3 |
| 29 | Moving time for the drillboat barge (minutes) | 17 | 17 |
| 30 | Time for setting explosives per bore hole (minutes) | 6.67 | 6.67 |
| 31 | Total time for setting a line of 8 bore holes (minutes) | 13.34 | 13.34 |
| 32 | Preparation time for blasting one pattern (minutes) | 116.36 | 116.36 |
| 33 | **Preparation time for blasting one pattern (hours)** | **1.94** | **1.94** |
| 34 | **Total time for activities in addition to drilling (hours)** | **1.50** | **1.50** |
| 35 | **Total drilling and blasting time for one pattern (hours)** | **7.64** | **5.11** |
| 36 | **High Tide drilling production factor** | **1.00** | **1.00** |
| 37 | **Number of patterns per week** | **16** | **20** |
| 38 | **Area of progress per week (square meters per week)** | **7,732** | **9,665** |
| 39 | Weekly volume (cubic meters) | **23,576** | **29,470** |
| 40 | Production percentage ratio | 44 | 56 |
| 41 | Rate of perforation per pattern, estimated for one tower in feet per minute. | **0.159** | **0.201** |
| 42 | **Notes:** | | |
| 43 | (1) A 13% increase in the productivity of the drillboat THOR was assumed for the times calculated for the THOR. | | |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 46'@ 50'
# (REV.-22)

**Cell:** C3
**Comment:** All times used to define the THOR productivity were obtained from drilling tests made by Dredging Division to different depths in November 2001.

**Cell:** D3
**Comment:** All times used to define the Tamrock productivity were obtained from land based drilling logs provided by Dredging Division.

**Cell:** C11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** D11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** C17
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** C25
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** D25
**Comment:** Total time in cell No. 17 was multiplied by the number of drill holes per line, and then divided by 4 because 4 towers will be installed in the new drill barge.

**Cell:** C31
**Comment:** Total loading time has been divided by four, assuming that the four THOR towers are working sinultaneously.

**Cell:** D31
**Comment:** Total loading time has been divided by four because the 4 towers will work simultaneously.

**Cell:** C32
**Comment:** To calculate the THOR blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** D32
**Comment:** To calculate the Tamrocks blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** C34
**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** D34

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 46'@ 50'
# (REV.-22)

**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** C37
**Comment:** Assuming an effective working hours of 18 per day (2 hours of maintenance and relay for each watch).
18 hours times 7 days per week divided by the total drilling and blasting time for one pattern

**Cell:** D37
**Comment:** Assuming an efficiency increase of 25% more than the THOR

**Cell:** C38
**Comment:** Area of progress per week equals the number of patterns per week multiplied by the area of a pattern.

**Cell:** C39
**Comment:** Volume of progress per week equals the number of patterns per week multiplied by the volume of one pattern.

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 46'@ 50'**
**(REV.-22)**

| 1 | B | E | F | G |
|---|---|---|---|---|
| 2 | **REACHES** | **AREA AND VOLUME - DRAFT 50' ( Phase 3 )** | | |
| 3 | | D&B from -60.6 to -70.6(mts$^2$) | % Drilling & Blasting Required | Net Area for D&B -60.6´to -70.6' PLD (mts2) |
| 4 | Pacific Entrance Deepening | | | |
| 5 | STA( 71+200 @ 74+000 ) | 598,200 | 100% | 598,200 |
| 6 | STA( 74+000 @ 76+000 ) | 429,230 | 100% | 429,230 |
| 7 | STA( 76+000 @ 78+000 ) | 458,350 | 91% | 417,099 |
| 8 | STA( 78+000 @ 80+000 ) | 410,430 | 91% | 373,491 |
| 9 | STA( 80+000 @ 82+000 ) | 565,185 | 34% | 192,163 |
| 10 | STA( 82+000 @ 83+000 ) | 386,380 | 32% | 123,642 |
| 11 | STA( 83+000 @ 85+920 ) | 892,936 | 0% | 0 |
| 12 | **TOTAL** | 3,740,711 | 57% | 2,133,824 |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 46'@ 50'
# (REV.-22)

**Cell:** C3
**Comment:** The dredging volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** D3
**Comment:** The overdredge volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** E3
**Comment:** Reach area is calculated using AUTOCAD software.

**Cell:** F3
**Comment:** Percentages based on seismic profiles data of November 1999, performed by Coastal and Inland Marine Services.

**Cell:** G3
**Comment:** Drilling and Blasting net area for each reach was calculated by multiplying the area of each reach (Col. E) by the percentage of hard material, according to the seismic profiles( Col. F ).

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 46'@ 50'**
**(REV.-22)**

| 1 | B | C | D | E | F |
|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Areas ( $m^3$ )** | AVAILABLE DRILLBOATS | DRILLBOAT PRODUCTIVITY | Duration (weeks) |
| 3 | | D&B from -60.6' to -70.6' PLD | | $Mts^2$ / week | Total duration per reach |
| 4 | Pacific Entrance Deepening | Phase 2 | | | |
| 5 | STA( 71+200 @ 74+000 ) | 598,200 | Thor | 7,732 | 77 |
| 6 | STA( 74+000 @ 76+000 ) | 429,230 | New Barge(4 towers) | 9,665 | 44 |
| 7 | STA( 76+000 @ 78+000 ) | 417,099 | Thor | 7,732 | 54 |
| 8 | STA( 78+000 @ 80+000 ) | 373,491 | New Barge(4 towers) | 9,665 | 39 |
| 9 | STA( 80+000 @ 82+000 ) | 192,163 | New Barge(4 towers) | 9,665 | 20 |
| 10 | STA( 82+000 @ 83+000 ) | 123,642 | New Barge(4 towers) | 9,665 | 13 |
| 11 | STA( 83+000 @ 85+920 ) | 0 | | | |
| 12 | **TOTAL** | 2,133,824 | | | 247 |
| 13 | | | | | |
| 14 | | | | | |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 46'@ 50'
# (REV.-22)

**Cell:** E2
**Comment:** Output values correspond to the equipment productivity by areas of progress determined in Spreadsheet No. 1, comparative table of drilling times for the THOR and the new drillboat with four towers.

**Cell:** E3
**Comment:** Output is the number of drilling patterns per week multiplied by the area of a pattern of 100' by 52'.

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 46'@ 50'**
**(REV.-22)**

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Area (m3)** | Available Drillboat | DURATION (WEEKS) | Cost ($ per week) | Drilling & Blasting Cost ($) |
| 3 | | D&B from -60.6' to -70.6' PLD | | | | |
| 4 | **Pacific Entrance** | Phase 2 | | | | |
| 5 | **STA( 71+200 @ 74+000 )** | 598,200 | Thor | 77 | $251,084 | $19,424,729 |
| 6 | **STA( 74+000 @ 76+000 )** | 429,230 | New Barge(4 towers) | 44 | $251,084 | $11,150,353 |
| 7 | **STA( 76+000 @ 78+000 )** | 417,099 | Thor | 54 | $251,084 | $13,544,007 |
| 8 | **STA( 78+000 @ 80+000 )** | 373,491 | New Barge(4 towers) | 39 | $251,084 | $9,702,397 |
| 9 | **STA( 80+000 @ 82+000 )** | 192,163 | New Barge(4 towers) | 20 | $251,084 | $4,991,925 |
| 10 | **STA( 82+000 @ 83+000 )** | 123,642 | New Barge(4 towers) | 13 | $251,084 | $3,211,908 |
| 11 | **STA( 83+000 @ 85+920 )** | 0 | | 0 | | |
| 12 | **TOTAL** | 2,133,824 | | 247 | | **$62,025,320** |
| 13 | | | | | | |
| 14 | **Notas:** | | | | | |
| 15 | | | | | | |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 46'@ 50'
# (REV.-22)

**Cell:** E2
**Comment:** Value imported from Spreadsheet 3, Column F.

**Cell:** F2
**Comment:** THOR operating costs per week were calculated by dividing the average monthly operation cost ($1,087,195) by 4.33 weeks per month. To calculate operating cost of a new drillboat with four towers, the THOR cost was used as a reference.

**Cell:** G2
**Comment:** The cost per reach is equal to the total duration per reach in weeks (E) multiplied by the operation cost per week (F), including explosives.

**Cell:** C3
**Comment:** Value imported from Spreadsheet 2, Column G.

# DRILLING AND BLASTING COST ESTIMATE

## 2 PHASES:

## 39.5' Draft to 46' Draft

## 46' Draft to 50' Draft

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 39.5'@ 46'
# (REV.-22)

| 1 | B | C | D |
|---|---|---|---|
| 2 | **DRILLING AND BLASTING AREA WITH NO RESTRICTIONS - 46' DRAFT ( Phase 1 )** | | |
| 3 | **DESCRIPTION** | **THOR** | **4-TOWER** |
| 4 | Drilling level | PLD-66.6' | PLD-66.6' |
| 5 | **Drilling Grid (feet); Spacing=12.5'; Burden=13'.** | **12.5' x 13'** | **12.5' x 13'** |
| 6 | **Actual pattern area (feet)** | **100' x 52'** | **100' x 52'** |
| 7 | Drilling spacing ( feet ) | 12.5 | 12.5 |
| 8 | Spacing between drilling rows ( feet ) | 13 | 13 |
| 9 | Pattern length (feet) | 100 | 100 |
| 10 | Pattern width (feet) | 52 | 52 |
| 11 | Volume per pattern ( cubic meters) | 2137 | 2137 |
| 12 | Number of patterns | 1 | 1 |
| 13 | Number of rows | 4 | 4 |
| 14 | Drill depth (feet) | **14.5** | **14.5** |
| 15 | Number of passes | N / A | N / A |
| 16 | Average time to connect additional drill pipe (minutes) | N / A | N / A |
| 17 | Average time to drill a blasting hole (minutes)-(1) | 20.67 | 15.88 |
| 18 | Install Casing | | 1 |
| 19 | Lower tri-cone column | | 2 |
| 20 | Drill to required depth | | 10.88 |
| 21 | Raise rods, change drill bit for shoe | | n/a |
| 22 | Straighten borehole, sounding and load borehole | | n/a |
| 23 | Remove rods and casing | | 2 |
| 24 | Number of drillholes per line | 8 | 8 |
| 25 | Average time required to drill an 8-hole line (hours) | 1.52 | 0.53 |
| 26 | Rate of perforation per line, per drill tower (feet per minute) | 0.32 | 0.91 |
| 27 | **Average time required to drill a pattern of 4 lines of 8 boreholes each line (in hours)** | **6.09** | **2.12** |
| 28 | Estimated time to move the towers per line (minutes) | 3 | 3 |
| 29 | Moving time for the drillboat barge (minutes) | 17 | 17 |
| 30 | Time for setting explosives per bore hole (minutes) | 6.67 | 6.67 |
| 31 | Total time for setting a line of 8 bore holes (minutes) | 13.34 | 13.34 |
| 32 | Preparation time for blasting one pattern (minutes) | 116.36 | 116.36 |
| 33 | **Preparation time for blasting one pattern (hours)** | **1.94** | **1.94** |
| 34 | **Total time for activities in addition to drilling (hours)** | **1.50** | **1.50** |
| 35 | **Total drilling and blasting time for one pattern (hours)** | **9.53** | **5.56** |
| 36 | **High Tide drilling production factor** | **1.00** | **1.00** |
| 37 | **Number of patterns per week** | **13** | **16** |
| 38 | **Area of progress per week (square meters per week)** | **6,283** | **7,732** |
| 39 | Weekly volume (cubic meters) | **27,776** | **34,185** |
| 40 | Production percentage ratio | 45 | 55 |
| 41 | Rate of perforation per pattern, estimated for one tower in feet per minute. | **0.199** | **0.246** |
| 42 | **Notes:** | | |
| 43 | (1) A 13% increase in the productivity of the drillboat THOR was assumed for the times calculated for the THOR. | | |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 39.5'@ 46'
# (REV.-22)

**Cell:** C3
**Comment:** All times used to define the THOR productivity were obtained from drilling tests made by Dredging Division to different depths in November 2001.

**Cell:** D3
**Comment:** All times used to define the New Drill Barge productivity were obtained from land based drilling logs provided by Dredging Division.

**Cell:** C11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** D11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** C17
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** C25
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** D25
**Comment:** Total time in cell No. 17 was multiplied by the number of drill holes per line, and then divided by 4 because 4 towers will be installed in the new drill barge.

**Cell:** C31
**Comment:** Total loading time has been divided by four, assuming that the four THOR towers are working sinultaneously.

**Cell:** D31
**Comment:** Total loading time has been divided by four because the 4 towers will work simultaneously.

**Cell:** C32
**Comment:** To calculate the THOR blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** D32
**Comment:** To calculate the Tamrocks blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 39.5'@ 46'
# (REV.-22)

**Cell:** C34
**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** D34
**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** C37
**Comment:** Assuming an effective working hours of 18 per day (2 hours of maintenance and relay for each watch).
18 hours times 7 days per week divided by the total drilling and blasting time for one pattern

**Cell:** D37
**Comment:** Assuming an efficiency increase of 25% more than the THOR

**Cell:** C38
**Comment:** Area of progress per week equals the number of patterns per week multiplied by the area of a pattern.

**Cell:** C39
**Comment:** Volume of progress per week equals the number of patterns per week multiplied by the volume of one pattern.

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 39.5'@ 46'**
**(REV.-22)**

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | **AREA AND VOLUME - DRAFT 46' ( Phase 1 )** | | | | |
| 3 | | Dredging Volume from -52.1' to -58.6' PLD (mts3) | Overdredge Volume from -58.6' to -60.6' PLD (mts3) | D&B from -52.1 to -66.6(mts$^2$) | % Drilling & Blasting Required | Net Area for D&B -52.1´to -66.6' PLD (mts2) |
| 4 | **Pacific Entrance Deepening** | | | | | |
| 5 | STA( 71+200 @ 74+000 ) | 1,129,205 | 435,121 | 598,200 | 100% | 598,200 |
| 6 | STA( 74+000 @ 76+000 ) | 1,071,232 | 299,849 | 429,230 | 100% | 429,230 |
| 7 | STA( 76+000 @ 78+000 ) | 691,987 | 298,920 | 458,350 | 84% | 385,014 |
| 8 | STA( 78+000 @ 80+000 ) | 479,297 | 281,568 | 410,430 | 87% | 357,074 |
| 9 | STA( 80+000 @ 82+000 ) | 834,118 | 443,572 | 565,185 | 34% | 192,163 |
| 10 | STA( 82+000 @ 83+000 ) | 134,534 | 150,810 | 386,380 | 32% | 123,642 |
| 11 | STA( 83+000 @ 85+920 ) | 51,135 | 58,523 | 892,936 | 0% | 0 |
| 12 | **TOTAL** | 4,391,508 | 1,968,363 | 3,740,711 | 56% | 2,085,323 |

## DRILLING BLASTING AREA AND DURATION
## PACIFIC ENTRANCE
## DRAFT 39.5'@ 46'
## (REV.-22)

**Cell:** C3
**Comment:** The dredging volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** D3
**Comment:** The overdredge volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** E3
**Comment:** Reach area is calculated using AUTOCAD software.

**Cell:** F3
**Comment:** Percentages based on seismic profiles data of November 1999, performed by Coastal and Inland Marine Services.

**Cell:** G3
**Comment:** Drilling and Blasting net area for each reach was calculated by multiplying the area of each reach (Col. E) by the percentage of hard material, according to the seismic profiles( Col. F ).

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 39.5'@ 46'**
**(REV.-22)**

| 1 | B | C | D | E | F |
|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Areas ($m^3$)** | AVAILABLE DRILLBOATS | DRILLBOAT PRODUCTIVITY | Duration (weeks) |
| 3 | | D&B from -52.1' to -66.6' PLD | | $Mts^2$ / week | Total duration per reach |
| 4 | **Pacific Entrance** | Phase 1 | | | |
| 5 | STA( 71+200 @ 74+000 ) | 598,200 | Thor | 6,283 | 95 |
| 6 | STA( 74+000 @ 76+000 ) | 429,230 | New Barge(4 towers) | 7,732 | 56 |
| 7 | STA( 76+000 @ 78+000 ) | 385,014 | Thor | 6,283 | 61 |
| 8 | STA( 78+000 @ 80+000 ) | 357,074 | New Barge(4 towers) | 7,732 | 46 |
| 9 | STA( 80+000 @ 82+000 ) | 192,163 | New Barge(4 towers) | 7,732 | 25 |
| 10 | STA( 82+000 @ 83+000 ) | 123,642 | New Barge(4 towers) | 7,732 | 16 |
| 11 | STA( 83+000 @ 85+920 ) | 0 | | | |
| 12 | **TOTAL** | 2,085,323 | | | 299 |
| 13 | | | | | |
| 14 | **Notas:** | | | | |
| 15 | | | | | |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 39.5'@ 46'
# (REV.-22)

**Cell:** E2
**Comment:** Output values correspond to the equipment productivity by areas of progress determined in Spreadsheet No. 1, comparative table of drilling times for the THOR and the new drillboat with four towers.

**Cell:** E3
**Comment:** Output is the number of drilling patterns per week multiplied by the area of a pattern of 100' by 52'.

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 46'@ 50'
# (REV.-22)

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Area ($m^3$)** | Available Drillboat | DURATION (WEEKS) | Cost ($ per week) | Drilling & Blasting Cost ($) |
| 3 | | D&B from -52.1' to -66.6' PLD | | | | |
| 4 | **Pacific Entrance** | Phase 1 | | | | |
| 5 | **STA( 71+200 @ 74+000 )** | 598,200 | Thor | 95 | $251,084 | $23,907,358 |
| 6 | **STA( 74+000 @ 76+000 )** | 429,230 | New Barge(4 towers) | 56 | $251,084 | $13,937,941 |
| 7 | **STA( 76+000 @ 78+000 )** | 385,014 | Thor | 61 | $251,084 | $15,387,275 |
| 8 | **STA( 78+000 @ 80+000 )** | 357,074 | New Barge(4 towers) | 46 | $251,084 | $11,594,897 |
| 9 | **STA( 80+000 @ 82+000 )** | 192,163 | New Barge(4 towers) | 25 | $251,084 | $6,239,907 |
| 10 | **STA( 82+000 @ 83+000 )** | 123,642 | New Barge(4 towers) | 16 | $251,084 | $4,014,886 |
| 11 | **STA( 83+000 @ 85+920 )** | 0 | | | | |
| 12 | **TOTAL** | 2,085,323 | | | | **$75,082,264** |
| 13 | | | | | | |
| 14 | | | | | | |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 46'@ 50'
# (REV.-22)

**Cell:** E2
**Comment:** Value imported from Spreadsheet 3, Column F.

**Cell:** F2
**Comment:** THOR operating costs per week were calculated by dividing the average monthly operation cost ($1,087,195) by 4.33 weeks per month. To calculate operating cost of a new drillboat with four towers, the THOR cost was used as a reference.

**Cell:** G2
**Comment:** The cost per reach is equal to the total duration per reach in weeks (E) multiplied by the operation cost per week (F), including explosives.

**Cell:** C3
**Comment:** Value imported from Spreadsheet 2, Column G.

## DRILLING BLASTING AREA AND DURATION
## PACIFIC ENTRANCE
## DRAFT 46'@ 50'
## (REV.-22)

| 1 | B | C | D |
|---|---|---|---|
| 2 | DRILLING AND BLASTING AREA WITH NO RESTRICTIONS - 50' DRAFT (FROM -60.6' TO -70.6' PLD)-Phase 2 | | |
| 3 | **DESCRIPTION** | **THOR** | **4-TOWER** |
| 4 | Drilling level | PLD-70.6' | PLD-70.6' |
| 5 | **Drilling Grid (feet); Spacing=12.5'; Burden=13'.** | **12.5' x 13'** | **12.5' x 13'** |
| 6 | **Actual pattern area (feet)** | **100' x 52'** | **100' x 52'** |
| 7 | Drilling spacing ( feet ) | 12.5 | 12.5 |
| 8 | Spacing between drilling rows ( feet ) | 13 | 13 |
| 9 | Pattern length (feet) | 100 | 100 |
| 10 | Pattern width (feet) | 52 | 52 |
| 11 | Volume per pattern ( cubic meters) | 1474 | 1474 |
| 12 | Number of patterns | 1 | 1 |
| 13 | Number of rows | 4 | 4 |
| 14 | Drill depth (feet) | **10** | **10** |
| 15 | Number of passes | N / A | N / A |
| 16 | Average time to connect additional drill pipe (minutes) | N / A | N / A |
| 17 | Average time to drill a blasting hole (minutes)-(1) | 14.26 | 12.50 |
| 18 | Install Casing | | 1 |
| 19 | Lower tri-cone column | | 2 |
| 20 | Drill to required depth | | 7.50 |
| 21 | Raise rods, change drill bit for shoe | | n/a |
| 22 | Straighten borehole, sounding and load borehole | | n/a |
| 23 | Remove rods and casing | | 2 |
| 24 | Number of drillholes per line | 8 | 8 |
| 25 | Average time required to drill an 8-hole line (hours) | 1.05 | 0.42 |
| 26 | Rate of perforation per line, per drill tower (feet per minute) | 0.32 | 0.80 |
| 27 | **Average time required to drill a pattern of 4 lines of 8 boreholes each line (in hours)** | **4.20** | **1.67** |
| 28 | Estimated time to move the towers per line (minutes) | 3 | 3 |
| 29 | Moving time for the drillboat barge (minutes) | 17 | 17 |
| 30 | Time for setting explosives per bore hole (minutes) | 6.67 | 6.67 |
| 31 | Total time for setting a line of 8 bore holes (minutes) | 13.34 | 13.34 |
| 32 | Preparation time for blasting one pattern (minutes) | 116.36 | 116.36 |
| 33 | **Preparation time for blasting one pattern (hours)** | **1.94** | **1.94** |
| 34 | **Total time for activities in addition to drilling (hours)** | **1.50** | **1.50** |
| 35 | **Total drilling and blasting time for one pattern (hours)** | **7.64** | **5.11** |
| 36 | **High Tide drilling production factor** | **1.00** | **1.00** |
| 37 | **Number of patterns per week** | **16** | **20** |
| 38 | **Area of progress per week (square meters per week)** | **7,732** | **9,665** |
| 39 | Weekly volume (cubic meters) | **23,576** | **29,470** |
| 40 | Production percentage ratio | 44 | 56 |
| 41 | Rate of perforation per pattern, estimated for one tower in feet per minute. | **0.159** | **0.201** |
| 42 | **Notes:** | | |
| 43 | (1) A 13% increase in the productivity of the drillboat THOR was assumed for the times calculated for the THOR. | | |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 46'@ 50'
# (REV.-22)

**Cell:** C3
**Comment:** All times used to define the THOR productivity were obtained from drilling tests made by Dredging Division to different depths in November 2001.

**Cell:** D3
**Comment:** All times used to define the Tamrock productivity were obtained from land based drilling logs provided by Dredging Division.

**Cell:** C11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** D11
**Comment:** Volume per pattern was calculated by multiplying the pattern area by the drilling depth.

**Cell:** C17
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** C25
**Comment:** The time recorded in the test was multiplied by a factor of 0.87, to include a 13% increase in the THOR's productivity.

**Cell:** D25
**Comment:** Total time in cell No. 17 was multiplied by the number of drill holes per line, and then divided by 4 because 4 towers will be installed in the new drill barge.

**Cell:** C31
**Comment:** Total loading time has been divided by four, assuming that the four THOR towers are working sinultaneously.

**Cell:** D31
**Comment:** Total loading time has been divided by four because the 4 towers will work simultaneously.

**Cell:** C32
**Comment:** To calculate the THOR blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** D32
**Comment:** To calculate the Tamrocks blasting preparation time for one pattern, the following were assumed:
(A) Four movements of the tower, one per line
(B) Three movements of the drillboat, between drilling lines
(C) Setting time of 8 boreholes per line, four lines per pattern.

**Cell:** C34
**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** D34

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 46'@ 50'
# (REV.-22)

**Comment:** Time estimate based on the experience of underwater drilling personnel.

**Cell:** C37
**Comment:** Assuming an effective working hours of 18 per day (2 hours of maintenance and relay for each watch).
18 hours times 7 days per week divided by the total drilling and blasting time for one pattern

**Cell:** D37
**Comment:** Assuming an efficiency increase of 25% more than the THOR

**Cell:** C38
**Comment:** Area of progress per week equals the number of patterns per week multiplied by the area of a pattern.

**Cell:** C39
**Comment:** Volume of progress per week equals the number of patterns per week multiplied by the volume of one pattern.

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 46'@ 50'**
**(REV.-22)**

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | **AREA AND VOLUME - DRAFT 50' ( Phase 2 )** | | | | |
| 3 | | Dredging Volume from -60.6' to -62.6' PLD (mts3) | Overdredge Volume from -62.6' to -64.6' PLD (mts3) | D&B from -60.6 to -70.6(mts$^2$) | % Drilling & Blasting Required | Net Area for D&B -60.6´to -70.6' PLD (mts2) |
| 4 | **Pacific Entrance Deepening** | | | | | |
| 5 | STA( 71+200 @ 74+000 ) | 343,813 | 463,203 | 598,200 | 100% | 598,200 |
| 6 | STA( 74+000 @ 76+000 ) | 298,872 | 299,362 | 429,230 | 100% | 429,230 |
| 7 | STA( 76+000 @ 78+000 ) | 297,945 | 298,431 | 458,350 | 91% | 417,099 |
| 8 | STA( 78+000 @ 80+000 ) | 329,516 | 307,203 | 410,430 | 91% | 373,491 |
| 9 | STA( 80+000 @ 82+000 ) | 415,216 | 416,141 | 565,185 | 34% | 192,163 |
| 10 | STA( 82+000 @ 83+000 ) | 246,647 | 241,656 | 386,380 | 32% | 123,642 |
| 11 | STA( 83+000 @ 85+920 ) | 172,556 | 355,875 | 892,936 | 0% | 0 |
| 12 | **TOTAL** | 2,104,565 | 2,381,871 | 3,740,711 | 57% | 2,133,824 |

## DRILLING BLASTING AREA AND DURATION
## PACIFIC ENTRANCE
## DRAFT 46'@ 50'
## (REV.-22)

**Cell:** C3
**Comment:** The dredging volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** D3
**Comment:** The overdredge volume was estimated by the Geotechnical Section in December 2002, and includes an overswing of 50 feet at each side of the canal.

**Cell:** E3
**Comment:** Reach area is calculated using AUTOCAD software.

**Cell:** F3
**Comment:** Percentages based on seismic profiles data of November 1999, performed by Coastal and Inland Marine Services.

**Cell:** G3
**Comment:** Drilling and Blasting net area for each reach was calculated by multiplying the area of each reach (Col. E) by the percentage of hard material, according to the seismic profiles( Col. F ).

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 46'@ 50'**
**(REV.-22)**

| 1 | B | C | D | E | F |
|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Areas ( $m^3$ )** | AVAILABLE DRILLBOATS | DRILLBOAT PRODUCTIVITY | Duration (weeks) |
| 3 | | D&B from -60.6' to -70.6' PLD | | $Mts^2$ / week | Total duration per reach |
| 4 | Pacific Entrance Deepening | Phase 2 | | | |
| 5 | STA( 71+200 @ 74+000 ) | 598,200 | Thor | 7,732 | 77 |
| 6 | STA( 74+000 @ 76+000 ) | 429,230 | New Barge(4 towers) | 9,665 | 44 |
| 7 | STA( 76+000 @ 78+000 ) | 417,099 | Thor | 7,732 | 54 |
| 8 | STA( 78+000 @ 80+000 ) | 373,491 | New Barge(4 towers) | 9,665 | 39 |
| 9 | STA( 80+000 @ 82+000 ) | 192,163 | New Barge(4 towers) | 9,665 | 20 |
| 10 | STA( 82+000 @ 83+000 ) | 123,642 | New Barge(4 towers) | 9,665 | 13 |
| 11 | STA( 83+000 @ 85+920 ) | 0 | | | |
| 12 | **TOTAL** | 2,133,824 | | | 247 |
| 13 | | | | | |
| 14 | | | | | |

## DRILLING BLASTING AREA AND DURATION
## PACIFIC ENTRANCE
## DRAFT 46'@ 50'
## (REV.-22)

**Cell:** E2
**Comment:** Output values correspond to the equipment productivity by areas of progress determined in Spreadsheet No. 1, comparative table of drilling times for the THOR and the new drillboat with four towers.

**Cell:** E3
**Comment:** Output is the number of drilling patterns per week multiplied by the area of a pattern of 100' by 52'.

**DRILLING BLASTING AREA AND DURATION**
**PACIFIC ENTRANCE**
**DRAFT 46'@ 50'**
**(REV.-22)**

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **REACHES** | **Net Area (m3)** | Available Drillboat | DURATION (WEEKS) | Cost ($ per week) | Drilling & Blasting Cost ($) |
| 3 | | D&B from -60.6' to -70.6' PLD | | | | |
| 4 | **Pacific Entrance** | Phase 2 | | | | |
| 5 | **STA( 71+200 @ 74+000 )** | 598,200 | Thor | 77 | $251,084 | $19,424,729 |
| 6 | **STA( 74+000 @ 76+000 )** | 429,230 | New Barge(4 towers) | 44 | $251,084 | $11,150,353 |
| 7 | **STA( 76+000 @ 78+000 )** | 417,099 | Thor | 54 | $251,084 | $13,544,007 |
| 8 | **STA( 78+000 @ 80+000 )** | 373,491 | New Barge(4 towers) | 39 | $251,084 | $9,702,397 |
| 9 | **STA( 80+000 @ 82+000 )** | 192,163 | New Barge(4 towers) | 20 | $251,084 | $4,991,925 |
| 10 | **STA( 82+000 @ 83+000 )** | 123,642 | New Barge(4 towers) | 13 | $251,084 | $3,211,908 |
| 11 | **STA( 83+000 @ 85+920 )** | 0 | | 0 | | |
| 12 | **TOTAL** | 2,133,824 | | 247 | | **$62,025,320** |
| 13 | | | | | | |
| 14 | **Notas:** | | | | | |
| 15 | | | | | | |

# DRILLING BLASTING AREA AND DURATION
# PACIFIC ENTRANCE
# DRAFT 46'@ 50'
# (REV.-22)

**Cell:** E2
**Comment:** Value imported from Spreadsheet 3, Column F.

**Cell:** F2
**Comment:** THOR operating costs per week were calculated by dividing the average monthly operation cost ($1,087,195) by 4.33 weeks per month. To calculate operating cost of a new drillboat with four towers, the THOR cost was used as a reference.

