The Taiwan Area Deep Water Port Development Project

Feasibility Study & Preliminary Planning

Executive Summary

June 1990
高雄深水港發展計畫透視圖

PERSPECTIVE OF KAOSHIUNG DEEPWATER PORT DEVELOPMENT PROJECT
# EXECUTIVE SUMMARY

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1. INTRODUCTION

The Deep Water Port Development (DWPD) Project study, which began in February, 1989, was completed in June 1990. This study examined the feasibility of building a deep water port on the northern and western coasts of Taiwan, in one or more of the five preselected sites: Keelung, Tamsui, Taichung, Waisanding and Kaohsiung.

The purpose of the first phase of the study, concluded at the end of 1990, was:

- to identify the needs for a deep water port in the Taiwan area and the possible development alternatives to meet them;
- to check the economic, technical and financial feasibility of these alternatives;
- to compare them and recommend the most satisfactory.

At the end of the first phase, the project of an industrial port, designed to accommodate a power plant, a steelworks and a refinery at Kaohsiung, was recommended and accepted by IOT in January, 1990.

The second phase of the study analyzed the condition of implementation of the selected project in greater detail: the master plan, economic performance, financial organization, and implementation.
2. NECESSITY FOR A DEEP WATER PORT IN TAIWAN

2.1 PRESENT INTERNATIONAL PORT TRAFFIC

The ROC’s economic history shows the importance of foreign trade in the general economic development of the island of Taiwan, mainly based on export and industrial activities. In this context, Taiwan has been favored for its geographical location in the Asia-Pacific region, leading to a strong maritime vocation.

Out of a total of 101 Mt seaborne exports and imports in 1987, two main categories involving different shipping patterns and port facilities are to be considered:

- Marine imports in bulks for the energy sector (coal and crude oil) as well as ores and raw materials for basic heavy industries (steel and chemicals) represented more than 65% of the 83 Mt of imports in 1987.

- General and containerized traffic reflect the imports of intermediary and capital goods in the manufacturing sector (19.3 Mt) as well as exports of final products (12.4 Mt).

In 1988, foreign trade through the ports soared with a 14.2% increase resulting in a 115.5 million ton total, this increase is related only to massive energy and basic industrial bulks, containerized traffic remaining stable around 21 million tons. On the other hand, crude oil, coal and mineral ores significantly increased by a total of 11.3 million ton. The most recent port traffic evolution is as follows:

- for Kaohsiung harbor, an increase of 15.4% in 1988 mainly due to soaring of bulk and non containerized traffic,

- for Keelung harbor, a slight increase of container traffic imports, but significant decrease as far as export tonnages are concerned,

- for Taichung harbour, an increase of container traffic which remain nevertheless below its regional potential.

The recent container traffic is marked by:

- a decrease in export tonnage,
- an increase in import container tonnage.

Another major change observed is the significant decrease of empty boxes (imports), an evolution related to the relative stagnation of exports and a simultaneous decrease in average tonnage/TEU resulting in a better balance of box movements.
These recent changes are likely to influence the future of container traffic in Taiwan.

2.2 THROUGHPUT FORECASTS

The forecasts prepared for port development projects are long term, due to the lifetime of the structures and equipment involved.

Two time periods were considered for forecasting:

- for the first period (up to the year 2000), the study relies on the general economic forecasts prepared by CEPD.

- for the second period (2000 - 2021), a realistic outcome was predicted from generally accepted ideas including references to economic development in other countries.

For the Taiwan economic prospects up to the year 2000, the major targets and corresponding economic indicators are defined by the CEPD reference document:

- Before the end of the century, the ROC will rank as one of the developed countries of the world, per capita revenue being 3 times that of 1988 (approximately US$18,000 compared to 6,000 at present in current prices).

- This objective will be reached with an average of 6.5% yearly economic growth rate and a slight population increase.

- Growth in domestic demand is considered to be the primary source of economic growth, and export expansion the secondary.

With a 5.3% average yearly growth rate, industry is expected to continue playing a prominent role in Taiwan’s future economic development.

As long term perspectives are uncertain, and because the uncertainty differs according to the various sectors of the economy which generate the seaborne traffic, three differentiated scenarios were proposed for the ROC economy:

- "Trend scenario"

It can be defined as smooth and growing but with a digressive pace from 50% per year as the average in 2000 - 2005 to 3% in 2020, as a result of both the stabilization of total population, and the declining role of the export industrial sector.
• "High - or industrial - scenario"

Based on world market opportunities, the "industrial scenario" could correspond to less basic and intermediary sector "delocalization" - and resulting in a higher share of intermediary manufactured products in a global, slightly more expanded export industrial sector.

This "high scenario" could influence the final energy demand as well as the import of raw and intermediate products and equipment.

• "Low - or post- industrial scenario"

A lower economic growth scenario, with a higher orientation to domestic demand, could result from relatively restricted exchange opportunities in world and Asian region economics, this scenario implies a slower expansion in all foreign trade oriented industrial sectors and primarily in the steel and chemical sectors for which "delocalization" would be favored.

Consequently, final energy demand and massive imports related to basic industrial sectors would be lower, balanced by partial imports of intermediate or final products.

2.3 FUTURE SHIPPING PATTERNS

• Tankers

Future shipping patterns can be based on probable source diversification with a notable increased share of South East Asian supplies. Due to the importance of tonnage to be imported from this region, the share of large vessels is expected to be significant at the 2000 horizon, and increasing in the very long term (60% in 2011).

On the traditional tanker routes from the Arab Persian Gulf to Taiwan, the remaining tonnages can reasonably be transported on large tankers (200,000 to 250,000 dwt).

• Coal and ore

As the major part of coal and ore imports will remain on long-run routes and because of the huge amount of cargo to be transported, future use of large bulk carriers could be considered as an opportunity, as for tankers, for freight fixtures attractivity.
Typical ships to be considered are 150 to 200,000 dwt bulk carriers, and 250,000 dwt class ships in the long-run provided that this alternative is proven economically attractive.

- Grain carriers

Panama ships' size (65,000 dwt) will still be considered as typical for Taiwan.

- Container vessels

The 1990s are expected to see the fourth generation container vessels put into service. This type of ship can be considered the maximum vessel to be operated in Taiwan between 1992 and 1995.

2.4 CONCLUSION

Based on the trend scenario, Fig. 1 shows the growth of total traffic up to the year 2021 for bulk containers, and ordinary cargo.

The container traffic forecasts for the three ports of Kaohsiung, Keelung and Taichung are shown in Fig. 2.

These forecasts confirm the expected increase in the ports traffic in Taiwan. This increase will be particularly important with regard to the goods in containers which are likely to play a key role in the economic development, particularly in the exports. Although the forecasts represented in this respect are far below the figures usually quoted in Taiwan, they clearly show the need for urgent development in the capacity of Keelung port and for the continuation of the development of Kaohsiung port. Although the facilities required are not deep water facilities (in the sense of depths alongside the quays larger than those available now), possible layouts at Keelung will be designed as a response to this need. In Kaohsiung the existing projects of terminal 5, and if needed terminal 6, will meet the traffic requirements for the years after 2000. Taichung is not likely to experience an immediate growth of the container traffic; and the existing facilities will be adequate for foreseeable future.

