The management of fuel ash originating from power generation

Environmental Impact Assessment
Stage III
Report on Ash Lagoon

Supplementary EIA
January 1994

Binnie Consultants Limited   The Hongkong Electric Co Ltd

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SUMMARY

S.1 This Supplementary Environmental Impact Assessment (SEIA) compares the environmental significance of the ash lagoon now proposed for the Lamma Power Station with the former lagoon which was approved by Government following a multi-stage Environmental Impact Assessment (EIA), undertaken between October 1986 and March 1993.

S.2 Government have decided to utilise ash as fill in Hong Kong's reclamation programme. Consequently the ash lagoon for the Lamma Power Station can be substantially smaller than the previously approved facility. The reduction in lagoon volume has brought about a reduction in the plan area of the lagoon, and in the cross section of the lagoon perimeter. The previous cross section was a trapezoidal form (embankment, Figure S.1) which has reduced to a half trapezoidal form provided by a seaward revetment supported by caissons (Figure S.2).

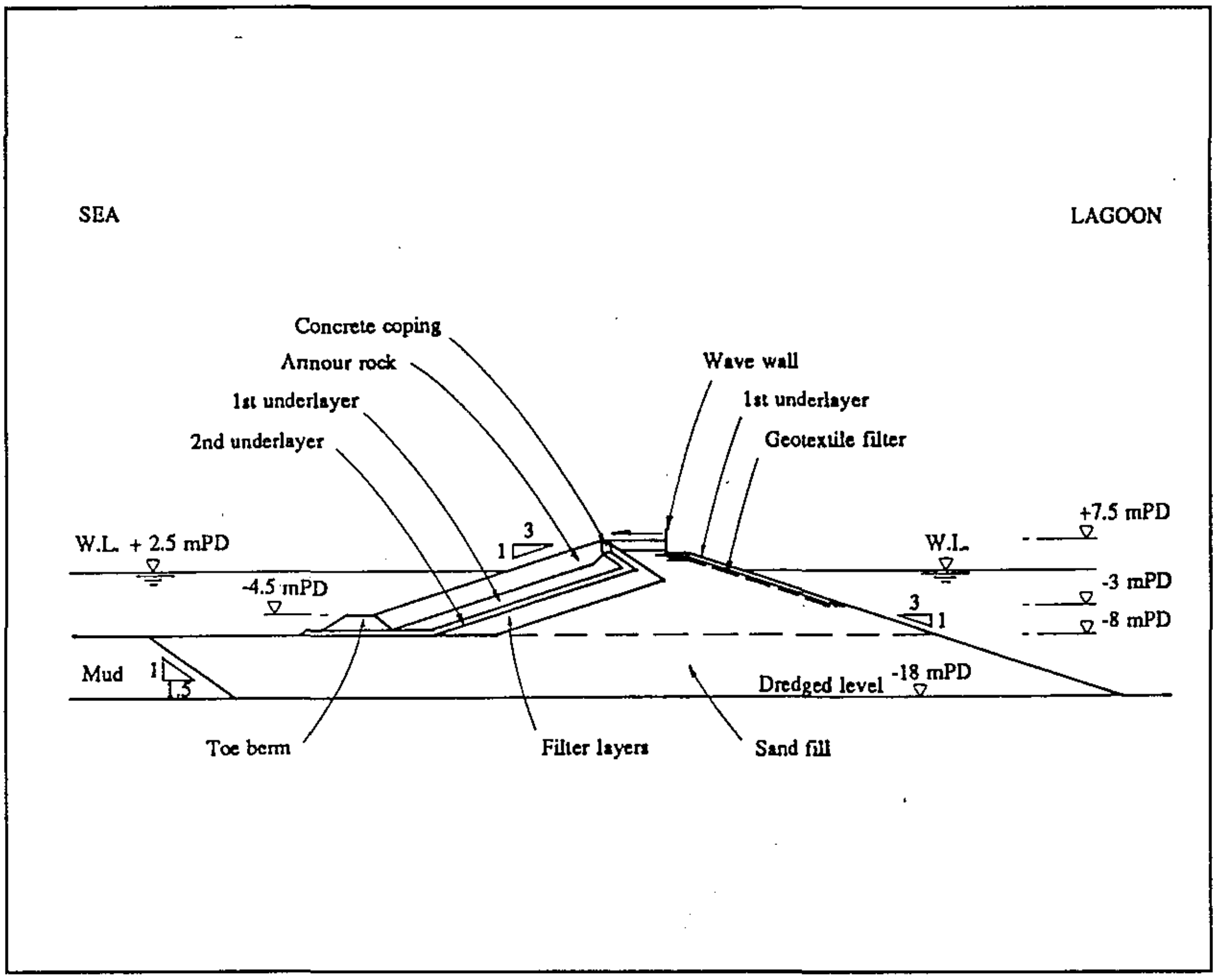


Figure S.1 Trapezoidal Perimeter Section (Embankment)

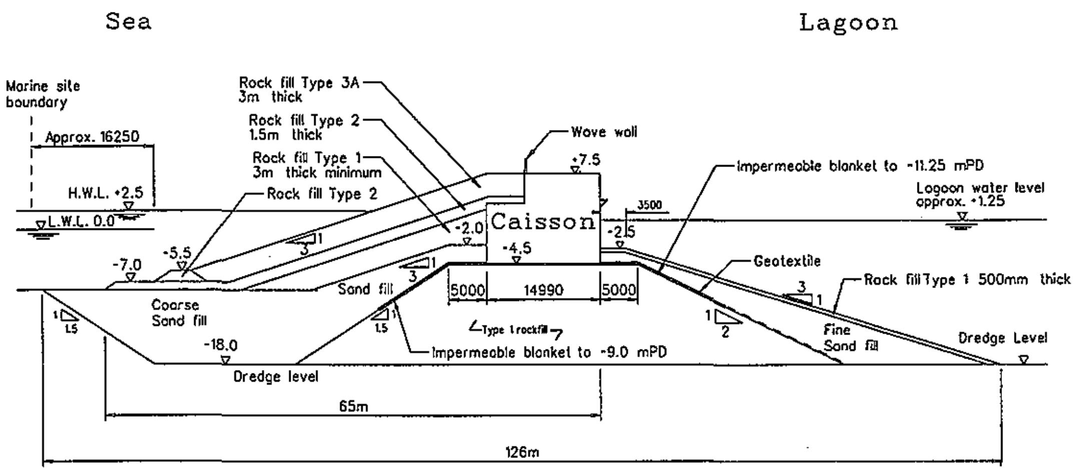


Figure S.2 Half Trapezoidal Perimeter Section (Revetment with Caissons)

S.3 Each factor of environmental significance relating to the trapezoidal form (and detailed in the EIA) has been reviewed with respect to the half trapezoidal form (in this SEIA). It is of particular importance that design of the new perimeter has ensured that it is less permeable than the previously approved structure.

S.4 The principal conclusions of the SEIA are:

(i) all the environmental issues assessed for the final stage of the EIA (Stage III) have been re-addressed and are within accepted criteria for environmental protection;

(ii) given that a lagoon is a necessary element in the approved ash disposal strategy, the half trapezoidal revetment and caisson perimeter now presents the best practical and most secure means for containing the facility.

(iii) the construction programme for the completion of the perimeter is about 21 months, the same as that for the previous embankment proposal.

1 INTRODUCTION

1.1 This report is a supplementary report to the 'Environmental Impact Assessment Stage III Report on Ash Lagoon' January 1993. It provides the background to developments that have occurred to the scheme since the issue of that report and compares the environmental impacts of the scheme that was proposed then (a lagoon with an embankment perimeter), and the scheme that is currently being proposed to accommodate the changes in duties of the lagoon.

1.2 There are a number of features of the current scheme that are the same as the previous scheme. Where appropriate, the same passages of text have been used in this report as used in the EIA Stage III reports, (which has already been approved by Government). Where these passages occur they have been distinguished by shading the text. Similarly figures and tables used previously, are shaded when presented in this report.

1.3 The Hongkong Electric Company Limited (HEC) commissioned Binnie Consultants Limited in 1986 to carry out an environmental impact assessment (EIA) for the long term disposal strategy of pulverised fuel ash (PFA) arising from its power station on Lamma Island. A series of studies carried out by the consultants under the auspices of a Government Study Management Group developed a strategy for 30 years, giving the least environmental impact of all the available options.

1.4 The EIA followed a feasibility study of ash disposal options presented to Government in February 1987. The recommendations of the feasibility study had been accepted by Government as providing an outline strategy for the long term disposal of PFA and as providing a basis for more detailed assessments.

1.5 The EIA had three stages. Stage 1 comprised a review of the feasibility study in the context of possible power station expansion and was completed in November 1987. The review conclusions, endorsed by the Government's Study Management Group were that the preferred strategy would evolve from a combination of:

(i) the marketing of PFA for industrial uses;

(ii) the use of PFA as fill for land formation;

(iii) the use of PFA as fill to restore the Lamma Quarry site;

(iv) the formation of an ash lagoon adjacent to the power station.

1.6 Stage 2 of the EIA, the Initial Assessment Stage studied the environmental implications in sufficient detail to enable decisions to be reached on a preferred scheme. This included the restoration of the Lamma Quarry and the use of a lagoon as an interim measure. When quarrying activities ceased, the site would be handed over to HEC for restoration, with PFA as the major fill source. The result would be the recreation of a vegetated hill side. The PFA would be transported through a purpose built tunnel with one portal within the power station and the other within the quarry. However, in the period before the handover of the quarry, a lagoon would be required to provide sufficient storage for the PFA produced in the interim. These studies culminated in the issue of the Initial

Assessment Report (IAR) in November 1988.

1.7 Stage 3 of the EIA involved the preliminary design of the identified works and the detailed assessment of the environmental impacts for the preferred management strategy. The approach was iterative to allow assessments of environmental impacts and the incorporation of mitigation measures as the proposals for various options developed.

1.8 At the outset of Stage 3 Government decided that the availability of the quarry would be brought forward thus permitting the size of the lagoon to be reduced (to a capacity of 1.5 Mm^3) to cater for a shorter intermediate period. Another consequence of this agreement was that the location of the lagoon was fixed in a position adjacent to the south east of the power station.

1.9 Throughout the Stage 3 studies a series of working papers were issued to Government for comment and approval, covering the environmental aspects of each of the elements of the strategy. The working papers were compiled in a report, January 1993, and summarised in the Summary Report, March 1993.

1.10 These studies were based upon the premise that the Lamma Quarry would be made available to Hongkong Electric for the long term disposal of ash from the power station, and that the capacity in the lagoon would provide an interim facility, prior to the preparation of the quarry. By May 1992 Government formalised its policy in permitting the use of ash in Government reclamation projects. Discussions between Government and HEC were initiated in May 1992 to establish the principle of using the ash generated at Lamma Power Station's in Government reclamations. The long term use of ash in reclamations negated the requirement for the permanent storage facility in the Lamma Quarry, but the need for a lagoon of reduced volume remained.

1.11 By September 1992, Government had agreed in principle to utilise the surplus ash from the station, and would accept this at convenient intervals based on the size of the lagoon to be constructed to hold the ash in the intervening periods. Various details and arrangements have been discussed between Government and HEC:

(i) the ash is to be held in a lagoon prior to acceptance by Government;

(ii) the lagoon is to have a capacity of about 1 million cubic meters, divided into two compartments of roughly 500,000 cubic meters each;

(iii) the ash is to be pumped from the lagoon to awaiting barges at a wharf, along one side of the lagoon, where it will be loaded onto barges of a Government contractor;

1.12 These changes in function and size of lagoon required a review of the outline design and the derivation of new proposals for the lagoon's shape and form. This review was carried out in early 1993, and more detailed proposals were developed throughout 1993.

1.13 This report outlines the current design for the lagoon and associated facilities required to achieve the Government requirements for the lagoon, and compares the predicted environmental impacts of the scheme with those of the scheme proposed in the EIA Stage III report, January 1993.

2 THE SITE

2.1 The existing Power Station is on a platform on the northern side of Ha Mei Wan bay, on the western coast of Lamma Island (Figure 2.1). The headland behind the power station separates the power station from the island's main population centre of Yung Shue Wan. The platform for the station is some 950 m long by 450 m wide, with the fuel jetty off the western end in Lamma's Western Channel. The site of the lagoon is to be along the sea frontage on the south eastern corner of the platform.

2.2 The original lagoon was to be some 529 m long, stretching from the eastern edge of the platform to about half way along, almost opposite the main control room and was to extend some 250 m into the sea. The revised lagoon will be significantly shorter. The lagoon will be some 350 m long, stretching from the eastern edge of the platform, stop short of the new Cooling Water 3 intake, and will extend some 250 m into the sea.

2.3 The water depth in Ha Mei Wan ranges from about 5 m near the coastline to about 11 m adjacent to the West Lamma Channel. In the area of the proposed lagoon the sea water depth is about 8 m and gradually becomes deeper toward the western end. The sea bed in the area consists of very soft marine mud, below which are firmer alluvial deposits with bed rock below that.

2.4 The marine ecology in the area of the lagoon consists of diverse infauna and epifauna such as Echinoderms, Molluscs, Crustacea and Polychaetes. These are common in shallow Hong Kong waters and this site provides no unique habitats or nursery grounds. It is therefore considered to be of low conservation value. Free swimming organisms, mainly fish, are commonly trapped in the power station's cooling water intakes adjacent to the site. The assemblage is not unusual, nor will the lagoon affect a significant portion of the habitat.

2.5 To the east of the site, along the shores of the Ha Mei Wan bay there are a number of beaches that support tourism, bathing and restaurants. There are two gazetted beaches in the bay, Lo So Shing some 1.5 km away, and Hung Shing Ye which also has restaurants above the beach. The closest beach is Tai Wan To, adjacent to the eastern perimeter of the power station but this is not gazetted. Attendance figures for the two gazetted beaches between 1985 and 1989 suggest that the popularity of the area is increasing. Although the data set is too small for a statistical analysis, the figures do indicate that much of the attendance occurs in the months of June, July and August. The bay is also used as an anchorage for pleasure craft in the summer months, particularly off Lo So Shing beach. Local observers suggest that pleasure craft attendance has been increasing in recent years, but there is no data to confirm this.

2.6 Extensive studies have been carried out to investigate the hydrodynamics of the bay for this project and others have been carried out for Hong Kong waters in general. The hydrodynamics in the area are dominated by the seasonal effects of the Pearl estuary, tidal effects and storms. The Ha Mei Wan bay is in general calm although there are rotation currents (a gyre) that sweep around the bay moving from east to west in front of the power station. The area has a slightly higher proportion of sediment than other parts of the bay. The construction of the lagoon will not affect the hydrodynamics of the bay although it may have minor effects on the area immediately around the site of the lagoon.

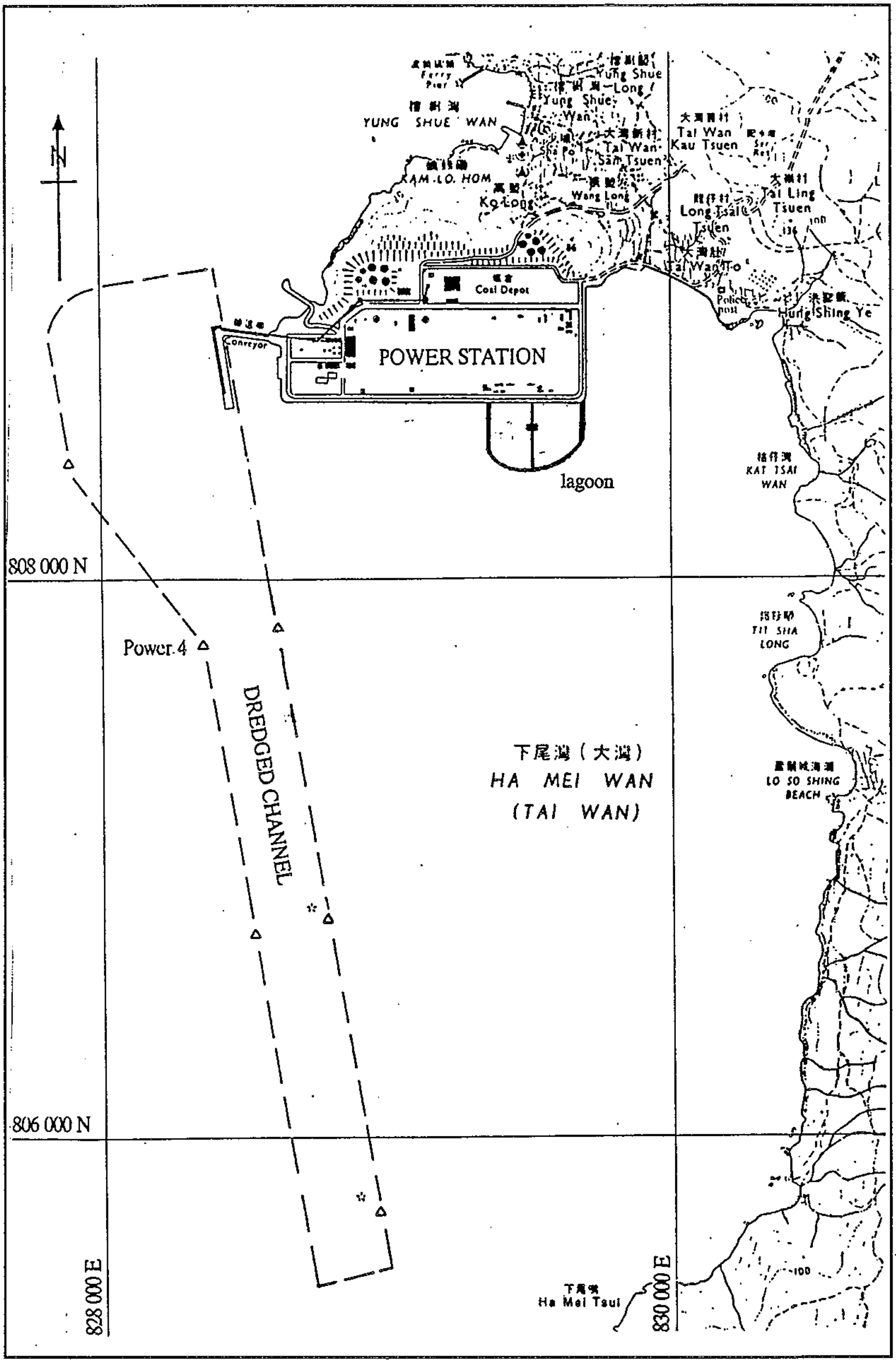


Figure 2.1 The Site

3 THE LAGOON

3.1 The expected production of ash over the next few years is some 700 m^3 per day. The original lagoon was to have an ultimate capacity of 1.5 Mm^3 of ash, and an expected life of about 6 to 8 years. The lagoon is now to have a capacity of about 1.0 million cubic meters, in two compartments, and will in addition provide for the occasional discharge of ash slurry of 46,000 m^3 in a day.

3.2 To accommodate the capacity within the confines of the site and primarily below the sea level, the marine mud within the site is to be excavated. The marine mud excavated during construction will be transported under licence to a designated area for marine disposal. Although the original proposal also required the dredging of marine mud, it required in addition that the ash be mounded above the lagoon perimeter to achieve the desired capacity.

3.3 In devising engineering proposals for the lagoon a number of environmental constraints have been considered, and these are the same as those considered during the preparation of the original lagoon proposals:

(i) the lagoon must not significantly affect the local sea hydrodynamics;

(ii) seepage from the lagoon must not significantly affect the local water quality;

(iii) the lagoon must not be visually intrusive;

(iv) construction duration should be the minimum possible to reduce local disturbance;

3.4 There are also a number of engineering constraints that influence various aspects of the design, these relate to the site conditions, the site's exposure to prevailing winds and the geometry of the existing power station platform:

(i) the very soft marine mud is not sufficiently strong to support a perimeter structure, thus the perimeter structure has to be founded in the firmer underlying alluvial deposits;

(ii) the storms in the area generate strong waves. These have to be guarded against in the shape and height of the perimeter. The chance of overtopping the perimeter is intended to be minimal;

(iii) although the lagoon does not envelop any of the power station's cooling water intakes, unlike the original proposal, the designs have to provide for uninterrupted flow of seawater to the power station throughout construction.

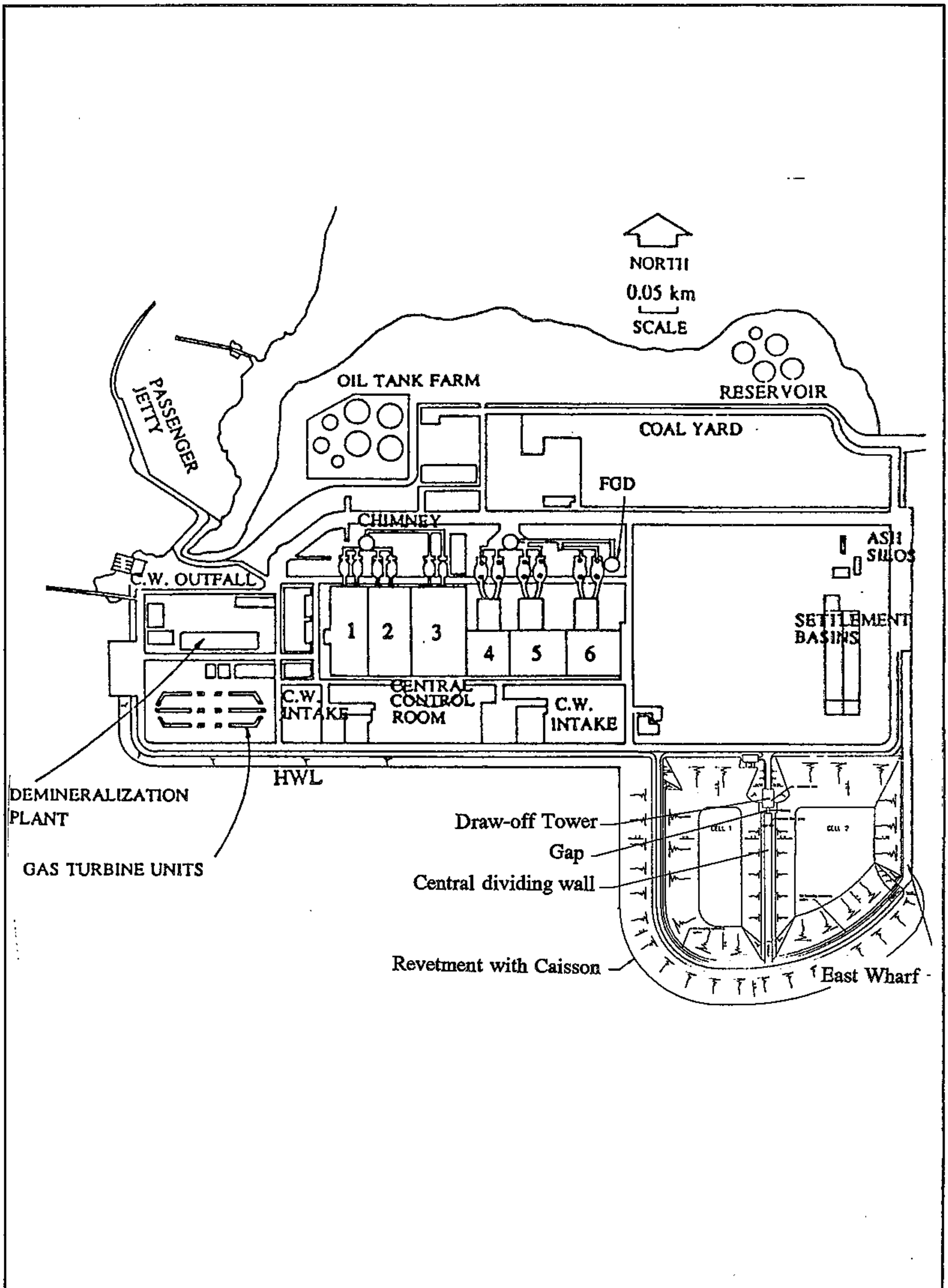


Figure 3.1 Lagoon Location

Perimeter Options

3.5 The favoured option for the perimeter of the original lagoon ("Environmental Impact Assessment Stage III Report on Ash Lagoon") was an embankment, consisting mainly of a sand core with rock armouring on the seaward face with suitable filters between the two. The crest of the embankment would carry a perimeter road at +7.5 mPD with a concrete wave wall on the lagoon side (Figure 3.2). The overall width of the perimeter construction would be about 158 m.

3.6 Given the agreed site limits, an arrangement cannot be found that provides two compartments and does not encroach upon the free entry of water to the cooling water intakes. If the lagoon were to encompass the intakes, culverts would be required, and these would make harvesting arrangements for the ash impractical. Thus the maximum volume that could be achieved would be 0.55 Mm^3, which is considerably less than the required volume.