**Cell:** G2
**Comment:** The cost per reach is equal to the total duration per reach in weeks (E) multiplied by the operation cost per week (F), including explosives.

**Cell:** C3
**Comment:** Value imported from Spreadsheet 2, Column G.

# DREDGING VOLUME AND COST ESTIMATE

## 3 PHASES:

## 39.5’ Draft to 41.5’ Draft

## 41.5’ Draft to 46’ Draft

## 46’ Draft to 50’ Draft

DREDGING VOLUME FROM 39.5' TO 41.5' DRAFT

| Station | Dredging Volume from -52.1' to -54.1' PLD (mts3) | Overdredge Volume from -54.1' to -56.1' PLD (mts3) | Total dredging volume from 52.1' to 56.1' |
|---|---|---|---|
| STA( 68+415 @ 70+000 ) | 408,134 | 203,720 | 611,854 |
| STA( 70+000 @ 74+000 ) | 576,075 | 361,947 | 938,022 |
| STA( 74+000 @ 76+000 ) | 452,291 | 249,408 | 701,699 |
| STA( 76+000 @ 78+000 ) | 158,012 | 179,735 | 337,747 |
| STA( 78+000 @ 80+000 ) | 200,718 | 58,536 | 259,254 |
| STA( 80+000 @ 82+000 ) | 298,098 | 207,059 | 505,157 |
| STA( 82+000 @ 83+000 ) | 5,564 | 54,250 | 59,814 |
| STA( 83+000 @ 85+920 ) | 0 | 289 | 289 |
| TOTAL | 2,098,892 | 1,314,944 | 3,413,836 |

DREDGING VOLUME FROM 39.5' TO 46' DRAFT

| | Dredging Volume from -52.1' to -58.6' PLD (mts3) | Overdredge Volume from -58.6' to -60.6' PLD (mts3) | Total dredging volume from 52.1' to 60.6' |
|---|---|---|---|
| STA( 71+200 @ 74+000 ) | 1,129,205 | 435,121 | 1,564,326 |
| STA( 74+000 @ 76+000 ) | 1,071,232 | 299,849 | 1,371,081 |
| STA( 76+000 @ 78+000 ) | 691,987 | 298,920 | 990,907 |
| STA( 78+000 @ 80+000 ) | 479,297 | 281,568 | 760,865 |
| STA( 80+000 @ 82+000 ) | 834,118 | 443,572 | 1,277,690 |
| STA( 82+000 @ 83+000 ) | 134,534 | 150,810 | 285,344 |
| STA( 83+000 @ 85+920 ) | 51,135 | 58,523 | 109,658 |
| TOTAL | 4,391,508 | 1,968,363 | 6,359,871 |

DREDGING VOLUME FROM 41.5' TO 46' DRAFT

| | Dredging Volume from -56.1' to -58.6' PLD (mts3) | Overdredge Volume from -58.6' to -60.6' PLD (mts3) | Total dredging volume from -54.1' to 60.6' |
|---|---|---|---|
| STA( 71+200 @ 74+000 ) | 472,590 | 435,121 | 907,711 |
| STA( 74+000 @ 76+000 ) | 369,533 | 299,849 | 669,382 |
| STA( 76+000 @ 78+000 ) | 354,240 | 298,920 | 653,160 |
| STA( 78+000 @ 80+000 ) | 220,043 | 281,568 | 501,611 |
| STA( 80+000 @ 82+000 ) | 328,961 | 443,572 | 772,533 |
| STA( 82+000 @ 83+000 ) | 74,720 | 150,810 | 225,530 |
| STA( 83+000 @ 85+920 ) | 50,846 | 58,523 | 109,369 |
| TOTAL | 1,870,933 | 1,968,363 | 3,839,296 |

DREDGING VOLUME FROM 41.5' TO 46' DRAFT

| Station | Dredging Volume from -54.1' to -58.6' PLD (mts3) | Overdredge Volume from -58.6' to -60.6' PLD (mts3) | Total dredging volume from -54.1' to 60.6' |
|---|---|---|---|
| STA( 71+200 @ 74+000 ) | 472,590 | 435,121 | 907,711 |
| STA( 74+000 @ 76+000 ) | 369,533 | 299,849 | 669,382 |
| STA( 76+000 @ 78+000 ) | 354,240 | 298,920 | 653,160 |
| STA( 78+000 @ 80+000 ) | 220,043 | 281,568 | 501,611 |
| STA( 80+000 @ 82+000 ) | 328,961 | 443,572 | 772,533 |
| STA( 82+000 @ 83+000 ) | 74,720 | 150,810 | 225,530 |
| STA( 83+000 @ 85+920 ) | 50,846 | 58,523 | 109,369 |
| TOTAL | **1,870,933** | **1,968,363** | **3,839,296** |

DREDGING COST FROM 41.5' TO 46' DRAFT

| Station | Total dredging volume from -54.1' to 60.6' | Hard and medium material estimated % | Hard and medium material volume ($m^3$) | Soft material ($m^3$) | Hard and medium hard material unit cost ($\$/m^3$) | Soft material unit cost ($\$/m^3$) | Total cost ($) |
|---|---|---|---|---|---|---|---|
| STA( 71+200 @ 74+000 ) | 907,711 | 100% | 907,711 | 0 | 14.66 | 5.86 | 13,307,043 |
| STA( 74+000 @ 76+000 ) | 669,382 | 100% | 669,382 | 0 | 16.00 | 6.40 | 10,710,112 |
| STA( 76+000 @ 78+000 ) | 653,160 | 84% | 548,654 | 104,506 | 16.00 | 6.40 | 9,447,306 |
| STA( 78+000 @ 80+000 ) | 501,611 | 87% | 436,402 | 65,209 | 16.00 | 6.40 | 7,399,765 |
| STA( 80+000 @ 82+000 ) | 772,533 | 34% | 262,661 | 509,872 | 14.66 | 5.86 | 6,838,462 |
| STA( 82+000 @ 83+000 ) | 225,530 | 32% | 72,170 | 153,360 | 16.00 | 6.40 | 2,136,220 |
| STA( 83+000 @ 85+920 ) | 109,369 | 0% | 0 | 109,369 | 16.00 | 6.40 | 699,962 |
| TOTAL | **3,839,296** | | **2,896,980** | **942,316** | | | **50,538,871** |

| DREDGING UNIT COST | | |
|---|---|---|
| **DESCRIPTION** | **HARD MATERIAL** | **SOFT MATERIAL** |
| PRODUCTION (m3/wk) | 24,000 | 60,000 |
| MINDI COST ( $/m3 ) | $14.66 | $5.86 |
| BOOSTER COST ( $/m3 ) | $1.34 | $0.54 |
| DI + BOOSTER COST ( $/m3 ) | $16.00 | $6.40 |

**DREDGING VOLUME FROM 39.5' TO 46' DRAFT**

| | Dredging Volume from -52.1' to -58.6' PLD (mts3) | Overdredge Volume from -58.6' to -60.6' PLD (mts3) | Total dredging volume from 52.1' to 60.6' |
|---|---|---|---|
| STA( 71+200 @ 74+000 ) | 1,129,205 | 435,121 | 1,564,326 |
| STA( 74+000 @ 76+000 ) | 1,071,232 | 299,849 | 1,371,081 |
| STA( 76+000 @ 78+000 ) | 691,987 | 298,920 | 990,907 |
| STA( 78+000 @ 80+000 ) | 479,297 | 281,568 | 760,865 |
| STA( 80+000 @ 82+000 ) | 834,118 | 443,572 | 1,277,690 |
| STA( 82+000 @ 83+000 ) | 134,534 | 150,810 | 285,344 |
| STA( 83+000 @ 85+920 ) | 51,135 | 58,523 | 109,658 |
| TOTAL | 4,391,508 | 1,968,363 | 6,359,871 |

**DREDGING VOLUME FROM 39.5' TO 50' DRAFT**

| | Dredging Volume from -52.1' to -62.6' PLD (mts3) | Overdredge Volume from -62.6' to -64.6' PLD (mts3) | Total dredging volume from 52.1' to 64.6' |
|---|---|---|---|
| STA( 71+200 @ 74+000 ) | 1,908,139 | 463,203 | 2,371,342 |
| STA( 74+000 @ 76+000 ) | 1,669,953 | 299,362 | 1,969,315 |
| STA( 76+000 @ 78+000 ) | 1,288,852 | 298,431 | 1,587,283 |
| STA( 78+000 @ 80+000 ) | 1,090,381 | 307,203 | 1,397,584 |
| STA( 80+000 @ 82+000 ) | 1,692,906 | 416,141 | 2,109,047 |
| STA( 82+000 @ 83+000 ) | 531,991 | 241,656 | 773,647 |
| STA( 83+000 @ 85+920 ) | 282,214 | 355,875 | 638,089 |
| TOTAL | 8,464,436 | 2,381,871 | 10,846,307 |

**DREDGING VOLUME FROM 46' TO 50' DRAFT**

| | Dredging Volume from -60.6' to -62.6' PLD (mts3) | Overdredge Volume from -62.6' to -64.6' PLD (mts3) | Total dredging volume from -60.6' to 64.6' PLD (mts3) |
|---|---|---|---|
| STA( 71+200 @ 74+000 ) | 625,220 | 463,203 | 1,088,423 |
| STA( 74+000 @ 76+000 ) | 298,872 | 299,362 | 598,234 |
| STA( 76+000 @ 78+000 ) | 297,945 | 298,431 | 596,376 |
| STA( 78+000 @ 80+000 ) | 329,516 | 307,203 | 636,719 |
| STA( 80+000 @ 82+000 ) | 415,216 | 416,141 | 831,357 |
| STA( 82+000 @ 83+000 ) | 246,647 | 241,656 | 488,303 |
| STA( 83+000 @ 85+920 ) | 172,556 | 355,875 | 528,431 |
| TOTAL | 2,385,972 | 2,381,871 | 4,767,843 |

DREDGING VOLUME FROM 46' TO 50' DRAFT

| | Dredging Volume from -60.6' to -62.6' PLD (mts3) | Overdredge Volume from -62.6' to -64.6' PLD (mts3) | Total dredging volume from -60.6' to 64.6' PLD (mts3) |
|---|---|---|---|
| STA( 71+200 @ 74+000 ) | 625,220 | 463,203 | 1,088,423 |
| STA( 74+000 @ 76+000 ) | 298,872 | 299,362 | 598,234 |
| STA( 76+000 @ 78+000 ) | 297,945 | 298,431 | 596,376 |
| STA( 78+000 @ 80+000 ) | 329,516 | 307,203 | 636,719 |
| STA( 80+000 @ 82+000 ) | 415,216 | 416,141 | 831,357 |
| STA( 82+000 @ 83+000 ) | 246,647 | 241,656 | 488,303 |
| STA( 83+000 @ 85+920 ) | 172,556 | 355,875 | 528,431 |
| TOTAL | 2,385,972 | 2,381,871 | 4,767,843 |

DREDGING COST FROM 46' TO 50' DRAFT

| Station | Total dredging volume from -60.6' to 64.6' PLD (mts3) | Hard and medium material estimated % | Hard and medium material volume ($m^3$) | Soft material ($m^3$) | Hard and medium hard material unit cost ($/$m^3$) | Soft material unit cost ($/$m^3$) | Total cost ($) |
|---|---|---|---|---|---|---|---|
| STA( 71+200 @ 74+000 ) | 1,088,423 | 100% | 1,088,423 | 0 | 14.66 | 5.86 | 15,956,281 |
| STA( 74+000 @ 76+000 ) | 598,234 | 100% | 598,234 | 0 | 16.00 | 6.40 | 9,571,744 |
| STA( 76+000 @ 78+000 ) | 596,376 | 91% | 542,702 | 53,674 | 16.00 | 6.40 | 9,026,747 |
| STA( 78+000 @ 80+000 ) | 636,719 | 91% | 579,414 | 57,305 | 16.00 | 6.40 | 9,637,379 |
| STA( 80+000 @ 82+000 ) | 831,357 | 34% | 282,661 | 548,696 | 14.66 | 5.86 | 7,359,172 |
| STA( 82+000 @ 83+000 ) | 488,303 | 32% | 156,257 | 332,046 | 16.00 | 6.40 | 4,625,206 |
| STA( 83+000 @ 85+920 ) | 528,431 | 0% | 0 | 528,431 | 16.00 | 6.40 | 3,381,958 |
| TOTAL | 4,767,843 | | 3,247,692 | 1,520,151 | | | 59,558,488 |

| DREDGING UNIT COST | | |
|---|---|---|
| DESCRIPTION | HARD MATERIAL | SOFT MATERIAL |
| PRODUCTION (m3/wk) | 24,000 | 60,000 |
| MINDI COST ( $/m3 ) | $14.66 | $5.86 |
| BOOSTER COST ( $/m3 ) | $1.34 | $0.54 |
| DI + BOOSTER COST ( $/m3 ) | $16.00 | $6.40 |

# APPENDIX No. 9

## ACP Cutter Suction Dredge MINDI

# DREDGING RATES OF THE "MINDI"

| | |
|---|---|
| **Inflation Factor Conversion** | **1.023** |
| **Division Overhead** | **12%** |

| | | **Total Costs** | | **Marginal Costs** |
|---|---|---|---|---|
| Hourly Cost for Availability | $ | 781 | | n.a. |
| Hourly Cost for Labor | | 624 | | 624 |
| Indirect Costs relating to Labor | | 75 | | 75 |
| Average Hourly Cost of Fuel | | 233 | | 233 |
| Support for 3 small tugboats | | 344 /1 | | 344 |
| Guard or Passenger Boat Support | | 81 /1 | | 81 |
| Hydrographic Launches Support (5 days a week - day shift) | | 15 | | |
| Sub-total for Support | | 439 | | 439 |
| **Total** | **$** | **2,153** | **$** | **1,371** |
| **Cost by Shift** | | | | |
| Cost for Availability for 8 hours | $ | 6,251 | | n.a. |
| Cost of Labor for 8 hours | | 5,591 | | 5,591 |
| Fuel Consumption for 8 hours | | 1,399 | | 1,399 |
| Support for 8 hours | | 3,514 | | 3,514 |
| **Total Cost by Shift** | **$** | **16,756** | | **10,504** |
| **Daily Cost** | | | | |
| Cost for Availability | | 18,754 | | n.a. |
| Labor Cost | | 16,774 | | 16,774 |
| Fuel Consumption | | 4,196 | | 4,196 |
| Support | | 10,542 | | 10,542 |
| **Total Daily Cost** | **$** | **50,267** | | **$31,512** |
| **Weekly Cost** | | | | |
| Cost for Availability | | 131,281 | | n.a. |
| Labor Cost | | 117,421 | | 117,421 |
| Fuel Consumption | | 29,370 | | 29,370 |
| Support | | 73,794 | | 73,794 |
| **Total Weekly Cost** | **$** | **351,866** | | **$220,585** |

**Estimated Excavated Volumes by Week (Cubic Meters in Bank)**

| | |
|---|---|
| **Productivity a** | **36,000** |
| **Productivity b** | **28,000** |
| **Productivity c** | **24,000** |
| **Productivity d** | **60,000** |

**Cost of Cubic Meter in Bank**

| | | |
|---|---|---|
| **Productivity a** | **$9.77** | **$6.13** |
| **Productivity b** | **$12.57** | **$7.88** |
| **Productivity c** | **$14.66** | **$9.19** |
| **Productivity d** | **$5.86** | **$3.68** |

**Appendix No. 9 B**
Updated on Feb. 12, 2001

## "MINDI" DREDGE

| | |
|---|---|
| Overhead | 12% |
| Employee Benefits | 38% |
| Night Shift Differential | 10% |
| Complementary Sunday | 25% |
| Overtime | 50% |

**DAY SHIFT**

| On Deck Department: | Grade | No. | Hourly Rate | Total Hourly Rate | Annual Rate | With Benefits Annually | 5 hours weekly with benefits annually | 8 hours overtime weekly with benefits annually |
|---|---|---|---|---|---|---|---|---|
| Captain in charge | FE-17 | 1 | $ 34.21 | $ 34.21 | $ 71,157 | $ 98,211 | $ 18,414 | $ 29,463 |
| Welder | MG-10 | 3 | 17.56 | 52.68 | 109,574 | 151,235 | 28,356 | 45,370 |
| Seaman | MG-07 | 1 | 6.96 | 6.96 | 14,477 | 19,981 | 3,746 | 5,994 |
| Laborer | MG-03 | 1 | 5.75 | 5.75 | 11,960 | 16,507 | 3,095 | 4,952 |
| **Subtotal** | | **6** | | **$ 99.60** | **207,168** | **285,933** | **53,612** | **85,780** |
| **Engine Department:** | | | | | | | | |
| Chief Engineer | ME-16 | 1 | $ 32.02 | $ 32.02 | $ 66,602 | $ 91,924 | $ 17,236 | $ 27,577 |
| Deputy Chief Engineer | ME-15 | 1 | 29.99 | 29.99 | 62,379 | 86,096 | 16,143 | 25,829 |
| Engineer | ME-14 | 1 | 28.15 | 28.15 | 58,552 | 80,813 | 15,153 | 24,244 |
| Electrician | FE-11 | 1 | 24.35 | 24.35 | 50,648 | 69,904 | 13,107 | 20,971 |
| Machinist | MG-10 | 1 | 17.56 | 17.56 | 36,525 | 50,412 | 9,452 | 15,123 |
| Nautical engine mechanic | MG-10 | 2 | 17.56 | 35.12 | 73,050 | 100,823 | 18,904 | 30,247 |
| Electrical Equipment Repairer | MG-09 | 1 | 11.12 | 11.12 | 23,130 | 31,923 | 5,986 | 9,577 |
| **Subtotal** | | **8** | | **178.31** | **370,885** | **511,895** | **95,980** | **153,569** |
| **Staff at Dredged Material Disposal Sites** | | | | | | | | |
| Leader | ML-10 | 1 | $ 19.31 | $ 19.31 | $ 40,165 | $ 55,435 | $ 10,394 | $ 16,631 |
| Helpers | MG-05 | 2 | 6.23 | 12.46 | 25,917 | 35,770 | 6,707 | 10,731 |
| **Subtotal** | | **3** | | **31.77** | **66,081.60** | **91,205.82** | **17,101.09** | **27,361.75** |
| **TOTAL- DAY SHIFT CREW** | | **14** | | **$ 309.68** | **644,134** | **889,034** | **166,694** | **266,710** |
| **ROTATION CREW** | | | | | | | | |
| **On-deck Department:** | | | | | | | | |
| Dredge Operator | FE-14 | 1 | $ 28.15 | $ 28.15 | $ 58,552 | $ 80,813 | $ 15,153 | $ 24,244 |
| Dredge Officer | FE-11 | 1 | 24.35 | 24.35 | 50,648 | 69,904 | 13,107 | 20,971 |
| Dredge Seaman Leader | ML-08 | 1 | 9.74 | 9.74 | 20,259 | 27,962 | 5,243 | 8,389 |
| Winch Operator | MG-08 | 2 | 8.25 | 16.50 | 34,320 | 47,368 | 8,882 | 14,211 |
| Dredge Seaman | MG-07 | 7 | 6.96 | 48.72 | 101,338 | 139,866 | 26,225 | 41,960 |
| **Subtotal** | | **12** | | **$ 127.46** | **265,117** | **365,914** | **68,609** | **109,774** |
| **Engine Department:** | | | | | | | | |
| Dredge Engineer | ME-14 | 1 | $ 28.15 | $ 28.15 | $ 58,552 | $ 80,813 | $ 15,153 | $ 24,244 |
| Dredge Engineer | ME-11 | 1 | $ 24.35 | 24.35 | 50,648 | 69,904 | 13,107 | 20,971 |
| Oiler | MG-08 | 2 | 8.25 | 16.50 | 34,320 | 47,368 | 8,882 | 14,211 |
| **Subtotal** | | **4** | | **$ 69.00** | **143,520** | **198,086** | **37,141** | **59,426** |
| **Staff at Dredged Material Disposal Sites** | | | | | | | | |
| Tractor Operators | MG-10 | 2 | $ 17.56 | $ 35.12 | $ 73,050 | $ 100,823 | $ 18,904 | $ 30,247 |
| Helper | MG-08 | 2 | 8.25 | 16.50 | 34,320 | 47,368 | 8,882 | 14,211 |
| **Subtotal** | | | | **$ 51.62** | **107,370** | **148,192** | **27,786** | **44,457** |
| **TOTAL- ROTATION CREW** | | **16** | | **$ 248.08** | **516,006** | **712,192** | **133,536** | **213,658** |
| **TOTAL - 4 ROTATION CREWS** | | | | | **2,064,026** | **2,848,768** | **534,144** | **854,630** |
| **TOTAL - 5 ROTATION CREWS** | | | | | **2,580,032** | **3,560,960** | | |
| **TOTAL WITH 4 CREWS, 1 DAY SHIFT AND OVERTIME** | | | | | | | **3,904,496** | **4,859,143** |
| | | | | | | | 446 | 555 |
| **TOTAL WITH 5 CREWS 1 DAY SHIFT AND NO OVERTIME** | | | | | | **4,449,994** | | |
| | | | | | | 508 | | |

**Total Average Rate with cargo - 4 rotation crews and 8 hours of overtime weekly for each crew**

| | | |
|---|---|---|
| Monday to Friday | 660.01 | |
| Saturday | 474.79 | |
| Sunday | 593.49 | |
| **Total Average Hourly Rate** | **$ 624.05** | **5,466,664** |

**Total Average Rate with cargo - 5 rotation crews and 1 hour of overtime weekly**

| | | |
|---|---|---|
| Monday to Friday | 645.15 | |
| Saturday | 497.34 | |
| Sunday | 621.67 | |
| **Total Average Hourly Rate** | **$ 620.68** | **5,437,166** |

1/ There are 5 steps in the hourly wage grade, and the last step was used.
2/ Employee benefits were included at 38.02% of the average hourly wages
3/ Included in the average hourly wages were 10% for night differential, 25% for complementary Sunday, and 50% for overtime.
4/ Eight hours of weekly overtime were included for each crew.

**Appendix No. 9 C**
Updated on March 20, 2001

**12%** Division Overhead (applied to labor)

## Dredging Division - Mindi Suction Dredge

| Costs | FY 1995 Actual | FY 1996 Actual | FY 1997 Actual | FY 1998 Actual | Yearly Estimate | |
|---|---|---|---|---|---|---|
| Labor | $ - | $ - | $ - | $ - | - | |
| Supplies/Materials (excluding fuel) | 905,333 | 676,442 | 1,232,400 | 1,038,000 | 963,044 | |
| Supplies/Materials for Disposal Sites | | | 58,000 | 313,000 | 185,500 | |
| Other Direct Expenses | 1,328,672 | 1,612,966 | | | 1,470,819 | |
| General Maintenance | 531,943 | 310,300 | 1,180,000 | 852,000 | 718,561 | |
| Indirect Maintenance CC 556 | | | | | 79,200 | 1/ |
| Equipment Maintenance at Disposal Sites | | | 32,000 | 88,000 | 60,000 | |
| Overhaul Expenses | 328,029 | 691,217 | 1,571,000 | | 863,415 | |
| Depreciation | 508,597 | 491,390 | 544,654 | 601,226 | 536,467 | 2/ |
| Maintenance at Disposal Sites | | | | | | |
| Maritime Insurance | | | | | 72,837 | 3/ |
| Total | $3,602,574 | $ 3,782,315 | $ 4,618,054 | $2,892,226 | $ 4,949,842 | |

| | |
|---|---|
| Total Annual Estimate | $ 4,949,842 |
| Number of Available Days | 270 |
| Daily Cost for Availability without crew (demand) | $ 18,333 |
| **Hourly Cost for Availability without crew (demand)** | **$ 764** |

| | Inter-Divisional | | Capital (with Division overhead) | Commercial (w/RGG) |
|---|---|---|---|---|
| Hourly Cost for Availability | $ 764 | | $ 764 | $ 1,039 |
| Stand-by or day crew, hourly | $ 310 | | $ 347 | $ 472 |
| **Total Hourly Cost for Availability** | **$ 1,074** | | **$ 1,111** | **$ 1,511** |
| Hourly Cost for Availability | $ 764 | | $ 764 | $ 1,039 |
| Operations Crew - hourly cost | $ 624 | | $ 699 | $ 951 |
| Hourly Cost of Fuel | $ 228 | 4/ | $ 228 | $ 310 |
| **Hourly Cost of Operation (without support equipment)** | **$ 1,616** | | **$ 1,691** | **$ 2,299** |
| Support of 3 small tugboats | $ 319 | 5/ | $ 336 | $ 457 |
| Guard or Passenger Support Boat | $ 73 | | $ 79 | $ 107 |
| Hydrography Support Launches (5 days a week - day shift) | $ 14 | | $ 15 | $ 20 |
| **Hourly Cost of Operation (with support equipment)** | **$ 2,022** | | **$ 2,120** | **$ 2,883** |

**Rate for Mobilization**

| | | | |
|---|---|---|---|
| Hourly Cost for Availability (without crew) | $ 764 | $ 764 | $ 1,039 |
| Hourly Cost of Operations Crew | $ 624 | $ 699 | $ 951 |
| Hourly Cost of Pilot (required to move dredge) | $ 45 | $ 51 | $ 69 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cost of a large tugboat to move the dredge | $ | 332 | $ | 354 | $ | 482 |
| Cost of a small tugboat to move the dredge | $ | 106 | $ | 112 | $ | 152 |
| Cost of a mid-size tugboat to move pipes and pontoons | $ | 202 | $ | 217 | $ | 295 |
| Cost of a small tugboat to move pipes and pontoons | $ | 106 | $ | 112 | $ | 152 |
| **Total Hourly Rate for Mobilization** | **$** | **2,180** | **$** | **2,309** | **$** | **3,140** |

1/ Distribution of Support of "other 550" of 556 was based on the equitable assignment of the 5 largest equipment of the central cost system.

2/ The depreciation includes the dredge and its improvements, its auxiliary equipment, the discharge pipes and pontoons, as well a 4 tractors.

3/ The cost of maritime insurance paid by ACP in 2000 was proportionately allocated to all insured floating equipment.

4/ Usage of 290 gallons/hour, 42 gallons/barrel, $33/barrel.

5/ One CHAME class and two ULUA types.

# APPENDIX No. 10

## Yearly Cost Indexes for Channels & Canal

## And

## Consumer Price Index

## YEARLY COST INDEXES FOR CHANNEL & CANALS

**SOURCE: U.S. CORPS OF ENGINEERS (USACE)**

| FISCAL YEARS | YEARLY COSTS | YEARLY PERCENTAGE CHANGE |
|---|---|---|
| 1995 | 470.64 | |
| 1996 | 482.90 | 0.026 |
| 1997 | 492.16 | 0.019 |
| 1998 | 503.55 | 0.023 |
| 1999 | 516.11 | 0.025 |
| 2000 | 526.72 | 0.021 |
| 2001 | 536.03 | 0.018 |
| 2002 [2] | 550.03 | 0.026 |
| **LAST 8-YEAR AVERAGE** | | **0.023** |

Notes:

1. Fiscal year correspond the period from October 1 to September 30
2. Forecasted data developed based on US Office of Management and Budget projections.

## Consumer Price Index (CPI) Conversion Factors to Convert to 2001 Dollars
### Using the CPI-U-X1 series, which applies the CPI used starting 1983 to 1950-1982
### Should be used when exact comparisons are needed between years during the period since 1950

To convert dollars of a year to 2001 dollars, __divide__ the dollar amount
of that year by the conversion factor (CF) for that year
For example, $1000 dollars of 1953 = $6135 dollars of 2001 ($1000 / 0.163)

| Year | CF | Year | CF | Year | CF | Year | CF | Year | CF | Year | CF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 0.148 | 1960 | 0.182 | 1970 | 0.233 | 1980 | 0.465 | 1989 | 0.700 | 1999 | 0.941 |
| 1951 | 0.160 | 1961 | 0.184 | 1971 | 0.243 | 1981 | 0.509 | 1990 | 0.738 | 2000 | 0.972 |
| 1952 | 0.163 | 1962 | 0.185 | 1972 | 0.251 | 1982 | 0.540 | 1991 | 0.769 | 2001 | **1.000** |
| 1953 | 0.164 | 1963 | 0.188 | 1973 | 0.267 | **CPI-U = CPI-U-X1** | | 1992 | 0.792 | 2002 | 1.018 |
| 1954 | 0.165 | 1964 | 0.190 | 1974 | 0.293 | 1983 | 0.562 | 1993 | 0.816 | 2003 | 1.042 |
| 1955 | 0.164 | 1965 | 0.193 | 1975 | 0.317 | 1984 | 0.587 | 1994 | 0.837 | 2004 | 1.067 |
| 1956 | 0.167 | 1966 | 0.199 | 1976 | 0.335 | 1985 | 0.608 | 1995 | 0.861 | 2005 | 1.093 |
| 1957 | 0.172 | 1967 | 0.205 | 1977 | 0.357 | 1986 | 0.619 | 1996 | 0.886 | 2006 | 1.120 |
| 1958 | 0.177 | 1968 | 0.213 | 1978 | 0.381 | 1987 | 0.641 | 1997 | 0.906 | 2007 | 1.147 |
| 1959 | 0.178 | 1969 | 0.223 | 1979 | 0.418 | 1988 | 0.668 | 1998 | 0.920 | 2008 | 1.176 |

CPI is CPI-U-X1, which applies the post-1982 CPI methods to the period 1950 to 1982.
By definition, CPI-U-X1 equals CPI-U starting in 1983, so the conversion factors are the same.
2000 conversion factors use the final 2000 year-to-year CPI (172.2). Conversion factors for 2001-2008 use the average of inflation estimates by the Office of Management and Budget and the Congressional Budget Office.
It is recommended that numbers be __rounded__ to **no more than __three__ decimal places,**
for example, $6135 in the example at the top of this page becomes $6140

**Note:** To reverse the process, that is, to determine what a 2000-dollar figure would be in the dollars of another year, simply __**multiply**__ the 2001 figure by the conversion factor of that year. For example, $1000 2001 dollars would be $148 in 1950 ($1000 x 0.148 = 148), again rounded to 3 decimal places ($148).