The traffic of goods in bulk will also experience a significant increase, particularly as far as the imports are concerned. This is, related to the scarcity of raw materials in Taiwan. Among these goods, only the following could benefit from transportation by large vessels (more than 125,000 dwt carriers requiring depths larger than 16.5m):
Fig. 1 TOTAL TRAFFIC FORECASTS

(trend scenario)

Total traffic

Bulk

In containers

Ordinary cargo

TRAFFIC (million tonnes)

YEAR

Fig. 2 CONTAINER TRAFFIC FORECASTS

(trend scenario)

Traffic (million TEUs)

YEAR


Total

Kaohsiung

Keelung

Taichung
- crude oil;
- coal for power generation;
- coal and iron ore for steelmaking;

The need for the Taiwan economy to increase the imports of these goods is obvious. Although it is always possible to import refined and steel products, crude oil refining and steelmaking are strategic activities in a modern economy and are in the interest of CPC and CSC for future development in their respective sectors; they have confirmed this.

With regard to power generation, TPC is looking for the diversification of energy source and keeping the cost of electrical power as low as possible. Coal should continue playing a significant role in the development of the production and TPC also confirmed its interest in increased coal unloading facilities.

It is a well known fact that this traffic is generated by port related industries. This means that the plants (refinery; power plant, steelworks) should be located as close as possible to the berths where the goods are unloaded. The value per ton is low and inland transportation (including coastal shipping) would result in an unrealistic cost increase. Port planning should then consider, at the same time, the port facilities and the industrial land supply (as there are many examples of similar situations in the world) which will be a prerequisite to the design of development alternatives.

It can be argued that a refinery is not exactly a port related industry as it could be located some distance from the crude unloading berths and connected to them by a pipe line. This is a possible alternative but in the prevailing situation in Taiwan, where the industrial land is scarce, the construction of artificial land by reclamation should be considered as an alternative.

There is an interest in the use of large vessels for the traffic (vessels larger than 125,000 dwt) and the economy will have to check that this advantage will offset the construction cost of the facilities required to accommodate them.

Other traffic in bulk will experience growth: grain, cement, and coal for other purposes, etc. On one hand, however, it will not require deep water facilities, and on the other hand, improvement of handling efficiency will increase the capacity of the existing berths where these goods are unloaded. Bottlenecks are only expected at Keelung; but the projects now under investigation by the Harbor Bureau will provide a satisfactory answer.
3. COMPARISON OF ALTERNATIVES

Possible alternative schemes were compared for deep water ports able to receive the future forecast traffic which will likely use large vessels: crude oil, coal for power generation, iron ore and coal for steelmaking.

To accommodate this traffic, five ports or sites are considered: Keelung, Tamsui, Taichung, Waisanding and Kaohsiung.

The design of the identified alternatives is based on the analysis of physical conditions at the five sites.

The alternative developments studied are then compared from several points of view - including financial and economic aspects - and a multicriterion analysis is developed. Obviously, this multicriterion analysis would only show which is the best among these possible projects but would be unable to show that it is better than a project without deep water facilities. So a "reference case" is also developed without deep water facilities for the purpose of comparison, but which can receive the maximum size of vessel which can presently be accommodated in Taiwan ports.

3.1 USER'S REQUIREMENTS

To meet their future production, the three potential users (TPC, CSC, and CPC) submitted their original requirements concerning maritime terminal capacities to the consultants before the end of July, 1989.

The consultants have made their own determination in regard to the number and lengths of berths as well as water depths, using reasonably conservative assumptions for handling rates, unloading of bulk materials, and the loading of steel and petroleum products.

3.1.1 Traffic

- Power plant (TPC)

TPC has expressed its intention of building a new coal fired power plant, and an LNG fired plant as soon as possible, with the following capacities:
• 8 coal fired units of 750 MW each;
• 8 LNG fired units of 750 MW each.

The resulting traffic at full development:
• for coal: 12.8 Mt per year;
• for LNG: 14.7 Mm$^3$ of liquid gas per year.

• Steelworks (CSC)

According to the rates presently observed at CSC, the future production would generate the following annual traffic:

• 13.6 Mt of iron ore
• 8.0 Mt of coal
• 3.6 Mt of limestone
• 0.6 Mt of scrap iron
• 3.6 Mt of slags

and, in addition, 2.5 Mt of steel products are expected to be shipped directly from the steel plant.

• Refinery (CPC)

The existing domestic refinery capacity will not be sufficient to process the imported crude oil by the year 2000. Moreover, the existing Kaohsiung refinery is destined to stop operation, CPC proposes to plan for a new refinery in the DWPD area with a capacity of 600,000 BPSD. This would involve a traffic of:

• 30Mt of imported crude oil per year,
• a volume of refined products estimated between 10 and 20 Mt per year.

3.1.2 Land requirements

At the request of TPC, two separate land areas of 500 ha each has to be allocated for power plants. First, CPC required an area of 1,000 ha for its steel plant. Then, its requirements were increased to 1,200 ha.
The CPC requirement concerning land area is 1,500 ha. This figure must be considered as a minimum, and since the preliminary layouts have been finalized, CPC has expressed a preference of 2,500 ha.

In total, the land area required for industrial purposes amounts to 3,700 ha which is the basic figure used for the preliminary design layouts.

3.1.3 Shipping requirements

Iron ore, assumed to be imported from Australia, Brazil and South Africa, and coal from Australia, Canada and USA, will be transported in ships of 150 to 230,000 dwt. CSC has confirmed its interest in using 230,000 dwt ore carriers. For limestone, scrap iron and steel products, the largest vessels expected to call will be of the 40,000 dwt class.

Coal for the power plant will be transported in 150-230,000 dwt carriers, and liquid gas in 120,000 m$^3$ LNG carriers.

For the refinery, it seems reasonable to assume that crude oil will arrive in 230,000 - 250,000 dwt tankers. Refined products will be transported in coastal tankers of 40,000 dwt.

3.1.4 Berth requirements

- TPC terminals

The terminal for eight coal fired units will include two berths with a total length of 700 m at a depth of 22 m below LLW (Chart Datum).

For LNG carriers of 120,000 m$^3$, provisions have been made for 600 m berths (2) at a depth of 13 m.

- CSC terminal

After the calculation was based on reasonable handling rates, it was then considered that 1,070 m berths at -21.0 m should be sufficient for iron ore and coal, and 920 m at -13.0 m for limestone, scrap iron and steel products.

CSC has then expressed different requirements: 1,250 m of berths at -22.0 m and 1,500 m at -13.0 m.
• CPC terminal

For the refinery, it is considered that allocation of a single berth for crude imports does not allow for a sufficient margin of tolerance in case of accidents and delays. The length of deep water berths has thus been increased to 700 m (2 berths at -22.0 m). For refined products, 3 berths at -13.0 m for a total length of 600 m have been considered in the port layouts.

Land and marine requirements are summarized in Table 1.