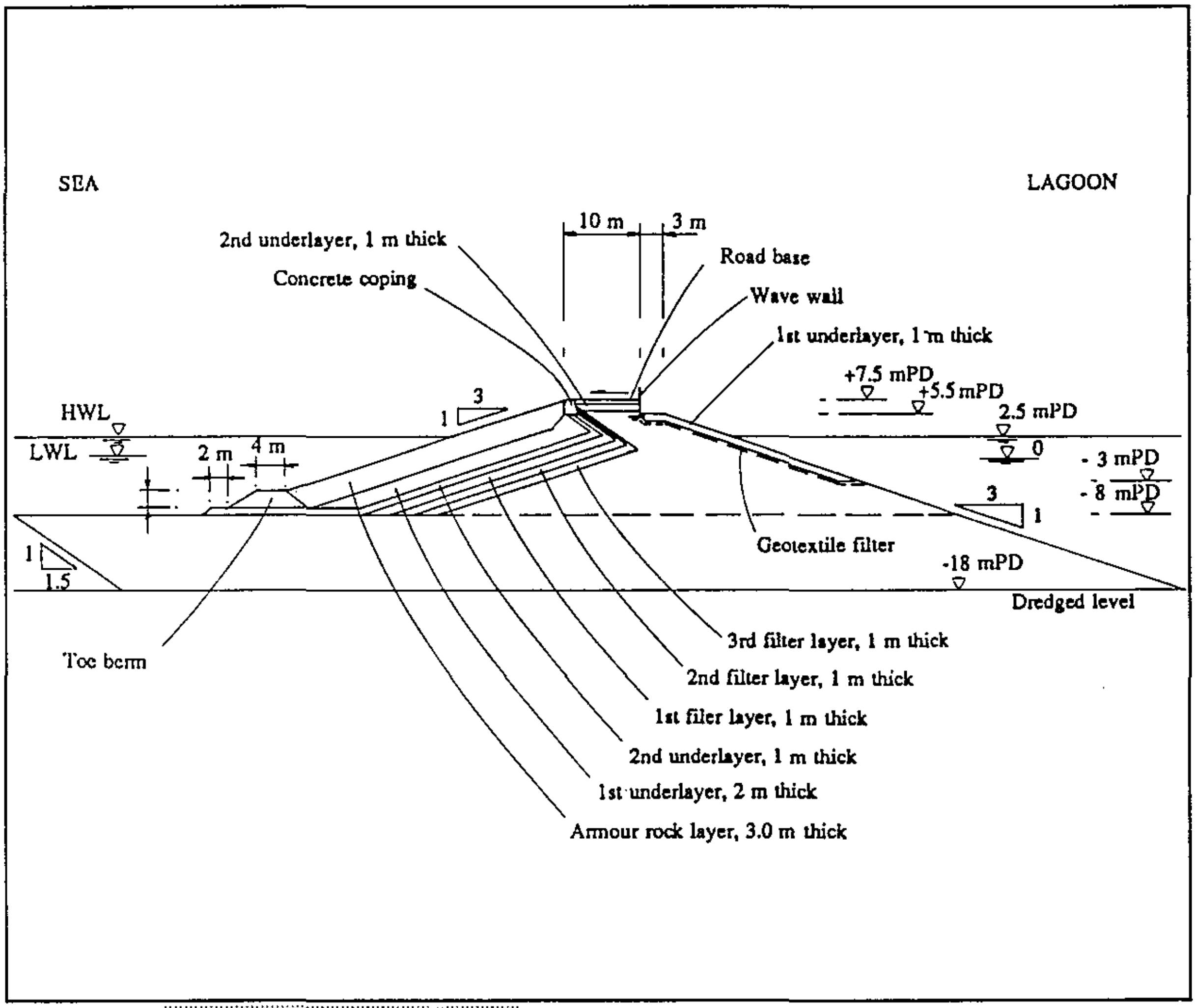


Figure 3.2 Embankment Cross Section

3.7 An alternative option that would achieve the required volume is a perimeter formed of caissons. To maintain stability during storms of a 100 year event the caissons would have to be about 20 m wide. The seaward toe of the caissons would be protected from scour in these severe events by rock armour. The caissons would be founded on a rock rubble mound to minimise settlement, and thus minimise disruption to jointing systems between the caissons. However there are a number of environmental disadvantages to this option over those options that have a revetment on the seaward side:

(i) the vertical seaward face of the caisson would be visually more intrusive than that of a revetment;

(ii) the greater wave reflections associated with the vertical seaward face would increase the potential for wave scour in the vicinity, and consequently the sediment held in suspension;

(iii) the marine species currently inhabiting the existing revetment would probably not be able to inhabit the smooth vertical face of the caissons;

(iv) damage to caissons due to accidental collision or wave impact would be inherently more difficult to repair than a flexible revetment.

3.8 A combination of caissons and revetment provides many of the advantages of both the options for an embankment and a perimeter formed of caissons alone (Figure 3.3). The caissons would be smaller and could be fabricated near the site. The outer revetment would be formed of marine sand and protected from wave attack by stone armouring in the same arrangement as that for the embankment option.

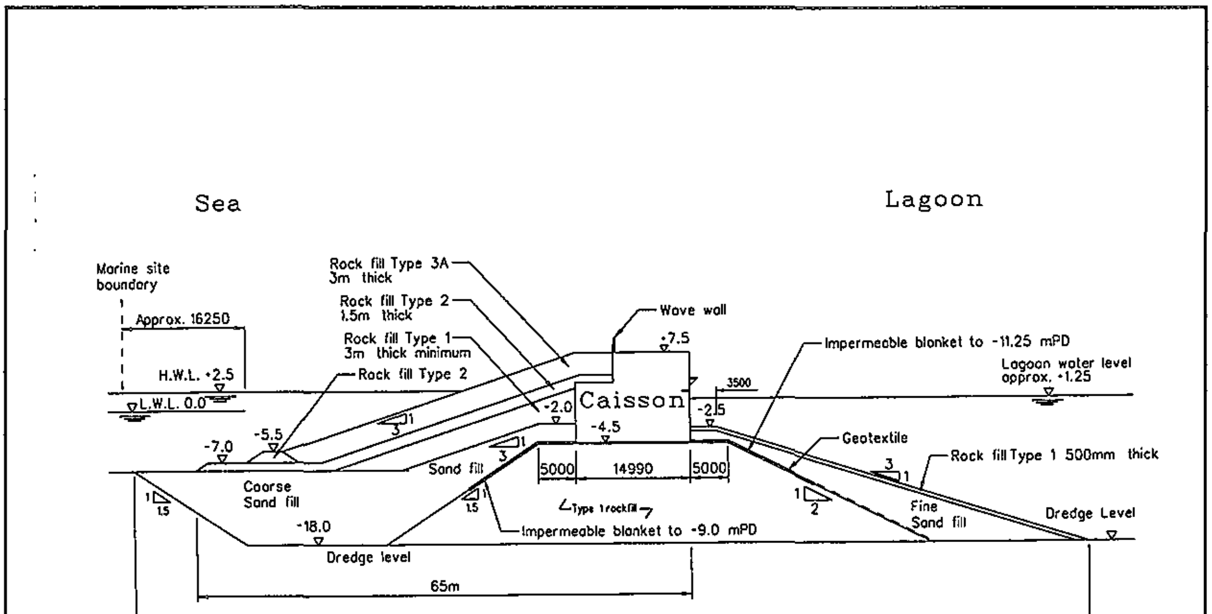


Figure 3.3 Revetment with Caissons Cross Section

Preferred Option

3.9 Of the three options described above: the embankment, the caissons alone, and the revetment with caissons, only the latter two provide technically viable options that meet the criteria for the lagoon. However, of these two, the revetment with caissons option provides better combination of environmental and engineering attributes.

3.10 The EIA Stage III report considered the embankment option to be only marginally better than the revetment with caissons option. They both have the following environmental and engineering characteristics:

Environmental

(i) the seaward aspect of the both is of a similar form to that of the existing station and will visually blend with it;

(ii) the marine fauna will re-colonise the sloping revetment for both, in a similar way to the existing platform revetment;

(iii) the substantial revetment to both forms will provide considerable inherent security against storm damage or accidental impact from large vessels;

(iv) the use of modern construction techniques provides no distinction between the construction periods for either form. The original lagoon was to be constructed 21 months, the revetment with caissons will take the same length of time.

Engineering

(i) although the construction of an embankment is more straightforward and is capable of being built using readily available construction equipment, the construction techniques required for the caissons have becoming more common in Hong Kong with the increase in development of marine structures and sea walls;

(ii) only a small portion of the work need be land based for both forms;

(iii) the form of an embankment is relatively insensitive to unforeseen ground conditions. However the design details for the foundations to caissons can be engineered to have a similar insensitivity to variability to ground conditions;

(iv) once finished, an embankment would require low maintenance, but also with modern construction specifications, caissons should also have a similar longevity and low maintenance.

3.11 Upon consideration of the environmental and engineering aspects of both the embankment and revetment with caisson forms for the perimeter, there is little to distinguish between the two.

Details of an Embankment Perimeter

3.12 The typical section of the embankment has a 10 m crest width with a wave wall at the back (Figure 3.2). This arrangement is compatible with the existing station platform and the crest allows for dissipation of waves running up the embankment. The outer revetment would be protected by stone armour with the necessary underlayers. The heart of the embankment would be formed of marine sand, which has a distribution of grain sizes suitable for limiting seepage to and from the lagoon. The inner face will be protected from minor wave action that may occur within the lagoon, by means of a stone surface underlain by a geotextile.

3.13 The surface slopes on both the inner and outer faces of the lagoon would be 3 horiz : 1 vert, this would give a construction width for the whole cross section of approximately 140 m. Presuming that the construction of an embankment perimeter were feasible and a viable option, the volume of sand fill required would be approximately 1 Mm^3, and in addition 1.2 Mm^3 of mud would have to be dredged to provide a lagoon capacity of 0.55 Mm^3.

Details of a Caisson with Revetment Perimeter

3.14 The majority of the lagoon's perimeter would be constructed of caissons and a revetment on the seaward side. The seaward aspect of the revetment would be similar to that of the embankment option, formed of sand fill and protected from wave attack with a rock armour facing. Between the two would be a series of filters and under layers. The construction width of this form of perimeter would be about 126 m (Figure 3.3).

3.15 The sea wall has been designed to accommodate the design criteria associated with a 1:100 storm event and other criteria set out in the Port Works Manual 1992. In addition the wave climate in the area of the site has been assessed in the light of previous studies and other studies for projects in the area. The design for the rock armour size has used these criteria to maintain the integrity of the revetment in the design event.

3.16 The rockfill foundations to the caissons would be formed in much the same way as the sand fill for the embankment option, by bottom or side tipping barges. The caissons are small enough to be precast close to site and then manoeuvred into position over the foundations. The caissons would then be flooded in a controlled manner to come to rest on the rubble foundation.

3.17 Filters and seals will be required on the inside face of the perimeter to prevent ash particle migration through the perimeter. The seepage through the foundation embankment would be controlled by sand fill layers on either side of the rubble foundation to the caissons and by impermeable blankets on below these sand fill layers, that are to be partial cutoffs, placed to part way down the rubble foundation. This will give the perimeter the same seepage characteristics as that proposed for the original embankment proposal (Section 6).

3.18 The existing power station revetment consists of rock armour overlying highly permeable general fill. Before this is to form the northern perimeter of the lagoon the rock armour will be removed to expose the type 2 material and treated to prevent the particles of ash escaping the lagoon in a suspension of seepage water (Figure 3.4). The type 2 material will be screeded with a fine sand to prevent damage to the overlying geotextile. Above this a series of filters will be placed. These will have gradings suitable for arresting the egress of ash particles to be placed on top.

3.19 To provide the facilities required for transporting the ash by barge from the site, a wharf is required. Once an operation for the harvesting and transportation of ash is under way, the wharf would be used almost continuously during the hours of daylight for the loading of barges. Thus existing facilities at the East Wharf are inadequate for the existing duties and the additional duties required for re-handling the harvested ash.

3.20 Consequently additional wharf facilities are to be provided by the extension of the existing wharf, down the eastern side of the lagoon. The eastern side of the lagoon will be the most sheltered location for the wharf and provide for the least possible interruption of barge loading by high seas. The proposed wharf is a series of continuous piles along with a grid of piles to support the deck, these will be tied together with a lattice of beams. This is similar to the design for the existing wharf.

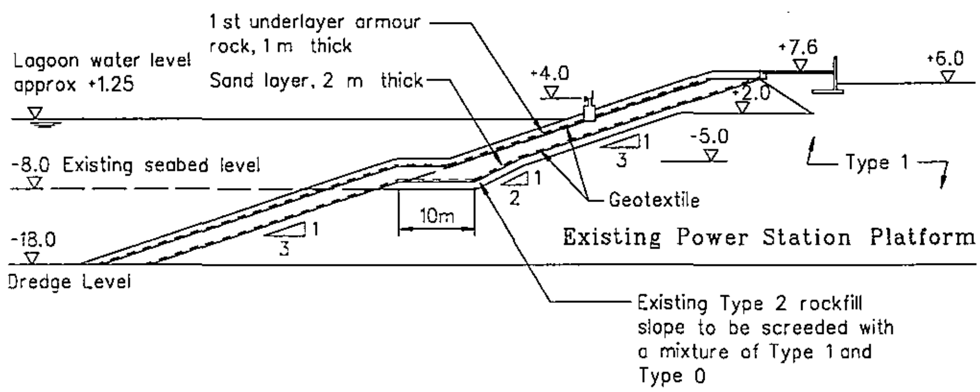


Figure 3.4 Northern Perimeter - Proposed Typical Section

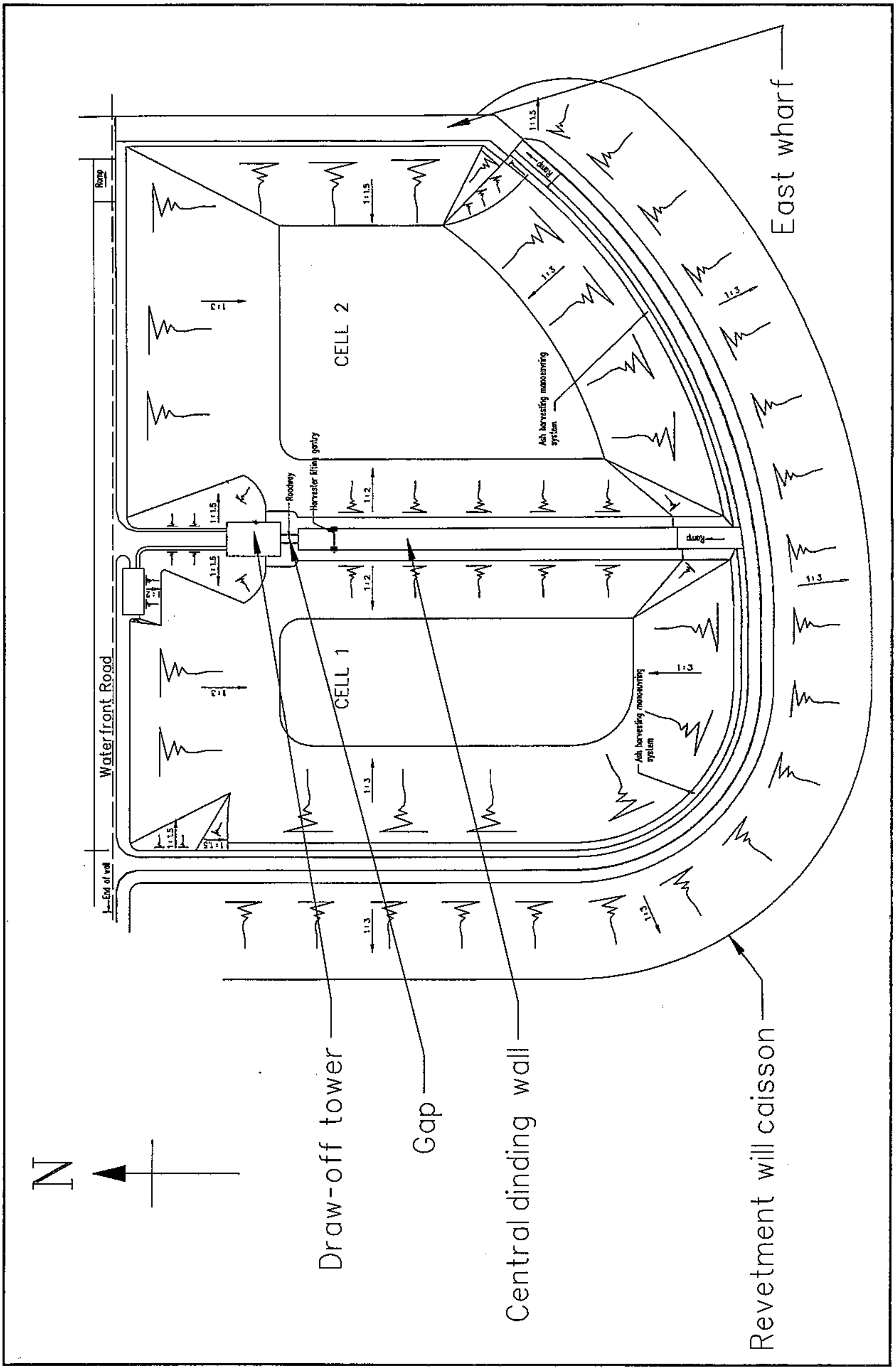


Figure 3.5 Lagoon Layout

Material Sources

3.21 The principal materials required for the caisson with revetment perimeter will be rock, sand and concrete. These materials are common construction materials in Hong Kong and difficulties with supply are not envisaged.

3.22 The concrete specification will specify, in accordance with HEC policy, the use of PFA as a substitute for cement where appropriate. The concrete may be produced by the plant at the Lamma Power Station, which is capable of producing the concrete specified for the marine environment. However, the choice of concrete source will be for the contractor to determine.

3.23 The size of rocks required for armouring the sea revetment and the smaller gradings for underlayers are all available from quarries either within Hong Kong or nearby (Figure 3.6).

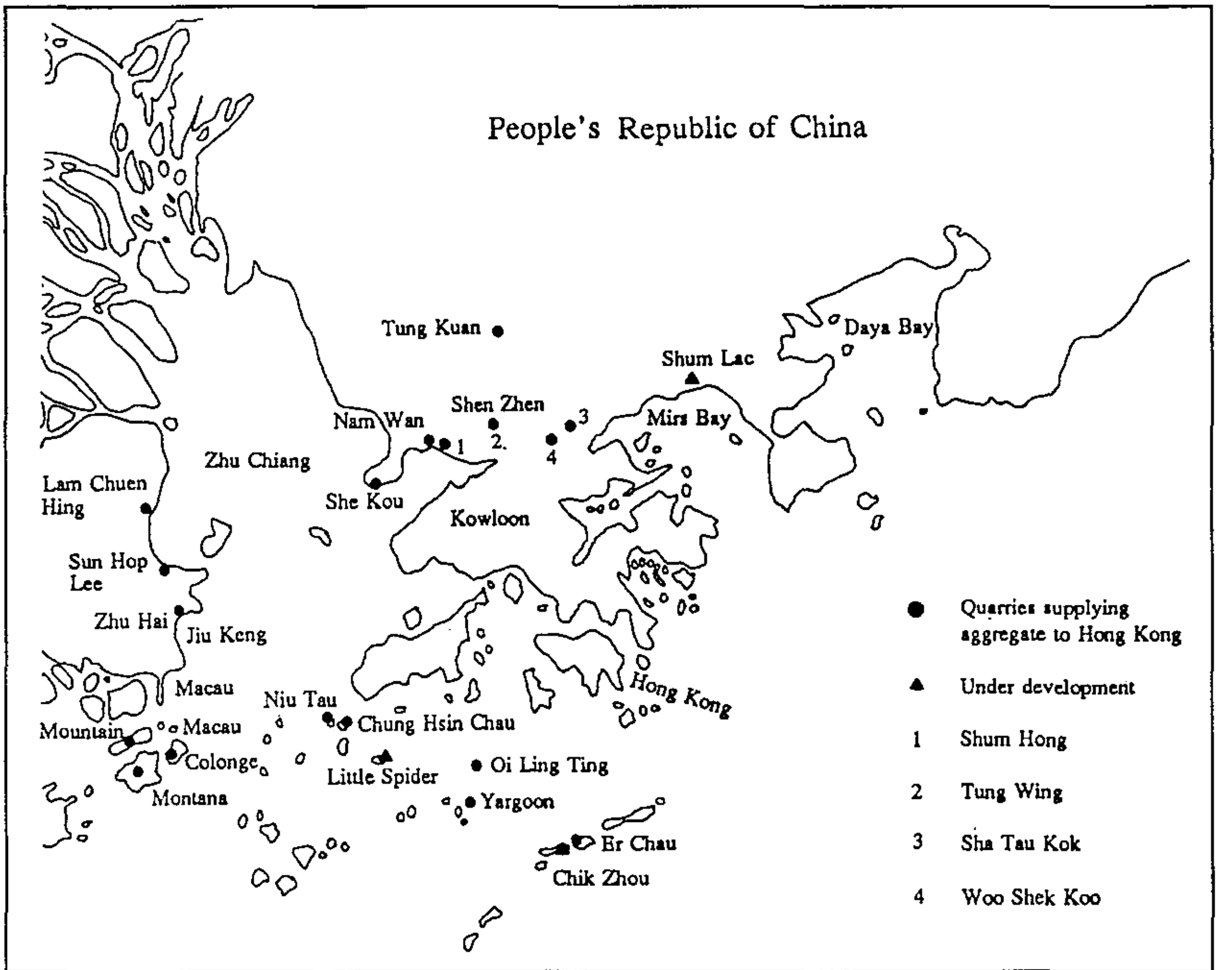


Figure 3.6 Quarries in PRC Supplying Hong Kong

3.24 In recent years extensive surveys of available marine sand deposits have proved the existence of substantial reserves within Hong Kong waters. Exploitation of these reserves have proved to be viable on a number of large projects. The sources vary in grading, thus careful selection of the sources will permit different marine sands to be used for both the hearting and various filter layers required to prevent PFA particles migrating through the perimeter. Since the work for the EIA Stage III report, the requirements for the filters have been altered to comply with current standards (Figure 3.7).

3.25 Alternatively the contractor may elect to use proven land based sources.

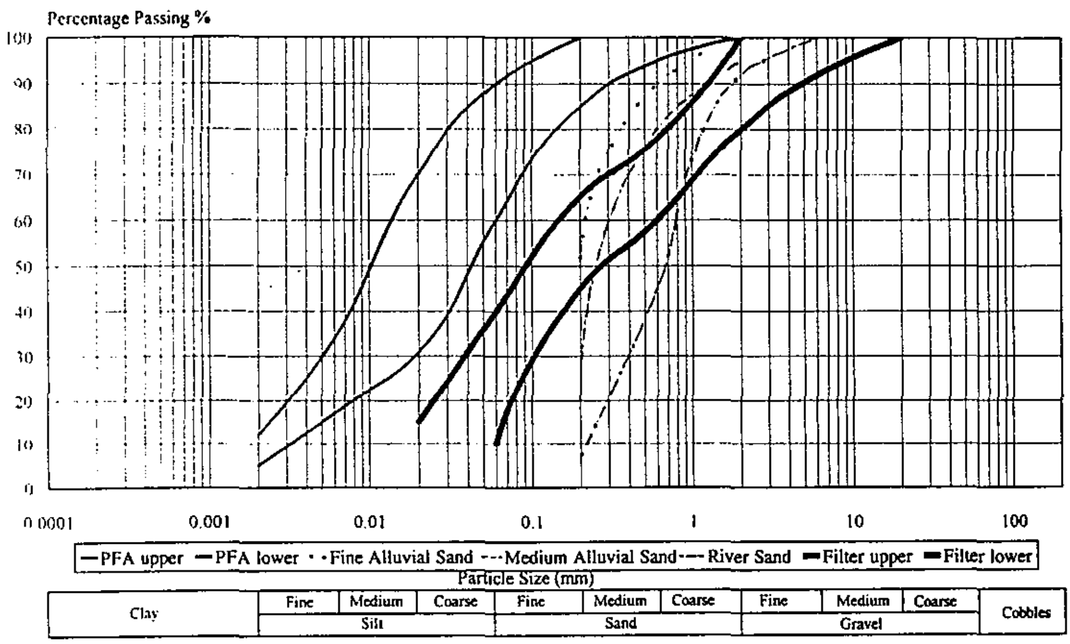


Figure 3.7 Grading of Ash and Appropriate Filters

4 LAGOON CONSTRUCTION

4.1 The reduction of any environmental impacts resulting from construction involves not only careful assessment and management of construction operations but also the limiting of the construction period to a minimum. Although the final choice of construction methods is for the contractor, he will have to remain within all governmental criteria and contractual specifications in force at the time. However, an assessment of the likely impacts can be made, based on similar construction projects and techniques used in Hong Kong.

Principal Construction Operations

4.2 The construction operations required for the revetment with caisson perimeter will be very similar to those for the embankment in terms of the nature of the operations, and slightly less in extent for most of the operations.

4.3 There will probably be six main construction operations, much of which will be conducted as marine based activities. In addition to these six there will be the construction of a draw-off tower within the central dividing wall. However this is small, and formed from a caisson similar to others for the perimeter. Consequently it is unlikely to present any significant impact, and it is not discussed further in relation to construction operations. There were six main operations for the original lagoon proposal as there are for the current lagoon with revetment with caissons (Table 4.1).