The 1983 changes reduced the inflation rate by changing the way costs of home ownership are measured.
For reference, the following lists yearly inflation rate 1970 to 1985 using the CPI and the CPI-U-X1 series, which applies the 1983 measure to the period 1950 to 1982.

| | CPI | CPI-U-X1 | CPI Inflation | X1 Inflation | Difference (CPI minus X1) |
|---|---|---|---|---|---|
| 1970 | 38.8 | 41.3 | 5.7 | 4.8 | 0.9 |
| 1971 | 40.5 | 43.1 | 4.4 | 4.4 | 0.0 |
| 1972 | 41.8 | 44.4 | 3.2 | 3.0 | 0.2 |
| 1973 | 44.4 | 47.2 | 6.2 | 6.3 | -0.1 |
| 1974 | 49.3 | 51.9 | 11.0 | 10.0 | 1.0 |
| 1975 | 53.8 | 56.2 | 9.1 | 8.3 | 0.8 |
| 1976 | 56.9 | 59.4 | 5.8 | 5.7 | 0.1 |
| 1977 | 60.6 | 63.2 | 6.5 | 6.4 | 0.1 |
| 1978 | 65.2 | 67.5 | 7.6 | 6.8 | 0.8 |
| 1979 | 72.6 | 74.0 | 11.3 | 9.6 | 1.7 |
| 1980 | 82.4 | 82.3 | 13.5 | 11.2 | 2.3 |
| 1981 | 90.9 | 90.1 | 10.3 | 9.5 | 0.8 |
| 1982 | 96.5 | 95.6 | 6.2 | 6.1 | 0.0 |
| 1983 | 99.6 | 99.6 | 3.2 | 4.2 | -1.0 |

Starting 1983, CPI = CPI-U-X1, but comparing changes between 1982 and 1983 price levels in CPI and CPI-U-X1 results in different rates of inflation for 1983.

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TABLE A-2, YEARLY COST INDEXES BY CWBS FEATURE CODE
Base Year 1967 = 100

| CWBS - FEATURE CODES | Wt % | FY68 Oct 67 - Sep 68 | FY69 Oct 68 - Sep 69 | FY70 Oct 69 - Sep 70 | FY71 Oct 70 - Sep 71 | FY72 Oct 71 - Sep 72 | FY73 Oct 72 - Sep 73 | FY74 Oct 73 - Sep 74 | FY75 Oct 74 - Sep 75 | FY76 Oct 75 - Sep 76 | FY77 Oct 76 - Sep 77 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 02 RELOCATIONS | 5% | 105.52 | 112.79 | 118.78 | 134.70 | 146.50 | 153.85 | 167.31 | 193.03 | 206.77 | 218.70 |
| 03 RESERVOIRS | 5% | 104.95 | 115.82 | 126.39 | 146.60 | 161.77 | 167.43 | 175.64 | 201.34 | 215.69 | 226.15 |
| 04 DAMS | 15% | 104.99 | 112.21 | 121.16 | 132.02 | 142.58 | 149.41 | 165.26 | 186.45 | 203.20 | 214.55 |
| 05 LOCKS | 2% | 104.91 | 111.93 | 119.92 | 132.69 | 143.03 | 150.04 | 167.12 | 190.30 | 201.75 | 213.78 |
| 06 FISH & WILDLIFE FACILITIES | 5% | 104.72 | 112.28 | 120.22 | 132.70 | 143.52 | 150.83 | 171.27 | 193.50 | 205.30 | 216.70 |
| 07 POWER PLANT | 10% | 104.79 | 111.26 | 119.72 | 128.54 | 135.78 | 141.26 | 159.74 | 185.20 | 194.61 | 206.65 |
| 08 ROADS, RAILROADS & BRIDGES | 10% | 105.52 | 112.79 | 118.78 | 134.70 | 146.50 | 153.85 | 167.31 | 193.03 | 206.77 | 218.70 |
| 09 CHANNELS & CANALS | 3% | 105.43 | 112.16 | 120.51 | 132.28 | 141.12 | 146.21 | 161.64 | 186.46 | 202.12 | 212.28 |
| 10 BREAKWATER & SEAWALLS | 5% | 104.83 | 111.42 | 118.88 | 127.05 | 136.29 | 141.06 | 158.76 | 188.03 | 201.26 | 213.56 |
| 11 LEVEES & FLOODWALLS | 5% | 105.31 | 112.16 | 120.69 | 132.30 | 143.87 | 149.31 | 166.79 | 190.35 | 204.98 | 216.62 |
| 12 NAVIGATION PORTS & HARBORS | 10% | 104.36 | 109.78 | 116.39 | 127.54 | 135.81 | 143.73 | 162.24 | 189.32 | 204.99 | 220.93 |
| 13 PUMPING PLANT | 5% | 104.83 | 112.17 | 119.75 | 131.73 | 141.94 | 149.36 | 170.45 | 190.49 | 202.61 | 215.84 |
| 14 RECREATION FACILITIES | 5% | 104.83 | 112.17 | 119.75 | 131.73 | 141.94 | 149.36 | 170.45 | 190.49 | 202.61 | 215.84 |
| 15 FLOODWAY CONTROL & DIVERSION STRUCTURE | 2% | 104.72 | 112.28 | 120.22 | 132.70 | 143.52 | 150.83 | 171.27 | 193.50 | 205.30 | 216.70 |
| 16 BANK STABILIZATION | 2% | 105.08 | 111.41 | 118.87 | 128.79 | 138.40 | 143.26 | 160.28 | 176.63 | 190.48 | 200.18 |
| 17 BEACH REPLENISHMENT | 2% | 106.12 | 113.34 | 123.12 | 136.97 | 149.55 | 154.85 | 167.00 | 188.41 | 204.97 | 214.59 |
| 18 CULTURAL RESOURCE PRESERVATION | 2% | 104.83 | 112.17 | 119.75 | 131.73 | 141.94 | 149.36 | 170.45 | 190.49 | 202.61 | 215.84 |
| 19 BUILDINGS, GROUNDS & UTILITIES | 5% | 104.83 | 112.17 | 119.75 | 131.73 | 141.94 | 149.36 | 170.45 | 190.49 | 202.61 | 215.84 |
| 20 PERMANENT OPERATING EQUIPMENT | 2% | 104.83 | 112.17 | 119.75 | 131.73 | 141.94 | 149.36 | 170.45 | 190.49 | 202.61 | 215.84 |
| COMPOSITE INDEX (WEIGHTED AVERAGE) | 100% | 104.98 | 112.09 | 119.92 | 132.17 | 142.49 | 149.16 | 166.25 | 189.80 | 203.43 | 215.68 |
| YEARLY PERCENTAGE CHANGE | | | *6.8%* | *7.0%* | *10.2%* | *7.8%* | *4.7%* | *11.5%* | *14.2%* | *7.2%* | *6.0%* |

*Note: FY* indicates data developed based on OMB projections.*

## TABLE A-2, YEARLY COST INDEXES BY CWBS FEATURE CODE
Base Year 1967 = 100

| CWBS - FEATURE CODES | Wt % | FY78<br>Oct 77 - Sep 78 | FY79<br>Oct 78 - Sep 79 | FY80<br>Oct 79 - Sep 80 | FY81<br>Oct 80 - Sep 81 | FY82<br>Oct 81 - Sep 82 | FY83<br>Oct 82 - Sep 83 | FY84<br>Oct 83 - Sep 84 | FY85<br>Oct 84 - Sep 85 | FY86<br>Oct 85 - Sep 86 | FY87<br>Oct 86 - Sep 87 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 02 RELOCATIONS | 5% | 239.50 | 260.37 | 280.18 | 306.16 | 327.40 | 340.86 | 349.51 | 355.43 | 358.36 | 366.32 |
| 03 RESERVOIRS | 5% | 243.39 | 261.77 | 285.56 | 315.28 | 346.62 | 365.07 | 375.29 | 381.95 | 386.61 | 394.55 |
| 04 DAMS | 15% | 234.29 | 254.47 | 277.12 | 302.42 | 323.67 | 334.76 | 344.25 | 350.47 | 352.94 | 358.99 |
| 05 LOCKS | 2% | 233.87 | 254.13 | 276.11 | 301.87 | 323.21 | 334.84 | 343.82 | 348.28 | 350.35 | 356.84 |
| 06 FISH & WILDLIFE FACILITIES | 5% | 238.15 | 260.08 | 280.32 | 304.02 | 322.75 | 332.91 | 342.38 | 347.18 | 348.99 | 354.63 |
| 07 POWER PLANT | 10% | 222.75 | 241.68 | 266.35 | 294.48 | 314.76 | 324.11 | 333.16 | 337.53 | 341.85 | 348.65 |
| 08 ROADS, RAILROADS & BRIDGES | 10% | 239.50 | 260.37 | 280.18 | 306.16 | 327.40 | 340.86 | 349.51 | 355.43 | 358.36 | 366.32 |
| 09 CHANNELS & CANALS | 3% | 230.44 | 249.44 | 276.52 | 306.57 | 333.45 | 346.07 | 354.42 | 358.24 | 362.93 | 371.71 |
| 10 BREAKWATER & SEAWALLS | 5% | 232.34 | 252.07 | 280.18 | 311.09 | 336.64 | 347.98 | 355.31 | 361.66 | 366.25 | 374.63 |
| 11 LEVEES & FLOODWALLS | 5% | 235.94 | 256.08 | 280.75 | 308.97 | 333.68 | 346.21 | 354.99 | 359.69 | 362.50 | 370.28 |
| 12 NAVIGATION PORTS & HARBORS | 10% | 236.08 | 264.25 | 312.54 | 348.37 | 372.04 | 369.17 | 379.93 | 376.98 | 369.85 | 358.99 |
| 13 PUMPING PLANT | 5% | 235.78 | 257.20 | 277.60 | 302.25 | 320.13 | 330.82 | 341.06 | 346.12 | 347.33 | 353.35 |
| 14 RECREATION FACILITIES | 5% | 235.78 | 257.20 | 277.60 | 302.25 | 320.13 | 330.82 | 341.06 | 346.12 | 347.33 | 353.35 |
| 15 FLOODWAY CONTROL & DIVERSION STRUCTURE | 2% | 238.15 | 260.08 | 280.32 | 304.02 | 322.75 | 332.91 | 342.38 | 347.18 | 348.99 | 354.63 |
| 16 BANK STABILIZATION | 2% | 217.80 | 236.77 | 262.55 | 290.13 | 312.93 | 324.76 | 333.55 | 342.96 | 349.49 | 358.71 |
| 17 BEACH REPLENISHMENT | 2% | 231.77 | 249.67 | 273.04 | 299.95 | 327.10 | 342.33 | 351.39 | 358.74 | 365.02 | 373.80 |
| 18 CULTURAL RESOURCE PRESERVATION | 2% | 235.78 | 257.20 | 277.60 | 302.25 | 320.13 | 330.82 | 341.06 | 346.12 | 347.33 | 353.35 |
| 19 BUILDINGS, GROUNDS & UTILITIES | 5% | 235.78 | 257.20 | 277.60 | 302.25 | 320.13 | 330.82 | 341.06 | 346.12 | 347.33 | 353.35 |
| 20 PERMANENT OPERATING EQUIPMENT | 2% | 235.78 | 257.20 | 277.60 | 302.25 | 320.13 | 330.82 | 341.06 | 346.12 | 347.33 | 353.35 |
| COMPOSITE INDEX (WEIGHTED AVERAGE) | 100% | 234.58 | 255.68 | 280.71 | 308.09 | 329.87 | 340.21 | 349.63 | 354.31 | 356.24 | 361.43 |
| YEARLY PERCENTAGE CHANGE | | *8.8%* | *9.0%* | *9.8%* | *9.8%* | *7.1%* | *3.1%* | *2.8%* | *1.3%* | *0.5%* | *1.5%* |

*Note: FY* indicates data developed based on OMB projections.*

TABLE A-2, YEARLY COST INDEXES BY CWBS FEATURE CODE
Base Year 1967 = 100

| CWBS - FEATURE CODES | Wt % | FY88 Oct 87 - Sep 88 | FY89 Oct 88 - Sep 89 | FY90 Oct 89 - Sep 90 | FY91 Oct 90 - Sep 91 | FY92 Oct 91 - Sep 92 | FY93 Oct 92 - Sep 93 | FY94 Oct 93 - Sep 94 | FY95 Oct 94 - Sep 95 | FY96 Oct 95 - Sep 96 | FY97 Oct 96 - Sep 97 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 02 RELOCATIONS | 5% | 380.42 | 394.57 | 402.95 | 411.27 | 422.37 | 440.44 | 454.26 | 463.84 | 473.27 | 486.24 |
| 03 RESERVOIRS | 5% | 407.44 | 420.33 | 435.31 | 447.08 | 457.13 | 467.07 | 477.72 | 490.54 | 502.77 | 511.08 |
| 04 DAMS | 15% | 371.82 | 385.00 | 393.91 | 402.98 | 410.31 | 422.71 | 435.37 | 450.08 | 460.21 | 470.29 |
| 05 LOCKS | 2% | 371.05 | 383.63 | 390.92 | 398.73 | 405.85 | 418.00 | 430.98 | 445.65 | 454.94 | 464.50 |
| 06 FISH & WILDLIFE FACILITIES | 5% | 367.96 | 379.94 | 386.38 | 394.22 | 402.07 | 416.83 | 430.89 | 444.68 | 454.33 | 466.15 |
| 07 POWER PLANT | 10% | 360.93 | 376.54 | 387.78 | 398.99 | 406.50 | 416.04 | 425.62 | 438.32 | 445.08 | 451.66 |
| 08 ROADS, RAILROADS & BRIDGES | 10% | 380.42 | 394.57 | 402.95 | 411.27 | 422.37 | 440.44 | 454.26 | 463.84 | 473.27 | 486.24 |
| 09 CHANNELS & CANALS | 3% | 383.49 | 400.61 | 415.58 | 427.22 | 437.81 | 449.00 | 459.60 | 470.64 | 482.90 | 492.16 |
| 10 BREAKWATER & SEAWALLS | 5% | 385.55 | 405.23 | 422.20 | 435.04 | 446.15 | 457.62 | 467.96 | 478.33 | 490.36 | 499.73 |
| 11 LEVEES & FLOODWALLS | 5% | 384.15 | 400.02 | 410.71 | 419.99 | 429.95 | 441.84 | 453.83 | 467.41 | 477.68 | 486.21 |
| 12 NAVIGATION PORTS & HARBORS | 10% | 367.45 | 381.27 | 396.89 | 401.41 | 407.73 | 419.08 | 422.73 | 434.64 | 451.45 | 463.22 |
| 13 PUMPING PLANT | 5% | 369.45 | 383.14 | 386.75 | 392.35 | 399.07 | 410.63 | 424.91 | 439.72 | 445.58 | 454.99 |
| 14 RECREATION FACILITIES | 5% | 369.45 | 383.14 | 386.75 | 392.35 | 399.07 | 410.63 | 424.91 | 439.72 | 445.58 | 454.99 |
| 15 FLOODWAY CONTROL & DIVERSION STRUCTURE | 2% | 367.96 | 379.94 | 386.38 | 394.22 | 402.07 | 416.83 | 430.89 | 444.68 | 454.33 | 466.15 |
| 16 BANK STABILIZATION | 2% | 368.75 | 380.82 | 392.20 | 402.54 | 412.09 | 423.49 | 433.89 | 446.05 | 457.20 | 465.43 |
| 17 BEACH REPLENISHMENT | 2% | 383.51 | 399.48 | 414.03 | 425.67 | 438.77 | 451.27 | 460.91 | 474.09 | 487.28 | 495.55 |
| 18 CULTURAL RESOURCE PRESERVATION | 2% | 369.45 | 383.14 | 386.75 | 392.35 | 399.07 | 410.63 | 424.91 | 439.72 | 445.58 | 454.99 |
| 19 BUILDINGS, GROUNDS & UTILITIES | 5% | 369.45 | 383.14 | 386.75 | 392.35 | 399.07 | 410.63 | 424.91 | 439.72 | 445.58 | 454.99 |
| 20 PERMANENT OPERATING EQUIPMENT | 2% | 369.45 | 383.14 | 386.75 | 392.35 | 399.07 | 410.63 | 424.91 | 439.72 | 445.58 | 454.99 |
| COMPOSITE INDEX (WEIGHTED AVERAGE) | 100% | 374.45 | 388.68 | 398.34 | 406.78 | 415.22 | 427.83 | 439.45 | 452.31 | 462.16 | 472.17 |
| YEARLY PERCENTAGE CHANGE | | *3.6%* | *3.8%* | *2.5%* | *2.1%* | *2.1%* | *3.0%* | *2.7%* | *2.9%* | *2.2%* | *2.2%* |

*Note: FY* indicates data developed based on OMB projections.*

TABLE A-2, YEARLY COST INDEXES BY CWBS FEATURE CODE
Base Year 1967 = 100

| CWBS - FEATURE CODES | Wt % | FY98 Oct 97 - Sep 98 | FY99 Oct 98 - Sep 99 | FY00 Oct 99 - Sep 00 | FY01 Oct 00 - Sep 01 | FY02* Oct 01 - Sep 02 | FY03* Oct 02 - Sep 03 | FY04* Oct 03 - Sep 04 | FY05* Oct 04 - Sep 05 | FY06* Oct 05 - Sep 06 | FY07* Oct 06 - Sep 07 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 02 RELOCATIONS | 5% | 490.26 | 501.14 | 507.97 | 513.30 | 526.95 | 541.17 | 555.79 | 570.79 | 586.20 | 602.03 |
| 03 RESERVOIRS | 5% | 521.42 | 540.51 | 552.38 | 568.09 | 583.83 | 599.60 | 615.79 | 632.41 | 649.49 | 667.02 |
| 04 DAMS | 15% | 479.06 | 488.39 | 496.78 | 503.96 | 515.89 | 529.82 | 544.12 | 558.81 | 573.90 | 589.40 |
| 05 LOCKS | 2% | 472.47 | 480.10 | 488.88 | 495.43 | 507.88 | 521.59 | 535.68 | 550.14 | 564.99 | 580.25 |
| 06 FISH & WILDLIFE FACILITIES | 5% | 472.75 | 481.62 | 488.90 | 494.06 | 506.03 | 519.69 | 533.72 | 548.13 | 562.93 | 578.13 |
| 07 POWER PLANT | 10% | 458.96 | 465.38 | 472.73 | 479.63 | 489.52 | 502.74 | 516.31 | 530.25 | 544.57 | 559.27 |
| 08 ROADS, RAILROADS & BRIDGES | 10% | 490.26 | 501.14 | 507.97 | 513.30 | 526.95 | 541.17 | 555.79 | 570.79 | 586.20 | 602.03 |
| 09 CHANNELS & CANALS | 3% | 503.55 | 516.11 | 526.72 | 536.03 | 550.39 | 565.25 | 580.51 | 596.18 | 612.28 | 628.81 |
| 10 BREAKWATER & SEAWALLS | 5% | 510.50 | 520.83 | 527.86 | 534.68 | 548.77 | 563.59 | 578.80 | 594.43 | 610.48 | 626.96 |
| 11 LEVEES & FLOODWALLS | 5% | 495.99 | 503.35 | 512.62 | 518.66 | 532.71 | 547.10 | 561.87 | 577.04 | 592.62 | 608.62 |
| 12 NAVIGATION PORTS & HARBORS | 10% | 457.55 | 465.45 | 500.23 | 504.84 | 504.07 | 517.67 | 531.65 | 546.01 | 560.75 | 575.89 |
| 13 PUMPING PLANT | 5% | 459.40 | 460.16 | 468.05 | 472.18 | 483.50 | 496.55 | 509.96 | 523.73 | 537.87 | 552.39 |
| 14 RECREATION FACILITIES | 5% | 459.40 | 460.16 | 468.05 | 472.18 | 483.50 | 496.55 | 509.96 | 523.73 | 537.87 | 552.39 |
| 15 FLOODWAY CONTROL & DIVERSION STRUCTURE | 2% | 472.75 | 481.62 | 488.90 | 494.06 | 506.03 | 519.69 | 533.72 | 548.13 | 562.93 | 578.13 |
| 16 BANK STABILIZATION | 2% | 476.48 | 489.61 | 501.50 | 513.00 | 527.35 | 541.59 | 556.21 | 571.23 | 586.65 | 602.49 |
| 17 BEACH REPLENISHMENT | 2% | 507.09 | 521.89 | 532.71 | 543.21 | 562.57 | 577.76 | 593.36 | 609.38 | 625.83 | 642.73 |
| 18 CULTURAL RESOURCE PRESERVATION | 2% | 459.40 | 460.16 | 468.05 | 472.18 | 483.50 | 496.55 | 509.96 | 523.73 | 537.87 | 552.39 |
| 19 BUILDINGS, GROUNDS & UTILITIES | 5% | 459.40 | 460.16 | 468.05 | 472.18 | 483.50 | 496.55 | 509.96 | 523.73 | 537.87 | 552.39 |
| 20 PERMANENT OPERATING EQUIPMENT | 2% | 462.01 | 460.16 | 468.05 | 472.18 | 483.50 | 496.55 | 509.96 | 523.73 | 537.87 | 552.39 |
| COMPOSITE INDEX (WEIGHTED AVERAGE) | 100% | 478.10 | 486.21 | 497.07 | 503.52 | 514.80 | 528.70 | 542.98 | 557.64 | 572.69 | 588.16 |
| YEARLY PERCENTAGE CHANGE | | *1.3%* | *1.7%* | *2.2%* | *1.3%* | *2.2%* | *2.7%* | *2.7%* | *2.7%* | *2.7%* | *2.7%* |

*Note: FY* indicates data developed based on OMB projections.*

# APPENDIX No. 11

## Booster Pump Estimated Cost

Updated on Dec. 03, 2002

# DREDGING RATES OF THE "BOOSTER PUMP-MINDI"

**Inflation Factor Conversion** **1.023**

**Division Overhead** **12%**

| | | Total Costs | | Incidental Costs |
|---|---|---|---|---|
| Hourly Cost for Availability | $ | 60 | | n.a. |
| Hourly Cost for Labor | | 78 | | 78 |
| Indirect Costs relating to Labor | | 9 | | 9 |
| Average Hourly Cost of Fuel | | 59 | | 59 |
| Support for 3 small tugboats | | 0 /1 | | 0 |
| Guard or Passenger Boat Support | | 0 /1 | | 0 |
| Hydrographic Launches Support (5 days a week - day shift) | | 0 | | |
| Sub-total for Support | | 0 | | 0 |
| **Total** | **$** | **206** | **$** | **147** |
| **Cost by Shift** | | | | |
| Cost for Availability for 8 hours | $ | 476 | | n.a. |
| Cost of Labor for 8 hours | | 703 | | 703 |
| Fuel Consumption for 8 hours | | 354 | | 354 |
| Support for 8 hours | | 0 | | - |
| **Total Cost by Shift** | **$** | **1,533** | | **1,057** |
| **Daily Cost** | | | | |
| Cost for Availability | | 1,429 | | n.a. |
| Labor Cost | | 2,108 | | 2,108 |
| Fuel Consumption | | 1,063 | | 1,063 |
| Support | | 0 | | - |
| **Total Daily Cost** | **$** | **4,600** | | **$3,171** |
| **Weekly Cost** | | | | |
| Cost for Availability | | 10,000 | | n.a. |
| Labor Cost | | 14,755 | | 14,755 |
| Fuel Consumption | | 7,442 | | 7,442 |
| Support | | 0 | | - |
| **Total Weekly Cost** | **$** | **32,197** | | **$22,197** |

**Estimated Excavated Volumes by Week (Cubic Meters in Bank)**

| | | |
|---|---|---|
| **Productivity a** | **36,000** | |
| **Productivity b** | **30,000** | |
| **Productivity c** | **24,000** | |
| **Productivity d** | **60,000** | |

**Cost of Cubic Meter in Bank**

| | | |
|---|---|---|
| **Productivity a** | **$0.89** | **$0.62** |
| **Productivity b** | **$1.07** | **$0.74** |
| **Productivity c** | **$1.34** | **$0.92** |
| **Productivity d** | **$0.54** | **$0.37** |

Updated on Dec. 03, 2002

## BOOSTER PUMP OPERATION ESTIMATED COST

**12%** Division Overhead (applied to labor)

| Costs | FY 1995 Actual | FY 1996 Actual | FY 1997 Actual | FY 1998 Actual | Yearly Estimate | |
|---|---|---|---|---|---|---|
| Labor | $ - | $ - | $ - | $ - | - | |
| Supplies/Materials (excluding fuel) | - | - | - | - | 54,750 | |
| Supplies/Materials for Disposal Sites | | | - | - | - | |
| Other Direct Expenses | | | | | 8,213 | |
| General Maintenance | | | | | 16,425 | |
| Indirect Maintenance CC 556 | | | | | 1,643 | |
| Equipment Maintenance at Disposal Sites | | | | | - | |
| Overhaul Expenses | - | - | - | | - | |
| Depreciation | | | | | 275,000 | 1/ |
| Maintenance at Disposal Sites | | | | | | |
| Maritime Insurance | | | | | 21,000 | 2/ |
| Total | | | | | **$ 377,030** | |

| | |
|---|---|
| Total Annual Estimate | $ 377,030 |
| Number of Available Days | 270 |
| Daily Cost for Availability without crew (demand) | $ 1,396 |
| **Hourly Cost for Availability without crew (demand)** | **$ 58** |

| | Inter-Divisional | | Capital (with Division overhead) | Commercial (w/RGG) |
|---|---|---|---|---|
| Hourly Cost for Availability | $ 58 | | $ 58 | $ 79 |
| Stand-by or day crew, hourly | $ - | | $ - | $ - |
| **Total Hourly Cost for Availability** | **$ 58** | | **$ 58** | **$ 79** |
| Hourly Cost for Availability | $ 58 | | $ 58 | $ 79 |
| Operations Crew - hourly cost | $ 78 | | $ 88 | $ 119 |
| Hourly Cost of Fuel | $ 58 | 3/ | $ 58 | $ 79 |
| **Hourly Cost of Operation (without support equipment)** | **$ 194** | | **$ 204** | **$ 277** |
| Support of 3 small tugboats | | | | |
| Guard or Passenger Support Boat | $ - | | | |
| Hydrography Support Launches (5 days a week - day shift) | $ - | | $ - | $ - |
| **Hourly Cost of Operation (with support equipment)** | **$ 194** | | **$ 204** | **$ 277** |

### Rate for Mobilization

| | Inter-Divisional | Capital (with Division overhead) | Commercial (w/RGG) |
|---|---|---|---|
| Hourly Cost for Availability (without crew) | $ 58 | $ 58 | $ 79 |
| Hourly Cost of Operations Crew | $ 78 | $ 88 | $ 119 |
| Hourly Cost of Pilot (required to move dredge) | $ - | $ - | $ - |
| Cost of a large tugboat to move the dredge | $ 332 | $ 354 | $ 482 |
| Cost of a small tugboat to move the dredge | | | |
| Cost of a mid-size tugboat to move pipes and pontoons | $ - | | |
| Cost of a small tugboat to move pipes and pontoons | $ - | $ - | $ - |
| **Total Hourly Rate for Mobilization** | **$ 469** | **$ 500** | **$ 680** |

1/ Distribution of Support of "other 550" of 556 was based on the equitable assignment of the 5 largest equipment of the central cost system.

2/ The depreciation includes the dredge and its improvements, its auxiliary equipment, the discharge pipes and pontoons, as well a 4 tractors.

3/ The cost of maritime insurance paid by ACP in 2000 was proportionately allocated to all insured floating equipment.

4/ Usage of 290 gallons/hour, 42 gallons/barrel, $33/barrel.

5/ One CHAME class and two ULUA types.