3.1.5 Priorities of the users

From discussions with the users, the following priorities have been revealed:

• To cope with future electricity demand, TPC requires one site of 500 ha to be handed over to start construction of the generating station by the year 1997. This is in order to produce electricity from the first 750 MW generator in the year 2003. It emphasizes that reclamation of the entire site must be completed before construction. Berthing requirements will follow upon completion of the first generator in 2006.

• CPC also requires the handing over of 500 ha at the end of the phase I construction in 1996. This priority arises from the enforced closure of their plant at Kaohsiung for environmental reasons, and the need to replace the lost refining capacity. The first berthing facilities will be required to be completed as soon as the first refining unit is completed in the year 2000.

• CSC has not expressed an urgency for the commencement of construction of the steelworks, so it was assumed that commencement can be deferred until the initial needs of the other two industries have been satisfied.

3.2 PRELIMINARY DESIGN OF ALTERNATIVES

Three layouts for each site were designed:

- layout "A": project designed to receive 3 industrial plants,
- layout "B": project designed to receive 2 industrial plants,
- layout "C": project designed to receive 1 industrial plants,
Table 1  LAND AND MARINE REQUIREMENTS

<table>
<thead>
<tr>
<th>INDUSTRIES</th>
<th>LAND (ha)</th>
<th>TYPE</th>
<th>SIZE (DWT)</th>
<th>DRAFT (m)</th>
<th>REQUIRED DEPTH ALONG SIDE (m BELOW LLW)</th>
<th>NUMBER</th>
<th>LENGTH (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>POWER PLANTS (TPC)</td>
<td>1,000</td>
<td>Coal carrier</td>
<td>150/230,000</td>
<td>20</td>
<td>22</td>
<td>2</td>
<td>700</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LNG carrier</td>
<td>120,000</td>
<td>12</td>
<td>13</td>
<td>2</td>
<td>600</td>
</tr>
<tr>
<td>STEELWORKS (CSC)</td>
<td>1.200</td>
<td>Ore and coal carriers other cargo</td>
<td>150/230,000</td>
<td>20</td>
<td>22</td>
<td>3</td>
<td>1,250</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10/40,000</td>
<td>11</td>
<td>13</td>
<td>4</td>
<td>1,500</td>
</tr>
<tr>
<td>REFINERY (CPC)</td>
<td>1.500</td>
<td>Tanker (crude oil) (refined products)</td>
<td>230/250,000</td>
<td>19</td>
<td>22</td>
<td>2</td>
<td>700</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10/40,000</td>
<td>11.3</td>
<td>13</td>
<td>3</td>
<td>600</td>
</tr>
</tbody>
</table>

* or m3 for LNG carrier
These total 12 different layouts after eliminating Keelung where it would be too costly to accommodate a deep water port with corresponding industrial land. The actual number of possible project developments is larger. There are 28, as for each site there are: one unique solution for 3 industries on the same site (case "A"); 3 possible combinations of 2 plants (case "B"); and 3 possible single industrial projects (case "C"). But it is obvious that the differences between the combinations of industrial requirements in case "B" (and the same applies to case "C") are small and do not lead to significant changes in the main characteristics of the layouts. Therefore, only one layout is presented to illustrate case "B", and one to illustrate case "C".

A single phasing time schedule has been adopted for all the alternatives. This enables a simple comparison to be made between them. Comparing 2 alternatives with different plant operation and implementation schedules would lead to difficulties and inaccuracy. But of course this common schedule might appear loose or tight for one alternative or the other depending on the actual amount of work, general organization, etc. Any advantage attached to a particular alternative, the schedule of which could easily be shortened, will be taken into account in the multicriterion analysis.

The final costs of each site layout alternative plus the two layouts of the reference case and the external harbor for the container terminal at Keelung are summarized in Table 2.

These costs include port infrastructures, industrial infrastructures, buildings, equipment, and utilities costs. A contingency allowance of 20% is added to these estimates, because of the tentative nature of the present study, which is only for comparing the various combinations of site layouts.

In the case of Kaohsiung, it has been necessary to prepare an estimate of all 7 alternative layouts excluding the container terminal and future airport of the full scheme, in order to arrive at a cost which can be directly compared with the costs of the other three industrial ports.

In order to make the economic and financial appraisals of the relative benefits of each possible combination of alternatives of site layouts and allocation of industries to each site, it is necessary to assess the capital investment required per year. For this purpose all the proposed industrial developments have been designated in six 5-year phases starting in 1992 and the corresponding costs calculated.

3.3 MULTICRITERION ANALYSIS
<table>
<thead>
<tr>
<th>ALTERNATIVE</th>
<th>COST B NT$</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAM &quot;A&quot; (SPR)</td>
<td>297.82</td>
</tr>
<tr>
<td>TAM &quot;B&quot; (SP.)</td>
<td>179.64</td>
</tr>
<tr>
<td>TAM &quot;B&quot; (.PR)</td>
<td>208.99</td>
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<tr>
<td>TAM &quot;B&quot; (S.R)</td>
<td>162.54</td>
</tr>
<tr>
<td>TAM &quot;C&quot; (S.)</td>
<td>69.82</td>
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<td>TAM &quot;C&quot; (..R)</td>
<td>89.31</td>
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<tr>
<td>TAM &quot;C&quot; (..P.)</td>
<td>96.52</td>
</tr>
<tr>
<td>TAI &quot;A&quot; (SPR)</td>
<td>232.25</td>
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<tr>
<td>TAI &quot;B&quot; (SP.)</td>
<td>148.87</td>
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<tr>
<td>TAI &quot;C&quot; (S.)</td>
<td>65.45</td>
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<tr>
<td>TAI &quot;C&quot; (..R)</td>
<td>86.22</td>
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<tr>
<td>TAI &quot;C&quot; (..P.)</td>
<td>97.34</td>
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<td>WAI &quot;A&quot; (SPR)</td>
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<tr>
<td>WAI &quot;C&quot; (S.)</td>
<td>55.75</td>
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<td>WAI &quot;C&quot; (..P.)</td>
<td>92.12</td>
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<td>KAO &quot;A&quot; (SPR)</td>
<td>220.77</td>
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<td>KAO &quot;B&quot; (SP.)</td>
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<td>KAO &quot;B&quot; (.PH)</td>
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<td>KAO &quot;B&quot; (S.R)</td>
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<td>KAO &quot;C&quot; (S.)</td>
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<td>KAO &quot;C&quot; (..R)</td>
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<td>KAO &quot;C&quot; (..P.)</td>
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<tr>
<td>KEE &quot;A&quot; (....) (C.)</td>
<td>(1)(2)</td>
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<td>KEE &quot;B&quot; (....) (C.)</td>
<td>(1)(2)</td>
</tr>
<tr>
<td>KAO &quot;A&quot; (SPR) (CA)</td>
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<td>KAO &quot;B&quot; (SP.) (CA)</td>
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<td>KAO &quot;B&quot; (.PR) (CA)</td>
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<td>KAO &quot;B&quot; (S.R) (CA)</td>
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<td>KAO &quot;C&quot; (S.) (CA)</td>
<td>(1)</td>
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<tr>
<td>KAO &quot;C&quot; (..R) (CA)</td>
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<tr>
<td>KAO &quot;C&quot; (..P.) (CA)</td>
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<tr>
<td>TAI REF</td>
<td></td>
</tr>
<tr>
<td>KAO REF</td>
<td></td>
</tr>
</tbody>
</table>

(S) Steelwork  
(P) Power plant  
(R) Refinery  
(C) Containers  
(A) Airport  
"REF." reference  

(1) Equipment and superstructure for containers and (or) airport not included  
(2) Navigational aids not included
The ranking of the alternatives has been made by means of a multicriterion analysis. The method adopted for the DWPD project is the ELECTRE 3 mathematical model developed by LAMSAD ("laboratory for analysis and modelling of decision support systems", Paris).

