2. TAI O DEVELOPMENT AND ANCHORAGE DESIGN/CONSTRUCTION

2.1 Existing and Planned Tai O Development

Tai O has undergone several developmental stages. In 1972 the Government put forward the Public Works programme to improve living conditions in Tai O by providing 3,000 rural public houses and associated facilities (Wilbur Smith 1987). This included the reclamation of the low lying area to the north of Tai O Road and to south of Tai O Creek and the provision of a river wall along the southern bank of the river channel. Since the early 1970's there have been several development packages that have involved the provision of storm water and foul sewer mains, pumping stations, reclamations and road extensions.

In 1987 Wilbur Smith produced a Tai O Development Strategy Review for the Territory Development Department (TDD) which set out the requirements for the strategic development of Tai O. One aim of the strategy was to halt the declining population of Tai O. The Tai O Development Strategy Review recommended the provision of additional surface drainage facilities to control flooding caused by storm surges, a drainage nullah, provision of additional sewerage collection facilities, sewage pumping stations, a footbridge across Tai O Creek, clearance of stilted village areas, provision of additional river wall facilities, a sampan anchorage located in the inner part of Tai O Creek as well as development of a sheltered boat anchorage. The 1987 Tai O Development Strategy Review has been the main point of reference through which the requirement for town improvement measures has been evaluated. Some of the recommended proposals have been implemented, such as the construction of a footbridge over Tai O Creek. Other developments are currently being implemented, such as the construction of sewerage collection facilities, sewage pumping stations and stormwater drainage which are due for completion in 1999. Construction of a river wall along the southern bank of Tai O Creek together with associated sewerage and drainage improvement works is being carried out and should be completed by the end of 2000. A Study on the Revitalisation of Tai O has been commissioned by Planning Department which aims to formulate a planning strategy for revitalising Tai O, with emphasis on tourism and recreational development potential. The study will also assess the need for environmental and engineering improvement works for the preferred revitalisation strategy so as to facilitate further detailed design and studies.

As indicated above, there are improvement works currently on-going in Tai O, others are about to be implemented, whilst development strategies are being formulated. However, there are no major developments which are expected to be on-going at the time of the sheltered boat anchorage dredging/construction works and mangrove habitat creation which is due for implementation in July 2001 and completion in December 2003. Thus, no cumulative impacts associated with construction activities are anticipated to occur and will not be assessed during this Assignment.

2.2 Description of the Tai O Sheltered Boat Anchorage Project

The Tai O sheltered boat anchorage development includes the following key components (refer to **Figure 2.1**):

- construction of a sheltered boat anchorage with an effective area of approximately 8ha for approximately 220 small boats/fishing vessels;

- construction of an approximately 700m long breakwater, marker dolphins, public landings and other marine facilities;

- reclamation of 1.0ha of land for boat maintenance facilities and a loading/unloading area;

- dredging and disposal of marine mud to lower the seabed within the sheltered boat anchorage, the associated fairways/access approaches, the breakwater foundation and reclamation;

- seawall protection measures involving the construction of a 20m deep sheet piling wall alongside the existing salt pan outer seawall (subject to confirmation during the detailed design); and

- associated engineering works to prepare for subsequent planting works in the new mangrove habitat. The formation is proposed to be achieved by re-shaping some of the internal bunds in the salt pans and the addition of some marine mud dredged from the adjacent boat anchorage.

The following sections review the CED anchorage development design as detailed above and make recommendations with respect to working methods, works programme and plant requirements which are of importance respect to this EIA.

2.3 Benefits of the Project and Implications of the "Do-nothing" Scenario

The Tai O sheltered boat anchorage has been proposed given that it is perceived that the development will offer numerous advantages to the people and environment of Tai O. Development of the anchorage facility is fully supported by the Islands Provisional District Board members and is seen as a means of reviving the town's fishing industry and thus contributing to the revitalisation of Tai O. The anchorage will also assist in meeting the shortfall of available typhoon shelter space in Hong Kong.