## BOOSTER PUMP

| | |
|---|---|
| Overhead | 12% |
| Employee Benefits | 38% |
| Night Shift Differential | 10% |
| Complementary Sunday | 25% |
| Overtime | 50% |

**DAY SHIFT**

| On Deck Department: | Grade | No. | Hourly Rate | Total Hourly Rate | Annual Rate | With Benefits Annually | 5 hours weekly with benefits annually | 8 hours overtime weekly with benefits annually |
|---|---|---|---|---|---|---|---|---|
| Captain in charge | FE-17 | 0 | $ 34.21 | $ - | $ - | $ - | $ - | $ - |
| Welder | MG-10 | 0 | 17.56 | - | 0 | 0 | 0 | 0 |
| Seaman | MG-07 | 0 | 6.96 | - | 0 | 0 | 0 | 0 |
| Laborer | MG-03 | 0 | 5.75 | - | 0 | 0 | 0 | 0 |
| **Subtotal** | | **0** | | **$ -** | **0** | **0** | **0** | **0** |
| **Engine Department:** | | | | | | | | |
| Chief Engineer | ME-16 | 0 | $ 32.02 | $ - | $ - | $ - | $ - | $ - |
| Deputy Chief Engineer | ME-15 | 0 | 29.99 | - | 0 | 0 | 0 | 0 |
| Engineer | ME-14 | 0 | 28.15 | - | 0 | 0 | 0 | 0 |
| Electrician | FE-11 | 0 | 24.35 | - | 0 | 0 | 0 | 0 |
| Machinist | MG-10 | 0 | 17.56 | - | 0 | 0 | 0 | 0 |
| Nautical engine mechanic | MG-10 | 0 | 17.56 | - | 0 | 0 | 0 | 0 |
| Electrical Equipment Repairer | MG-09 | 0 | 11.12 | - | 0 | 0 | 0 | 0 |
| **Subtotal** | | **0** | | **-** | **0** | **0** | **0** | **0** |
| **Staff at Dredged Material Disposal Sites** | | | | | | | | |
| Leader | ML-10 | 0 | $ 19.31 | $ - | $ - | $ - | $ - | $ - |
| Helpers | MG-05 | 0 | 6.23 | - | 0 | 0 | 0 | 0 |
| **Subtotal** | | **0** | | **-** | **-** | **-** | **-** | **-** |
| **TOTAL- DAY SHIFT CREW** | | **0** | | **$ -** | **0** | **0** | **0** | **0** |
| **ROTATION CREW** | | | | | | | | |
| **On-deck Department:** | | | | | | | | |
| Dredge Operator | FE-14 | 0 | $ 28.15 | $ - | $ - | $ - | $ - | $ - |
| Dredge Officer | FE-11 | 0 | 24.35 | - | 0 | 0 | 0 | 0 |
| Dredge Seaman Leader | ML-08 | 0 | 9.74 | - | 0 | 0 | 0 | 0 |
| Winch Operator | MG-08 | 0 | 8.25 | - | 0 | 0 | 0 | 0 |
| Dredge Seaman | MG-07 | 1 | 6.96 | 6.96 | 14,477 | 19,981 | 3,746 | 5,994 |
| **Subtotal** | | **1** | | **$ 6.96** | **14,477** | **19,981** | **3,746** | **5,994** |
| **Engine Department:** | | | | | | | | |
| Dredge Engineer | ME-14 | 0 | $ 28.15 | $ - | $ - | $ - | $ - | $ - |
| Dredge Engineer | ME-11 | 1 | $ 24.35 | 24.35 | 50,648 | 69,904 | 13,107 | 20,971 |
| Oiler | MG-08 | 1 | 8.25 | 8.25 | 17,160 | 23,684 | 4,441 | 7,105 |
| **Subtotal** | | **2** | | **$ 32.60** | **67,808** | **93,589** | **17,548** | **28,077** |
| **Staff at Dredged Material Disposal Sites** | | | | | | | | |
| Tractor Operators | MG-10 | 0 | $ 17.56 | $ - | $ - | $ - | $ - | $ - |
| Helper | MG-08 | 0 | 8.25 | - | 0 | 0 | 0 | 0 |
| **Subtotal** | | | | **$ -** | **0** | **0** | **0** | **0** |
| **TOTAL- ROTATION CREW** | | **3** | | **$ 39.56** | **82,285** | **113,569** | **21,294** | **34,071** |
| **TOTAL - 4 ROTATION CREWS** | | | | | **329,139** | **454,278** | **85,177** | **136,283** |
| **TOTAL - 5 ROTATION CREWS** | | | | | **411,424** | **567,847** | | |
| **TOTAL WITH 4 CREWS, 1 DAY SHIFT AND OVERTIME** | | | | | | | **454,278** | **590,561** |
| | | | | | | | **52** | **67** |
| **TOTAL WITH 5 CREWS 1 DAY SHIFT AND NO OVERTIME** | | | | | | **567,847** | | |
| | | | | | | **65** | | |

**Total Average Rate with cargo - 4 rotation crews and 8 hours of overtime weekly for each crew**

| | | |
|---|---|---|
| Monday to Friday | 75.71 | |
| Saturday | 75.71 | |
| Sunday | 94.64 | |
| **Total Average Hourly Rate** | **$ 78.42** | **686,933** |

**Total Average Rate with cargo - 5 rotation crews and 1 hour of overtime weekly**

| | | |
|---|---|---|
| Monday to Friday | 79.31 | |
| Saturday | 79.31 | |
| Sunday | 99.13 | |
| **Total Average Hourly Rate** | **$ 82.14** | **719,546** |

1/ There are 5 steps in the hourly wage grade, and the last step was used.

2/ Employee benefits were included at 38.02% of the average hourly wages

3/ Included in the average hourly wages were 10% for night differential, 25% for complementary Sunday, and 50% for overtime.

4/ Eight hours of weekly overtime were included for each crew.

# APPENDIX No. 12

## Drill Boat THOR Productivity Test

## PARAMETERS FOR MEASURING PRODUCTION AND COSTS OF THE THOR

| | TEST ON THE THOR | | GRADE OF DRILLING | | | |
|---|---|---|---|---|---|---|
| | | | 26' PLD | 22' PLD | 20' PLD | 17' PLD |
| | | | Nov 8 - 2001 | Nov 12 - 2001 | Nov 13 - 2001 | Nov 14 - 15, 2001 |
| 1 | **Diameter of Drill (inches)** | | 6.5 | 6.5 | 6.5 | 6.5 |
| 2 | **Effective Pattern Area Used (a 12.5'x10' pattern)** | | 100' x 60' | 100' x 60' | 100' x 60' | 100' x 60' |
| 3 | **Number of Patterns** | | 1 | 1 | 1 | 1 |
| 4 | **Nominal Depth of a Drill (feet)** | | 11 | 15 | 17 | 20 |
| 5 | **Average Depth of Drill (feet)** | | 7.4 | 10.51 | 13.65 | 16.88 |
| 6 | **Lake Elevation (PLD feet)** | | 87 | 87 | 87 | 87 |
| 7 | **Longitude of tower bars** | | 72 | 76 | 78 | 81 |
| 8 | **Test Site for Drilling** | | Culebra - Cascadas | Cascadas | Cascadas | Cascadas |
| 9 | **Characteristics of Drilled Material** | | Sof to medium hard | Soft to medium hard | Soft to hard | Soft to hard |
| 10 | **Number of drilling attempts** | | Only one | Only one | Two attempts - Additional 2' Bar | Two attempts - Additional 5' Bar |
| 11 | **Maximum number of drillings per line** | | 8 | 8 | 8 | 8 |
| 12 | **Number of lines executed** | | 6 | 6 | 6 | 6 |
| 13 | **Coordination Time with MTC: Authorization and Blasting Programming** | | Not predictable | Not predictable | Not predictable | Not predictable |
| 14 | **Average time required to drill a line (minutes)** | /1 | 24.50 | 24.58 | 43.80 | 39.48 |
| 15 | **Average time required to perforate an 8-drill line** | /2 | 1.50 | 1.81 | 2.47 | 2.68 |
| 16 | **Total Drilling Time for a pattern, with no movements or explosives (hours)** | | **9.02** | **10.87** | **14.80** | **16.10** |
| 17 | **Average time to mobilize the THOR to the following line (minutes)** | /3 | 19.75 | 14.5 | 16.5 | 17.5 |
| 18 | **Total time to mobilize the THOR between lines in a pattern (hours)** | | 1.65 | 1.21 | 1.38 | 1.46 |
| 19 | **Time to mobilize the THOR 500' from the pattern (minutes)** | /4 | 15 | 15 | 15 | 15 |
| 20 | **Total time to mobilize the THOR with no perforation and no explosive** | | **1.90** | **1.46** | **1.63** | **1.71** |
| 21 | **Time estimated to load a drill (minutes)** | /5 | 5.67 | 6.67 | 7.33 | 7.67 |
| | **Total time to load a pattern - does not include time to fasten detonants (hours)** | | **1.13** | **1.33** | **1.47** | **1.53** |
| 22 | **Total time in theory of pattern - drilling, mobilization, blasting (hours)** | | **12.05** | **13.66** | **17.89** | **19.34** |
| | **% of drilling** | | 75% | 80% | 83% | 83% |
| | **% de mobilization** | | 16% | 11% | 9% | 9% |
| | **% de explosive charges** | | 9% | 10% | 8% | 8% |
| 23 | **Measured time to execute a pattern (hours)** | /6 | 9.57 | 13.75 | 18.92 | 16.5 |
| 23.a | Total holes drilled according to pattern | | 40 | 45 | 39 | 41 |
| 24 | **Time required to set up the blasting of a pattern - Fastening detonants (hours)** | | 1.50 | 1.50 | 1.50 | 1.50 |
| 25 | **Estimated time to load a pattern (hours)** | | 1.13 | 1.33 | 1.47 | 1.53 |
| 26 | **Measured time to drill and load a pattern, including mobilization (hours)** | | **12.20** | **16.58** | **21.88** | **19.53** |
| 27 | **Volume of a pattern (100' x 60' x Average Depth of drill) $m^3$** | | **1,257** | **1,785** | **2,319** | **2,868** |
| 28 | **Average Production of THOR ($m^3$/hr)** | | 103 | 108 | 106 | 147 |
| 29 | **Average production per week 3 watch - 7 day (m3/week)** | | **17,310** | **18,087** | **17,802** | **24,662** |
| 30 | **Length of detonating wick required for a pattern (feet)** | | 4700 | 5000 | 5000 | 5200 |
| 31 | **Amount of detonants** | | | | | |
| 32 | **17 ms** | | 52 | 52 | 52 | 52 |
| 33 | **25 ms** | | 10 | 10 | 10 | 10 |
| 34 | **Initial detonator of 500 feet** | | 1 | 1 | 1 | 1 |
| 35 | **Amount of explosives required per drill (lbs)** | | 76 | 106.4 | 114 | 136.8 |

**Appendix No. 12 A**

Note

1. The time recorded begins when the casing is being lowered, and ends when the drill has been verified and tested. It includes the time required to add another bar, if needed. This time does no include loading the explosives on the drill.

2. The time recorded begins with the perforation of the first drills and ends with the last one. It includes the time required to lift the casing, but does not include the time required to load the drill nor to fasten the little buoy.

3. The time elapsed from when the casing is out of the water until the barge is in position at the new line.

4. The 15 minutes of mobilization by the THOR are included in the 1.5 hours it takes the explosives operator to fasten the detonators.

5. Average time, based on historical data. This time begins when the drill is verified or tested and when the small buoy has been fastened. It does not include the lifting of the casing.

6. The time recorded includes mobilization of the barge between the drill lines, but does not include the loading of the explosives.

# APPENDIX No. 13

**Pacific Entrance Navigation Channel**
**Seismic Profile Test Results & Report by**
**COASTAL AND INLAND MARINE SERVICES**

**DRILLING AND BLASTING PERCENTAGE ESTIMATE REQUIRED IN THE PACIFIC ENTRANCE NAVIGATION CHANNELS FOR 41.5' DRAFT**

**From buoy No. 21 to whistle buoy**

| STATION | D&B from -52.1 to -62.1 PLD(mts2) | % Drilling & Blasting Required | Net Area for D&B -52.1´to -62.1' PLD (mts2) |
|---|---|---|---|
| STA( 68+415 @ 70+000 ) | 511,950 | 100% | 511,950 |
| STA( 70+000 @ 74+000 ) | 598,200 | 100% | 598,200 |
| STA( 74+000 @ 76+000 ) | 429,230 | 100% | 429,230 |
| STA( 76+000 @ 78+000 ) | 458,350 | 84% | 385,014 |
| STA( 78+000 @ 80+000 ) | 410,430 | 87% | 357,074 |
| STA( 80+000 @ 82+000 ) | 565,185 | 34% | 192,163 |
| STA( 82+000 @ 83+000 ) | 386,380 | 32% | 123,642 |
| STA( 83+000 @ 85+920 ) | 892,936 | 0% | 0 |
| **TOTAL** | **4,252,661.00** | **61%** | **2,597,273** |

**DRILLING AND BLASTING PERCENTAGE ESTIMATE REQUIRED IN THE PACIFIC ENTRANCE NAVIGATION CHANNELS FOR 46' DRAFT**

**From buoy No. 21 to whistle buoy**

| STATION | D&B from -52.1 to -66.6(mts$^2$) | % Drilling & Blasting Required | Net Area for D&B -52.1´to -66.6' PLD (mts2) |
|---|---|---|---|
| STA( 71+200 @ 74+000 ) | 598,200 | 100% | 598,200 |
| STA( 74+000 @ 76+000 ) | 429,230 | 100% | 429,230 |
| STA( 76+000 @ 78+000 ) | 458,350 | 84% | 385,014 |
| STA( 78+000 @ 80+000 ) | 410,430 | 87% | 357,074 |
| STA( 80+000 @ 82+000 ) | 565,185 | 34% | 192,163 |
| STA( 82+000 @ 83+000 ) | 386,380 | 32% | 123,642 |
| STA( 83+000 @ 85+920 ) | 892,936 | 0% | 0 |
| **TOTAL** | **3,740,711** | **56%** | **2,085,323** |

**DRILLING AND BLASTING PERCENTAGE ESTIMATE REQUIRED IN THE PACIFIC ENTRANCE NAVIGATION CHANNELS FOR 50' DRAFT**

**From buoy No. 21 to whistle buoy**

| STATION | D&B from -52.1 to -70.6(mts$^2$) | % Drilling & Blasting Required | Net Area for D&B 52.1´to 70.6' PLD (mts2) |
|---|---|---|---|
| STA( 71+200 @ 74+000 ) | 598,200 | 100% | 598,200 |
| STA( 74+000 @ 76+000 ) | 429,230 | 100% | 429,230 |
| STA( 76+000 @ 78+000 ) | 458,350 | 91% | 417,099 |
| STA( 78+000 @ 80+000 ) | 410,430 | 91% | 373,491 |
| STA( 80+000 @ 82+000 ) | 565,185 | 34% | 192,163 |
| STA( 82+000 @ 83+000 ) | 386,380 | 32% | 123,642 |
| STA( 83+000 @ 85+920 ) | 892,936 | 0% | 0 |
| **TOTAL** | **3,740,711** | **57%** | **2,133,824** |

## DRILLING AND BLASTING PERCENTAGE ESTIMATE REQUIRED IN THE PACIFIC ENTRANCE NAVIGATION CHANNELS FOR 46' DRAFT

**From buoy No. 21 to whistle buoy**

| Area | East | Mid East | Prism line Center line | Mid West | West | Average |
|---|---|---|---|---|---|---|
| 0-1800 | 100 | 100 | 100 | 100 | 100 | 100 |
| 1800-3550 | 100 | 100 | 100 | 100 | 100 | 100 |
| 3550-5300 | 100 | 70 | 78 | 73 | 100 | 84.2 |
| 5300-7050 | 80 | 89 | 89 | 84 | 95 | 87.4 |
| 7050-8850 | 42 | 31 | 25 | 48 | 22.2 | 33.64 |
| 8850-10600 | 22 | 31 | 28 | 30.6 | 48 | 31.92 |
| 10600-12350 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12350-14000 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Average** | **55.50** | **52.63** | **52.50** | **54.45** | **58.15** | **54.645** |

**TOTAL AVERAGE (%) 54.65**

# REPORT OF SEISMIC SURVEY

# PACIFIC ENTRANCE PANAMA CANAL

# PANAMA CANAL COMMISSION

NOVEMBER 1999

'repared by : Coastal and Inland Services, Inc.
Centro commercial Siglo XXI
Av R. J. Alfaro y Juan Pablo II
Republic of Panama

lients Ref : Panama Canal Commission
Administration building, Balboa heights
Republic of Panama

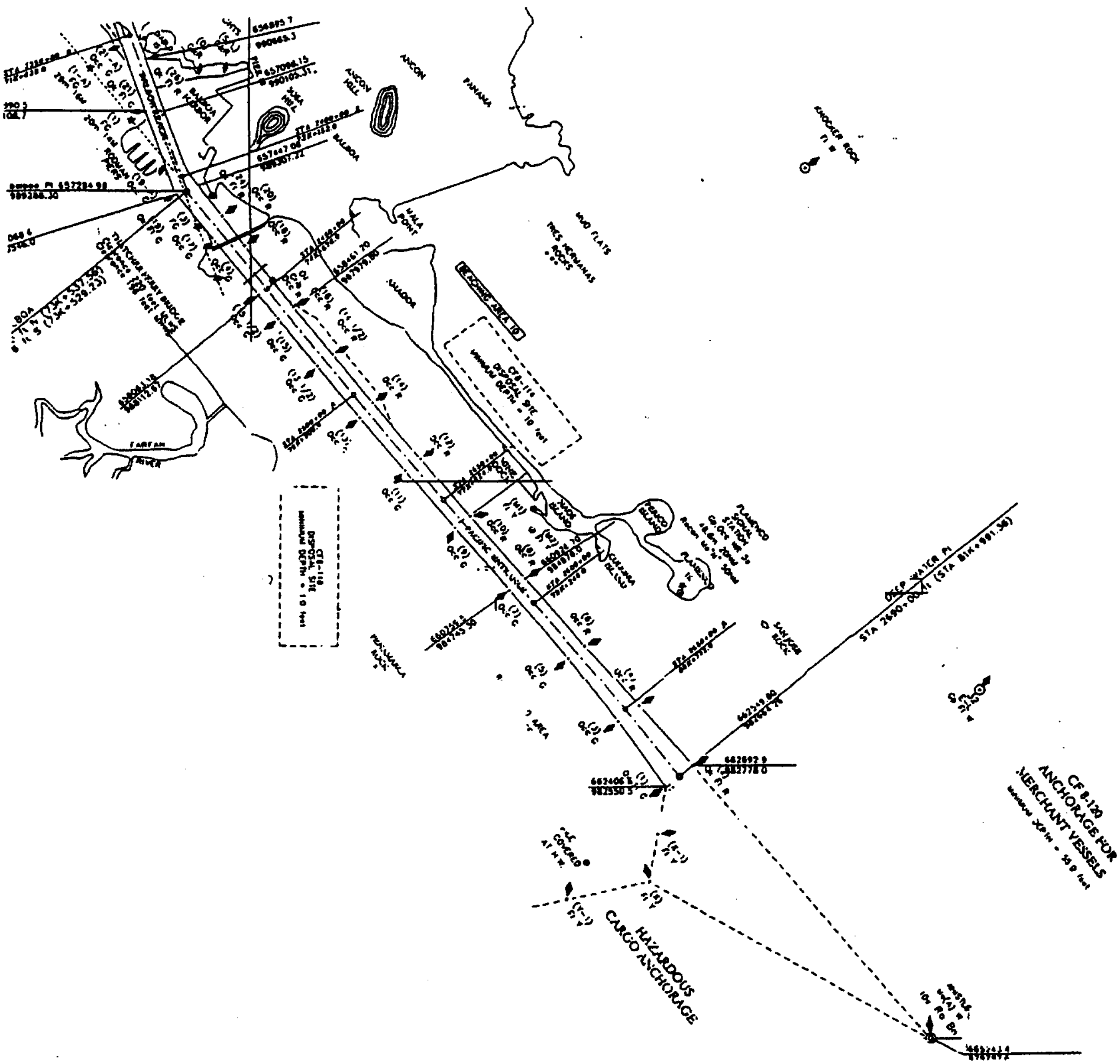


**Figure 1: Key plan**

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# 1. SUMMARY OF RESULTS

## 1.1 Bathymetric survey

Waterdepths in the surveyed area increase towards the south-east. Along the centreline depths vary between 13 metres (KP 0506) and 19 metres (KP 14124)

## 1.2 Sub bottom profiler survey

The sub bottom geology consists of Basalt bedrock covered by acoustically transparent loose sediments. The centreline can be divided in three sections:

| | |
|---|---|
| Kp 0 - Kp 6800 | : bedrock forms the seabed only occasionally covered by sediments |
| Kp 6800 - Kp 9400 | : alteration between bedrock outcrops and sediments form the seabed |
| Kp 9400 - Kp 14000 | : seabed consisting of loose sediments |

# 2. INTRODUCTION

## ..1. Summary

PANAMA CANAL COMMISSION contracted Coastal and Inland Marine Services, Inc. to conduct seismic surveys along the following route (figure 1):

| | Easting | Northing |
|---|---|---|
| Whistle Buoy | 665243.4 | 979787.6 |
| Buoy N21 | 656890.5 | 990108.7 |

Coastal and Inland Services, Inc. provided the necessary personnel, equipment and vessel to carry out the work.
The results obtained are presented in this report, as well as information regarding equipment and methods used to arrive at these results. Drawings showing the results are given in Appendix C, Charting, of this report. In addition relevant information regarding seismic records and borehole information can be found in the appendices.
The report has been prepared by G. van der Boog, C. Anderton and S. Pitka of Osiris B.V. under supervision of Mr. W. Fontein of Coastal and Inland Marine Services Inc.

## 2.2. Scope of Work

The purpose of the surveys is to gather information:
- seabed topography,
- sub-seabed layers.

The scope of work is detailed as follows:
5 longitudinal lines extending 13.50 Km will be run using echo sounder and subbottom profiler.
One center line, one at each prism line (2), and one each lane halfway between the center line and each prism line (2).

This information accompanied by boreholes information provided by the Client will be integrated into a geological model of the subsurface of the navigation channel.

The geological model will be visualised in 5 parallel profiles along the sailed seismic lines, containing seismic reflectors and interpretation.

The extension of different soiltypes at the seabed in the channel will be visualised by means of an outcrop map.

## 2.3. Resources of Work

| PERSONNEL | NAME | FUNCTION |
|---|---|---|
| Offshore | W. Fontein | Party Chief / Geologist |
| | M. Eg | Surveyor |
| | J.M. Gallissaires | Geologist |
| | M.J. Korving | Engineer |
| | N. Rivers | Engineer |
| Reporting | W. Fontein | Reporting Manager |
| | J.M. Gallissaires | Geologist |
| | M. Eg | Surveyor |
| | G. v.d. Boog | Geologist |
| | S. Pitka | Geologist |
| | C.L. Anderton | Surveyor |

Table 1: **Personnel**

| EQUIPMENT | No | DESCRIPTION |
|---|---|---|
| Positioning | 1 | Sercel NR 103 receiver c/w antennae, cable and psu |
| | 1 | HP 382 PC with Navigation software |
| | 1 | HP 2225CU ThinkJet printer |
| Bathymetry | 1 | Atlas Deso 15 echo sounder |
| | 1 | STD/CTD model SD204 system |
| Subbottom Profiler | 1 | Datasonics CAP-6600 Chirp Acoustic Profiler |
| | | Datasonics DSP-661 System |
| | 1 | Datasonics TTV-170A tow fish |
| | 1 | HP paint jet printer |

Table 2: **Equipment**

## .4. Geodetic Parameters

All geographical co-ordinates in the report are based on Local Datum. Local Datum is NAD 1927. DGPS satellite navigation and positioning was used. GPS geographical co-ordinates are based on Datum "World Geodetic System 1984" (WGS 84). The datum shift, rotation and scale parameters were used for the transformation from WGS 84 co-ordinates to the Local Datum co-ordinates. The geodetic parameters used are detailed below.

| DGPS geodetic parameters | | | |
|---|---|---|---|
| Datum | | World Geodetic System 1984 (WGS 84) | |
| Spheroid | | World Geodetic System 1984 | |
| Semi-Major Axis | | a = 6378137.000 m | |
| Semi-Minor Axis | | b = 6356752.314 m | |
| First Eccentricity Squared | | $e^2$ = 0.006694379 | |
| Inverse Flattening | | $^1/_f$ = 298.2572236 | |
| **Local Datum geodetic parameters** | | | |
| Datum | | NAD 1927 | |
| Spheroid | | Clarke 1866 | |
| Semi-Major Axis | | a = 6378206.4 m | |
| Semi-Minor Axis | | b = 6356583.8 m | |
| Inverse Flattening | | $^1/_f$ = 294.9787 | |
| **Projection parameters** | | | |
| Projection | | Universal Transverse Mercator | |
| Central Meridian | | 81° West | |
| Origin Latitude | | 0° | |
| False Easting | | 500000 m | |
| False Northing | | 0 m | |
| Scale Factor on CM | | 0.9996 | |
| Units | | Metres | |
| **Datum transformation parameters from WGS 84 to NAD27** | | | |
| **Shift** | | **Rotation and Scale** | |
| dX | +4 m | Rx | +0 |
| dY | +91.0 m | Ry | +0 |
| dZ | 202.5 m | Rz | +0 |
| | | Scale factor | 0.0 ppm |

Table 3: **Geodetic parameters**

## 2.5. Units in Use

Unless stated otherwise the following units are used throughout the report:

| UNITS | |
|---|---|
| DGPS Time | U.T.C. Time zone |
| Local Time | Greenwich Mean Time (GMT) - 6 hours |
| Distances | Metres |
| Depth | Metres |
| Angles | degrees, minutes and seconds in the 360° system |
| Velocity | m/s |
| Temperature | °C |
| Salinity | ‰ |

Table 4: **Units in use**

## 2.6. Horizontal Control

### 2.6.1. Offsets and Datum Point

The vessel's main mast was defined as the origin of the vessel co-ordinate system (Vessel Datum Point).

The offset convention used in this report is indicated in figure 2:

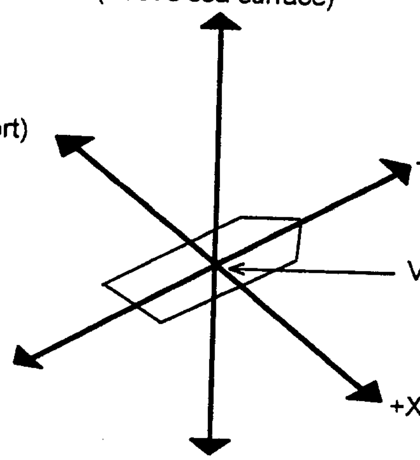



**Figure 2:** Offset convention

| OFFSETS o/b launch ILKA | | | |
|---|---|---|---|
| **Offset Point** | **Athwart (X) m** | **Forward(Y) m** | **Height (Z) m** |
| Vessel Datum Point | 0.00 | 0.00 | 0.00 |
| Sercel DGPS Antenna | 0.00 | 0.00 | N/a |
| Echo Sounder Transducer | +2.18 | -0.70 | -0.60 |
| Subbottom Profiler Tow Point | +2.18 | -5.20 | -1.80 |

Table 5: **Offsets from vessel Datum point**

### 6.2. Surface Positioning

A Sercel NR 103 DGPS receiver and the DGPS reference station were used as positioning system. The reference station used is detailed below.

| SOSA HILL DGPS Reference Station | | |
|---|---|---|
| | Datum WGS 84 Co-ordinates | |
| **Reference Station** | **Latitude north** | **Longitude east** |
| SOSA HIGH II | 08°57'16.731611" | 79°33'39.943984" |

Table 6: **Reference station details**

This station provided the differential corrections to calculate a mobile position. The antenna of the Sercel NR103 receiver was mounted on the main mast of the survey vessel.

The GPS system was operated under the following conditions :

- Elevation mask 10 degrees
- PDOP better than 5
- Minimal 5 numbers of satellites

The positioning system was interfaced to a computer system using Coastal and Inland Marine Services "DREDGEVIEW" running on a HP 382 workstation, data logging and positioning software package.
Co-ordinates of the vessel position were calculated using GPS data. The quality parameters of the DGPS position fixes were used to validate the data and to control the processing. All positioning data were stored on hard disc for post-processing purposes.

### 2.6.3. Positioning System Check

A DGPS verification was carried out in CELI point Coastal and Inland Marine Services base station on 17 November 1999.
The DGPS antenna position was recorded at the base station position and compared to the position measured with the DGPS. The following results were obtained:

| VERIFICATION AND CALIBRATION RESULTS IN CELI POINT | | |
|---|---|---|
| | **ΔE m** | **ΔN m** |
| DGPS antenna position | -0.341 | 0.078 |

Table 7: **Verification and calibration results**

## .7. Vertical Control

### .7.1. Introduction

Chart Datum is relative to Mean Lowest Water Spring (MLWS). Depths are reduced to Chart Datum using tides record as obtained from measurements each 10 minutes on a tide gauge, installed for this survey on pier 18 in the port of Balboa.

2.7.2. Bathymetric Systems

An Atlas Deso 15 echo sounder with the ships hull mounted transducer was used on board of the vessel. The echo sounder was operated on 210 kHz.

Analogue depth measurements were sampled with the Coastal and Inland Marine Services in-house developed survey program DREDGEVIEW running on a HP 382 workstation. Depth measurements were stored on disk for off-line processing.

2.7.3. STD/CTD Measurements

In the survey area several speed of sound measurements were made with the MINI STD/CTD model SD204 self contained probe, with conductivity, temperature and pressure sensor.
The measured speed of the sound was 1525 m/s during the survey. This speed of sound was entered in the echo sounder. To verify the good sound velocity, a bar check was done every meter from 2 to 12 m water depth.

2.7.4. Seismic calibration

Calibration of seismic subbottom profiler was done using the provided geological bore hole information. Acoustic reflectors were correlated with bore holes data. A propagation speed of 1600 m/s was assumed to interpret the sub bottom profiler data.

**2.9. Subbottom Profiler System**

The CAP-6600 system was used to determine sub seabed obstructions and layers. The system comprized:

- Datasonics DSP-661 System consisting of a windows based digital image processor and sonar transceiver, housed in one portable unit. The transmit/receive electronics and preamplifiers are installed in the sonar transceiver.
- Datasonics TTV-170A tow fish configured with four low frequency transducers, a single high frequency array and a linear hydrophone.
- HP paint jet printer.

The higher frequencies provide better resolution, detection and more accuracy, the lower frequencies give more penetration in the seabed.

## 3. METHOD OF WORK

Survey operations were performed from 23 to 24 November 1999.

A barcheck of the echosounder within the harbour area and CTD profile near whistle buoy were taken to determine the speed of sound through the water column. The sound velocity values were entered in the Atlas Deso echosounder system.

The survey lines were as much as possible sailed as continuous lines. This was not completely achieved due to shipping and minor operational problems.

# 4. RESULTS

## .1. Bathymetry

All bathymetric data has been reduced to Mean Low Water Spring (MLWS) using tides from tide gauge records. Profiles along the sailed lines have been generated from digital terrain model based on the survey data.
Waterdepths in the surveyed area increase towards the south-east. Along the centreline depths vary between 13 metres (KP 0506) and 19 metres (KP 14124)

## 4.2. Subseabed features

The results of the subbottom profiling are presented in a map and vertical profiles. The profiles have a horizontal scale of 1 : 2500 and a vertical scale of 1 : 100. It should be borne in mind, that these scales lead to a 25 times vertical exaggeration. To construct the profiles a sound propagation speed in sediments of 1600 m/s has been assumed. This resulted in a coverage of 1.9 metres per centimetre on the printouts.
It should be noted that most of the available borehole information is more than 40 years old and not equally distributed over the profiles. The reference level at the time of drilling, the amount of erosion/sedimentation and deepening of the seabed by dredging and/or blasting techniques since then is unclear. Therefore the borehole information was used as a guideline only to interpret the acoustic data whereby, in case of difference, the latter was used to construct the profile. Despite the above it was chosen to plot the borehole data on the profiles. With a reference level of mean low water spring a maximum shift of 2 metres was necessary to correlate the top of the borehole data with the present seabed. Boreholes with larger depth inconsistencies were disregarded.