Because of the large number of alternatives and the amount of calculations required to evaluate the criteria, the multicriterion analysis was operated in 2 steps. The first dealt with the 64 alternatives but used simplified economic and financial criteria. It led to the selection of 12 attractive alternatives which were compared in the second step, using more precise criteria carefully evaluated through EVEC simulation. The list of criteria is presented in Table 3.

To make sure that the selection of the 12 most attractive alternatives would not unduly discard an interesting one, a large number of sensitivity tests were carried out for the comparisons (13 cases).

The results of the second step of the multicriterion analysis are given in Table 4. Again, a fairly large number of sensitivity tests have been carried out to check that the selected alternative is robust. These tests mainly deal with economic values and the weighing of criteria.

As a conclusion to this multicriterion analysis, the solution, KAO SPR (development at Kaohsiung of the full project including steelworks, power plant and refinery), looks the most attractive. The second best solution, KAO PR TAI S, is not as obvious and ranks third in some cases. Other interesting alternatives are:

KAO SP TAM R (a refinery in Tamsui would be close to the consumption gravity center and would not cause significant traffic in this already crowded area);

KAO SR TAM P, (the same remark as above could be made but the inland transportation cost of refined products is higher);

TAI SPR (the second "full development alternative" suffers from a high industrial land cost and from natural conditions).

The KAO SPR alternative was presented to the Chinese authorities for further studies (preliminary engineering studies).

4. RECOMMENDED DWPD PROJECT
Table 3  LIST OF CRITERIA USED BY THE MULTICRITERION ANALYSIS  
(2nd step)

GROUP 1. Technical criteria

1 - Mobilization and supplies for construction work
2 - Risk for construction works
3 - Flexibility of the program

GROUP 2. Operational and maintenance criteria

4 - Maintenance risk
5 - Operational risk
6 - Natural conditions

GROUP 3. Environmental criteria

7 - Sea water quality and marine ecology
8 - Air quality and public safety
9 - Water resources
10 - Land and terrestrial ecology
11 - Human and social aspects

GROUP 4. Economic and financial criteria

12 - Port infrastructure IRR
13 - Total economic IRR  
   (1st step: land value benefit)
14 - State funding phase 1  
   (1st step: state funding)
15 - State funding phase 2  
   (1st step: inland transportation cost)

GROUP 5. Government and users policies

16 - Port development policy
17 - Land development policy
18 - Defence strategy and safety
19 - Users' preferences
<table>
<thead>
<tr>
<th>Test No.</th>
<th>Changes on criteria No.</th>
<th>Characteristic of change</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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<tr>
<td>261</td>
<td>IRF &quot;project&quot; instead of IRF &quot;economic tools&quot;</td>
<td>3</td>
<td>8</td>
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<tr>
<td>262</td>
<td>IFR cost +10% in Sea (ALT.6)</td>
<td>3</td>
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<td>4</td>
<td>8</td>
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<td>3</td>
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<td>IFR cost +70% in Sea (ALT.4)</td>
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<td>IFR cost +10% in Sea and Tai (ALT.4)</td>
<td>2</td>
<td>7</td>
<td>3</td>
<td>2</td>
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<td>4</td>
<td>8</td>
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<td>2</td>
<td>5</td>
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<td></td>
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<tr>
<td>265</td>
<td>IFR cost +20% in Sea and Tai (ALT.4)</td>
<td>3</td>
<td>8</td>
<td>4</td>
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<td>5</td>
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<td>Value of created land -15% in Sea (ALT.3) and Tai (ALT.6)</td>
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<td>4</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>5</td>
<td>9</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td></td>
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<td>267</td>
<td>Value of created land +10% in Sea (ALT.4)</td>
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<td>8</td>
<td>4</td>
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<td>5</td>
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<td>4</td>
<td>6</td>
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<tr>
<td>268</td>
<td>Value of created land -10% in Tai (ALT.4)</td>
<td>3</td>
<td>8</td>
<td>4</td>
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<td>5</td>
<td>9</td>
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<td>4</td>
<td>6</td>
<td>8</td>
<td></td>
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<td>269</td>
<td>Land cost of created land +20% in Sea (ALT.6) and Tai (ALT.4)</td>
<td>3</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>5</td>
<td>9</td>
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<td>4</td>
<td>6</td>
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<tr>
<td>270</td>
<td>Land cost of created land +20% in Tai (ALT.4)</td>
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<td>8</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>5</td>
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<td>4</td>
<td>6</td>
<td>8</td>
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<tr>
<td>271</td>
<td>Weighting of eco and financial criteria: No.12=11, No.13=10, No.14=13, No.15=10</td>
<td>3</td>
<td>8</td>
<td>3</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>5</td>
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<td>4</td>
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<td>Weighting of eco and financial criteria: No.12=12.6, No.13=12.5, No.14=12.5, No.15=12.5</td>
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<td>4</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>8</td>
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<td>5</td>
<td>7</td>
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<td>273</td>
<td>Weighting of port and land policy: No.16=13, No.17=10</td>
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<td>6</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>7</td>
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<td></td>
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<tr>
<td>274</td>
<td>Core transport cost -15% for all size of ships</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>1</td>
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<td>3</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>
The recommended DWPD project (see its location in Fig. 3) is divided into two phases:

- **First phase:**
  - Land for Kaohsiung City Government (KCG)
  - Steelworks (CSC)
  - Tank farm (CPC)

- **Second phase:**
  - Land for the development of Kaohsiung Metropolitan Area (KMA).
  - Airport

The land area required to complete the first phase is 3,357 ha; for the second phase - 2,820 ha. Therefore, total area to be reclaimed is 6,177 ha.

### 4.1 TIME REQUIREMENTS

Considering the time required for building the plants, and the earliest date for the start of operations, the estimated dates for the availability of land are given below:

- Power plant (TPC): year 2003
- Steelworks (CSC): year 2000

In addition, it is hoped that the whole project is completed within 20 years.

### 4.2 TECHNICAL FEATURES

The required port facilities are summarized in Table 5.

Considering the land area required for industrial and urban development (6,177 ha), and the natural limits of the project toward the north (second entrance of Kaohsiung harbor) and the south (mouth of the Kaoping river), the only way to meet with the requirements is to extend the port offshore to water depths of 30 meters.

Because no refinery will be built on this site, and there is little chance of implementing a fired power plant, a one basin layout alternative was finally selected.