	EIA Stage III - Lagoon with Embankment	Lagoon - Revetment with Caissons
1	foundation preparation	foundation preparation
2	bulk filling of foundations and embankments	bulk filling of foundations
3	construction of the intake culvert	caisson construction and revetment
4	front pond quay wall construction	East Wharf construction
5	lagoon closure	lagoon closure
6	construction of perimeter road and wave wall	construction of perimeter road and wave wall

Table 4.1 Lagoon Construction Operations

4.4 The removal of marine mud from the sea bed is required for the preparation of a firm foundation. The mud will be dredged and disposed of in a suitable marine area. The mud has been tested in the approved manner, and prior to removal and disposal of the mud, the relevant Government procedures will be completed and approvals obtained. There is a registered area off Cheung Chau for the disposal of dredged mud which is thought to be a suitable location for disposal. The EIA Stage III report also proposed this site as the most likely suitable site, indeed since then the site has gained approval from Government. The embankment option required the disposal of approximately 1.6 Mm^3, but the present proposal requires the disposal of only 1.2 Mm^3.

4.5 Like the embankment perimeter, the present proposals will require a bulk filling operation for the formation of the foundation. However a large portion of the foundations, under the caisson, will be formed of rubble rockfill to reduce the expected settlement of the caissons and enhance their stability. Sand fill will be required for the shoulders to the rockfill mound, but significantly less than the 1.62 Mm^3 required for the embankment perimeter of the original proposal.

4.6 The original proposal required intake culverts to be placed through the lagoon, which would have been precast units, and probably constructed on a submersible barge before being sunk into position. The current proposal does not require such culverts but does require caissons which are of a similar nature, and would be constructed and floated into position in a similar way.

4.7 The construction of the quay wall for a front pond to the cooling water intake, will no longer be required. However the construction of a quay wall to form an extension to the East Wharf will be required. This will be done using either the techniques used in the existing wharf, bored piles and cast deck, an alternative using caissons may be considered.

4.8 Prior to the final closure of the lagoon, and whilst taking due consideration of typhoon seasons, the rock armour from the power station revetment will be removed and placed on the revetment in front of the caissons. By this time the station revetment will be protected by the lagoon perimeter. The station platform's exposed slope will be prepared with a geotextile, sand and rock to form a filter to the northern perimeter to the lagoon. Once this has been achieved the lagoon's eastern perimeter can be closed and completed.

4.9 The finishing to the perimeter, as with the embankment perimeter, will be construction of the perimeter road and wave wall. The wave wall may be formed of pre-cast units or cast in-situ concrete. The nature of the construction activities will depend to a great extent on the contractor's working methods and in part on the design details.

Construction Programme

4.10 The optimum sequence of the various construction activities is crucial if the minimum construction programme is to be achieved. This was true for the original embankment lagoon and remains true for the present proposals. The estimate for the optimum construction programme for the embankment lagoon was 21 months, and the construction of the perimeter to the current scheme is programmed to take 21 months also (Figure 4.1).

4.11 The construction sequence for the main elements remains essentially the same. The site formation will be prepared by the necessary dredging, and then the construction will proceed from the west to the east. This will afford the site the maximum protection against the prevailing wave direction.

4.12 Following the placement of the caissons the construction of the revetment on the seaward side will proceed as closely as possible, to reduce the risk of damage to the caissons by direct wave attack, particularly during typhoons. Once the existing platform has been afforded the necessary protection from wave attack, nearing the end of construction, the rock armour can be removed from the platform revetment and used for the remainder of the revetment in front of the caissons.

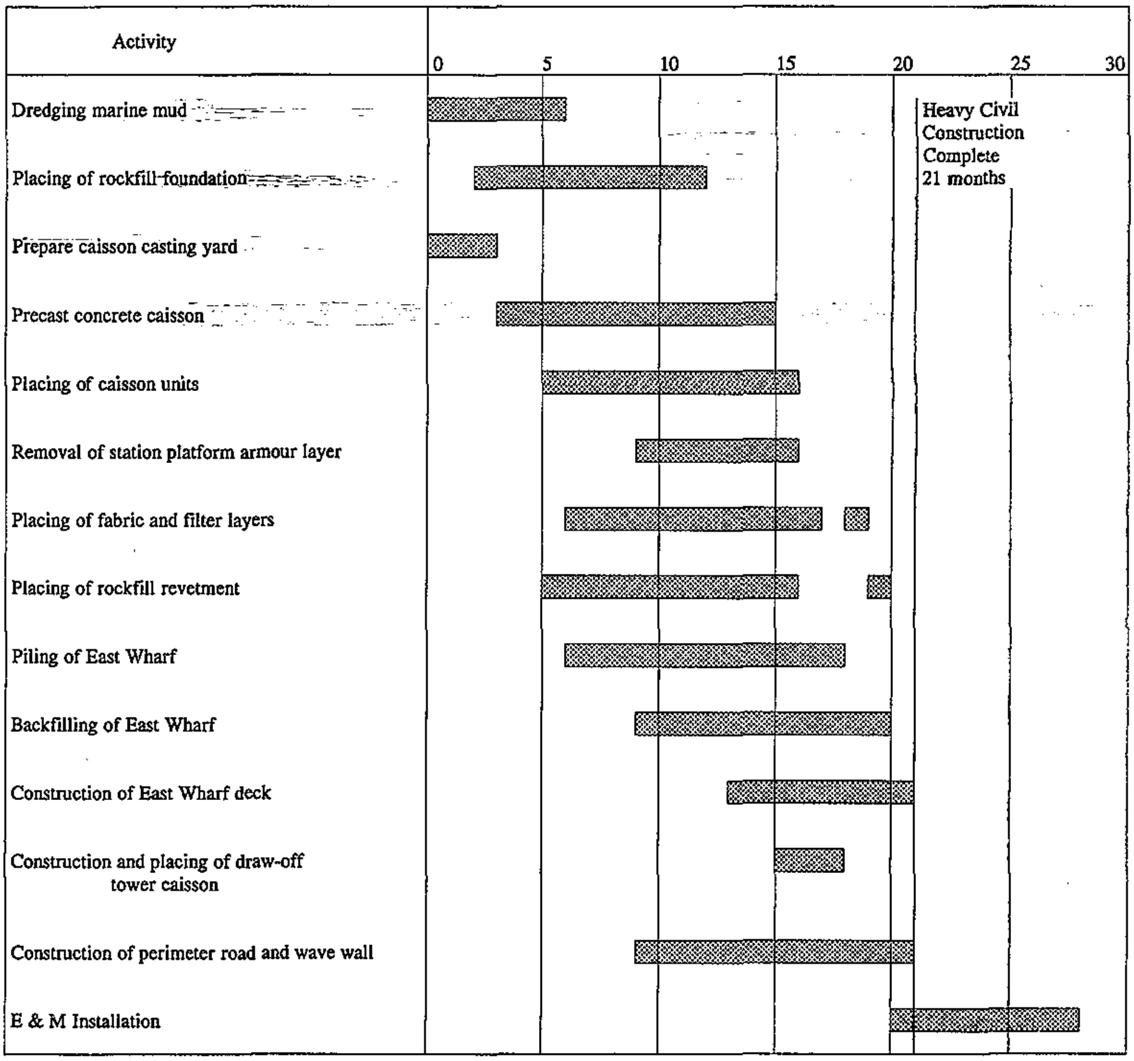


Figure 4.1 Estimated Construction Programme

Construction Effects

4.13 During the construction period there will be a number of environmental effects, some of them permanent and some temporary. However all of them will be limited in extent and significance. This general assessment is the same for both the current proposals and for the previous proposals of the EIA Stage III report. The effects are related to impacts on:

(i) marine biota;

(ii) sea water quality;

(iii) noise;

(iv) visual impact;

(v) community reaction;

(vi) tourism;

(vii) employment opportunity derived from construction.

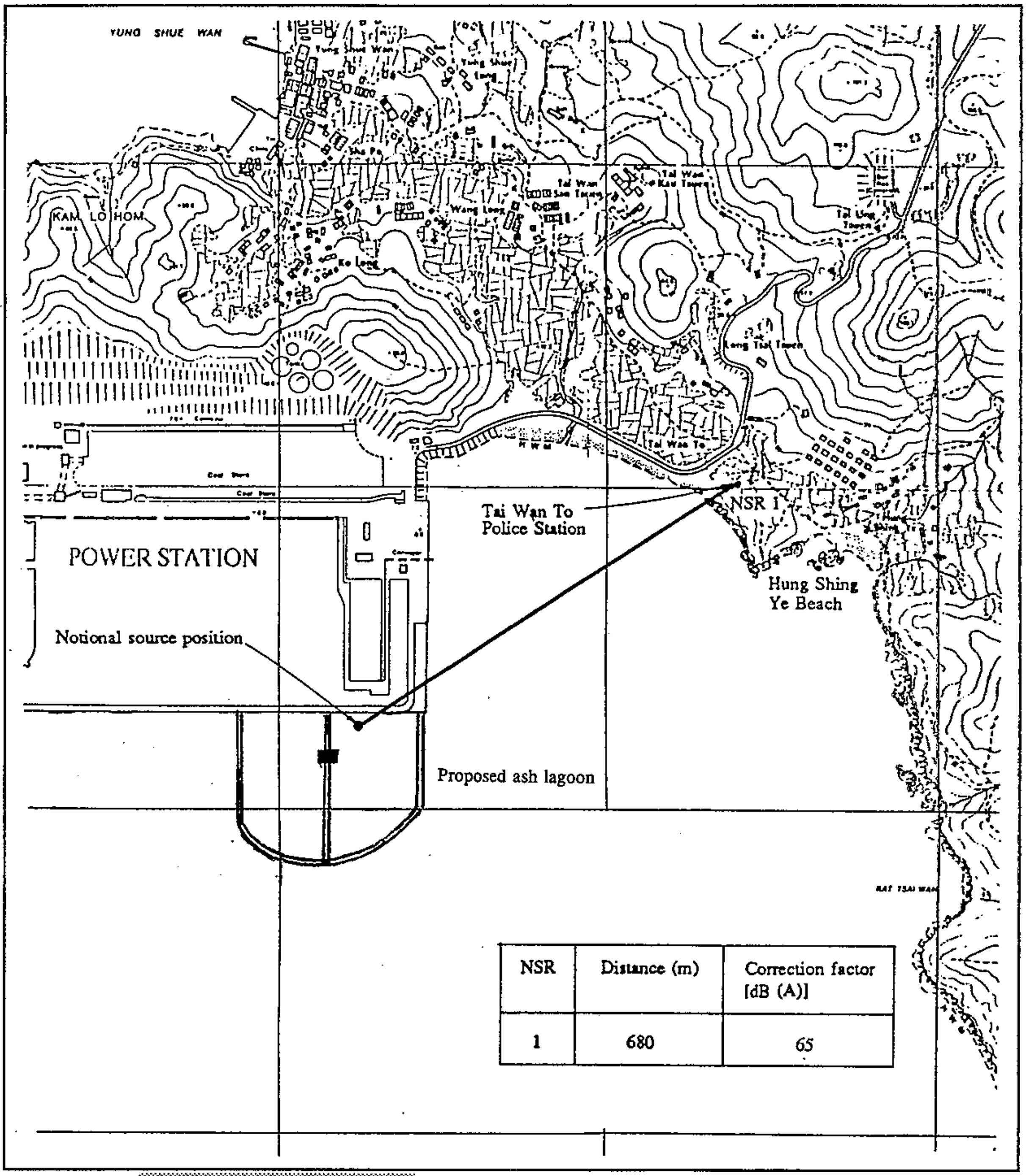
4.14 Although the marine biota is reasonably diverse it is not unique, nor is the site a nursery or unique habitat (Section 2.4). Thus a limited area of seabed, smaller than the original proposals, will be lost during construction but this is not a significant size in the context of Ha Mei Wan bay or other similar areas in Hong Kong waters. The population of free swimming organisms will not be significantly affected by the loss of this area in Ha Mei Wan.

4.15 The construction activities will have no permanent effect on the local sea water quality. During construction there may be temporary but localised effects. Turbidity due to the marine dredging operation may increase. However this can be limited by the specification of good working practices and is distant from the bathing areas of Hung Shing Ye and Tai Wan To beaches. The marine mud around the power station is in a healthy state (IAR), thus the release of excessive nutrients or toxins during the dredging operations is unlikely.

4.16 The visual impact of the construction activities, particularly the impact of the marine vessels is to be kept to a minimum by reducing the construction period to the minimum possible. The impact of the marine traffic is likely to be small because of the distance to the beaches from which they could be seen, and because there is currently marine traffic associated with material movements to and from the power station's eastern wharf. The permanent effect of the construction is the finished works, which have been designed to blend with the existing forms of the power station. The major part of the visible works will be the external revetment, the form of which has been chosen to be similar to that of the existing station.

4.17 The area around the power station is a rural setting, and government technical memoranda rate such areas as having the highest noise sensitivity rating. As such the noise from any construction work should not exceed 60 dB(A) at the nearest habitation, this is taken to be the Tai Wan To police station (Figure 4.2).

4.18 The noise generated from any of the principal operations for the construction of the original embankment proposals were estimated in the EIA Stage III report. The estimates were based upon six principal operations from the foundation preparation to completion of the lagoon. These were found to have been within the limits (Table 4.2). Various combinations of principal operations were also assessed and found to be acceptable, except during restricted hours (1900 to 0700 hours and general holidays, including Sundays).



NSR	Distance (m)	Correction factor [dB (A)]
1	680	65

Figure 4.2 Noise Sensitive Receiver

	Noise [dB(A)]						TSPL [dB(A)][1]	CNL [dB(A)][2] at NSR
Operation 1 (4 months):	- Dredging Marine Mud							
1 Grab dredger	112 >	115 >	115.5 >				)	
1 Trailer dredger	112 >		>	116			)	
2 Support barges	104 >	107 >	>				) 116	116-67[3] = 49
	104 >		>				)	
Operation 2 (13 months):	- Sand filling for foundation - Rock filling for embankment - Armour rock placing							
3 Bottom dump barges	104 >	107 >					)	
	104 >	>	110 >				)	
	104 >	107 >	>	115 >			)	
4 Derrick lighters	104 >		>	>			)	
	104 >	107 >	>	>			)	
	104 >	>	113.5	>			)	
	104 >	112.5 >		>	>		)	
3 Grab dredgers	112 >			>	122 >		)	
	112 >	115 >	118 >	>	>		)	
	112 >	>	>	>	>		)	
5 Backhoes	112 >	115 >	>	120.5 >	>		)	
	112 >		>		>		) 122	
	112 >	115 >	>		>	122	)	122-67[3] = 55
	112 >	>	117		>		)	
	112 >	112 >			>		)	
6 Vibro compaction probes	80 >		>		>		)	
	80 >	83 >	>		>		)	
	80 >	>	86 >	87 >	87 >		)	
	80 >	83 >	>				)	
	80 >						)	
	80 >	80 >	80 >				)	
Operation 3 (7 months):	- Placing of intake culvert units.							
1 Submersible barge	104 >	104 >					)	
2 Floating cranes	112 >	>	115.5 >				)	
	112 >	115 >	>				)	
2 Tug boats	110 >		>	117.5			) 118	118-67[3] = 51
	110 >	113 >	113 >				)	
							)	
Operation 4 (6 months):	- Quay wall construction for front pond							
1 Derrick lighter	104 >	104 >					)	
	>	>	115.5 >				)	
2 Land-based cranes	112 >	115 >	>	116			) 116	116-67[3] = 49
	112 >	>	>				)	
Operation 5 (9 months):	- Remove existing armour rock and screed surface - Place sand layer and 1st underlayer armour protection - Sand filling and foundation - Rock filling for embankment - Armour rock to placing							
3 Derrick lighters	104 >	107 >					)	
	104 >	>	113.5 >	>			)	
	104 >	112.5 >	>	118.5 >			)	
4 Backhoes	112 >		>	>			)	
	112 >	115 >	>	>	118.5		) 119	119-67[3] = 52
	112 >	>	117 >	>			)	
	112 >	112 >		>			)	
1 Vibro compaction probe	80 >						)	
1 Bottom dump barge	104 >	104 >	104 >	104 >			)	
Operation 6 (7 months):	- Construct perimeter road and wave wall							
1 Graders	113 >	113.5 >					)	
		>	115 >				)	
2 Compactors	105 >	>	>				)	
	105 >	110 >	>	118			) 118	
1 Concrete batching system	108 >		>				)	118-67[3] = 51
2 Backhoes	112 >	115 >	115 >				)	
	112 >						)	

Remarks: (1) Total Sound Power Level

(2) Corrected Noise Level

(3) Correction Factor for Distance Attenuation between the NSR and the construction site [-65 dB(A)], partial screening of NSR [-5 dB(A)] and NSR being a building [+ 3 dB(A)]

Table 4.2 Construction Noise Levels - Embankment Proposals

	Noise [dB(A)]	TSPL [dB(A)][1]	CNL [dB(A)][2] at NSR
Operation 1 (4 months):	- Dredging Marine Mud		
2 Grab dredger	118+3 >	)	
	> 123	) 123	123-67[3] = 56
4 Support barges and tugs	110+9 >	)	
Operation 2 (13 months):	- Sand filling for foundation - Rock filling for foundation - Armour rock placing		
10 derrick lighters	104+3 >	)	
	> 110 >	)	
	104+3 > > 111 >	) 122	122-67[3] = 55
	104 > 104 > > 122	)	
	112+9 > > 121 >	)	
4 Backhoes		)	
Operation 3 (7 months):	- Caisson construction and revetment		
1 Submersible barge	104 > 104 >	)	
5 Cranes	76+3 > >	)	
	> 82 > > 104 >	)	
	76+3 > > 83 > >	)	
	76 > 76 > > 107	) 107	107-67[3] = 40
1 Concrete Pump	104 104 > >	)	
	> 104 > >	)	
3 Air Compressors	68+3 > 71 > > 104 >	)	
	68 > >	)	
1 Generator	80 > 80 > 80 >	)	
Operation 4 (6 months):	- East Wharf construction		
1 Piling Barge	118 >	)	
	> 118.5 >	)	
1 Vibrating hammer	108 > >	)	
	> 119.5 >	)	
1 Percussion drill	103 > > >	)	
	> 103 > >	)	
3 Casing Oscillators	65 > > 121.5	) 122	122-67[3] = 55
	>	)	
1 Diesel Hammer	113 > >	)	
	> 115 > >	)	
1 Pneumatic Hammer	111 > > 117 >	)	
	>	)	
1 Hydraulic Hammer	112 > 112 >	)	
Operation 5 (9 months):	- Remove existing armour rock and screed surface - Place sand layer and 1st underlayer armour protection - Armour rock to placing		
5 Crawler Cranes	121 >	)	
	> 121 >	)	
1 Concrete Pump	104 > > 121	) 121	121-67[3] = 54
	> >	)	
3 Air Compressors	73 > 73 >	)	
Operation 6 (7 months):	- Construct perimeter road and wave wall		
5 Crawler Cranes	121 >	)	
	> 121 >	)	
1 Concrete Pump	104 > > 121	) 121	121-67[3] = 54
	> >	)	
3 Air Compressors	73 > 73 >	)	

Remarks:
(1) Total Sound Power Level
(2) Corrected Noise Level
(3) Correction Factor for Distance Attenuation between the NSR and the construction site [-65 dB(A)], partial screening of NSR [-5 dB(A)] and NSR being a building [+ 3 dB(A)]

Table 4.3 Construction Noise Levels - Revetment with Caissons

4.19 The revetment with caissons perimeter will require similar principal construction operations with similar plant. The anticipated noise levels for the construction of the revetment with caisson perimeter has been assessed by similar methods to those for the EIA Stage III assessment. The noise level estimates for construction operations in the current proposals are expected to be below 60 dB(A) (Table 4.3), and that suitable combinations of these operations are also below the 60 dB(A) (Table 4.4). However the operations are generally not acceptable during restricted hours (1900 to 0700 hours and general holidays, including Sundays). This exclusion is the same as the operations for the EIA Stage III proposals.

	TSPL [dB(A)]			CNL [dB(A)]
Operation 1	123			
		125.5		
Operation 2	122			
			127	60
Operation 3	107			
		122		
Operation 4	122			
Operation 2	122			
		122		
Operation 3	107			
			125	58
Operation 4	122	122		
Operation 2	122	122		
Operation 5	121		126	59
		124		
Operation 6	121			

Table 4.4 Construction Noise - Simultaneous Operations - Revetment with Caissons

4.20 The Lamma community gives the impression that the rational for the lagoon have been accepted, albeit reluctantly in some cases. This impression was reinforced by the discussions held during the ash management exhibition held on Lamma from 13 th October 1989 to 15 th October 1989, when all the proposed works for the ash management strategy were presented and explained to Lamma residents. Subsequently the Lamma Conservation Society have publicly announced their acceptance of the plans.

4.21 At that time the proposals were for the larger lagoon with the embankment perimeter. The current lagoon is smaller in extent and the majority of the perimeter will have a similar aspect to that of the embankment. Also many of the construction activities will be similar in nature and last for a similar length of time. Consequently significant adverse community reaction to the lagoon's construction is not expected.

4.22 The principal tourist activities in the area are bathing, picnics, pleasure boating and restaurants, these are associated with:

(i) Tai Wan To beach;

(ii) Hung Shing Ye beach and restaurants;

(iii) Lo So Shing beach;

(iv) Ha Mei Wan bay for pleasure craft.

4.23 The attendance of the beaches has been rising since 1985 (Government attendance figures for gazetted beaches), and residents report that pleasure craft attendance has also been rising over the years. The majority of the attendance is probably during the three months of June, July and August. The construction activities will not affect water quality or restrict current swimming or sailing facilities, thus it is highly unlikely that many beach users will be discouraged. Lo So Shing is 1.5 km to the south and east of the site, so there is unlikely to be any effect on the beach area. Hung Shing Ye and Tai Wan To beaches are both closer and consequently the minor visual intrusion of construction work may give a less attractive aspect, likewise for a number of the pleasure craft anchorages off the beaches. However the facilities themselves will not be affected and the attendance will probably not be affected.

4.24 Much of the construction work will be associated with the marine activities, thus the contractor will probably use his own skilled staff for the particular duties. However the small amount of land based work for the perimeter road, wave wall and quay wall construction may require skilled and semi-skilled labour for which there may be a limited scope for local employment. Depending on the contractor's method of working, a minimum of 20 persons may be required.

Environmental Audit

4.25 There will be two Environmental Monitoring and Audit procedures for the project, one for the construction phase and one for the operational phase. In both cases the procedures will be discussed and agreed with EPD. The proposals for the Environmental Audit of the construction phase have not changed from the principles set out in the EIA Stage III report, but have been developed within an environmental monitoring manual, in accordance with Government requirements. These procedures are being discussed with Government (December 1993 - January 1994) under a separate submission.

4.26 Environmental auditing procedures will be instituted throughout the construction period to provide a methodical framework for monitoring and control procedures. The environmental audit will also report regularly to provide information both to HEC management and to government authorities on the effects of the construction activities. Two audits will be carried out in the first year and one in the second year of construction. A further audit will be carried out sometime after construction completion to assess any long-term effects of construction and assess the accuracy of the EIA.

Environmental Monitoring

4.27 The proposals for the Environmental Monitoring have not changed from the principles set out in the EIA Stage III report, but have been developed within an environmental monitoring manual, in accordance with Government requirements. These procedures are being discussed with Government (December 1993 - January 1994) under a separate submission for the "Environmental Monitoring and Audit Manual for the Construction of Lamma Power Station Ash Lagoon".

4.28 Monitoring is required to provide the necessary data for an informed assessment of the environmental impacts of the various activities and to what extent any impacts persist beyond the completion of the activities. This can only be achieved by measuring the relevant parameters before, during and after the activities.

4.29 The sea water quality will be monitored at three locations close to the construction site, and one remote from the site ST4 to determine ambient conditions (Figure 4.3). The monitoring programme and procedures is detailed in the monitoring and audit manual.

4.30 Noise will be monitored throughout the construction period. The procedures for the noise monitoring and interpretation are currently under discussion with Government and will be documented in a separate Environmental Monitoring and Audit Manual to be submitted to Government.

4.31 Although subjective judgements of the effect of construction on tourism may be made, the quantifiable method proposed here is to assess the government statistics for the attendance at the gazetted beaches of Lo So Shing and Hung Shing Ye. These figures will also be affected by other factors such as the season and weather conditions, which would have to be allowed for in the assessment.