The water depth in general, limits the subbottom profiler penetration. Information below this depth is obscured by a strong multiple reflection of the seabed. However penetration in the Basalt bedrock which is often present at or just below the seabed is not possible.

## 4.3. Nature of seismic reflectors

The sub bottom profiler records are generally of excellent quality, seismic reflectors are thin and sharp. At locations where the bedrock reaches the seabed, dense scattering of the acoustic signal occurs, possibly caused by weathering and/or fracturing of the bedrock during the construction of the Panama Canal.

## 4.4. Geology

The seabed and sub seabed in the surveyed area is characterised by a complex magmatic intrusive geology. Fluid Basalt has intruded older overlying sediments leaving domeshaped features after crystallisation. Locally shale is present as result of contact metamorfism when the basalt magma intruded clayey sediments.
Along the centreline from Kp 0 to Kp 6800, the seabed consists of the Basalt bedrock which is only occasionally covered by a thin layer of acoustically transparent lithology interpreted as fine loose sediments such as muddy sands clay and silt.

From Kp 6800 to Kp 9400 the bedrock strongly alters in height and forms outcrops at the seabed which dip steeply to depths of more than 10 metres below seabed. Between the outcrops acoustically transparent loose sediments cover the bedrock.

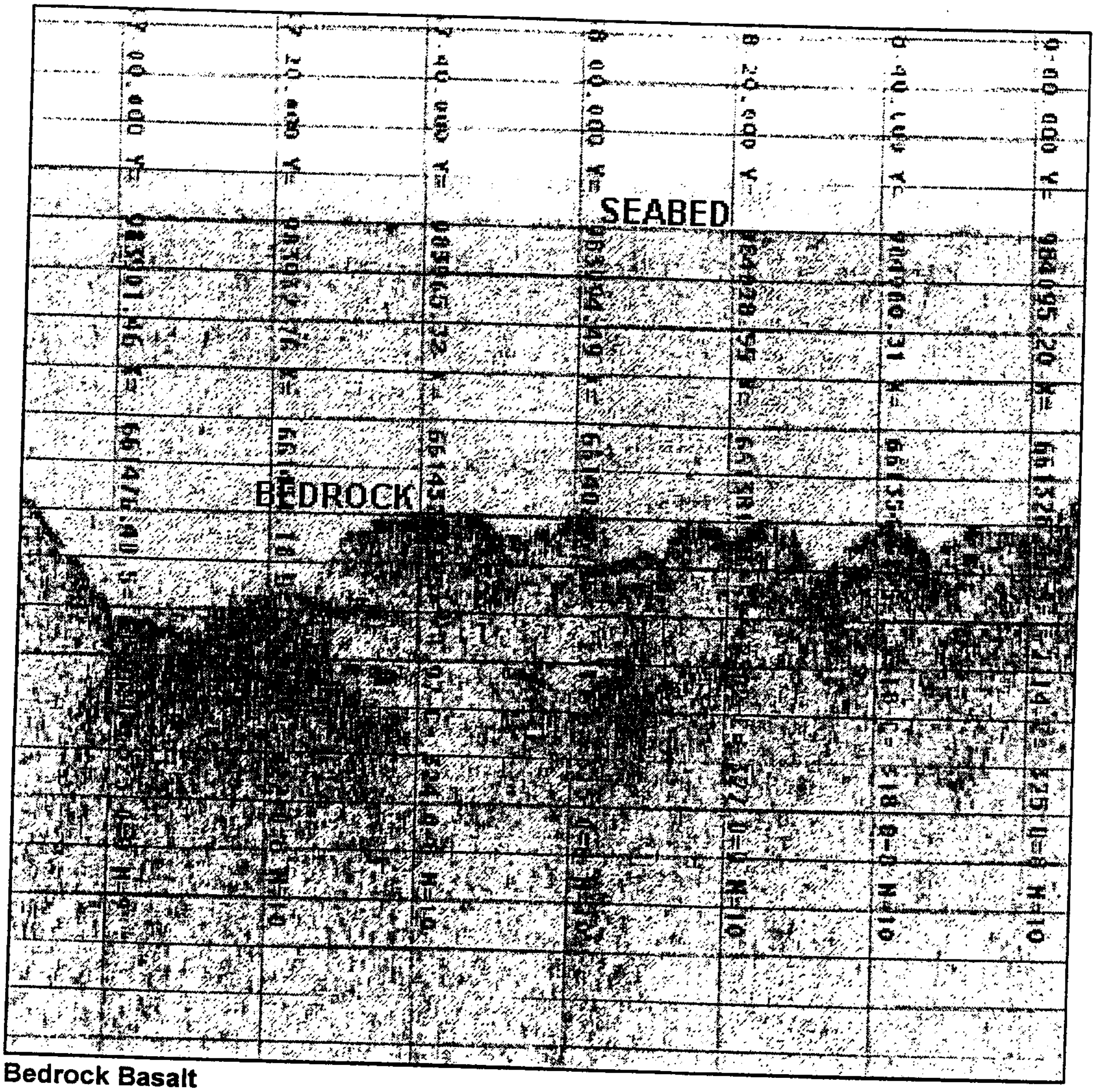
From Kp 9400 to Kp 14000 no more bedrock outcrops are present along the centreline. The seabed consists of fine sediments, possibly silt and clays, with a thickness of approximately 9 metres The bedrock is present directly below the sediments at and dips slightly steeper than the seabed towards the south-east.

The sub bottom geology of the parallel lines is similar except for the prism lines from Kp 0 to Kp 6000 where hardly any sediment cover is present at the surface.

## 5. APPENDICES AND ENCLOSURES

A. Seismic Record Sample
B. Borehole Information
C. Charting

## A. Seismic Record Sample




Bedrock Basalt

## B. Borehole Information

| Hole | UTM | |
|---|---|---|
| | Northing | Easting |
| ICC-66 | 988836.32 | 657683.66 |
| ICC-100 | 989164.64 | 657466.00 |
| ICC-102 | 989969.79 | 657027.00 |
| ICC-103 | 989683.78 | 657150.05 |
| ICC-111 | 989784.06 | 657073.47 |
| ICC-116 | 990128.28 | 657029.47 |
| ICC-118 | 988307.99 | 658192.70 |
| ICC-119 | 988392.81 | 658058.27 |
| ICC-120 | 988520.32 | 657932.81 |
| ICC-121 | 988656.93 | 657794.07 |
| ICC-122 | 988748.06 | 657714.48 |
| ICC-133 | 989500.93 | 657153.80 |
| ICC-135 | 989857.21 | 657076.23 |
| ICC-136 | 990085.45 | 656986.97 |
| ICC-143 | 990535.85 | 656814.55 |
| ICC-238 | 987287.94 | 659013.55 |
| ICC-239 | 987044.77 | 659179.07 |
| ICC-241 | 986630.92 | 659345.26 |
| ICC-248 | 987900.92 | 658535.65 |
| ICC-250 | 986537.25 | 659552.88 |
| ICC-252 | 987484.62 | 658854.25 |
| | | |
| ICB-37 | 989699.10 | 657183.50 |
| ICB-42 | 989747.90 | 657177.20 |
| | | |
| BBR-16 | 988336.10 | 657886.60 |
| BBR-17 | 988287.60 | 657740.60 |
| | | |
| TL-22 | 988706.20 | 657690.90 |
| TL-30 | 988586.80 | 657782.20 |
| TL-62 | 989105.30 | 657493.70 |
| TL-69 | 989030.80 | 657524.40 |
| TL-72 | 989051.90 | 657484.70 |
| TL-75 | 989064.30 | 657515.20 |
| | | |
| LTC-11 | 989200.00 | 657319.30 |
| LTC-12 | 989191.80 | 657401.00 |
| LTC-13 | 989183.60 | 657491.20 |

(0.0) [illegible], (from driller's log; no sample)

-58.7
(1.7) **BASALT**, hard, massive, fine-grained, black, fresh.
RECOVERY: 3.9'

[illegible].6
([illegible]6) FINAL DEPTH

NO. 14 GR. ELEV. -0.6

[illegible].6
(0.0) SILT, (from driller's log; no sample)

[illegible]7.5
([illegible]6.9) BASALT, hard, massive, fine-grained, black, fresh.
RECOVERY: 5.7'

[illegible]4.4
(-3.8) FINAL DEPTH

[illegible]. 15 GR. ELEV. +0.7

[illegible]7
([illegible]0) SILT, (from driller's log; no sample)

[illegible].6
[illegible].3) BASALT, hard, medium-grained, fresh, black.
RECOVERY: 1.2'

[illegible]) FINAL DEPTH

[illegible] 16 GR. ELEV. +8.5 (approximately)

[illegible].5
[illegible]) SILT, (from driller's log; no sample)

[illegible].5
[illegible]) Driller reports "weathered shale", no sample.
(Probably soft tuff).

[illegible].5
[illegible]) TUFF, or tuffaceous AGGLOMERATE, weathered, soft to medium hard.
RECOVERY: 6.0'

[illegible]) FINAL DEPTH

(0.0) SILT, (from driller's log; no sample)

-68.0
(26.5) CLAY, very stiff, plastic, admixed with rock fragments.

.5
(0) TOP OF ROCK
BASALT, upper part reddish, weathered, lower part unweathered, fine-grained, hard, black.
RECOVERY: 1.8'

-4.5
( 3.0) FINAL DEPTH

. 10 GR. ELEV. -41.4

-41.4
( .0) SILT, (from driller's log; no sample)

56.5
( .1) SHALE, black, carbonaceous, soapy, weathered. Lower part of core soft and more weathered.
RECOVERY: 3.0'

.6
(2.2) FINAL DEPTH

. 11 GR. ELEV. -51.0 LTC-11

( ) SILT, (from driller's log; no sample)

7
( 7) SHALE, black, carbonaceous, silty. Top 2' of core fresh, unweathered, but broken. Becomes softer downward to bottom of core.
RECOVERY: 4.0'

4.8
( 8) FINAL DEPTH

~~LTC-12~~

12 GR. ELEV. -55.0 LTC-12

.0
( ) SILT, (from driller's log; no sample)

( .9) SHALE, black, carbonaceous, medium hard.
RECOVERY: 2.7'

( 2) FINAL DEPTH

TL-75

## GEOLOGICAL LOG DRILL HOLE TL-75

( UGH) Line, Canal Axis; Station 2254+10; Offset 50'E

RECOVERY: 93.5%
GROUND ELEV: -51.5

51.5 ( 0) **MUCK**, soft, sandy.

52.3 ( 3) **TOP OF SOUND ROCK**

**BASALT**, very hard, broken, coarse grained, grey, somewhat weathered.
RECOVERY: 0.4'

5_.1 (.6) **BASALT**, coarse grained, fractured, many cracks filled with chlorite, breakage above average down to 75'; badly broken.
RECOVERY: 72.3'

_.7 ( 2) **FINAL DEPTH**

Classified by Young, Fallon, Rothrock, MacDonald, 7-21-41
Typed by J. Williams, 8-22-41
Checked by:

cc-Miraflores Field Office
Soils Lab.
E.L. Koparski

GEOLOGICAL LOG DRILL HOLE TL-62

) Line, Canal Axis; Station 2253+00; Offset 50'E

RECOVERY: 99.0%
GROUND ELEV: -53.2

MUCK, soft, plastic, somewhat sandy, color gray.
RECOVERY: 0.8'

SAND, mixed with muck, soft, color black.
RECOVERY: 1.0'

TOP OF WEATHERED ROCK & BASE OF COMMON
BASALT, disintegrated, sandy, color greenish.
RECOVERY: 1.0'

TOP OF SOUND ROCK
BASALT, hard, medium to coarse-grained, water stained, considerably broken.
RECOVERY: 3.0'

BASALT, hard, medium to coarse-grained, fractured, blind to open seams with some calcite filling.
RECOVERY: 61.7'

FINAL DEPTH

Log substantially correct. (MacDonald, 7-10-41)

Classified by Fallon, Goldstrom, Berini, Dwells, Rothrock, Young, 7-10-41
Typed by M. Curtis, 7-21-41
Checked by:

cc-Miraflores Field Office
Soils Lab.
E.L. Koperski

...; ...; ... Axis; Station 2272+00; Offset 250'W GROUND ELEV: -41.3

-.3 (.0) **ROCK**, medium soft. Color dark gray.
RECOVERY: 10.5'

3 (.0) **SILT**, soft, sandy, a few shell fragments, rotten wood embedded in bottom of stratum. Color black.
RECOVERY: 9.4'

-.3 (.0) **CLAY & BOULDER FRAGMENTS** of quartz, chert, chalcedony and basalt. Hard.
RECOVERY: 0.8'

.3 (.0) **TOP OF WEATHERED ROCK** ?
**CLAY & BOULDER FRAGMENTS** of chert, quartz, basalt & chalcedony. Hard.
RECOVERY: 0.1'

1.7 (.4) **TOP OF FAIRLY SOUND ROCK**
**TUFF BRECCIA**, top 5.0' looks like dark sandy shale, somewhat soft. Below elev. -90.0' lighter colored and firmer, grading into agglomerate and becoming coarser.
RECOVERY: 24.6'

33.8 (-5) **AGGLOMERATE**, medium hard, broken locally, embedded with fragments up to 1-1/2 inches, some partly rounded coarse sand grains. Upper portion has some seams filled with calcite. Color gray.
RECOVERY: 14.6'

Not particularly strong or very favorable for tunneling.
(MacDonald, 6-14-41).

.9 (4.6) **FINAL DEPTH**

Log substantially correct. (MacDonald, 6-14-41)

Classified by Fallon & Quillinan, 6-13-41
Typed by M. Curtis, 6-17-41
Checked by:

cc-Miraflores Field Office
Soils Lab.
E.L. Koperski

Line, Canal Axis; Station 2267+00; Offset 250'W

RECOVERY: 98.5%
GROUND ELEV: -48.4

SILT, medium hard, well compacted, shell fragments. Color dark gray.
RECOVERY: 0.8'

TOP OF SOUND ROCK

BASALT, hard, dense, fine-grained. Core broken due to barge movement. Color dark gray.
RECOVERY: 86.1'

BASALT, hard, dense, fine-grained, hydrothermally altered. This alteration probably occurred along several vertical cracks, one of which, shown in core, is 1/2" wide and is filled with calcite and some chlorite. Altered rock considerably softer than the unaltered basalt, though good foundation material. Some pyrite crystals noted. Color gray to greenish.
RECOVERY: 9.1'

FINAL DEPTH

Log substantially correct. (MacDonald, 6-6-41)

Classified by Linney & Quillinan, 6-5-41
Typed by M. Curtis, 6-9-41
Checked by:

co-Miraflores Field Office
Soils Lab.
E.L. Koperski

TL-72

GEOLOGICAL LOG DRILL HOLE TL-72

Line, Canal Axis; Station 2253+80; Offset 50'W

RECOVERY: 93.5%
GROUND ELEV: -53.0

MUCK, medium soft to soft, dark gray in color.

CLAY, soft to medium hard, very sandy, dark gray.

TOP OF WEATHERED ROCK
BASALT, hard, sandy, color black, much disintegrated, weathered.
RECOVERY: 0.2'

TOP OF SOUND ROCK
BASALT, very hard, color gray. Seams filled with chlorite. Fractured less than average except below 55' where fracturing may be slightly above average.
RECOVERY: 61.8'

FINAL DEPTH

Log substantially correct (MacDonald 7-21-41)

Classified by Dwelle, Rothrock, Bewmar, Young, 7-21-41
Typed by V. I. Hall, 8-12-41
Checked by:

cc-Miraflores Field Office
Soils Lab.
E.L. Koperski

/ ⌐ ✓ /

# GEOLOGICAL LOG DRILL HOLE TL-69

I) Line, Canal Axis; Station 2255/00; Offset Canal Axis; RECOVERY: 96.5% GROUND ELEV: -53.0

0.0 MUCK, soft, very plastic, sandy, color dark gray.

2.0 TOP OF SOUND ROCK
BASALT, hard, dense, coarse-grained, considerably fractured below 60.0' to bottom of hole. Less than average fracturing above 60.0'. (Good basalt)
RECOVERY: 64.7'

9.1 FINAL DEPTH

Log substantially correct. (MacDonald, 7-15-41)

Classified by Dwelle, Beemer, Rothrock, 7-15-41
Typed by M. Curtis, 8-5-41
Checked by:

cc-Miraflores Field Office
Soils Lab.
E.L. Koperski

ENGINEERING AND CONSTRUCTION BUREAU

INSPECTORS GEOLOGICAL FIELD LOG

Hole No.: BBR-17, Inspector: R. H. Stewart, Date Completed: 11/22/57

Latitude: 8° 56'+ 2788.9, Longitude: 79° 34'+ 450.4, Driller: C. Kroger A. Lincoln

Ground Elevation: - 4.4 ft, Recovery: ________, Sheet No.: 1 of 2

Balboa Bridge Studies

| Elevation | Depth | Columnar Section | Description of Material | Drilling Characteristics | Recovery |
|---|---|---|---|---|---|
| -4.4 | 0.0 | | Muck, OH-1 soft, weak, variable plasticity, variable dry strength, high water content, variably sandy and silty, contains abundant carbonaceous plant debris and calcareous shell debris, contains a bouldery zone near base; color, dark grey to black. | Push drills with ease, dry with fair core recovery. | |
| | 13.0 | | | | 10.0 |
| | 25.0 | | | | 10.0 |
| | 35.3 | | | | 10.2 |
| | 45.8 | | | | 10.0 |

ENGINEERING AND CONSTRUCTION BUREAU

Corrected Copy

INSPECTORS GEOLOGICAL FIELD LOG

Hole No.: BBR-16, Inspector: R. H. Stewart, Date Completed: 11-21-58

Latitude: 8° 56' + 2945.6, Longitude: 79° 33' + 5984.4, Driller: C.Kregar A.Lincoln

Ground Elevation: -27.0 ft., Recovery: 38.8' (49.6%), Sheet No.: 2 of 2

Corrected Copy

BALBOA BRIDGE STUDIES

| Elevation | Depth | Columnar Section | Description of Material | Drilling Characteristics | Recovery |
|---|---|---|---|---|---|
| | 52.0 | | Tuff Agglomeratic, (Cont'd). darker greys at base. | As above. | 1.7 |
| | 59.2 | | | | 5.6 |
| | 69.3 | | | | 6.0 |
| -105.3 | 78.3 | | | | 7.7 |
| | | | Bottom of Hole<br><br>Note: The depths and elevations in this hole are adjusted to what is believed correct. There was a driller's error in the first 52 feet of hole which was corrected before completion. | | |

PANAMA CANAL COMPANY

# SUMMARY OF DRILL HOLE DATA

La Boca Dam - 1907

from V.F. 22C
Location of Borings Scaled from ICC-1114
Borings from Aquadulce South, Sept. 1905 to July 1907

problematical G.P.

Stationing from Sosa End.

| ICB Hole No. | Date | Line | Latitude | Longitude | Ground Elev. | TWR Elev. | TSR Elev. | Bottom of Hole Elev. | Bottom of Hole Depth | Water Table Low Elev. | Water Table High Elev. | Material | Formation | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 79°39'+1790 | +1.0 | | -96.5 | -87.0 | 88.0 | 1527.4 | 65.8L | Mud, /Rock | | soft Rock |
| 1 | 3-5-07 | | 8°57'+1390 | +1660 | 0.0 | -59.0 | -62.0 | -85.5 | 85.5 | 1400 | Axis | Mud Sd, sl.ll, Cly, /Rock | | " " |
| 2 | 2-23-07 | | +1400 | +1850 | +2.0 | -55.0 | -57.0 | -154.0 | 156.0 | 1600 | " | Sd. cl. sh. | | Shales started -258' drilled |
| 3 | 3-22-07 | | +1410 | +1950 | +1.5 | -62.5 | -68.0 | -94.5 | 96.0 | 1700 | " | Sd, Cly, Grav. / Rock | | soft Rock |
| 4 | 3-13-07 | | +1420 | +1760 | +1.5 | -66.5 | -72.5 | -122.5 | 124.0 | 1500 | " | Cly, Sd, /Rock | | " " |
| 5 | 3-27-07 | | +1460 | +2090 | +2.0 | -42.0 | -48.0 | -82.0 | 84.0 | 1800 | " | " " Gr. Sd, / " | | " " |
| 6 | 3-23-07 | | +1430 | +1700 | +1.5 | — | -66.5 | -78.5 | 80.0 | 1450 | 100 R | ", Sd., trach, cl, slag, /Rock | | " " |
| 7 | 3-23-07 | | +1490 | +1800 | +1.8 | — | -69.5 | -84.2 | 86.0 | 1550 | 100 R | Cly, Sd, sl.ll, Grav. /Rock | | " " |
| 8 | 3-26-07 | | +1500 | +1990 | +1.7 | - | -58.5 | -78.3 | 80.0 | 1750 | .00 R | " " " " /Rock | | " " |
| 9 | 3-28-07 | | +1520 | +1900 | +1.0 | — | -51.5 | -90.0 | 91.0 | | | " " /Rock | | " " |
| 10 | 3-30-07 | | +1510 | +2140 | +1.0 | — | -34.5 | -76.0 | 77.0 | | | " " / " | | " " |
| 11 | 4-3-07 | | +1440 | +1550 | 0.0 | - | -59.0 | -77.0 | 77.0 | | | " " /Rock | | " " |
| 12 | 4-1-07 | | +1390 | — | +1.5 | — | -65.5 | -84.5 | 86.0 | | | " " " / " | | " " |
| 13 | 4-4-07 | | — | +1600 | +1.5 | | -55.5 | -96.5 | | | | " " " /Rock | | " " |
| 14 | 4-1-07 | | +1480 | +2080 | +1.5 | — | -38.5 | -111.5 | | | | " " " / " | | Boulder -96.5 to -50.5 |
| 15 | 4-15-07 | | +1530 | +1470 | -13.0 | | -27.0 | -82.0 | | | | " " " " /Rock | | " " |
| 16 | 4-12-07 | | +1280 | +1710 | +1.5 | -70.5 | -77.5 | -109.5 | | | | Mud " " /Rock | | " " |
| 17 | 4-15-07 | | +1290 | +1820 | +1.0 | | -59.0 | -107.0 | | | | " " " " " /Rock | | " " |
| 18 | 4-17-07 | | +1300 | +2240 | +1.0 | -32.0 | -62.0 | -89.5 | | | | " " / " | | Soft R -52 to -44 to -63 [illegible] |
| 19 | 4-15-07 | | +1440 | +2010 | +1.0 | | -44.0 | -86.0 | | | | " " " " / " | | " " |
| 20 | 4-17-07 | | +1310 | +1420 | +17.5 | -48.0 | -50.0 | -88.0 | | | | " " " " / " | | " " |
| 21 | 4-22-07 | | +1270 | +2100 | +2.5 | | -30.5 | -94.0 | | | | " " " / " | | |
| 22 | 4-18-07 | | +1320 | +1050 | +9.1 | | +1.0 | -8.1 | | | | Sd. /Traprock | | - Basalt |
| 23 | 4- -07 | | +1350 | +1020 | +1.7 | | -12.0 | -23.8 | | | | Cl, Sd, Gr. / " | | Basalt |
| 24 | 4-17-07 | | +1240 | +0910 | +3.9 | | -11.0 | -20.5 | | | | Sd. Mud /Rock | | Soft Rock |
| 25 | 4-18-07 | | +1230 | +0950 | +6.9 | | -0.5 | -8.6 | | | | Cl. sd. gr. /traprock | | Basalt |
| 26 | 4-16-07 | | +1340 | +1100 | +4.0 | | ~~+4.0~~ | -4.5 | | | | /Hard rock | | Hd Rock |
| 27 | 4-17-07 | | +1450 | +1160 | +2.0 | | -6.0 | -13.0 | | | | Sd /Rock | | Soft " |
| 28 | 4-17-07 | | +1360 | +1160 | +1.0 | | -7.0 | -17.5 | | | | Mud & sd /Hard rock | | Hard " |
| 29 | 4-19-07 | | +1270 | +0740 | +11.0 | | -1.0 | -11.0 | | | | sd & shale /Rock | | Soft " |
| 30 | 4-19-07 | | +1320 | +2180 | +9.0 | | -60.0 | -87.0 | | | | Mud, shale, gravel / " | | " |
| 31 | 4-25-07 | | +1530 | +1610 | -10.0 | | -19.0 | -105.0 | | | | Mud & sd. sh. / " | | " |
| 32 | 4-24-07 | | +1290 | +4680 | +14.5 | | -4.0 | -4.0 | | | | Mud, Cl. / " | | " |
| 33 | 10-6-05 | | +1740 | +3940 | +11.5 | | -22.0 | -22.0 | | | | " " / " | | " |
| 34 | 10-7-05 | | +1610 | +3140 | +7.5 | | -25.0 | -25.0 | | | | " " / " | | " |
| 35 | 10-6-05 | | +1500 | +2960 | +7.5 | | -37.0 | -37.0 | | | | " " / " | | " |
| 36 | 10-6-05 | | +1470 | +2260 | +2.0 | | -73.5 | -73.5 | | | | " " / " | | " |
| 37 | 10-5-05 | | +1380 | +1970 | +1.5 | | -66.0 | -66.0 | | | | " / " | | " |
| 38 | 10-4-05 | | +1340 | — | +2.0 | | -14.5 | -14.5 | | | | " " / " | | " |
| 39 | 10-8-05 | | — | — | +11.3 | | 0.0 | 0.0 | | | | " " / " | | " |
| 40 | 10-7-05 | | — | +3240 | +7.2 | | -57.0 | -74.0 | | | | " " / " | | " |
| 41 | 4-26-07 | | +1520 | +2280 | +3.0 | | -41.0 | -72.0 | | | | " gr. / " | | " |
| 42 | 4-23-07 | | +1540 | +2630 | +6.3 | | -18.7 | -83.0 | | | | " Sd. cl / " | | " |
| 43 | 4-24-07 | | +1470 | | | | | | | | | | | |

LTC

# PANAMA CANAL COMPANY

## SUMMARY OF DRILL HOLE DATA

on SK-2-1-21
from SK-1806-263

NS-CANAL PIPELINE - LA BOCA

Stor. Container 33

| | Date | Latitude | Longitude | Ground Elev | TWR Elev | TSR Elev | Bottom of Hole Elev | Bottom of Hole Depth | Water Table Low Elev | Water Table High Elev | Material | Formation | Remar |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3-29-42 | 8°56' + 5960.5 | 79°39' + 3743.6 | 0.1 | -26.9 | — | -32.5 | 32.6 | | | Basalt | | Silt on top |
| | 3-30-42 | + 5941.9 | + 3591.6 | -0.6 | -27.5 | — | -37.1 | 36.5 | | | " | | " |
| | 3-31-42 | + 5923.1 | + 3337.1 | -1.0 | -31.2 | — | -41.9 | 40.9 | | | " | | " |
| | 4-1-42 | + 5909.2 | + 3132.3 | -2.1 | -27.2 | — | -38.5 | 36.9 | | | " | | " |
| | 4-2-42 | + 5872.5 | + 2789.2 | -2.5 | -32.0 | — | -43.7 | 41.2 | | | " | | " |
| | 4-4-42 | + 5838.0 | + 2414.7 | -2.0 | -39.3 | — | -50.5 | 48.5 | | | " | | " 5' of gravel at |
| | 4-6-42 | + 5829.8 | + 2325.2 | -1.0 | -42.7 | — | -53.1 | 52.1 | | | " | | " |
| | 4-7-42 | + 5819.6 | + 2215.1 | -5.0 | -52.0 | — | -57.1 | 52.1 | | | " | | X.5' silt - 5.5' of clay |
| | 4-8-42 | + 5808.8 | + 2096.6 | -41.5 | -72.5 | — | -74.5 | 33.0 | | | " | | Silt on top |
| | 4-9-42 | + 5798.2 | + 1982.0 | -41.9 | -56.5 | — | -63.6 | 22.2 | | | Shale | | " |
| 110 | 4-11-42 | + 5787.9 | + 1820.9 | -51.0 | -68.7 | — | -74.8 | 23.8 | | | Shale | | " |
| 120 | 4-11-42 | + 5759.8 | + 1553.2 | -55.0 | -66.9 | — | -70.2 | 15.2 | | | Shale | | " |
| 130 | 4-11-42 | + 5732.5 | + 1257.3 | -57.0 | -54.7 | -58.7 | -62.6 | 5.6 | | | Basalt | | " |
| | 4-12-42 | + 5701.5 | + 931.9 | -0.6 | -3.5 | -37.5 | -44.4 | 43.8 | | | Basalt | | " |
| | 4-14-42 | + 5672.6 | + 617.7 | + 0.7 | — | -26.6 | -31.0 | 31.7 | | | Basalt | | " |
| | 4-16-42 | + 6039.9 | + 4600.0 | + 8.5 | -21.5 | — | -46.0 | 54.5 | | | Tuff & Agglom. | | " |
| | 4-17-42 | + 5997.1 | + 4142.0 | + 6.1 | -21.9 | -50.9 | -54.4 | 60.5 | | | Shale / Basalt & Shale | | |

# APPENDIX No. 14

## Preliminary Assessment for the Cartridge and Proposed Bulk Explosive Systems for the Submarine Blasting Report by *Blasting Analysis International Inc.*

# PRELIMINARY ASSESSMENT FOR THE CARTRIDGE AND PROPOSED BULK EXPLOSIVE SYSTEMS FOR THE SUBMARINE BLASTING

Prepared for

**Panama Canal Authority (PCA)**
ADM. Y SUP. GEN - CAUCE Y RIB.
EDIF. 37, GAMBOA
Republica de Panama

Prepared by


R. Frank Chiappetta
(Explosives Applications Engineer)

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Requested by

Mr. Ricardo Perez

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**PRELIMINARY ASSESSMENT FOR THE CARTRIDGE AND PROPOSED BULK EXPLOSIVE SYSTEMS FOR THE SUBMARINE BLASTING**

## SUMMARY OF CONCLUSIONS, RECOMMENDATION AND OPINIONS

Blasting Analysis International, Inc. (BAI) completed a preliminary technical study to evaluate the current Kelly bar system using cartridged explosives and a proposed modified drill platform using bulk explosives. Emphasis was placed on what was needed to make both reliable explosive systems. A summary of the conclusions, recommendations and opinions are listed as follows:

1. The best blasting system is one which can deliver reliable blast results to the intended deepening elevation, with minimal problems and at the least cost. It is highly recommended that a re-evaluation of the cartridge and proposed bulk systems be done with the new technical information contained within this report, particularly for the bulk system. Serious consideration also needs to be given to the hole loading procedures, reliability and safety for each system. If an economic re-evaluation is not performed with the new information, it could lead to false economics and conclusions.