The mangrove habitat to be created in the salt pan area will mitigate the loss of mangroves that occurred during construction of Chek Lap Kok airport and associated port and airport developments on the northern shore of Lantau. This mangrove habitat creation scheme will significantly benefit the ecology of Tai O. The mangrove to be created is likely to develop into a robust ecological habitat which will be an important intertidal feeding ground for avifauna of local and international importance. In addition, the mangrove is likely to become an important nursery area for juvenile fish and organisms, which are prey items of fish, thus contributing to the project's benefits to the local fisheries industry. It is also possible that the breakwater to be developed will attract fish through the provision of escape and shelter habitats, again this has the potential to benefit local fishery resources.

In light of the above, it is anticipated that the integration of the anchorage and mangrove restoration schemes has the potential to generate significant economic, social and environmental benefits to the Tai O community. These benefits provide the justification for the project to proceed.

In the event that the project is not implemented, the principal effect of the "do nothing" scenario would be that the benefits identified above would not be realised. In short the identified decline in the Tai O fishing industry would continue and an alternative location for the mangrove

habitat creation scheme would be necessary. The proposals for the "Revitalisation of Tai O" being defined by the on-going Study by Planning Department would also need to be amended.

It is identified in the following Chapters that the environmental impacts associated with the Project are both limited in their severity and mitigable. In the light of these findings, and the overall net benefits of the scheme, it is considered that the "do-nothing scenario" is not appropriate.

2.4 Consideration of Alternatives

Under the terms of the EIA Ordinance there is a specific requirement for the consideration of alternative options to the development. Whilst this is a statutory requirement, the manner in which this issue is addressed is specific to the particular project in hand. The issue of alternatives to the sheltered boat anchorage scheme has principally been addressed through the consultation process that has arrived at the preferred scheme.

2.4.1 Development of the Sheltered Boat Anchorage Scheme

The background to the Tai O sheltered boat anchorage scheme has been described in Section 1.1. In recognition of the lack of mooring facilities at Tai O, the anchorage scheme was requested several years ago by residents of Tai O village. The Territory Development Department instigated preliminary investigations during the 1980s, and a decision to implement the requests of Tai O villagers was pursued on the basis of a variety of factors, as follows:

- Tai O village has a sheltered bay which affords some protection to the existing boats moored there;
- the space available in Tai O Bay is limited, resulting in the mooring of some boats in Tuen Mun and Cheung Chau;
- Tai O has a traditional fishing industry which is in decline and would clearly benefit from the anchorage development;
- Tai O is positioned on north Lantau where there are no other available anchorages or typhoon shelters; and
- development of the anchorage facility has the support of villagers and the Islands District Board members.

The project was upgraded to a Category B project in October 1985. However, the project was deferred until after 1997 due to the Territory boundary issues as described in Section 1.1. The local community and fisherman's associations of Tai O have expressed strong concerns about the delay in the commencement of the project. A "Case Conference on the Request for Expeditious Completion of Tai O Sheltered Boat Anchorage by the Administration" was held by the Legislative Council in February 1998, in which revisions to the scheme and programme were discussed. The Government subsequently agreed to advance the project through creation of a Category D item to fund the EIA/DIA studies.

CED circulated a preliminary layout plan to all relevant government departments and the local community for their comment in October 1997. A Project Profile was circulated for departmental

comments in January 1998, and an Environmental Review was subsequently completed by EPD.

The layout of the anchorage and its approaches was revised and updated by CED taking into account the comments received during this consultation phase. The preliminary layout plan was endorsed by the Tai O Rural Committee, the Sai Kung and Islands District Board and the Islands District Board, following a District Board Meeting held in June 1998. This EIA is based upon this revised anchorage layout design as illustrated in **Figure 2.1**.

2.4.2 Development of the Mangrove Planting Scheme

The New Airport Master Plan Study (1991) made recommendations to provide a new mangrove habitat to mitigate the loss of mangroves due to the construction of Chek Lap Kok airport and associated port and airport developments on the northern shore of Lantau. Following the review of various potential locations, AFD highlighted the Tai O salt pans as being a potential site for mangrove habitat creation given the occurrence of mangroves in the area and potentially suitable intertidal conditions. The site was subsequently investigated by Tam and Wong (1997) for AFD who found that the site was suitable for the mangrove mitigation programme.

