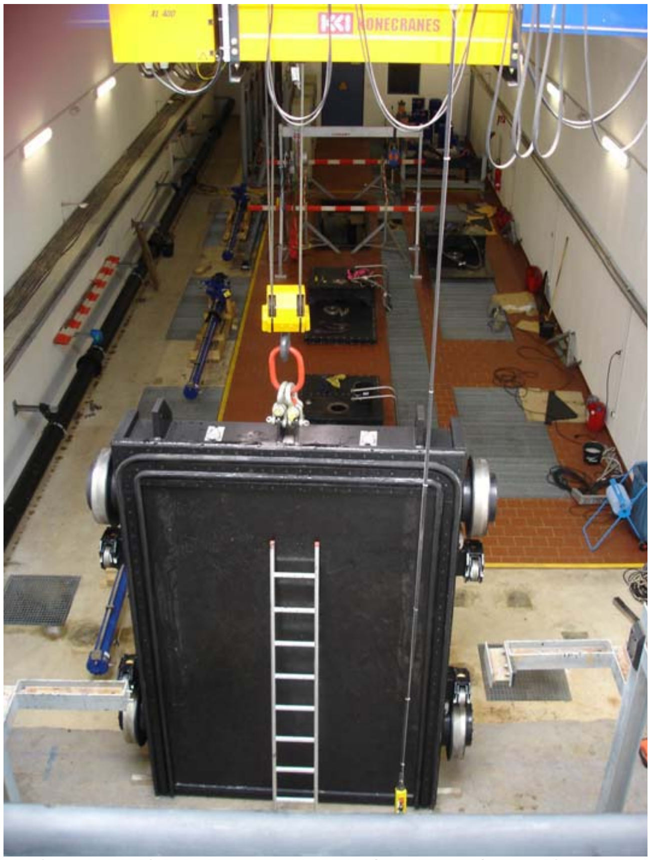

GATES OF WSB OF THE MAGDEBOURG (ROTHENSEE) LOCK SYSTEM

Alternative Conceptual Design of Pacific and Atlantic Post-Panamax Locks – 3x2 WSB - Contract SAA-150551

ATLANTIC LOCKS 3X2 wsb

TASK A4e-3x2 – CULVERT AND WSB CONDUIT GATES

Rev A

in association with

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PREAMBLE

This report is for a triple lift lock (55 m width) at the Atlantic side equipped with 3x2 water saving basins.

There are no major changes compared with the triple lift lock (also 55 m width) equipped with 3x3 water saving basins except the number of WSB conduit gates.

The size of the gates is the following :

- width 4.5 m x height 6 m for culvert gates,
- width 4 m x height 5 m for WSB conduit gates.

The maximum static heads (resulting from the hydraulic study) on the sills are slightly different:

- for the culvert gates : 37.20 m (for triple lift, 3x2 WSB) instead of 37.03 m (for triple lift, 3x3 WSB),
- for the WSB conduit gates : 39.43 (for triple lift, 3x2 WSB) instead of 42.52 m (for triple lift, 3x3 WSB).

Nevertheless the weights of both culvert and WSB conduit gates have been computed for the static heads of the triple lift, 3x2 WSB configuration.

The weights are as follows:

- for one culvert gate :25.5 T (for triple lift, 3x2 WSB). It is still the same as the previous weight of 25.5 T (for triple lift, 3x3 WSB),
- for one WSB conduit gate : 19.9 T (for triple lift, 3x2 WSB) instead of 20.9 T (for triple lift, 3x3 WSB).

The number of culvert gates is the same.
The number of WSB conduit gates is reduced from 36 to 24.

Therefore the total weight for both the culvert and WSB conduit gates (including bulkheads and slots) is reduced from 6,650 T to 5,035 T.

1 SUITABILTY OF DIFFERENT TYPES OF GATES

1.1 GENERAL

Throughout this report, the term “valve” will only be used in case of *butterfly valves* or of *cylindrical valves*. All other valves will be called gates. The culvert valves and conduit valves have then been replaced by *culvert gates* and *conduit gates*. The latter is also referred to as WSB gates (Water Saving Basins gates).

The analysis of the suitability of different types of gates is given in the report R4-E (Conceptual Design of Post Panamax locks – TASK 4 E - CULVERT AND CONDUIT VALVES), dated 15.11.2002.

In this report the different types of gates have been analyzed taking into account reliability, maintenance, manufacturing and construction costs, expected service life, design and construction, sensibility to cavitations and vibration.

In relation with the civil works, the overall size of the gates has also played a major role in determining the most suitable type of operating gate for filling and emptying the lock.

The types of gates/valves that have been examined are:

- Vertical-lift gates including:
    - fixed-wheel gates,
    - sliding gates
- Tainter gates including:
    - conventional tainter gates,
    - reverse tainter gates,
- Stoney gates,
- Butterfly valves,
- Cylindrical valves,
- Grid type gates.

To assess the most suitable type of gates/valves to be used for the Post Panamax locks, a comparative table has been elaborated. It is given in paragraph 1.2. below.

1.2 COMPARATIVE TABLE

The different types of lock gates/valves are listed in the table below. Several criteria are used to evaluate the gate/valve types. These criteria are linked with a weight factor, determined according to their importance.

The gates/valves are appraised on a 1 to 5 scale for each criterion. These scores are multiplied by the weight factor, resulting in a total evaluation for each type of gate/valve.

The fixed wheel gate obtained the best overall evaluation.

	weight factor	Fixed-wheel gate (FW)	Sliding Gate (Sl)	Grid Type Gate (GT)	Tainter Gate (Tt)	Butterfly Valve (Bt)	Cylindrical Valve (Cy)	Stoney Gate (St)
Reliability	0.20	4	4	2	4	4	3	3
Maintenance	0.20	4	4	2	3	3	3	2
Construction cost	0.15	5	4	3	3	3	3	3
Service life	0.15	4	3	2	4	4	3	2
Design and construction	0.15	4	3	2	4	3	3	3
Sensibility to vibration / cavitation	0.15	3	4	3	3	2	3	3
	Total							
Total weight factors	1.00							
Total evaluation (max 5)		4.00	3.7	2.30	3.5	3.20	3.00	2.65
Total evaluation (%)		80	74	46	70	64	60	53

Note: the results of this comparative table remain valid for both flow directions through the gates/valves

1.3 CONCLUSIONS

The conclusions of the report R4E as referenced in §3 were as follows:

"Based on experience with Post Panamax locks and on engineering judgment there are only two types of gates that may realistically be used for the Post Panamax locks of the Panama Canal i.e. fixed wheel gates and sliding gates.

Nowadays vertical-lift gates are preferred for big locks because they are much cheaper to build and do not require the large space that is necessary (for example) for a tainter gate. Moreover, the hydraulic efforts are better distributed to the culvert walls and maintenance is easier.

Within this perspective the choice of fixed wheel gates seems obvious.

Another advantage of course is the actual know-how of ACP and the infrastructure for the maintenance of flat gates in use at the Panama Canal."

Moreover, the vertical lift gates have proven well for designs where sealing in both directions of water flow is required, such as between the lock chambers and the water saving basins.

2 DESCRIPTION AND DIMENSIONING

2.1 GENERAL

The analysis of the suitability of different types of gates has led to the conclusion that the most suitable type of gate is the fixed-wheel type.

For the 55 m lock chamber width (instead of 61 m previously), the dimensions of the lock culverts and water saving basins (WSB) conduits have been determined in the hydraulic study (report P4C).

The culvert dimensions are **9 (width) x 6 (height) m**.

The WSB conduit dimensions are **4 (width) x 5 (height) m**.

Redundancy (two gates for each culvert) has to be foreseen for the culvert gates, therefore the size of the culvert gates shall be **4.5 x 6m. For the WSB conduits, gate dimensions of 4 x 5m are proposed.**

Hence, on the Atlantic side all culverts and WSB conduits are equipped with gates of different size.

The height to width ratio is 1.33 for the culvert gates and 1.25 for the WSB conduit gates, which is quite acceptable.

For the culvert gates, the basic principle adopted for operation reliability is to work with two gates in parallel so that any incident to any gate will not stop the operation of the locks. Furthermore, it also reduces the required gate size.

However the **risk of an asymmetrical operation** of the gates (if one gate fails to open or remains open in an intermediate position) shall have to be assessed (in the preliminary and/or final design). If required, interlocking devices shall have to be foreseen.

Each of the six **water saving basins** is connected to the locks by four conduits. Two are connected on left hand (near to WSB) side of the corresponding lock chamber, two are connected to the right hand (far to WSB) side. **No** additional provision has been made for **redundancy** of the gates. In case of any trouble on a gate, one conduit will be out of order but the three remaining conduits of the concerned basin will be sufficient to operate the locks.

However the consequent **asymmetrical operation of the emptying and/or filling** of the lock chamber (if one gate fails to open or remains open in an intermediate position) shall have to be assessed during further design stages, especially as far as operating times and procedures are concerned.

2.2 LAYOUT OF CULVERTS AND WSB CONDUITS

Each culvert and conduit gate is equipped upstream and downstream with bulkhead gates allowing access to the gate(s) after emptying by pumping (by movable pumps) of the space on both sides.

The basins conduits have been arranged two by two (in total four per WSB). The arrangement, with one conduit located on top of the other as foreseen in the initial conceptual design has been abandoned. It makes the WSB gates arrangement much easier and the operation much more reliable.

2.2.1 CULVERTS AND CULVERT GATES

There are two culverts running along each side of the locks. Their sill is at the sill level of the lock chamber. However, the bottom of the rolling gates chambers prevents the culverts from remaining horizontal. Therefore, the culverts are diverted under the rolling gates and the culvert gates are implemented between the main rolling gates.

As mentioned here above, the culvert dimensions are W x H = 9m x 6m. The culverts are locally divided into two sections of W x H = 4.5m x 6m where the culvert gates are to be installed. At full opening of the gate, the total size and thus the mean water velocity remains unchanged.

The next figure shows a basic layout for a culvert gate with two isolating bulkheads. **There is only one flow direction from the left to the right.**

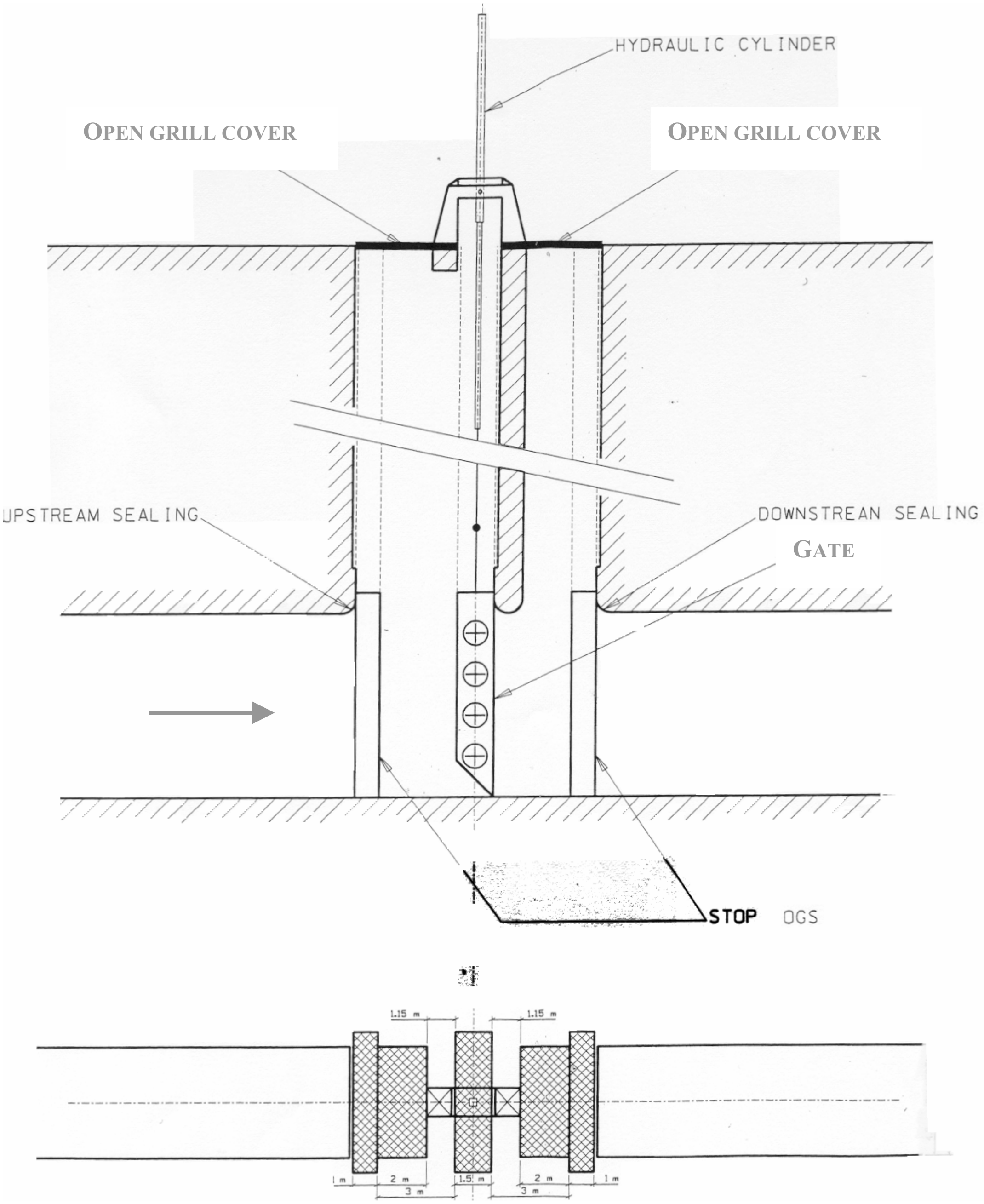


Figure 1 : basic layout for a culvert gate with two isolating bulkheads

For emptying both sides of the culvert gate, the **sealing conditions** are to be as follows:

- the upstream bulkhead has to be tight on its upstream side,
- the downstream bulkhead has to be tight on its downstream side,
- the gate has to be **tight on its downstream side**.

That design has the advantage (regarding civil works) that only one vertical separation wall is required.

2.2.2 WSB CONDUITS AND CONDUIT GATES

The arrangement of the gates and bulkhead gates is shown on the civil works drawing (ref D4-A-403).

The **fixed-wheel gates** are designed with **upstream and downstream sealing.**

Their leaf structures (and therefore the corresponding slots) are dimensioned to support the maximum static pressure on both sides corresponding to following pressure conditions:

- maximum lock chamber level on one side and WSB completely empty on the other side,
- maximum WSB level on one side and lock chamber completely empty on the other side.

The hydraulic cylinders operating the gates have been pre dimensioned for two cases:

- for the normal operation with the locks and basins filled with water,
- for the maximum static head.

The power required for the gate operation in the most critical case, is the one taking into account maximum static head.

The bulkhead gate (WSB side) is of the sliding type in two or three elements and is designed with a double sealing system which allows to:

- empty the WSB while keeping the locks in operation,
- empty the space between the two bulkhead gates to give access to the conduit gate and slots for maintenance.

The bulkhead gate on the lock chamber side is also in two or three pieces and is designed with a sealing system which allows to:

- empty either the lock chamber or the WSB (for the emptying of the WSB it makes a redundancy while keeping the locks in operation),
- empty the space between the two bulkhead gates to give access to the conduit gate and slots for maintenance.

The basic data for designing the gates (dimensions and maximum static head) are the same as those of the bulkhead gates.

The bulkhead elements can be lowered or removed by means of a mobile gantry crane equipped with an automatic lifting beam.

The 24 conduit gates are also the same. They are dimensioned for the maximum head of 39.43m.

2.3 BASIC DATA FOR DESIGN

The values indicated below provide, for the culvert and WSB gates as well as for the bulkhead gates, the maximum static heads of water which have been taken into account for the estimation of the weight of the moving parts.

Maximum head on sill level of culvert gates: 37.20 m
Maximum head on sill level of WSB gates: 39.43 m

The weight of the gates has also been estimated taking into account the operating heads. The values indicated below provide the maximum operating heads of water which have been taken into account.

Maximum head on sill level of culvert gates: 25 m
Maximum head on sill level of WSB gates: 10 m

For each shaft (culvert or WSB conduit), the calculation of the weight of the gate and its related bulkheads has been computed using the same water heads.

2.4 ESTIMATED WEIGHTS

A reliable determination of the moving part of a fixed-wheel gate by a comprehensive study based on preliminary data and admissible stresses is a quite long and difficult exercise. To determine an approximate weight, it is common practice to make a comparison with existing gates, of course, of the same type.

Estimation of the weight is based on the main parameters, i.e.:

- the dimensions (width and height);
- water pressure on the sill.

It can be developed by a formula based on statistical data. The weight of the slot embedded fixed parts has then to be added.

This procedure gives an acceptable approach for conceptual design.

The formula used here (see Water Power and Dam Construction by P.C. Erbiste May 1984) is a function of W, h, and H where:

- W is the span,
- h is the gate height,
- H is the static head on the gate bottom seal.

The weight of the gate leaf is given by the formula (see abacus – annex 1):

Weight of a fixed-wheel gate: = $0.706\,(W^2.h.H)^{0.7}$

Given the static heads are the highest ones (compared to the operating heads), only them have been taken into account for the calculation of the weights.
Span width, height, static head on seal bottom and weight of gate or bulkhead leaf are given in annex 3.

The estimated weight of the culvert gate is 25.5 tons and the estimated weight of the WSB conduit gate is 19.9 tons. The weights of the culvert and WSB conduit gates are very close to each other. At this conceptual stage, it clearly appears that the same design should be used for both gates.

The incurred costs/benefits that will result are the following :

- From the standardization point of view : same drawings, same manufacturing processes, erection procedures, …
- From the operational and maintenance point of view : reduced amount of spare parts, better material knowledge from the maintenance people, …

It is reminded that to check the procedure, a preliminary calculation of a WSB fixed-wheel gate structure has been performed (see Annex 2). The calculation has confirmed the results of the above formula.

Moreover, the weight of **one meter** of embedded fixed parts is estimated to:

- Culvert fixed-wheel gates at the bottom of the slot:	800 kg (last 12m[1])
- Culvert fixed-wheel gates at the upper part of the slot (only for guiding):	200 kg
- Culvert sliding bulkhead at the bottom of the slot:	500 kg (last 9m[2])
- Culvert sliding bulkhead (only for guiding)	200 kg
- WSB fixed-wheel gates at the bottom of the slot:	1,000 kg (last 12m)
- WSB fixed-wheel gates at the upper part of the slot:	200 kg
- WSB sliding bulkhead at the bottom of the slot:	500 kg (last 9m)
- WSB sliding bulkhead (only for guiding)	200 kg

Note: Lintel and sill embedded parts have been added separately. For the gates the weight of said parts is taken as 800 kg/m, for the bulkheads, it has been taken as 500 kg/m.

---

[1] *Two times the height of the gates (2x6=12m)*
[2] *One time first leaf plus two times second leaf (3+2x3=9m)*

2.5 CONSTRUCTION DETAILS

Hydraulic servomotor operated, the fixed wheel gates are equipped with wheels revolving on fixed axles cantilevered from the gate frame (see annex 4 for typical example of a sectional view of one wheel of the Berendrecht culvert gates). Wheels can be of the flat type (rolling on stainless steel tracks) or of the flanged type (rolling on rails). Tracks must withstand the bearing pressures and distribute them to the concrete structure behind. The **number of wheels** will be based on the steel characteristics. It shall **not be less than 6 wheels.**

A typical horizontal sectional view of a gate (or bulkhead) welded structure is shown in Annex 5. Horizontal plate girders or standard T or I-shape beams are the main force resisting members of the gate.

The distance between horizontal girders may vary according to the hydrostatic pressure. Diaphragm plates and intercostals are also used as reinforcement to distribute loads more uniformly.

WSB fixed-wheel gates have to resist to water pressure and **be tight in both directions** as for the locks submitted to tidal effects.

The access shaft for maintenance will be used as **surge chambers** during operation of the gates.

Tolerances must be adequate to ensure watertight seals. That is the reason why it is recommended to use very rigid U-shape steel guiding for the gates to avoid any movement during embedding of the fixed parts.

The gate and wheels are permanently under water. Maintenance of these wheels and bearings is possible by lifting the moving parts out of water. Wear of these elements can be considerably reduced by using **self lubricating** material.

SEALING SYSTEM

Seals are usually made of rubber with or without a PTFE (Teflon) overlay (**PTFE overlay is preferred**). The seals are often of the music note shape or lip type.

For the WSB gates being tight for water flowing in both directions, the lip seals adopted for Berendrecht (see sectional view of the wheel) should be convenient.

Lintel seal and side seals: can be of the upstream or downstream type (see figure - Annex 6)

Bottom seal can be flat or also of the J-shape type.(see figure – Annexes 6 and 7)

MAINTENANCE OF THE GATES AND BULKHEADS

Maintenance work on gates and bulkheads (as wheels and relevant slots) consists mainly in the replacement of rubber seals and painting. Overhaul and/or replacement of wheels could also be foreseeable. Moreover, the maintenance works will have to include the replacement of the sacrificial anodes whenever necessary.

During normal operation, any trouble with one culvert or WSB gate (blocking or incident on the oil system) will not interfere on the ship transit except concerning the operation time. Every gate can be isolated and maintenance people can reach the upstream or downstream side of the gate by use of bulkheads after emptying of the space between them.

In case of planned replacement of seals or painting, the gate will be lifted out by use of a 100 tons gantry crane moving on rails. This crane will be provided by truck, assembled and installed on the railway located above the gate slot. After dismantling of the gate, the work will be carried out in good conditions in the maintenance building. Two mobile cranes will be necessary for the 40 gates and 12 bulkheads. Rails will be installed between and outside of all the rows of WSB and culvert slots.

For the culverts, 8 (4 x 2) bulkheads are foreseen. It enables to close completely one culvert using 2 x 2 bulkheads at each of the culvert extremities.
For the WSB conduit, 6 (2 x 3) bulkheads are foreseen. It enables to close completely one conduit.

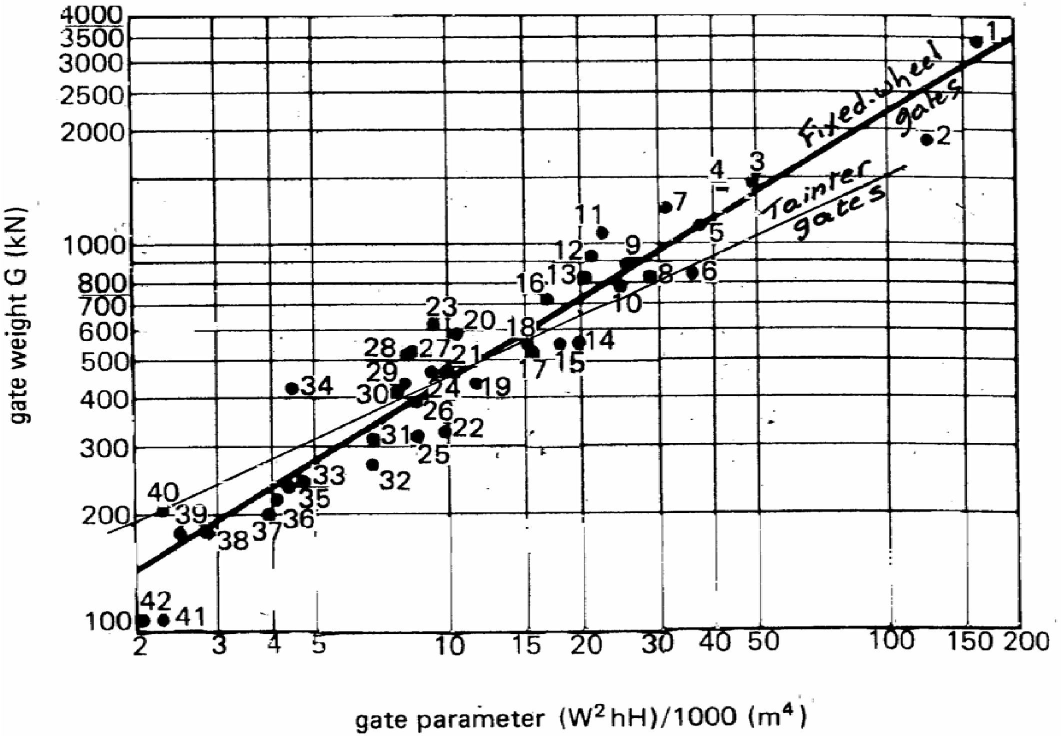
Bulkheads gates can be stored outside or suspended into the slots (one piece of bulkhead gate per slot). To remove a bulkhead gate, the cranes will be equipped with an automatic lifting beam. Planned maintenance will also be done in the maintenance building.

3 REFERENCES

- Hydraulic gates and valves in free surface flow and submerged outlets by Jack Lewin
- Water Power and Dam Construction (review)
- Final report of the International commission for the study of locks (PIANC)
- Engineer manuals
- CCP (2002) “Diseño conceptual de las esclusas Post Panamax – Triple Lift Lock System, Task 4”

ANNEX 1

Abacus of gate weight versus gate parameter (W, h, H)



Weight of large fixed-wheel gates ($W^2hH > 2000\ m^4$).

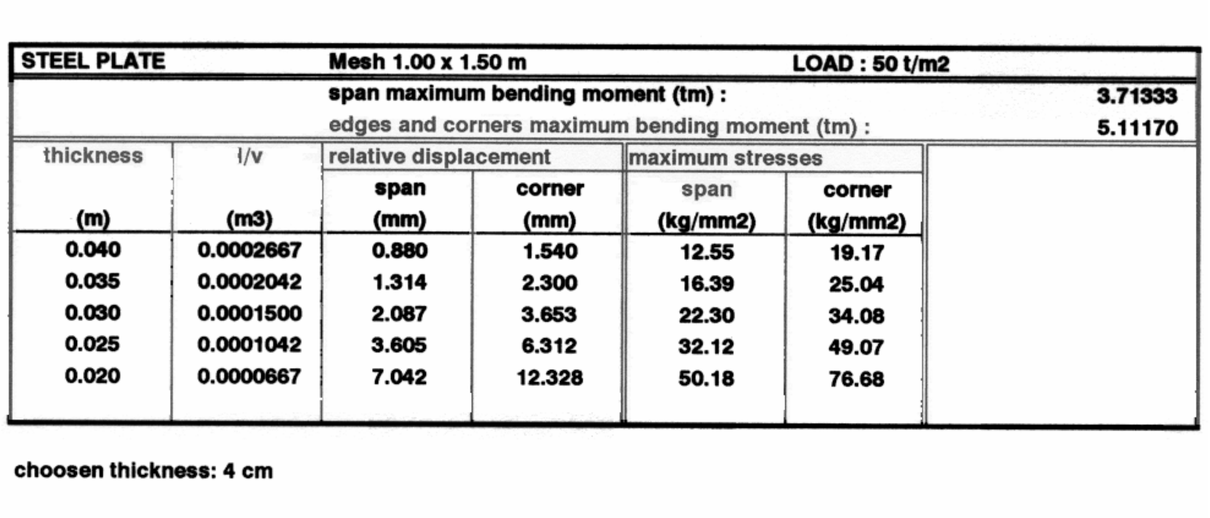
ANNEX 2 (Remind of report R4-E date 15.11.2002)

TYPICAL CALCULATION OF A WSB GATE (Hs = 50m)

This calculation is the same as the one included in the report mentioned at the beginning of paragraph 1.1 of this report. The only goal of this calculation is to prove that the use of the general formula (see page 2-6) is relevant for weight calculation.