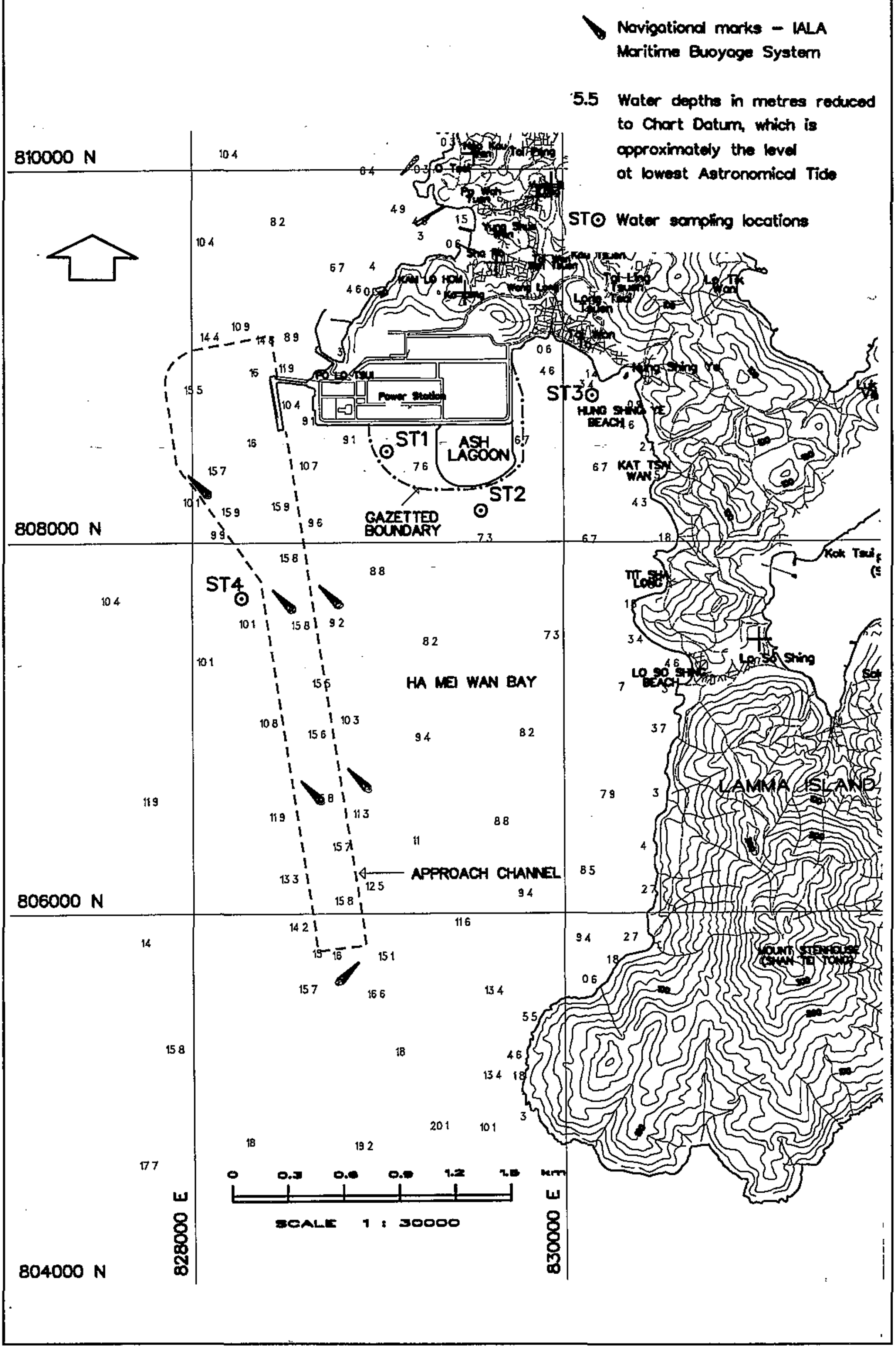


Figure 4.3 Sea Water Sampling Stations - Construction

Control Procedures

4.32 The control procedures for the various effects relate primarily to the adherence to a minimum construction period and the control of dredging operations. Although the effects of dredging are likely to be small, various working methods can be used in the operations to mitigate impacts, these are:

(i) mechanical grabs shall be designed and maintained to avoid spillage and seal tightly while being lifted. Closed grabs shall be used;

(ii) ladders of bucket dredgers shall be designed to minimise disturbance of the sea bed;

(iii) cutters of cutter suction dredgers shall be suitable for the materials being excavated and shall be designed to minimise overbreak and sedimentation around the cutter;

(iv) washing out or overflowing of hoppers on hopper dredgers or barges while dredging and loading material will not be permitted in Ha Mei Wan;

(v) the decks of all vessels shall be kept tidy and free of oil or any other substances or articles which may be washed overboard. Rubbish shall not be dumped in the sea.

4.33 These aspects of procedures for construction control have not changed between the previous embankment proposals and those for the caisson with revetment proposals.

5 LAGOON OPERATION

5.1 The operating systems for the lagoon are associated with the placing of the PFA, its removal (harvesting) when necessary and measures to control the environmental impact. These systems are:

(i) PFA transport and placing systems;

(ii) PFA harvesting system;

(iii) PFA sluicing system;

(iv) landscaping;

(v) water quality control system;

(vi) floater collection system;

(vii) dust suppression system.

Ash Transport and Placing System

5.2 The ash was to have been placed in the lagoon as conditioned ash. This would have been transported to the lagoon by a series of conveyors and then spread across the lagoon as required by conventional construction equipment such as bulldozers. All the motors on the conveyors would have required motor housings to limit the noise emissions and the conveyors would have been covered to prevent dust emissions.

5.3 The current proposal is to transport the ash as a slurry, with water as the carrying medium. The slurry will be transported around the perimeter of each compartment by two pipes, and discharge points will be placed at even centres around the perimeter. There will be eight discharge points to each compartment, which will allow the ash to be distributed evenly across the compartments. This form of deposition reduces the extent of mechanical machinery required and negates the need for any further dust suppression measures, because the ash is transported in water.

5.4 The water for the slurry system will be taken from the lagoon, by pumps in the draw off tower. This will ensure that the system in the lagoon is hydraulically balanced and if a small daily deficit of water is incurred this will be made up from the incoming seepage of sea water around the lagoon's perimeter.

5.5 The ash will be deposited in the lagoon generally below water level, which will be about +1.25 mPD. Ash above this will be washed by rain water infiltration, and maintained in a moist condition by the capillary action of the ash.

Ash Harvesting System

5.6 The original proposal required harvesting of ash from both above sea level and below. This was to have been achieved by conventional construction equipment, such as backhoes, crawler cranes and lorries. This would have then been delivered to awaiting barges. This form of harvesting required strict moisture control of the ash to prevent it from developing into a dust nuisance.

5.7 The current proposals are to harvest the ash as a slurry, by means of a small dredger and pump it to awaiting barges at the East Wharf.

5.8 The dredger (Figure 5.1) is to be based on a commercially available small cutter suction dredger, which has successfully harvested ash from a number of power station lagoons in the USA (Figure 5.2). The dredger will be modified to harvest from the depths required, and achieve the desired harvesting rate of 2,000 m^3 (solids)/day.

5.9 The dredger is to propel itself, in a north-south direction, across the lagoon by means of a winching system along a steel hawser stretched between the two sides of the lagoon. This hawser will be moved on a rail system to provide full coverage within each compartment of the lagoon. The harvested ash will be conveyed in a closed pipe system across floating pontoons to the central dividing wall, just south of the draw-off tower. The pump on the dredger will be rated to be able to pump the slurry through a pipe along the dividing wall and perimeter road to the East Wharf to awaiting barges.

5.10 Harvesting operations are expected to take place for approximately 8 months in every two years. Which is consistent with the expected filling rate of the lagoon and the harvesting rate of the dredger. The dredger is too long to be lifted between the two compartments of the lagoon without being dismantled into various sections. Therefore there is to be a gap in the central dividing wall to allow the dredger to be floated between the two compartments when necessary. The platform along side this gap will serve as an access to the dredger when laid up along side the central dividing wall, and for mooring the attendant dingy for the dredger. Since the dredger will not be required at all times, and maintenance will be required, there is to be lifting gantry on the central dividing wall which can remove the dredger in sections from either compartment for repairs and storage.

5.11 The dredger will be powered by an electrical motor fitted with a noise inhibiting engine housing. The electrical power will be carried by cable along the pontoons for the ash slurry. When required the dredger will operate during daylight hours (7 am to 11 pm), but operations will be suspended during times of typhoons.

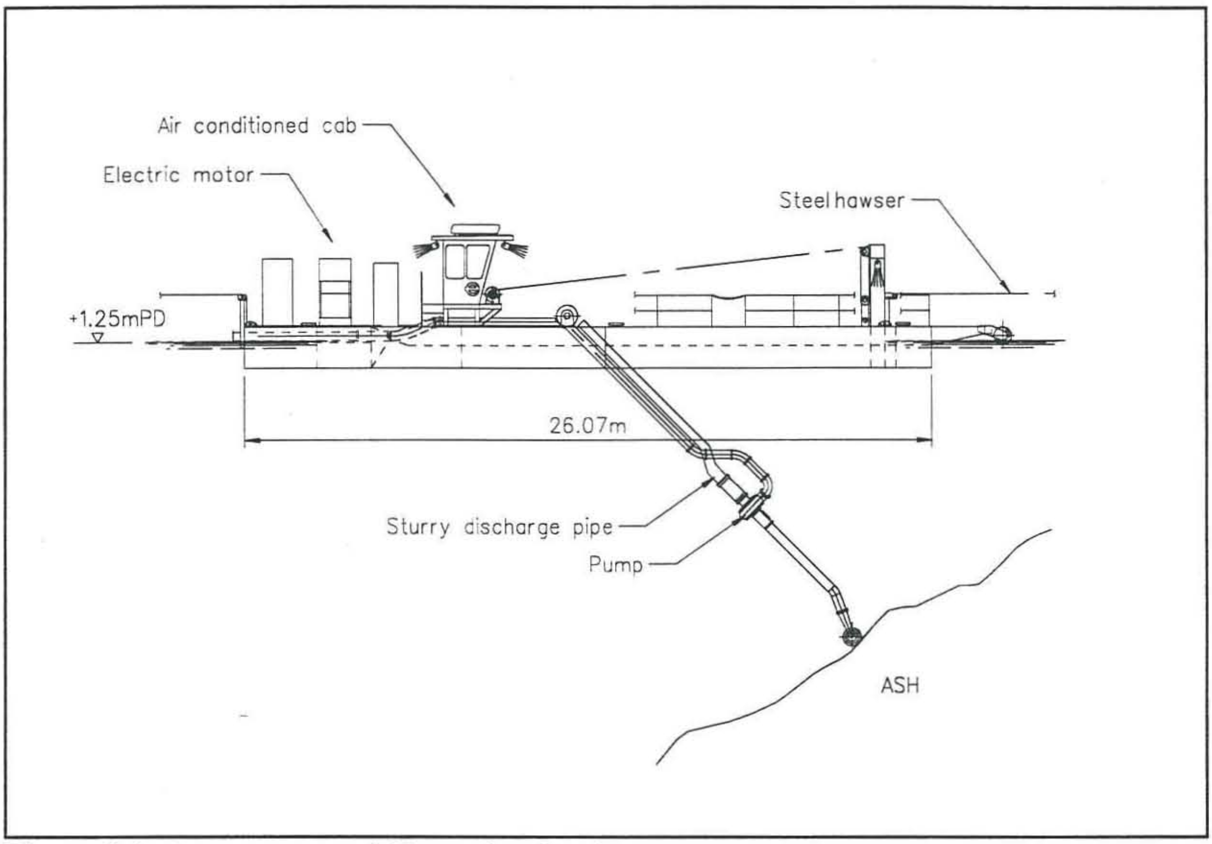


Figure 5.1 Arrangement of Harvesting Dredger

Figure 5.2 Small Dredger working on Ash Lagoon, USA

Ash Sluicing System

5.12 The original proposals required a designated area, at the western end of the lagoon, for the emergency sluicing requirement. This also necessitated the provision of machinery and pipe work for this specific task.

5.13 The emergency sluicing system for the current proposal will be an integral part of the main sluicing system for the deposition of ash in the lagoon. Thus no additional fixed equipment will be required over and above the normal operational equipment for the deposition of the ash.

Landscaping

5.14 The original operational proposals for the lagoon included the mounding of the ash to achieve the required volume. To mitigate the visual and potential dust problem associated with this mound, it was to be landscaped by a covering with 250 mm of top soil and planted on the eastern side of the mound.

5.15 In the current proposals the ash is not generally to be raised, for operational reasons, above the water level, which is well below the crest of the perimeter. Thus the ash will not be visible from the beaches, nor will the ash have to be covered to protect it from dust erosion. This reduced visual intrusion is thought to be a positive environmental advantage of the current proposals.

5.16 A visual impact assessment for this scheme has been prepared by Urbis Travers Morgan Limited, and is to be submitted separately.

Water Quality Control System

5.17 The perimeter of the lagoon has been designed to prevent ash particles from migrating across the perimeter and into the surrounding seawater. However various chemical can be dissolved from the surface of the particles. These may be carried by seepage through the perimeter which will be, to a certain extent, permeable. Since the deposited ash will itself reduce the permeability, the daily quantity of seepage will reduce over the life of the lagoon by an order of magnitude to about 1,300 m^3/day (Table 6.8).

5.18 The factors affecting the chemical composition of the lagoon water are numerous and subject to many inter-related processes. However, estimations of the water quality have been made on the basis of extremely conservative assumptions and the process of dispersal in Ha Mei Wan has been carried out using sophisticated mathematical modelling techniques with resolutions down to about 80 m. EPD agreed with the results of investigations for the EIA Stage III report and were satisfied with the expected sea water quality. The investigations for the current proposals follow the same reasoning for the determination of the expected sea water quality, and the results are as good as those for the original proposals (Section 6).

5.19 Notwithstanding these expectations, a positive means of controlling the water quality within the lagoon is advocated. To remain within the water quality criteria set within the Government's Technical Memorandum for Effluent Discharges, a quantity of lagoon water is to be discharged daily through the station's cooling water outfall to the West Lamma Channel. Again, based on various conservative assumptions, the quantity to be discharged is 20,000 m^3/day (Section 6).

5.20 The original proposals in the EIA Stage III report advocated that this discharge be achieved by pumping from a draw-off tower at the western end of the lagoon. This draw-off tower would accommodate six pumps capable of pumping this 20,000 m^3/day or the maximum storm water runoff. The current proposals include a similar draw-off tower. However, to permit draw off from both the compartments to the lagoon the draw-off tower is to be placed within the central dividing wall between the two compartments (Figure 5.3).

Floater Collection System

5.21 PFA has a collection of various size small particles, the majority of which are heavier than water. However a small portion are hollow spheres (floaters) which tend to float on water. If allowed to build up on the surface of the water they form a solid raft and the surface can dry out and blow with the wind. The current proposals for the prevention of this build up is a floater collection system, similar in many aspects to the proposals originally proposed in the EIA Stage III report. Within the draw-off tower a skimming device will draw off the floaters as a slurry. They will be separated on a rotating drum screen and bagged for disposal. Should the floaters fail to collect around the draw-off tower a floating boom will be provided to draw the floaters to the tower for collection.

Dust Suppression System

5.22 The previous proposals for the lagoon, included the mounding of the ash above the perimeter level of the lagoon and required a dust suppression system, to prevent ash from becoming windblown. This involved a network of mobile water sprinklers that would spray water from the lagoon when necessary to suppress the potential for ash being wind blown.

5.23 The current proposals will maintain the ash at a level generally below water level, well below the perimeter crest level to the lagoon, consequently it will not dry out or become wind blown. This aspect of the current proposals is thought to be a positive environmental advantage over the previous proposals.

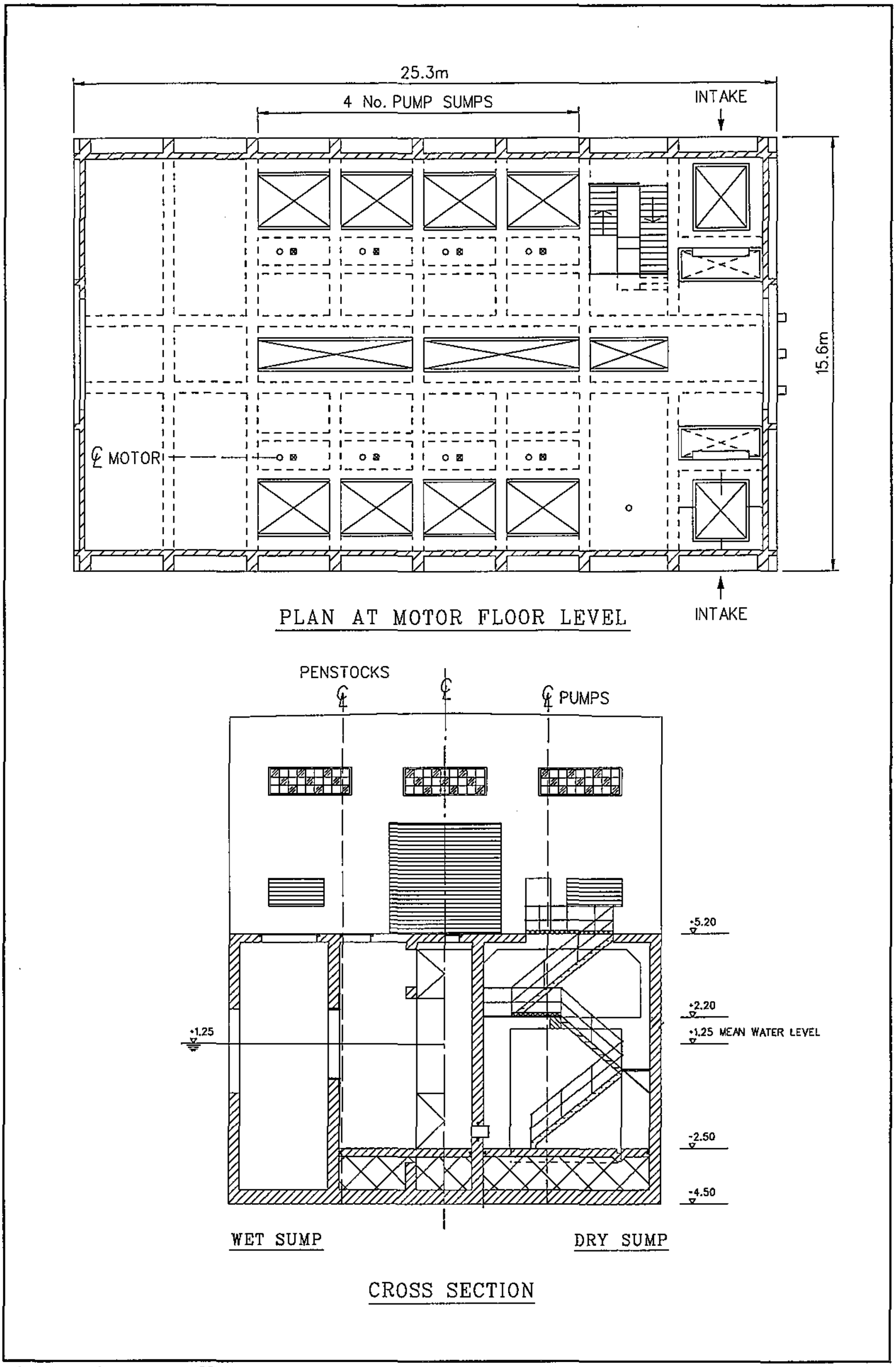


Figure 5.3 Draw-off Tower Arrangements

6 OPERATING EFFECTS

6.1 In the preparation of both the current and the previous proposals of the EIA Stage III report various measures have been incorporated to mitigate identified adverse impacts of the lagoon's operation, and to ensure that the predicted impacts fall within acceptable criteria. The current proposals, in some respects, are thought to considerably enhance the measures over those of the previous proposals. The effects are associated with:

(i) sea water quality;

(ii) marine biota;

(iii) dust;

(iv) noise;

(v) visual impact;

(vi) community reaction;

(vii) tourism.

Sea Water Quality

6.2 The estimation of the effects on the sea water quality are a combination of the studies of the characteristic seepage flows, through different perimeter sections, discharge flows from the draw-off tower, the leaching of determinands from the ash particulates, and the fate of solid particulates held in suspension. These various aspects are discussed in turn to derive the estimated water quality of both the water in the lagoon and the sea surrounding the lagoon in Ha Mei Wan bay.

6.3 The EIA Stage III report based the assessment of the seepage and water quality on the method of flownets, using steady state conditions. These estimates were then used in the assessment of the concentrations for various determinands, both inside and outside the lagoon. This method has been repeated for the current proposals with the caisson with revetment perimeter, to provide a comparison of the two schemes.

6.4 The current proposals require a more detailed knowledge of the operating water level within the lagoon, both through tidal cycles and through the life of the lagoon. The detail required has been provided by a transient finite element model of the various perimeter sections. In addition to this, the evaluation of the water quality has been repeated using the data for seepage derived from the transient finite element model. This evaluation follows the conservative procedures for the estimates using the steady state flownets.

Seepage Characteristics

6.5 The proposals for the original lagoon with an embankment perimeter had three different types of section through which it was presumed that seepage from the lagoon could reach the Ha Mei Wan bay: the embankment, the northern perimeter and the quay wall around the intake. The lengths of these perimeter sections are given in Table 6.1.

perimeter section for lagoon with embankment perimeter	effective length (m)
embankment	645
northern perimeter	400
quay wall	145

Table 6.1 Perimeter Sections - EIA Stage III

6.6 The current proposals for the perimeter to the lagoon also consist of three major cross section types, the caisson with revetment, the wharf detail on the eastern boundary to the lagoon and the existing platform to the power station (Table 6.2).