The preliminary investigations by Tam and Wong (1997) indicated a need to increase the existing sediment levels in the salt pan area in order to ensure the successful growth of a new mangrove. Given the need to place sediments in the planting area, it was considered beneficial if the mangrove habitat were created during the construction of the Tai O sheltered boat anchorage given that excess sediment arisings would be generated during the necessary dredging programme.

Whilst Tai O has been highlighted as being suitable for both a sheltered boat anchorage and as the site of a created mangrove habitat, it is of key importance that these two functions are not mutually exclusive given that both can proceed without adversely impacting upon the each other.

2.4.3 Opportunities for Development of the Sheltered Boat in Alternative Locations

Given the nature of the project, in particular the intended direct use of the anchorage by Tai O residents, the opportunities for developing the anchorage in an alternative location is not considered practicable. In this regard, it is considered that locating the anchorage away from the village would not serve the purpose for which it is intended.

2.5 Mangrove Habitat Creation

The principal aim of the Tai O mangrove restoration is to mitigate the loss of mangroves at Chek Lap Kok and north Lantau due to airport and associated port and airport development projects. The mangrove restoration aims to create a self-sustaining mangrove with a surface area, species composition and tree density comparable to those lost during these infrastructure developments. The mangrove planting scheme will be carried out by AFD separately from the sheltered boat anchorage project.

The Tai O Mangrove Layout Plan (Scott Wilson 1999) has made recommendations for the conversion of the Tai O salt pans into a habitat suitable for the development of a mangrove habitat. Whilst the mangrove habitat layout is not a component of the EIA, it has an interface with the EIA given that it impacts upon the following:

- methods of sediment dredging;

- sediment disposal volumes;
- plant required to create the required layout and thus potential noise impacts associated with the works;
- impacts of construction activities upon water quality;
- ecological and fisheries impacts during the construction phase; and
- cultural heritage impacts.

Following definition of the mangrove restoration objectives, the Tai O Mangrove Layout Plan has investigated the key elements that control the successful development of mangrove restoration projects. Key elements considered relate to sediment elevation, inundation, sediment physico-chemical properties, salinity and pollution tolerance. Taking into account these key controlling factors, the actions necessary to create a mangrove at the Tai O salt pans were evaluated, taking into account identified constraints such as the conservation of existing mangroves and the cultural heritage of the salt pans and the associated seawall. Based upon an assessment of the factors detailed above, the configuration illustrated in **Figure 2.2** was selected as the preferred conceptual layout.

2.6 Dredging Requirements and Dredged Material Balance

Dredging will be undertaken to form the foundation trench for the breakwater, the north and south approach channels, the anchorage and the access to the proposed western reclamation at the mouth of Tai O Creek.

The estimated volumes of dredging required to facilitate sheltered boat anchorage development are set out in **Table 2.1**. The overall total volume of material to be dredged is estimated to be approximately 2.045Mm^3.

Table 2.1: Estimated Dredging Volumes for the Tai O Sheltered Boat Anchorage Development.

Area	Bulk Dredging (Mm^3)	Slopes (Mm^3)	0.3m Over-dredge (Mm^3)	Total (Mm^3)
North channel	0.052	0.004	0.010	0.065
South channel	0.131	0.008	0.017	0.156
Seaward extension of access channels	-	-	-	0.025
Anchorage	0.620	0.006	0.040	0.666
Breakwater	-	-	-	0.850[1]
Berthing area	0.029	0.001	0.003	0.033
Foundation trench for reclamation area	-	-	-	0.25[1]
Notes:			**Total**	**2.045**

[1] as advised by CED

It is noted that in the Initial Assessment Report (IAR), the Port Development Division of CED had developed a preliminary design for the breakwater which required approximately 1.5Mm^3 of dredging to form the foundation trench. A conceptual design was developed for the IAR based upon the results of a geophysical survey undertaken by EGS (Asia) Ltd in July 1998 (EGS 1998) – this breakwater conceptual design involved approximately 0.5Mm^3 of dredging. The dredging volume required for breakwater formation has since been revised to 0.85Mm^3 by CED in the light of the results of a borehole investigation undertaken during this Study. It stressed that a key aim of the anchorage design is the minimisation of dredging requirements. In this regard it is noted that prior to the initiation of this Study, CED anticipated that the development of the anchorage would require dredging of 5.5Mm^3 of sediment. Through the adoption of innovative design techniques (e.g. the use of a partially dredged foundation) for the breakwater, the volume of dredging required to form the anchorage has been significantly reduced.