2. It is important to note that the current cartridge system has had a very long history of reliability, and that the proposed bulk system remains untested and unproved for the severe field conditions in the submarine blasting. Thus, it is strongly recommended that one or two towers on the drill platform be converted to the bulk system for testing and evaluation purposes, to allow a phase-in period and retraining of personnel. Converting the entire drill fleet to a bulk system without testing could be irreversible, incurring a considerable expense if the bulk system proves ineffective, or is not economical in relation to the total project costs, objectives and completion schedule.

3. The proposed bulk system is more sensitive to failure than the cartridge system because loading bulk explosives in small diameter holes with very short explosive columns is not technically favorable compared to the cartridge system. In addition, the bulk system will require additional in-hole accessories and more detailed attention to the loading procedures to make it a reliable system. Specific details are provided to overcome the technical difficulties,

including explosive contamination and floating primers during the hole loading for the bulk system.

4. Any additional drilling to deepen the canal now, over and above what is needed for the immediate objectives, will improve the blast results and could save money over the very long term. This assumes that the funding is available to do this within the present schedule.

5. Relying on only one drill platform until the year 2004 with no backup system is strategically risky, should anything happen to the THOR in the interim period. Consideration should be given to getting the second drill platform on-line sooner.

6. Regardless of whether a cartridge or bulk explosive system is used, the top 5 feet of a 15 foot drill hole does not need any explosives. This upper part of the explosive column is basically wasted energy, and in some cases could cause other blasting problems. Thus, all future holes should not be loaded right to the top of the hole. This should be implemented immediately, since a savings of at least 33% in explosives consumption can be realized throughout the project duration.

7. A number of other cautionary notes are included in the report for both explosive systems. In terms of their technical merits, the cartridge system will provide a more reliable, less demanding and trouble free operation over the bulk system. The bulk system can be made to work, but will require more effort pertaining to the details. These trade-offs should be reflected in the final economic re-evaluation.

## 1.0 INTRODUCTION

Blasting Analysis International, Inc. (BAI) was commissioned by the Panama Canal Authority (PCA) to conduct a technical evaluation for the current drill boat THOR with a Kelly Bar System using cartridged explosives, and a proposed modified drill boat with an on-board bulk explosive loading system. The main purpose was to evaluate the technical feasibility, application logistics and what would be required to make both reliable systems. Although direct comparisons are made between the two systems to put some things into perspective, a final decision will weigh heavily on the final economics, reliability and the inherent safety of each system.

This report is based and qualified on the following:

1. An on site visit to the Panama Canal facilities during April 30 to May 2, 2002.
2. Meetings and discussions with PCA representatives from all of the relevant departments, including the legal and contracts divisions.
3. Technical information and reports supplied by PCA representatives.
4. Report on a "Proposed Bulk Explosives System", prepared by ETI Canada, dated February 21, 2002
5. Digital images taken during the on site visit
6. The author's familiarity with the former Panama Canal Commission's operation pertaining to blasting operations for the land and submarine blasting.

BAI is an international consulting group specializing in custom blast designs, technical and safety audits, blast monitoring instrumentation and training. To date, BAI has designed, monitored, evaluated and/or supervised over 6,000 full-scale blasts in a variety of field conditions spanning 22 countries.

BAI certifies that it is completely independent and is not associated with the financial business activities of the Panama Canal Authority, nor in the sale of explosives or rock products. Our services were retained strictly as an independent engineering firm to provide objective technical evaluations and advice.

## 2.0 GENERAL ECONOMIC CONSIDERATIONS

For purposes of discussion, the currently used drill boat THOR with the Kelly bar and use of cartridged explosives will be referred to as the "cartridge system". The proposed modified drill platform using bulk explosives will be referred to as the "bulk system".

In order to evaluate and optimize the blasting system, the drilling and blasting costs must be evaluated in conjunction with the total project costs. Economic evaluations based on a single unit cost reduction can only be valid when the operator is assured, for example, that a reduction in the explosive cost will not affect the total project costs, or the 7 year completion deadline to deepen the canal. Thus, one of the first things that must be done is a detailed cost sensitivity analysis for both the cartridge and bulk systems, which should take into account all unit costs, including the cost of capital, retrofitting and ownership. The intangible elements regarding reliability and safety should also be carefully considered when evaluating both systems. Failure to do this may not be in the best long term economic interests for the project, and could lead to erroneous conclusions and false economics.

On a broad basis, the overall project costs can be expressed as:

$$C = dr + bl + di + l + h + d + ov \qquad \text{...Eqn. 1}$$

Where:
- dr = drilling and accessories
- bl = explosives and accessories
- di = digging and dredging
- l = loading
- h = hauling
- d = dumping
- ov = oversize rehandle and secondary blasting

The drilling cost (Cdr), is dependent on borehole diameter, burden and spacing, thus Cdr = f1 (D, B, S). Blasting cost, (Cbl), depends primarily on the type of explosive, E, primer, P, and the initiation system, I. Thus, Cbl = f2 (E, P, I). Since the last five terms of Eqn. 1 (di, l, h, d, ov) are directly related to the fragment size distribution, they can be represented by a single function, f3 (F).

Equation 1 can now be rewritten as:

$$C = f1 + f2 + f3 \qquad \text{...Eqn. 2}$$

Where:
- f1 = drilling function costs
- f2 = blasting function costs
- f3 = fragmentation size distribution and processing costs

or

$$C = f1\ (D, B, S) + f2\ (E, P, I) + f3\ (di, l, h, d, ov) \qquad \text{...Eqn. 3}$$

Equation 3 allows one to perform a cost sensitivity analysis for a combination of input parameters for each option considered. An optimization program generally aims at lowering the highest cost element in the total project breakdown, without adversely affecting the other unit costs, production schedules, reliability or safety. In theory, an increased cost in any unit operation should not be a major concern if the total project costs are equal to or less than the system being compared. If productivity is improved or remains unchanged, an overall savings may have been realized. In practice, however, there must be a minimum improvement, since there is always a cost associated with any new operational change, retraining and to allow for some factor of safety in the calculations.

BAI's roles is to outline what is required from a technical and logistical standpoint to make both the cartridge and bulk systems work. Emphasis will be placed on the operational details, logistics and required accessories. This information will be useful input to complete and refine the economic analysis.

# 3.0 TECHNICAL ASPECTS APPLICABLE TO BOTH THE CARTRIDGE AND BULK SYSTEMS

## 3.1 Drill Hole Depth

The Panama Canal deepening project is currently planned for completion within the next 7 years. Figure 3.11 illustrates the target deepening elevation, subdrill and additional drilling for a total drill hole depth of 15 feet in the rock. The drill towers and rods for the THOR have been extended an additional 10 feet to accommodate the planned hole depth in the rock, and to maintain an efficient one pass system for the drilling setup.

The deepening objective is a large and relatively expensive project. Although the drill hole depth is already planned to go well below the necessary depth to achieve the new targeted deepening elevation, consideration should be given to drilling as deep as possible now for the future. The greatest cost is always in getting everything setup again in the initial program.

Assuming that the physical constrains on the drills are not exceeded for a one-pass system, and the economics and funding are favorable over the long term, additional hole depths will provide more flexibility for deepening the canal on an-as-needed basis in the future. The dredge Christensen will always have the option of dredging only to the desired elevation, even though the rock is broken to deeper elevations. This could save a substantial sum of money in the future should additional deepening be required, without the initial costs of setting up again from scratch.

In addition, deeper drill holes will provide the following technical advantages:

- Assured breakage to the desired deepening elevation.
- Better distribution of explosive energy, since the explosive column is elongated to more of a cylindrical charge rather than a point (i.e., crater) charge.
- Lower powder factors to break the same volume of rock, by allowing larger drill patterns.
- Allows the bottom of the hole to act as a catch basin for mud, slimes and sediment which will always end up at the hole bottom.

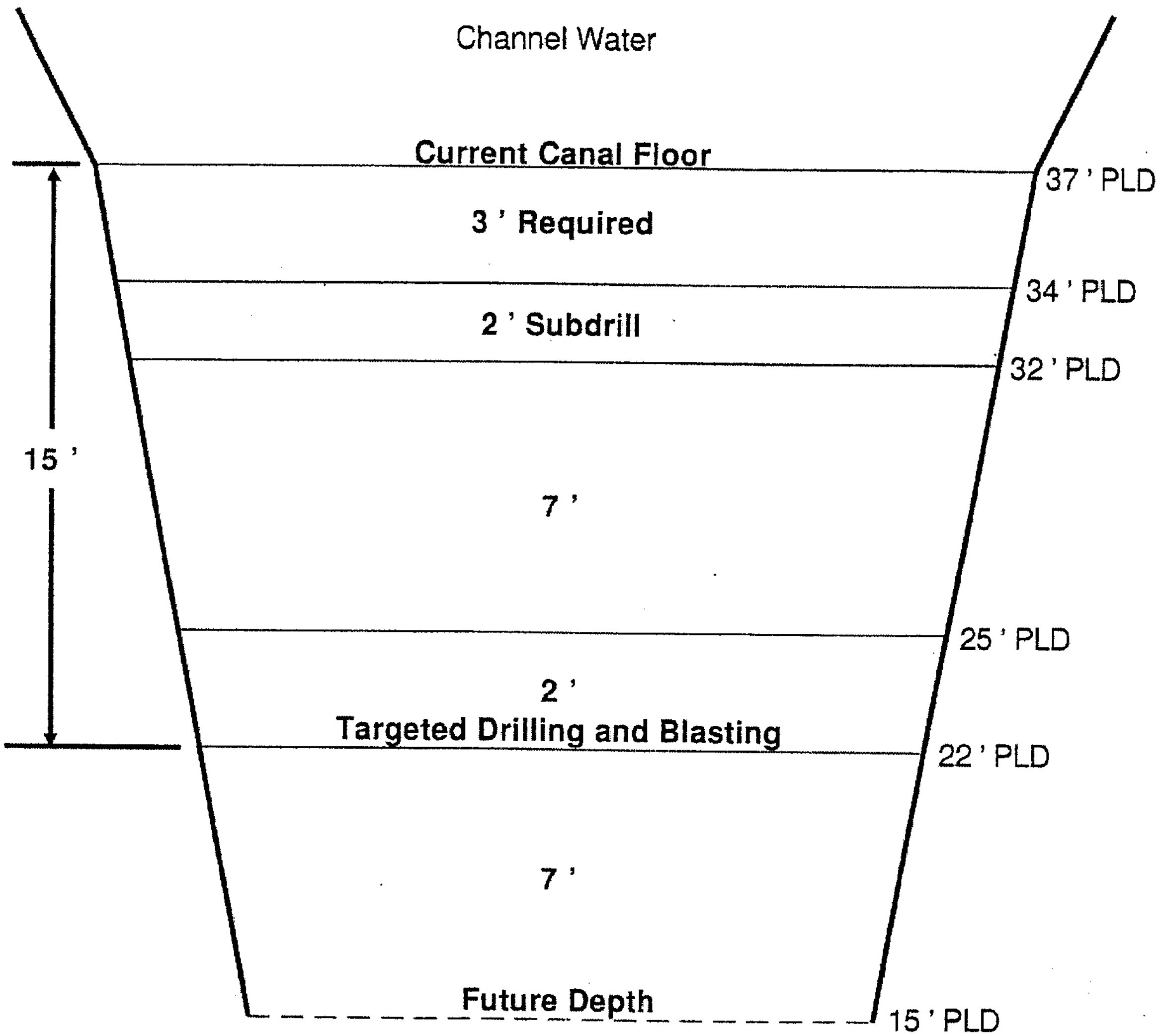



Figure 3.11 Current and future deepening plans for the Panama Canal

## 3.2 Drill Availability

At the present time, the drill boat THOR is the only platform available for the project. A new drill platform is planned for service by the fiscal year of 2004 by retrofitting the existing land-based drills.

Consideration should be given to getting the second drill platform prepared earlier for strategic purposes, even though the second drill platform is already budgeted into the scheduled plan for 2004.

Although no known serious accidents rendering the THOR unusable for prolonged periods have occurred from marine traffic collisions in the past, there have been a few close calls and future accidents can happen. We must also consider the effects of lightning and large quantities of explosive stored in holding tanks on the THOR or alongside the THOR on barges. Even though personnel are evacuated well before the onset of an electrical storm, a direct lightning hit could cause permanent, catastrophic and irrepairable damage to the THOR.

Most of the equipment in the Panama Canal is usually specialized and requires long lead times to acquire and put into commission. The point here is that if the THOR goes down for any reason (mechanical, fire on board, lightning, explosion, and/or vessel collision, etc.), the critical path schedule for completion of the project will be severely affected.

This is why large mining companies who use very large volumes of explosives always have two suppliers. If, for example, an explosive manufacturing plant's production is disrupted (i.e., accidental explosions, direct lightning strikes, shortage of raw materials, and/or labor disputes, etc.) the mining company can always continue operations with the second explosive supplier. The same consideration needs to be seriously given in the early stages of the deepening project. Basically, there is one drill platform until the year 2004 to carry out a very critical function, for a very important and expensive project. No backup drilling system is available until 2004.

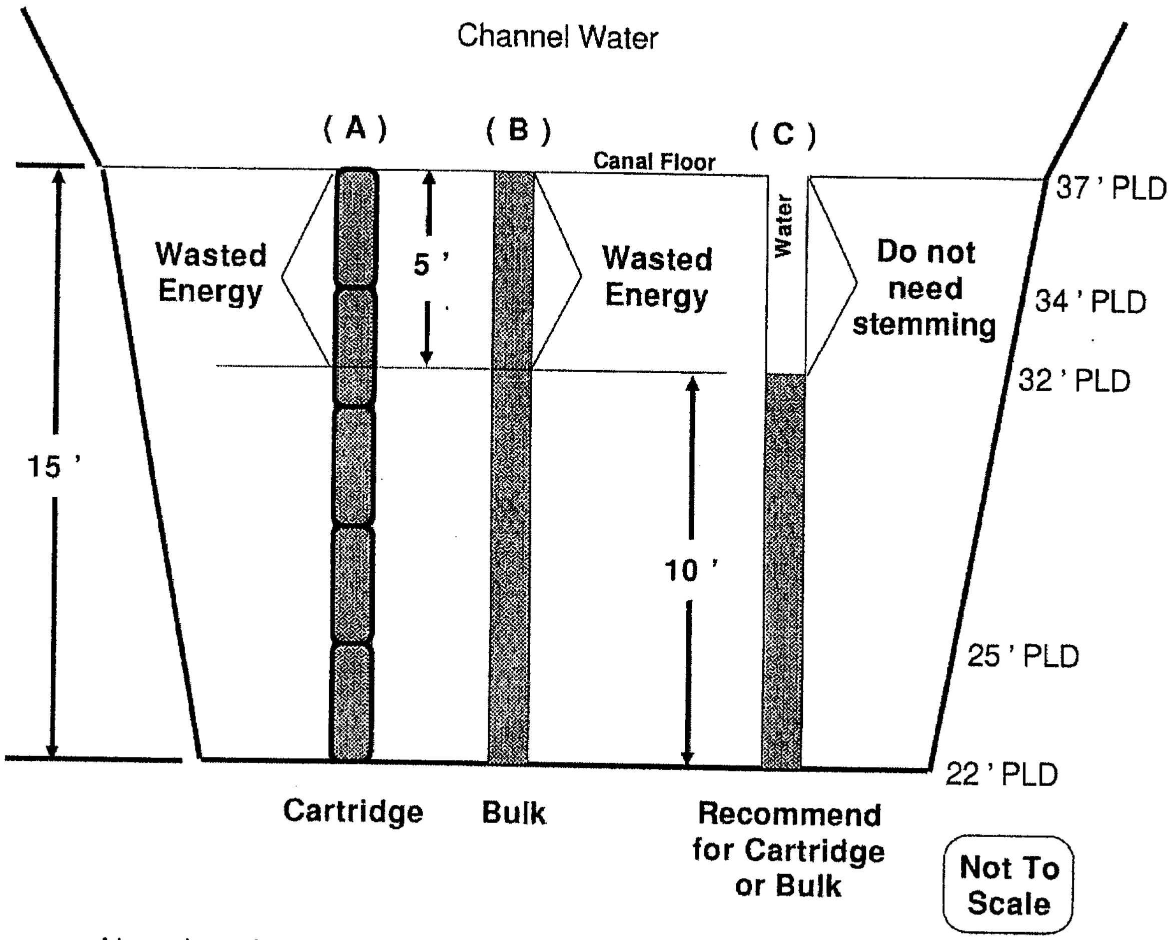
## 3.3 Explosive Column Load

Figure 3.21 illustrates three holes drilled 15 feet in the rock for the deepening project. The current and planned methods of loading a drill hole for the submarine blasting is to load the entire 15 feet of hole right to the top, as illustrated in A and B. But, regardless of whether the drill hole is loaded with cartridged or bulk explosives, the top 5 feet of explosives in the hole will be wasted and serves no useful function.

In fact, loading a hole with explosives right up to the top will tend to cause more problems in the form of misfires and erratic results, because the top part of the explosive could rob an adjacent hole of its collar burden. Also, the very top part of the explosive will tend to detonate in an unconfined condition, resulting in low order detonations, deflagrations or even partial explosive column failures.

In the case of bulk loaded explosives, a lower column will help to alleviate explosives being sucked out of the hole from the drag pressure created by heavy close passing vessels.

Removing a conservative 5 feet of the explosive column from the top of a 15 feet hole will reduce the explosive consumption by 33% on the project. This represents a substantial savings and should be implemented immediately, regardless of whether a cartridged or bulk system is used. In soft, weak or highly fractured rock formations, removing 6 to 7 feet of the top explosive column may also be possible. But it is doubtful that the removal of the top 5 feet of explosive will cause any measurable differences in the blast results.




Note: In soft, friable, weak or highly fractured rock areas, the explosive column could be reduced an additinal 1 - 2 feet.

Figure 3.21 Current and recommended hole loading

# 4.0 EXPLOSIVE CHARACTERISTICS

## 4.1 Critical Diameter

Both cartridge and bulk explosives can be formulated as high explosives or as blasting agents. A high explosive is defined here as one which will reliably detonate with only a No. 8 strength detonator. A blasting agent is defined as one which will not detonate with a No. 8 strength detonator, and thus will require a high-explosive (i.e., primer) in the detonation chain.

In general, cartridged explosives are better suited as high explosives, and are more conducive for use in small diameter, short explosive columns. In contrast, bulk explosives are generally better suited in the larger diameter holes and/or long explosive columns.

Another thing to consider is the critical diameter of the explosive. All explosives have a distinct critical diameter rating. If an explosive is put in a hole which is less than its critical diameter, it will fail regardless of the size or strength of primer used. If an explosive is used close to but above its critical diameter, the explosive will generally detonate, but may do so at a lower order detonation, thus robbing the hole of some of its initial available energy. Overall blast results could be unreliable, unpredictable and erratic.

Although some bulk explosive agents can be designed with specialized formulations to accommodate their use close to the critical diameter, most bulk explosive agents will struggle depending on their characteristics. High explosive cartridged products, on the other hand, can be reliably formulated for use in very small diameter holes with very little energy loss. This factor alone could equalize the effective energy output for fully coupled explosive loads compared to water decoupled cartridged explosives.

Thus, if contemplating bulk explosives agents for use in 4 7/8 inch to 6 1/2 inch holes, you want to select an explosive that is as far way from its critical diameter as possible. This factor could disqualify some explosive blasting agents. On the other hand, the smaller 4 7/8 inch hole will provide a better distribution of energy relative to the small hole depths of 15 feet.

## 4.2 Explosive Decoupling

Figure 4.21 illustrates the same 2 inch diameter of explosive in a fully coupled hole, in a larger 6 inch hole with air decoupling, and in a larger 6 inch hole with water decoupling. Note that the water acts as an excellent coupler of the explosive energy imparted into the surrounding rock medium compared to air decoupling.

Although a fully coupled explosive will technically produce the greater rock damage, it is not overly significant in the drill pattern expansion for purposes of obtaining the same fragmentation, given the conditions in the Panama Canal.

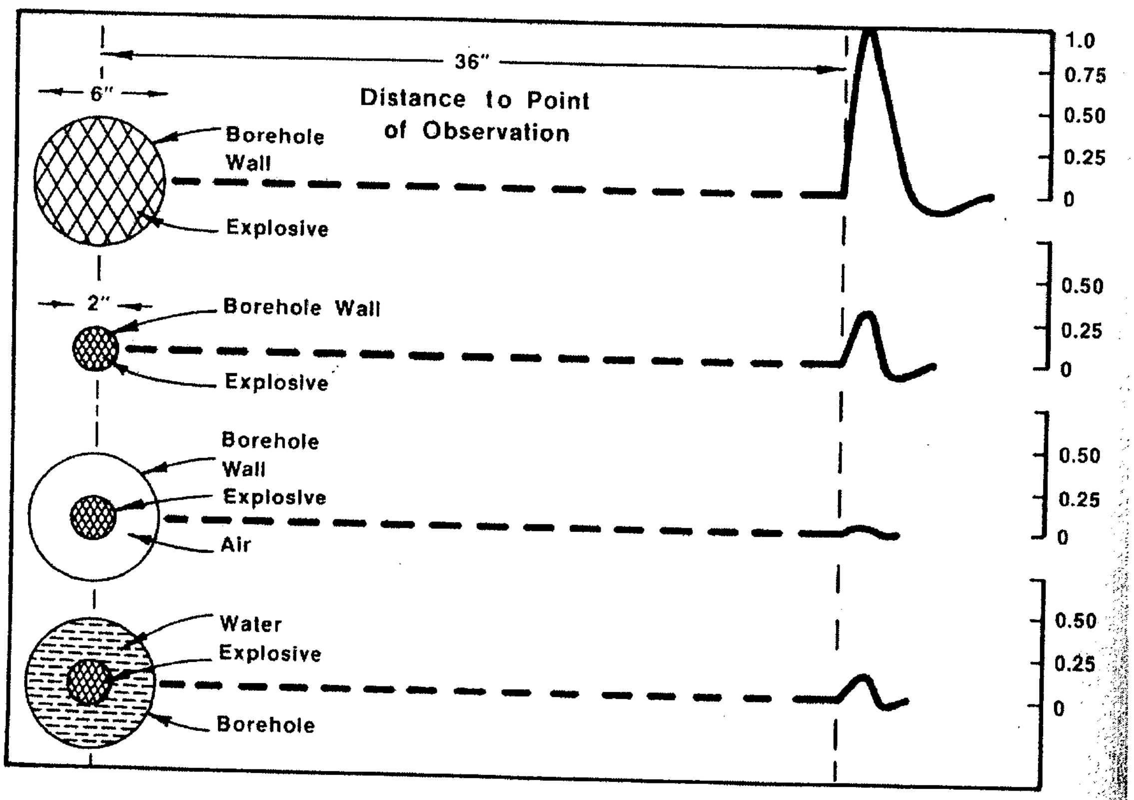



**Figure 4.21 - Effects of Air and Water Decoupling**

**Source:** Day, P. R. (1982). Controlled Blasting to Minimize Overbreak with Big Boreholes Underground. *Proceedings of the 8th Conference on Explosives and Blasting Techniques* (pp. 262-274) New Orleans, LA: Society of Explosives Engineers.

# 5.0 TECHNICAL CONSIDERATIONS FOR THE CARTRIDGE SYSTEM

## 5.1 Advantages of the Cartridge System

The present cartridge system with the Kelly bar on the drill boat THOR is a very reliable and proven blasting system. In spite of the explosive accident which occurred many years ago due to the use of NG-based high explosives, the cartridge system has withstood the test of time and has undergone many refinements in the loading procedures to be warranted a very reliable system. Today, NG based explosives are not allowed in the Panama Canal.

Significant advantages in using the cartridge system are listed as follows:

1. Once the hole is drilled and cased, there is very little or no possibility of the hole collapsing. This minimizes the number of lost holes, redrilled holes and assures that all holes can be properly loaded.

2. The use of sausage linked cartridged explosives with a detonating cord downline is a simple, reliable and quick one-step loading process.

3. The detonating cord downline is in contact with all of the cartridged explosives, thus providing a higher reliability of full column detonation.

4. Other than the detonating cord downline and the surface delays, no primers, in-hole delays, plugs or other accessories are required.

5. With cartridged produces, there is absolutely no possibility of contaminating or diluting the explosives with mud, slime, sediment or water. This is a very important consideration, particularly when loading very short explosive columns of 8 to 10 foot lengths in small diameter holes.

6. Cartridged products always assure the exact quantity of explosives with respect to the designed amount, for inventory and auditing purposes.

7. Other than having to extend the current drill towers and drill stems to accommodate an additional 10 feet of drill length, no other retrofitting is required.

8. Cartridged high-explosives are much better suited to smaller diameter holes for reliability.

9. A cartridge explosive system does not produce any undesirable remnants such as shock tube lines, plugs or PVC pipe floating on top of the water. This is important for marine traffic safety, environmental concerns and possibly clogging up water line intakes

10. Employees are already accustomed to the use of the cartridge system, and thus would require very little, if any training since it does not involve a major operational change.

## 5.2 Disadvantages of the Cartridge System

The three disadvantages with the cartridge system are:

1. On a unit cost per cwt, cartridged explosives will generally be more expensive. However, a new economic analysis is required to determine if this impacts the overall total project costs.

2. Cartridged explosives will require a slightly smaller drill pattern due to the decoupling, and hence a few more drill holes per blast block.

3. Rehandling in regards to delivery, storage and on-site use is more labor intensive, but not while loading individual holes.

# 6.0 TECHNICAL CONSIDERATIONS FOR THE BULK SYSTEM

## 6.1 Advantages of the Bulk System

The proposed bulk system also has some advantages and disadvantages in view of the specific application. The main advantages of implementing a bulk system are:

1. On a unit cost basis per cwt, bulk explosives are generally more economical, but this needs to be verified with an economic analysis within the total project costs and not on the explosive costs alone.

2. Bulk explosives are a blasting agent and thus less sensitive, but require a high-explosive primer and a No. 8 detonator for reliable detonation.

3. Larger volumes of explosives can be transported via approved ISO containers and pumped through electronically controlled systems, thus reducing the manpower required to get the explosives onto the drill barge in preparation for hole loading.

4. Slightly larger drill patterns will be possible, which leads to a few less drill holes per blast block. This assumes that each hole is properly prepared prior to loading and that everything has been implemented to assure a reliable blasting system.

## 6.2 Disadvantages of the Bulk System

The following disadvantages need to be seriously considered for the proposed bulk system:

1. The bulk system appears as a straight-forward simple system, but it has had no performance history for application on a drill platform and/or for the submarine blasting. Basically the bulk system remains unproven in terms of its proposed ease of use and reliability in meeting the PCA's final objectives.

   Thus, it is strongly recommended that one or two drill towers be set up on a test basis, prior to retrofitting all of the drill towers. This will allow management to perform a full unbiased evaluation in assessing the physical and economic constraints, compared to the current cartridge system. If all of the drill towers are converted over to accommodate a bulk system without some test or phase-in period, it could be quite costly and also highly embarrassing for everyone if the system fails to meet its predictions, and then has to be reverted back to the standard cartridged system.

2. A reliable means will need to be engineered to keep a drill hole from caving-in or getting plugged when the drill bit is retracted out of the hole. In hard, competent, undisturbed, massive rock formations, this will not be so much of a problem. But in areas which consist of soft compacted sands or weak, friable and highly fractured rock, this will become a significant problem and a challenge to keep the hole cleared for loading. At this stage a means of keeping the hole open has not been very well defined. If a reliable method is not devised to keep the hole cleared in the early stages of the program, a significant number of lost and redrilled holes can be expected. This will extend the drilling time for a standard blast block.

   But, we must remember that in areas of bad ground conditions, the chances are high that an adjacent redrilled hole will also encounter the same conditions and could also be lost. The challenge then becomes to drill enough good holes that can be properly loaded. If a hole cannot be properly loaded, it will defeat the deepening project.

3. The greatest challenge, however, will be to keep the bulk explosive from being contaminated from the mud, slimes and sediment situated at the hole bottom. In any water saturated blast environment, where you have water in a hole, you will always have some accumulation of mud, slimes and sediments. Also the amount of impurities at the bottom of each hole could vary.

   When the loading hose is placed at the hole bottom through the impurities and the explosive is pumped into the hole, the impurities will get mixed into the explosive. Refer to Figure 6.21.

   This could contaminate and/or dilute the explosive for several feet into the explosive column. We must emphasize that there is only a 10 foot explosive column or approximately 100 to 120 lbs of explosives per hole. This is not a significant amount of explosive, but nevertheless a very critical and necessary amount to do the job. Even if only one foot of the sediment got mixed into the explosive while loading, this would represent a 10% dilution. A 10% dilution would result in a low order detonation and a large energy loss. A 20% dilution or 2 feet of sediment mixed into the explosive will cause a complete failure.