SKIN PLATE

The estimated skin plate thickness corresponds to a distance of 1.5m between the horizontal I beams and 1m between the vertical T shape intercostals is 4cm



STEEL PLATE **Mesh 1.00 x 1.50 m** **LOAD : 50 t/m2**

span maximum bending moment (tm) : **3.71333**

edges and corners maximum bending moment (tm) : **5.11170**

thickness	I/v	relative displacement		maximum stresses	
		span	corner	span	corner
(m)	(m3)	(mm)	(mm)	(kg/mm2)	(kg/mm2)
0.040	0.0002667	0.880	1.540	12.55	19.17
0.035	0.0002042	1.314	2.300	16.39	25.04
0.030	0.0001500	2.087	3.653	22.30	34.08
0.025	0.0001042	3.605	6.312	32.12	49.07
0.020	0.0000667	7.042	12.328	50.18	76.68

choosen thickness: 4 cm

MAIN BEAMS

The horizontal main beams size depends on the span between them and load. According to the I/v required, alternatives were investigated i.e.:

- HE 1000 A
- W 1100 x 400 x 433

MAIN GIRDERS length (m) : 5.7 distance (m): 1.5 load (t/m): 75 Moment (tm): 304.59375
E (t/m2): 21000000

DISPLACEMENT vs INERTIA		STRESS vs I/v	
I (m4)	f (m)	I/v (m3)	STRESS (t/m2)
0.0005	0.098177093	0.005	60918.75
0.0006	0.081814244	0.007	43513.392857
0.0007	0.070126495	0.009	33843.75
0.0008	0.061360683	0.011	27690.340909
0.0009	0.054542829	0.013	23430.288462
0.001	0.049088546	0.015	20306.25
0.0011	0.044625951	0.017	17917.279412
0.0012	0.040907122	0.019	16031.25
0.0013	0.03776042	0.021	14504.464286
0.0014	0.035063247	0.023	13243.206522
0.0015	0.032725698	0.025	12183.75
0.0016	0.030680341	0.027	11281.25
0.0017	0.028875615	0.029	10503.232759
0.0018	0.027271415	0.031	9825.6048387
0.0019	0.025836077	0.033	9230.1136364
0.002	0.024544273	0.035	8702.6785714
0.0021	0.023375498	0.037	8232.2635135
0.0022	0.022312976	0.039	7810.0961538
0.0023	0.021342846	0.041	7429.1158537
0.0024	0.020453561	0.043	7083.5755814
0.0025	0.019635419	0.045	6768.75
0.0026	0.01888021	0.047	6480.7180851
0.0027	0.018180943	0.049	6216.1989796
0.0028	0.017531624	0.051	5972.4264706
0.0029	0.016927085	0.053	5747.0518868
0.003	0.016362849	0.055	5538.0681818
0.0031	0.015835015	0.057	5343.75
0.0032	0.015340171	0.059	5162.6059322
0.0033	0.014875317	0.061	4993.3401639
0.0034	0.014437808	0.063	4834.8214286
0.0035	0.014025299	0.065	4686.0576923
0.0036	0.013635707	0.067	4546.1753731
0.0037	0.013267175	0.069	4414.4021739
0.0038	0.012918039	0.071	4290.0528169
0.0039	0.012586807	0.073	4172.5171233
0.004	0.012272137	0.075	4061.25
0.0041	0.011972816	0.077	3955.762987
0.0042	0.011687749	0.079	3855.6170886
0.0043	0.011415941	0.081	3760.4166667
0.0044	0.011156488	0.083	3669.8042169
0.0045	0.010908566	0.085	3583.4558824
0.0046	0.010671423	0.087	3501.0775862
0.0047	0.010444372	0.089	3422.4016854
0.0048	0.01022678	0.091	3347.1840659
0.0049	0.010018071	0.093	3275.2016129
0.005	0.009817709	0.095	3206.25
0.0051	0.009625205	0.097	3140.1417526
0.0052	0.009440105	0.099	3076.7045455
0.0053	0.00926199	0.101	3015.779703
0.0054	0.009090472	0.103	2957.2208738
0.0055	0.00892519	0.105	2900.8928571
0.0056	0.008765812	0.107	2846.6705607
0.0057	0.008612026	0.109	2794.4380734
0.0058	0.008463542	0.111	2744.0878378
0.0059	0.008320093	0.113	2695.5199115
0.006	0.008181424	0.115	2648.6413043
0.0061	0.008047303	0.117	2603.3653846
0.0062	0.007917507	0.119	2559.6113445
0.0063	0.007791833	0.121	2517.303719
0.0064	0.007670085	0.123	2476.3719512
0.0065	0.007552084	0.125	2436.75
0.0066	0.007437659	0.127	2398.3759843
0.0067	0.007326649	0.129	2361.1918605
0.0068	0.007218904	0.131	2325.1431298
0.0069	0.007114282	0.133	2290.1785714
0.007	0.007012649	0.135	2256.25
0.0071	0.00691388	0.137	2223.3120438
0.0072	0.006817854	0.139	2191.3219424
0.0073	0.006724458	0.141	2160.2393617
0.0074	0.006633587	0.143	2130.0262238
0.0075	0.00654514	0.145	2100.6465517
0.0076	0.006459019	0.147	2072.0663265
0.0077	0.006375136	0.149	2044.2533557
0.0078	0.006293403	0.151	2017.1771523
0.0079	0.00621374	0.153	1990.8088235
0.008	0.006136068	0.155	1965.1209677
0.0081	0.006060314	0.157	1940.0875796
0.0082	0.005986408	0.159	1915.6839623
0.0083	0.005914283	0.161	1891.888646
0.0084	0.005843875	0.163	1868.6733129
0.0085	0.005775123	0.165	1846.0227273
0.0086	0.005707971	0.167	1823.9146707
0.0087	0.005642362	0.169	1802.3298817
0.0088	0.005578244	0.171	1781.25
0.0089	0.005515567	0.173	1760.6575145
0.009	0.005454283	0.175	1740.5357143
0.0091	0.005394346	0.177	1720.8686441
0.0092	0.005335712	0.179	1701.6410615
0.0093	0.005278338	0.181	1682.8383978

for a deformation =
span/1000 (.0057),
I must be > 860000 cm4

To keep a stress
< 15 kg/mm2, I/v
must be > 20000 cm3

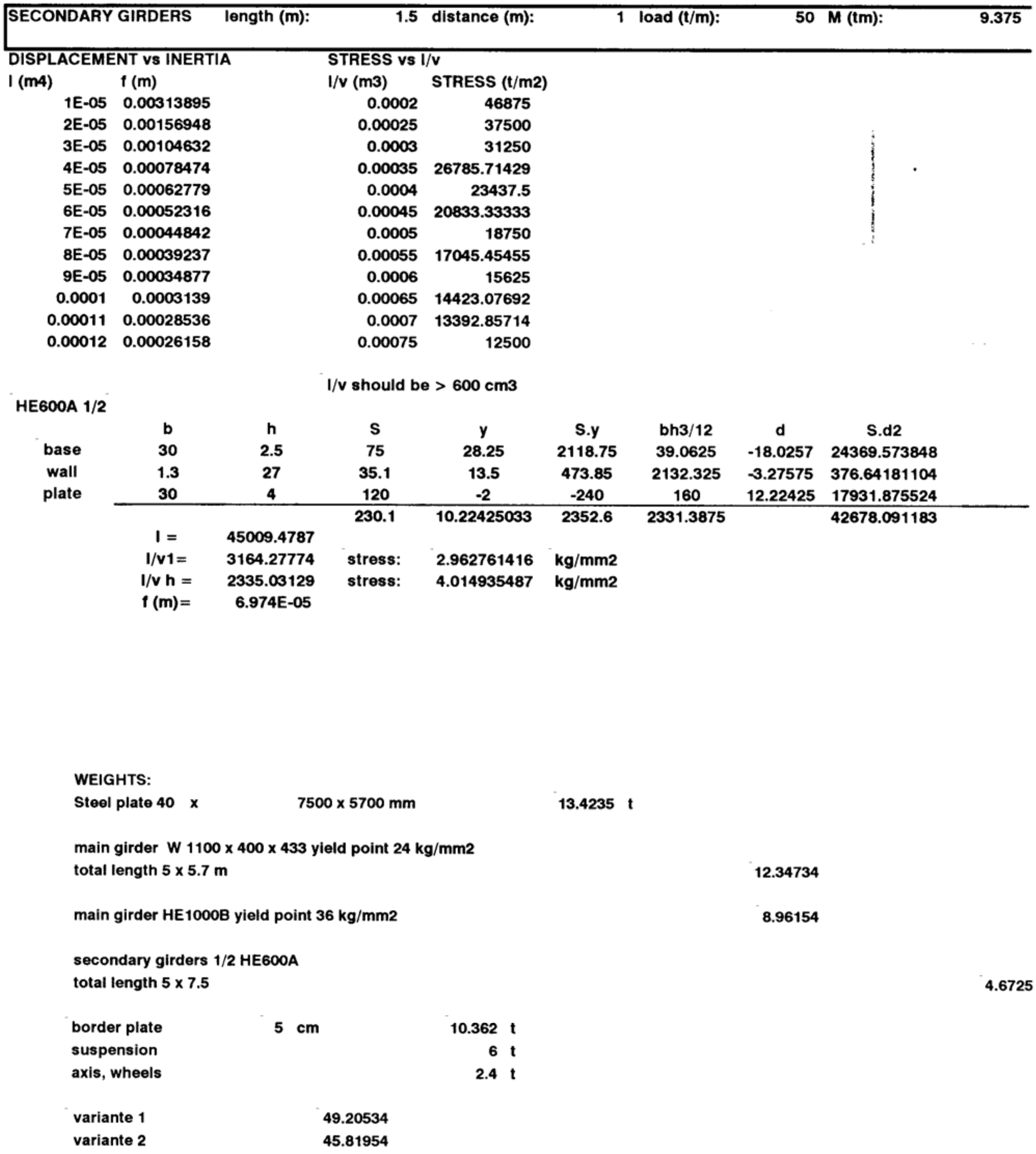
Best profile matching the 2 requirements (lower weight):

W 1100 x 400 x 433	433.24	kg/m'				
I =	1125573.94	cm4	deformation :	4.3612E-11	m	
I/v =	20317.22	cm3	stress:	14.991901	kg/mm2	ok with steel yield strength 24 kg/mm2

With a HE1000B:	314.44	kg/m'				
I =	644748.07	cm4	deformation :	7.6136E-11	m	
I/v =	12894.96	cm3	stress:	23.6211473	kg/mm2	ok with steel yield strength 36 kg/mm2

SECONDARY BEAMS

T beams coming from HE 600 A were considered



SECONDARY GIRDERS	length (m):	1.5	distance (m):	1	load (t/m):	50	M (tm):	9.375

DISPLACEMENT vs INERTIA		STRESS vs I/v	
I (m4)	f (m)	I/v (m3)	STRESS (t/m2)
1E-05	0.00313895	0.0002	46875
2E-05	0.00156948	0.00025	37500
3E-05	0.00104632	0.0003	31250
4E-05	0.00078474	0.00035	26785.71429
5E-05	0.00062779	0.0004	23437.5
6E-05	0.00052316	0.00045	20833.33333
7E-05	0.00044842	0.0005	18750
8E-05	0.00039237	0.00055	17045.45455
9E-05	0.00034877	0.0006	15625
0.0001	0.0003139	0.00065	14423.07692
0.00011	0.00028536	0.0007	13392.85714
0.00012	0.00026158	0.00075	12500

I/v should be > 600 cm3

HE600A 1/2

	b	h	S	y	S.y	bh3/12	d	S.d2
base	30	2.5	75	28.25	2118.75	39.0625	-18.0257	24369.573848
wall	1.3	27	35.1	13.5	473.85	2132.325	-3.27575	376.64181104
plate	30	4	120	-2	-240	160	12.22425	17931.875524
			230.1	10.22425033	2352.6	2331.3875		42678.091183

I = 45009.4787

I/v1= 3164.27774 stress: 2.962761416 kg/mm2

I/v h = 2335.03129 stress: 4.014935487 kg/mm2

f (m)= 6.974E-05

WEIGHTS:

Steel plate 40 x	7500 x 5700 mm	13.4235 t	
main girder W 1100 x 400 x 433 yield point 24 kg/mm2 total length 5 x 5.7 m			12.34734
main girder HE1000B yield point 36 kg/mm2			8.96154
secondary girders 1/2 HE600A total length 5 x 7.5			4.6725
border plate	5 cm	10.362 t	
suspension		6 t	
axis, wheels		2.4 t	

variante 1 49.20534

variante 2 45.81954

CONCLUSION:

The estimated weight by 1st calculation is 46 or 49 tons according to the beam choice (HE 1000 A or W 1100 x 400 x 300 according to the ARBED catalogue (see extract hereunder). These values are to be compared with the 51 tons found by the above statistical formula.

Catalog
ProfilARBED - Beams selection program

PROFILARBED

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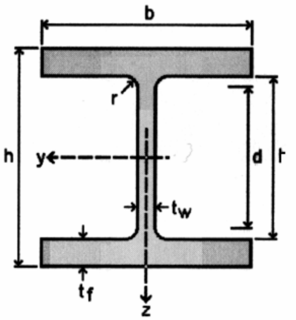
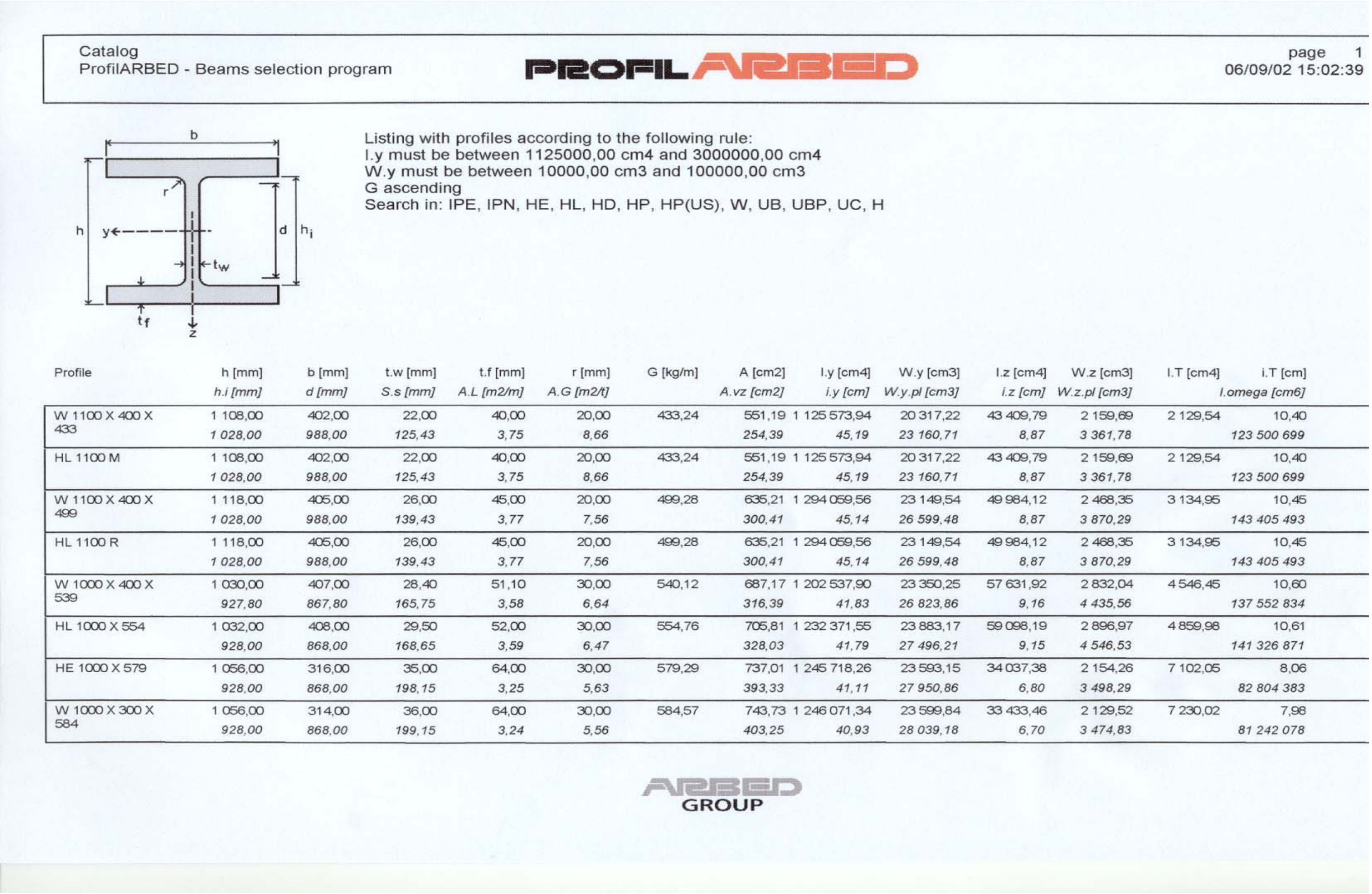


Listing with profiles according to the following rule:
I.y must be between 5000,00 cm4 and 3000000,00 cm4
W.y must be between 9000,00 cm3 and 71000,00 cm3
G ascending
Search in: IPE, IPN, HE, HL, HD, HP, HP(US), W, UB, UBP, UC, H

Profile						G [kg/m]	A [cm2]	I.y [cm4]	W.y [cm3]	I.z [cm4]	W.z [cm3]	.T [cm4]	i.T [cm]
							A.vz [cm2]	*i.y [cm]*	*W.y.pl [cm3]*	*i.z [cm]*	*W.z.pl [cm3]*		*I.omega [cm6]*
W 1000 X 300 X 249	980,00	300,00	16,50	26,00	30,00	249,04	316,85	481 078,52	9 817,93	11 754,44	783,63	584,40	7,39
	928,00	*868,00*	*103,65*	*3,08*	*12,37*		*180,74*	*38,97*	*11 346,88*	*6,09*	*1 244,71*		*26 620 893*
HE 900 A	890,00	300,00	16,00	30,00	30,00	251,93	320,53	422 074,83	9 484,83	13 547,46	903,16	736,77	7,63
	830,00	*770,00*	*111,15*	*2,90*	*11,51*		*163,33*	*36,29*	*10 811,04*	*6,50*	*1 414,48*		*24 961 500*
UB 914 X 305 X 253	918,40	305,50	17,30	27,90	19,10	253,74	322,83	436 304,46	9 501,40	13 301,11	870,78	630,51	7,71
	862,60	*824,40*	*95,48*	*2,99*	*11,80*		*167,85*	*36,76*	*10 942,00*	*6,42*	*1 370,54*		*26 284 181*
W 920 X 310 X 253	919,00	306,00	17,30	27,90	19,00	254,02	323,18	437 456,16	9 520,26	13 366,25	873,61	630,91	7,72
	863,20	*825,20*	*95,36*	*2,99*	*11,80*		*167,86*	*36,79*	*10 962,73*	*6,43*	*1 374,80*		*26 449 053*
W 920 X 310 X 271	923,00	307,00	18,40	30,00	19,00	272,03	346,09	471 573,42	10 218,28	14 518,01	945,80	775,02	7,76
	863,00	*825,00*	*100,66*	*3,00*	*11,06*		*178,81*	*36,91*	*11 782,87*	*6,48*	*1 490,95*		*28 842 178*
W 1000 X 300 X 272	990,00	300,00	16,50	31,00	30,00	272,62	346,85	553 846,02	11 188,81	14 004,44	933,63	822,41	7,55
	928,00	*868,00*	*113,65*	*3,10*	*11,37*		*184,56*	*39,96*	*12 824,38*	*6,35*	*1 469,71*		*32 073 875*
HE 1000 A	990,00	300,00	16,50	31,00	30,00	272,62	346,85	553 846,02	11 188,81	14 004,44	933,63	822,41	7,55
	928,00	*868,00*	*113,65*	*3,10*	*11,37*		*184,56*	*39,96*	*12 824,38*	*6,35*	*1 469,71*		*32 073 875*
H 900 X 300 X 18 X 34	912,00	302,00	18,00	34,00	18,00	283,01	360,06	491 010,69	10 767,78	15 654,09	1 036,69	980,82	7,77
	844,00	*808,00*	*107,09*	*2,97*	*10,49*		*173,06*	*36,93*	*12 337,07*	*6,59*	*1 622,45*		*30 079 980*

ARBED GROUP



Catalog
ProfilARBED - Beams selection program

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Listing with profiles according to the following rule:
I.y must be between 1125000,00 cm4 and 3000000,00 cm4
W.y must be between 10000,00 cm3 and 100000,00 cm3
G ascending
Search in: IPE, IPN, HE, HL, HD, HP, HP(US), W, UB, UBP, UC, H

Profile	h [mm] *h.i [mm]*	b [mm] *d [mm]*	t.w [mm] *S.s [mm]*	t.f [mm] *A.L [m2/m]*	r [mm] *A.G [m2/t]*	G [kg/m]	A [cm2] *A.vz [cm2]*	I.y [cm4] *i.y [cm]*	W.y [cm3] *W.y.pl [cm3]*	I.z [cm4] *i.z [cm]*	W.z [cm3] *W.z.pl [cm3]*	I.T [cm4]	i.T [cm] *I.omega [cm6]*
W 1100 X 400 X 433	1 108,00 *1 028,00*	402,00 *988,00*	22,00 *125,43*	40,00 *3,75*	20,00 *8,66*	433,24	551,19 *254,39*	1 125 573,94 *45,19*	20 317,22 *23 160,71*	43 409,79 *8,87*	2 159,69 *3 361,78*	2 129,54	10,40 *123 500 699*
HL 1100 M	1 108,00 *1 028,00*	402,00 *988,00*	22,00 *125,43*	40,00 *3,75*	20,00 *8,66*	433,24	551,19 *254,39*	1 125 573,94 *45,19*	20 317,22 *23 160,71*	43 409,79 *8,87*	2 159,69 *3 361,78*	2 129,54	10,40 *123 500 699*
W 1100 X 400 X 499	1 118,00 *1 028,00*	405,00 *988,00*	26,00 *139,43*	45,00 *3,77*	20,00 *7,56*	499,28	635,21 *300,41*	1 294 059,56 *45,14*	23 149,54 *26 599,48*	49 984,12 *8,87*	2 468,35 *3 870,29*	3 134,95	10,45 *143 405 493*
HL 1100 R	1 118,00 *1 028,00*	405,00 *988,00*	26,00 *139,43*	45,00 *3,77*	20,00 *7,56*	499,28	635,21 *300,41*	1 294 059,56 *45,14*	23 149,54 *26 599,48*	49 984,12 *8,87*	2 468,35 *3 870,29*	3 134,95	10,45 *143 405 493*
W 1000 X 400 X 539	1 030,00 *927,80*	407,00 *867,80*	28,40 *165,75*	51,10 *3,58*	30,00 *6,64*	540,12	687,17 *316,39*	1 202 537,90 *41,83*	23 350,25 *26 823,86*	57 631,92 *9,16*	2 832,04 *4 435,56*	4 546,45	10,60 *137 552 834*
HL 1000 X 554	1 032,00 *928,00*	408,00 *868,00*	29,50 *168,65*	52,00 *3,59*	30,00 *6,47*	554,76	705,81 *328,03*	1 232 371,55 *41,79*	23 883,17 *27 496,21*	59 098,19 *9,15*	2 896,97 *4 546,53*	4 859,98	10,61 *141 326 871*
HE 1000 X 579	1 056,00 *928,00*	316,00 *868,00*	35,00 *198,15*	64,00 *3,25*	30,00 *5,63*	579,29	737,01 *393,33*	1 245 718,26 *41,11*	23 593,15 *27 950,86*	34 037,38 *6,80*	2 154,26 *3 498,29*	7 102,05	8,06 *82 804 383*
W 1000 X 300 X 584	1 056,00 *928,00*	314,00 *868,00*	36,00 *199,15*	64,00 *3,24*	30,00 *5,56*	584,57	743,73 *403,25*	1 246 071,34 *40,93*	23 599,84 *28 039,18*	33 433,46 *6,70*	2 129,52 *3 474,83*	7 230,02	7,98 *81 242 078*