A dredging plan is presented in **Figure 2.3**. The permanent slopes to the dredged areas (i.e. the access channels and the anchorage) are assumed to be at a nominal 1:3 gradient.

The presence of fishing boats prevented geophysical surveying of the approach to the berthing area adjacent to the proposed reclamation area (EGS 1998). The volume estimate for this area has, therefore, been based on an assumed seabed level of 0.0mCD. In addition, the geophysical survey did not extend westwards as far as the -4mCD seabed contour (EGS 1998), thus the access channel will have to be extended beyond that which is shown in **Figure 2.3**. A nominal dredging volume of 25,000m^3 has been allowed for this dredging to extend the access channel.

The materials to be dredged will comprise predominantly marine mud, although it is possible that a small amount of alluvium may also have to be dredged to form the breakwater foundation trench.

A survey of the salt pan area has been undertaken by CED during this Study. The existing layout and level contours in the salt pans, based on the results of this survey, are shown in **Figure 2.4**. The design of the mangrove habitat area has yet to be undertaken, however, in order to achieve the conceptual layout as discussed in Section 2.5 and illustrated in **Figure 2.2**, only a small volume of mud needs to be placed in the salt pans to create the required levels. Depending on the details of the final design, the volume of material expected to be placed in the salt pans will be in the order of 10,000 - 20,000 m^3.

On the basis of the above assessment, it is currently expected that almost all of the approximately 2Mm^3 of material to be dredged to form the Tai O sheltered boat anchorage will require off-site disposal (refer to Chapter 4).

2.7 Factors Influencing Dredging Methods

The water depths in the areas to be dredged in Tai O Bay are relatively shallow. Seabed levels derived from the EGS 1998 survey are shown in **Figure 2.5**, whilst **Figure 2.6** illustrates the level of the base of marine deposits. **Figure 2.5** illustrates that in the sheltered boat anchorage and along the breakwater alignment, seabed levels range between about +0.1mPD in the south to about -0.5mPD in the north. The seabed along the alignment of the southern access channel varies from 0.0mPD at the southern end and -2.5mPD at the northern end where it converges with the northern channel. The final design of the layout will need to be modified to extend the combined access channels westwards to intersect the -4mCD seabed contour. The northern

channel is approximately aligned with the existing channel into Tai O; seabed levels in the channel are typically -1.5 to -2.0 mPD.

The shallow water depths indicate that the first stage of the dredging works will need to be for the formation of a channel to permit marine plant access to the breakwater and anchorage areas. This should be along the alignment of the proposed northern access channel because water depths in this area are greatest and the volume of dredging which is required is thus relatively small. This would permit early access to the inshore area.

Debris is likely to be present in the upper layers of the marine mud in some locations within Tai O Bay. In view of the past use of the area, debris is likely to comprise predominantly small items of rubbish, ropes, nets (many are visible in the intertidal area) and chains. The seabed area immediately adjacent to the proposed western reclamation at the northern end of the salt pans is scattered with numerous boulders and cobbles. A small rubble-mound breakwater structure is located at the north-western tip of the salt pans and will need to be removed. Debris and boulders cause difficulties for most types of dredging plant with the exception of grab dredgers.

The general site characteristics, and the nature of the materials to be dredged, indicate that grab dredging is the most appropriate method for all of those materials which are to be taken off-site for disposal. Trailing suction hopper dredgers cannot be used because of depth and working space restrictions. Cutter suction dredgers could, in theory be used, however, they suffer from several disadvantages in this case, notably:

- the use of cutter suction dredgers involves substantial dilution of the materials leading to bulking and significantly increased transport costs;
- it is difficult to match the output of a cutter suction dredger to the relatively small volume of the transporting barges, spillage of sediment is therefore difficult to avoid; and
- they would be hindered by the presence of debris and boulders.