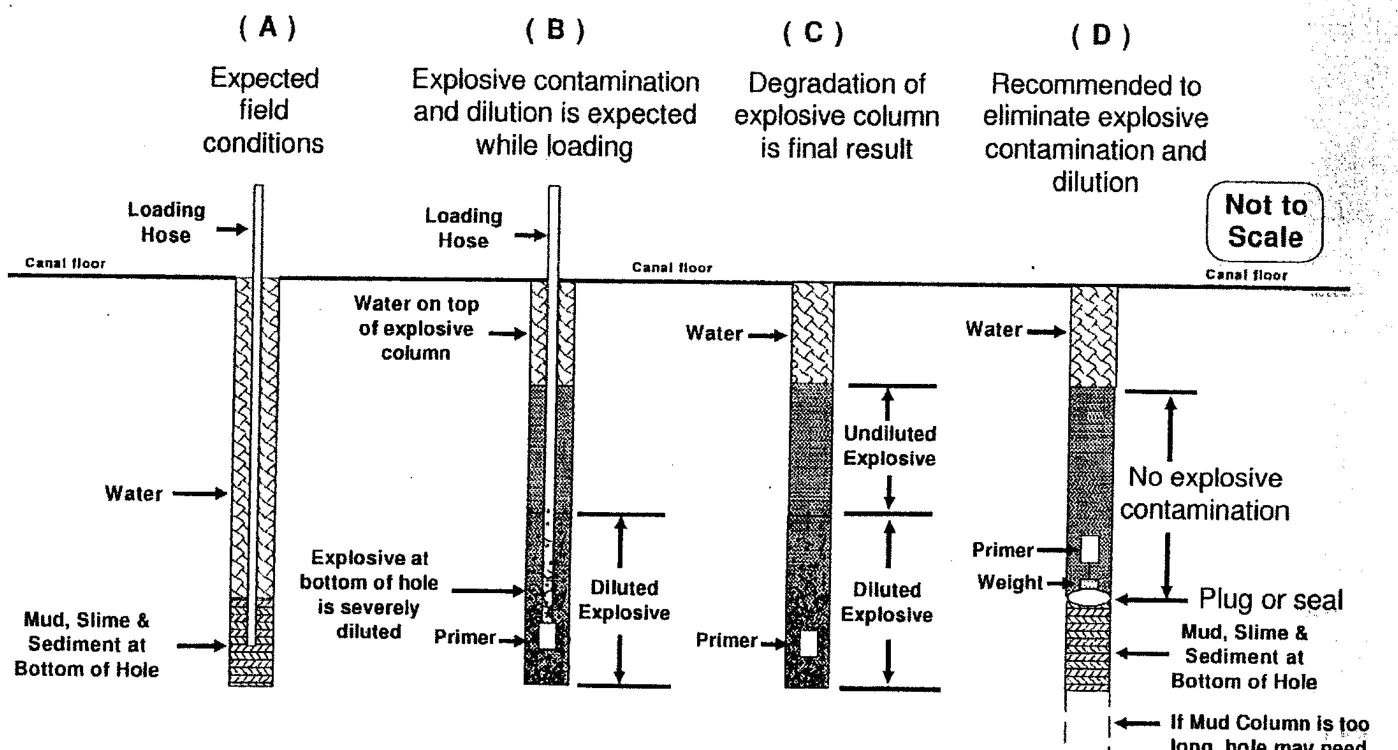



Figure 6.21 Explosive Dilution Due To Mud/Simes/sediment at Bottom of Hole

BAI has monitored the extent and effects of explosive dilution in many parts of the world. Explosive contamination is always a major problem and concern in severe wet borehole conditions. Explosive dilution in the bottom 3 to 5 feet of the explosive column would not be unusual, given the field conditions encountered in the Panama Canal. In some cases, well over 10 feet of explosive dilution have been documented, depending on the explosive density, explosive viscosity, field conditions and pumping rate. Thus, it is quite possible to get some degree of explosive dilution for the entire column height for the explosive columns anticipated in the Panama Canal application.

In order to eliminate the dilution problem, an effective plug must be inserted into each hole and placed above the sediments prior to loading. To position the plug at the correct elevation in the hole, a measurement would first need to be taken to establish where the top of the sediment is. Figure 6.22 illustrates a plug which is suitable for this application, and is highly recommended. The cost of this plug is approximately $3.00 each.

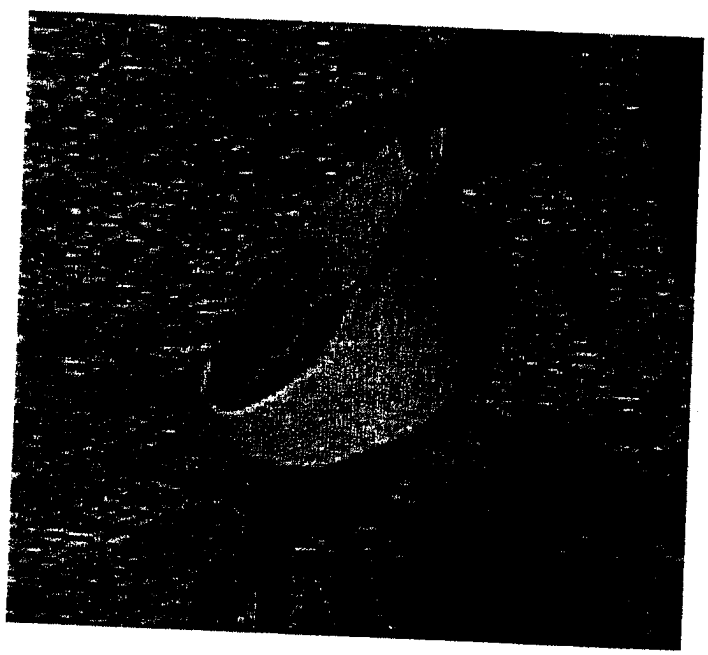


**Figure 6.22**

The problems associated with explosive dilution cannot be over emphasized. Remember that we do not have a large amount of explosives per hole to work with. Even a small amount of explosive dilution will have a large negative effect on the blast results. Unless the explosive dilution problem is eliminated, the bulk system will not work.

# APPENDIX No. 15

## ACP Drillboat THOR Cost

Appendix No. 15 A

# "THOR" RATES

Updated on July 15, 2002

**Inflation conversion factor** **1.023**

**Division Overhead** **12%**

| | | **Total Costs** | | **Incidental Costs** |
|---|---|---|---|---|
| Hourly Cost for availability | | $ 164 | | n.a. |
| Hourly Cost of Labor | | 517 | | 517 |
| Incidental Costs applied to Labor | | 62 | | 62 |
| Average Hourly Cost of Fuel | | 54 1/ | | 54 |
| Small Tugboat support | | 112 | | 112 |
| Guard or passenger boat support | | 99 | | 99 |
| Sub-total for support | | 216 | | 216 |
| **Total** | | **$ 1,013** | **$** | **849** |
| **Cost by Shift** | | | | |
| Cost for availabily for 8 hours | | $ 1,309 | n.a. | |
| Cost of Labor for 8 hours | | 4,632 | | 4,632 |
| Fuel Usage for 6 hours | | 324 2/ | | 324 |
| Support for 8 hours | | 1,730 | | 1,730 |
| **Total Cost by Shift** | | **$ 7,995** | | **6,686** |
| **Daily Cost -3 shifts** | | | | |
| Cost for Availability | | 3,926 | n.a. | |
| Cost of Labor | | 13,896 | | 13,896 |
| Fuel Usage | | 972 | | 972 |
| Support | | 5,190 | | 5,190 |
| **Total Daily Cost** | | **$ 23,985** | | **$20,059** |
| **Weekly Cost - 3 shifts/7days** | | | | |
| Cost for Availability | | 27,484 | n.a. | |
| Cost of Labor | | 97,272 | | 97,272 |
| Fuel Usage | | 6,806 | | 6,806 |
| Support | | 36,333 | | 36,333 |
| **Total Weekly Cost** | | **$ 167,894** | | **$140,411** |
| **Weekly Estimate of Drilling and Blasting Volume (Cubic meters in bank)** | **a** | **23,576** | | **23,576** |
| | **b** | **27,776** | | **27776** |
| | **c** | **29,986** | | **29986** |
| **Cost for one cubic meter in bank without explosives** | **a** | **$ 7.12** | **$** | **5.96** |
| | **b** | **6.04** | | **5.06** |
| | **c** | **5.60** | | **4.68** |
| **Cost of Explosives for one cubic meter in bank** | | **$ 2.00** | **$** | **2.30** |
| **Total Cost of One Cubic Meter** | **a** | **$ 9.12** | **$** | **8.26** |
| | **b** | **8.04** | | **7.36** |
| | **c** | **7.60** | | **6.98** |

Notes:

1/ Average Usage of 48 gallons/hour, $1.10/gallon

2/ It was assumed that the THOR spends an average of 6 hours idle daily; therefore, the barge uses fuel for 18 hours a day, or an average of 6 hours each shift.

## Dredging Division - THOR Drilling and Blasting Barge

General Overhead Expenses of the Dredging Division **12%**

| | FY 1995 | FY 1996 | FY 1997 | FY 1998 | Annual Estimate | |
|---|---|---|---|---|---|---|
| Supplies/Materials (excluding fuel) | $ 276,104 | * | $ 158,000 | $ 936,000 | $ 456,701 | |
| Other Direct Expenses | $ 7,119 | * | | | $ 7,200 | |
| General Maintenance | $ 103,643 | $ 189,896 | $ 321,000 | $ 416,000 | $ 257,635 | |
| Overhaul Expenses | $ - | $ - | | | $ 320,000 | |
| Maritime Insurance | | | | | $ 16,648 | |
| Depreciationn (THOR is fully depreciated) | $ - | $ - | $ 19,861 | $ 20,375 | $ 20,118 | |
| Indirect Maintenance CC 556 | | $ 73,080 | | | $ 73,080 | 1/ |
| Total Expenses | $ 386,866 | $ 189,896 | | | $ 1,151,383 | |

| | | |
|---|---|---|
| Total Annual Expenses | | $ 1,151,383 |
| Availability (in days) | ÷ | 300 |
| Daily Cost for Availability without crew (demand) | | $ 3,838 |
| **Hourly Cost for Availability without crew (demand)** | | **$ 160** |

| | | Inter-Divisional | | Capital (with division overhead) | Com-mercial (c/RGG) |
|---|---|---|---|---|---|
| Hourly Cost for Availability | | $ 160 | | $ 160 | $ 217 |
| Hourly Cost of on-call crew | + | $ 86 | | $ 96 | $ 130 |
| **Total Hourly Cost for Availability** | | **$ 245** | | **$ 256** | **$ 348** |
| Hourly Cost for Availability | | $ 160 | | $ 160 | $ 217 |
| Hourly Cost of Operations Crew 2 shifts/5 days | | $ 449 | | $ 503 | $ 684 |
| Hourly Cost of Operations Crew 3 shifts/5 days | | $ 543 | | $ 608 | $ 827 |
| Hourly Cost of Operations Crew 3 shifts/7 days | | $ 517 | | $ 579 | $ 787 |
| Hourly Cost of Fuel | + | $ 53 | 2/ | $ 53 | $ 72 |
| **Hourly Cost of Operations Crew 2 shifts/5 days (without support equipment)** | | **$ 661** | | **$ 715** | **$ 973** |
| **Hourly Cost of Operations Crew 3shifts/5 days (without support equipment)** | | **$ 756** | | **$ 821** | **$ 1,117** |
| **Hourly Cost of Operations Crew 3 shifts/7 days (without support equipment)** | | **$ 730** | | **$ 792** | **$ 1,077** |
| Small Tugboat Support | | $ 106 | | $ 112 | $ 152 |
| Guard or Passenger Boat Support | | $ 94 | | $ 99 | $ 135 |
| **Hourly Cost of Operations Crew 2 shifts/5 days (with support equipment)** | | **$ 861** | | **$ 927** | **$ 1,260** |
| **Hourly Cost of Operations Crew 3 shifts/5 days (with support equipment)** | | **$ 956** | | **$ 1,033** | **$ 1,404** |
| **Hourly Cost of Operations Crew 3 shifts/7 days (with support equipment)** | | **$ 930** | | **$ 1,003** | **$ 1,364** |

**Mobilization Rate**

| | | Inter-Divisional | Capital (with division overhead) | Com-mercial (c/RGG) |
|---|---|---|---|---|
| Hourly Cost of Pilot (required to move dredge) | | $ 45 | $ 51 | $ 69 |
| Cost of a large tugboat to move dredge | | $ 341 | $ 365 | $ 496 |
| Hour Cost for Availability | | $ 160 | $ 160 | $ 217 |
| Hourly Cost of Operations Crew | + | $ 449 | $ 503 | $ 684 |
| **Total Hourly Rate for Mobilization** | | **$ 995** | **$ 1,078** | **$ 1,466** |

1/ Distribution of support for "other 554" is based on the allocation of 58% of the costs at the cost center. This percentage was determined based on the effort of556 for the 554, according to the JCS report.

2/ Average Usage of 48 gallons/hour, $1.10/gallon

**Appendix 15 C**
Updated on July 15, 2002

# "THOR" DRILLING AND BLASTING BARGE

| | |
|---|---|
| Employee Benefits | 38% |
| Night Shift Differential | 10% |
| Complementary Sunday | 25% |
| Overtime | 50% |

**DAYTIME CREW**

| **On-deck Department:** | **Grade** | **No.** | **Hourly Rate** | **Total Hourly Rate** |
|---|---|---|---|---|
| **On-deck Department:** | | | | |
| Captain in Charge | FE-16 | 1 | $ 32.02 | $ 32.02 |
| **Engine Department** | | | | |
| Chief Engineer in Charge | ME-15 | 1 | 29.99 | 29.99 |
| **Land-based Support Crew** | | | | |
| Explosives Operator | MG-06 | 6 | 6.52 | 39.12 |
| **TOTAL DAYTIME CREW** | | **8** | | **$ 101.13** |
| **ROTATION CREW** | | | | |
| **On-deck Department** | | | | |
| Officer | FE-14 | 1 | $ 28.15 | $ 28.15 |
| Blasting Technician | FE-09 | 1 | 22.98 | 22.98 |
| **Engine Department** | | | | |
| Dredge Engineer | ME-14 | 1 | 28.15 | 28.15 |
| Drilling Equipment Operator | MG-10 | 4 | 17.56 | 70.24 |
| Drilling Equipment Operator | MG-08 | 9 | 8.25 | 74.25 |
| Oiler | MG-08 | 2 | 8.25 | 16.5 |
| Explosives Operator | MG-06 | 1 | 6.52 | 6.52 |
| **TOTAL ROTATION CREW** | | **19** | | **$ 246.79** |
| **2shifts/5days with no overtime** | | | | |
| Monday to Thursday | | | | $ 427.38 |
| Sunday | | | | 534.22 |
| **Average Rate - 2shifts/5days** | | | | **$ 448.75** |
| **3shifts/5days with overtime** | | | | |
| Monday to Thursday | | | | $ 517.37 |
| Sunday | | | | 646.71 |
| **Average Rate - 3shifts/5days** | | | | **$ 543.23** |
| **3shifts/7days with overtime** | | | | |
| Monday to Thursday | | | | $ 517.37 |
| Saturday | | | | $ 458.63 |
| Sunday | | | | $ 573.29 |
| **Average Rate - 3shifts/7days** | | | | **$ 516.97** |

Note: Seven hours of overtime was estimated for each person, weekly

Updated on Aug. 30, 2002

# PERFORATING AND DRILLING BARGE - COST OF EXPLOSIVES

**Drilling Pattern 100' x 50', burden 10' x spacing 12.5'**
**Number of drills for pattern 48 - Depth of drill 11' (37' PLD - 26' PLD)**
**Effective Area 100' x 60'**

| | Amount | Total number of detonators | Total number of rolls | $ / lb | $/roll | $/ms | $ |
|---|---|---|---|---|---|---|---|
| **Volume of required drilling ($m^3$)** | 15,000,508 | | | | | | |
| **Total area of required blasting ($m^2$)** | 4,474,243 | | | | | | |
| **Effective area of blasting (100' x 60') ($m^2$)** | 557 | | | | | | |
| **Required number of patterns** | 8,028 | | | | | | |
| **Number of drills per pattern** | 48 | | | | | | |
| **Total number of drills required** | 385,320 | | | | | | |
| **Depth of a drill (m)** | 3.35 | | | | | | |
| **Depth of the lake (m)** | 16.76 | | | | | | |
| **Explosive Power Factor Required** | 1.98 | | | 0.87 | | | $ 25,839,876 |
| **Total amount of explosives** | 29,701,006 | | | | | | |
| **Prime chord** | | | | | | | |
| Required amount of chord (m) | 9,219,034 | | | | | | |
| One roll (m) | 305 | | 30,248 | | 97.74 | | 2,956,375 |
| **Detonator** | | | | | | | |
| 17 ms (# / pattern | 6 | 48,165 | | | | 2.53 | 121,858 |
| 25 ms (# / 100 lbs of explosives) | 1 | 297,010 | | | | 2.53 | 751,435 |
| "NLIL" (# roll/pattern) | 1 | | 8,028 | | 25.63 | | 205,776 |
| **TOTAL** | | | | | | | **$ 29,875,319** |
| **COST/UNIT $/cubic meter** | | | | | | | **1.99** |

Appendix 15 D

# APPENDIX No. 16

## Pacific Entrance Disposal Sites

**PACIFIC ENTRANCE TERRESTRIAL DISPOSAL SITES**
**Heights according to the topography at 10/17/2000**

| DESCRIPTION | HEIGHT (FT.) | AREA (ACRES) | AREA (HECT.) | REMAINING CAPACITY (C/Y) | REMAINING CAPACITY ($m^3$) | PREVIOUS DISCHARGE | PREVIOUS DISCHARGED VOLUME (C/Y) | RECOMMENDED MAINTENANCE FREQUENCY IN YEARS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| FARFAN (Pacific West Side) | * 8 | 310 | 125 | 4,000,000 | 3,058,104 | 1985 | 500,000 | 5 TO 10 | One concrete spillway. The surface of the access road is crushed rock. An additional area of 254 acres will be added to this spoil area. The additional capacity will be approximately 3,275,000 cubic yards. |
| VELASQUEZ (Pacific West Side) | * 7 | 207 | 84 | 2,300,000 | 1,758,410 | 1992 | 3,500,000 | 5 TO 10 | The surface of the access road is coarse base. Two steel spillways. The last reconstruction of the site was in 1997. No future increase in the height of the dikes is anticipaded. |
| VICTORIA (Pacific West Side) | * 8 | 51.26 | 21 | 661,500 | 505,734 | 1993 | 500,000 | 5 TO 10 | One steel spillway The surface of the access road is crushed rock. Filled to approximately one-third of total capacity. For maintenance dredging use. |
| CAMP ROUSSEAU (Pacific West Side) | * 8 assumed | 62 | 25 | 800,000 assumed | 611,621 | to be built | to be built | to be built | Dikes, drainage system, and spillway to be built. |

Appendix No. 16 A

* Heights do not include a minimum of two foot freeboard clearance from top of dikes. However the effective volume does contemplate the two foot freeboard.

# CONSTRUCTION OF A NEW DIKE AND REMOVAL OF AN EXISTING PORTION FOR DISPOSAL SITE FARFAN

| | METERS | SQUARE METERS | HECTARES | CUBIC METERS | CUBIC YARDS | COST $/M³ | TOTAL COST |
|---|---|---|---|---|---|---|---|
| LENGTH THAT MUST BE REMOVED FROM EXISTING DIKE | 2,050.00 | | | | | | |
| LENGTH OF DIKE TO BE BUILT IN NEW AREA | 1,700.00 | | | | | | |
| AVERAGE AREA OF THE SECTION OF THE NEW DIKE | | 49.00 | | | | | |
| ADDITIONAL AREA RESULTING FROM NEW AREA | | | 51.00 | | | | |
| VOLUME OF MATERIAL THAT MUST BE REMOVED TO JOIN EXISTING AREA TO NEW AREA | | | | 100,450.00 | 131,589.50 | | |
| VOLUME OF MATERIAL THAT MUST BE REMOVED AND DISPOSED OF FROM AREA IS APPROXIMATELY 40% | | | | 40,180.00 | 52,635.80 | 3.00 | $ 120,540.00 |
| VOLUME OF MATERIAL THAT MUST BE REMOVED BUT MAY BE USED IN THE NEW DIKE IS APPROXIMATELY 60% | | | | 60,270.00 | 78,953.70 | 2.50 | $ 150,675.00 |
| VOLUME OF MATERIAL NEEDED AS FILL FOR THE CONSTRUCTION OF THE NEW DIKE | | | | 83,300.00 | 109,123.00 | | |
| VOLUME OF MATERIAL THAT MUST BE BROUGHT FROM OUTSIDE THE FARFAN AREA | | | | 23,030.00 | 30,169.30 | 5.50 | $ 126,665.00 |
| VOLUME OF MATERIAL REQUIRED FOR THE NEW DIKE, AND WHICH WILL BE TAKEN FROM THE EXISTING DIKE THAT WILL BE REMOVED TO JOIN THE NEW AREA TO THE EXISTING AREA | | | | 60,270.00 | 78,953.70 | | |
| AREA REQUIRING GEOTEXTILE--THE MATERIAL TO BE USED FOR REINFORCING THE FOUNDATIONS OF THE DIKE | | 39,270.00 | | | | 1.80/M^2 | $ 70,686.00 |
| ADDITIONAL CAPACITY AFTER INCLUDING THE NEW AREA | | | | 2,140,450.00 | 2,803,989.50 | | |

| | | | |
|---|---|---|---|
| TOTAL COST OF THE NEW DIKE AND REMOVAL OF AN EXISTING PORTION--COST OF CONTRACT | $ 468,566.00 | BUDGETED COST | **$613,821.46** |
| COST OF EACH CUBIC METER OF ADDITIONAL CAPACITY AFTER CONSTRUCTION OF THE NEW DIKE | $ 0.22 | | $ 0.29 |
| COST OF EACH CUBIC YARD OF ADDITIONAL CAPACITY AFTER CONSTRUCTION OF THE NEW DIKE | $ 0.17 | | $ 0.22 |

Appendix No. 16 B

INCREMENTO DE LA ALTURA DEL DIQUE EN 1.5 METROS EN EL AREA EXISTENTE Y EN LA AMPLIACION

## RAISING HEIGHT OF DISPOSAL SITE FARFAN EXISTING DIKE AND DIKE EXPANSION BY 1.5 METERS

| | METERS | SQUARE METERS | HECTARES | CUBIC METERS | CUBIC YARDS | COST $/M³ | TOTAL COST |
|---|---|---|---|---|---|---|---|
| TOTAL PERIMETER OF EXISTING AREA = | 7,500.00 | | | | | | |
| LENGTH OF DIKE THAT DOES NOT HAVE TO BE RAISED | 1,000.00 | | | | | | |
| LENGTH OF ADDITIONAL DIKE - EXPANSION | 1,700.00 | | | | | | |
| LENGTH OF DIKE TO BE REMOVED | 2,050.00 | | | | | | |
| **PERIMETER THAT MUST BE RAISED** | **6,150.00** | | | | | | |
| | | | | | | | |
| AVERAGE AREA OF THE NEW DIKE SECTION | | 26.00 | | | | | |
| ADDITIONAL AREA RESULTING FROM THE FARFAN EXPANSION | | | 51.00 | | | | |
| AREA WITHIN EXISTING DIKE IN THE FARFAN AREA | | | 125.00 | | | | |
| LOST AREA RESULTING FROM NEW DIKE | | | 8.50 | | | | |
| **AVAILABLE AREA AFTER RAISING THE DIKE** | | | **167.50** | | | | |
| | | | | | | | |
| **VOLUME OF FILL MATERIAL TO RAISE DIKE** | | | | **159,900.00** | **209,469.00** | 5.5 | $ 879,450.00 |
| | | | | | | | |
| **AREA REQUIRING GEOTEXTILE TO REINFORCE THE BASE OF THE DIKE** | | **47,355.00** | | | | 1.80/M^2 | $ 85,239.00 |
| | | | | | | | |
| **ADDITIONAL CAPACITY OF FARFAN AREA AFTER RAISING DIKE** | | | | **2,206,500.00** | **2,890,515.00** | | |

| | | |
|---|---|---|
| TOTAL COST OF RAISING EXISTING DIKE - CONTRACT COST | | $ 964,689.00 |
| COST OF EACH CUBIC METER OF ADDITIONAL CAPACITY AFTER CONSTRUCTION OF THE NEW DIKE | | $ 0.44 |
| COST OF EACH CUBIC YARD OF ADDITIONAL CAPACITY AFTER CONSTRUCTION OF THE NEW DIKE | | $ 0.33 |

| | |
|---|---|
| BUDGETED COST | **$ 1,263,742.59** |

**Appendix No. 16 C**

## NEW DISPOSAL SITE ROSSEAU, WEST TO EXISTING DISPOSAL SITE VICTORIA

## SCENARIO: JOINING PROPOSED DISPOSAL SITE ROSSEAU WITH DISPOSAL SITE VICTORIA

## CONSTRUCTION OF A NEW DIKE AND REMOVAL OF AN EXISTING PORTION OF DISPOSAL SITE VICTORIA

| | METERS | SQUARE METERS | HECTARES | CUBIC METERS | CUBIC YARDS | COST $/M³ | TOTAL COST |
|---|---|---|---|---|---|---|---|
| LENGTH THAT MUST BE REMOVED FROM EXISTING DIKE | 500.00 | | | | | | |
| **LENGTH OF DIKE TO BE BUILT IN NEW AREA** | **1,500.00** | | | | | | |
| | | | | | | | |
| AVERAGE AREA OF THE SECTION OF THE NEW DIKE | | 126.00 | | | | | |
| **ADDITIONAL AREA RESULTING FROM NEW AREA** | | | **20.00** | | | | |
| **VOLUME OF MATERIAL THAT MUST BE REMOVED TO JOIN EXISTING AREA TO NEW AREA** | | | | **45,000.00** | **58,950.00** | 2.5 | $ 112,500.00 |
| | | | | | | | |
| **VOLUME OF MATERIAL REQUIRED FOR FILLING TO BUILD THE NEW DIKE** | | | | **189,000.00** | **247,590.00** | 2.5 | $ 472,500.00 |
| | | | | | | | |
| **VOLUME OF MATERIAL REQUIRED TO BE REMOVED FOR WATER DEVIATION** | | | | **25,000.00** | **32,750.00** | 2.75 | $ 68,750.00 |
| **AREA REQUIRING GEOTEXTILE--THE MATERIAL TO BE USED FOR REINFORCING THE FOUNDATIONS OF THE DIKE** | | **52,800.00** | | | | 1.80/M^2 | $ 95,040.00 |
| | | | | | | | |
| **DISPOSAL SITE APPROXIMATE CAPACITY** | | | | **1,200,000.00** | **1,572,000.00** | | |

| | | BUDGETED COST |
|---|---|---|
| TOTAL COST OF THE NEW DIKE AND REMOVAL OF AN EXISTING PORTION--COST OF CONTRACT | $ 748,790.00 | **$ 980,914.90** |
| COST OF EACH CUBIC METER OF ADDITIONAL CAPACITY AFTER CONSTRUCTION OF THE NEW DIKE | $ 0.62 | $ 0.82 |
| COST OF EACH CUBIC YARD OF ADDITIONAL CAPACITY AFTER CONSTRUCTION OF THE NEW DIKE | $ 0.48 | $ 0.62 |

NOTE:
THE CONSTRUCTION OF A SPILLWAY IS ABOUT $40,000

**Appendix No. 16 D**

## CONSTRUCTION OF NEW DISPOSAL SITE DIKE ROSSEAU WITHOUT JOINING DISPOSAL SITE VICTORIA

| | METROS | METROS CUADRADOS | HECTAREAS | METROS CUBICOS | YARDAS CUBICAS | COSTO M³ | COSTO TOTAL |
|---|---|---|---|---|---|---|---|
| LENGTH THAT MUST BE REMOVED FROM EXISTING DIKE | 0.00 | | | | | | |
| **LENGTH OF DIKE TO BE BUILT IN NEW AREA** | **2,000.00** | | | | | | |
| AVERAGE AREA OF THE SECTION OF THE NEW DIKE | | 126.00 | | | | | |
| **ADDITIONAL AREA RESULTING FROM NEW AREA** | | | **17.00** | | | | |
| **VOLUME OF MATERIAL THAT MUST BE REMOVED TO JOIN EXISTING AREA TO NEW AREA** | | | | **0.00** | **0.00** | 2.5 | $ - |
| **VOLUME OF MATERIAL REQUIRED FOR FILLING TO BUILD THE NEW DIKE** | | | | **252,000.00** | **330,120.00** | 2.5 | $ 630,000.00 |
| **VOLUME OF MATERIAL REQUIRED TO BE REMOVED FOR WATER DEVIATION** | | | | **0.00** | **0.00** | 2.5 | $ - |
| **AREA REQUIRING GEOTEXTILE--THE MATERIAL TO BE USED FOR REINFORCING THE FOUNDATIONS OF THE DIKE** | | **70,400.00** | | | | 1.80/M^2 | $ 126,720.00 |
| **DISPOSAL SITE APPROXIMATE CAPACITY** | | | | **1,020,000.00** | **1,336,200.00** | | |

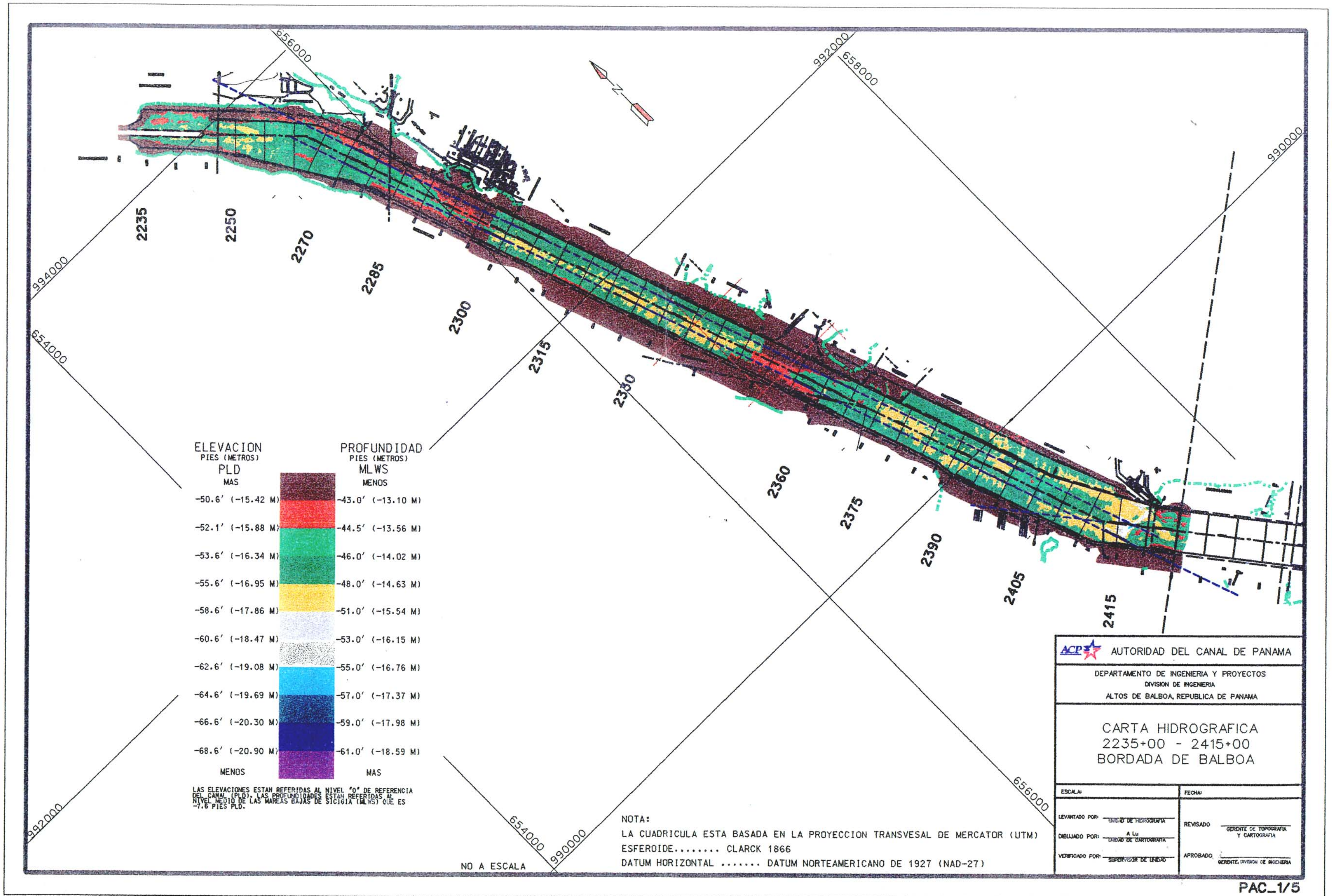
| | | BUDGETED COST |
|---|---|---|
| TOTAL COST OF THE NEW DIKE AND REMOVAL OF AN EXISTING PORTION--COST OF CONTRACT | $ 756,720.00 | **$ 991,303.20** |
| COST OF EACH CUBIC METER OF ADDITIONAL CAPACITY AFTER CONSTRUCTION OF THE NEW DIKE | $ 0.74 | $ 0.97 |
| COST OF EACH CUBIC YARD OF ADDITIONAL CAPACITY AFTER CONSTRUCTION OF THE NEW DIKE | $ 0.57 | $ 0.74 |

NOTE:
THE CONSTRUCTION OF A SPILLWAY IS ABOUT $50,000, WHICH INCLUDES MATERIALS AND INSTALLATION.