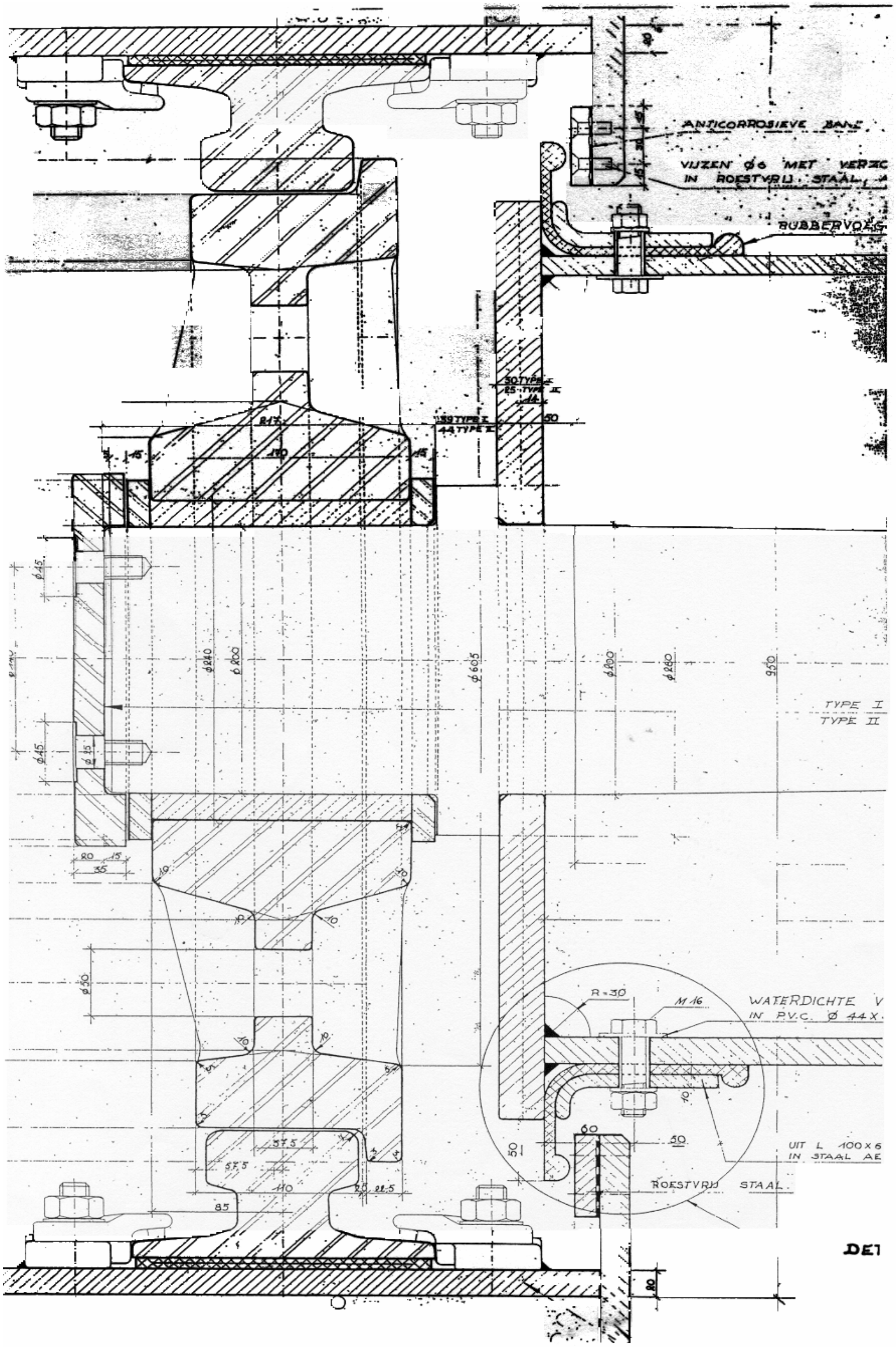
ANNEX 3

ESTIMATION OF WEIGHT FOR CULVERT AND CONDUIT GATES TAKING INTO ACCOUNT MAXIMUM STATIC HEADS

ATLANTIC SIDE : TRIPLE LIFT (W=55m) 3 X 2 WATER SAVING BASINS

			Width(m)	height(m)	Hmwc(m)	Hsécurité	Htot	T/m	L tot(m)	Estimated weight (T)	n	Total weight (T)
CULVERT GATES	Culvert gates		**4,5**	**6**	**37,2**					**25,5**	16	409
	Culvert gates slots	2*2gate height		12				0,8	24	19,2	16	
		2*[Htot-(2gate height)]		12	37,2	1,5	38,7	0,2	53,4	10,7	16	
		2*width	4,5					0,8	9	7,2	16	
		tot culvert gates slots										593
	Culvert bulkhead	equal to culvert gate - 3T								22,5	8	180
	Culvert bulkhead slots	2*2bulkhead height		12				0,5	24	12	32	
		2*[Htot-(2bulkhead height)]		12	37,2	1,5	38,7	0,2	53,4	10,7	32	
		2*width	4,5					0,5	9	4,5	32	
		tot culvert bulkhead slots										870
CONDUIT GATES	Conduit gates		**4**	**5**	**39,43**					**19,9**	24	477
	Conduit gates slots	2*2gate height		10				1	20	20	24	
		2*[Htot-(2gate height)]		10	39,43	1,5	40,93	0,2	61,86	12,4	24	
		2*width	4					1	8	8,0	24	
		tot conduit gates slots										969
	Conduit bulkhead	equal to conduit gate - 3T								16,9	6	101
	Conduit bulkhead slots	2*2bulkhead height		10				0,5	20	10	48	
		2*[Htot-(2bulkhead height)]		10	39,43	1,5	40,93	0,2	61,86	12,4	48	
		2*width	4					0,5	8	4,0	48	
		tot conduit bulkhead slots										1266

ANNEX 4 – CROSS SECTION OF A GATE WHEEL OF BERENDRECHT LOCK



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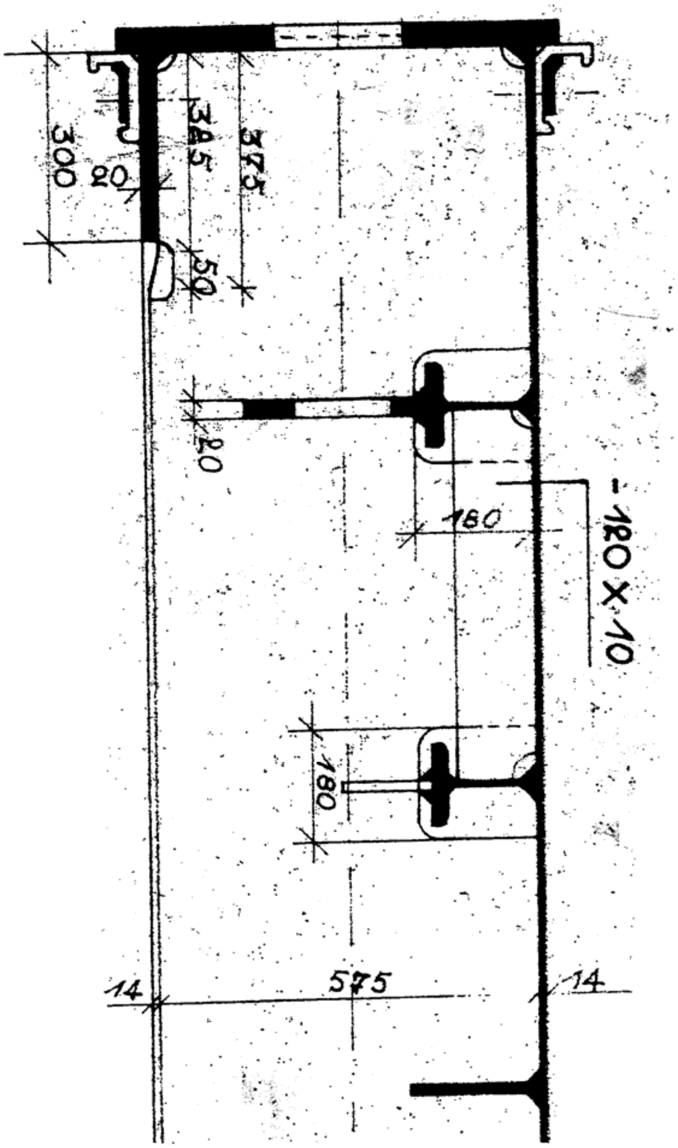
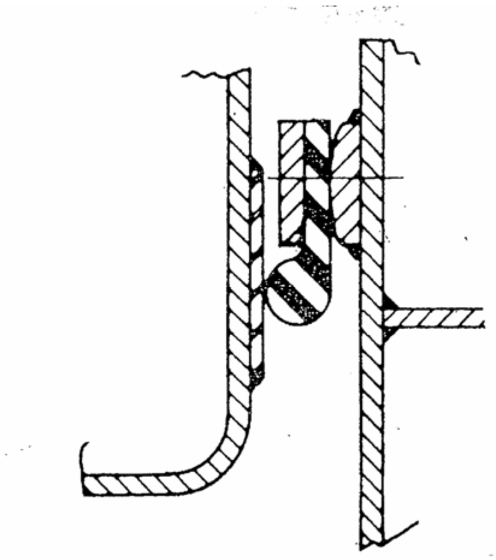
ANNEX 5

TYPICAL GATE STRUCTURE

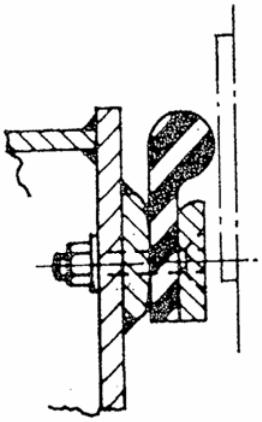


ANNEX 6

UPSTREAM AND DOWNSTREAM SEALING (Music not J-shape type)



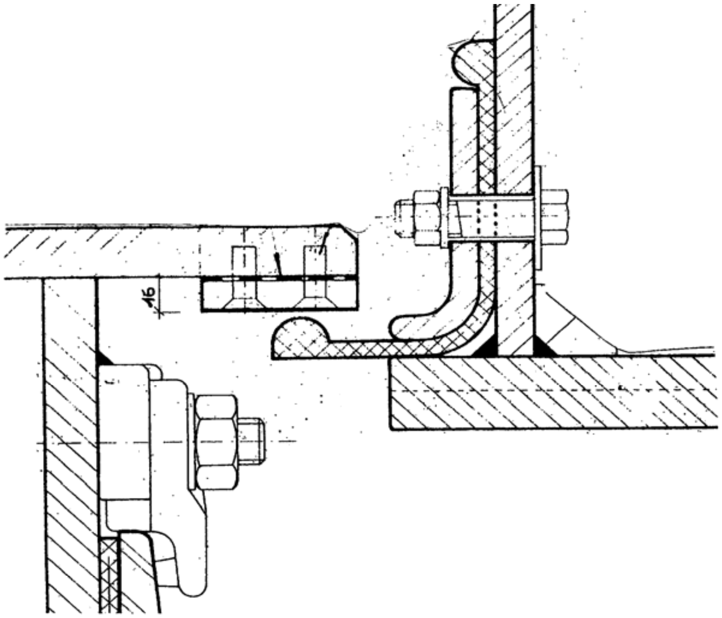
UPSTREAM SEALING

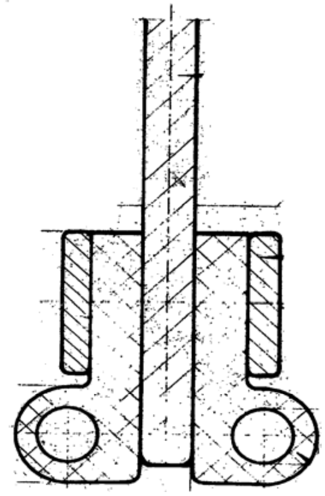


DOWNSTREAM SEALING

ANNEX 7

SIDE AND BOTTOM SEALS (BERENDRECHT)





ANNEX 8 : Pictures – typical seals view (Zandvliet lock, Belgium)

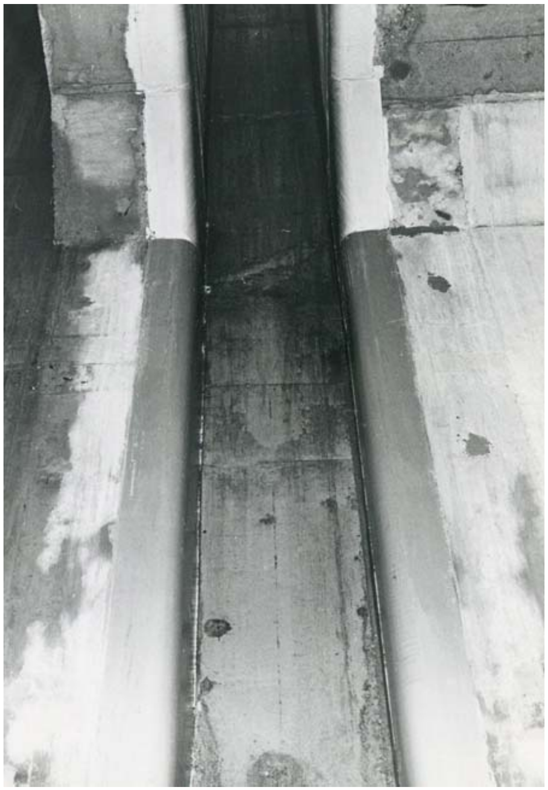
Side seal left position (angular music note type)

Front seal (simple music note seal)

Side seal right position (angular music note type)

Bended music note seal – Pressing plate and protecting device

Double bottom seals

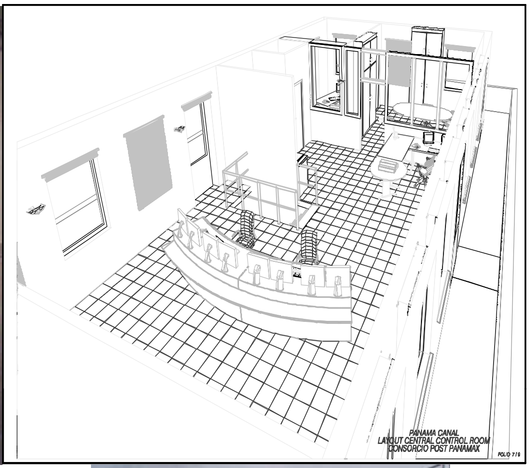


Detail of a gate slot

Handling device details

General view of culvert gate

CPP Consorcio Post-Panamax



Alternative Conceptual Design of Pacific and Atlantic Post-Panamax Locks – 3x2 WSB - Contract SAA-150551

ATLANTIC LOCKS 3x2 wsb

Task A4f-3x2 – OPERATING MACHINERY
Task A4g-3x2 – LIGHTING
Task A4h-3x2 – ELECTRICAL AND POWER REQUIREMENTS
Task A4j-3x2 – OPERATING STRUCTURES

Rev A

in association with

TABLE OF CONTENTS

Annexes

1. Estimation of gate engine power for culvert and conduit gates taking into account operating heads
2. Estimation of gate engine power for culvert and conduit gates taking into account maximum static heads

1 INTRODUCTION

The original conceptual design of the Atlantic side of the third Post Panamax lock lane (made by others, it means not by CPP) has been made for a triple lift lock with a width of 61m and 3x3 WSB.

For the Atlantic harmonization study, a 55m triple lift lock has been considered (with 3x3 WSB). Vessel positioning was foreseen by tugboat assistance.

The Atlantic locks harmonization has been based entirely on Pacific Locks Actualization.

The present document gives the impact on the previous study of the replacement of the 3x3 WSB option by the 3x2 WSB one on the following subjects:

- the gates and valves operating machinery (Task 4 F-3x2). This corresponds to the operating machinery of the main lock gates and of the culvert and conduit gates,
- the control system architecture (including SCADA[1]), which includes the monitoring of the whole lock system (the control system architecture is part of Task 4F-3x2),
- the lighting system (Task 4 G-3x2),
- the electrical and power requirements (Task 4 H-3x2),
- the operating structures (Task 4 J-3x2), which deals with the arrangement of the various technical buildings[2].

---

[1] ***SCADA = System Control And Data Acquisition***

[2] ***Electrical rooms, Maintenance building, Rolling gates technical rooms, WSB technical building, Culvert technical building, Emergency Diesel Room and (Main) Control room***

2 Operating machinery (Task A4f-3x2)

2.1 MACHINERY OF THE (MAIN) ROLLING GATES

Reference is made to Task P4f (3x2 WSB).

2.2 MACHINERY OF THE CULVERT AND WSB CONDUIT GATES

The calculation of the rated output of the motor of the main oil pumps mounted on the hydraulic power pack is enclosed in Annexes 1 and 2, respectively for operating and maximum static heads. This calculation takes into account the actual dimensions of the culvert and WSB conduit gates (see A4e-3x2).

A summary of the output for different options is given hereafter:

55 m (operating heads)	culvert gates:	53kW,
	WSB conduit gates:	15kW.

(see annex 1 – Estimate of the gate engine power taking into account operating heads)

55 m (maximum static heads)	culvert gates:	77kW,
	WSB conduit gates:	56kW.

(see annex 2 – Estimate of the gate engine power taking into account maximum static heads)

Regarding the two last values, standardization of the servomotors is possible if we consider the operation under maximum static heads.
But, regarding the design of the motors (two per gates), another alternative could be envisaged in the next step of the studies:

- for the operating heads, one motor will operate the gate, one will remain on stand-by (one redundancy degree).
- operation under maximum static heads should be with the two motors in operation (no redundancy).

Of course the power output of the motors will have to be slightly adapted to fit the above operation procedures.

2.3 CONTROL SYSTEM ARCHITECTURE

Reference is made to Task P4f-3x2.
For the drawings, reference is made to the 2002 report and its drawings.

3 Lighting (Task A4g-3x2)

3.1 OUTSIDE LIGHTING

3.1.1 LOCK CHAMBER WALLS

Reference is made to Task P4g-3x2.

3.1.2 LIGHTING POLES

The location of the lighting poles is slightly easier without the locomotive tracks.
The philosophy of the lighting is to have a lighting level along the lock chamber (both side) and decreasing lighting level after the fictive line running along the dead end of the main rolling gates recesses.

For the triple lift lock with 3x2 WSB, the length of the entrance wall is the same as for the triple lift lock with 3x3 WSB. However, the length of the entrance is shorter than for the Pacific locks. The number of lighting poles is 50 instead of 61.

Given there are now only 3x2 water saving basins, the number of floodlights has also decreased from 12 to 10 because 2 floodlights were foreseen for the lighting of the last water saving basin.
The external lighting arrangement is summarised hereafter :

Side WSB – Gatun lake entrance :
- 3 lighting poles.
- 60m between two LP
- 6 floodlights of 1000 W

Side WSB – Chamber locks :
- 3 x 5 lighting poles.
- 93m between two LP
- 10 floodlights of 1000 W

Side WSB – Atlantic entrance :
- 4 lighting poles.

- 60m between two LP
- 6 floodlights of 1000 W

Other side :

- 28 lighting poles
- 59m between two LP
- 6 floodlights of 1000 W

The number of floodlights has slightly decreased but the price is quite similar.
Estimated budget price for 50 high masts, 360 floodlights, lock chamber and gallery lighting : USD 2 millions.

Reference is made to the 2002 report. For the layout, reference is made to drawing D4-A-403.

3.2 INTERNAL LIGHTING

Reference is made to Task P4g-3x2.

4 Electrical and power requirements (Task A4h-3x2)

There is no major change in the estimate of power consumptions. The rated power of the various transformers remains the same.

Reference is made to Task P4h-3x2. For the general layout, reference is made to drawing D4-A-203.

5 Operating structures (Task A4j-3x2)

Reference is made to Task P4j-3x2.

6 References

- CPP (2002). Diseño conceptual de las Esclusas Post Panamax. Triple Lift Lock System, task 4.
- ALTERNATIVE PACIFIC LOCKS 3x2, Tasks P4f-3x2, P4g-3x2, P4h-3x2 and P4j-3x2.

ANNEXES

ESTIMATION OF THE GATE ENGINE POWER
ATLANTIC SIDE : TRIPLE LIFT (W=55m) 3 X 2 WATER SAVING BASINS
TAKING INTO ACCOUNT OPERATING HEADS

	LOCK CULVERT GATE	WSB CONDUIT GATE
Maximum effort (T)	96	33
Oil pressure (bar)	200	200
Stroke (m)	6,00	5,00
Opening time (min)	2,00	2,00
Cylinder section (m²)	0,048	0,017
Cylinder oil volume (m³)	0,288	0,084
Oil flow (m³/min)	0,144	0,042
mechanical efficiency	0,9	0,9
POWER (kW)	**53**	**15**

Calculus of the forces on the gate

Gate width (m)	4,5	4
length of horizontal seal (m)	4,9	4,4
Gate heigth (m)	6	5
length of vertical seal (m)	6,3	5,3
width of seal (cm)	3	3

OPENING

Sealing friction forces Fs			
Fs = f x 1,5 x p x A	f (friction coefficient)	0,15	0,15
	p (hydraulic pressure on the gate) (bar)	2,5	1,0
	A (Area of sealing contact) (m²)	0,525	0,45
	Fs (kg)	2953	1013
Wheel friction Fw			
Fw = Q x (fd x d + fr) / D	Q (max load on the gate) (kg)	771750	233200
(six wheels have been foreseen)	fd (friction coeff of the wheel bushings)	0,12	0,12
	fr (friction coeff of wheels rolling on slot rails)	0,2	0,2
	d (diameter of wheel shaft) (cm)	20	20
	D (wheel diameter) (cm)	80	80
	Fw (kg)	25082	7579
Hydraulic load F1 on the top seal of the gate			
F1 = p x l x ls	p (hydraulic pressure on the gate) (bar)	2,5	1,0
	l (width of the seal) (m)	0,08	0,08
	ls (length of the seal) (m)	4,9	4,4
	F1 (kg)	9800	3520
Hydraulic load F2 on the top of the gate			
F2 = p x gt x ls	p (hydraulic pressure on the gate) (bar)	2,5	1,0
	gt (gate thickness) (m)	1	1
	ls (length of the seal) (m)	4,9	4,4
	F2 (kg)	122500	44000
Hydraulic load F3 under the gate			
F3 = F2 x dlc	F2 (kg)	122500	44000
	dlc (dynamic load coefficient)	0,8	0,8
	F3 (kg)	98000	35200
Weight W (under water)			
W = rw x 6.85/7.85 x 1.05	rw (real weight) (kg)	19345	7603
	W (weight under water) (kg)	17725	6966
Maximum opening load			
F = Fs + Fw + F1 + F2 - F3 + W	**F (T)**	**80**	**28**

CLOSING

Sealing friction forces F's			
F's = 0.1 x p x A	p (hydraulic pressure on the gate) (bar)	2,5	1,0
	A (Area of sealing contact) (m²)	0,525	0,45
	Fs (kg)	1313	450
Wheel friction F'w			
F'w = Q x (f'd x d + f'r) / D	Q (max load on the gate) (kg)	771750	233200
	f'd (friction coeff of the wheel bushings)	0,08	0,08
	f'r (friction coeff of wheels rolling on slot rails)	0,1	0,1
	d (diameter of wheel shaft) (cm)	20	20
	D (wheel diameter) (cm)	80	80
	F'w (kg)	16400	4956
Hydraulic load F'1 on the top seal of the gate			
F'1 = 0.5 x F1	F1 (kg)	9800	3520
	F'1 (kg)	4900	1760
Hydraulic load F'2 on the top of the gate			
F'2 = 0.9 x F2	F2 (kg)	122500	44000
	F'2 (kg)	110250	39600
Hydraulic load F'3 under the gate			
F'3 = 0.5 x F3	F3 (kg)	98000	35200
	F'3 (kg)	49000	17600
Weight W'			
real weight of the gate	W' (kg)	19345	7603
Maximum braking force			
B = W' + F'1 + F'2 - F'3 - F'w - F's	**B (T)**	**68**	**26**

ESTIMATION OF THE GATE ENGINE POWER
ATLANTIC SIDE : TRIPLE LIFT (W=55m) 3 X 2 WATER SAVING BASINS
TAKING INTO ACCOUNT MAXIMUM STATIC HEADS

	LOCK	WSB
	CULVERT GATE	CONDUIT GATE
Maximum effort (T)	139	121
Oil pressure (bar)	200	200
Stroke (m)	6,00	5,00
Opening time (min)	2,00	2,00
Cylinder section (m²)	0,070	0,060
Cylinder oil volume (m³)	0,418	0,302
Oil flow (m³/min)	0,209	0,151
mechanical efficiency	0,9	0,9
POWER (kW)	**77**	**56**

Calculus of the forces on the gate

Gate width (m)	4,5	4
length of horizontal seal (m)	4,9	4,4
Gate heigth (m)	6	5
length of vertical seal (m)	6,3	5,3
width of seal (cm)	3	3

OPENING

Sealing friction forces Fs			
Fs = f x 1,5 x p x A	f (friction coefficient)	0,15	0,15
	p (hydraulic pressure on the gate) (bar)	3,7	3,9
	A (Area of sealing contact) (m²)	0,525	0,45
	Fs (kg)	4394	3992
Wheel friction Fw			
Fw = Q x (fd x d + fr) / D	Q (max load on the gate) (kg)	1148364	919508
(six wheels have been foreseen)	fd (friction coeff of the wheel bushings)	0,12	0,12
	fr (friction coeff of wheels rolling on slot rails)	0,2	0,2
	d (diameter of wheel shaft) (cm)	20	20
	D (wheel diameter) (cm)	80	80
	Fw (kg)	37322	29884
Hydraulic load F1 on the top seal of the gate			
F1 = p x l x ls	p (hydraulic pressure on the gate) (bar)	3,7	3,9
	l (width of the seal) (m)	0,08	0,08
	ls (length of the seal) (m)	4,9	4,4
	F1 (kg)	14582	13879,36
Hydraulic load F2 on the top of the gate			
F2 = p x gt x ls	p (hydraulic pressure on the gate) (bar)	3,7	3,9
	gt (gate thickness) (m)	1	1
	ls (length of the seal) (m)	4,9	4,4
	F2 (kg)	182280	173492
Hydraulic load F3 under the gate			
F3 = F2 x dlc	F2 (kg)	182280	173492
	dlc (dynamic load coefficient)	0,8	0,8
	F3 (kg)	145824	138793,6
Weight W (under water)			
W = rw x 6.85/7.85 x 1.05	rw (real weight) (kg)	25550	19863
	W (weight under water) (kg)	23410	18199
Maximum opening load			
F = Fs + Fw + F1 + F2 - F3 + W	**F (T)**	**116**	**101**

CLOSING

Sealing friction forces F's			
F's = 0.1 x p x A	p (hydraulic pressure on the gate) (bar)	3,7	3,9
	A (Area of sealing contact) (m²)	0,525	0,45
	Fs (kg)	1953	1774
Wheel friction F'w			
F'w = Q x (f'd x d + f'r) / D	Q (max load on the gate) (kg)	1148364	919507,6
	f'd (friction coeff of the wheel bushings)	0,08	0,08
	f'r (friction coeff of wheels rolling on slot rails)	0,1	0,1
	d (diameter of wheel shaft) (cm)	20	20
	D (wheel diameter) (cm)	80	80
	F'w (kg)	24403	19540
Hydraulic load F'1 on the top seal of the gate			
F'1 = 0.5 x F1	F1 (kg)	14582	13879,36
	F'1 (kg)	7291	6939,68
Hydraulic load F'2 on the top of the gate			
F'2 = 0.9 x F2	F2 (kg)	182280	173492
	F'2 (kg)	164052	156142,8
Hydraulic load F'3 under the gate			
F'3 = 0.5 x F3	F3 (kg)	145824	138793,6
	F'3 (kg)	72912	69396,8
Weight W'			
real weight of the gate	W' (kg)	25550	19863
Maximum braking force			
B = W' + F'1 + F'2 - F'3 - F'w - F's	**B (T)**	**98**	**92**

Alternative Conceptual Design of Pacific and Atlantic Post-Panamax Locks – 3x2 WSB – Contract SAA-150551

ATLANTIC LOCKS 3x2 wsb

Task A4m-3x2- QUANTITIES AND COST ESTIMATION

Rev B

in association with

1 Quantities and Cost Estimation

1.1 PREAMBLE

The harmonized Triple Lift Lock configuration for the new Post Panamax Locks at the Atlantic side of the Panama Canal is a huge construction project, probably one of the largest that are going to be built during the forthcoming decades.

A total construction cost for the **Pacific** Locks has already been quantified:

- for the Triple Lift Lock Configuration and presented by CPP in November 2002 in the Final Report - 3 Steps Lock System - Task 4 Chapter R4-M Cost Estimation.
- for the Single Lift Lock Configuration and presented by CPP in March 2003 in the Final Report - Single Lift Lock System - Task 4 Chapter R4-M Cost Estimation.
- for the Double Lift Lock Configuration and presented by CPP in May 2003 in the Final Report - Double Lift Lock System - Task 4 Chapter R4-M Cost Estimation.
- For the actualized Triple Lift Lock Configuration and presented by CPP in April 2005 in the Final Report – Pacific Locks Actualization – Task 4 Chapter P4m Quantities and Cost estimation.