The master plan at full development is shown in Fig. 4.
Fig. 3 LOCATION OF D.W.P.D. PROJECT
Table 5  SUMMARY OF REQUIRED PORT FACILITIES

<table>
<thead>
<tr>
<th>TRAFFIC</th>
<th>QUANTITY</th>
<th>SHIP</th>
<th>AVERAGE</th>
<th>AVER. QUANT.</th>
<th>HANDLING</th>
<th>HANDLING RATES</th>
<th>HANDLING AND ALONGSIDE TIME PER SHIP</th>
<th>NUMBER OF</th>
<th>BERTH</th>
<th>NUMBER</th>
<th>BERTHS</th>
<th>BERTH OCCUP. RATES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(MT)</td>
<td>(DWT)</td>
<td>(DWT)</td>
<td>(DWT/MT)</td>
<td>PER CALL</td>
<td>PER Calls/Years</td>
<td>TIME(HOURS)</td>
<td>AVERAGE</td>
<td>TIME(HOURS)</td>
<td>AVERAGE</td>
<td>TIME(DAYS)</td>
<td>CALLS</td>
</tr>
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<td>CRUDE OIL</td>
<td>30.00</td>
<td>40/125,000</td>
<td>100,000</td>
<td>87,500</td>
<td>ship pumps</td>
<td>tanker unloaded</td>
<td>24</td>
<td>12</td>
<td>1.50</td>
<td>137</td>
<td>205.5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1125/230,000</td>
<td>177,500</td>
<td>155,000</td>
<td>1)</td>
<td>in one day</td>
<td>24</td>
<td>12</td>
<td>1.50</td>
<td>116</td>
<td>174.0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TOTAL</td>
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<td>2</td>
<td>54</td>
<td></td>
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<td></td>
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<td>40,000</td>
<td>10,000</td>
<td>35,000</td>
<td>gravity</td>
<td>24</td>
<td>8</td>
<td>1.33</td>
<td>571</td>
<td>761.9</td>
<td>3</td>
<td>73</td>
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<tr>
<td>COAL</td>
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<td>90,000</td>
<td>81,000</td>
<td>1)</td>
<td>2 cranes (40 t/2,400 t/hr</td>
<td>33.8</td>
<td>12</td>
<td>2.29</td>
<td>52</td>
<td>119.0</td>
<td>1</td>
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<tr>
<td></td>
<td>1125/230,000</td>
<td>180,000</td>
<td>162,000</td>
<td>1)</td>
<td>/berth</td>
<td>/berth</td>
<td>67.5</td>
<td>12</td>
<td>3.96</td>
<td>53</td>
<td>210.7</td>
<td>1</td>
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<td></td>
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<td>2</td>
<td>47</td>
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<tr>
<td>LIME</td>
<td>6.92</td>
<td>50/100,000</td>
<td>10,000</td>
<td>56,400</td>
<td>1)</td>
<td>pumps</td>
<td>2/hr for unload.</td>
<td>12.0</td>
<td>12</td>
<td>1.00</td>
<td>123</td>
<td>122.7</td>
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<tr>
<td>LIME, ORE &amp; LIMESTONE</td>
<td>7.99</td>
<td>40/125,000</td>
<td>90,000</td>
<td>81,000</td>
<td>1)</td>
<td>2 cranes (40 t/2,400 t/hr</td>
<td>33.8</td>
<td>12</td>
<td>2.29</td>
<td>43</td>
<td>90.4</td>
<td>1</td>
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<td></td>
<td>1125/230,000</td>
<td>180,000</td>
<td>162,000</td>
<td>1)</td>
<td>/berth</td>
<td>/berth</td>
<td>67.5</td>
<td>12</td>
<td>3.90</td>
<td>28</td>
<td>111.1</td>
<td>1</td>
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<tr>
<td>ORE</td>
<td>13.61</td>
<td>40/125,000</td>
<td>90,000</td>
<td>104,500</td>
<td>1)</td>
<td>2 cranes (40 t/2,400 t/hr</td>
<td>43.3</td>
<td>12</td>
<td>2.70</td>
<td>56</td>
<td>155.5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1125/230,000</td>
<td>180,000</td>
<td>171,000</td>
<td>1)</td>
<td>/berth</td>
<td>/berth</td>
<td>71.3</td>
<td>12</td>
<td>4.16</td>
<td>45</td>
<td>187.3</td>
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</tr>
<tr>
<td>LIMESTONE</td>
<td>3.60</td>
<td>5/40,000</td>
<td>10,000</td>
<td>10,000</td>
<td>1)</td>
<td>2 cranes (40 t/2,400 t/hr</td>
<td>4.2</td>
<td>12</td>
<td>0.81</td>
<td>360</td>
<td>291.0</td>
<td>1</td>
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<td>TOTAL</td>
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<td>5</td>
<td>48</td>
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<td>ISLAGS</td>
<td>3.60</td>
<td>1/10,000</td>
<td>3,000</td>
<td>3,000</td>
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<td>loaders</td>
<td>1,000 t/hr/ship</td>
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<td>1200</td>
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<td>5/40,000</td>
<td>10,000</td>
<td>10,000</td>
<td>1)</td>
<td>2 cranes</td>
<td>120 t/hr/ship</td>
<td>83.3</td>
<td>12</td>
<td>5.96</td>
<td>60</td>
<td>357.5</td>
</tr>
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<td>STEEL PRODUCTS</td>
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<td>20,000</td>
<td>20,000</td>
<td>1)</td>
<td>2 cranes</td>
<td>150 t/hr/ship</td>
<td>133.3</td>
<td>12</td>
<td>9.08</td>
<td>50</td>
<td>454.2</td>
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</tbody>
</table>

(*): 24 hours per day for liquid bulk, 20 hours for dry bulk and 16 hours for scrap iron and steel products.
The distribution of reclaimed land between the three main industries and the Kaohsiung City Government, as well as common land such as green belts, port boulevard and main roads is as follows:

- **First phase**
  - Kaohsiung City Government 1,085 ha
  - Power Plant 650 ha
  - Steelplant 1,152 ha
  - Refinery storage area 200 ha
  - Service port 57 ha
  - Green belt 213 ha
  
  **Total** 3,357 ha

- **Second phase**
  - Kaohsiung City Government 1,820 ha *
  - Airport 1,000 ha
  
  **Total** 2,820 ha

* This area includes the green belt, but not the 600 m wide channel connecting the Honpi-Tou planned fishing port project to the sea.

According to the distribution of land defined in Fig. 4, the east side of the basin should be reserved for the terminal of CSC, and the south side for the terminal of TPC. A land strip 100m wide should receive the pipe lines connecting the CPC tank farm to the main breakwater where a berth for unloading crude oil can be accommodated by CPC.

The allocation of berths is shown in Fig. 5.

### 4.3 BILL OF QUANTITIES AND COST ESTIMATE

The cost estimate of the DWPD project is detailed for the first and second phase.

The basic unit prices for the labor and materials assumed for the present estimates are based on local unit prices from April, 1990 applied in usual Taiwan construction conditions. They account for labor, material, plant, changes, benefits and 5% taxes.