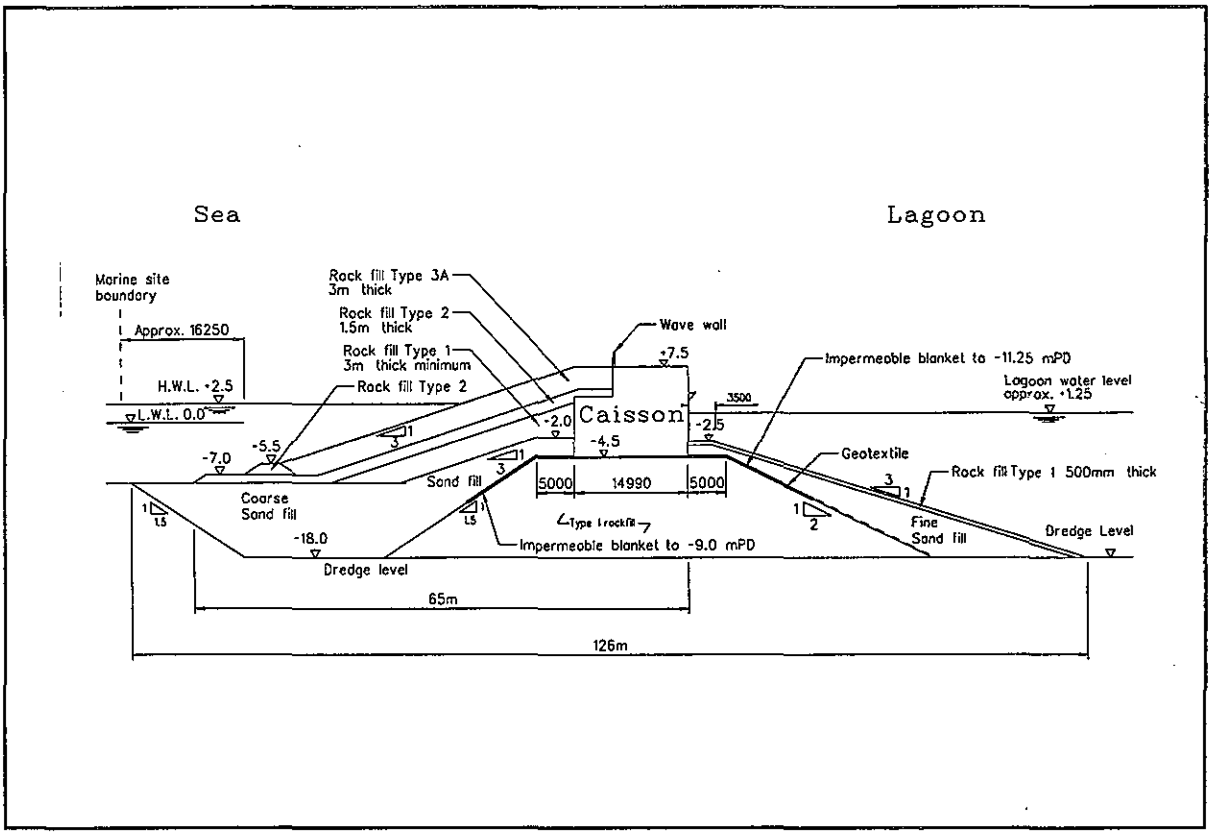


Figure 6.1 Revetment with Caissons Cross Section

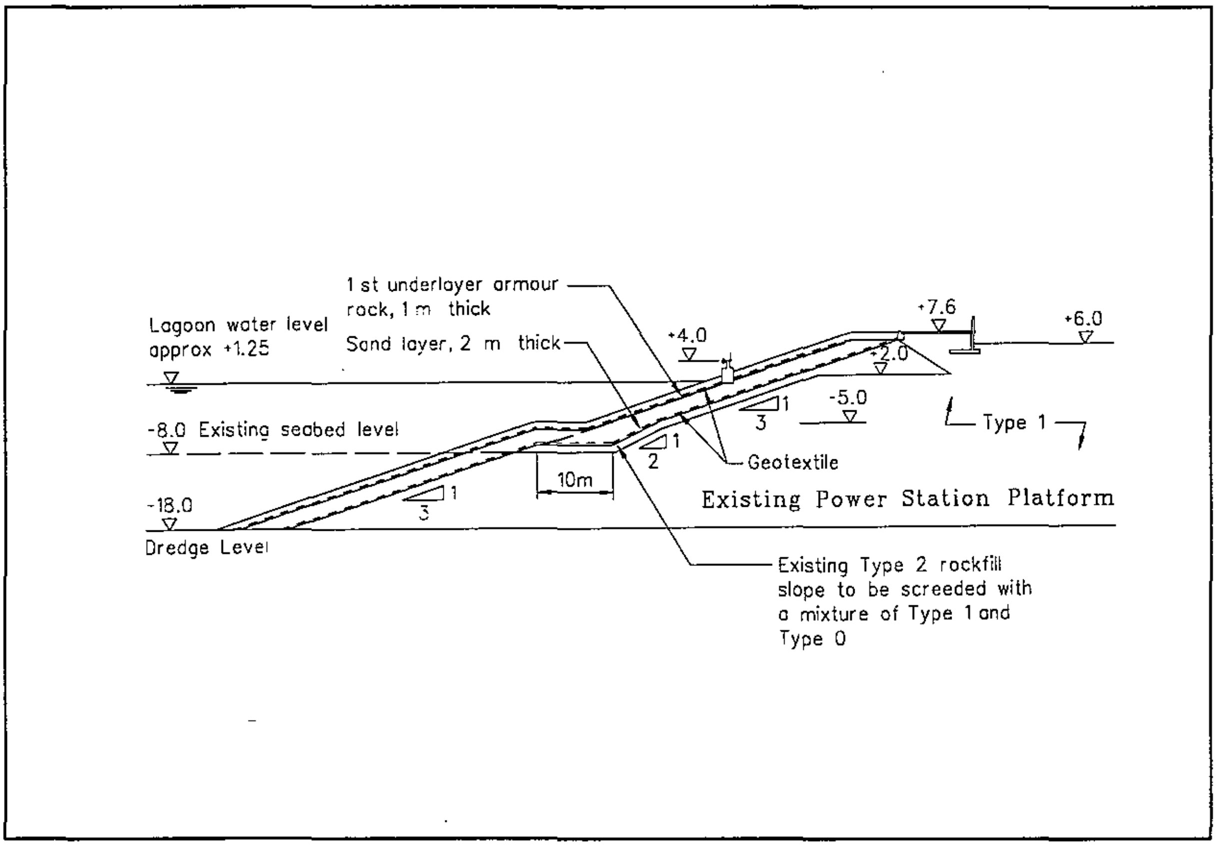


Figure 6.2 Northern Perimeter Cross Section

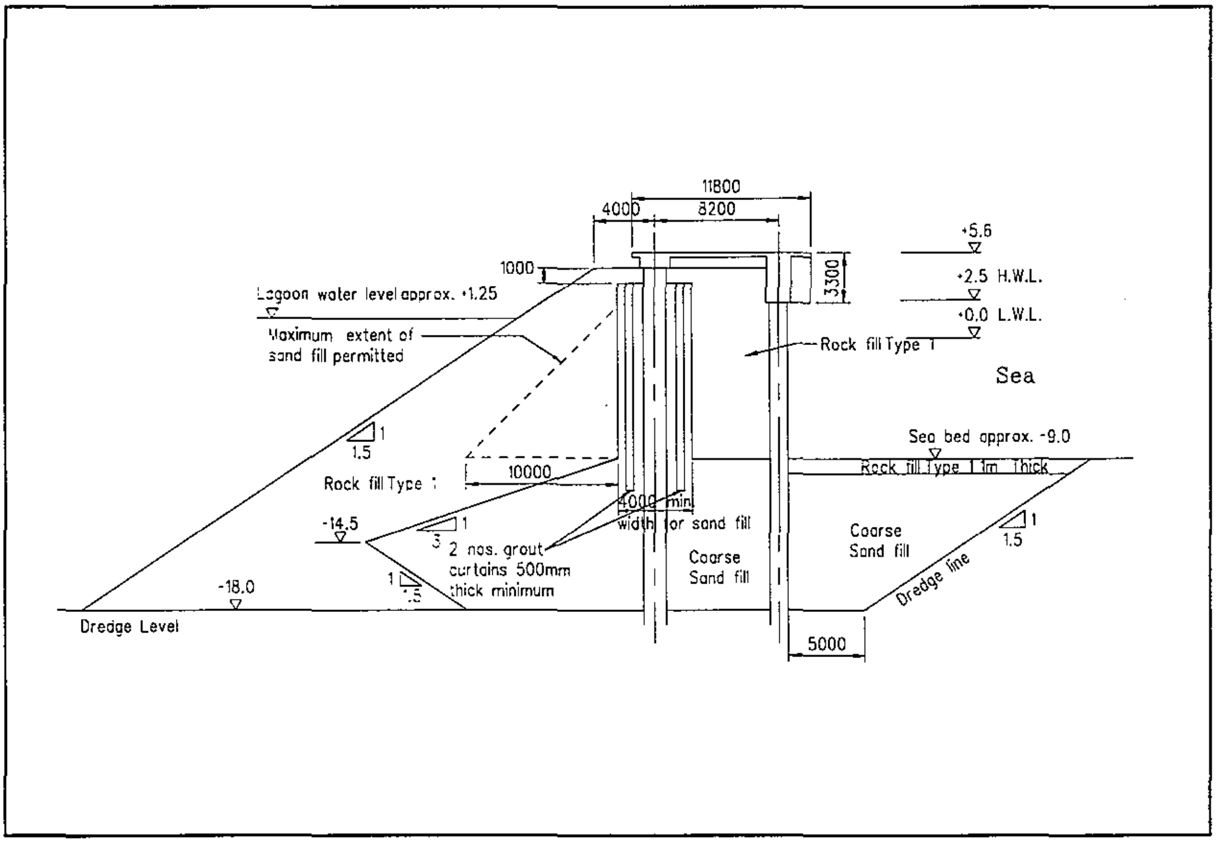


Figure 6.3 East Wharf Cross Section

perimeter section	section type	effective length (m)
revetment with caissons	Figure 6.1	520
northern perimeter station platform	Figure 6.2	290
Eastern Wharf section	Figure 6.3	160

Table 6.2 Perimeter Sections - Lagoon - Revetment with Caissons

6.7 The seepage characteristics of each of these sections have been assessed for the three stages of ash deposition in the lagoon, when there is no ash in the lagoon, when there is a 2 m layer of ash around the perimeter of each cell to the lagoon and when the cells are filled with ash.

6.8 The permeability for the various materials have been chosen to reflect an estimated reasonable upper bound value for their permeability once they have been placed (Table 6.3). The permeability of the in-situ alluvium is about a hundred times less permeable than the ash. Various assessments were made with the alluvium included, but the effect is very small and has been excluded from the analysis presented here. Also the permeability of the armour rockfill protecting the revetment is considerably higher than the other materials and has no effect on the seepage analysis.

Material	Permeability (m/s)	
	horizontal	vertical
ash	1.0×10^{-6}	1.0×10^{-6}
fine sand fill	5.0×10^{-5}	5.0×10^{-5}
coarse sand fill	1.0×10^{-4}	1.0×10^{-4}
quarry run rockfill	1.0×10^{-3}	1.0×10^{-3}
armour rock	infinite	infinite
in-situ alluvium	impermeable	impermeable

Table 6.3 Material Permeability Parameters for Analysis

6.9 The estimates of seepage through the different perimeter section for the lagoon with an embankment perimeter were carried out using flownets to derive steady state seepage flows. Similar estimates have been carried out for the perimeter sections for the current proposals for comparison. The northern perimeter form of section is the same as that original proposals. The two other perimeter sections, the revetment with caissons and the East Wharf have lower seepage flows than that of the embankment section.

6.10 Apart from these estimates for comparison of the two forms of perimeter construction, further calculations have been carried out to determine the behaviour of seepage flows through tidal cycles, to derive a more realistic evaluation of the seepage characteristic and thence the flux of heavy metals from the lagoon.

6.11 Two common forms of tidal cycle have been considered that of the spring cycle and that of the neap cycle. In each case spline curves have been fitted through the high and low tide values for Chi Ma Wan (Figure 6.4) (Appendix A). Chi Ma Wan is to the west of the site on the eastern shore of Lantau island, the tidal data is likely to be similar to that at the site, thus the results from the seepage analysis are thought to be appropriate.

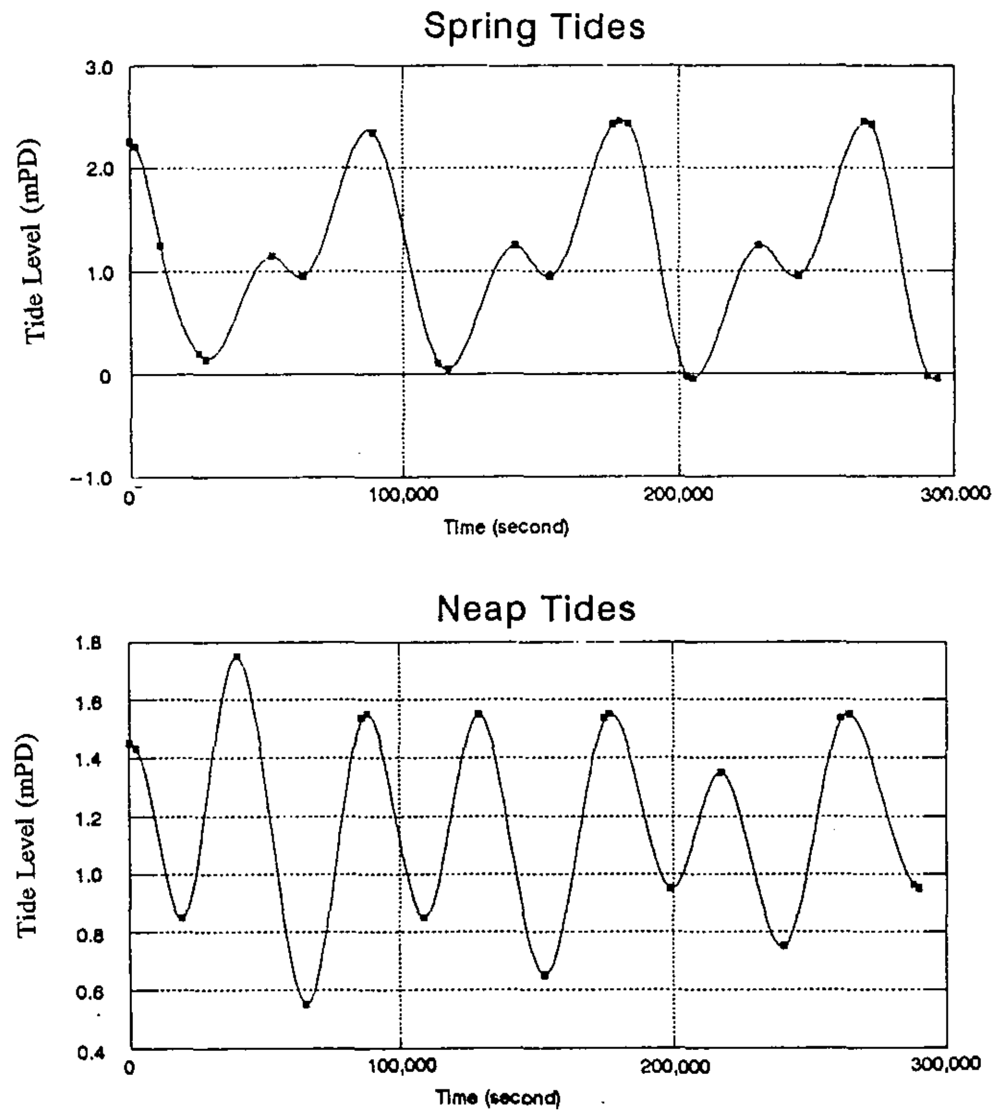


Figure 6.4 Tidal Cycles for Analysis

6.12 For each analysed section a representative area of lagoon has been associated with the perimeter to model the effect on the lagoon water level. Also, the storage functions for the materials have been estimated to make an allowance for the porewater storage as the water level falls and rises within each cycle (Appendix B).

6.13 The sections of the perimeter have been analyzed using the finite element programme SEEP/W. The effects of tidal variations have been modelled with calculations at discrete time intervals. The time step between the calculations is one hour, which forms a reasonable continuity between each step and prevents model instability.

6.14 Assessments have been made to establish the water level regime within the lagoon. The analysis demonstrates that upon completion of the lagoon, the lagoon water level will vary by approximately 470 mm through a tidal cycle (spring tide) about the mean sea level of +1.25 mPD. This variation reduces as ash is placed in the lagoon (Table 6.4) (Appendix G). Since the variation in water level within the lagoon is relatively small, the finite element analyses for seepage through different perimeter sections is based on the mean lagoon water level of +1.25 mPD. The analysis also assumes that the lagoon will be operated as a balanced system, with the quantity of decantrate discharged from the lagoon being matched by the equivalent quantity of ash slurry being introduced.

state of lagoon	variation in lagoon level with tidal cycle (mm)	
	spring tide	neap tide
no ash	470	249
full of ash	98	40

Table 6.4 Tidal Variation of Water Level in the Lagoon

Seepage through an Embankment Section

6.15 The flownets produced for the EIA Stage III report for the embankment section gave a seepage flow of 6.44 x 10^{-5} m^3/s for the condition of a 1 m water head difference between the lagoon and the sea (Figure 6.5). Also, once the inside of the lagoon had been lined with ash the estimated depth of seepage penetration on each tidal cycle was estimated to be about 1 m. These figures were used to derive estimates of seepage flows through tidal cycles and then used for the estimation of the water quality of the seepage to the Ha Mei Wan bay.

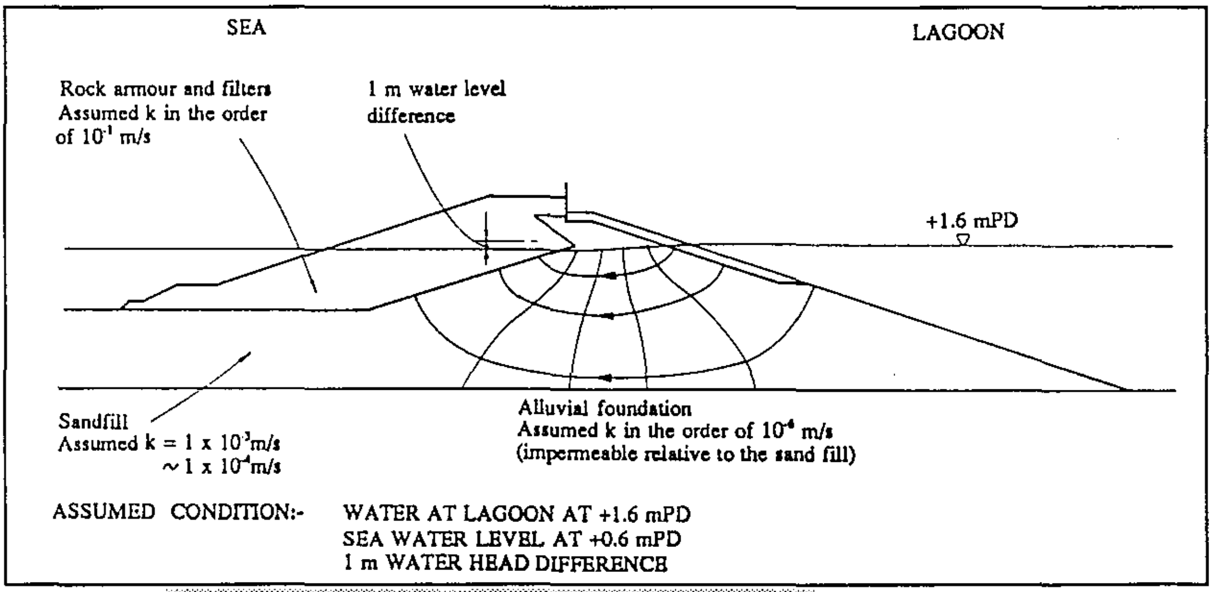


Figure 6.5 Seepage Through Embankment Perimeter Section

Seepage through a Revetment with Caisson Section

6.16 The revetment with caisson perimeter structure is the largest portion of the lagoon's perimeter. This forms the southern and western boundary to the lagoon. The proposed cross section includes several measures to limit and control the seepage through the perimeter. On either side of the rubble mound foundation to the caissons there is a sand blanket to reduce the flow of seepage. However this does not limit the seepage to the same extent as that for the embankment section proposed previously. To reduce the seepage further two impermeable blankets are to be placed on either side of the rubble mound, to part of the depth of the lagoon. Placing this form of impermeable blanket to the bottom of the lagoon at -18 mPD would effectively introduce a single barrier system, and the resulting reliance on a single system is considered to be unwise. Also the construction of a barrier of this type, with the suitable quality control, to this depth of water is thought to be impractical. The analysis demonstrates that the impermeable blankets should extend to - 9.0 mPD on the seaward side and to -11.25 mPD on the lagoon side of the rubble mound, to achieve the desired seepage criteria. These levels will be reviewed at the Detailed Design stage to determine whether the blanket can be extended further.

6.17 A flownet estimation of the seepage through the section with a one meter head difference demonstrates that the flow is 6.17×10^{-5} m^3/s (Figure 6.6). This is slightly less, per meter length of the perimeter, than the equivalent estimation for the embankment.

6.18 In each of the cases investigated minor boundary effects occur within the mathematical model, along the internal riprap blanket and at the upper levels on the seaward side of the caisson. Neither of these significantly affect the magnitude of the flux across the chosen boundary, the centre line of the caisson.

6.19 On completion of the lagoon's construction, the seepage flows are not impeded by the deposition of ash. In this state the hydrostatic drop occurs mainly in the two sand fill layers on either side of the rock mound foundation to the caissons (Appendix C). Once a two metre layer of ash has been placed around the lagoon, the seepage flows reduce considerably, and the majority of the hydrostatic head drops across the ash layer, due to its lower permeability. The calculated seepage does not appreciably reduce further by filling of the lagoon with ash.

Seepage through the Northern Perimeter Section

6.20 The proposed section for the northern perimeter is the same as that proposed in the EIA Stage III report. The high permeability of the platform rockfill, limits the effective distance over which the potential head drops, throughout the life of the lagoon. The flow in each of the cases studied is directly across the sand liner system. The estimation of the flows derived by flownets is taken from the EIA Stage III report.

6.21 The finite element model for this section (Appendix D) does produce minor mathematical inconsistencies due to the geometry of the model, but these effects can be ignored. Although the flow across the boundary does reduce considerably following the placement of 2 m of ash, the potential seepage flow does not reduce further with further placement of ash.

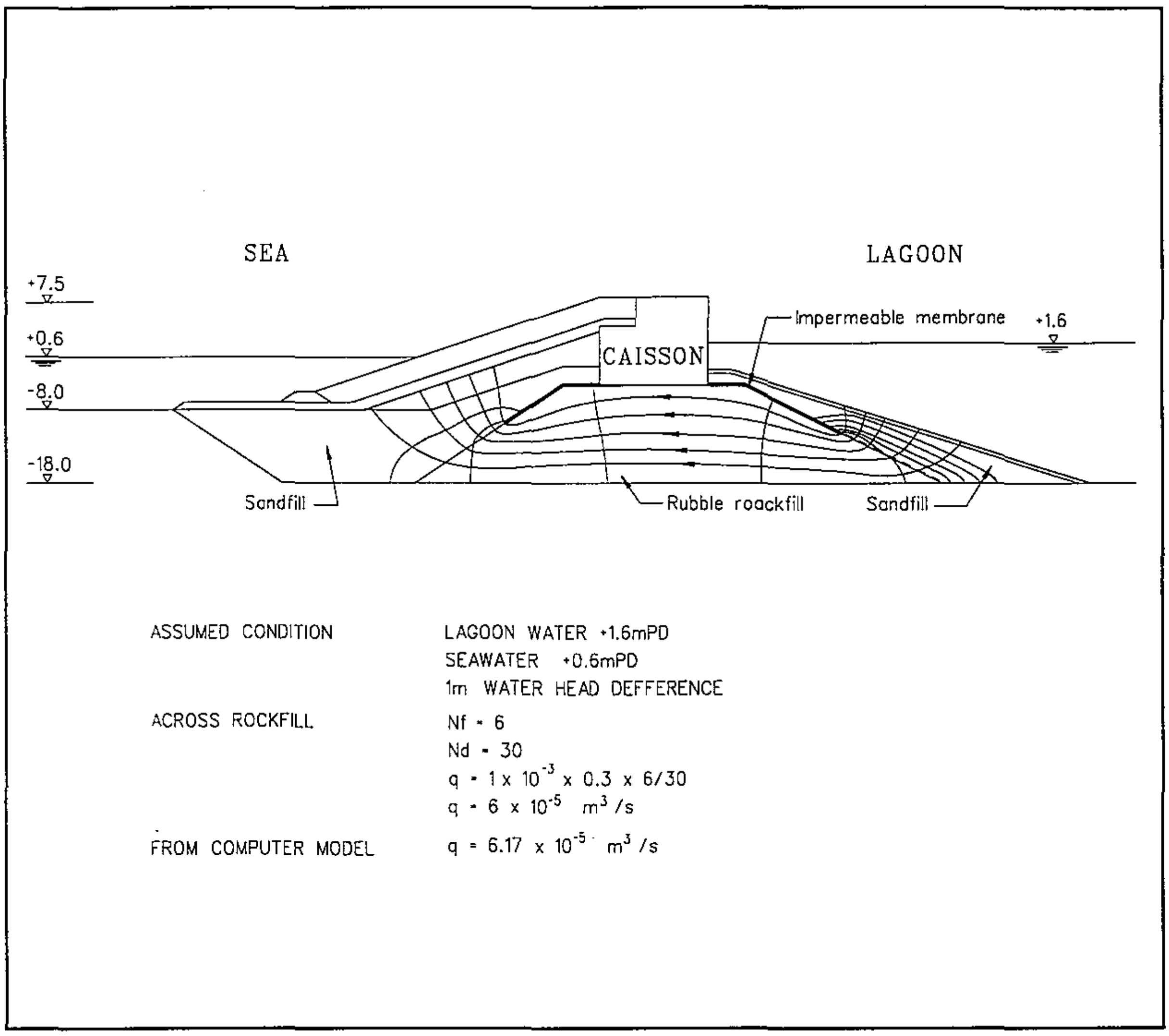
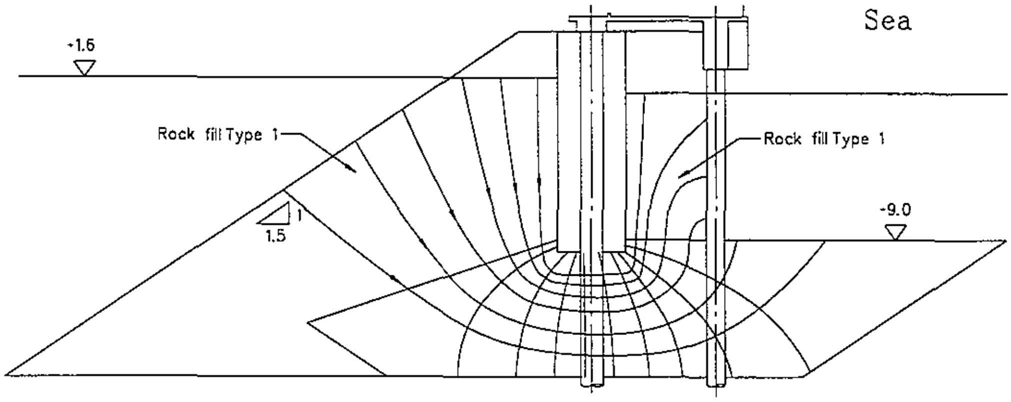


Figure 6.6 Seepage Through Revetment and Caisson Section

Seepage through the East Wharf Section

6.22 The low permeability barrier in the wharf section of the lagoon is formed by a 4 m wide sand barrier in the centre of the wharf construction and two continuous grout curtains on the outer edges of the sand fill. These grout curtains provide the dual function of reducing the permeability and holding the sand fill in place to prevent it from being washed out by tidal action through the rock fill on either side. This form reduces the seepage characteristics of the section to that of the caisson with revetment. Once a 2 m layer of ash is placed on the inside of the lagoon, little reduction of the seepage is achieved by increase filling of the lagoon (Appendix E).

6.23 A flownet for the section with a head difference consistent with the other sections demonstrates that the wharf section has a lower flow rate than that of the embankment section (Figure 6.7).



ASSUMED CONDITION — LAGOON WATER +1.6mPD
SEAWATER +0.6mPD
1m WATER HEAD DEFFERENCE

ACROSS SANDFILL — Nf = 7
Nd = 10

$q = k \times \Delta h \times \frac{Nf}{Nd}$

$q = 1 \times 10^{-4} \times 0.8 \times \frac{7}{10}$

$q = 5.6 \times 10^{-5}\ m^3/s$

FROM COMPUTER MODEL — $q = 5.80 \times 10^{-5}\ m^3/s$

Figure 6.7 Seepage through East Wharf Section

Seepage from the Lagoon

6.24 The results from the three forms of sections can be added together over their respective lengths to derive an overall seepage balance for the lagoon as a whole, at various stages of the lagoon's life. The inflows and outflows across the lagoon perimeter have been estimated for a 48 hour period with tidal cycles of both neap and spring tides, and the result halved to provide daily flows. This averaging of the calculated result overcomes some of the problems associated with establishing a stable regime.

6.25 For each of the tidal cases, the perimeter has been analysed using the finite element techniques at three different stages of ash deposition; when no ash has been deposited, with 2 m of ash around the perimeter and with the lagoon full of ash (Tables 6.5 to Table 6.7). The estimated seepage within the perimeter construction reduces by an order of magnitude following the deposition of 2 m of ash.