A total construction cost for the harmonized Triple Lift Lock configuration with 3x3 WSB at the Atlantic side has also been quantified. It is presented by CPP in May 2005 in the Final report – Atlantic Locks Harmonization – Task 4 Chapter A4m Quantities and Cost estimation.

The present Report contains quantities and cost estimates of the Civil Works and Electromechanical Equipment required to build the Post Panamax Atlantic Locks of the Panama Canal in its harmonized Triple Lift configuration with 3x2 WSB.

The costs of the present project have been based on the same aggregated unit price list prepared and justified in the above first mentioned Report (3 Steps Lock System - Task 4 Chapter R4-M Cost Estimation). However it has to be mentioned that generally the steel prices have been increasing strongly since early 2004. For reasons of comparison between original and harmonization the prices have not yet been modified, which means that the new total cost is slightly underestimated.

The present Report consolidates individual reports prepared by the different CPP teams, each in accordance with their particular field of know-how. It groups the information provided in three Chapters: Quantities, Cost Estimates, and Total Project Cost. In addition, the Report includes two Appendices that contain detailed information on quantities of construction item (Appendix A) and project cost estimates (Appendix B).

1.2 QUANTITIES

1.2.1 GENERAL

According to the different tasks that have been undertaken during the harmonization study, it was possible to identify all new design criteria, , and determine the most suitable Lock siting and layout. Subsequently, the concept studies of the numerous elements of the new Locks were actualized, as there are:

- Lock walls;
- Filling and Emptying System, including Water Saving Basins;
- Lock Operating Gates;
- Culvert and Conduit Valves;
- Electromechanical Devices;

For each of these elements, studies and analysis results have been included in the preceding chapters of this final report. They have been sufficiently worked out by means of proper modern engineering design tools, shown on drawings with all required dimensions on a conceptual level of design, in order to allow calculating the quantities of materials involved. The Terms of Reference require an accuracy of 25% for the cost estimation; therefore it is necessary that the quantities are determined at a higher level of precision, which is most certainly being obtained.

All Quantities are summarized in a series of Tables presented in the Appendix A of the present report.

1.2.2 LOCK WALLS & ENTRANCE WALLS

Lock walls and entrance walls are gravity type retaining walls, which have to be constructed in an open excavation. Due to the enormous dimensions, especially in depth, they require very large excavations, mainly in Gatun rock.

In the Task 3 Report of the Triple Lift Configuration (Pacific side), dealing with the excavation volumes for the new canal by-pass, an estimation of $607,000,000 USD (based on unit prices communicated by ACP as to year 2000) has been put forward as a construction cost for the excavation of the new by-pass including the Locks excavations . Although the new alignment (Pacific and Atlantic side) needs considerable less excavation volumes, it is clear that excavation costs will be a very important factor in determining the total construction cost.

The excavation and backfill volumes have been determined using the digital map "*Curvas nivel*", the plan view D4-A-403 and the lock Profile Drawings D4-B-401 and 402. Generation of cross sections was done with the AutoCAD 2005 Autodesk Land Desktop software tool, which also calculates the volumes of excavation and backfill. *Excavation and backfill volumes are calculated in cubic meters [m³].*

As far as the entrance walls are concerned, the excavation include the entrance channel up to the outer corner of the east wall; from that point on the excavation for the west wall is restricted to the minimum profile required for the construction of the single wall, and does not include the volume of the canal situated in between the entrance wall and the eastern canal embankment, these volumes have to be considered in the total excavation required for the by-pass canal.

An attempt was also made to determine the type of excavation volumes [rock and common (overburden) excavation]. Common excavation refers to boulders of less than 1 m³ or to material that can be excavated using a maximum of three passes of a ripper. These assumptions have been based on the available information, which is in our opinion not sufficient to determine the quantities of the different materials with sufficient accuracy. However, the total calculated excavation volume is to be considered as a reliable estimation.

Nevertheless, it was noticed during the analysis of the geo-technical longitudinal profiles that the top levels of the overburden do not correspond with the data from the topographic survey "*Curvas nivel*". It is recommended that these profiles be modified as soon as possible, for instance, as a subject during further design.

As a subject during further design we also advise the execution of a bathymetric survey of the flooded areas located under the future WSB. This survey is important for the exact calculation of the backfill quantities. At the stage of conceptual design the water depth of these areas had to be estimated.

The following assumptions were made for quantity estimates:

- Percentages of Gatun rock and overburden in different types of excavation:

Gatun rock	70 %
Overburden	30 %

During excavation, and afterwards during construction of the Lock and entrance walls, the excavated area will have to be dewatered to allow concrete works. As the Lock site is enclosed in a nearly impervious rock formation, the contractor will probably only have to inject some cracks to prevent too much water infiltration. However, care has to be exercised, especially with the many faults which were identified and which could be important in the hydrological context. This problem might need further investigation; however, provision has been made by including lump sums to cover foundation treatment, such as grouting and drainage.

The construction of the walls and also the lock heads are to be considered as rather ordinary concrete works, although the applied volumes are rather gigantic and require concrete batching plants with a very high capacity.

In order to determine the concrete volumes with sufficient accuracy, it was necessary to make drawings for each lock partition, i.e. the 4 Lock heads, the Lock walls and the Entrance walls.

Reference is made to drawings D4-B-401 to 406 (lock walls), D4-B-207 to 219 (lock heads) and D4-I-201 (entrance walls).

These drawings contain the design details of the following:

- Lockwall - Single Option (RC – reinforced concrete gravity wall and counterforts, crushed stone backfill).
- Entrance:
  - Walls in rock– Single Option (RC – reinforced concrete gravity wall and counterforts, crushed stone backfill)
  - Steel piles in muck – Single option (steel piles filled with sand and concrete)

It is to be noted that contrary to the formerly studied Triple Lift Configuration, here, in this instance, only the best construction option which has been proved to be the most economical one in the corresponding former Cost Estimations, is designed and evaluated for each structure.

The concrete structures are of reinforced concrete, which requires a large amount of steel reinforcement.

The quantities (tons) of steel reinforcement have been determined as a fixed weight per m³ of concrete, based on the engineer's judgment and experience with similar constructions (Lock walls at Berendrecht which are also of reinforced concrete, quay walls). *Steel reinforcement is measured in tons [tons].*

The following assumptions were made for quantity estimates:

- Quantity of reinforcement steel in reinforced concrete (RC) used for estimating purposes in the Post Panamax Pacific Locks Project:
  75 kg/m³, according to the structure type, its role, and, of course, as required by the design

The longitudinal culverts at both sides of the Locks are integrated in the Lock walls and Lock heads; as such they do not appear separately in the quantity list.

The Lock walls and Lock heads, as well as the entrance walls are exposed to temperature variations, curing and shrinkage, and therefore they have to be subdivided in independent parts (segments). In this conceptual design the segments are 30 m in length, with some exceptions, for example, in the transition between Lock walls and Lock heads. Each joint between the wall segments is made water and soil tight by means of a rubber joint, which is anchored in the concrete at both sides. *Rubber joints are measured in meters [m].*

At the corner edge of the top of the Lock walls, a steel corner protection profile is provided to protect the concrete against damage from the towing cables. *The protective steel profile is measured in meters [m].*

After construction the walls that require backfill, as shown on the drawings, are filled at the rear with crushed stone that can be recovered from the rock excavations, but the rock has to be crushed properly in a dedicated installation to obtain an acceptable size, suitable for backfilling and compaction in order to avoid settlements afterwards. *Backfilling in crushed stone is measured in cubic meters [m^3].*

Roller compacted concrete (RCC) (*expressed in [m^3]*) is placed to protect the bottom of the Lock Chambers founded in Gatun rock formation and also at the culvert and conduit outlets to prevent erosion and weakening of the fractured rock bottom due to currents and exposure (see drawing D4-B-401 to 405). Holes in the RCC are foreseen to make the layer permeable to prevent uplift pressures caused by the lockages. A gravel layer *[m^3]* is spread beneath the RCC layer and covered by a geotextile *[m^2].*

The sills and the vertical bearings in the Lock heads that make the sealing surface of the gate are constructed with hard rock-like basalt, granite or prefabricated hard concrete blocks. They have to be anchored in the concrete by means of steel anchors. *The blocks are measured in [m^3].*

The gates move with the carriage wagons over rails anchored in the bottom floor of the Lock heads and the sidewall recesses of the recess chamber. Other rails are fixed on the recess walls to guide the gate when moving. *The rails are measured in meter [m].*

Drawing D4-A-403 shows a general plan view of the Locks. It has been used to indicate a number of accessories, such as bollards, fenders, light poles, cable-ducts equipped with steel cover (not indicated), etc… *Such items are always expressed in pieces [pcs].*

The result of quantity estimates for different items is given in the Appendix A.

1.2.3 LOCK OPERATING GATES.

The rolling gate type has been selected for use in the recent triple lift configuration. The layout of the rolling gate is shown on drawings D4-D 200 to 205. Report A4d on Lock gate design gives unit weight of Lock gates for the different sizes according to the Lock head position.

The unit weight allows determining the total weight of each gate, and an additional weight has to be taken into account for wheelbarrow wagons and steel auxiliaries. *The steel weight of the total gate structure is expressed in [tons].*

The sealing of the gate against the basalt or granite blocks is obtained with exotic wooden (azobé) beams that are fixed by bolting to the Lock gate. *These wooden beams are expressed in [m³].*

In order to use the Lock gate chambers as a place to maintain the gates, a slot bulkhead is required. The *bulkhead is a steel construction, expressed in tons [tons].*

1.2.4 ELECTROMECHANICAL EQUIPMENT

Quantities of mechanical equipment, expressed in tons, were based on the experience of the Consultants in large hydropower projects, using graphs and charts relating the weight of equipment with the size and the pressures handled by the proposed equipment. Electrical and power equipment quantities have been based on the conceptual design projects and on the experience provided by the existing Panama Canal Locks.

1.3 COST ESTIMATES

1.3.1 INTRODUCTION

Reference is made to Configuration 1 (Pacific side) -"**3 Lift Lock System**"- Report R4-M. For this Configuration, the cost estimation for the Civil Works was based on the **aggregation method** in which a cost database is created by analyzing the price/costs of similar work (type/volumes) obtained from international past and present market prices, and adjusting them to obtain current prices. These prices, called aggregate prices, include direct and indirect construction costs. The aggregate prices as of the Year 2002 thus obtained are then applied to the Post Panamax Locks Project to establish its cost. This aggregation method is normally applied by the firms constituting the Consortium, and is of common use in Europe to estimate the cost of projects at a conceptual design stage and even in more detailed study stages. As already explained in the fifth paragraph of the Preamble to the present Report, the same unit prices from the Table 2.1 *Aggregate Unit Price* of the above mentioned Triple Lift Lock System-Report R4-M, have been used to establish costs for the harmonized Triple Lift Lock system. Once again the attention is drawn to the fact that the increased steel prices since early 2004 have not yet been taken into account.

1.3.2 COST ESTIMATE FOR CIVIL WORKS

As explained in Paragraph 1.2, the present report presents for each structure of the harmonized Triple Lift Configuration with 3x2 WSB only a single construction option that has been proved to be the most economical one in the former cost estimates. These are the following:

- Lockwall - Single Option (RC – reinforced concrete gravity wall and counterforts, crushed stone backfill).
- Entrance:
  - Walls in rock– Single Option (RC – reinforced concrete gravity wall and counterforts, crushed stone backfill)
  - Steel piles in muck – Single Option (steel piles filled with sand and concrete)

The Water Savings Basins layout presents as well one single scheme with two adjacent basins for each chamber. The first basin is the one with the highest bottom level and closest to the Eastern Lockwall.

As it has been shown in the former Triple Lift Configuration Cost Estimation Report R4 M, the Aggregated Unit Prices are related to the global quantities involved in the Project for the main items. This relation between prices and volumes has been represented by trend graphs presented in the Appendices B of the former cost estimate reports. Considering that it has been proved in the Single Lift Configuration Cost Estimation Report that the differences in quantities between different lock configurations are not significant enough to justify a revision of the formerly selected unit prices and observing that the quantities for the harmonized Triple Lift Configuration with 3x2 WSB are again in the same order of magnitude, it can be finally concluded that, the same series of selected prices remain also valid for calculating the cost of the harmonized Triple Lift Lock Configuration with 3x2 WSB.

The following Table 2.1 presents the complete list of Aggregate Unit Prices used to estimate the cost of the Project.

Table 2.1
Conceptual Design
Post-Panamax Lock Structure
Harmonization Atlantic 3x2 WSB
Aggregate Unit Price

Item	Description	Unit	Selected Unit Price USD 2002
1	**Excavations**		
1,1	Overburden	m³	3,50
1,2	Atlantic muck	m³	0,00
1,3	Gatun rock	m³	4,75
2	**Fill**		
2,1	Backfill	m³	3,00
2,2	Gravel layer	m³	6,00
2,3	Bank protection WSB1	m²	13,00
2,4	Overhaul for spoil (10 km)	m³km	0,30
3	**Concrete**		
3,1	RC	m³	120,00
3,2	RCC	m³	28,00
3,3	Lean Concrete	m²	9,00
3,4	Pavement	m²	24,00
3,5	Concrete layer chamber bottom	m³	90,00
4	**Reinforcement**		
4,1	Steel reinforcement	tons	875,00
5	**Other**		
5,1	Steel corner protection	m	73,00

5,2	Rubber joint	m	71,00
5,3	Geotextile	m²	1,80
5,4	Liner HDPE (WSB)	m²	13,31
5,5	Underlaying protective geotextile (WSB)	m²	1,88
5,6	Geotextile for drainage (WSB)	m²	4,71
5,7	Rails	m	280,00
5,8	Wooden vertical guidances	m	400,00
5,9	Steel for support rail and frames	ton	2.400,00
5,10	Vertical element for seals east/recesses	m³	3.050,00
5,11	Vertical element for seals west	m³	2.700,00
5,12	Horizontal elements for seals lock chamber	m³	2.700,00
5,13	Elements for placement habitat	m³	275,00
5,14	Horizontal elements for seals gate recesses	m³	1.520,00
5,15	Technical building	m²	300
6	**Accessories**		
6,1	Bollards 1500kN	pcs	4.900,00
6,2	Wheel fenders	pcs	540.000
6,3	Roller fenders	pcs	540.000
6,4	Fenders Atlantic side	pcs	50.000
6,5	Fenders Gatun Lake side	pcs	40.000
6,6	Ladders	m	100,00
6,7	Mooring bits	pcs	950,00
7	**Steel piles**		
7,1	Procurement of steel piles	tons	1.200,00
7,2	Driving of steel piles	pcs	7.500,00
7,3	Sandfill steel pile	m³	25,00
7,4	Concrete fill steel pile	m³	120,00
7,5	Steel reinforcement BE500	tons	875,00

Cost Estimates of Civil Works are summarized in the following Table. Detailed information is presented in Appendix B.

Costs of the Civil Works

Summary

Item	Description	Selected Cost USD - 2002
1	**Lock only**	304.362.970
2	**Water Savings Basins only**	114.646.080
3	**Lock and WSB`s**	419.009.050

1.3.3 COST ESTIMATE OF THE ELECTROMECHANICAL EQUIPMENT

1.3.3.1 CULVERT AND CONDUIT VALVES

Estimated Weights of the Culvert and WSB Valves and Bulkheads

The following Table (Ref. Report A4e-3x2) is the base for estimating the price of the valves and bulkheads. The price for welded construction is usually estimated by multiplying a weight by a kg price. That kg price has been estimated at 5 USD/kg, all-inclusive.

	Number	Unit weight (tons)	Total weight (tons)
Culvert valves	16	25.5	408
Culvert bulkheads	8	22.5	180
Culvert valves slots	16	37	592
Culvert bulkhead slots	32	27.1	867
WSB valves	24	20.9	502
WSB bulkheads	6	17.9	107
WSB valves slots	24	41.6	998
WSB bulkhead slots	48	27.6	1325
TOTAL			**4980 tons**

The total price for the **52 fixed-wheel valves** and related bulkheads and slots is estimated to:

4980000 x 5 = ***USD 24.90 Million***

That price is including transport, erection and commissioning. It does not include either the operating machinery (cylinders, oil hydraulic unit, etc) and the maintenance cranes or the control boards.

$5/kg is a usual price “all included” considered for similar valves of welded construction in the hydro field. Welded construction kg price ex-works is considered to be normally in a range of $3 to $3.5. Transportation and erection are estimated to vary between 30 and 40%. The top of the range has been preferred for the valves due to some machining and stainless material (wheels, sealing systems).

Valve operating machinery and local control boards: ***USD 10.40 Million***

The valve operating machinery price has been based on a preliminary budget price given by an important supplier (Bosch Rexroth) for 52 hydraulic cylinders all identical with oil sumps and control boards. A rough comparison was also made with the cost of the refurbishment of hydraulic cylinders for 40 pairs of miter gates at the Panama Canal (for 80 hydraulic cylinders).

Maintenance tools, cranes and railways: ***USD 1.00 Million***

This price is including 2 maintenance gantry cranes of 70ton capacity, span about 7m, 720m of rails and maintenance tooling as handling beam to lower and remove valves and bulkhead from the slots. Weight of cranes has been estimated to 2 x 40 tons, price: 2 x 320,000 = $640,000 (kg price: $8) - Rails: 1,000m x 100kg/m x $3/m =$300,000 – Maintenance tools: $60,000.

Rolling gate operating machinery: ***USD 10.0 Million***

Is composed of:

- 16 main AC motors with variable speed (according to a preliminary budget price of a manufacturer): 16 x 67, 000 = $ 1.1 Million
- 8 primary gear boxes: 8 x 200, 000 = $ 1.6 Million
- 16 secondary gear boxes: 16 x 300,000 = $ 4.8 Million

  The prices of gear boxes have been based on hydro gear boxes prices (kg price between $15 and $25 according to the size)
- balance of equipment (auxiliary AC motors, cable drums, pulleys, cables, bearings,..): $.2.50 Million

1.3.3.2 OPERATING MACHINERY: CONTROL SYSTEM

Estimated budget price: ***USD 2.80 Million***

The budget price is based on the description given in the report A4f-j-3x2. It is including the control equipment, installation, cabling and commissioning.

CPU 1 to 20 (Panboard, Rack 19", I/O,…)	2,100,000
Main Control room	350,000
Backup control Room	50,000
CCTV	300,000
Total	$2,800,000

Prices have been based on unit prices of a similar control system.

1.3.3.3 LIGHTING

Estimated price for 50 high masts, 360 floodlights of 1000W, lock chamber and rolling gates lighting and galleries lighting:

USD 2.00 Million

1.3.3.4 ELECTRICAL AND POWER REQUIREMENTS

Estimated budget price: ***USD 13.15 Million***
Detailed as follow:

		Alternative 4	Alternative 5
1	High Voltage		
1.1	Cables	940,000	1,646,400
1.2	HV Switchgear	1,670,000	1,995,000
2	Transformers	342,000	342,000
3	Emergency power supply		
	Diesel set 1200 kVA + transformers + ...	585,000	585,000
4	Low Voltage		
4.1	Low Voltage switchboard	1,380,000	1,380,000
4.2	Low Voltage Cables	1,280,000	1,280,000
4.3	Low Voltage equipment	297,000	297,000
5	Cable Trays and Supports	1,177,000	1,177,000
6	Miscellaneous	930,000	930,000

Total	9,201,000	10,232,000
Including transportation and erection	**USD 11.75 Million**	**USD 13.15 Million**

Note: No provision has been made either for the operating structures (overhead crane of the maintenance building or for HVAC necessary for control room and HV technical rooms).

Alternative 5, which offers more security, has been selected (see Report Task 4-A4f-j-3x2, *Electrical Power and Power Requirement*). Therefore, the corresponding prices of Alternative 5 have been used in the present Cost Estimation.

1.3.4 COST ESTIMATE FOR LOCK GATES

1.3.4.1 Price - Berendrecht lock gates

The cost of the Berendrecht Lock gates including equipment:

0	General working costs	363,000 USD
1	Detailed calculation and construction drawings	310,000 USD
2	Metal construction + equipment	
	Lock gates (4)	19,288,000 USD
	Lower support wagon (4 + 1)	177,000 USD
	Upper support wagon (4)	544,000 USD
	Maintenance support wagons (24)	186,000 USD
	Bulkhead	575,000 USD
3	Mechanical parts	958,000 USD
4	Positioning and testing	455,000 USD
5	Temporary storage and additional works	198,000 USD
	Total	23,054,000 USD

These costs were accurate in 1983.

The costs include the 4 gates, 5 lower support wagons (1 spare one), 4 upper support wagons, 4 maintenance support wagons (2 gates can be maintained simultaneously) and 1 bulkhead.

When we divide this total sum by the total weight of the 4 gates + equipment:

23,054,000 USD / 6,800,000 kg = 3.390 USD/kg

Knowing that this price was made in 1983, it has to be multiplied with a factor to take into account the price evolution:

3.390 USD/kg x 1.75 = 5.933 USD/kg

We add to this price the transport of the gates from the workshop to the site:

5.933 USD/kg + 0.24 USD/kg = 6.173 USD/kg

We extrapolated this for the complete **harmonized Triple-lift situation with 3x2 WSB**:

3100 t (2 x gate 1) + 10400 t (4 x gate 2/3) + 5000 t (2 x gate 4) + 1774 t (equipment) = **20274 tons**

6.173 USD/kg x 20,274,000 kg = **125,151,402 USD**

1.3.4.2 Fendering

We have foreseen 4 sets of wheel fenders (1 set = 5 wheels), one on each side of the harmonized Triple lift configuration with 3x2 WSB.

Based on recent information the cost of one wheel with casing is 90,000 USD (2002).

The cost of four sets of fenders + positioning on site:

(20 x 90,000 USD) x 1.2 = 2,160,000 USD

This is much cheaper (factor 2) than an extrapolation of the costs of the fendering of the Berendrecht Lock. Based on the evolution during the last years, these materials are less expensive.

Based on recent information the cost of one tidal fender is 50.000 USD (including positioning on site).

1.4 TOTAL PROJECT COST

The Total Project Cost is detailed in the following four Tables:

- Table 3.1 contains the Total Lock Cost.
- Table 3.2 contains the Total Water Saving Basins cost.
- Table 3.3 contains a summary (rounded numbers) of the Total Project Cost.

The total costs of the Civil Works and of the Electromechanical Equipment have been incremented by lump sum percentages corresponding to items not quantified in terms of volume of work but, nevertheless, required for the completion of the project. These items are the following:

- **Detailed Studies and Supervision**

This item includes all the engineering service to be performed after awarding the Civil Work construction contract(s), the detailed execution studies (shop drawings) and the cost of complete works supervision. Excluded from this item are the basic design, final design, preparation of Tender documents, hydraulic model studies, and the geological and geotechnical investigations (except those related directly to the construction).

Based on the FIDIC recommendations, the estimated percentage covering the above Item 1 comes to 7%. This value is applicable to both the Civil Works and the Electromechanical total costs.

- **Instrumentation**

This Item covers purchase, installation and activation of all permanent instruments dedicated to record the physical behavior of the Civil structures. It covers as well the monitoring and reporting during the construction period. It is estimated that 2% of the total cost of the Civil Works is sufficient to cover this Item 2.

- **Grouting and Consolidation**

It is very unlikely that a project of the size of the Post Panamax Lock will not require grouting, drainage and consolidation of the foundation. At the present stage, the geological and geotechnical local characteristics of the Locks foundation are not known in detail but it is likely that some zones might require special foundation treatment, such as impermeabilization grouting, drainage or consolidation grouting. The Item 3 grouting and consolidation aims to cover the costs related to these works. It is estimated that 3% applicable to the total Civil Works cost is sufficient provision to cover this item.

- **Contingencies**

This item covers all the works, services and equipment that cannot be precisely identified and quantified at the present stage of the studies. It is commonly accepted that these contingencies amount to from 15 to

20 percent of the total cost of the Civil Works at a conceptual design stage. Considering that the Civil Works have been defined for the Atlantic Post Panamax Lock Project (3x2 WSB) with quite a high level of precision for a conceptual study stage, the CPP estimate that a contingencies Item amounting to 15% of the total civil works cost is a sufficient provision.

Of course, with the increasing information gained regarding the geological and geotechnical features of the foundation, and with the increased level of detail achieved in the design of the Civil Work, the amount of this contingencies provision will progressively decrease.

Regarding the contingencies for Electromechanical Equipment, it is again commonly accepted that these works are generally quantified with a quite good level of precision, mainly because the geological and geotechnical uncertainties do not affect the cost estimates. At a Conceptual Design stage, a provision of 10% of the total cost of Electromechanical Equipment is considered perfectly adequate to cover the contingencies.

- **Administrative Costs**

This Item includes all the management, communications and various other expenses incurred by the Owner to control the execution of the project. It does *not* include the financial costs. The Administrative Costs are estimated at 2% of the total cost of Civil Works and Electromechanical Equipment.