It is concluded that the use of grab dredgers loading the dredged materials into barges for transport to the disposal site(s) is the most appropriate method for dredging all of the materials which need to be taken off site for disposal. The number of barge trips required to dispose of the dredged material arisings is depend upon the size of the barges used. Assuming a barge capacity of approximately 800m^3 (typical of those used in Hong Kong), it is anticipated that approximately 2,500 to 2,750 trips will be required to remove all dredged material. As detailed in Section 2.11, the maximum number of barge trips a week is anticipated to be 32 during dredging of the breakwater trench.

2.8 Potential Mangrove Area Formation Methods

In the IAR it was assumed that about 144,000m^3 of dredged material would have to be placed in the salt pans in order to form the mangrove area. Subsequent salt pan survey data (refer to **Figure 2.4**), and the definition of a conceptual mangrove habitat layout (refer to Section 2.5 and **Figure 2.2**) illustrate that at most, only about 20,000m^3 of additional material needs to be placed in the salt pans to create as habitat suitable for mangrove propagation. As will be illustrated in Chapter 4, it is not considered necessary for the placed material to be mixed with sand as has previously been proposed (Tam and Wong 1997).

The most significant operation during the mangrove habitat formation will be the re-shaping of the existing internal bunds to achieve the desired levels. The dredged mud that is added can be placed in thin layers and mixed with the bund material during re-shaping works. There are essentially two options for the placement of the dredged mud:

1) use mechanically-dredged (i.e. grab-dredged) material and place it in the salt pans using land-based plant; or

2) use hydraulically-dredged material (i.e. dredged using a cutter suction dredger) and pump it directly into the salt pans, allowing it to flow to form natural slopes.

The IAR concluded that hydraulic placement of mud would be preferable to mechanical placement, however, given that it is now considered that only a very small volume of material needs to be placed in the salt pans, and the need to undertake extensive re-shaping of the internal bunds, means that mechanical placement methods are now preferred. These methods of mangrove habitat creation are discussed below.

2.8.1 Mechanical Placement

The small volume of mud to be placed in the salt pans, and the fact that thick layers need not be placed, means that mechanical placement methods are the most practical and easily-achieved. Mechanically placed sediments are more easily controlled and managed, as such it is also the method which is least likely to cause damage to those existing mangroves which have been identified as being worthy of conservation (refer to Chapter 6).

Mechanical filling would need to be matched to the rate at which the salt pans are re-shaped and could be achieved using a low ground pressure bulldozer. The complex topography and the requirement to preserve some of the existing mangroves indicates that this work needs to be undertaken with considerable care and it is thus unlikely to carried out quickly. This has the advantage that few plant will be required, both for the re-shaping of the salt pan and the placement of dredged mud, thus minimising potential noise impacts (refer to Chapter 3) and the potential for sediment release (refer to Chapter 5).

The CED construction programme (refer to **Figure 2.7**) indicates that a total of 65 weeks are available for formation of the mangrove area. It is estimated that approximately 25,000m^3 of existing salt pan bund and bed material will need to be moved, generally over short distances, to achieve the topography required and illustrated in **Figure 2.2**. Assuming a six-day working week, at 50% efficiency to allow for tidal working, gives 195 days to undertake this work. If a maximum of 20,000m^3 of mud is placed in the salt pans during this time, the bulldozer will need to re-shape the existing bunds and spread the added mud at a combined rate of about 230m^3 per working day. The required daily volume of mud would thus be about 100m^3.

In the light of these low rates of production, it is likely that the most economic approach would be to dredge the mud using a derrick lighter barge during periods when tide conditions prevent work in the salt pans. The lighter barge could unload material directly into trucks at the western reclamation area which would be given over as a temporary works area for the salt pan reshaping. One or two rough-ground trucks would be required to transport the mud to the working area in the salt pans, where it would then be spread and mixed with the existing bund and bed materials to the required profiles during low tidal conditions.