6.26 The gross outflow of seepage is that volume of water that crosses a boundary chosen for analysis. Much of this flow will flow back again into the lagoon on the change of tide. An estimation of the distance travelled by particular seepage water cross the perimeter section can be made based on the gross outflow volume and the area of the perimeter. In all cases the distance that the water might be expected to travel from the lagoon face across the perimeter section is likely to be less than a metre.

6.27 The estimation of water quality in the bay surrounding the lagoon assumes that the revetment provides no storage and that the gross seepage flowing out of the lagoon, and not the net flow, is dispersed in the bay. This approach is a worst case or a very conservative scenario.

Section	Spring tide	Neap tide
	gross outflow (m^3/day)	gross outflow (m^3/day)
revetment with caisson	961	528
northern perimeter	28,938	15,463
East Wharf section	278	151
TOTAL	30,177	16,142

Table 6.5 Seepage from Lagoon on Initial Completion

Section	Spring tide	Neap tide
	gross outflow (m^3/day)	gross outflow (m^3/day)
revetment with caisson	304	175
northern perimeter	1,559	991
wharf section	225	133
TOTAL	2,088	1,299

Table 6.6 Seepage from Lagoon with 2 m of Ash around Perimeter

Section	Spring tide	Neap tide
	gross outflow (m^3/day)	gross outflow (m^3/day)
revetment with caisson	220	148
northern perimeter	1,543	984
wharf section	219	131
TOTAL	1,982	1,263

Table 6.7 Seepage from Lagoon with Lagoon full of Ash

6.28 The seepage characteristics for the flows through the different stages of the lagoon's operation are similar to those estimated in the EIA Stage III report (Table 6.8). In the intermediate period, between the placing of the ash around the perimeter and when the lagoon is full of ash, does not show the same reduction of flow as was the case for the EIA Stage III report. This is because the estimation method in the EIA Stage III report was an approximation of the circumstances, not accounting fully for the tidal influences. The reduction, following the placement of 2m of ash, demonstrates that 2 m of ash around the perimeter provides an effective means of reducing the seepage flow.

Stage	Flow to Bay m^3/day				Seepage Quality
	EIA Stage III (flownets)	Current Proposal (flownets)	Current Proposal (FE)		
			(Spring)	(neap)	
no ash	62,294	45,583	30,177	16,142	lagoon water
2 m around perimeter	1,468	1,065	2,088	1,299	washed ash
full of ash	605	564	1,982	1,263	washed ash

Table 6.8 Estimation of flows to the Ha Mei Wan bay

Lagoon Water Quality Estimation

6.29 The water quality in the lagoon is dependant upon the extent of leaching of the metals from the ash deposited in the lagoon. For the EIA Stage III report various conservative estimates were made for both means of leaching and extent of leaching. The same conservative assumptions have been made for these investigations and are repeated here for completeness.

6.30 The extent of leaching of metals and other determinands from ash to water is a complex relationship of various processes and parameters, related to the chemical constituents of both the ash and the receiving water. Van der Sloot's work (1986) indicates that the degree of leaching is also dependent on the ratio of the volumes of ash and water with which it is mixed as well as the time of contact with the water. Van der Sloot studied 7 determinands in detail, or five of the thirteen defined as toxic metals in the Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (TM). Environment Canada (1986) collected data on ash leachate quality from around the world. The water quality in these leachates varied considerably, which were concluded to be due to differences in water quality, proportions of mixing, the length of time for mixing and the ash constituents. These conclusions are in agreement with Van der Sloot's work. Environment Canada did not attempt to separate or quantify the various effects (unlike Van der Sloot) but presented the ranges that have been found to exist in all the variations.

6.31 Various studies have been carried out into the effect of time on the extent of leaching. Environment Canada reported on work by Reed et al 1976, Talbet et al 1978 and others. The data from both laboratory and field studies indicate that most leaching occurs within one hour of contact with water, except for Potassium and Magnesium where leaching may continue for several days. The data presented by Van der Sloot concurs with this for the determinands studied, except those of Selenium and Molybdenum, this is particularly pronounced with a neutral ash in seawater.

6.32 The majority of the ash will be placed below water level and will be mixed directly with the lagoon seawater. Various determinands will be leached out and then dispersed throughout the lagoon water. Van der Sloot describes methods of estimating the resulting concentrations of the determinands studied, accounting for the various means of deposition, i.e. dumping from barges, sluicing into lagoons, and placing dry into lagoons.

6.33 An estimation of the concentrations based on the Van der Sloot recommendations is given in column C of Table 6.9. However, where these are exceeded by the world data presented by Environment Canada (column D), the latter concentrations are used in the analysis. The world data exceeds all the estimates given by Van der Sloot; only the Molybdenum concentration is retained, because Environment Canada does not present data for this element. In order to investigate the sensitivity of the Van der Sloot analysis, the figures are reworked in columns (G) to (J) for a dilution in 20 parts of seawater. Again the estimate is governed by the maximum values of the Environment Canada work, except for Molybdenum as before.

6.34 The lagoon water quality will be established in much the same way as that for the CLP ash lagoon at Tsang Tsui, the concentrations for a number of elements are presented for comparison in column (K). None of the parameters investigated exceed the estimate given in column (E, E_2, E_3).

6.35 The processes forming the leachate from the quarry trial at Sok Kwu Wan are not directly comparable, but the maximum concentrations in any sample are presented in column (F). Although the estimated concentrations are exceeded for Antimony, Cadmium, Chromium, Lead, Mercury and Molybdenum, usually by small margins, the total metal and the total toxic metal concentration is less than the estimate (column E).

6.36 The foregoing indicates that the estimate of concentrations for the water quality (column E) on initial contact with lagoon water is probably realistic, and for the lagoon water as a whole it will be conservative.

6.37 Once the lagoon has been lined with PFA, the seepage flow across the lagoon boundary will be much reduced (Table 6.8); the only seepage will be the marine waters carried into a limited depth of ash at the perimeter by the flood tide which will be flushed out on the ebb tide. Thus further leaching, and flux to marine waters, can occur only through this mechanism. Although leaching will already have occurred due to the method of placing, the analysis presented here presumes that the ash is fresh and no determinands have been leached. The porosity of placed ash will probably be of the order of 0.25, giving a solids volume to pore ratio of 3:1.

6.38 The contact time for the marine water is a maximum of only one tidal cycle, i.e. 12 hours. For the purpose of this analysis a conservative contact time of 50 hours and an ash to water ratio of 1:1 has been taken, because this corresponds with research done by Van der Sloot. The estimated water quality of the seepage can be estimated in the same way as for the lagoon water. By the same reasoning as has been described for the lagoon water, the quality can be taken as column (E), which is conservative.

pH in the Lagoon

6.39 Monitoring results from the existing ash settlement basins give a general indication of the behaviour of PFA in sea water. Values of pH measured to date, typically range from approximately 7.0 to 8.5. The seawater in the ash lagoon will probably behave in a similar manner and hence pH will not be a critical parameter needing to be controlled.

6.40 During the initial period of lagoon filling, the ash to water ratio will be low and any changes in pH which do occur will be gradual. Routine monitoring of lagoon water quality will detect changes in pH at an early stage and enable control procedures, if necessary, to be developed. However, such measures are not expected to be necessary.

Decantrate Water Quality

6.41 The EIA Stage III proposed that the water quality in the lagoon be maintained by the daily discharge of water through the draw-off tower to the power station's cooling water outfall. This would carry the discharge to the relatively deep West Lamma Channel. The daily flow was based on an estimate of the daily exchange of water required to maintain an acceptable water quality, expressed as an elevation of the Total Toxic Metals. The criterion was that the lagoon water should not exceed an elevation of 0.1 mg/l above the ambient.

6.42 The same philosophy and criteria is adopted for the current proposals. The daily discharge was based on the rate at which the ash would be deposited in the lagoon. This rate of deposition is unchanged for the current proposals (700 m^3/day), thus the required daily rate of discharge from the draw-off tower to the cooling water outfall remains the same.

Dispersion in Ha Mei Wan

6.43 For the EIA Stage III report a rational, and conservative, approach was adopted to derive the maximum likely effects of the lagoon filling operations on the seawater quality, and how this quality might vary around the Ha Mei Wan bay under the influence of the circulating currents. Under the worst circumstances the elevation of the metals content in the water immediately around the lagoon (less than 100 m) is probably 5 μg/l although the upper bounds of all variables is 15 μg/l, even though some of these variables are mutually exclusive. These metals would dissipate to much lower concentrations with increasing distance from the lagoon. PFA does not contain organic chemicals thus there would be none of the effects associated with these forms of chemical. EPD agreed with the procedure and results of these investigations, and were satisfied with the expected quality of the bathing water.

6.44 The same approach to the estimation of water quality in the Ha Mei Wan bay has been used for the preparation of the current proposals for the lagoon. These procedures are repeated for completeness along with the results of the investigations.

6.45 Between the ash in the lagoon and open marine waters there are to be graded sand filter layers and quarry run rockfill foundations, which will promote ion exchange, chemisorption, precipitation, adsorption and microbiological processes. All of these will attenuate the concentrations of determinands in the seepage, prior to any dispersion in Ha Mei Wan bay. Quantification of the effects is not attempted and are ignored in order to provide a conservative assessment of the water quality in the bay.

6.46 The hydrodynamic model for the dispersion effects of determinands within the bay (Binnie & Partners, September 1990, also included with EIA Stage III report) used conservative estimates of the seepage and concentrations in the seepage water. The model is a linear dispersion model, assuming no decay of the determinands and can be used to investigate the sensitivity of the results, to changes in the daily load of determinands and seepage flows. The model used a daily load of 14.46 kg of heavy metals and a concentration of metals in the seepage of 0.23 mg/l, this corresponds to a seepage flow of 62,870 m^3/day. The least dispersion occurs during neap tides where the model's determinand load disperses to less than 5 μg/l within a maximum of 170 m and an average of less than 85 m. These figures are updated in the following section.

6.47 Although, for operational reasons, there is likely to be a net daily inflow to the lagoon, throughout the life of the lagoon, there will be an exchange of the water in the perimeter's foundation. This exchange flow will be less than the estimated gross outflow from the lagoon (Section 2).

6.48 The estimation of determinand load has been based on a rate of depositing ash in the lagoon at 700 m^3/day. Before the perimeter has a lining of ash, all the soluble fractions are presumed to cross the perimeter each day, with a load of 14.46 kg total metals, within which is 2.17 kg of Total Toxic Metals (TM). In Table 6.10, the metal concentrations for the period before the perimeter has been lined with 2 m of ash, are based upon the total load of metals per day to be deposited in the lagoon.

6.49 Throughout the operation of the lagoon, there will probably be a net inflow of seawater into the lagoon to provide the necessary water for the decantrate pumping mechanism, but for the purposes of a conservative estimation, the gross outflow given in Table 6.8 is used for the estimation of the load to the bay. Although the ash will have been washed on initial placing in the lagoon, the determinand concentration in the seepage is presumed to be that of freshly deposited ash, ie the concentration of heavy metals within the flow is assumed to be 20.668 ppm, with 3.148 ppm being Total Toxic Metals (TM), (column E Table 6.9).

6.50 These estimates of the large potential rise in concentrations are likely to be higher than the figure actually achieved in the sea due to the number of conservative assumptions that have been made, particularly those of concentrations for the case when the lagoon has been lined with 2 m of ash, which will greatly reduce the permeability of the lagoon's perimeter.

6.51 The estimated average elevation for an estimated load of Total Metals of 14.46 kg/day is less than 5μg/l at the edge of the 85 m grid (refer to the EIA Stage III Report, BCL January 1993) and using these figures the gradient of the metals elevation can be calculated. The dispersion of the metals is assumed to be linear.

$$\text{Concentration gradient} = 5\ (\mu g/l)\ /\ 14.46\ (kg/day) = 0.345 \times 10^{-9}\ (days/litre)$$

Total Metals Elevation = Concentration gradient x metal load

Total Toxic Metals = 3.15 ppm / 20.67 ppm
Elevation ≃ 15 % of Total Metals

ash deposition	Tide	estimated gross outflow m³/day (1)	estimated load of total metals (kg/day)	estimated average elevated concentration Metals (μg/l) at 85 m from lagoon	
				Total Metals	Total Toxic Metals
EIA Stage III - flownet estimation					
no ash in the lagoon		62,294	14.46	<5	<0.7
2m ash around perimeter		1,468	33.1	<15	<2.1
full of ash		605	12.5	4.3	0.6
Current Proposal - flownet estimation					
no ash in the lagoon		45,583	14.46	<5	<0.7
2m ash around perimeter		1,065	22.0	7.6	1.1
full of ash		564	11.7	4.0	0.6
Current Proposal - finite element analysis					
no ash in the lagoon	neap	16,142	14.46	< 5.0	< 0.7
	spring	30,177	14.46	< 5.0	< 0.7
full of ash	neap	1,263	26.11	9.0	1.4
	spring	1,982	40.97	14.1	2.1

Note: (1) refer to Table 6.8

Table 6.10 Estimation of Determinand Concentrations at 85 m from the Lagoon

Marine Biota

6.52 Although some marine biota are in food chains that lead eventually to humans and are to a certain extent bio-accumulators of metals, there was not expected to be a significant increase in the metal content of these species, for the proposals in the EIA Stage III report nor is there expected to be for the current proposals.

Containment of Suspended Solids

6.53 The criterion for TSS (Total Suspended Solids) for effluent set in the TM is 30 ppm for discharges to inshore waters in the area of Lamma. There are two processes that might be considered to be effluent derived from the lagoon water, firstly seepage water that permeates the lagoon perimeter, and secondly the decantrate water that is to be discharged to the cooling water outfall.

6.54 The loss of solids through the perimeter is to be prevented by the design of the sand fill around the inside of the lagoon perimeter. The grading of the particles in the sand fill is to be specified such that the particles cannot migrate across the perimeter sections. This constitutes the same proposal for confinement of ash solids as in the EIA Stage III report.

6.55 Suspended solids in the lagoon water will derive from the action of depositing PFA in the lagoon and from the occasional emergency sluicing of FBA. A similar process currently occurs in the ash settlement basins of the existing station, although they differ in important respects:

(i) the size of the lagoon will initially be considerably larger than the ash settlement basins, although this discrepancy will diminish with time. Also the detention time will be longer in the lagoon, thus there will be considerably longer time in the lagoon for the solids to settle out;

(ii) the extraction of decantrate need not be continuous in the lagoon and the power station operations would not be affected by detaining the decantrate for extended periods on occasions. In the event of high TSS the decantrate pumping could be suspended until the TSS reduced;

(iii) the water in the lagoon is essentially quiescent in comparison to that in the ash settlement basins, thus the lagoon water will have less capacity to sustain suspended solids;

(iv) the operation of the two weir penstocks on the decantrate tower will skim off only the top of the water profile in the lagoon which will have the least TSS of the profile;

(v) although the ash settlement basins are intended primarily for the extraction of FBA, which has a higher course material content than PFA, the TSS in the ash settlement basins is mainly determined by the fines content.

6.56 Given the current performance of the ash settlement basin, the TSS in the lagoon is expected to be comparable, or better. In the early stages of the lagoon operation the performance might be expected to be considerably better, and fall within the criterion that would permit the pumping of decantrate. Any deterioration in the performance of the lagoon with respect to TSS will be gradual as the volume of water in the lagoon decreases. This will allow sufficient time for alterations in the operating practice should this be required. Early operational experience will determine whether or not procedures would have to be altered to comply with the criteria in the later stages of lagoon operations.

Dust

6.57 The operational proposals and control procedures for filling and harvesting PFA have been drawn up with particular attention to the concerns associated with the generation of dust. The measures to be incorporated into the lagoon's operation should prevent a dust nuisance from arising.

6.58 The ash is to be placed generally below water level by means of sluicing with water, this is considered to reduce the potential for dust emission significantly, over the proposals of the previous scheme.

Noise

6.59 The original proposals in the EIA Stage III report for the operation of the lagoon required a number of different items of mechanical plant for transporting the ash to the lagoon, placing it, and harvesting it. These different items included: conveyor belts, a bulldozer, a vibratory compactor, a loader and lorries. The noise associated with this equipment was assessed, whilst taking a number of conservative assumptions, in line with methods laid down in Government Technical Memoranda. The resulting noise (Table 6.11) from the operations is expected to be within the Government criteria for day-time operations (Technical Memorandum on Noise) in an area that is designated as having the highest sensitivity to noise. However, operations would not be carried out at night because the estimated CNL exceeds the night-time noise limit.

Equipment	Noise [dB(A)]							TSPL(1)	CNL(2) for NSR
3 conveyors	90 >						)		
	90 >	93 >					)		
	90 >		>115 >				)		
1 bulldozer	115 >	115 >	>	>			)		
1 Vibratory compactor	105 >			>119	>		)		
1 Loader	112 >	113 >	>	>	>		)	120 dB(A)	$120-65^{(3)}-5^{(4)}+3^{(5)} = 53$
3 Lorries	112 >		>117 >		>		)		
	112 >	115 >			>	120	)		
	112 >				>		)		
1 Pump (electrical)	88 >	112 >	112 >	112	>		)		

Notes:
(1) Total Sound Power Level
(2) Corrected Noise Level
(3) Correction factor for noise attenuation
(4) Negative correction factor for partial screening
(5) Positive correction factor for being a building

Table 6.11 Noise Levels - Embankment Lagoon - Operating Systems

6.60 The mechanical equipment required for the operation of the lagoon with the current proposals has been greatly simplified. The lagoon operations only require pumps for the operation of the ash transportation system, the decantrate system and the harvesting system. The largest pump in the system is likely to be that associated with the dredger, which is to have a capacity of about 180 l/s. The other pumps are to be within control and pump houses, and are expected to exhibit negligible noise outside these buildings. The pump and motors for the harvesting system are to be electric and submersible. The noise rating for this is expected to be about 85 dB(A) at a distance of 1 m, thus the consequent noise at the NSR will is not expected to exceed 18 dB(A), which is well within the noise limits.

Visual Impact

6.61 The form of the lagoon, with a revetment perimeter, has been devised to be compatible with the existing power station platform, and the operations within the lagoon will be below the level of the perimeter crest. The extent of the operations within the lagoon will be limited to the use of a small dredger, considerably less mechanical plant than in the previous proposal. The operations will be hidden from those views with aspects from the beaches on Ha Mei Wan, and are not expected to be intrusive from elsewhere.

6.62 A visual impact assessment has been prepared by Urbis Travers Morgan Limited and is submitted separately.

Community Reaction

6.63 The ash management exhibition held on Lamma Island in October 1989 appeared to have allayed local concerns with respect to the operation of a 1.5 Mm^3 lagoon with an embankment perimeter. The current proposals will have a revetment around much of the lagoon, and the operations associated with the current proposals are considerably less intrusive to the local population than previously. Therefore significant community reaction to the current proposals for the lagoon is not expected.

Tourism

6.64 Lagoon operations will have no physical effect on the local tourist facilities (the beaches and restaurants) thus no significant effect on tourism is expected.

Employment Opportunity

6.65 The lagoon operations for the proposals in the EIA Stage III report may have afforded some local employment opportunity, principally in connection with the implementation and maintenance of the landscaping works. However, the opportunity would not be great, comprising only a few additional labourers working under the direction of the existing station supervisor. There is likely to be less opportunity for local employment with the current scheme because the operations have low labour requirements, and those that would be available are for specialist operators, such as for the small dredger.

			A	B	B2	C	C2	D	E	E2
			Concentration in Tatung Coal PFA	% released when placed in lagoon (1:1 dilution)	% released when placed in lagoon (1:1 dilution)	Estimated release from 1:1 dilution (A) x (B)	Estimated release from 1:1 dilution (A) x (B2)	Alternative estimate of concentration	Concentration used for Estimation	Higher value of (C2) or (D)
Element	TM	Symbol	(ppm)	Neutral Ash in Seawater	Alkaline Ash in Seawater	Neutral Ash (ppm)	Alkaline Ash (ppm)	(ppm)	(ppm)	(ppm)
Antimony	*	Sb	8	2.5	0.02	0.2	0.0016	<0.1 - 0.2	0.2	0.2
Arsenic	*	As	40	0.04	0.4	0.016	0.016	<0.002 - 0.03	0.03	0.03
Boron		B	98	-		-		4 - 8.2	8.2	8.2
Cadmium	*	Cd	2	-		-		<0.001 - 0.037	0.037	0.037
Chromium	*	Cr	-	1.1	1.3	-		0.02 - 0.98	0.98	0.98
Copper	*	Cu	10	-		-		<0.01 - 0.31	0.31	0.31
Iron		Fe	-	-		-		<0.05 - 1.93	1.93	1.93
Lead	*	Pb	10	-		-		<0.01 - 0.06	0.06	0.06
Mercury	*	Hg	4	-		-		<0.0002-0.001	0.001	0.001
Manganese		Mn	-	-		-		<0.01 - 0.48	0.48	0.48
Molybdenum		Mo	30	18	4	5.4	1.2	-	5.4	1.2
Selenium	*	Se	10	10	0.33	1	0.03	0.002 - 0.058	1	0.058
Vanadium	*	V	80	0.66	0.001	0.53	0.0008	0.1 - 0.5	0.53	0.5
Zinc		Zn	80	-		-		0.02 - 1.51	1.51	1.51
								Total Metals	20.668	15.496
								Total Toxic Metals	3.148	2.176

(A) Tatung coal is commonly used at the Lamma Power Station
(B) From H.A. van der Sloot et al,1986
(D) From Report EPS 3/PG/5, Environment Canada, May 1986

* Those metals listed as Toxic in the TM
\- no data available
(1) with permission of China Light & Power Co. Ltd

			F	G	H	I	E3	J	K
			Quarry trial Highest Concentration in any sample	% released from 1:20 dilution (Alkaline Ash)	Estimated release from 1:20 dilution (A) x (G)	Concentration in 1:20 release water (H) / 20	Concentration usable for estimate 1:20	Estimated release per tonne of PFA (1:20) dilution	Max recorded in Tsang Tsui[1] Lagoon Jan 88 to Sep 88
Element	TM	Symbol	(ppm)		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Antimony	*	Sb	0.9	16	1.28	0.64	0.2	1.28	
Arsenic	*	As	<0.0005	0.43	0.172	0.0086	0.03	0.172	0.0061
Boron		B	7.6				8.2	8.2	
Cadmium	*	Cd	0.05				0.037	0.037	0.00043
Chromium	*	Cr	1.2	6.2			0.98	0.98	
Copper	*	Cu	0.03				0.31	0.31	0.0076
Iron		Fe	0.4				1.93	1.93	
Lead	*	Pb	0.3				0.06	0.06	0.0071
Mercury	*	Hg	0.05				0.001	0.001	
Manganese		Mn	0.19				0.48	0.48	
Molybdenum		Mo	5.5	9.6	2.88	0.144	0.144	2.88	
Selenium	*	Se	0.015	13	1.3	0.065	1	1.3	0.54
Vanadium	*	V	0.53	0.13	0.104	0.0052	0.5	0.104	
Zinc		Zn	0.06				1.51	1.51	0.035
Total Metals			16.83				15.382	19.244	g / tonne
Total Toxic Metals			3.075				3.118	4.244	g / tonne

Table 6.9 Lagoon Water Quality Estimation

7 OPERATING ENVIRONMENTAL MONITORING AND AUDIT

7.1 There will be two Environmental Monitoring and Audit procedures for the project, one for the construction phase and one for the operational phase. In both cases the procedures will be discussed and agreed with EPD. The current proposals for the environmental monitoring and audit for the operation of the lagoon are the same as those for the previous proposals for the operation of a lagoon with an embankment perimeter. Although the function of the lagoon has changed in particular aspects, many of the operations are similar and the objectives of environmental audit and control remain valid.

Environmental Audit

7.2 The environmental audit system will methodically check the lagoon's activities, its effect on the local environment and provide a framework for the monitoring and control procedures. The procedures will note those activities that are within the pre-defined environmental criteria, highlight those that transgress criteria, and institute control procedures or remedial measures when required. The audit reports will reassure HEC management and regulatory agencies that the lagoon is being operated in an environmentally acceptable manner. The process will also permit a post project analysis to be carried out to examine the accuracy of the original environmental impact assessment. Following the cessation of the filling operations the regular audits will continue until the impacts are stable or are steadily reducing, at which point an appraisal of the environmental impact assessment can be carried out.

7.3 Environmental audit reports will be produced regularly throughout the operating life of the lagoon. In the first year of operation there will be two audit reports and they will be produced annually thereafter. This frequency will be reviewed and revised as necessary as part of the audit process. The scope of the audit will cover the following:

(i) the quality of sampling and analytical procedures associated with the monitoring;

(ii) consider factors that may influence monitoring results, such as tidal seasonal or local weather effects;

(iii) ascertain whether other factors, such as construction activities nearby, have influenced monitoring results;

(iv) identify the operations within the lagoon which were concurrent with sampling e.g. harvesting or sluicing of PFA;

(v) whilst considering the foregoing, identify those environmental impacts that are within or outside the defined criteria;

(vi) recommend measures or control procedures to mitigate those impacts that fall outside the criteria, and identify trends which may eventually transgress criteria if measures are not taken;

(vii) review impacts that cannot be quantified, such as visual impact;

(viii) review public complaints or reactions relating to the lagoon operations. If appropriate, recommend actions which could be implemented;

(ix) review and revise if necessary the monitoring procedures;

(x) revise the scope and frequency of the environmental audit to reflect changes in impacts and lagoon operating procedures;

(xi) carry out an analysis to compare the predicted impacts with the actual impacts, and to comment on any discrepancies.