Table 3.1
Conceptual Design
Post-Panamax Lock Structure
Harmonization Atlantic 3x2 WSB
TOTAL LOCK COST

Item	Description	%	Total USD - 2002
	LOCK		
1	**Civil Works**		**392.628.232**
1,1	Civil works		304.362.970
1,2	Detailed studies and supervision	7%	21.305.408
1,3	Instrumentation	2%	6.087.259
1,4	Grouting and consolidation	3%	9.130.889
1,5	Contingencies	15%	45.654.446
1,6	Administrative costs	2%	6.087.259
2	**Electromechanical equipment**		**207.937.508**
2,1	Electromechanical equipment		174.737.402
2,2	Detailed studies and supervision	7%	12.231.618
2,3	Contingencies	10%	17.473.740
2,4	Administrative costs	2%	3.494.748
	TOTAL LOCK COST		**600.565.740**

Table 3.2

Conceptual Design

Post-Panamax Lock Structure

Harmonization Atlantic 3x2 WSB

TOTAL WSB COST

Item	Description	%	Total USD - 2002
	WSB		
1	**Civil Works**		**147.893.443**
1,1	Civil works		114.646.080
1,2	Detailed studies and supervision	7%	8.025.226
1,3	Instrumentation	2%	2.292.922
1,4	Grouting and consolidation	3%	3.439.382
1,5	Contingencies	15%	17.196.912
1,6	Administrative costs	2%	2.292.922
2	**Electromechanical equipment**		**17.446.590**
2,1	Electromechanical equipment		14.661.000
2,2	Detailed studies and supervision	7%	1.026.270
2,3	Contingencies	10%	1.466.100
2,4	Administrative costs	2%	293.220
	TOTAL WSB COST		**165.340.033**

Table 3.3
Conceptual Design
Post-Panamax Lock Structure
Harmonization Atlantic 3x2 WSB

Summary
of the
Total Project Cost

Item	Description	%	Total USD - 2002
	Total project cost without WSB		601.000.000
	Total project cost with WSB		766.000.000

APPENDIX A

QUANTITIES

TASK 4

Table A.1

Conceptual Design
Post-Panamax Lock Structure
Atlantic 3x2 wsb

CIVIL WORKS

Quantities Summary

Lock without WSB

Item	Description	Unit	Quantity
1	**Excavation**		5.576.977
1,1	Overburden	m³	1.673.093
1,2	Gatun rock	m³	3.903.884
2	**Fill**		
2,1	Backfill	m³	2.218.532
2,2	Gravel layer	m³	28.323
2,3	Bank protection	m²	0
2,4	Overhaul for spoil (10 km)	m³km	22.405.027
3	**Concrete**		
3,1	RC	m³	1.282.414
3,2	RCC	m³	96.851
3,3	Lean Concrete	m²	116.069
3,4	Pavement	m²	133.358
4	**Reinforcement**		
4,1	Steel reinforcement	tons	96.181
5	**Other**		
5,1	Steel corner protection	m	4.693
5,2	Rubber joint	m	7.121
5,3	Geotextile	m²	62.577
5,4	Liner HDPE	m²	3.000
5,5	Underlaying protective geotextile	m²	3.000
5,6	Geotextile for drainage	m²	0
5,7	Rails	m	4.848
5,8	Wooden vertical guidances	m	675
5,9	Steel for support rail and frames	ton	1.228
5,10	Vertical element for seals east/recesses	m³	663
5,11	Vertical element for seals west	m³	843
5,12	Horizontal elements for seals lock chamber	m³	896
5,13	Elements for placement habitat	m³	932
5,14	Horizontal elements for seals gate recesses	m³	152
5,15	Technical building	m²	4.741

TASK 4

Table A.1

Conceptual Design
Post-Panamax Lock Structure
Atlantic 3x2 wsb

CIVIL WORKS

Quantities Summary

Lock without WSB

Item	Description	Unit	Quantity
6	**Accessories**		
6,1	Bollards 1500kN	pcs	122
6,2	Wheel fenders	pcs	4
6,3	Roller fenders	pcs	4
6,4	Fenders Atlantic side	pcs	16
6,5	Ladders	m	122
6,6	Mooring bits	pcs	244
7	**Steel piles**		
7,1	Procurement of steel piles	tons	879
7,2	Driving of steel piles	pcs	10
7,3	Sandfill steel pile	m³	856
7,4	Concrete fill steel pile	m³	554
7,5	Steel reinforcement BE500	tons	28

Table A.2
Excavation and Fill Quantities

Item	Description	Unit	Excavation	Backfill
1	Lock from edge east wall Gatun side up to edge east wall Atlantic side	m³	5.424.591	44.633
1,1	Overburden excavation	m³	1.627.377	
1,2	Gatun Rock excavation	m³	3.797.214	
2	Extra entrance wall Atlantic	m³	152.386	5.651
2,1	Overburden excavation	m³	45.716	
2,2	Gatun Rock excavation	m³	106.670	
3	Backfill for temporary dam			
3,1	Atlantic side	m³		45.000
4	Overhaul for spoil (10 km)	m³km		22.405.027
	Total Volume Excavation / Backfill	m³	5.576.977	95.284

Table A.3
Entrance Walls

Quantities Summary

Item	Description	Unit	Atlantic Side Quantity	Gatun Side Quantity
	Standard 30 m - segment			
1	Reinforced Concrete	m³	3.622	3.622
2	Steel Reinforcement BE500	tons	272	272
3	Backfill Crushed Stone	m³	9.891	9.891
4	Steel Corner Protection	m	30	30
5	Rubber Joint	m	37	37
6	Lean Concrete	m²	612	612
	Quantities for one 30 m-segment:			
	Number of segments of 30 m:		9	6
	Cornersegment			
1	Reinforced Concrete	m³	8.421	7.794
2	Steel Reinforcement BE500	tons	632	585
3	Backfill Crushed Stone	m³	18.654	18.394
4	Steel Corner Protection	m	77	75
5	Rubber Joint	m	37	37
6	Lean Concrete	m²	1.326	1.291
	Curvesegment			
1	Reinforced Concrete	m³	9.494	8.434
2	Steel Reinforcement BE500	tons	712	633
3	Backfill Crushed Stone	m³	15.622	13.550
4	Steel Corner Protection	m	92	84
5	Rubber Joint	m	37	37
6	Lean Concrete	m²	1.451	1.283
	Endsegment			
1	Reinforced Concrete	m³	1.524	1.992
2	Steel Reinforcement BE500	tons	114	149
3	Backfill Crushed Stone	m³	4.161	5.440
4	Steel Corner Protection	m	13	17
5	Rubber Joint	m	37	37

Table A.3

Entrance Walls

Quantities Summary

6	Lean Concrete	m²	257	337
	<u>Steel piles in muck</u>			
1	Procurement of steel piles ϕ 3000 mm - e = 30 mm - L = 40 m	tons	88	
2	Driving of steel piles - L = 40 m	pcs	1	
3	Sandfill steel pile	m³	86	
4	Concrete fill steel pile	m³	55	
5	Steel reinforcement BE500	tons	3	
	Quantities for one pile			
	Number of piles:		10	

Table A.3

Entrance Walls

Quantities Summary

			Quantities Summary	
			Atlantic Side	Gatun Side
Item	Description	Unit	Quantity	Quantity
	Walls			
1	Reinforced Concrete	m^3	52.037	39.953
2	Steel Reinforcement BE500	tons	3.903	2.996
3	Backfill Crushed Stone	m^3	127.455	96.729
4	Steel Corner Protection	m	451	356
5	Rubber Joint	m	444	333
6	Lean Concrete	m^2	8.543	6.582
8	Pavement	m^2	10.119	10.119
	Steel piles in muck			
1	Procurement of steel piles	tons	879	
	ϕ 3000 mm - e = 30 mm - L = 40 m			
2	Driving of steel piles - L = 40 m	pcs	10	
3	Sandfill steel pile	m^3	856	
4	Concrete fill steel pile	m^3	554	
5	Steel reinforcement BE500	tons	28	

TASK 4

Table A.4
Lock Walls

Quantities Summary

Item	Description	Unit	Chamber 1	Chamber 2	Chamber 3
			Quantity	Quantity	Quantity
1	Reinforced Concrete	m³	7.792	7.734	7.698
2	Steel Reinforcement BE500	tons	584	580	577
3	Backfill Crushed Stone	m³	20.044	19.413	19.040
4	Roller compacted concrete	m³	1.005	1.005	1.005
5	Gravel Layer	m³	285	285	285
6	Geotextile	m²	645	645	645
7	Steel Corner Protection	m	30	30	30
8	Rubber joint	m	68	68	68
9	Lean Concrete	m²	899	899	899
11	Pavement	m²	1.391	1.391	1.391
	Quantities for one 30 m-segment:				
	Number of segments of 30 m:		22	22	22

TASK 4

Table A.5

WSB and Conduits (Civil Works)
Side by side conduits disposition

Quantities Summary

Item	Description	Unit	Quantity
1	Reinforced concrete for valve chambers	m^3	37.886
2	Steel reinforcement BE500	tons	2.841
3	Reinforced concrete for conduits	m^3	37.893
4	Steel reinforcement BE500	tons	2.842
5	Reinforced concrete for intakes WSB	m^3	118.152
6	Steel reinforcement BE500	tons	8.861
7	Roller compacted concrete	m^3	160.470
8	Backfill Crushed Stone over conduits	m^3	560.332
9	Reinforced concrete for walls between WSB	m^3	61.227
10	Steel reinforcement BE500	tons	4.592
11	Liner HDPE (WSB)	m^2	170.000
12	Underlaying protective geotextile (WSB)	m^2	170.000
13	Geotextile for drainage (WSB)	m^2	21.000
14	Bank protection (WSB)	m^2	38.000
16	Excavations		
16,1	WSB along Chamber 1	m^3	1.495.356
16,2	WSB along Chamber 2	m^3	1.981.556
16,3	WSB along Chamber 3	m^3	2.143.829
16,4	Extra conduits and valve chambers	m^3	1.170.997
17	Backfill crushed stone along chambers		
17,1	WSB along Chamber 1	m^3	94
17,2	WSB along Chamber 2	m^3	0
17,3	WSB along Chamber 3	m^3	0
18	Lean concrete	m^2	24.329
19	Overhaul for spoil (10 km)	m^{3}km	62.313.120
20	Technical building	m^2	4.320
21	Equalisation layer WSB and spillway bottom	m^3	89.000

TASK 4

Table A.5

WSB and Conduits (Civil Works)

Quantities Summary

Item	Description	Unit	Quantity
1	Reinforced concrete	m³	255.158
2	Steel reinforcement BE500	tons	19.137
3	Roller compacted concrete	m³	160.470
4	Backfill Crushed Stone over conduits	m³	560.332
5	Liner HDPE (WSB)	m²	170.000
6	Underlaying protective geotextile (WSB)	m²	170.000
7	Geotextile for drainage (WSB)	m²	21.000
8	Bank protection (WSB)	m²	38.000
9	Excavations	m³	6.791.738
10	Backfill Crushed Stone along chambers	m³	94
11	Lean concrete	m²	24.329
12	Overhaul for spoil (10 km)	m³km	62.313.120
13	Technical building	m²	4.320
14	Equalisation layer WSB and spillway bottom	m³	89.000

Table A.6
Lock Head Gate

Quantities Summary

Item	Description	Unit	Quantity
1	**Lock Head Gate 1**		
1,1	Reinforced Concrete	m³	94.427
1,2	Steel Reinforcement BE500	ton	7.082
1,3	Backfill crushed stone	m³	16.755
1,4	RCC chamber floor	m³	1.856
1,5	Gravel layer	m³	619
1,6	Geotextile	m²	1.238
1,7	Steel corner protection	m	325
1,8	Rubber joint	m	200
1,9	Lean concrete	m²	5.162
1,10	Pavement	m²	5.330
1,11	Technical building	m²	1.185
2	**Lock Head Gate 2**		
2,1	Reinforced Concrete	m³	138.280
2,2	Steel Reinforcement BE500	ton	10.371
2,3	Backfill crushed stone	m³	45.528
2,4	RCC chamber floor	m³	2.434
2,5	Gravel layer	m³	811
2,6	Geotextile	m²	1.623
2,7	Steel corner protection	m	331
2,8	Rubber joint	m	200
2,9	Lean concrete	m²	6.319
2,10	Pavement	m²	5.330
2,11	Technical building	m²	1.185
3	**Lock Head Gate 3**		
3,1	Reinforced Concrete	m³	138.131
3,2	Steel Reinforcement BE500	ton	10.360
3,3	Backfill crushed stone	m³	44.326
3,4	RCC chamber floor	m³	2.434
3,5	Gravel layer	m³	811
3,6	Geotextile	m²	1.623
3,7	Steel corner protection	m	331
3,8	Rubber joint	m	200
3,9	Lean concrete	m²	6.319
3,10	Pavement	m²	5.330
3,11	Technical building	m²	1.185

Table A.6

Lock Head Gate

Quantities Summary

Item	Description	Unit	Quantity
4	**Lock Head Gate 4**		
4,1	Reinforced Concrete	m³	137.327
4,2	Steel Reinforcement BE500	ton	10.300
4,3	Backfill crushed stone	m³	42.665
4,4	RCC chamber floor	m³	2.434
4,5	Gravel layer	m³	811
4,6	Geotextile	m²	1.623
4,7	Steel corner protection	m	331
4,8	Rubber joint	m	200
4,9	Lean concrete	m²	6.319
4,10	Pavement	m²	5.330
4,11	Technical building	m²	1.185
5	**Concrete L-shaped walls and walls in backfilled area to avoid by-pass seepage behind lock heads 1, 2, 3 and 4**		
5,1	Reinforced Concrete	m³	27.819
5,2	Steel Reinforcement BE500	ton	2.086
5,3	Backfill crushed stone	m³	126.830

TASK 4

Table A.7

Transition Segment

Quantities Summary

Item	Description	Unit	Quantity
1	**Lock Head Gate 1**		
1,1	Segment with inlet zone east side		
1,11	Reinforced Concrete	m³	11.697
1,12	Steel Reinforcement BE500	tons	877
1,13	Backfill Crushed Stone	m³	22.095
1,14	Steel Corner Protection	m	54
1,15	Rubber Joint	m	60
1,16	Lean Concrete	m²	1.555
1,17	Roller compacted concrete	m³	2.007
1,18	Gravel Layer	m³	669
1,19	Geotextile	m²	1.338
1,2	Segment with inlet zone west side		
1,21	Reinforced Concrete	m³	11.786
1,22	Steel Reinforcement BE500	tons	884
1,23	Backfill Crushed Stone	m³	22.348
1,24	Steel Corner Protection	m	53
1,25	Rubber Joint	m	60
1,26	Lean Concrete	m²	1.579
1,27	Roller compacted concrete	m³	2.007
1,28	Gravel Layer	m³	669
1,29	Geotextile	m²	1.338
1,3	Segment side chamber 1 east side		
1,31	Reinforced Concrete	m³	7.662
1,32	Steel Reinforcement BE500	tons	575
1,33	Backfill Crushed Stone	m³	19.710
1,34	Roller compacted concrete	m³	989
1,35	Gravel layer	m³	280
1,36	Geotextile	m²	634
1,37	Steel Corner Protection	m	30
1,38	Rubber joint	m	68
1,39	Lean Concrete	m²	884
1,4	Segment side chamber 1 west side		
1,41	Reinforced Concrete	m³	7.662
1,42	Steel Reinforcement BE500	tons	575

Table A.7

Transition Segment

Quantities Summary

1,43	Backfill Crushed Stone	m³	19.710
1,44	Roller compacted concrete	m³	989
1,45	Gravel layer	m³	280
1,46	Geotextile	m²	634
1,47	Steel Corner Protection	m	30
1,48	Rubber joint	m	68
1,49	Lean Concrete	m²	884
2	**Lock Head Gate 2**		
2,1	<u>Segment side chamber 1 east side</u>		
2,11	Reinforced Concrete	m³	9.870
2,12	Steel Reinforcement BE500	tons	740
2,13	Backfill Crushed Stone	m³	25.389
2,14	Roller compacted concrete	m³	1.273
2,15	Gravel layer	m³	361
2,16	Geotextile	m²	817
2,17	Steel Corner Protection	m	38
2,18	Rubber joint	m	68
2,19	Lean Concrete	m²	1.139
2,2	<u>Segment side chamber 1 west side</u>		
2,21	Reinforced Concrete	m³	9.870
2,22	Steel Reinforcement BE500	tons	740
2,23	Backfill Crushed Stone	m³	25.389
2,24	Roller compacted concrete	m³	1.273
2,25	Gravel layer	m³	361
2,26	Geotextile	m²	817
2,27	Steel Corner Protection	m	38
2,28	Rubber joint	m	68
2,29	Lean Concrete	m²	1.139
2,3	<u>Segment side chamber 2 east side</u>		
2,31	Reinforced Concrete	m³	6.316
2,32	Steel Reinforcement BE500	tons	474
2,33	Backfill Crushed Stone	m³	15.854
2,34	Roller compacted concrete	m³	821
2,35	Gravel layer	m³	233
2,36	Geotextile	m²	527
2,37	Steel Corner Protection	m	25

Table A.7

Transition Segment

Quantities Summary

2,38	Rubber joint	m	68
2,39	Lean Concrete	m²	734
2,4	Segment side chamber 2 west side		
2,41	Reinforced Concrete	m³	6.316
2,42	Steel Reinforcement BE500	tons	474
2,43	Backfill Crushed Stone	m³	15.854
2,44	Roller compacted concrete	m³	821
2,45	Gravel layer	m³	233
2,46	Geotextile	m²	527
2,47	Steel Corner Protection	m	25
2,48	Rubber joint	m	68
2,49	Lean Concrete	m²	734
3	**Lock Head Gate 3**		
3,1	Segment side chamber 2 east side		
3,11	Reinforced Concrete	m³	10.183
3,12	Steel Reinforcement BE500	tons	764
3,13	Backfill Crushed Stone	m³	25.560
3,14	Roller compacted concrete	m³	1.324
3,15	Gravel layer	m³	375
3,16	Geotextile	m²	849
3,17	Steel Corner Protection	m	40
3,18	Rubber joint	m	68
3,19	Lean Concrete	m²	1.184
3,2	Segment side chamber 2 west side		
3,21	Reinforced Concrete	m³	10.183
3,22	Steel Reinforcement BE500	tons	764
3,23	Backfill Crushed Stone	m³	25.560
3,24	Roller compacted concrete	m³	1.324
3,25	Gravel layer	m³	375
3,26	Geotextile	m²	849
3,27	Steel Corner Protection	m	40
3,28	Rubber joint	m	68
3,29	Lean Concrete	m²	1.184
3,3	Segment side chamber 3 east side		
3,31	Reinforced Concrete	m³	6.287
3,32	Steel Reinforcement BE500	tons	472

Table A.7
Transition Segment

Quantities Summary

3,33	Backfill Crushed Stone	m^3	15.549
3,34	Roller compacted concrete	m^3	821
3,35	Gravel Layer	m^3	233
3,36	Geotextile	m^2	527
3,37	Steel Corner Protection	m	25
3,38	Rubber joint	m	68
3,39	Lean Concrete	m^2	734
3,4	<u>Segment side chamber 3 west side</u>		
3,41	Reinforced Concrete	m^3	6.287
3,42	Steel Reinforcement BE500	tons	472
3,43	Backfill Crushed Stone	m^3	15.549
3,44	Roller compacted concrete	m^3	821
3,45	Gravel Layer	m^3	233
3,46	Geotextile	m^2	527
3,47	Steel Corner Protection	m	25
3,48	Rubber joint	m	68
3,49	Lean Concrete	m^2	734
4	**Lock Head Gate 4**		
4,1	<u>Segment side chamber 3 east side</u>		
4,11	Reinforced Concrete	m^3	10.136
4,12	Steel Reinforcement BE500	tons	760
4,13	Backfill Crushed Stone	m^3	25.069
4,14	Roller compacted concrete	m^3	1.324
4,15	Gravel Layer	m^3	375
4,16	Geotextile	m^2	849
4,17	Steel Corner Protection	m	40
4,18	Rubber joint	m	68
4,19	Lean Concrete	m^2	1.184
4,2	<u>Segment side chamber 3 west side</u>		
4,21	Reinforced Concrete	m^3	10.136
4,22	Steel Reinforcement BE500	tons	760
4,23	Backfill Crushed Stone	m^3	25.069
4,24	Roller compacted concrete	m^3	1.324
4,25	Gravel Layer	m^3	375
4,26	Geotextile	m^2	849
4,27	Steel Corner Protection	m	40

TASK 4

Table A.7
Transition Segment

Quantities Summary

4,28	Rubber joint	m	68
4,29	Lean Concrete	m^2	1.184
4,3	<u>Segment with outlet zone east side</u>		
4,31	Reinforced Concrete	m^3	9.263
4,32	Steel Reinforcement BE500	tons	695
4,33	Backfill Crushed Stone	m^3	18.098
4,34	Steel Corner Protection	m	44
4,35	Rubber Joint	m	60
4,36	Lean Concrete	m^2	1.294
4,37	Roller compacted concrete	m^3	2.113
4,38	Gravel Layer	m^3	704
4,39	Geotextile	m^2	1.409
4,4	<u>Segment with outlet zone west side</u>		
4,41	Reinforced Concrete	m^3	9.859
4,42	Steel Reinforcement BE500	tons	739
4,43	Backfill Crushed Stone	m^3	19.222
4,44	Steel Corner Protection	m	45
4,45	Rubber Joint	m	60
4,46	Lean Concrete	m^2	1.338
4,47	Roller compacted concrete	m^3	2.113
4,48	Gravel Layer	m^3	704
4,49	Geotextile	m^2	1.409

TASK 4

Table A.7
Transition Segment

Quantities Summary

Quantities Summary

Item	Description	Unit	Quantity
1	Reinforced Concrete	m^3	143.512
2	Steel Reinforcement BE500	tons	10.763
3	Backfill Crushed Stone	m^3	336.026
4	Steel Corner Protection	m	588
5	Rubber Joint	m	1.056
6	Lean Concrete	m^2	17.484
7	Roller compacted concrete	m^3	21.343
8	Gravel Layer	m^3	6.461
9	Geotextile	m^2	13.900

TASK 4

Table A.8

Lock Head Gate

Quantities Summary
Equipment (Civil Part)

Item	Description	Unit	Quantity
1	**Lock Head Gate 1**		
1,1	Equipment lock gate (civil part)		
1.1.1	Rails USW	m	260
1.1.2	Rails LSW	m	260
1.1.3	Rails MSW	m	432
1.1.4	Rails horizontale guidances in recesses	m	260
1.1.5	Wooden vertical guidance in recesses	m	110
1.1.6	Steel for support rails USW	tons	104
1.1.7	Steel for support rails LSW	tons	104
1.1.8	Steel for support rails guidance	tons	39
1.1.9	Maintenance support frames	tons	60
1,2	Equipment lock head (civil part)		
1.2.1	Vertical elements for seals - east/recesses	m³	124
1.2.2	Vertical elements for seals - west	m³	157
1.2.3	Horizontal elements for seals- lock chamber	m³	224
1.2.4	Elements for placement habitat	m³	233
1.2.5	Horizontal elements for seals- gate recesses	m³	38
2	**Lock Head Gate 2**		
2,1	Equipment lock gate (civil part)		
2.1.1	Rails USW	m	260
2.1.2	Rails LSW	m	260
2.1.3	Rails MSW	m	432
2.1.4	Rails horizontal guidance in recesses	m	260
2.1.5	Wooden vertical guidance in recesses	m	190
2.1.6	Steel for support rails USW	tons	104
2.1.7	Steel for support rails LSW	tons	104
2.1.8	Steel for support rails guidance	tons	39
2.1.9	Maintenance support frames	tons	60
2,2	Equipment lock head (civil part)		
2.2.1	Vertical elements for seals - east/recesses	m³	182
2.2.2	Vertical elements for seals - west	m³	233
2.2.3	Horizontal elements for seals- lock chamber	m³	224
2.2.4	Elements for placement habitat	m³	233
2.2.5	Horizontal elements for seals- gate recesses	m³	38

TASK 4

Table A.8

Lock Head Gate

Quantities Summary

Equipment (Civil Part)

Item	Description	Unit	Quantity
3	**Lock Head Gate 3**		
3,1	Equipment lock gate (civil part)		
3.1.1	Rails USW	m	260
3.1.2	Rails LSW	m	260
3.1.3	Rails MSW	m	432
3.1.4	Rails horizontal guidances in recesses	m	260
3.1.5	Wooden vertical guidance in recesses	m	190
3.1.6	Steel for support rails USW	tons	104
3.1.7	Steel for support rails LSW	tons	104
3.1.8	Steel for support rails guidance	tons	39
3.1.9	Maintenance support frames	tons	60
3,2	Equipment lock head (civil part)		
3.2.1	Vertical elements for seals - east/recesses	m³	182
3.2.2	Vertical elements for seals - west	m³	228
3.2.3	Horizontal elements for seals- lock chamber	m³	224
3.2.4	Elements for placement habitat	m³	233
3.2.5	Horizontal elements for seals- gate recesses	m³	38
4	**Lock Head Gate 4**		
4,1	Equipment lock gate (civil part)		
4.1.1	Rails USW	m	260
4.1.2	Rails LSW	m	260
4.1.3	Rails MSW	m	432
4.1.4	Rails horizontale guidances in recesses	m	260
4.1.5	Wooden vertical guidance in recesses	m	185
4.1.6	Steel for support rails USW	tons	104
4.1.7	Steel for support rails LSW	tons	104
4.1.8	Steel for support rails guidance	tons	39
4.1.9	Maintenance support frames	tons	60
4,2	Equipment lock head (civil part)		
4.2.1	Vertical elements for seals - east/recesses	m³	175
4.2.2	Vertical elements for seals - west	m³	225
4.2.3	Horizontal elements for seals- lock chamber	m³	224
4.2.4	Elements for placement habitat	m³	233
4.2.5	Horizontal elements for seals- gate recesses	m³	38

TASK 4

Table A.9
ACCESSORIES

Quantities Summary

Item	Description	Unit	Quantity
1	**Accessories**		
1,1	Bollards 1500kN	pcs	122
1,2	Wheel fenders	pcs	4
1,3	Roller fenders	pcs	4
1,4	Fenders Atlantic side	pcs	16
1,6	Ladders	pcs	122
1,7	Mooring bits	pcs	244

Table A.10

ELECTROMECHANICAL EQUIPMENT

Quantities Summary

Item	Description	Unit	Quantity (pcs)	Unit Weight (t)	Total Weight (t)
1	**EM Equipment Lock**				
1,1	Lock gates				
1.1.1	Lock head 1			*Total 1.1.1.*	**3.410**
	Lock gates (2)	tons	2	1.550	3.100
	Bulkheads (1)	tons	1	200	200
	Upper support wagon (2)	tons	2	30	60
	Lower support wagon (2)	tons	2	25	50
1.1.2	Lock head 2			*Total 1.1.2.*	**5.660**
	Lock gates (2)	tons	2	2.600	5.200
	Bulkheads (1)	tons	1	300	300
	Upper support wagon (2)	tons	2	45	90
	Lower support wagon (2)	tons	2	35,0	70
1.1.3	Lock head 3			*Total 1.1.3.*	**5.660**
	Lock gates (2)	tons	2	2.600	5.200
	Bulkheads (1)	tons	1	300	300
	Upper support wagon (2)	tons	2	45	90
	Lower support wagon (2)	tons	2	35,0	70
1.1.4	Lock head 4			*Total 1.1.4.*	**5.460**
	Lock gates (2)	tons	2	2.500	5.000
	Bulkheads (1)	tons	1	300	300
	Upper support wagon (2)	tons	2	45	90
	Lower support wagon (2)	tons	2	35,0	70
1.1.5	Spare parts			*Total 1.1.5.*	**84**
	Lower support wagon (LH1)	tons	1	35	35
	Lower support wagon (LH2, 3, 4)	tons	1	25	25
	Maintenance support wagons (LH1)	tons	12	1	12
	Maintenance support wagons (LH2, 3, 4)	tons	12	1	12
1,2	Culvert valves and bulkheads			*Total 1.2:*	**2.047**
1.2.1	Culvert valves	tons	16	26	408
1.2.2	Culvert bulkheads	tons	8	23	180
1.2.3	Culvert valves slot	tons	16	37	592
1.2.4	Culvert bulkhead slots	tons	32	27	867
1,4	Support equipment		1		
1,5	Control system		1		
1,6	Lighting System		1		
1,7	Electrical and Power System		1		

TASK 4

Table A.10

ELECTROMECHANICAL EQUIPMENT

Quantities Summary

Item	Description	Unit	Quantity (pcs)	Unit Weight (t)	Total Weight (t)
2	**EM Equipment WSB**			*Total 2.:*	**2.932**
2,1	WSB valves	tons	24	21	502
2,3	WSB bulkheads	tons	6	18	107
2,4	WSB valves slots	tons	24	42	998
2,6	WSB bulkheads slots	tons	48	28	1.325

TASK 4

Table A.11
Construction and permanent dams

Quantities Summary

Item	Description	Unit	Quantity
1	**Liner HDPE**		
1,1	Atlantic Side	m²	3000
2	**Underlaying protective geotextile**		
2,1	Atlantic Side	m²	3000