**Appendix No. 16 E**

# APPENDIX No. 17

## Pacific Entrance Navigation Channel Bathymetry

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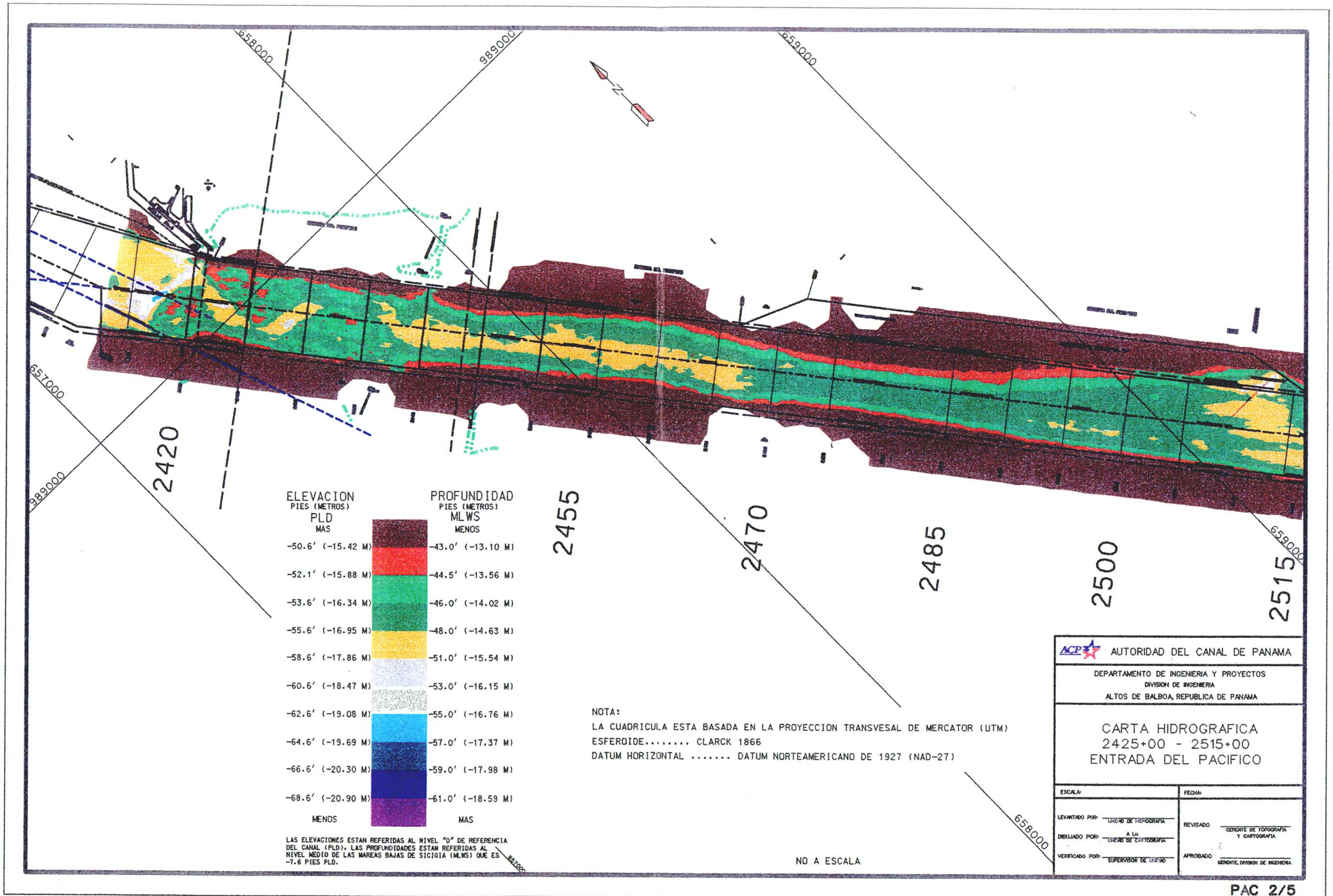


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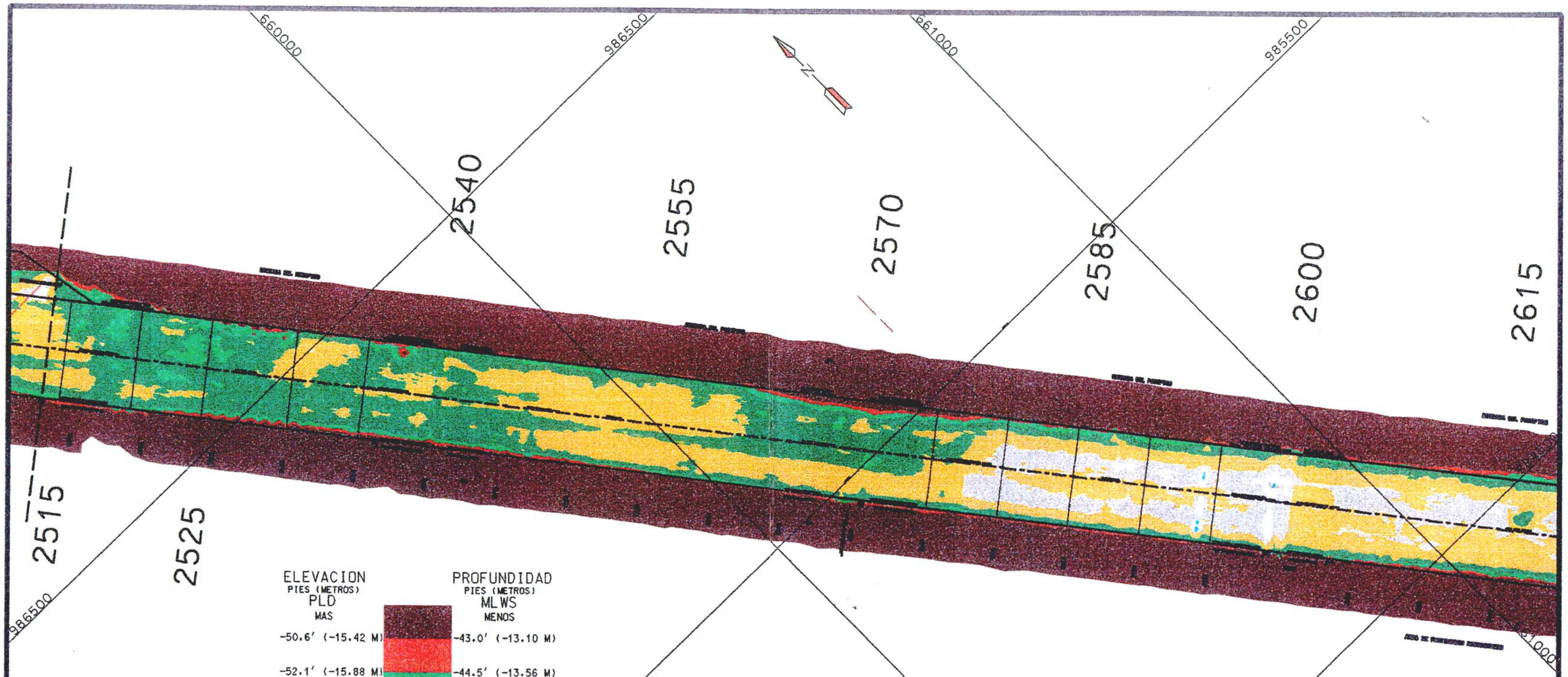



ELEVACION
PIES (METROS)
PLD
MAS

PROFUNDIDAD
PIES (METROS)
MLWS
MENOS

| ELEVACION PLD | PROFUNDIDAD MLWS |
|---|---|
| -50.6' (-15.42 M) | -43.0' (-13.10 M) |
| -52.1' (-15.88 M) | -44.5' (-13.56 M) |
| -53.6' (-16.34 M) | -46.0' (-14.02 M) |
| -55.6' (-16.95 M) | -48.0' (-14.63 M) |
| -58.6' (-17.86 M) | -51.0' (-15.54 M) |
| -60.6' (-18.47 M) | -53.0' (-16.15 M) |
| -62.6' (-19.08 M) | -55.0' (-16.76 M) |
| -64.6' (-19.69 M) | -57.0' (-17.37 M) |
| -66.6' (-20.30 M) | -59.0' (-17.98 M) |
| -68.6' (-20.90 M) | -61.0' (-18.59 M) |
| MENOS | MAS |

LAS ELEVACIONES ESTAN REFERIDAS AL NIVEL "0" DE REFERENCIA DEL CANAL (PLD). LAS PROFUNDIDADES ESTAN REFERIDAS AL NIVEL MEDIO DE LAS MAREAS BAJAS DE SICIGIA (MLWS) QUE ES -7.6 PIES PLD.

NO A ESCALA

NOTA:
LA CUADRICULA ESTA BASADA EN LA PROYECCION TRANSVESAL DE MERCATOR (UTM)
ESFEROIDE........ CLARCK 1866
DATUM HORIZONTAL ....... DATUM NORTEAMERICANO DE 1927 (NAD-27)

ACP AUTORIDAD DEL CANAL DE PANAMA

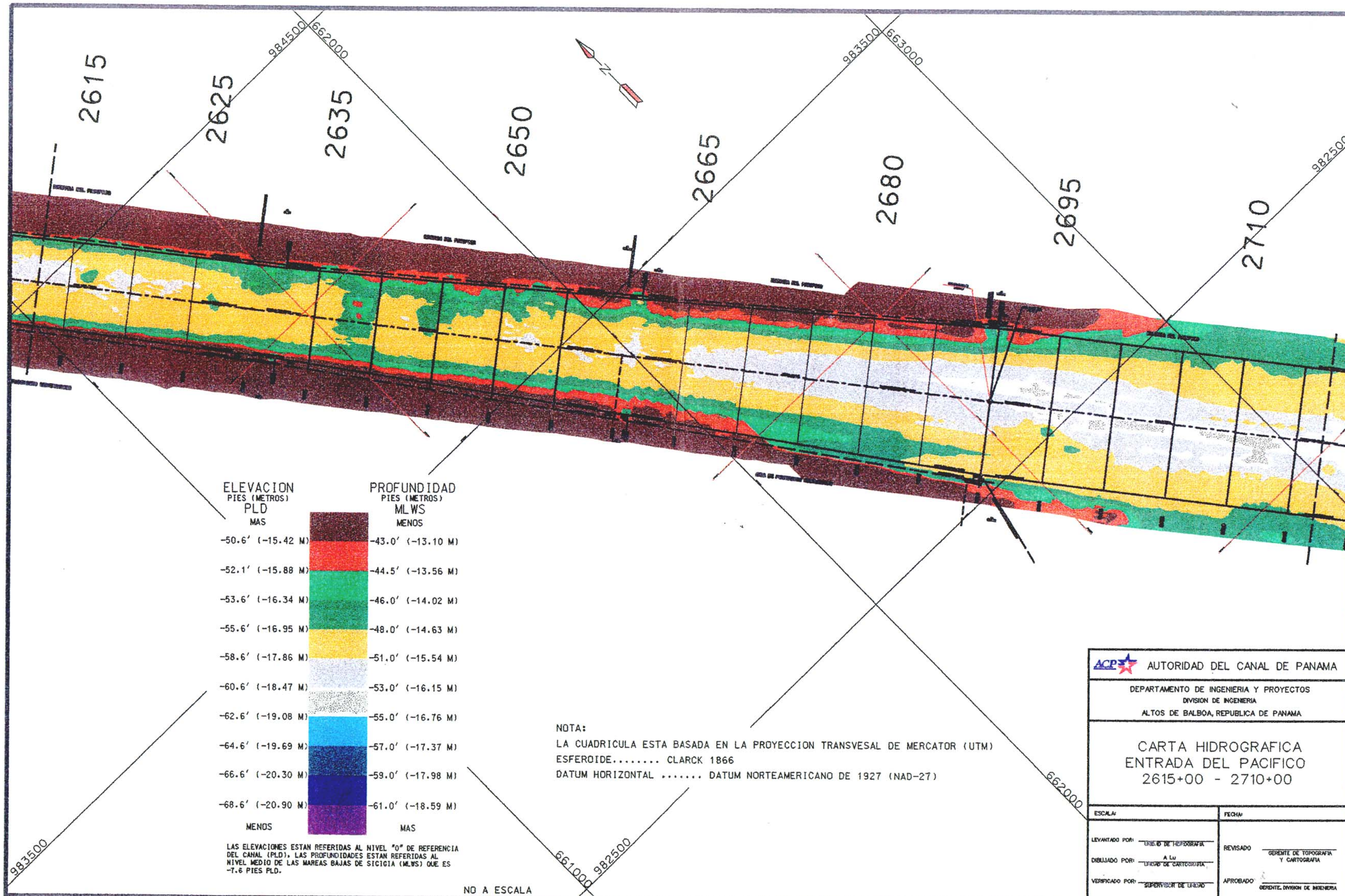
DEPARTAMENTO DE INGENIERIA Y PROYECTOS
DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

# CARTA HIDROGRAFICA
# ENTRADA DEL PACIFICO
# 2515+00 - 2615+00

ESCALA:
FECHA:

LEVANTADO POR: UNIDAD DE HIDROGRAFIA
DIBUJADO POR: A Lu / UNIDAD DE CARTOGRAFIA
VERIFICADO POR: SUPERVISOR DE UNIDAD
REVISADO: GERENTE DE TOPOGRAFIA Y CARTOGRAFIA
APROBADO: GERENTE, DIVISION DE INGENIERIA

PAC 3/5

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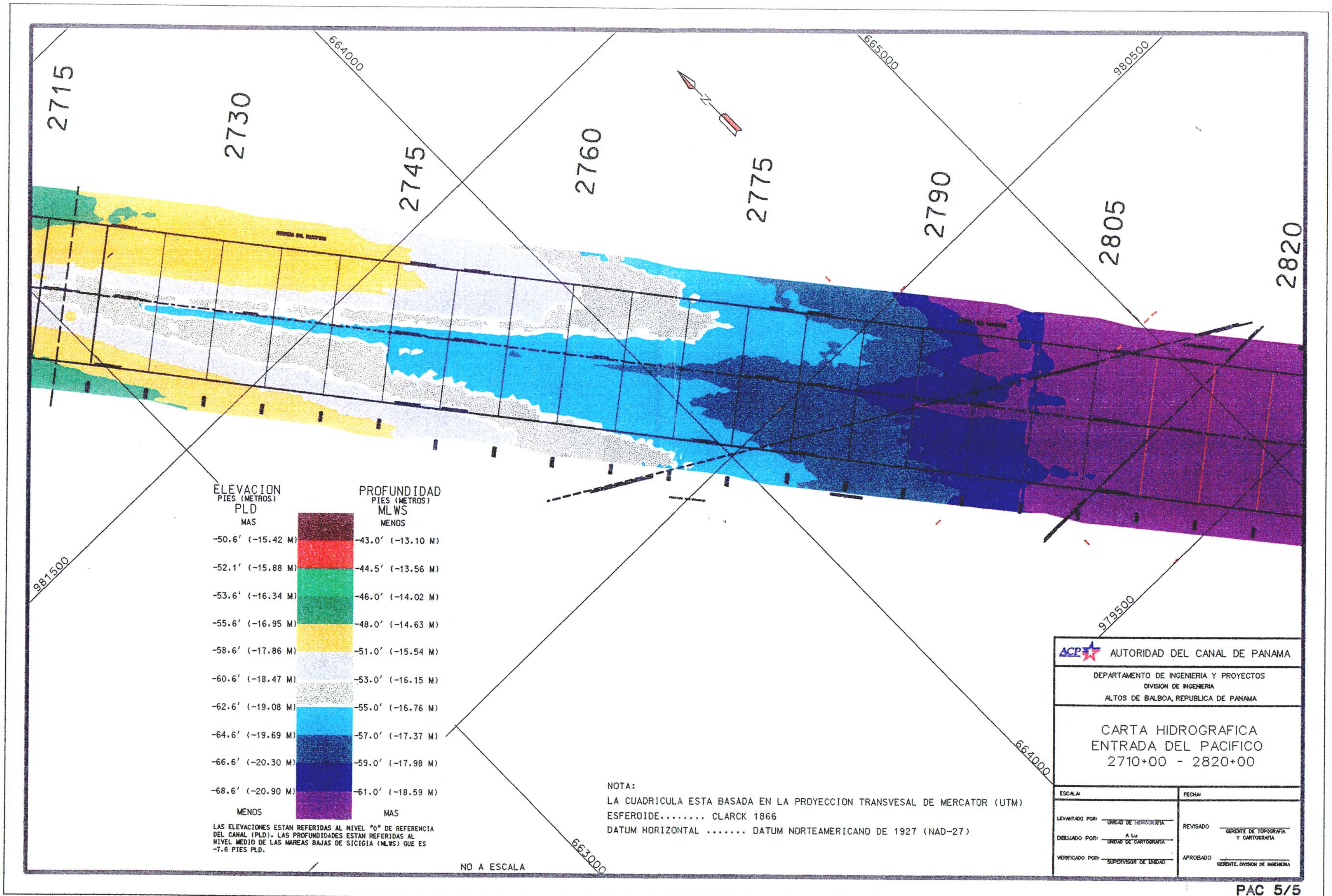


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# APPENDIX No. 18

## Geologic information

AUTORIDAD DEL CANAL DE PANAMA
**Engineering Division – Geotechnical Branch**

## PANAMA FORMATION

This formation consists primarily of agglomerates and tuffs, which extend from the Miraflores Lake to the Panama City and to the northeast through the continental divide and to the east in the area of the Pacific coast.

The Panama formation also includes tuffaceous sandstones, tuffaceous siltstones, lenses of stream deposits and lenses of marine limestones.

The agglomerate consists of sub-angular to sub-rounded blocks of andesite, highly disseminated in a fine-grained tuffaceous matrix.

The stream deposits are made of tuffaceous sandstone, which exhibit crude bedding, they contain rounded to sub-rounded and sub-angular boulders, cobbles and pebbles.

The age assigned to this formation is from lower to upper Oligocene.

The hardness of the formation varies between RH-1 and RH-3, soft to medium hard rock.

*Adapted from*
*Stewart and Stewart*
*By Pastora Franceschi S.*
*1986*

## PACIFIC MUCK

### Introduction:

This province extends from the vicinity of the Miraflores Locks south to Panama Bay. Muck deposits formed at low elevations by a process similar to that described in the Atlantic Muck; are found extensively along the coast and the lower reaches of all larger streams flowing into the Pacific. Similar deposits also occur beneath the waters of Panama Bay. These deposits are known as Pacific Muck. Its physical properties are also similar to the properties of the Atlantic Muck.

### Pruebas de Laboratorio:

Laboratory tests performed at the ACP Soils Lab on material from core boring DMR-1, located in the area of the old Rio Grande, to the south of the Miraflores locks, between Diablo and Corozal.

1. Granulometry: according to UCS the material is CH, fat clay with sand.
2. LL = 113
3. IP = 74
4. Gs = 2.75
5. e = 2.5
6. $\gamma$sat = 1484 kg/m$^3$
7. 7 $\gamma$dry = 777 kg/m
8. Consistency: OC-1 to OC-3, very soft to medium high consistency.

*Adapted from*
*1947 – Isthmian Canal Studies*
*by Pastora Franceschi S.*
*26/Ju;y/2000*

## BASALT:

Occurs in the Canal area as a very hard - RH-5, dense, tough, often columnar-jointed, dark gray, fine to very fine-grained mass, deposited as flows or pillow lavas, and some times it is porphyritic, representing sub-intrusive and intrusive masses, such as dikes, sills, plugs or laccolithic bodies, from which the overlying sediments have been eroded.

Basalt from Sosa Hill occurs as flow and probably as pillow lava deposited on top of softer formations.

Porphyritic, sub-intrusive masses of basalt occur at the West Bank, south of the Pedro Miguel Locks; this material has been observed in holes drilled along the alignments in the Pacific for the proposed third set of locks. This material has been kept in stockpiles at Çocoli and at both sides of the entrance to Borinquen road.

## MIRAFLORES BASALT:

This body consists of a thick mass of fresh, dense, very hard – RH-5, and dark-gray to blue-black igneous rock, which has been intruded into the moderately dipping La Boca sedimentary beds of the area. It represents either a laccolith or a large sill. In general the rock is posed in the excavation for the New Miraflores Locks and is the rock of which Cocoli and Aguadulce Hills are composed. This material is found at drill holes in the Balboa Port.

## ANCON HILL DACITE:

Ancon Hill is a thick, steeply dipping Rhyolite dike or oblate plug of north-south axial trend. Extensions of the Rhyolite mass to the south of Ancon Hill are represented by Chorrillo Hill, Culebra Island and Naos Island. The rock of the hill is a dense, porphyritic, heavily jointed, very hard – RH-5, of light-gray color. This material has been found in holes drilled at Balboa Port.

*Adapted from*
*1947 – Isthmian Canal Studies*
*By Pastora Franceschi S.*
*1987*

## ENGIN[illegible]NG PROPERTIES—CANAL ZONE ROCK UNITS

| FORMATION | DESCRIPTION | GEOLOGICAL CLASSIFICATION OF RELATIVE HARDNESS, Average | RANGE IN UNIT HARDNESS | UNIT WEIGHT, pounds per cu. ft. | SHEAR STRENGTH ∅, degrees | SHEAR STRENGTH c, pounds per sq. in. | COMPRESSIVE STRENGTH,* pounds per sq. in. | ASSIGNED ALLOWABLE BEARING CAPACITY, tons per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| OVERBURDEN** | Silts, sands, clays, gravels, etc. | Soft to very hard overburden | OH-1 to OH-5 | Variable | Variable | | Variable | Variable |
| ATLANTIC MUCK | Poorly consolidated clays and silts | Soft to medium soft overburden | OH-1 to OH-2 | *90± | *17 | *0 | 0.3-18.1 | Very low |
| PACIFIC MUCK | Poorly consolidated clays and silts | Soft to medium soft overburden | OH-1 to OH-2 | 90± | 17 | 0 | | Very low |
| CUCARACHA | Largely dense greenish-gray clay shales highly slickensided within certain horizons. Black carbonaceous shales, sandstones, and conglomerates in subordinate proportions | Soft rock | RH-1 to RH-3 | *135± | *10 | *16 | 1.3-956 | ***6-15 |
| CULEBRA | Medium-hard sandstones, soft sandy and carbonaceous shales | Soft rock | RH-1 to RH-3 | *135± | *11 | *168 | 69-4020 | 15 |
| LA BOCA | Dense silty or sandy dark gray shales with intercalated sandstone beds sporadically present | Soft rock | RH-1 to RH-3 | *140± | | | 75-3940 | 15 |
| PANAMA TUFF | Coarse- to fine-grained acid tuffs, sandstones, and soft clay shales | Soft rock | RH-1 to RH-3 | 140± | Medium high strength | | | 15 |
| LAS CASCADAS | Agglomeratic tuff and tuff-breccia consisting of angular fragments of hard dark gray andesite in a clayey dark gray to light green altered tuff matrix | Medium hard rock | RH-2 | 140± | | | 34-5922 | 15+ |
| CAIMITO | Coarsely bedded medium- and fine-grained medium-hard limy sandstones and tuffs | Medium hard rock | RH-2 to RH-3 | *135± | | | 113-8470 | 20 |
| GATUN | Fine-grained argillaceous and calcareous sandstones with interbedded dense tuffs and conglomerates | Medium hard rock | RH-2 | *120± | *17 | *220 | 470-940 | 20 |
| CHAGRES SANDSTONE | Generally fine-grained medium-hard massively and tightly bedded dense gray friable sandstone | Medium hard rock | RH-2 to RH-3 | 120-125 | High strength | | | 20 |
| TORO LIMESTONE | Slightly cemented shell- and coral-fragment limestone with minor intercalated lenses of medium- and coarse-grained sandstone | Medium hard rock | RH-2 | 130± | High strength | | | 20 |
| BOHIO CONGLOMERATE | Subangular to rounded pebbles, cobbles, and boulders up to two feet in diameter in a dark gray or brown, generally coarse, friable tuffaceous sand matrix | Hard rock | RH-3 | *150± | | | 334-2185 | 20+ |
| EMPERADOR LIMESTONE | Algal and coralline reef limestone of local extent and spotty distribution | Hard rock | RH-3 | 170± | Very high strength | | | 30+ |
| PEDRO MIGUEL AGGLOMERATE | Hard light to dark gray fine- to coarse-textured agglomerates and tuffs | Hard rock | RH-3 to RH-4 | *155± | | | 4240-6970 | 50+ |
| BAS OBISPO | Largely hard subangular to angular fragments of andesite and basalt in a sandy hard matrix of the same composition | Hard rock | RH-3 to RH-4 | *155± | | | 2248-4956 | 50+ |
| BASALT | Hard columnar-jointed basalt flows and intrusives | Very hard rock | RH-4 | *165± | | | 2740-26150 | 50+ |
| MISCELLANEOUS RHYOLITE AND ANDESITE | Generally very hard moderately jointed intrusions (dikes, etc.) and flows | Very hard rock | RH-4 | 160-170 | Very high strength | | | 50+ |

* Data determined by laboratory tests. Similar data for other rock units are estimates only, based upon lithologic similarity of the respective formations to those for which test data are available or upon local experience and field investigations.

** Includes weathered rock.

*** Data determined by field bearing test.

### GEOLOGICAL HARDNESS SCALE

#### Overburden and Weathered Rock

| | | |
|---|---|---|
| OH-1 | Soft | Easily squeezed through the fingers. Consistency of fresh putty. (Muck, some clays.) |
| OH-2 | Medium Soft | Cannot be squeezed readily through the fingers, but is easily indented with finger point at moderate pressure. |
| OH-3 | Medium Hard | Nonpenetrable at moderate finger pressure. A pencil point can be readily pushed into sample. |
| OH-4 | Hard | Difficult to take drive sample. Difficult to push pencil point into sample. |
| OH-5 | Very Hard | Material of near-rock character. |

#### Sound Rock

| | | |
|---|---|---|
| RH-1 | Soft | Harder than OH-5 and cannot be crumbled between the fingers but can be easily picked with geology hammer. (Some shales and uncemented sandstones.) |
| RH-2 | Medium Hard | Can be picked with moderate blows of geology hammer. Can be cut with knife. |
| RH-3 | Hard | Cannot be picked with geology hammer but can be chipped with moderate blows of hammer. |
| RH-4 | Very Hard | Chips can be broken off with heavy blows of geology hammer. |