Costs of protective and berthing facilities have been estimated on a cost per linear meter basis of completed structures for various sea-bed level typical cross-sections. The unit rates have then been applied to the lengths of these structures corresponding to these cross-sections, which are sufficiently accurate for this stage of project preparation.
Fig. 5 BERTHING FACILITIES

(-22) REQUIRED DEPTH

CSC TERMINAL

(300) 2100

(1100) 500 500

B1 B2 B3 B4 B5 B6 B7

(-22.0) (-22.0)

B8 B13

B10 B11

(-14.0)

TPC TERMINAL

B14

B15

(400) 1050 200

MAIN BREAKWATER

1250 CPC TERMINAL

2750

350 200
Rock quantities for breakwaters, sea walls and quay revetment have been estimated according to the theoretical profiles as shown on typical cross-sections. Allowance has been made in the quantities used for quarry-run rock and armoring for the increase of actual quantities due to settlement of the subsoil and rock placed in excess of theoretical profiles.

It is impossible to predict the final cost per cubic meter of the dredging/reclamation work in this project with sufficient accuracy because the quantities involved and the rate at which they are required to be delivered are without precedent; and also because some important technical parameters are still to be defined or made more exact.

Since there is very little information on the soil properties of the borrow areas and keeping in mind the technical considerations exposed in previous chapters, certain assumptions have to be made for the purpose of the cost estimation of the project. For this, the unit cost is calculated accounting for 10% of fill from land sources, including free-of-charge materials such as slags, 15% of clean medium fine sand with a grain size distribution at least equal to type "B" material, and 75% of type "A" material. Thus the average unit cost of fill for reclaimed land would be about 130 NT$/cu.m.

The final estimates are detailed in Table 6 and 7 corresponding respectively to the first and second phase. A contingency allowance of 15% has been added to these estimates which is usual at the present stage of project preparation.

4.4 ECONOMIC ANALYSIS

The economic assessment of the "recommended project (see economic indexes in Table 8) shows positive results as regards the port itself. The values found for the various economic indexes are high compared with similar projects in the world, and are similar to the values found for the initial KAO SPR alternative presented in Section 3. This is a natural consequence of the large volume of traffic expected and of the significant decrease in sea transportation cost resulting from a wide use of large vessels.

The results presented by the industrial land component of the projects is lower than for the initial KAO SPR alternative (but nevertheless satisfactory). This decrease first results from the size of the dredging-filling work. As it is large than the former, a higher percentage of it is located in deep water zones with a high unit construction cost. Also, because of its size, the reference case is less realistic and its definition may lead to an under estimate of the profitability.

The total profitability, and the profitability of each component, is positive, and the implementation of the project is recommended.
<table>
<thead>
<tr>
<th>Item</th>
<th>Particulars</th>
<th>Unit</th>
<th>Quantity</th>
<th>Unit Price +1,000NTS</th>
<th>Total +1,000NTS</th>
<th>Remarks</th>
</tr>
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<tbody>
<tr>
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<td>INFRASTRUCTURE</td>
<td></td>
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<td></td>
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<td>Seawall(rubble) -16m</td>
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<td>1501.00</td>
<td>1,350,900</td>
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<td></td>
<td>M</td>
<td>750</td>
<td>1705.00</td>
<td>1,278,750</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>625</td>
<td>1910.00</td>
<td>1,193,750</td>
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<td></td>
<td>M</td>
<td>400</td>
<td>2144.00</td>
<td>857,600</td>
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<td></td>
<td>M</td>
<td>800</td>
<td>2376.00</td>
<td>1,900,800</td>
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<td>1.2</td>
<td>Seawall(caisson) -26m</td>
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<td>3050</td>
<td>1927.00</td>
<td>7,033,550</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>Breakwater(caisson) -26m</td>
<td>M</td>
<td>300</td>
<td>2030.00</td>
<td>609,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>3100</td>
<td>2213.00</td>
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<td>M</td>
<td>1800</td>
<td>2414.00</td>
<td>4,345,200</td>
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<tr>
<td>1.4</td>
<td>Inner temporary dyke -7m</td>
<td>M</td>
<td>1000</td>
<td>196.00</td>
<td>196,000</td>
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<tr>
<td></td>
<td></td>
<td>M</td>
<td>1100</td>
<td>374.00</td>
<td>411,400</td>
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</tr>
<tr>
<td></td>
<td>Temporary dyke -12m</td>
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<td>1000</td>
<td>1092.00</td>
<td>1,092,000</td>
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<td>M</td>
<td>775</td>
<td>1314.00</td>
<td>1,018,350</td>
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<td>M</td>
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Table 6 (contd) COST ESTIMATE OF THE FIRST PHASE

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26 - 1
Table 7  COST ESTIMATE OF THE SECOND PHASE

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27
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<th>NPV (B. NT$)</th>
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5 IMPLEMENTATION PLAN

5.1 WORKS SCHEDULE

Due to the huge volume of materials required for reclamation purposes (more than 600 million m$^3$) for each of the two phases, the construction schedule is completely governed by the reclamation works.

The work schedule for the first and second phase is shown in Table 9 and 10.

From these tables, it can be seen that the first phase would be completed in the year 2003, for the reclaimed land, and in the year 2006 for the port facilities. The second phase would be completed in the year 2011.

5.2 FINANCIAL PLAN

The general financial organization has made sure that incomes and expenses related to the DWPD are balanced and will not put KHB in financial difficulties.

5.2.1 Share of land

It is proposed that the land required by the industrial activities be sold to the industrial firms in full property with the following exceptions:

- a strip of land 300 m wide along the quays, which will be rented to the users on a long term basis;
- the primary and secondary roads of the industrial zones. The tertiary roads (i.e. the roads inside each user's premises) are part of the user plots;
- the green belt.

The above quoted pieces of land remain the property of the Harbor Bureau with the port infrastructures.

The 300 m wide quay land is rented and not sold so that, at the end of the lease period, the Harbor Bureau can easily re-organize the land allocation according to possible changes in the actual requirements.
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<td></td>
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STARTING DATE (CONTRACTS AWARDED)
Table 10  SECOND PHASE CONSTRUCTION WORKS SCHEDULE

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</tr>
<tr>
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</tbody>
</table>

STARTING DATE
(CONTRACTS AWARDED)
It is also assumed that the unloading equipment is bought and installed by the Harbor Bureau and conceded to the users who take care of its maintenance.

5.2.2 Maintenance and operation

The Harbor Bureau will deal with the maintenance and operation of the port itself and will receive accordingly the "ship revenue" in keeping with the official tariff decided by the authorities. It will also deal with the maintenance of the roads, the green belt and the seawalls and will receive a special "land fee" from the users against the use and maintenance of these works. It also receives from them the "equipment fee", rental of the equipment, "port fee", and rental of the quay zone.

All these current fees are calculated so that they are relatively cheap for the users if compared to a fully private development; but so that they ensure an adequate current of income to the Harbor Bureau.

5.2.3 Funding of construction cost (Fig. 6)

With regard to the construction costs, it is proposed to consider separately 2 components paid from different funding sources.

- The construction and sale of the private land. This construction cost is borne by a special fund (for instance a "mutual enterprise fund") which is reimbursed by the users at the actual cost.

- The port construction cost, including the cost of the quay zone, naval and handling equipment, primary and secondary roads and a green belt. The funding of this cost will be ensured year by year from the following sources:
  
  - the available cash flow of KHB (including DWPD).
  