This approach would require partial completion of the reclamation areas in the northern part of the salt pans prior to the start of mangrove habitat creation. In addition to mud placement and bund re-shaping, the recommended mangrove habitat layout (refer to **Figure 2.2**) requires the opening-up of five of the existing breaches in the outer seawall in order to facilitate tidal flushing. This could be undertaken using the derrick lighter barge working from the seaward side of the outer seawall. Only small volumes of material would need to be removed to deepen and widen the existing breaches in the seawall. It would be preferable to undertake this work at an early stage, prior to the main re-shaping works in the salt pans because the increased cross-sectional area of the breaches will result in reduced current speeds in the salt pans and in more rapid drainage of the pans during ebb tides. This will have the effect of both minimising the loss of sediment from the pans and increasing the available working time at low water.

In the event that the detailed design shows that the proposed sheet pile wall on the western side of the outer seawall is necessary, this should be constructed last. The anticipated general sequence of construction for the mangrove area is summarised as follows:

1) dredge northern access channel and berthing area to provide access to western reclamation site;

2) partial completion of the reclamation to provide a works area, in combination with opening-up of the outer seawall breaches to promote efficient flushing at reduced water velocities;

3) salt pan re-shaping and mud placement;

4) construction of an outer seawall protective sheet pile wall.

2.8.2 Hydraulic Placement

Hydraulic placement, favoured in the IAR on the basis of significantly larger volumes of material than those which are now known to be required, would require the closure of the existing outer seawall to prevent excessive losses of fines during filling.

The reduced volume of mud which is now known to be required, in combination with the particular topography of the preferred mangrove layout, effectively precludes hydraulic placement as a viable option. The disadvantage of the hydraulic placement method is that placement is relatively uncontrolled and the best that is likely to be achieved is the formation of a few small mounds of mud at discrete points around the eastern margin of the salt pans. Inevitably, these would have to be re-shaped using earthmoving plant in order to achieve the required mangrove topography. In addition, the relatively uncontrolled nature of hydraulic material placement would make the preservation of existing mangroves in the salt pans difficult and increase the potential for sediment release into Tai O Bay during the works.

The cost of sealing the outer seawall to control sediment release (and breaching it again on completion), and the fact that a cutter suction dredger would need to be used which is not required for any of the other works, the characteristics of the proposed mangrove habitat layout and the requirement to preserve existing mangroves, effectively precludes this method of filling.

2.9 Construction Methods for Other Works

In addition to the dredging works and the creation of the mangrove habitat area, the proposed project includes the following which could give rise to construction impacts:

- construction of the breakwater, following trench dredging;
- construction of the two reclamation areas in the northern part of the salt pans, one of which will require a berthing face;
- construction of marker dolphins; and
- the construction of a sheet pile wall in front of (i.e. west of) the existing salt pan outer seawall.

The detailed design of these proposed works has yet to be undertaken. In view of the difficult road access, it is likely that all large items of plant will need to be brought to the site by sea. It is certain that almost all construction materials which are required will also be transported by sea. These will include the sand required for the backfilling of the breakwater trench, the rockfill and armour stone for the breakwater and the fill materials required to form the two small reclamation areas.

Sand for the trench backfilling will be delivered by barge. The type of barge will depend on where the sand is sourced. If it is sourced from the Pearl River Estuary, it may be delivered by "Pelican" barges of 300 - 400 m^3 capacity and placed in the trench using a bow-mounted conveyor belt unloading system. Alternatively, split barges may be used to transport the sand and place it by direct bottom-dumping. If sand for backfilling the breakwater trench is delivered to site using barges of 800m^3 capacity, approximately 1,000 barge trips may be required.

Rock fill and armour stone for the breakwater is likely to be delivered to site in derrick barges of about 1,000 - 1,500 m^3 capacity and placed using grabs. It is currently anticipated that approximately 250 barge loads will be required to deliver the material to site.

In accordance with WBTC No. 4/98, the Public Fill Sub-committee has recommended that public fill should be used for the reclamation works which would be transported to the site by lorry. However, based on the past records, the quantity of public fill generated in the vicinity of Tai O is minimal and thus the reclamation areas will be formed by importing sand fill material. Sand fill for the two reclamation areas will be delivered by barge. It is estimated that a maximum of about 30,000m^3 of fill material will be required for the reclamation areas, i.e. approximately 30 barge-loads, assuming the use of derrick lighter barges. The berthing face of the western reclamation area will be designed by CEO/CED in the light of the results of the ground investigations and is likely to comprise a vertical blockwork wall.