Environmental Monitoring

7.4 The environmental effects associated with lagoon operations will be measured whenever possible by quantifiable scientific methods, to Government standards where appropriate. The results can then be compared with the predefined environmental criteria.

7.5 The seawater quality will be measured both inside and outside the lagoon, in accordance with the procedures set out in the Technical Memorandum on Effluent Standards. Initially samples will be taken at monthly interval from four sites, two inside the lagoon, one adjacent to the eastern end of the lagoon and the fourth in the West Lamma Channel for reference (Figure 7.1). Following the first year of operation the monitoring may be modified in light of experience and the sampling period extended to two months.

7.6 Shrimps will also be caught in Ha Mei Wan to measure the effects on marine biota. Shrimps will be caught at 3 month intervals both before operations commence and during the first year of operations. The samples will be analysed for their heavy metal content and the results compared with the Government guidelines for acceptable metal levels in sea food [Food Adulteration (Metallic Contamination) Regulations Cap 132 Section 55(1)]. During preparations for the Environmental Monitoring and Audit programme, there will be discussions with EPD on the use and applicability of other bio-indicators in addition.

7.7 Dust will be monitored using HEC's two existing high volume air samplers, one at the east gate and the other on top of Reservoir road. These instruments draw approximately 1.5 m^3/min through a filter to collect airborne particulates. The particulates can be weighed and if necessary microscopically examined to determine whether any PFA is present in the air. The measurements will be taken in accordance with USEPA Standard Method 40, CFR Part 50 Appendix B. The samplers will be indicative of the air borne dust in the area as a whole and will not be able to measure that of the lagoon operations in isolation. However previous monitoring will indicate background variation and the careful recording of operational activities will be indicative of the lagoon's operational effect. Acceptable levels for total suspended particulates are specified in the Air Pollution Control Ordinance.

7.8 The EIA Stage III report proposed that the noise be measured during the operation of the lagoon at HEC's two existing monitoring stations at Ching Lam and Hung Shing Ye, using existing equipment and methods. The methods of measurement and procedures for noise evaluation will be documented in a separate Environmental Monitoring and Audit Manual to be submitted to Government.

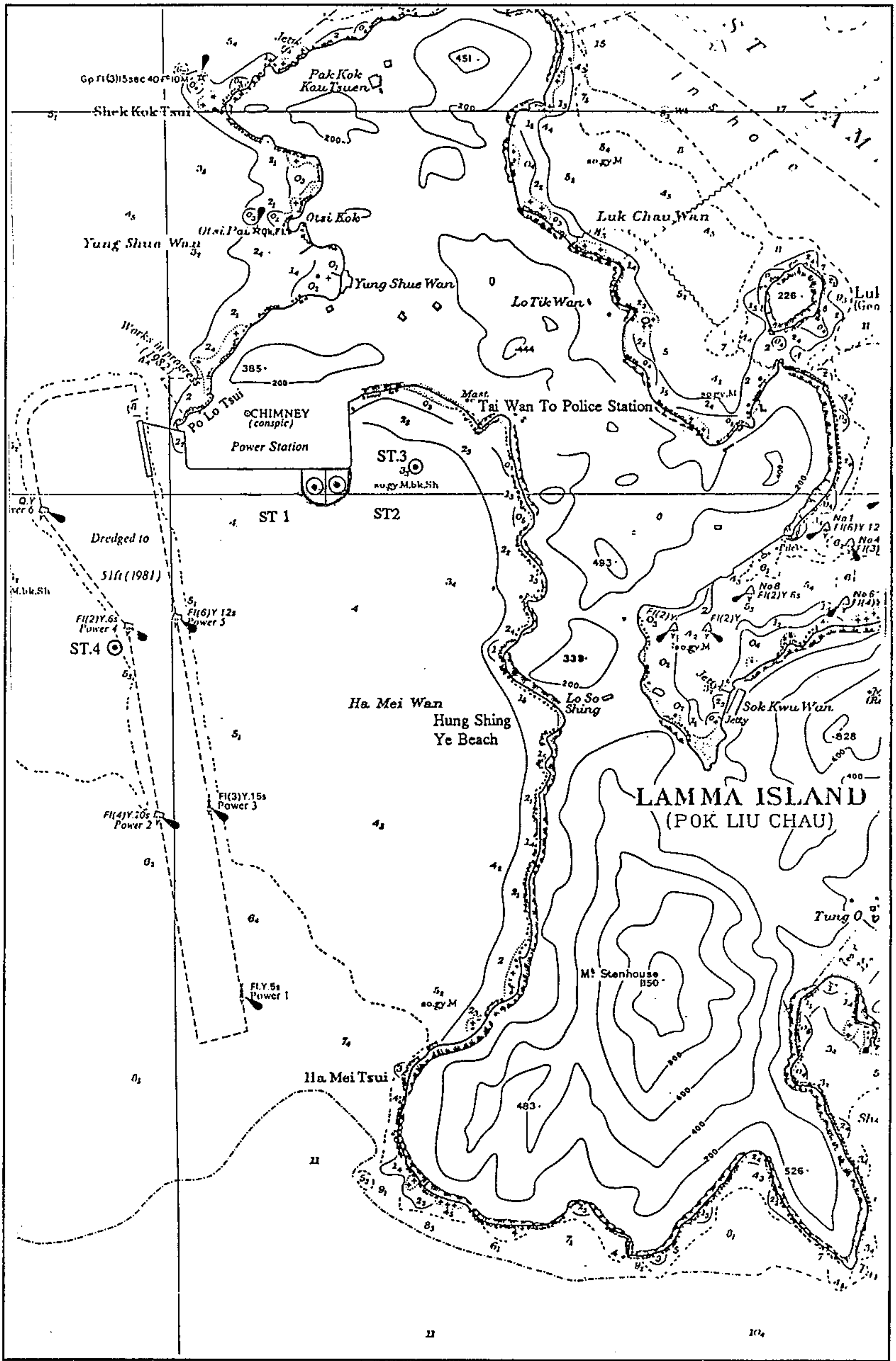


Figure 7.1 Sea Water Sampling Stations - Operations

Control Procedures

7.9 A clearly defined reporting procedure will ensure that results of monitoring are available as soon as possible to personnel controlling the lagoons operating systems.

7.10 The water quality within the lagoon will be positively controlled by the use of the decantrate system, discharging 20,000 m³ of water a day to the West Lamma Channel. The operating procedures are intended to be sufficiently flexible that it can be altered should the water quality either within the lagoon or in the bay prove to transgress the criteria and be due to the lagoon operations. On the occasions when emergency sluicing occurs the pumping of decantrate will be suspended for a number of hours to allow the suspended solids to precipitate and thus fall with the criteria permitting the resumption of pumping.

7.11 Although a dust nuisance is not expected to arise with the current proposals, dust suppression measures will be in place. The measures are also sufficiently comprehensive to mitigate an impact should it arise from the handling or storing of ash.

Acceptance Criteria

7.12 Acceptance criteria against which the measured environmental parameters will be judged, are generally those specified by the Hong Kong Government. Where local standards do not exist, criteria from other sources are proposed and are described in more detail where appropriate. The criteria for these proposals remain the same as those for the EIA Stage III report that have been agreed with Government.

7.13 There are few standards against which to judge acceptability of sea water quality in Hong Kong, and none relating to heavy metal concentrations. Some of those applicable to the monitoring programme are listed in Table 7.1 and they will help to put into perspective the results from the proposed monitoring programme. By comparing concentrations before and during lagoon operations, the impact of the facility on the environment, if any, can be assessed.

7.14 Although there are a number of criteria in the TM that have to be met for the discharge of effluents, a single critical criterion is proposed for monitoring, to provide a clear appreciation of the water quality in the lagoon. The nature of PFA and the solution of the soluble fractions suggest that the Total Toxic Metals would be the most critical criterion and thus form a suitable basis for control. The other determinands and criteria set in the TM could be established from samples at intervals to ensure that the system is performing well, but would not form part of the control mechanism.

7.15 The upper limit for Total Toxic Metals is proposed for the water quality to be permitted in the lagoon. This is to be 0.1 mg/l elevation over the background ambient concentration of the seawater, chosen to mimic the criterion set in the TM (Table 10a).

7.16 The definition of the ambient background concentration in the sea water surrounding Lamma is to be defined as an average of the data gathered from the analysis of samples from ST4 averaged over a length of time. Although the site ST4 will be regularly flushed by the ocean waters it is likely to be stratified during certain parts of the year and will have to be accounted for in arriving at representative base line concentrations.

7.17 Expected values for the physical parameters of pH and total suspended solids (TSS) are discussed in Section 6. The monitoring and auditing process will determine whether or not these limits are met, and whether the operating procedures have to be changed following the initial experience of operation.

Parameters	Typical range			Acceptable range
Temperature (°C)	17.3	-	29.5	< ±2°C from ambient
Dissolved Oxygen (mg/l)[e]				>4
pH (unit)	8.04	-	8.6	6.5 - 8.5
Salinity (0/00)	25.2	-	34.1	< ±10% from ambient
Turbidity (NTU)	1.8	-	15.7	<75[d]
Total Suspended Solids (mg/l)	1.8	-	16.7	< +30% from ambient
Nitrate (NO_3^--N), mg/l				<0.1
Nitrite (NO_2^--N), mg/l				<0.03[b][c]
Orthophosphate (PO_4^{3-}-P), mg/l	0.005	-	0.02	<0.16[c]
Sulphate (SO_4^{2-}), mg/l				<2710[a]
BOD_5 (mg/l)	0.3	-	2.6	<5
COD (mg/l)				<30

References

1. The acceptable range is based on the Southern Water Control Zone statement of Water Quality Objectives [Laws of Hong Kong Vol 22 (CAP 358), 1988] except (a), (b), (c), (d) and (e).

2. The typical range is based on the water quality of the west Lamma Channel in 1988 (EPD Marine Water Quality in Hong Kong, 1989).

a. Tait, R.V. (1972). Elements of Marine Ecology. London Butterworths : 73 and 81.

b. Chen, K.C. (1965). Analytical Chemistry of Sea Water. Scientific Publications, Peking : 130 and 140.

c. Goldberg E.D. (1972). A guide to Marine Pollution. Gordon and Beach Science Publishers, London.

d. Mok, M.H. (1979). "Discussion on the Standardization of Water Qualities - summary report".:91 in Conference on the Standardization of Methodology of Water Pollution (edited by Chung, M.T. and Chui, V.). Note : NTU approximate JTU but not exactly the same.

e. Arithmetic mean of at least 3 measurements at 1 metre below water surface, mid-depth and 1 metre above seabed.

Table 7.1 Expected Sea Water Quality

7.18 The Hong Kong Government provides standards for acceptable metal levels in sea food as shown in Table 7.2, these will be used to evaluate the effect on the operation on marine biota. These standards are applicable to the shrimp monitoring. Samples of shrimps will be digested before analysis, according to the procedure described in "Standard Methods for the Examination of Water and Waste Water" 17th Edition, APHA, AWWA, WPCF or similar international standard method.

Metal	Concentration (ppm)
Antimony	1
Arsenic	10
Cadmium	2
Chromium	1
Lead	6
Mercury	0.5
Tin	230

Notes: All units expressed as wet weight

Table 7.2 Permitted Metal Levels in Shellfish

7.19 Acceptable levels for dust (total suspended particulates) are specified by the Hong Kong Government in the Air Pollution Control Ordinance. The limits for total suspended particulates are as follows:

(i) the concentration of total suspended particulates in air averaged over any 24 hour period shall not exceed 260 microgrammes per cubic metre more than once a year;

(ii) the concentration of total suspended particulates in air averaged over a year shall not exceed 80 microgrammes per cubic metre.

7.20 Measuring dust concentrations at the existing monitoring locations will provide details of general dust emissions from the power station site as a whole and not specifically from the ash lagoon. It is not possible to monitor the lagoon alone, since wind changes could carry dust from outside sources to a monitoring instrument placed anywhere around the lagoon perimeter.

7.21 Acceptable noise levels arising from lagoon filling, classified as an industrial operation, are governed by the 1988 Noise Control Ordinance (Table 7.3). Following the procedures set out in this ordinance the Acceptable Noise Levels (ANLs) for the principal Noise Sensitive Receiver (NSR), the Tai Wan To police station, are listed below for working days. For planning purposes, a negative correction factor of 5 dB(A) has been applied to the ANL because the NSR is a building.

Time Period	ANL dB(A)
All days during the night-time (2300 to 0700 hours)	45
All days (0700 to 1900 hours) and evenings (1900 to 2300 hours)	55

Table 7.3 Operational Permitted Noise Levels

8 CONCLUSIONS

8.1 Prior to the third stage of the environmental impact assessment of the Ash Management Study for The Hongkong Electric Company Limited, various options for the disposal of ash were explored in the Initial Assessment Report (1989) (IAR). The IAR concluded that a lagoon adjacent to the power station should be an integral, and key element of the strategy. A preferred site for a lagoon of 1.5 Mm^3 capacity on the south eastern corner of the power station was adopted, and an EIA completed for it. The EIA took due regard of the environmental effects of both the likely construction techniques and the operational activities throughout the facility's life. Various measures were incorporated into the design to reduce the expected impacts to within criteria acceptable to EPD.

8.2 Subsequent to the approval of the EIA, Government have agreed to use ash for reclamations provided it has previously been deposited in a marine lagoon for a period of time. Consequently the requirement for a lagoon at Lamma Power Station remains, although of reduced capacity of about 1 Mm^3.

8.3 All the issues identified for the EIA have been re-addressed and are within accepted criteria for environmental protection. These criteria have been previously agreed with Government. The local community on Lamma have given the impression that the need for a lagoon is accepted although some concerns remain. This report has re-addressed the concerns, and the effects are likely to be better than originally envisaged in the EIA Stage III investigations, in some cases they are likely to be considerably less (Table 8.1 and Table 8.2).

8.4 The construction of the lagoon will take about 21 months and environmental audits will be carried out initially at 6 month intervals. The period of operation of the lagoon will be determined by the demand for ash in Government reclamations. During the operation of the lagoon two environmental audits will be carried out in the first year and annually thereafter.

8.5 Given that a lagoon is a necessary element in the approved ash disposal strategy, the revetment and caisson perimeter now presents the best practicable means for the structure.

8.6 A methodical assessment of the EIA and the lagoon performance is to be provided by instituting an environmental monitoring and audit system. This is to be carried out during both the construction and operational phases of the lagoon. The auditing system will not only provide affirmation of the expected performance of the lagoon, but also identify transgressions of criteria and institute remedial measures to rectify the situations should they arise.

Item	Comment on EIA Stage III proposals	Comment on Current Proposal	Differences in Environmental Impact
General			
size	529 m long x 250 m wide	350 m long x 250 m wide	a reduced area is required for the lagoon
capacity	1.5 Mm^3	1 Mm^3	a reduced volume of mud has to be dredged
Construction Effects			
duration	21 months construction	21 months construction	the duration is unchanged
marine biota	the proposals required, dredging and placing of materials	the same operations are required, but the area is reduced and the same control measures are proposed	a reduced area of sea bed is likely to be disturbed
sea water quality	various measures were proposed for control and mitigation of impacts	the same controls and measures are to be implemented	unlikely to change
noise	the expected noise impact was to have been about 58 dB(A) at the NSR	the expect construction noise is now a maximum of 59 dB(A) at the NSR	one dB(A) worse for one combination but within the limits
visual impact	much of the construction was to be marine based	the majority of the construction activity will be marine based	there will not be a change in the expected impact
community reaction	the community reaction has always been one of reluctant acceptance	a lagoon remains as a necessary part of the disposal strategy	unlikely to change
tourism	the works were to have taken place within a restricted area under environmental controls	these restrictions and controls remain the same for the current scheme	unlikely to change
employment	there were limited activities in which local construction labour could be employed	activities remain in which employment of local construction labour could be employed	unlikely to change

Table 8.1 Comparison of Expected Environmental Impacts - Construction

Item	Comment on EIA Stage III proposals	Comment on Current Proposal	Differences in Environmental Impact
Operating Effects			
sea water quality	seepage flows from the lagoon were estimated, and concentrations of determinands and loads derived	the seepage flows, concentrations of determinands and loads to the Ha Mei Wan bay are expected to be less	the effect on the sea water quality is expected to be less
marine biota	marine biota would recolonise the seaward revetment	a similar revetment is to be provided on the seaward face	no change in expected impact
dust	mitigation measures were proposed for ash above the water level	the ash will be placed by a slurry system and will be stored generally below water level, and the opportunity for dust arising is greatly reduced	the potential for a dust nuisance is greatly reduced
noise	various conveyor systems were required for transportation and further equipment required for harvesting	the systems for transportation and harvesting have been greatly simplified, to the use of a few pumping systems	the expected noise level arising for the lagoon operations is much reduced.
visual impact	the appearance was to be a revetment with a mound above	the appearance remains the same revetment but there is to be no mound above the perimeter level	marginally improved visual appearance
community reaction	the community reaction has always been one of reluctant acceptance	a lagoon remains as a necessary part of the disposal strategy	unlikely to change
tourism	the operation of the lagoon was designed to minimise the impact on tourism	the same measures have been incorporated in this scheme	unlikely to change
employment	the operation of the lagoon was to have required some labour for landscaping and irrigation	the current operations are less labour intensive and require more specialised staff	reduced local employment opportunity

Table 8.2 Comparison of Expected Environmental Impacts - Operations

APPENDIX A

TIDAL DATA FOR ANALYSIS

Boundary Condition : Variation of head against time

Neap tides

Time	mCD	Change in time hr.	Interval	T sec.	Level mPD
12:12	1.6	0.000	1	0	1.45
17:48	1	5.600	2	20160	0.85
23:39	1.9	11.450	3	41220	1.75
06:22	0.7	18.167	4	65400	0.55
12:40	1.7	24.467	5	88080	1.55
18:34	1	30.367	6	109320	0.85
00:10	1.7	35.967	7	129480	1.55
06:45	0.8	42.550	8	153180	0.65
13:09	1.7	48.950	9	176220	1.55
19:29	1.1	55.283	10	199020	0.95
00:46	1.5	60.567	11	218040	1.35
07:07	0.9	66.917	12	240900	0.75
13:43	1.7	73.517	13	264660	1.55
20:45	1.1	80.550	14	289980	0.95

Tide levels are take from Tide Table 1993, Royal Hong Kong Observatory Predictions at Chi Ma Wan, 27th to 30th January 1993.

Spring tides

Time	mCD	Change in time hr.	Interval	T sec.	Level mPD
19:10	2.4	0.000	1	0	2.25
02:57	0.3	7.783	2	28020	0.15
09:47	1.3	14.617	3	52620	1.15
12:56	1.1	17.767	4	63960	0.95
19:56	2.5	24.767	5	89160	2.35
03:33	0.2	32.383	6	116580	0.05
10:21	1.4	39.183	7	141060	1.25
13:54	1.1	42.733	8	153840	0.95
20:45	2.6	49.583	9	178500	2.45
04:11	0.1	57.017	10	205260	−0.05
10:52	1.4	63.700	11	229320	1.25
14:54	1.1	67.733	12	243840	0.95
21:35	2.6	74.417	13	267900	2.45
04:50	0.1	81.667	14	294000	−0.05

Tide levels are take from Tide Table 1993, Royal Hong Kong Observatory Predictions at Chi Ma Wan, 6th to 9th January 1993.

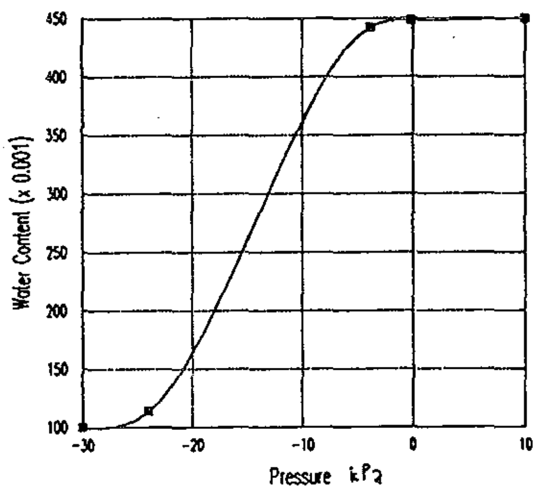
APPENDIX B

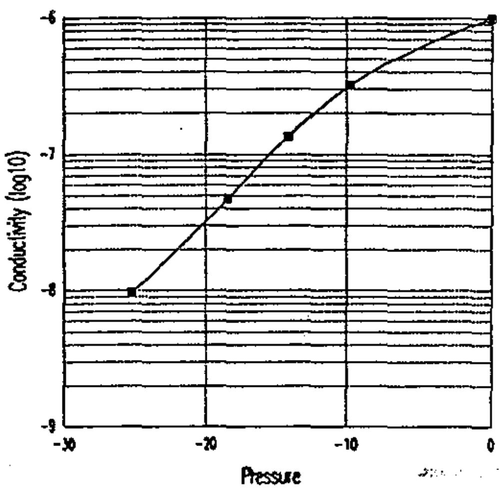
MATERIAL STORAGE FUNCTIONS

```
TITLE
     Lamma Power Station Ash Lagoon - PFA
     29 September 19              = DATE
     PFA.KIN                      = DATE FILE NAME
SOIL
              5,        = NUMBER OF PORE CLASSES
          .4500,        = MAXIMUM WATER CONTENT
          .1000,        = RESIDUAL WATER CONTENT
      .1000E-05,        = SATURATED PERMEABILITY
WATER
           20.0,        = TEMPERATURE (C)
           72.8,        = SURFACE TENSION (dyn/cm)
         1.0250,        = DENSITY (g/cubic cm)
         .01002,        = VISCOSITY (dyn.sec/sq cm)
          980.0,        = GRAVITATIONAL CONSTANT
            1.3,        = EXPONENT
POINT       ,     5
    1,        -30.000,  .1000,  = PORE WATER PRESSURE, WATER CONTENT
    2,        -23.969,  .1140,  = PORE WATER PRESSURE, WATER CONTENT
    3,         -3.750,  .4421,  = PORE WATER PRESSURE, WATER CONTENT
    4,          -.098,  .4483,  = PORE WATER PRESSURE, WATER CONTENT
    5,           .000,  .4500,  = PORE WATER PRESSURE, WATER CONTENT
END
Lamma Power Station Ash Lagoon - PFA
29 September 19          = DATE
```

CLASS (I)	NEGATIVE PRESSURE (M OF WATER)	(KPa)	WATER CONTENT (BY VOL)	CALCULATED K (M/S)	MATCHED K (M/S)
1	-2.575	-25.259	.1350	.2455E-06	.9702E-08
2	-1.872	-18.361	.2050	.1201E-05	.4747E-07
3	-1.432	-14.047	.2750	.3415E-05	.1350E-06
4	-.992	-9.734	.3450	.8075E-05	.3192E-06
5	.000	.000	.4500	.2530E-04	.1000E-05

END

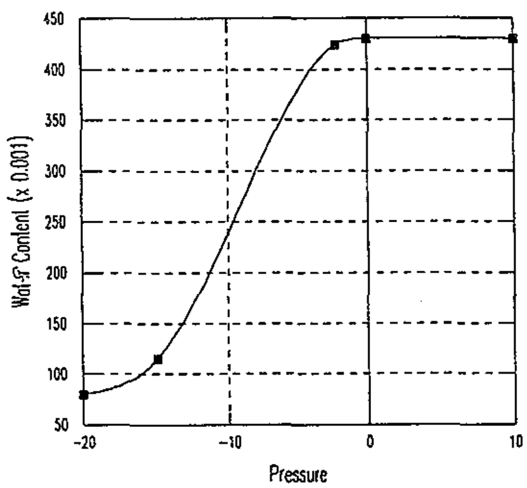


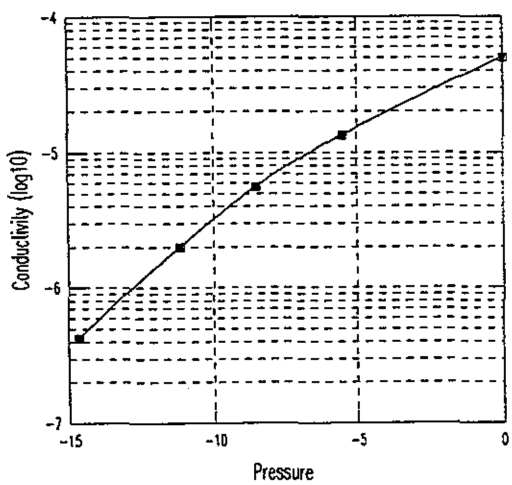


```
TITLE
     Lamma Power Station Ash Lagoon - Sandfill (finer)
     28 September 19              = DATE
     sand.KIN                     = DATE FILE NAME
SOIL
              5,        = NUMBER OF PORE CLASSES
          .4300,        = MAXIMUM WATER CONTENT
          .0000,        = RESIDUAL WATER CONTENT
      .5000E-04,        = SATURATED PERMEABILITY
WATER
           20.0,        = TEMPERATURE (C)
           72.8,        = SURFACE TENSION (dyn/cm)
         1.0250,        = DENSITY (g/cubic cm)
         .01002,        = VISCOSITY (dyn.sec/sq cm)
          980.0,        = GRAVITATIONAL CONSTANT
            1.3,        = EXPONENT
POINT      ,   5
    1,       -16.766,  .1150,  = PORE WATER PRESSURE, WATER CONTENT
    2,       -12.091,  .1850,  = PORE WATER PRESSURE, WATER CONTENT
    3,        -9.209,  .2550,  = PORE WATER PRESSURE, WATER CONTENT
    4,        -6.327,  .3250,  = PORE WATER PRESSURE, WATER CONTENT
    5,          .000,  .4300,  = PORE WATER PRESSURE, WATER CONTENT
END
Lamma Power Station Ash Lagoon - Sandfill
28 September 19           = DATE
```