  - the KHB contribution to the Harbor Construction Fund (HCF).
  
  - an additional contribution of HCF, the years when it is required.
  
  - when required, a withdrawal from KHB reserves.

According to this financial plan, the total funding of the port construction cost would be as follows:
Fig. 6 FUNDING SYSTEM

(1) Final yearly CASH FLOW
(surplus + depreciation
of the year)

Port investment (yearly)
= I1 (existing port)
+ I2 (DWP port)

Balance (1)
Investment - Cash flow

* If yearly final cash flow > yearly port investment
  (positive balance)
* If yearly final cash flow < yearly port investment

(2) HARBOR CONSTRUCTION FUND
of KAOSHIUNG PORT
maximum = 30% of HC dues of
KAO, port + DWPD port

Balance (2)
Balance (1) - KAO HCF

* If Balance (2) < 0
* If Balance (2) > 0

Diff. = increase in surplus & depreciation Fund of KHB

(3) HARBOR CONSTRUCTION FUND
of KEELUNG & TAICHUNG
maximum = 30% of HC dues less
what is required by
their own develop. program

Balance (3)
Balance (2) - KEE + TAI HCF

* If Balance (3) < 0
* If Balance (3) < 0

use part of KEE + TAI HCF
(part = Balance (3))

(4) CUMULATED KHB Reserve Fund
(retained earnings)
present reserves = 50% of
working capital

NB: calculation made year by year
Total Kaohsiung development cost  
(up to 2017) in current prices  
(of which DWPD construction cost)  
from KHB cash flow  
from HCF  
from KHB reserves  

5.2.4 Investment distribution

The following distribution of the investment for the whole project (1st and 2nd phases) is suggested (in NT$ million):

- Government investment
  - port, breakwaters, seawalls  
  - airport area  
  - Kaohsiung City and Metropolitan areas  

- Users' investment
  - CSC  
  - CPC  
  - TPC  

Total*  

* including additional investigations, EIA, planning and design studies, management and supervision of the project.

5.2.5 Selling prices

The actual selling price of the industrial land is NT$ 5,003 in constant 1990 prices.

It corresponds to the following selling prices for the users (current prices):

- NT$ 5,995 for Kaohsiung City Government  
- NT$ 6,170 for TPC  
- NT$ 6,065 for CSC  
- NT$ 5,995 for CPC
5.2.6 Conclusion

This financial plan is recommended. It safeguards the flexibility of the port activity and development in the future. It ensures a satisfactory income to the Harbor Bureau, without any change to the tariff system. The unit selling prices of the land to the users remain reasonable when compared to other possible solutions. Finally, the government funding (including the funding of the existing international ports: Keelung, Taichung and Kaohsiung in its present limits) is only a small percentage of the Harbor Construction Fund resources on average, and never exceeds 30% of a single year's revenue.

The sources of financing and the cash flow of the Kaohsiung harbor are shown in Fig. 7, and 8.

5.3 PROJECT ORGANIZATION AND MANAGEMENT

5.3.1 Implementation organization

The implementation period should be distinguished from the operational period of the DWPD project.

Elaborated after consultation with IOT and other agencies involved in the project, it is assumed that the proposed organization reflects common Taiwan practices.

Fig. 9 shows the proposed organization during the preparation of the project construction and the implementation period which is supposed to last 19 years.

The principal function would be to administer the final design and the construction of the DWPD project.

The management organization of the DWPD project is commented on below:

- COMMITTEE

After the approval of the project by the government, a committee would be named for a 20 year period (non permanent authority).

This Committee, responsible for the overall project, would include 12 members coming from:

1. Auditing Bureau of Executive Yuan
2. Development Bureau CEPD
Fig. 7 KAOHSIUNG (INCLUDING DWPD) SOURCES OF FINANCING FOR PORT CONSTRUCTION

(current prices)

- KAO cash flow
- from KAO HCF
- from KEE+TAI HCF
- from KAO reserves
- port constr. cost

FINANCING (billion NT $)

YEAR

Fig. 9 MANAGEMENT ORGANIZATION OF DWPD PROJECT
3. Land Department, Ministry of Internal Affairs (MOIA)
4. IDB of Ministry of Economic Affairs (MOEA)
5. Navigation and Aviation Department of Ministry of Communications (MOC)
6. Aviation Bureau
7. Taiwan Power Company
8. China Steel Corporation
9. Chinese Petroleum Corporation
10. Taiwan Provincial Government
11. Kaohsiung City Government
12. Kaohsiung Harbor Bureau

- WORKING TEAM

During the construction preparation period, the committee would be assisted by a working team named for two years and including 12 members (engineers).

- DWPD CONSTRUCTION BUREAU

It would be named at the beginning of the construction works, and would be under the authority of the Committee.

This bureau would include 3 people:

- one director, directly responsible for the progress of the project,
- two deputy directors,

who would be assisted by:

- a chief engineer and two deputy chief engineers,
- an executive secretary (coming from MOC).

- DEPARTMENTS

Seven departments would be under the control of the DWPD Construction Bureau: Design Department, Construction Department, Quality Assurance Department, Administrative Department, Personnel Department and Accounting Department.

The total number of people recommended for the DWPD Construction Bureau is 84.

5.3.2 Operating management organization

During the implementation period, the state will manage the DWPD project defining with the industrial users the contractual arrangements for final privatized land; at the
same time, responsibility of management of the port area (including "public land" of the industrial zone) could be progressively transferred to the Kaohsiung Port Bureau.

- Regarding "port area and facilities", the DWPD project can be managed by the Harbor Bureau in the framework of conceded terminals policy with its' own quays and related zones and leasing it to the different users.

Referring to the present policy, quay equipment (gantry cranes) can be included in the concession terms (compensated by a "quay equipment fee").

- As far as land facilities are concerned, it is recommended that the Harbor Bureau should be in charge of constructing and maintaining "common" roads and utilities.

A particular point concerns the seawalls and dykes which will remain at the border of certain industrial lots and should be maintained in the future: as they are maritime works, it is recommended that they will remain state property and be maintained by the Harbor Bureau.

- Harbor Bureau organization and staffing

The new harbor zone of the DWPD project is to be considered as an extension of Kaohsiung Port facilities, compatible with the present organization structure of the Harbor Bureau, port construction and maintenance depending on the technical department and ship operations from the harbor operating department.

Concerning industrial zone management, it is recommended to build up a specific department inside the Kaohsiung Harbor Bureau organization, department in charge of maintenance works (roads, utilities, etc.), as well as of the administrative management (follow-up of contracts, invoicing of land fees, etc.).

5.4 CONSTRUCTION PREPARATION PHASE

This extremely large project, and its associated very high cost, calls for extraordinary care in preparation of the detailed design, specifications, and tender documents as well as for prequalification of contractors, evaluation of tenders, preparation of contract documents, and the supervision of construction.

Before - or at the same time - as the detailed design of the project is drawn up, various studies have to be carried out such as additional field investigations, Environmental Impact Assessment, and mathematical and physical models. To prepare the above mentioned investigations, and also to update the basic design of the DWPD project, a
planning and basic design study is suggested. It should start just after the approval of the project by the government.