APPENDIX B

COST ESTIMATES

TASK 4

Table B.1.1
Conceptual Design
Post-Panamax Lock Structure
Atlantic 3x2 wsb
Total Cost Civil Works

Lock without WSB

Item	Description	Unit	Quantity	Selected Unit Price	
				Unit Price	Total USD
1	**Excavation**				**24.399.274**
1,1	Overburden	m³	1.673.093	3,50	5.855.826
1,2	Gatun rock	m³	3.903.884	4,75	18.543.449
2	**Fill**				**13.547.043**
2,1	Backfill	m³	2.218.532	3,00	6.655.596
2,2	Gravel layer	m³	28.323	6,00	169.939
2,3	Bank protection	m²	0	13,00	0
2,4	Overhaul for spoil (10 km)	m³km	22.405.027	0,30	6.721.508
3	**Concrete**				**160.846.678**
3,1	RC	m³	1.282.414	120,00	153.889.632
3,2	RCC	m³	96.851	28,00	2.711.832
3,3	Lean Concrete	m²	116.069	9,00	1.044.621
3,4	Pavement	m²	133.358	24,00	3.200.592
4	**Reinforcement**				**84.158.393**
4,1	Steel reinforcement	tons	96.181	875,00	84.158.393
5	**Other**				**14.208.059**
5,1	Steel corner protection	m	4.693	73,00	342.590
5,2	Rubber joint	m	7.121	71,00	505.591
5,3	Geotextile	m²	62.577	1,80	112.638
5,4	Liner HDPE	m²	3.000	13,31	39.930
5,5	Underlaying protective geotextile	m²	3.000	1,88	5.640
5,6	Geotextile for drainage	m²	0	4,71	0
5,7	Rails	m	4.848	280,00	1.357.440
5,8	Wooden vertical guidances	m	675	400,00	270.000
5,9	Steel for support rail and frames	ton	1.228	2.400,00	2.947.200
5,10	Vertical element for seals east/recesses	m³	663	3.050,00	2.022.150
5,11	Vertical element for seals west	m³	843	2.700,00	2.276.100
5,12	Horizontal elements for seals lock chamber	m³	896	2.700,00	2.419.200
5,13	Elements for placement habitat	m³	932	275,00	256.300
5,14	Horizontal elements for seals gate recesses	m³	152	1.520,00	231.040
5,15	Technical building	m²	4.741	300,00	1.422.240

TASK 4

Table B.1.1
Conceptual Design
Post-Panamax Lock Structure
Atlantic 3x2 wsb

Total Cost Civil Works

Lock without WSB

				Selected Unit Price	
Item	Description	Unit	Quantity	Unit Price	Total USD
6	**Accessories**				**5.961.800**
6,1	Bollards 1500kN	pcs	122	4.900,00	597.800
6,2	Wheel fenders	pcs	4	540.000,00	2.160.000
6,3	Roller fenders	pcs	4	540.000,00	2.160.000
6,4	Fenders Atlantic side	pcs	16	50.000,00	800.000
6,5	Ladders	m	122	100,00	12.200
6,6	Mooring bits	pcs	244	950,00	231.800
7	**Steel piles**				**1.241.723**
7,1	Procurement of steel piles	tons	879	1.200,00	1.054.560
7,2	Driving of steel piles	pcs	10	7.500,00	75.000
7,3	Sandfill steel pile	m³	856	25,00	21.407
7,4	Concrete fill steel pile	m³	554	120,00	66.508
7,5	Steel reinforcement BE500	tons	28	875,00	24.248
	Total Cost				**304.362.970**

TASK 4

Table B.1.2
Conceptual Design
Post-Panamax Lock Structure
Atlantic 3x2 wsb

Total Cost Civil Works WSB
Side by side conduits disposition

Item	Description	Unit	Quantity	Selected Unit Price	
				Unit Price	Total USD
1	Reinforced concrete	m^3	255.158	120,00	30.618.946
2	Steel reinforcement BE500	tons	19.137	875,00	16.744.736
3	Roller compact concrete over conduits	m^3	160.470	28,00	4.493.160
4	Backfill crushed stone over conduits	m^3	560.332	3,00	1.680.996
5	Liner HDPE (WSB)	m^2	170.000	13,31	2.262.700
6	Underlaying protective geotextile (WSB)	m^2	170.000	1,88	319.600
7	Geotextile for drainage (WSB)	m^2	21.000	4,71	98.910
8	Bank protection (WSB)	m^2	38.000	13,00	494.000
9	Excavation				
9,1	Overburden excavation	m^3	2.037.521	3,50	7.131.325
9,2	Gatun Rock excavation	m^3	4.754.217	4,75	22.582.529
10	Backfill crushed stone along chambers	m^3	94	3,00	282
11	Lean concrete	m^2	24.329	9,00	218.961
12	Overhaul for spoil (10km)	m^3km	62.313.120	0,30	18.693.936
13	Technical building	m^2	4.320	300,00	1.296.000
14	Equalisation layer WSB and spillway bottom	m^3	89.000	90,00	8.010.000
	Total Cost				**114.646.080**

TASK 4

Table B.1.3
Conceptual Design
Post-Panamax Lock Structure
Atlantic 3x2 wsb
Civil Works
Lock Cost by Structure

Item	Description	Total USD - 2002
1	Excavation and Fill for lock	31.406.635
2	Entrance walls	19.725.674
3	Lock walls	103.949.546
4	Lock heads	143.273.746
5	Accessories	5.961.800
6	Dams	45.570
	TOTAL COST LOCK	304.362.970
6	WSB and conduits (excavation and fill included)	114.646.080
	TOTAL COST WITH WSB	419.009.050

Table B.2

Cost Estimate
Excavation and Fill

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Excavation				
1,1	Overburden excavation	m³	3,50	1.673.093	5.855.826
1,2	Gatun Rock excavation	m³	4,75	3.903.884	18.543.449
2	Fill				
2,1	Backfill	m³	3,00	95.284	285.852
2,2	Overhaul for spoil (10 km)	m³km	0,30	22.405.027	6.721.508
	Total Cost				**31.406.635**

TASK 4

Table B.3

Cost Estimate
Entrance Walls

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
	Walls				
1	Reinforced Concrete	m³	120,00	91.989	11.038.700
2	Steel Reinforcement BE500	tons	875,00	6.899	6.036.789
3	Backfill Crushed Stone	m³	3,00	224.184	672.552
4	Steel Corner Protection	m	73,00	807	58.902
5	Rubber Joint	m	71,00	777	55.167
6	Lean Concrete	m²	9,00	15.125	136.129
7	Pavement	m²	24,00	20.238	485.712
	Steel piles				
1	Procurement of steel piles ϕ 3000 mm - e = 30 mm - L = 40 m	tons	1.200,00	879	1.054.560
2	Driving of steel piles - L = 40 m	pcs	7.500,00	10	75.000
3	Sandfill steel pile	m³	25,00	856	21.407
4	Concrete fill steel pile	m³	120,00	554	66.508
5	Steel reinforcement BE500	tons	875	28	24.248
	Total Cost				**19.725.674**

TASK 4

Table B.4
Cost Estimate
Lock Walls

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Reinforced Concrete	m^3	120,00	510.928	61.311.360
2	Steel Reinforcement BE500	tons	875,00	38.320	33.529.650
3	Backfill Crushed Stone	m^3	3,00	1.286.934	3.860.802
4	Roller compacted concrete	m^3	28,00	66.350	1.857.794
5	Gravel Layer	m^3	6,00	18.810	112.860
6	Geotextile	m^2	1,80	42.570	76.626
7	Steel Corner Protection	m	73,00	1.980	144.540
8	Rubber joint	m	71,00	4.488	318.648
9	Lean Concrete	m^2	9,00	59.341	534.065
10	Pavement	m^2	24,00	91.800	2.203.200
	Total Cost				**103.949.546**

TASK 4

Table B.5
Cost Estimate
WSB and Conduits (Civil Works)
Side by side conduits disposition

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Reinforced concrete	m^3	120,00	255.158	30.618.946
2	Steel reinforcement BE500	tons	875,00	19.137	16.744.736
3	Roller compact concrete over conduits	m^3	28,00	160.470	4.493.160
4	Backfill crushed stone over conduits	m^3	3,00	560.332	1.680.996
5	Liner HDPE (WSB)	m^2	13,31	170.000	2.262.700
6	Underlaying protective geotextile (WSB)	m^2	1,88	170.000	319.600
7	Geotextile for drainage (WSB)	m^2	4,71	21.000	98.910
8	Bank protection (WSB)	m^2	13,00	38.000	494.000
9	Excavation				
9,1	Overburden excavation	m^3	3,50	2.037.521	7.131.325
9,2	Gatun rock excavation	m^3	4,75	4.754.217	22.582.529
10	Backfill crushed stone along chambers	m^3	3,00	94	282
11	Lean concrete	m^2	9,00	24.329	218.961
12	Overhaul for spoil (10km)	m^3km	0,30	62.313.120	18.693.936
13	Technical building	m^2	300,00	4.320	1.296.000
14	Equalisation layer WSB and spillway bottom	m^3	90,00	89.000	8.010.000
	Total Cost				**114.646.080**

TASK 4

Table B.6

Cost Estimate
Lock Head Gate

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Reinforced Concrete	m³	120,00	535.984	64.318.080
2	Steel Reinforcement BE500	ton	875,00	40.199	35.173.950
3	Backfill crushed stone	m³	3,00	276.104	828.312
5	RCC chamber floor	m³	28,00	9.158	256.431
6	Gravel layer	m³	6,00	3.052	18.311
7	Geotextile	m²	1,80	6.107	10.992
8	Steel corner protection	m	73,00	1.318	96.214
9	Rubber joint	m	71,00	800	56.800
10	Lean concrete	m²	9,00	24.119	217.071
11	Pavement	m²	24,00	21.320	511.680
12	Technical building	m²	300,00	4.741	1.422.240
	Total Cost				**102.910.080**

TASK 4

Table B.7

Cost Estimate
Transition Segment

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Reinforced concrete	m³	120,00	143.512	17.221.493
2	Steel reinforcement BE500	ton	875,00	10.763	9.418.004
3	Backfill crushed stone	m³	3,00	336.026	1.008.078
4	Steel corner protection	m	73,00	588	42.933
5	Rubber joint	m	71,00	1.056	74.976
6	Lean concrete	m²	9,00	17.484	157.356
9	RCC	m³	28,00	21.343	597.607
10	Gravel layer	m³	6,00	6.461	38.768
11	Geotextile	m²	1,80	13.900	25.021
	Total Cost				**28.584.236**

TASK 4

Table B.8

Cost Estimate

Lock Head Gate

Equipment (Civil Part)

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Equipment lock gate (civil part)				4.574.640
1,1	Rails	m	280,00	4.848	1.357.440
1,2	Wooden vertical guidances	m	400,00	675	270.000
1,3	Steel for support rails and frames	tons	2.400,00	1.228	2.947.200
2	Equipment lock head (civil part)				7.204.790
2,1	Vertical elements for seals - east/recesses	m³	3.050,00	663	2.022.150
2,2	Vertical elements for seals - west	m³	2.700,00	843	2.276.100
2,3	Horizontal elements for seals- lock chamber	m³	2.700,00	896	2.419.200
2,4	Elements for placement habitat	m³	275,00	932	256.300
2,5	Horizontal elements for seals- gate recesses	m³	1.520,00	152	231.040
	Total Cost				**11.779.430**

TASK 4

Table B.9

Cost Estimate
Accessories

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	**Accessories**				
1,1	Bollards 1500kN	pcs	4.900	122	597.800
1,2	Wheel fenders	pcs	540.000	4	2.160.000
1,3	Roller fenders	pcs	540.000	4	2.160.000
1,4	Fenders Atlantic side	pcs	50.000	16	800.000
1,5	Ladders	m	100	122	12.200
1,6	Mooring bits	pcs	950	244	231.800
	Total Cost				**5.961.800**

TASK 4

Table B.10

Cost Estimate

ELECTROMECHANICAL EQUIPMENT

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	**EM Equipment lock**				**174.737.402**
1,1	EM Equipment Lock (rolling gates and bulkheads)	tons	6.173	20.274	125.151.402
1,2	EM Equipment Lock (valves and bulkheads)	tons	5.000	2.047	10.236.000
1,3	Support equipment		21.400.000	1	21.400.000
1,4	Control system		2.800.000	1	2.800.000
1,5	Lighting System		2.000.000	1	2.000.000
1,6	Electrical and Power System (alternative 5)		13.150.000	1	13.150.000
2	**EM Equipment WSB (Support and control system**	tons	5.000	2.932	**14.661.000**
	Total Cost				**189.398.402**

TASK 4

Table B.11

Cost estimate

Construction and permanent dams

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Liner HDPE	m²	13,31	3.000	39.930
2	Underlaying protective geotextile	m²	1,88	3.000	5.640
	Total Cost				**45.570**

Alternative Conceptual Design of Pacific and Atlantic Post-Panamax Locks – 3x2 WSB – Contract SAA-150551

ATLANTIC LOCKS 3x2 wsb

Task A4m-3x2- QUANTITIES AND COST ESTIMATION

Rev B

Tractebel Development Engineering   TECHNUM   COYNE ET BELLIER   Compagnie Nationale du Rhône

in association with

SBE   PORT OF ANTWERP   FITA AOSO

1 Quantities and Cost Estimation

1.1 PREAMBLE

The harmonized Triple Lift Lock configuration for the new Post Panamax Locks at the Atlantic side of the Panama Canal is a huge construction project, probably one of the largest that are going to be built during the forthcoming decades.

A total construction cost for the **Pacific** Locks has already been quantified:

- for the Triple Lift Lock Configuration and presented by CPP in November 2002 in the Final Report - 3 Steps Lock System - Task 4 Chapter R4-M Cost Estimation.
- for the Single Lift Lock Configuration and presented by CPP in March 2003 in the Final Report - Single Lift Lock System - Task 4 Chapter R4-M Cost Estimation.
- for the Double Lift Lock Configuration and presented by CPP in May 2003 in the Final Report - Double Lift Lock System - Task 4 Chapter R4-M Cost Estimation.
- For the actualized Triple Lift Lock Configuration and presented by CPP in April 2005 in the Final Report – Pacific Locks Actualization – Task 4 Chapter P4m Quantities and Cost estimation.

A total construction cost for the harmonized Triple Lift Lock configuration with 3x3 WSB at the Atlantic side has also been quantified. It is presented by CPP in May 2005 in the Final report – Atlantic Locks Harmonization – Task 4 Chapter A4m Quantities and Cost estimation.

The present Report contains quantities and cost estimates of the Civil Works and Electromechanical Equipment required to build the Post Panamax Atlantic Locks of the Panama Canal in its harmonized Triple Lift configuration with 3x2 WSB.

The costs of the present project have been based on the same aggregated unit price list prepared and justified in the above first mentioned Report (3 Steps Lock System - Task 4 Chapter R4-M Cost Estimation). However it has to be mentioned that generally the steel prices have been increasing strongly since early 2004. For reasons of comparison between original and harmonization the prices have not yet been modified, which means that the new total cost is slightly underestimated.

The present Report consolidates individual reports prepared by the different CPP teams, each in accordance with their particular field of know-how. It groups the information provided in three Chapters: Quantities, Cost Estimates, and Total Project Cost. In addition, the Report includes two Appendices that contain detailed information on quantities of construction item (Appendix A) and project cost estimates (Appendix B).

1.2 QUANTITIES

1.2.1 GENERAL

According to the different tasks that have been undertaken during the harmonization study, it was possible to identify all new design criteria, , and determine the most suitable Lock siting and layout. Subsequently, the concept studies of the numerous elements of the new Locks were actualized, as there are:

- Lock walls;
- Filling and Emptying System, including Water Saving Basins;
- Lock Operating Gates;
- Culvert and Conduit Valves;
- Electromechanical Devices;

For each of these elements, studies and analysis results have been included in the preceding chapters of this final report. They have been sufficiently worked out by means of proper modern engineering design tools, shown on drawings with all required dimensions on a conceptual level of design, in order to allow calculating the quantities of materials involved. The Terms of Reference require an accuracy of 25% for the cost estimation; therefore it is necessary that the quantities are determined at a higher level of precision, which is most certainly being obtained.

All Quantities are summarized in a series of Tables presented in the Appendix A of the present report.

1.2.2 LOCK WALLS & ENTRANCE WALLS

Lock walls and entrance walls are gravity type retaining walls, which have to be constructed in an open excavation. Due to the enormous dimensions, especially in depth, they require very large excavations, mainly in Gatun rock.

In the Task 3 Report of the Triple Lift Configuration (Pacific side), dealing with the excavation volumes for the new canal by-pass, an estimation of $607,000,000 USD (based on unit prices communicated by ACP as to year 2000) has been put forward as a construction cost for the excavation of the new by-pass including the Locks excavations . Although the new alignment (Pacific and Atlantic side) needs considerable less excavation volumes, it is clear that excavation costs will be a very important factor in determining the total construction cost.

The excavation and backfill volumes have been determined using the digital map "*Curvas nivel*", the plan view D4-A-403 and the lock Profile Drawings D4-B-401 and 402. Generation of cross sections was done with the AutoCAD 2005 Autodesk Land Desktop software tool, which also calculates the volumes of excavation and backfill. *Excavation and backfill volumes are calculated in cubic meters [m³].*

As far as the entrance walls are concerned, the excavation include the entrance channel up to the outer corner of the east wall; from that point on the excavation for the west wall is restricted to the minimum profile required for the construction of the single wall, and does not include the volume of the canal situated in between the entrance wall and the eastern canal embankment, these volumes have to be considered in the total excavation required for the by-pass canal.

An attempt was also made to determine the type of excavation volumes [rock and common (overburden) excavation]. Common excavation refers to boulders of less than 1 m³ or to material that can be excavated using a maximum of three passes of a ripper. These assumptions have been based on the available information, which is in our opinion not sufficient to determine the quantities of the different materials with sufficient accuracy. However, the total calculated excavation volume is to be considered as a reliable estimation.

Nevertheless, it was noticed during the analysis of the geo-technical longitudinal profiles that the top levels of the overburden do not correspond with the data from the topographic survey "*Curvas nivel*". It is recommended that these profiles be modified as soon as possible, for instance, as a subject during further design.

As a subject during further design we also advise the execution of a bathymetric survey of the flooded areas located under the future WSB. This survey is important for the exact calculation of the backfill quantities. At the stage of conceptual design the water depth of these areas had to be estimated.

The following assumptions were made for quantity estimates:

- Percentages of Gatun rock and overburden in different types of excavation:

Gatun rock	70 %
Overburden	30 %

During excavation, and afterwards during construction of the Lock and entrance walls, the excavated area will have to be dewatered to allow concrete works. As the Lock site is enclosed in a nearly impervious rock formation, the contractor will probably only have to inject some cracks to prevent too much water infiltration. However, care has to be exercised, especially with the many faults which were identified and which could be important in the hydrological context. This problem might need further investigation; however, provision has been made by including lump sums to cover foundation treatment, such as grouting and drainage.

The construction of the walls and also the lock heads are to be considered as rather ordinary concrete works, although the applied volumes are rather gigantic and require concrete batching plants with a very high capacity.

In order to determine the concrete volumes with sufficient accuracy, it was necessary to make drawings for each lock partition, i.e. the 4 Lock heads, the Lock walls and the Entrance walls.

Reference is made to drawings D4-B-401 to 406 (lock walls), D4-B-207 to 219 (lock heads) and D4-I-201 (entrance walls).

These drawings contain the design details of the following:

- Lockwall - Single Option (RC – reinforced concrete gravity wall and counterforts, crushed stone backfill).
- Entrance:
  - Walls in rock– Single Option (RC – reinforced concrete gravity wall and counterforts, crushed stone backfill)
  - Steel piles in muck – Single option (steel piles filled with sand and concrete)

It is to be noted that contrary to the formerly studied Triple Lift Configuration, here, in this instance, only the best construction option which has been proved to be the most economical one in the corresponding former Cost Estimations, is designed and evaluated for each structure.

The concrete structures are of reinforced concrete, which requires a large amount of steel reinforcement.

The quantities (tons) of steel reinforcement have been determined as a fixed weight per m³ of concrete, based on the engineer's judgment and experience with similar constructions (Lock walls at Berendrecht which are also of reinforced concrete, quay walls). *Steel reinforcement is measured in tons [tons].*

The following assumptions were made for quantity estimates:

- Quantity of reinforcement steel in reinforced concrete (RC) used for estimating purposes in the Post Panamax Pacific Locks Project:

75 kg/m³,	according to the structure type, its role, and, of course, as required by the design

The longitudinal culverts at both sides of the Locks are integrated in the Lock walls and Lock heads; as such they do not appear separately in the quantity list.

The Lock walls and Lock heads, as well as the entrance walls are exposed to temperature variations, curing and shrinkage, and therefore they have to be subdivided in independent parts (segments). In this conceptual design the segments are 30 m in length, with some exceptions, for example, in the transition between Lock walls and Lock heads. Each joint between the wall segments is made water and soil tight by means of a rubber joint, which is anchored in the concrete at both sides. *Rubber joints are measured in meters [m].*

At the corner edge of the top of the Lock walls, a steel corner protection profile is provided to protect the concrete against damage from the towing cables. *The protective steel profile is measured in meters [m].*

After construction the walls that require backfill, as shown on the drawings, are filled at the rear with crushed stone that can be recovered from the rock excavations, but the rock has to be crushed properly in a dedicated installation to obtain an acceptable size, suitable for backfilling and compaction in order to avoid settlements afterwards. *Backfilling in crushed stone is measured in cubic meters [m^3].*

Roller compacted concrete (RCC) (*expressed in [m^3]*) is placed to protect the bottom of the Lock Chambers founded in Gatun rock formation and also at the culvert and conduit outlets to prevent erosion and weakening of the fractured rock bottom due to currents and exposure (see drawing D4-B-401 to 405). Holes in the RCC are foreseen to make the layer permeable to prevent uplift pressures caused by the lockages. A gravel layer *[m^3]* is spread beneath the RCC layer and covered by a geotextile *[m^2]*.

The sills and the vertical bearings in the Lock heads that make the sealing surface of the gate are constructed with hard rock-like basalt, granite or prefabricated hard concrete blocks. They have to be anchored in the concrete by means of steel anchors. *The blocks are measured in [m^3].*

The gates move with the carriage wagons over rails anchored in the bottom floor of the Lock heads and the sidewall recesses of the recess chamber. Other rails are fixed on the recess walls to guide the gate when moving. *The rails are measured in meter [m].*

Drawing D4-A-403 shows a general plan view of the Locks. It has been used to indicate a number of accessories, such as bollards, fenders, light poles, cable-ducts equipped with steel cover (not indicated), etc… *Such items are always expressed in pieces [pcs].*

The result of quantity estimates for different items is given in the Appendix A.

1.2.3 LOCK OPERATING GATES.

The rolling gate type has been selected for use in the recent triple lift configuration. The layout of the rolling gate is shown on drawings D4-D 200 to 205. Report A4d on Lock gate design gives unit weight of Lock gates for the different sizes according to the Lock head position.

The unit weight allows determining the total weight of each gate, and an additional weight has to be taken into account for wheelbarrow wagons and steel auxiliaries. *The steel weight of the total gate structure is expressed in [tons].*

The sealing of the gate against the basalt or granite blocks is obtained with exotic wooden (azobé) beams that are fixed by bolting to the Lock gate. *These wooden beams are expressed in [m^3].*

In order to use the Lock gate chambers as a place to maintain the gates, a slot bulkhead is required. The *bulkhead is a steel construction, expressed in tons [tons].*

1.2.4 ELECTROMECHANICAL EQUIPMENT

Quantities of mechanical equipment, expressed in tons, were based on the experience of the Consultants in large hydropower projects, using graphs and charts relating the weight of equipment with the size and the pressures handled by the proposed equipment. Electrical and power equipment quantities have been based on the conceptual design projects and on the experience provided by the existing Panama Canal Locks.

1.3 COST ESTIMATES

1.3.1 INTRODUCTION

Reference is made to Configuration 1 (Pacific side) -“**3 Lift Lock System**”- Report R4-M. For this Configuration, the cost estimation for the Civil Works was based on the **aggregation method** in which a cost database is created by analyzing the price/costs of similar work (type/volumes) obtained from international past and present market prices, and adjusting them to obtain current prices. These prices, called aggregate prices, include direct and indirect construction costs. The aggregate prices as of the Year 2002 thus obtained are then applied to the Post Panamax Locks Project to establish its cost. This aggregation method is normally applied by the firms constituting the Consortium, and is of common use in Europe to estimate the cost of projects at a conceptual design stage and even in more detailed study stages. As already explained in the fifth paragraph of the Preamble to the present Report, the same unit prices from the Table 2.1 *Aggregate Unit Price* of the above mentioned Triple Lift Lock System-Report R4-M, have been used to establish costs for the harmonized Triple Lift Lock system. Once again the attention is drawn to the fact that the increased steel prices since early 2004 have not yet been taken into account.

1.3.2 COST ESTIMATE FOR CIVIL WORKS

As explained in Paragraph 1.2, the present report presents for each structure of the harmonized Triple Lift Configuration with 3x2 WSB only a single construction option that has been proved to be the most economical one in the former cost estimates. These are the following:

- Lockwall - Single Option (RC – reinforced concrete gravity wall and counterforts, crushed stone backfill).
- Entrance:
    - Walls in rock– Single Option (RC – reinforced concrete gravity wall and counterforts, crushed stone backfill)
    - Steel piles in muck – Single Option (steel piles filled with sand and concrete)

The Water Savings Basins layout presents as well one single scheme with two adjacent basins for each chamber. The first basin is the one with the highest bottom level and closest to the Eastern Lockwall.

As it has been shown in the former Triple Lift Configuration Cost Estimation Report R4 M, the Aggregated Unit Prices are related to the global quantities involved in the Project for the main items. This relation between prices and volumes has been represented by trend graphs presented in the Appendices B of the former cost estimate reports. Considering that it has been proved in the Single Lift Configuration Cost Estimation Report that the differences in quantities between different lock configurations are not significant enough to justify a revision of the formerly selected unit prices and observing that the quantities for the harmonized Triple Lift Configuration with 3x2 WSB are again in the same order of magnitude, it can be finally concluded that, the same series of selected prices remain also valid for calculating the cost of the harmonized Triple Lift Lock Configuration with 3x2 WSB.

The following Table 2.1 presents the complete list of Aggregate Unit Prices used to estimate the cost of the Project.