The construction of marker dolphins will be straightforward and will involve a limited amount of piling work.

2.10 Programme and Plant Requirements

A construction programme provided by Port Development Division of CED (refer to **Figure 2.7**) indicates a total of 30 months has been allocated to complete the works. A total of 12 months has been allowed for the construction of the breakwater.

On the basis of the methods specified herein, the time required to complete the various sections of the dredging works have been estimated – refer to **Table 2.2**. These times assume that grab dredging is undertaken using grabs of $8m^3$ capacity, a size commonly available in Hong Kong. The weekly production rates have been estimated on the assumption that work will take place for six days per week, 12 hours per working day.

Table 2.2: Time Required to Complete Tai O Sheltered Boat Anchorage Dredging Works.

Area	Volume (Mm^3)	Weekly Production Rate (m^3)	Time for Completion (weeks)
North channel	0.065	18,900	3.4
South channel	0.156	18,900	8.3
Seaward extension of access channels	0.025	18,900	1.3
Anchorage (less material required for mangrove area)	0.666	21,150	31.5
Breakwater	0.850	22,000	38.6
Berthing area	0.033	18,900	1.75
Material placement in mangrove area	0.020	13,500	8.6
Foundation trench for reclamation area	0.25	18,900	13.2

The bulk dredging could be undertaken using a single $8m^3$ dredger, but this will depend on the final construction programme. The northern access channel (and the seaward extension to the -4mCD contour) would have to be dredged first in order to provide plant access to the breakwater and anchorage areas (refer to Section 2.7).

At peak rates of production, when dredging the breakwater trench, the dredger would load approximately 32 barges per week for dredged material transport to the disposal site. The actual number of barges which are required will depend on the location of the disposal site, but the number of barge movements in and out of Tai O Bay will not be affected. A tug will be required for towing the barges and it is likely that a second tug will remain in Tai O Bay to assist with movement of other items of plant and for personnel transport.

A single small cutter suction dredger would be required for a period of about 9 weeks for placing mud in the mangrove, if hydraulic placement methods as described in Section 2.8.2 are adopted, although as discussed, mechanical methods of mud placement are preferred. The formation of a temporary bund to seal the salt pan area would almost certainly be undertaken using a single low ground pressure bulldozer working tidally.

Assuming mechanical mud placement methods are adopted, a derrick lighter would be required to dredge the mud and place it ashore into trucks. One or two rough-terrain trucks would transport the mud to the working area in the salt pans where it would be spread using a low-ground pressure bulldozer.

A floating piling rig will be required for the construction of marker dolphins. A crane barge would be required to construct blockwork walls. Ancillary plant such as launches, work boats and survey boats would also be required at various stages during the execution of the works.

2.11 Conclusions

Based upon the review and assessment as detailed above, the following conclusions can be made:

- that the total volume of material which will be dredged in order to create the Tai O sheltered boat anchorage will be approximately 2.05Mm^3, the vast majority of which is likely to comprise marine mud;
- most of the dredging should be undertaken using one, or possibly two, grab dredgers. These would load material into barges for disposal;
- almost all of the dredged material is expected to be taken off-site for disposal;
- approximately 20,000m^3 of dredged material is anticipated to be placed in the salt pans in order to create the recommended mangrove habitat profile. The proposed mangrove habitat area in the salt pans can be formed by using either mechanical or hydraulic placement methods - mechanical methods appear to be the most attractive option in terms of both economics and practicality;
- approximately 30,000m^3 of fill material will be required to form the two proposed reclamation areas in the northern end of the salt pans - the fill material will be transported to site in barges; and
- other materials such as sand, rockfill and armour stone for the breakwater, material for the construction of the berthing facility are also likely to be transported to site using barges.

The following chapters consider the environmental impacts that may potentially occur during the construction and operation of the Tai O sheltered boat anchorage as described above.