- **Additional site investigations** have to be carried out:
  - topographic and hydrographic survey,
  - oceanographic surveys including sea level observation, wave data, currents in dry and wet seasons with current meters, sediment samples of sea bottom, and sea water samples,
  - meteorological data (wind speed and direction together with air temperature and humidity),
  - geotechnical investigations for reclamation and port structure areas, as well as for marine borrow areas magnetic and side scan sonar survey, seismic reflection survey, borehole survey, and laboratory tests, and for rock quarry sites (seismic refraction, field tests by drilling and laboratory tests).

The cost estimate of site investigations amounts to NTS 167.5 million.

- **Environmental Impact Assessment (EIA)**

  A preliminary environmental statement was performed during the current study.

  Before implementing the DWPD project an EIA has to be performed; it should follow five steps:
  - description of the existing environmental conditions in the area located within the limits of the project site, in the immediate vicinity of the project site, and far from the project site.

  It is recommended to divide the descriptive approach into three categories:
  - physical environment,
  - ecological environment,
  - human environment.

  - description of project components
  - impact analysis: sea ecosystem, land ecosystem and human activities.
  - mitigation plan and,
  - public opinion survey
This study involves several field investigations and mathematical models.

The cost of the EIA study is estimated at NT$ 32 million.

- **Mathematical and physical models**

  Numerical and physical models are required to perform the EIA and detailed design studies of the DWPD project.

  - Numerical models in order to study wave disturbance, surge, typhoon, harbor resonance, coast evolution, hydrodynamic current patterns, suspended sediment dispersion in the far field area, the risk of industrial and organic pollution, and the risk of recirculation of the discharged heated water by outfall structures, for a typical year, the risks of recirculation of hot water discharged from outfalls, improvement if necessary, of the water renewal rate in the coastline channel.

  - Physical models required are for wave disturbance, ship motion, completing the results of the coast evolution numerical model, stability tests (2D and 3D) in order to optimize the cross sections of hydraulic structures (breakwater, seawalls, etc.).

Cost estimate for performing numerical and physical tests amounts to NT$ 59.9 million.

- **Planning and basic design**

  Before starting the detailed design, the following is in order:

  - update the layout recommended in the current study,
  - prepare and monitor the site investigations,
  - prepare the preliminary design of the structures.

- **Detailed design**

  The detailed design should conform to the highest standards and should be based on clearly sufficient information in regard to physical conditions at the site and availability of construction materials.
The design of the different structures should reflect the availability of construction materials and employment of suitable construction methods.

Detailed design drawings should conform to the requirements of the Ministry of Communications as well as to international standards.

- **Specifications and conditions of contract**

  Specifications should conform to ASTM, British Standards, DIN (German) Standards, and AFNOR (French) Standards as applicable; and according to the preference of the Ministry of Communications, the General Conditions of Contract as recommended by FIDIC should be used and modified as required.

- **Submission of alternative designs**

  The tenderers should be allowed and encouraged to submit alternative designs for all major structures, together with a full set of design calculations for checking by the consulting engineers who have prepared the design on which the tendering is based.

- **Packaging of contracts**

  The different work items should be divided into suitable contract packages for tendering purposes. One or only a few contracts should be avoided in order to reduce, if not completely eliminate, imbalanced tenders and contracts.

- **Prequalification of contractors**

  The use of the latest World Bank Guidelines, modified as required for prequalification of contractors, is recommended. Prequalification should be carried out before detailed design and preparation of tender documents are completed, so as not to unnecessarily tendering.
• **Tender evaluation and award of contracts**

Evaluation of tenders should be carried out by the consulting engineers responsible for detailed design and tender documents, according to criteria established by and subject to approval of the Ministry of Communications.

The Ministry of Communications awards the contracts.

• **Supervision of construction**

It is essential that the consulting engineers, who have prepared the detailed design and the tender documents, carry out supervision of construction as the representatives of the owners of the works.

A DWPD construction preparation schedule is proposed in Table 11; it also gives the total cost estimate of the project (studies, management, supervision and works).

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6. **CONCLUSIONS AND RECOMMENDATIONS**

At the end of the study, it can be concluded that:

• The traffic forecasts up to the year 2021 have demonstrated that there will be a definite increase in crude oil, coal and iron ore traffic which can be imported through deep water port facilities.

• Industrial user requirements are prone to evolve in the future; and other users can appear also lacking land in Taiwan.

• With the help of a multicriterion analysis, Kaohsiung was selected as the most suitable site to set up a deep water port with the related industries. Being that Keelung is not suitable for a deep water port, Taichung is ranked second, Waisanding third, and Tamsui fourth.

• The recommended project at Kaohsiung amounts to NT$ 315 billion (construction cost) to be shared over 19 years.

  It will provide a large land area (6,177 ha) for industrial purpose, but without raising problems of land acquisition, or manpower.

• The DWPD project is technically feasible, but some construction methods-dredging works in particular-have to be suited to the magnitude of the project.
Table 11 CONSTRUCTION PREPARATION PHASE SCHEDULE

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<td>M NTS</td>
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<td>JFM</td>
<td>AMJ</td>
<td>JASON</td>
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<td>1.FEASIBILITY STUDY &amp; DWPD PLANNING</td>
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<td>* Consultant's final report</td>
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<td>2.GOVERNMENT CONSIDERATION &amp; APPROVAL</td>
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<tr>
<td>* Specifications and contracts</td>
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<td>* Performance</td>
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<td>* Performance</td>
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<td>7.DETAILED DESIGN, PREPARATION OF SPECIFICATIONS &amp; CONTRACT DOCUMENTS</td>
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<td>11.AWARDS OF CONTRACTS TO CONTRACTORS</td>
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<td>324,487.1</td>
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<td>* Commencement of construction</td>
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<td>* Works, management, supervision</td>
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<td>TOTAL COST</td>
<td>324,966.5</td>
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SOREX/CEO June 13, 1990
• The environmental impact of the DWPD is acceptable on condition of implementing some mitigative measures.

• The DWPD project is economically and financially feasible.

The economic indexes are:

<table>
<thead>
<tr>
<th></th>
<th>IRR/%</th>
<th>B/C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port</td>
<td>13.8</td>
<td>1.387</td>
</tr>
<tr>
<td>Industrial land</td>
<td>12.0</td>
<td>1.154</td>
</tr>
<tr>
<td>Total</td>
<td>12.5</td>
<td>1.170</td>
</tr>
</tbody>
</table>

Furthermore, the selling prices for the users are reasonable: approximately NT$ 6,000 per m² in current prices.

For the implementation of the DWPD project, it is recommended to:

• Create an authority to coordinate, manage and supervise the project during the construction works phase and its preparation.

• Set up the project financial plan which allows the flexibility of port activity and development in the future, and ensures a satisfactory income to the Harbor Bureau without any changes to the tariff system.

• Immediately implement several tasks previous to the construction works: field investigations, hydraulic studies, planning, basic and detailed designs.

• The Kaohsiung City Government and the Kaohsiung Metropolitan Area set up a Land Use Plan which must be in accordance with the port industrial development.