Table 2.1
Conceptual Design
Post-Panamax Lock Structure
Harmonization Atlantic 3x2 WSB
Aggregate Unit Price

Item	Description	Unit	Selected Unit Price USD 2002
1	**Excavations**		
1,1	Overburden	m^3	3,50
1,2	Atlantic muck	m^3	0,00
1,3	Gatun rock	m^3	4,75
2	**Fill**		
2,1	Backfill	m^3	3,00
2,2	Gravel layer	m^3	6,00
2,3	Bank protection WSB1	m^2	13,00
2,4	Overhaul for spoil (10 km)	m^3km	0,30
3	**Concrete**		
3,1	RC	m^3	120,00
3,2	RCC	m^3	28,00
3,3	Lean Concrete	m^2	9,00
3,4	Pavement	m^2	24,00
3,5	Concrete layer chamber bottom	m^3	90,00
4	**Reinforcement**		
4,1	Steel reinforcement	tons	875,00
5	**Other**		
5,1	Steel corner protection	m	73,00

5,2	Rubber joint	m	71,00
5,3	Geotextile	m²	1,80
5,4	Liner HDPE (WSB)	m²	13,31
5,5	Underlaying protective geotextile (WSB)	m²	1,88
5,6	Geotextile for drainage (WSB)	m²	4,71
5,7	Rails	m	280,00
5,8	Wooden vertical guidances	m	400,00
5,9	Steel for support rail and frames	ton	2.400,00
5,10	Vertical element for seals east/recesses	m³	3.050,00
5,11	Vertical element for seals west	m³	2.700,00
5,12	Horizontal elements for seals lock chamber	m³	2.700,00
5,13	Elements for placement habitat	m³	275,00
5,14	Horizontal elements for seals gate recesses	m³	1.520,00
5,15	Technical building	m²	300
6	**Accessories**		
6,1	Bollards 1500kN	pcs	4.900,00
6,2	Wheel fenders	pcs	540.000
6,3	Roller fenders	pcs	540.000
6,4	Fenders Atlantic side	pcs	50.000
6,5	Fenders Gatun Lake side	pcs	40.000
6,6	Ladders	m	100,00
6,7	Mooring bits	pcs	950,00
7	**Steel piles**		
7,1	Procurement of steel piles	tons	1.200,00
7,2	Driving of steel piles	pcs	7.500,00
7,3	Sandfill steel pile	m³	25,00
7,4	Concrete fill steel pile	m³	120,00
7,5	Steel reinforcement BE500	tons	875,00

Cost Estimates of Civil Works are summarized in the following Table. Detailed information is presented in Appendix B.

Costs of the Civil Works
Summary

Item	**Description**	**Selected Cost** **USD - 2002**
1	**Lock only**	304.362.970
2	**Water Savings Basins only**	114.646.080
3	**Lock and WSB`s**	419.009.050

1.3.3 COST ESTIMATE OF THE ELECTROMECHANICAL EQUIPMENT

1.3.3.1 CULVERT AND CONDUIT VALVES

Estimated Weights of the Culvert and WSB Valves and Bulkheads

The following Table (Ref. Report A4e-3x2) is the base for estimating the price of the valves and bulkheads. The price for welded construction is usually estimated by multiplying a weight by a kg price. That kg price has been estimated at 5 USD/kg, all-inclusive.

	Number	Unit weight (tons)	Total weight (tons)
Culvert valves	16	25.5	408
Culvert bulkheads	8	22.5	180
Culvert valves slots	16	37	592
Culvert bulkhead slots	32	27.1	867
WSB valves	24	20.9	502
WSB bulkheads	6	17.9	107
WSB valves slots	24	41.6	998
WSB bulkhead slots	48	27.6	1325
TOTAL			**4980 tons**

The total price for the **52 fixed-wheel valves** and related bulkheads and slots is estimated to:

4980000 x 5 = ***USD 24.90 Million***

That price is including transport, erection and commissioning. It does not include either the operating machinery (cylinders, oil hydraulic unit, etc) and the maintenance cranes or the control boards.

$5/kg is a usual price "all included" considered for similar valves of welded construction in the hydro field. Welded construction kg price ex-works is considered to be normally in a range of $3 to $3.5. Transportation and erection are estimated to vary between 30 and 40%. The top of the range has been preferred for the valves due to some machining and stainless material (wheels, sealing systems).

Valve operating machinery and local control boards: ***USD 10.40 Million***

The valve operating machinery price has been based on a preliminary budget price given by an important supplier (Bosch Rexroth) for 52 hydraulic cylinders all identical with oil sumps and control boards. A rough comparison was also made with the cost of the refurbishment of hydraulic cylinders for 40 pairs of miter gates at the Panama Canal (for 80 hydraulic cylinders).

Maintenance tools, cranes and railways: ***USD 1.00 Million***

This price is including 2 maintenance gantry cranes of 70ton capacity, span about 7m, 720m of rails and maintenance tooling as handling beam to lower and remove valves and bulkhead from the slots. Weight of cranes has been estimated to 2 x 40 tons, price: 2 x 320,000 = $640,000 (kg price: $8) - Rails: 1,000m x 100kg/m x $3/m =$300,000 – Maintenance tools: $60,000.

Rolling gate operating machinery: ***USD 10.0 Million***

Is composed of:

- 16 main AC motors with variable speed (according to a preliminary budget price of a manufacturer): 16 x 67, 000 = $ 1.1 Million
- 8 primary gear boxes: 8 x 200, 000 = $ 1.6 Million
- 16 secondary gear boxes: 16 x 300,000 = $ 4.8 Million

  The prices of gear boxes have been based on hydro gear boxes prices (kg price between $15 and $25 according to the size)
- balance of equipment (auxiliary AC motors, cable drums, pulleys, cables, bearings,..): $.2.50 Million

1.3.3.2 OPERATING MACHINERY: CONTROL SYSTEM

Estimated budget price: ***USD 2.80 Million***

The budget price is based on the description given in the report A4f-j-3x2. It is including the control equipment, installation, cabling and commissioning.

CPU 1 to 20 (Panboard, Rack 19", I/O,…)	2,100,000
Main Control room	350,000
Backup control Room	50,000
CCTV	300,000
Total	$2,800,000

Prices have been based on unit prices of a similar control system.

1.3.3.3 LIGHTING

Estimated price for 50 high masts, 360 floodlights of 1000W, lock chamber and rolling gates lighting and galleries lighting:

USD 2.00 Million

1.3.3.4 ELECTRICAL AND POWER REQUIREMENTS

Estimated budget price: ***USD 13.15 Million***
Detailed as follow:

		Alternative 4	Alternative 5
1	High Voltage		
1.1	Cables	940,000	1,646,400
1.2	HV Switchgear	1,670,000	1,995,000
2	Transformers	342,000	342,000
3	Emergency power supply		
	Diesel set 1200 kVA + transformers + ...	585,000	585,000
4	Low Voltage		
4.1	Low Voltage switchboard	1,380,000	1,380,000
4.2	Low Voltage Cables	1,280,000	1,280,000
4.3	Low Voltage equipment	297,000	297,000
5	Cable Trays and Supports	1,177,000	1,177,000
6	Miscellaneous	930,000	930,000

Total	9,201,000	10,232,000
Including transportation and erection	**USD 11.75 Million**	**USD 13.15 Million**

Note: No provision has been made either for the operating structures (overhead crane of the maintenance building or for HVAC necessary for control room and HV technical rooms).

Alternative 5, which offers more security, has been selected (see Report Task 4-A4f-j-3x2, *Electrical Power and Power Requirement*). Therefore, the corresponding prices of Alternative 5 have been used in the present Cost Estimation.

1.3.4 COST ESTIMATE FOR LOCK GATES

1.3.4.1 Price - Berendrecht lock gates

The cost of the Berendrecht Lock gates including equipment:

0	General working costs	363,000 USD
1	Detailed calculation and construction drawings	310,000 USD
2	Metal construction + equipment	
	Lock gates (4)	19,288,000 USD
	Lower support wagon (4 + 1)	177,000 USD
	Upper support wagon (4)	544,000 USD
	Maintenance support wagons (24)	186,000 USD
	Bulkhead	575,000 USD
3	Mechanical parts	958,000 USD
4	Positioning and testing	455,000 USD
5	Temporary storage and additional works	198,000 USD
	Total	23,054,000 USD

These costs were accurate in 1983.

The costs include the 4 gates, 5 lower support wagons (1 spare one), 4 upper support wagons, 4 maintenance support wagons (2 gates can be maintained simultaneously) and 1 bulkhead.

When we divide this total sum by the total weight of the 4 gates + equipment:

23,054,000 USD / 6,800,000 kg = 3.390 USD/kg

Knowing that this price was made in 1983, it has to be multiplied with a factor to take into account the price evolution:

3.390 USD/kg x 1.75 = 5.933 USD/kg

We add to this price the transport of the gates from the workshop to the site:

5.933 USD/kg + 0.24 USD/kg = 6.173 USD/kg

We extrapolated this for the complete **harmonized Triple-lift situation with 3x2 WSB**:

3100 t (2 x gate 1) + 10400 t (4 x gate 2/3) + 5000 t (2 x gate 4) + 1774 t (equipment) = **20274 tons**

6.173 USD/kg x 20,274,000 kg = **125,151,402 USD**

1.3.4.2 Fendering

We have foreseen 4 sets of wheel fenders (1 set = 5 wheels), one on each side of the harmonized Triple lift configuration with 3x2 WSB.

Based on recent information the cost of one wheel with casing is 90,000 USD (2002).

The cost of four sets of fenders + positioning on site:

(20 x 90,000 USD) x 1.2 = 2,160,000 USD

This is much cheaper (factor 2) than an extrapolation of the costs of the fendering of the Berendrecht Lock. Based on the evolution during the last years, these materials are less expensive.

Based on recent information the cost of one tidal fender is 50.000 USD (including positioning on site).

1.4 TOTAL PROJECT COST

The Total Project Cost is detailed in the following four Tables:

- Table 3.1 contains the Total Lock Cost.
- Table 3.2 contains the Total Water Saving Basins cost.
- Table 3.3 contains a summary (rounded numbers) of the Total Project Cost.

The total costs of the Civil Works and of the Electromechanical Equipment have been incremented by lump sum percentages corresponding to items not quantified in terms of volume of work but, nevertheless, required for the completion of the project. These items are the following:

- **Detailed Studies and Supervision**

This item includes all the engineering service to be performed after awarding the Civil Work construction contract(s), the detailed execution studies (shop drawings) and the cost of complete works supervision. Excluded from this item are the basic design, final design, preparation of Tender documents, hydraulic model studies, and the geological and geotechnical investigations (except those related directly to the construction).

Based on the FIDIC recommendations, the estimated percentage covering the above Item 1 comes to 7%. This value is applicable to both the Civil Works and the Electromechanical total costs.

- **Instrumentation**

This Item covers purchase, installation and activation of all permanent instruments dedicated to record the physical behavior of the Civil structures. It covers as well the monitoring and reporting during the construction period. It is estimated that 2% of the total cost of the Civil Works is sufficient to cover this Item 2.

- **Grouting and Consolidation**

It is very unlikely that a project of the size of the Post Panamax Lock will not require grouting, drainage and consolidation of the foundation. At the present stage, the geological and geotechnical local characteristics of the Locks foundation are not known in detail but it is likely that some zones might require special foundation treatment, such as impermeabilization grouting, drainage or consolidation grouting. The Item 3 grouting and consolidation aims to cover the costs related to these works. It is estimated that 3% applicable to the total Civil Works cost is sufficient provision to cover this item.

- **Contingencies**

This item covers all the works, services and equipment that cannot be precisely identified and quantified at the present stage of the studies. It is commonly accepted that these contingencies amount to from 15 to

20 percent of the total cost of the Civil Works at a conceptual design stage. Considering that the Civil Works have been defined for the Atlantic Post Panamax Lock Project (3x2 WSB) with quite a high level of precision for a conceptual study stage, the CPP estimate that a contingencies Item amounting to 15% of the total civil works cost is a sufficient provision.

Of course, with the increasing information gained regarding the geological and geotechnical features of the foundation, and with the increased level of detail achieved in the design of the Civil Work, the amount of this contingencies provision will progressively decrease.

Regarding the contingencies for Electromechanical Equipment, it is again commonly accepted that these works are generally quantified with a quite good level of precision, mainly because the geological and geotechnical uncertainties do not affect the cost estimates. At a Conceptual Design stage, a provision of 10% of the total cost of Electromechanical Equipment is considered perfectly adequate to cover the contingencies.

- **Administrative Costs**

This Item includes all the management, communications and various other expenses incurred by the Owner to control the execution of the project. It does *not* include the financial costs. The Administrative Costs are estimated at 2% of the total cost of Civil Works and Electromechanical Equipment.

Table 3.1
Conceptual Design
Post-Panamax Lock Structure
Harmonization Atlantic 3x2 WSB
TOTAL LOCK COST

Item	Description	%	Total USD - 2002
	LOCK		
1	**Civil Works**		**392.628.232**
1,1	Civil works		304.362.970
1,2	Detailed studies and supervision	7%	21.305.408
1,3	Instrumentation	2%	6.087.259
1,4	Grouting and consolidation	3%	9.130.889
1,5	Contingencies	15%	45.654.446
1,6	Administrative costs	2%	6.087.259
2	**Electromechanical equipment**		**207.937.508**
2,1	Electromechanical equipment		174.737.402
2,2	Detailed studies and supervision	7%	12.231.618
2,3	Contingencies	10%	17.473.740
2,4	Administrative costs	2%	3.494.748
	TOTAL LOCK COST		**600.565.740**

Table 3.2
Conceptual Design
Post-Panamax Lock Structure
Harmonization Atlantic 3x2 WSB
TOTAL WSB COST

Item	Description	%	Total USD - 2002
	WSB		
1	**Civil Works**		**147.893.443**
1,1	Civil works		114.646.080
1,2	Detailed studies and supervision	7%	8.025.226
1,3	Instrumentation	2%	2.292.922
1,4	Grouting and consolidation	3%	3.439.382
1,5	Contingencies	15%	17.196.912
1,6	Administrative costs	2%	2.292.922
2	**Electromechanical equipment**		**17.446.590**
2,1	Electromechanical equipment		14.661.000
2,2	Detailed studies and supervision	7%	1.026.270
2,3	Contingencies	10%	1.466.100
2,4	Administrative costs	2%	293.220
	TOTAL WSB COST		**165.340.033**

Table 3.3
Conceptual Design
Post-Panamax Lock Structure
Harmonization Atlantic 3x2 WSB

Summary of the Total Project Cost

Item	Description	%	Total USD - 2002
	Total project cost without WSB		601.000.000
	Total project cost with WSB		766.000.000

APPENDIX A

QUANTITIES

TASK 4

Table A.1

Conceptual Design
Post-Panamax Lock Structure
Atlantic 3x2 wsb

CIVIL WORKS

Quantities Summary

Lock without WSB

Item	Description	Unit	Quantity
1	**Excavation**		5.576.977
1,1	Overburden	m³	1.673.093
1,2	Gatun rock	m³	3.903.884
2	**Fill**		
2,1	Backfill	m³	2.218.532
2,2	Gravel layer	m³	28.323
2,3	Bank protection	m²	0
2,4	Overhaul for spoil (10 km)	m³km	22.405.027
3	**Concrete**		
3,1	RC	m³	1.282.414
3,2	RCC	m³	96.851
3,3	Lean Concrete	m²	116.069
3,4	Pavement	m²	133.358
4	**Reinforcement**		
4,1	Steel reinforcement	tons	96.181
5	**Other**		
5,1	Steel corner protection	m	4.693
5,2	Rubber joint	m	7.121
5,3	Geotextile	m²	62.577
5,4	Liner HDPE	m²	3.000
5,5	Underlaying protective geotextile	m²	3.000
5,6	Geotextile for drainage	m²	0
5,7	Rails	m	4.848
5,8	Wooden vertical guidances	m	675
5,9	Steel for support rail and frames	ton	1.228
5,10	Vertical element for seals east/recesses	m³	663
5,11	Vertical element for seals west	m³	843
5,12	Horizontal elements for seals lock chamber	m³	896
5,13	Elements for placement habitat	m³	932
5,14	Horizontal elements for seals gate recesses	m³	152
5,15	Technical building	m²	4.741

TASK 4

Table A.1

Conceptual Design
Post-Panamax Lock Structure
Atlantic 3x2 wsb

CIVIL WORKS

Quantities Summary

Lock without WSB

Item	Description	Unit	Quantity
6	**Accessories**		
6,1	Bollards 1500kN	pcs	122
6,2	Wheel fenders	pcs	4
6,3	Roller fenders	pcs	4
6,4	Fenders Atlantic side	pcs	16
6,5	Ladders	m	122
6,6	Mooring bits	pcs	244
7	**Steel piles**		
7,1	Procurement of steel piles	tons	879
7,2	Driving of steel piles	pcs	10
7,3	Sandfill steel pile	m³	856
7,4	Concrete fill steel pile	m³	554
7,5	Steel reinforcement BE500	tons	28

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TASK 4

Table A.2

Excavation and Fill Quantities

Item	Description	Unit	Excavation	Backfill
1	Lock from edge east wall Gatun side up to edge east wall Atlantic side	m^3	5.424.591	44.633
1,1	Overburden excavation	m^3	1.627.377	
1,2	Gatun Rock excavation	m^3	3.797.214	
2	Extra entrance wall Atlantic	m^3	152.386	5.651
2,1	Overburden excavation	m^3	45.716	
2,2	Gatun Rock excavation	m^3	106.670	
3	Backfill for temporary dam			
3,1	Atlantic side	m^3		45.000
4	Overhaul for spoil (10 km)	m^3km		22.405.027
	Total Volume Excavation / Backfill	m^3	5.576.977	95.284

TASK 4

Table A.3

Entrance Walls

Quantities Summary

Item	Description	Unit	Atlantic Side	Gatun Side
			Quantity	Quantity
	Standard 30 m - segment			
1	Reinforced Concrete	m³	3.622	3.622
2	Steel Reinforcement BE500	tons	272	272
3	Backfill Crushed Stone	m³	9.891	9.891
4	Steel Corner Protection	m	30	30
5	Rubber Joint	m	37	37
6	Lean Concrete	m²	612	612
	Quantities for one 30 m-segment:			
	Number of segments of 30 m:		9	6
	Cornersegment			
1	Reinforced Concrete	m³	8.421	7.794
2	Steel Reinforcement BE500	tons	632	585
3	Backfill Crushed Stone	m³	18.654	18.394
4	Steel Corner Protection	m	77	75
5	Rubber Joint	m	37	37
6	Lean Concrete	m²	1.326	1.291
	Curvesegment			
1	Reinforced Concrete	m³	9.494	8.434
2	Steel Reinforcement BE500	tons	712	633
3	Backfill Crushed Stone	m³	15.622	13.550
4	Steel Corner Protection	m	92	84
5	Rubber Joint	m	37	37
6	Lean Concrete	m²	1.451	1.283
	Endsegment			
1	Reinforced Concrete	m³	1.524	1.992
2	Steel Reinforcement BE500	tons	114	149
3	Backfill Crushed Stone	m³	4.161	5.440
4	Steel Corner Protection	m	13	17
5	Rubber Joint	m	37	37

TASK 4

Table A.3
Entrance Walls

Quantities Summary

6	Lean Concrete	m²	257	337
	Steel piles in muck			
1	Procurement of steel piles	tons	88	
	ϕ 3000 mm - e = 30 mm - L = 40 m			
2	Driving of steel piles - L = 40 m	pcs	1	
3	Sandfill steel pile	m³	86	
4	Concrete fill steel pile	m³	55	
5	Steel reinforcement BE500	tons	3	
	Quantities for one pile			
	Number of piles:		10	

TASK 4

Table A.3

Entrance Walls

Quantities Summary

			Quantities Summary	
			Atlantic Side	Gatun Side
Item	Description	Unit	Quantity	Quantity
	Walls			
1	Reinforced Concrete	m^3	52.037	39.953
2	Steel Reinforcement BE500	tons	3.903	2.996
3	Backfill Crushed Stone	m^3	127.455	96.729
4	Steel Corner Protection	m	451	356
5	Rubber Joint	m	444	333
6	Lean Concrete	m^2	8.543	6.582
8	Pavement	m^2	10.119	10.119
	Steel piles in muck			
1	Procurement of steel piles ϕ 3000 mm - e = 30 mm - L = 40 m	tons	879	
2	Driving of steel piles - L = 40 m	pcs	10	
3	Sandfill steel pile	m^3	856	
4	Concrete fill steel pile	m^3	554	
5	Steel reinforcement BE500	tons	28	

TASK 4

Table A.4
Lock Walls

Quantities Summary

Item	Description	Unit	Chamber 1	Chamber 2	Chamber 3
			Quantity	Quantity	Quantity
1	Reinforced Concrete	m^3	7.792	7.734	7.698
2	Steel Reinforcement BE500	tons	584	580	577
3	Backfill Crushed Stone	m^3	20.044	19.413	19.040
4	Roller compacted concrete	m^3	1.005	1.005	1.005
5	Gravel Layer	m^3	285	285	285
6	Geotextile	m^2	645	645	645
7	Steel Corner Protection	m	30	30	30
8	Rubber joint	m	68	68	68
9	Lean Concrete	m^2	899	899	899
11	Pavement	m^2	1.391	1.391	1.391
	Quantities for one 30 m-segment:				
	Number of segments of 30 m:		22	22	22

TASK 4

Table A.5

WSB and Conduits (Civil Works)
Side by side conduits disposition

Quantities Summary

Item	Description	Unit	Quantity
1	Reinforced concrete for valve chambers	m^3	37.886
2	Steel reinforcement BE500	tons	2.841
3	Reinforced concrete for conduits	m^3	37.893
4	Steel reinforcement BE500	tons	2.842
5	Reinforced concrete for intakes WSB	m^3	118.152
6	Steel reinforcement BE500	tons	8.861
7	Roller compacted concrete	m^3	160.470
8	Backfill Crushed Stone over conduits	m^3	560.332
9	Reinforced concrete for walls between WSB	m^3	61.227
10	Steel reinforcement BE500	tons	4.592
11	Liner HDPE (WSB)	m^2	170.000
12	Underlaying protective geotextile (WSB)	m^2	170.000
13	Geotextile for drainage (WSB)	m^2	21.000
14	Bank protection (WSB)	m^2	38.000
16	Excavations		
16,1	WSB along Chamber 1	m^3	1.495.356
16,2	WSB along Chamber 2	m^3	1.981.556
16,3	WSB along Chamber 3	m^3	2.143.829
16,4	Extra conduits and valve chambers	m^3	1.170.997
17	Backfill crushed stone along chambers		
17,1	WSB along Chamber 1	m^3	94
17,2	WSB along Chamber 2	m^3	0
17,3	WSB along Chamber 3	m^3	0
18	Lean concrete	m^2	24.329
19	Overhaul for spoil (10 km)	m^3km	62.313.120
20	Technical building	m^2	4.320
21	Equalisation layer WSB and spillway bottom	m^3	89.000

Table A.5
WSB and Conduits (Civil Works)

Quantities Summary

Item	Description	Unit	Quantity
1	Reinforced concrete	m³	255.158
2	Steel reinforcement BE500	tons	19.137
3	Roller compacted concrete	m³	160.470
4	Backfill Crushed Stone over conduits	m³	560.332
5	Liner HDPE (WSB)	m²	170.000
6	Underlaying protective geotextile (WSB)	m²	170.000
7	Geotextile for drainage (WSB)	m²	21.000
8	Bank protection (WSB)	m²	38.000
9	Excavations	m³	6.791.738
10	Backfill Crushed Stone along chambers	m³	94
11	Lean concrete	m²	24.329
12	Overhaul for spoil (10 km)	m³km	62.313.120
13	Technical building	m²	4.320
14	Equalisation layer WSB and spillway bottom	m³	89.000

TASK 4

Table A.6

Lock Head Gate

Quantities Summary

Item	Description	Unit	Quantity
1	**Lock Head Gate 1**		
1,1	Reinforced Concrete	m³	94.427
1,2	Steel Reinforcement BE500	ton	7.082
1,3	Backfill crushed stone	m³	16.755
1,4	RCC chamber floor	m³	1.856
1,5	Gravel layer	m³	619
1,6	Geotextile	m²	1.238
1,7	Steel corner protection	m	325
1,8	Rubber joint	m	200
1,9	Lean concrete	m²	5.162
1,10	Pavement	m²	5.330
1,11	Technical building	m²	1.185
2	**Lock Head Gate 2**		
2,1	Reinforced Concrete	m³	138.280
2,2	Steel Reinforcement BE500	ton	10.371
2,3	Backfill crushed stone	m³	45.528
2,4	RCC chamber floor	m³	2.434
2,5	Gravel layer	m³	811
2,6	Geotextile	m²	1.623
2,7	Steel corner protection	m	331
2,8	Rubber joint	m	200
2,9	Lean concrete	m²	6.319
2,10	Pavement	m²	5.330
2,11	Technical building	m²	1.185
3	**Lock Head Gate 3**		
3,1	Reinforced Concrete	m³	138.131
3,2	Steel Reinforcement BE500	ton	10.360
3,3	Backfill crushed stone	m³	44.326
3,4	RCC chamber floor	m³	2.434
3,5	Gravel layer	m³	811
3,6	Geotextile	m²	1.623
3,7	Steel corner protection	m	331
3,8	Rubber joint	m	200
3,9	Lean concrete	m²	6.319
3,10	Pavement	m²	5.330
3,11	Technical building	m²	1.185

TASK 4

Table A.6

Lock Head Gate

Quantities Summary

Item	Description	Unit	Quantity
4	**Lock Head Gate 4**		
4,1	Reinforced Concrete	m^3	137.327
4,2	Steel Reinforcement BE500	ton	10.300
4,3	Backfill crushed stone	m^3	42.665
4,4	RCC chamber floor	m^3	2.434
4,5	Gravel layer	m^3	811
4,6	Geotextile	m^2	1.623
4,7	Steel corner protection	m	331
4,8	Rubber joint	m	200
4,9	Lean concrete	m^2	6.319
4,10	Pavement	m^2	5.330
4,11	Technical building	m^2	1.185
5	**Concrete L-shaped walls and walls in backfilled area to avoid by-pass seepage behind lock heads 1, 2, 3 and 4**		
5,1	Reinforced Concrete	m^3	27.819
5,2	Steel Reinforcement BE500	ton	2.086
5,3	Backfill crushed stone	m^3	126.830

Table A.7

Transition Segment

Quantities Summary

Item	Description	Unit	Quantity
1	**Lock Head Gate 1**		
1,1	Segment with inlet zone east side		
1,11	Reinforced Concrete	m^3	11.697
1,12	Steel Reinforcement BE500	tons	877
1,13	Backfill Crushed Stone	m^3	22.095
1,14	Steel Corner Protection	m	54
1,15	Rubber Joint	m	60
1,16	Lean Concrete	m^2	1.555
1,17	Roller compacted concrete	m^3	2.007
1,18	Gravel Layer	m^3	669
1,19	Geotextile	m^2	1.338
1,2	Segment with inlet zone west side		
1,21	Reinforced Concrete	m^3	11.786
1,22	Steel Reinforcement BE500	tons	884
1,23	Backfill Crushed Stone	m^3	22.348
1,24	Steel Corner Protection	m	53
1,25	Rubber Joint	m	60
1,26	Lean Concrete	m^2	1.579
1,27	Roller compacted concrete	m^3	2.007
1,28	Gravel Layer	m^3	669
1,29	Geotextile	m^2	1.338
1,3	Segment side chamber 1 east side		
1,31	Reinforced Concrete	m^3	7.662
1,32	Steel Reinforcement BE500	tons	575
1,33	Backfill Crushed Stone	m^3	19.710
1,34	Roller compacted concrete	m^3	989
1,35	Gravel layer	m^3	280
1,36	Geotextile	m^2	634
1,37	Steel Corner Protection	m	30
1,38	Rubber joint	m	68
1,39	Lean Concrete	m^2	884
1,4	Segment side chamber 1 west side		
1,41	Reinforced Concrete	m^3	7.662
1,42	Steel Reinforcement BE500	tons	575

Table A.7

Transition Segment

Quantities Summary

1,43	Backfill Crushed Stone	m^3	19.710
1,44	Roller compacted concrete	m^3	989
1,45	Gravel layer	m^3	280
1,46	Geotextile	m^2	634
1,47	Steel Corner Protection	m	30
1,48	Rubber joint	m	68
1,49	Lean Concrete	m^2	884
2	**Lock Head Gate 2**		
2,1	Segment side chamber 1 east side		
2,11	Reinforced Concrete	m^3	9.870
2,12	Steel Reinforcement BE500	tons	740
2,13	Backfill Crushed Stone	m^3	25.389
2,14	Roller compacted concrete	m^3	1.273
2,15	Gravel layer	m^3	361
2,16	Geotextile	m^2	817
2,17	Steel Corner Protection	m	38
2,18	Rubber joint	m	68
2,19	Lean Concrete	m^2	1.139
2,2	Segment side chamber 1 west side		
2,21	Reinforced Concrete	m^3	9.870
2,22	Steel Reinforcement BE500	tons	740
2,23	Backfill Crushed Stone	m^3	25.389
2,24	Roller compacted concrete	m^3	1.273
2,25	Gravel layer	m^3	361
2,26	Geotextile	m^2	817
2,27	Steel Corner Protection	m	38
2,28	Rubber joint	m	68
2,29	Lean Concrete	m^2	1.139
2,3	Segment side chamber 2 east side		
2,31	Reinforced Concrete	m^3	6.316
2,32	Steel Reinforcement BE500	tons	474
2,33	Backfill Crushed Stone	m^3	15.854
2,34	Roller compacted concrete	m^3	821
2,35	Gravel layer	m^3	233
2,36	Geotextile	m^2	527
2,37	Steel Corner Protection	m	25

Table A.7

Transition Segment

Quantities Summary

2,38	Rubber joint	m	68
2,39	Lean Concrete	m²	734
2,4	Segment side chamber 2 west side		
2,41	Reinforced Concrete	m³	6.316
2,42	Steel Reinforcement BE500	tons	474
2,43	Backfill Crushed Stone	m³	15.854
2,44	Roller compacted concrete	m³	821
2,45	Gravel layer	m³	233
2,46	Geotextile	m²	527
2,47	Steel Corner Protection	m	25
2,48	Rubber joint	m	68
2,49	Lean Concrete	m²	734
3	**Lock Head Gate 3**		
3,1	Segment side chamber 2 east side		
3,11	Reinforced Concrete	m³	10.183
3,12	Steel Reinforcement BE500	tons	764
3,13	Backfill Crushed Stone	m³	25.560
3,14	Roller compacted concrete	m³	1.324
3,15	Gravel layer	m³	375
3,16	Geotextile	m²	849
3,17	Steel Corner Protection	m	40
3,18	Rubber joint	m	68
3,19	Lean Concrete	m²	1.184
3,2	Segment side chamber 2 west side		
3,21	Reinforced Concrete	m³	10.183
3,22	Steel Reinforcement BE500	tons	764
3,23	Backfill Crushed Stone	m³	25.560
3,24	Roller compacted concrete	m³	1.324
3,25	Gravel layer	m³	375
3,26	Geotextile	m²	849
3,27	Steel Corner Protection	m	40
3,28	Rubber joint	m	68
3,29	Lean Concrete	m²	1.184
3,3	Segment side chamber 3 east side		
3,31	Reinforced Concrete	m³	6.287
3,32	Steel Reinforcement BE500	tons	472

Table A.7
Transition Segment

Quantities Summary

3,33	Backfill Crushed Stone	m³	15.549
3,34	Roller compacted concrete	m³	821
3,35	Gravel Layer	m³	233
3,36	Geotextile	m²	527
3,37	Steel Corner Protection	m	25
3,38	Rubber joint	m	68
3,39	Lean Concrete	m²	734
3,4	<u>Segment side chamber 3 west side</u>		
3,41	Reinforced Concrete	m³	6.287
3,42	Steel Reinforcement BE500	tons	472
3,43	Backfill Crushed Stone	m³	15.549
3,44	Roller compacted concrete	m³	821
3,45	Gravel Layer	m³	233
3,46	Geotextile	m²	527
3,47	Steel Corner Protection	m	25
3,48	Rubber joint	m	68
3,49	Lean Concrete	m²	734
4	**Lock Head Gate 4**		
4,1	<u>Segment side chamber 3 east side</u>		
4,11	Reinforced Concrete	m³	10.136
4,12	Steel Reinforcement BE500	tons	760
4,13	Backfill Crushed Stone	m³	25.069
4,14	Roller compacted concrete	m³	1.324
4,15	Gravel Layer	m³	375
4,16	Geotextile	m²	849
4,17	Steel Corner Protection	m	40
4,18	Rubber joint	m	68
4,19	Lean Concrete	m²	1.184
4,2	<u>Segment side chamber 3 west side</u>		
4,21	Reinforced Concrete	m³	10.136
4,22	Steel Reinforcement BE500	tons	760
4,23	Backfill Crushed Stone	m³	25.069
4,24	Roller compacted concrete	m³	1.324
4,25	Gravel Layer	m³	375
4,26	Geotextile	m²	849
4,27	Steel Corner Protection	m	40

Table A.7

Transition Segment

Quantities Summary

4,28	Rubber joint	m	68
4,29	Lean Concrete	m^2	1.184
4,3	Segment with outlet zone east side		
4,31	Reinforced Concrete	m^3	9.263
4,32	Steel Reinforcement BE500	tons	695
4,33	Backfill Crushed Stone	m^3	18.098
4,34	Steel Corner Protection	m	44
4,35	Rubber Joint	m	60
4,36	Lean Concrete	m^2	1.294
4,37	Roller compacted concrete	m^3	2.113
4,38	Gravel Layer	m^3	704
4,39	Geotextile	m^2	1.409
4,4	Segment with outlet zone west side		
4,41	Reinforced Concrete	m^3	9.859
4,42	Steel Reinforcement BE500	tons	739
4,43	Backfill Crushed Stone	m^3	19.222
4,44	Steel Corner Protection	m	45
4,45	Rubber Joint	m	60
4,46	Lean Concrete	m^2	1.338
4,47	Roller compacted concrete	m^3	2.113
4,48	Gravel Layer	m^3	704
4,49	Geotextile	m^2	1.409

TASK 4

Table A.7
Transition Segment

Quantities Summary

Quantities Summary

Item	Description	Unit	Quantity
1	Reinforced Concrete	m^3	143.512
2	Steel Reinforcement BE500	tons	10.763
3	Backfill Crushed Stone	m^3	336.026
4	Steel Corner Protection	m	588
5	Rubber Joint	m	1.056
6	Lean Concrete	m^2	17.484
7	Roller compacted concrete	m^3	21.343
8	Gravel Layer	m^3	6.461
9	Geotextile	m^2	13.900

TASK 4

Table A.8

Lock Head Gate

Quantities Summary
Equipment (Civil Part)

Item	Description	Unit	Quantity
1	**Lock Head Gate 1**		
1,1	Equipment lock gate (civil part)		
1.1.1	Rails USW	m	260
1.1.2	Rails LSW	m	260
1.1.3	Rails MSW	m	432
1.1.4	Rails horizontale guidances in recesses	m	260
1.1.5	Wooden vertical guidance in recesses	m	110
1.1.6	Steel for support rails USW	tons	104
1.1.7	Steel for support rails LSW	tons	104
1.1.8	Steel for support rails guidance	tons	39
1.1.9	Maintenance support frames	tons	60
1,2	Equipment lock head (civil part)		
1.2.1	Vertical elements for seals - east/recesses	m^3	124
1.2.2	Vertical elements for seals - west	m^3	157
1.2.3	Horizontal elements for seals- lock chamber	m^3	224
1.2.4	Elements for placement habitat	m^3	233
1.2.5	Horizontal elements for seals- gate recesses	m^3	38
2	**Lock Head Gate 2**		
2,1	Equipment lock gate (civil part)		
2.1.1	Rails USW	m	260
2.1.2	Rails LSW	m	260
2.1.3	Rails MSW	m	432
2.1.4	Rails horizontal guidance in recesses	m	260
2.1.5	Wooden vertical guidance in recesses	m	190
2.1.6	Steel for support rails USW	tons	104
2.1.7	Steel for support rails LSW	tons	104
2.1.8	Steel for support rails guidance	tons	39
2.1.9	Maintenance support frames	tons	60
2,2	Equipment lock head (civil part)		
2.2.1	Vertical elements for seals - east/recesses	m^3	182
2.2.2	Vertical elements for seals - west	m^3	233
2.2.3	Horizontal elements for seals- lock chamber	m^3	224
2.2.4	Elements for placement habitat	m^3	233
2.2.5	Horizontal elements for seals- gate recesses	m^3	38

TASK 4

Table A.8

Lock Head Gate

Quantities Summary
Equipment (Civil Part)

Item	Description	Unit	Quantity
3	**Lock Head Gate 3**		
3,1	Equipment lock gate (civil part)		
3.1.1	Rails USW	m	260
3.1.2	Rails LSW	m	260
3.1.3	Rails MSW	m	432
3.1.4	Rails horizontal guidances in recesses	m	260
3.1.5	Wooden vertical guidance in recesses	m	190
3.1.6	Steel for support rails USW	tons	104
3.1.7	Steel for support rails LSW	tons	104
3.1.8	Steel for support rails guidance	tons	39
3.1.9	Maintenance support frames	tons	60
3,2	Equipment lock head (civil part)		
3.2.1	Vertical elements for seals - east/recesses	m^3	182
3.2.2	Vertical elements for seals - west	m^3	228
3.2.3	Horizontal elements for seals- lock chamber	m^3	224
3.2.4	Elements for placement habitat	m^3	233
3.2.5	Horizontal elements for seals- gate recesses	m^3	38
4	**Lock Head Gate 4**		
4,1	Equipment lock gate (civil part)		
4.1.1	Rails USW	m	260
4.1.2	Rails LSW	m	260
4.1.3	Rails MSW	m	432
4.1.4	Rails horizontale guidances in recesses	m	260
4.1.5	Wooden vertical guidance in recesses	m	185
4.1.6	Steel for support rails USW	tons	104
4.1.7	Steel for support rails LSW	tons	104
4.1.8	Steel for support rails guidance	tons	39
4.1.9	Maintenance support frames	tons	60
4,2	Equipment lock head (civil part)		
4.2.1	Vertical elements for seals - east/recesses	m^3	175
4.2.2	Vertical elements for seals - west	m^3	225
4.2.3	Horizontal elements for seals- lock chamber	m^3	224
4.2.4	Elements for placement habitat	m^3	233
4.2.5	Horizontal elements for seals- gate recesses	m^3	38

TASK 4

Table A.9
ACCESSORIES

Quantities Summary

Item	Description	Unit	Quantity
1	**Accessories**		
1,1	Bollards 1500kN	pcs	122
1,2	Wheel fenders	pcs	4
1,3	Roller fenders	pcs	4
1,4	Fenders Atlantic side	pcs	16
1,6	Ladders	pcs	122
1,7	Mooring bits	pcs	244

Table A.10

ELECTROMECHANICAL EQUIPMENT

Quantities Summary

Item	Description	Unit	Quantity (pcs)	Unit Weight (t)	Total Weight (t)
1	**EM Equipment Lock**				
1,1	Lock gates				
1.1.1	Lock head 1			*Total 1.1.1.*	**3.410**
	Lock gates (2)	tons	2	1.550	3.100
	Bulkheads (1)	tons	1	200	200
	Upper support wagon (2)	tons	2	30	60
	Lower support wagon (2)	tons	2	25	50
1.1.2	Lock head 2			*Total 1.1.2.*	**5.660**
	Lock gates (2)	tons	2	2.600	5.200
	Bulkheads (1)	tons	1	300	300
	Upper support wagon (2)	tons	2	45	90
	Lower support wagon (2)	tons	2	35,0	70
1.1.3	Lock head 3			*Total 1.1.3.*	**5.660**
	Lock gates (2)	tons	2	2.600	5.200
	Bulkheads (1)	tons	1	300	300
	Upper support wagon (2)	tons	2	45	90
	Lower support wagon (2)	tons	2	35,0	70
1.1.4	Lock head 4			*Total 1.1.4.*	**5.460**
	Lock gates (2)	tons	2	2.500	5.000
	Bulkheads (1)	tons	1	300	300
	Upper support wagon (2)	tons	2	45	90
	Lower support wagon (2)	tons	2	35,0	70
1.1.5	Spare parts			*Total 1.1.5.*	**84**
	Lower support wagon (LH1)	tons	1	35	35
	Lower support wagon (LH2, 3, 4)	tons	1	25	25
	Maintenance support wagons (LH1)	tons	12	1	12
	Maintenance support wagons (LH2, 3, 4)	tons	12	1	12
1,2	Culvert valves and bulkheads			*Total 1.2:*	**2.047**
1.2.1	Culvert valves	tons	16	26	408
1.2.2	Culvert bulkheads	tons	8	23	180
1.2.3	Culvert valves slot	tons	16	37	592
1.2.4	Culvert bulkhead slots	tons	32	27	867
1,4	Support equipment		1		
1,5	Control system		1		
1,6	Lighting System		1		
1,7	Electrical and Power System		1		

Table A.10

ELECTROMECHANICAL EQUIPMENT

Quantities Summary

Item	Description	Unit	Quantity (pcs)	Unit Weight (t)	Total Weight (t)
2	**EM Equipment WSB**			*Total 2.:*	**2.932**
2,1	WSB valves	tons	24	21	502
2,3	WSB bulkheads	tons	6	18	107
2,4	WSB valves slots	tons	24	42	998
2,6	WSB bulkheads slots	tons	48	28	1.325

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Table A.11

Construction and permanent dams

Quantities Summary

Item	Description	Unit	Quantity
1	**Liner HDPE**		
1,1	Atlantic Side	m²	3000
2	**Underlaying protective geotextile**		
2,1	Atlantic Side	m²	3000

APPENDIX B

COST ESTIMATES

TASK 4

Table B.1.1
Conceptual Design
Post-Panamax Lock Structure
Atlantic 3x2 wsb

Total Cost Civil Works

Lock without WSB

Item	Description	Unit	Quantity	Selected Unit Price	
				Unit Price	Total USD
1	**Excavation**				**24.399.274**
1,1	Overburden	m³	1.673.093	3,50	5.855.826
1,2	Gatun rock	m³	3.903.884	4,75	18.543.449
2	**Fill**				**13.547.043**
2,1	Backfill	m³	2.218.532	3,00	6.655.596
2,2	Gravel layer	m³	28.323	6,00	169.939
2,3	Bank protection	m²	0	13,00	0
2,4	Overhaul for spoil (10 km)	m³km	22.405.027	0,30	6.721.508
3	**Concrete**				**160.846.678**
3,1	RC	m³	1.282.414	120,00	153.889.632
3,2	RCC	m³	96.851	28,00	2.711.832
3,3	Lean Concrete	m²	116.069	9,00	1.044.621
3,4	Pavement	m²	133.358	24,00	3.200.592
4	**Reinforcement**				**84.158.393**
4,1	Steel reinforcement	tons	96.181	875,00	84.158.393
5	**Other**				**14.208.059**
5,1	Steel corner protection	m	4.693	73,00	342.590
5,2	Rubber joint	m	7.121	71,00	505.591
5,3	Geotextile	m²	62.577	1,80	112.638
5,4	Liner HDPE	m²	3.000	13,31	39.930
5,5	Underlaying protective geotextile	m²	3.000	1,88	5.640
5,6	Geotextile for drainage	m²	0	4,71	0
5,7	Rails	m	4.848	280,00	1.357.440
5,8	Wooden vertical guidances	m	675	400,00	270.000
5,9	Steel for support rail and frames	ton	1.228	2.400,00	2.947.200
5,10	Vertical element for seals east/recesses	m³	663	3.050,00	2.022.150
5,11	Vertical element for seals west	m³	843	2.700,00	2.276.100
5,12	Horizontal elements for seals lock chamber	m³	896	2.700,00	2.419.200
5,13	Elements for placement habitat	m³	932	275,00	256.300
5,14	Horizontal elements for seals gate recesses	m³	152	1.520,00	231.040
5,15	Technical building	m²	4.741	300,00	1.422.240

TASK 4

Table B.1.1
Conceptual Design
Post-Panamax Lock Structure
Atlantic 3x2 wsb

Total Cost Civil Works

Lock without WSB

Item	Description	Unit	Quantity	Selected Unit Price	
				Unit Price	Total USD
6	**Accessories**				**5.961.800**
6,1	Bollards 1500kN	pcs	122	4.900,00	597.800
6,2	Wheel fenders	pcs	4	540.000,00	2.160.000
6,3	Roller fenders	pcs	4	540.000,00	2.160.000
6,4	Fenders Atlantic side	pcs	16	50.000,00	800.000
6,5	Ladders	m	122	100,00	12.200
6,6	Mooring bits	pcs	244	950,00	231.800
7	**Steel piles**				**1.241.723**
7,1	Procurement of steel piles	tons	879	1.200,00	1.054.560
7,2	Driving of steel piles	pcs	10	7.500,00	75.000
7,3	Sandfill steel pile	m³	856	25,00	21.407
7,4	Concrete fill steel pile	m³	554	120,00	66.508
7,5	Steel reinforcement BE500	tons	28	875,00	24.248
	Total Cost				**304.362.970**

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Table B.1.2
Conceptual Design
Post-Panamax Lock Structure
Atlantic 3x2 wsb

Total Cost Civil Works WSB
Side by side conduits disposition

				Selected Unit Price	
Item	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total USD**
1	Reinforced concrete	m³	255.158	120,00	30.618.946
2	Steel reinforcement BE500	tons	19.137	875,00	16.744.736
3	Roller compact concrete over conduits	m³	160.470	28,00	4.493.160
4	Backfill crushed stone over conduits	m³	560.332	3,00	1.680.996
5	Liner HDPE (WSB)	m²	170.000	13,31	2.262.700
6	Underlaying protective geotextile (WSB)	m²	170.000	1,88	319.600
7	Geotextile for drainage (WSB)	m²	21.000	4,71	98.910
8	Bank protection (WSB)	m²	38.000	13,00	494.000
9	Excavation				
9,1	Overburden excavation	m³	2.037.521	3,50	7.131.325
9,2	Gatun Rock excavation	m³	4.754.217	4,75	22.582.529
10	Backfill crushed stone along chambers	m³	94	3,00	282
11	Lean concrete	m²	24.329	9,00	218.961
12	Overhaul for spoil (10km)	m³km	62.313.120	0,30	18.693.936
13	Technical building	m²	4.320	300,00	1.296.000
14	Equalisation layer WSB and spillway bottom	m³	89.000	90,00	8.010.000
	Total Cost				**114.646.080**

Table B.1.3

Conceptual Design

Post-Panamax Lock Structure

Atlantic 3x2 wsb

Civil Works

Lock Cost by Structure

Item	Description	Total USD - 2002
1	Excavation and Fill for lock	31.406.635
2	Entrance walls	19.725.674
3	Lock walls	103.949.546
4	Lock heads	143.273.746
5	Accessories	5.961.800
6	Dams	45.570
	TOTAL COST LOCK	**304.362.970**
6	WSB and conduits (excavation and fill included)	114.646.080
	TOTAL COST WITH WSB	**419.009.050**

Table B.2

Cost Estimate
Excavation and Fill

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Excavation				
1,1	Overburden excavation	m^3	3,50	1.673.093	5.855.826
1,2	Gatun Rock excavation	m^3	4,75	3.903.884	18.543.449
2	Fill				
2,1	Backfill	m^3	3,00	95.284	285.852
2,2	Overhaul for spoil (10 km)	m^3km	0,30	22.405.027	6.721.508
	Total Cost				**31.406.635**

Table B.3
Cost Estimate
Entrance Walls

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
	Walls				
1	Reinforced Concrete	m³	120,00	91.989	11.038.700
2	Steel Reinforcement BE500	tons	875,00	6.899	6.036.789
3	Backfill Crushed Stone	m³	3,00	224.184	672.552
4	Steel Corner Protection	m	73,00	807	58.902
5	Rubber Joint	m	71,00	777	55.167
6	Lean Concrete	m²	9,00	15.125	136.129
7	Pavement	m²	24,00	20.238	485.712
	Steel piles				
1	Procurement of steel piles ϕ 3000 mm - e = 30 mm - L = 40 m	tons	1.200,00	879	1.054.560
2	Driving of steel piles - L = 40 m	pcs	7.500,00	10	75.000
3	Sandfill steel pile	m³	25,00	856	21.407
4	Concrete fill steel pile	m³	120,00	554	66.508
5	Steel reinforcement BE500	tons	875	28	24.248
	Total Cost				**19.725.674**

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Table B.4
Cost Estimate
Lock Walls

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Reinforced Concrete	m^3	120,00	510.928	61.311.360
2	Steel Reinforcement BE500	tons	875,00	38.320	33.529.650
3	Backfill Crushed Stone	m^3	3,00	1.286.934	3.860.802
4	Roller compacted concrete	m^3	28,00	66.350	1.857.794
5	Gravel Layer	m^3	6,00	18.810	112.860
6	Geotextile	m^2	1,80	42.570	76.626
7	Steel Corner Protection	m	73,00	1.980	144.540
8	Rubber joint	m	71,00	4.488	318.648
9	Lean Concrete	m^2	9,00	59.341	534.065
10	Pavement	m^2	24,00	91.800	2.203.200
	Total Cost				**103.949.546**

TASK 4

Table B.5
Cost Estimate
WSB and Conduits (Civil Works)
Side by side conduits disposition

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Reinforced concrete	m³	120,00	255.158	30.618.946
2	Steel reinforcement BE500	tons	875,00	19.137	16.744.736
3	Roller compact concrete over conduits	m³	28,00	160.470	4.493.160
4	Backfill crushed stone over conduits	m³	3,00	560.332	1.680.996
5	Liner HDPE (WSB)	m²	13,31	170.000	2.262.700
6	Underlaying protective geotextile (WSB)	m²	1,88	170.000	319.600
7	Geotextile for drainage (WSB)	m²	4,71	21.000	98.910
8	Bank protection (WSB)	m²	13,00	38.000	494.000
9	Excavation				
9,1	Overburden excavation	m³	3,50	2.037.521	7.131.325
9,2	Gatun rock excavation	m³	4,75	4.754.217	22.582.529
10	Backfill crushed stone along chambers	m³	3,00	94	282
11	Lean concrete	m²	9,00	24.329	218.961
12	Overhaul for spoil (10km)	m³km	0,30	62.313.120	18.693.936
13	Technical building	m²	300,00	4.320	1.296.000
14	Equalisation layer WSB and spillway bottom	m³	90,00	89.000	8.010.000
	Total Cost				**114.646.080**

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Table B.6

Cost Estimate
Lock Head Gate

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Reinforced Concrete	m³	120,00	535.984	64.318.080
2	Steel Reinforcement BE500	ton	875,00	40.199	35.173.950
3	Backfill crushed stone	m³	3,00	276.104	828.312
5	RCC chamber floor	m³	28,00	9.158	256.431
6	Gravel layer	m³	6,00	3.052	18.311
7	Geotextile	m²	1,80	6.107	10.992
8	Steel corner protection	m	73,00	1.318	96.214
9	Rubber joint	m	71,00	800	56.800
10	Lean concrete	m²	9,00	24.119	217.071
11	Pavement	m²	24,00	21.320	511.680
12	Technical building	m²	300,00	4.741	1.422.240
	Total Cost				**102.910.080**

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Table B.7

Cost Estimate
Transition Segment

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Reinforced concrete	m^3	120,00	143.512	17.221.493
2	Steel reinforcement BE500	ton	875,00	10.763	9.418.004
3	Backfill crushed stone	m^3	3,00	336.026	1.008.078
4	Steel corner protection	m	73,00	588	42.933
5	Rubber joint	m	71,00	1.056	74.976
6	Lean concrete	m^2	9,00	17.484	157.356
9	RCC	m^3	28,00	21.343	597.607
10	Gravel layer	m^3	6,00	6.461	38.768
11	Geotextile	m^2	1,80	13.900	25.021
	Total Cost				**28.584.236**

Table B.8

Cost Estimate

Lock Head Gate

Equipment (Civil Part)

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Equipment lock gate (civil part)				4.574.640
1,1	Rails	m	280,00	4.848	1.357.440
1,2	Wooden vertical guidances	m	400,00	675	270.000
1,3	Steel for support rails and frames	tons	2.400,00	1.228	2.947.200
2	Equipment lock head (civil part)				7.204.790
2,1	Vertical elements for seals - east/recesses	m³	3.050,00	663	2.022.150
2,2	Vertical elements for seals - west	m³	2.700,00	843	2.276.100
2,3	Horizontal elements for seals- lock chamber	m³	2.700,00	896	2.419.200
2,4	Elements for placement habitat	m³	275,00	932	256.300
2,5	Horizontal elements for seals- gate recesses	m³	1.520,00	152	231.040
	Total Cost				**11.779.430**

TASK 4

Table B.9

Cost Estimate

Accessories

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	**Accessories**				
1,1	Bollards 1500kN	pcs	4.900	122	597.800
1,2	Wheel fenders	pcs	540.000	4	2.160.000
1,3	Roller fenders	pcs	540.000	4	2.160.000
1,4	Fenders Atlantic side	pcs	50.000	16	800.000
1,5	Ladders	m	100	122	12.200
1,6	Mooring bits	pcs	950	244	231.800
	Total Cost				**5.961.800**

Table B.10

Cost Estimate

ELECTROMECHANICAL EQUIPMENT

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	**EM Equipment lock**				**174.737.402**
1,1	EM Equipment Lock (rolling gates and bulkheads)	tons	6.173	20.274	125.151.402
1,2	EM Equipment Lock (valves and bulkheads)	tons	5.000	2.047	10.236.000
1,3	Support equipment		21.400.000	1	21.400.000
1,4	Control system		2.800.000	1	2.800.000
1,5	Lighting System		2.000.000	1	2.000.000
1,6	Electrical and Power System (alternative 5)		13.150.000	1	13.150.000
2	**EM Equipment WSB (Support and control system**	tons	5.000	2.932	**14.661.000**
	Total Cost				**189.398.402**

Table B.11

Cost estimate

Construction and permanent dams

Item	Description	Unit	Unit Price	Quantity	Total USD - 2002
1	Liner HDPE	m²	13,31	3.000	39.930
2	Underlaying protective geotextile	m²	1,88	3.000	5.640
	Total Cost				**45.570**