CLASS (I)	NEGATIVE PRESSURE (M OF WATER)	(KPa)	WATER CONTENT (BY VOL)	CALCULATED K (M/S)	MATCHED K (M/S)
1	-1.495	-14.662	.1465	.8445E-06	.4273E-06
2	-1.139	-11.172	.2095	.3988E-05	.2018E-05
3	-.865	-8.489	.2725	.1111E-04	.5619E-05
4	-.560	-5.494	.3355	.2676E-04	.1354E-04
5	.000	.000	.4300	.9882E-04	.5000E-04

END





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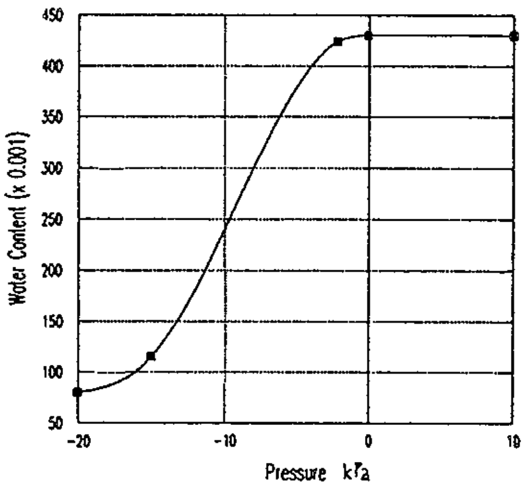
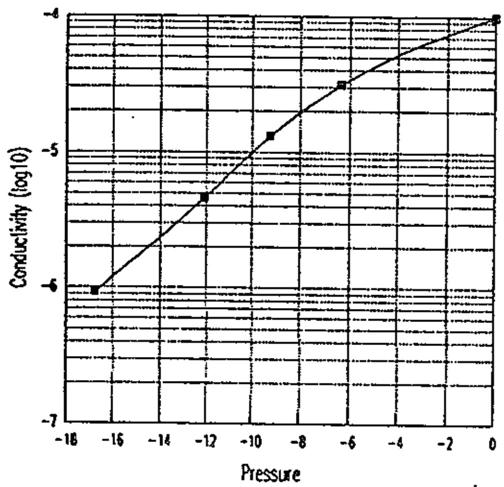
TITLE
     Lamma Power Station Ash Lagoon - Sandfill (coarser)
     28 September 19           = DATE
     sand1.KIN                 = DATE FILE NAME
SOIL
              5,        = NUMBER OF PORE CLASSES
          .4300,        = MAXIMUM WATER CONTENT
          .0800,        = RESIDUAL WATER CONTENT
      .1000E-03,        = SATURATED PERMEABILITY
WATER
           20.0,        = TEMPERATURE (C)
           72.8,        = SURFACE TENSION (dyn/cm)
         1.0250,        = DENSITY (g/cubic cm)
         .01002,        = VISCOSITY (dyn.sec/sq cm)
          980.0,        = GRAVITATIONAL CONSTANT
            1.3,        = EXPONENT
POINT      ,    5
    1,      -20.000,  .0800,  = PORE WATER PRESSURE, WATER CONTENT
    2,      -14.956,  .1154,  = PORE WATER PRESSURE, WATER CONTENT
    3,       -2.256,  .4239,  = PORE WATER PRESSURE, WATER CONTENT
    4,        -.521,  .4300,  = PORE WATER PRESSURE, WATER CONTENT
    5,         .000,  .4300,  = PORE WATER PRESSURE, WATER CONTENT
END
Lamma Power Station Ash Lagoon - Sandfill
29 September 19           = DATE
```

CLASS (I)	NEGATIVE PRESSURE (M OF WATER)	(KPa)	WATER CONTENT (BY VOL)	CALCULATED K (M/S)	MATCHED K (M/S)
1	-1.709	-16.766	.1150	.6102E-06	.9330E-06
2	-1.232	-12.091	.1850	.3004E-05	.4593E-05
3	-.939	-9.209	.2550	.8593E-05	.1314E-04
4	-.645	-6.327	.3250	.2049E-04	.3133E-04
5	.000	.000	.4300	.6540E-04	.1000E-03

END





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TITLE
     Lamma Power Station Ash Lagoon - Rockfill
     28 September 19             = DATE
     rock.KIN                    = DATE FILE NAME
SOIL
               5,       = NUMBER OF PORE CLASSES
           .4200,       = MAXIMUM WATER CONTENT
           .0000,       = RESIDUAL WATER CONTENT
       .1000E-02,       = SATURATED PERMEABILITY
WATER
            20.0,       = TEMPERATURE (C)
            72.8,       = SURFACE TENSION (dyn/cm)
          1.0250,       = DENSITY (g/cubic cm)
          .01002,       = VISCOSITY (dyn.sec/sq cm)
           980.0,       = GRAVITATIONAL CONSTANT
             1.3,       = EXPONENT
POINT      ,    5
    1,       -4.747,  .0870,  = PORE WATER PRESSURE, WATER CONTENT
    2,       -3.155,  .1610,  = PORE WATER PRESSURE, WATER CONTENT
    3,       -2.477,  .2350,  = PORE WATER PRESSURE, WATER CONTENT
    4,       -1.798,  .3090,  = PORE WATER PRESSURE, WATER CONTENT
    5,         .000,  .4200,  = PORE WATER PRESSURE, WATER CONTENT
END
Lamma Power Station Ash Lagoon - Rockfill
28 September 19             = DATE
```
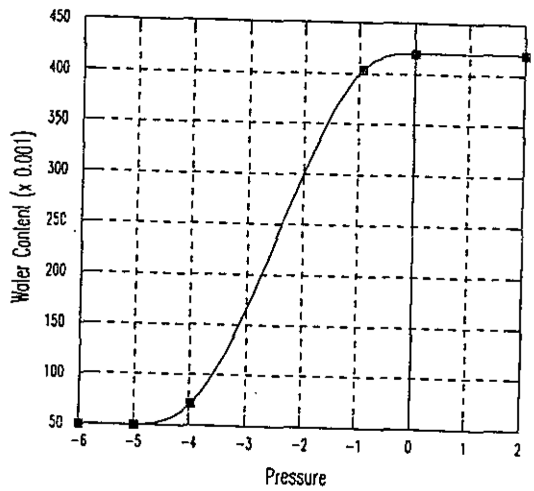
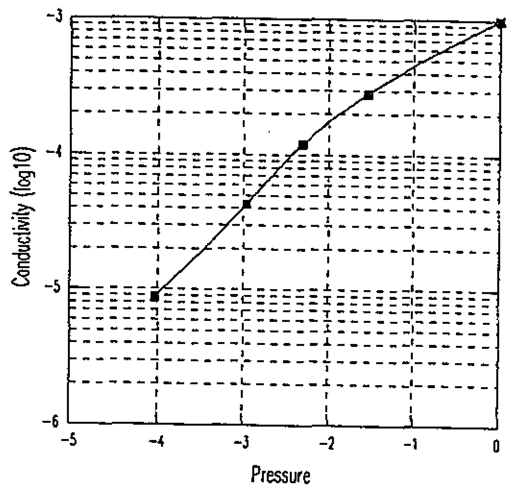

CLASS (I)	NEGATIVE PRESSURE (M OF WATER)	(KPa)	WATER CONTENT (BY VOL)	CALCULATED K (M/S)	MATCHED K (M/S)
1	-.411	-4.031	.1203	.1270E-04	.8804E-05
2	-.302	-2.963	.1869	.6158E-04	.4270E-04
3	-.235	-2.307	.2535	.1727E-03	.1197E-03
4	-.157	-1.540	.3201	.4095E-03	.2839E-03
5	.000	.000	.4200	.1442E-02	.1000E-02

END





APPENDIX C

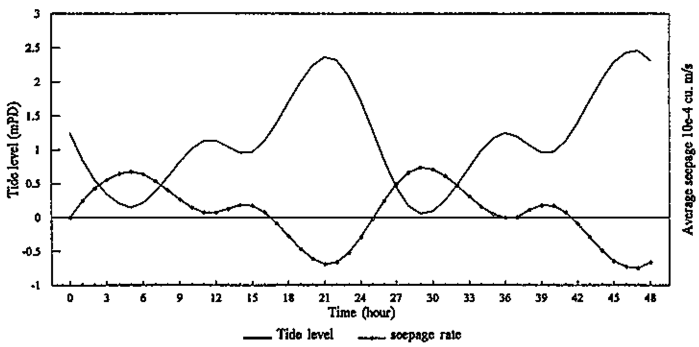
SEEPAGE, REVETMENT WITH CAISSONS

Lamma Power Station Ash Lagoon
Seepage across Caisson and Revetment Seawall

Status of filling: No PFA in lagoon
Tidal cycle: Spring tide

Effective length of seawall = 520 m   Lagoon surface area 82700 sq.m

Time hour	Tide level mPD	Flow rate per metre of seawall cu.m/s	Hourly seepage along entire length cu. m/h	Accumulated inflow cu. m	Accumulated outflow cu. m	Accumulated change in lagoon water level mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	0.854	2.4450E-05	45.77	0.00	45.77	-0.55
2	0.556	4.2821E-05	80.16	0.00	125.93	-1.52
3	0.344	5.5910E-05	104.66	0.00	230.59	-2.79
4	0.205	6.4496E-05	120.74	0.00	351.33	-4.25
5	0.146	6.8137E-05	127.55	0.00	478.88	-5.79
6	0.214	6.4001E-05	119.81	0.00	598.69	-7.24
7	0.377	5.3971E-05	101.03	0.00	699.73	-8.46
8	0.593	4.0660E-05	76.12	0.00	775.84	-9.38
9	0.819	2.6688E-05	49.96	0.00	825.80	-9.99
10	1.013	1.4692E-05	27.50	0.00	853.31	-10.32
11	1.132	7.3101E-06	13.68	0.00	866.99	-10.48
12	1.136	7.0660E-06	13.23	0.00	880.22	-10.64
13	1.046	1.2610E-05	23.61	0.00	903.82	-10.93
14	0.957	1.8075E-05	33.84	0.00	937.66	-11.34
15	0.969	1.7364E-05	32.51	0.00	970.17	-11.73
16	1.128	7.5758E-06	14.18	0.00	984.35	-11.90
17	1.388	-8.5187E-06	-15.95	15.95	984.35	-11.71
18	1.696	-2.7562E-05	-51.60	67.54	984.35	-11.09
19	1.998	-4.6181E-05	-86.45	153.99	984.35	-10.04
20	2.238	-6.1019E-05	-114.23	268.22	984.35	-8.66
21	2.362	-6.8710E-05	-128.63	396.85	984.35	-7.10
22	2.317	-6.5925E-05	-123.41	520.26	984.35	-5.61
23	2.087	-5.1725E-05	-96.83	617.09	984.35	-4.44
24	1.726	-2.9401E-05	-55.04	672.13	984.35	-3.78
25	1.294	-2.7162E-06	-5.08	677.21	984.35	-3.71
26	0.850	2.4660E-05	46.16	677.21	1030.51	-4.27
27	0.456	4.8977E-05	91.68	677.21	1122.20	-5.38
28	0.172	6.6519E-05	124.52	677.21	1246.72	-6.89
29	0.052	7.3917E-05	138.37	677.21	1385.09	-8.56
30	0.093	7.1462E-05	133.78	677.21	1518.87	-10.18
31	0.251	6.1754E-05	115.60	677.21	1634.47	-11.58
32	0.482	4.7504E-05	88.93	677.21	1723.40	-12.65
33	0.742	3.1454E-05	58.88	677.21	1782.28	-13.36
34	0.986	1.6347E-05	30.60	677.21	1812.88	-13.73
35	1.170	4.9611E-06	9.29	677.21	1822.17	-13.84
36	1.250	2.8343E-08	0.05	677.21	1822.22	-13.85
37	1.195	3.3665E-07	0.63	677.21	1822.85	-13.85
38	1.068	1.1221E-05	21.01	677.21	1843.86	-14.11
39	0.962	1.7781E-05	33.29	677.21	1877.15	-14.51
40	0.970	1.7281E-05	32.35	677.21	1909.50	-14.90
41	1.132	7.2735E-06	13.62	677.21	1923.11	-15.07
42	1.401	-9.3154E-06	-17.44	694.65	1923.11	-14.85
43	1.720	-2.9054E-05	-54.39	749.04	1923.11	-14.20
44	2.035	-4.8498E-05	-90.79	839.83	1923.11	-13.10
45	2.289	-6.4216E-05	-120.21	960.04	1923.11	-11.65
46	2.428	-7.2785E-05	-136.25	1096.29	1923.11	-10.00
47	2.456	-7.4525E-05	-139.51	1235.80	1923.11	-8.31
48	2.321	-6.6175E-05	-123.88	1359.68	1923.11	-6.81



Remarks:
Length of revetment
= 520 m

Surface area of
lagoon
= 82700 sq. m

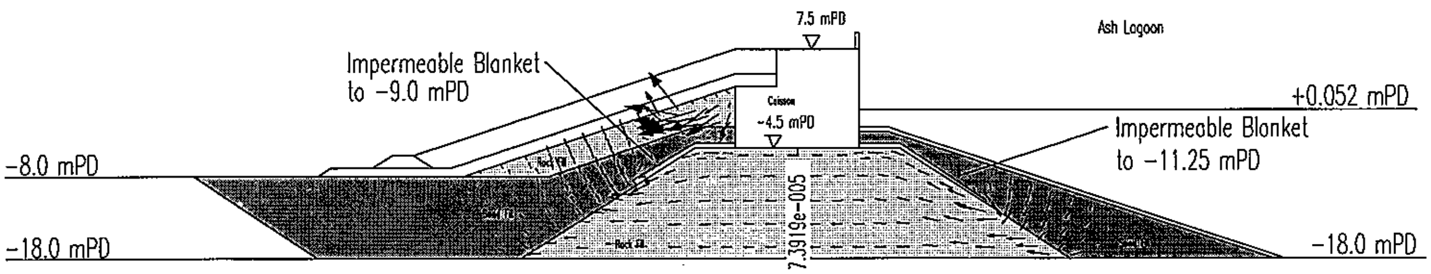
Inflow -ve   Outflow +ve

Hongkong Electric Company

Lamma Power Station Ash Lagoon

Spring Tide, initial condition Sea and Lagoon
Water Level = +1.25 mPD

No PFA in lagoon



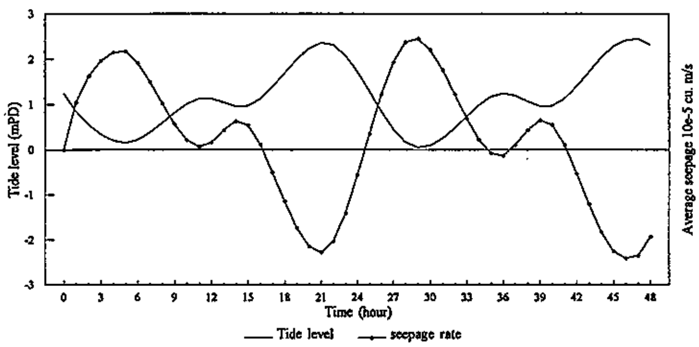
Flux in cu.m/s per m length of seawall

Lamma Power Station Ash Lagoon
Seepage across Caisson and Revetment Seawall

Status of filling: 2m thick of PFA on inner slope of seawall
Tidal cycle: Spring tide

Effective length of seawall = 520 m   Lagoon surface area 82700 sq.m

Time hour	Tide level mPD	Flow rate per metre of seawall cu.m/s	Hourly seepage along entire length cu. m/h	Accumulated inflow cu. m	Accumulated outflow cu. m	Accumulated change in lagoon water level mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	0.854	1.0516E-05	19.69	0.00	19.69	-0.24
2	0.556	1.6250E-05	30.42	0.00	50.11	-0.61
3	0.344	1.9629E-05	36.75	0.00	86.85	-1.05
4	0.205	2.1495E-05	40.24	0.00	127.09	-1.54
5	0.146	2.1750E-05	40.72	0.00	167.81	-2.03
6	0.214	1.9247E-05	36.03	0.00	203.84	-2.46
7	0.377	1.5074E-05	28.22	0.00	232.05	-2.81
8	0.593	1.0267E-05	19.22	0.00	251.27	-3.04
9	0.819	5.7002E-06	10.67	0.00	261.95	-3.17
10	1.013	2.2021E-06	4.12	0.00	266.07	-3.22
11	1.132	5.8883E-07	1.10	0.00	267.17	-3.23
12	1.136	1.6015E-06	3.00	0.00	270.17	-3.27
13	1.046	4.3493E-06	8.14	0.00	278.31	-3.37
14	0.957	6.3245E-06	11.84	0.00	290.15	-3.51
15	0.969	5.4260E-06	10.16	0.00	300.31	-3.63
16	1.128	1.1015E-06	2.06	0.00	302.37	-3.66
17	1.388	-4.9965E-06	-9.35	9.35	302.37	-3.54
18	1.696	-1.1528E-05	-21.58	30.93	302.37	-3.28
19	1.998	-1.7365E-05	-32.51	63.44	302.37	-2.89
20	2.238	-2.1457E-05	-40.17	103.61	302.37	-2.40
21	2.362	-2.2765E-05	-42.62	146.22	302.37	-1.89
22	2.317	-2.0280E-05	-37.96	184.19	302.37	-1.43
23	2.087	-1.4022E-05	-26.25	210.44	302.37	-1.11
24	1.726	-5.6161E-06	-10.51	220.95	302.37	-0.98
25	1.294	3.5460E-06	6.64	220.95	309.01	-1.06
26	0.850	1.2283E-05	22.99	220.95	332.00	-1.34
27	0.456	1.9420E-05	36.35	220.95	368.36	-1.78
28	0.172	2.3822E-05	44.59	220.95	412.95	-2.32
29	0.052	2.4507E-05	45.88	220.95	458.83	-2.88
30	0.093	2.2040E-05	41.26	220.95	500.09	-3.38
31	0.251	1.7646E-05	33.03	220.95	533.12	-3.77
32	0.482	1.2295E-05	23.02	220.95	556.14	-4.05
33	0.742	6.8723E-06	12.86	220.95	569.00	-4.21
34	0.986	2.2290E-06	4.17	220.95	573.17	-4.26
35	1.170	-7.8072E-07	-1.46	222.41	573.17	-4.24
36	1.250	-1.3295E-06	-2.49	224.90	573.17	-4.21
37	1.195	1.0205E-06	1.91	224.90	575.08	-4.23
38	1.068	4.3838E-06	8.21	224.90	583.29	-4.33
39	0.962	6.5131E-06	12.19	224.90	595.48	-4.48
40	0.970	5.5148E-06	10.32	224.90	605.81	-4.61
41	1.132	1.0175E-06	1.90	224.90	607.71	-4.63
42	1.401	-5.2977E-06	-9.92	234.82	607.71	-4.51
43	1.720	-1.2087E-05	-22.63	257.45	607.71	-4.24
44	2.035	-1.8206E-05	-34.08	291.53	607.71	-3.82
45	2.289	-2.2581E-05	-42.27	333.80	607.71	-3.31
46	2.428	-2.4162E-05	-45.23	379.03	607.71	-2.77
47	2.456	-2.3519E-05	-44.03	423.06	607.71	-2.23
48	1.49	-1.9344E-05	-36.21	459.27	607.71	-1.79



Remarks:
Length of revetment
= 520 m

Surface area of
lagoon
= 82700 sq. m

Inflow -ve   Outflow +ve

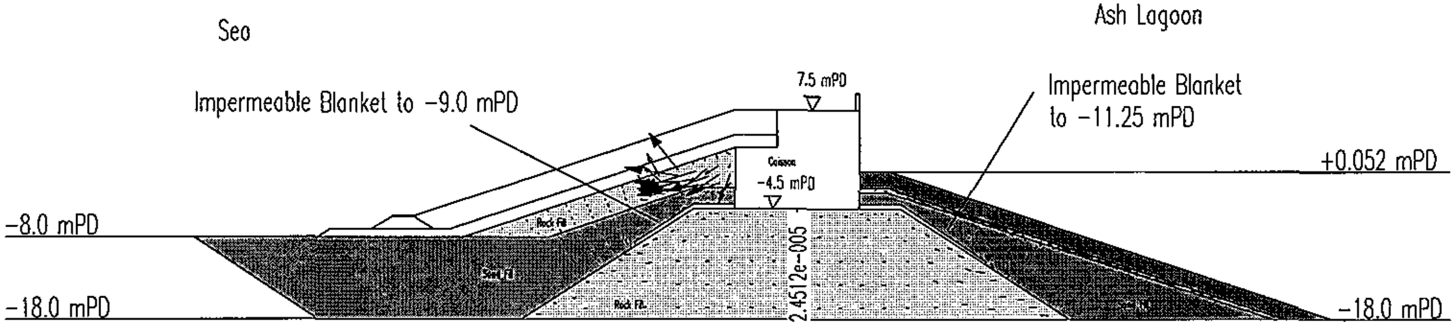
Hongkong Electric Company

Lamma Power Station Ash Lagoon

Spring Tide, initial condition Sea and Lagoon

Water Level = +1.25 mPD

2 metres of PFA on inner slope



Flux in cu.m/s per m length of seawall

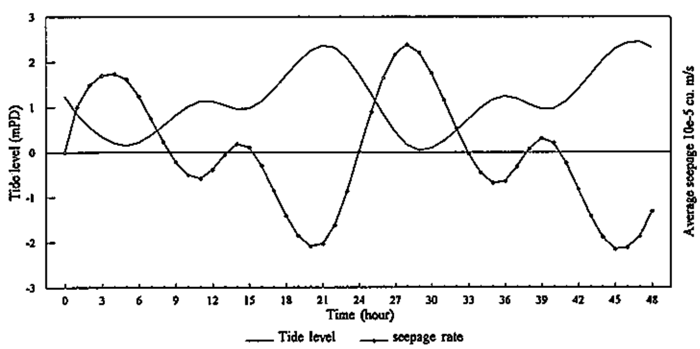
Lamma Power Station Ash Lagoon
Seepage across Caisson and Revetment Seawall

Status of filling: Lagoon full of PFA
Tidal cycle: Spring tide

Effective length of seawall = 520 m

Lagoon surface area 82700 sq.m

Time	Tide level	Flow rate per metre of seawall	Hourly seepage along entire length	Accumulated inflow	Accumulated outflow	Accumulated change in lagoon water level
hour	mPD	cu.m/s	cu. m/h	cu. m	cu. m	mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	0.854	1.0058E-05	18.83	0.00	18.83	-0.76
2	0.556	1.4943E-05	27.97	0.00	46.80	-1.89
3	0.344	1.7051E-05	31.92	0.00	78.72	-3.17
4	0.205	1.7437E-05	32.64	0.00	111.36	-4.49
5	0.146	1.6215E-05	30.35	0.00	141.72	-5.71
6	0.214	1.2456E-05	23.32	0.00	165.04	-6.65
7	0.377	7.4349E-06	13.92	0.00	178.95	-7.21
8	0.593	2.2898E-06	4.29	0.00	183.24	-7.39
9	0.819	-2.1066E-06	-3.94	3.94	183.24	-7.23
10	1.013	-5.0165E-06	-9.39	13.33	183.24	-6.85
11	1.132	-5.7929E-06	-10.84	24.18	183.24	-6.41
12	1.136	-3.9202E-06	-7.34	31.52	183.24	-6.12
13	1.046	-5.0542E-07	-0.95	32.46	183.24	-6.08
14	0.957	1.8471E-06	3.46	32.46	186.70	-6.22
15	0.969	1.1319E-06	2.12	32.46	188.82	-6.30
16	1.128	-2.9643E-06	-5.55	38.01	188.82	-6.08
17	1.388	-8.5403E-06	-15.99	54.00	188.82	-5.43
18	1.696	-1.4113E-05	-26.42	80.42	188.82	-4.37
19	1.998	-1.8540E-05	-34.71	115.13	188.82	-2.97
20	2.238	-2.0886E-05	-39.10	154.23	188.82	-1.39
21	2.362	-2.0330E-05	-38.06	192.28	188.82	0.14
22	2.317	-1.6148E-05	-30.23	222.51	188.82	1.36
23	2.087	-8.6823E-06	-16.25	238.77	188.82	2.01
24	1.726	1.9230E-07	0.36	238.77	189.18	2.00
25	1.294	8.9636E-06	16.78	238.77	205.96	1.32
26	0.850	1.6482E-05	30.85	238.77	236.81	0.08
27	0.456	2.1734E-05	40.69	238.77	277.50	-1.56
28	0.172	2.3844E-05	44.64	238.77	322.13	-3.36
29	0.052	2.2166E-05	41.49	238.77	363.63	-5.03
30	0.093	1.7605E-05	32.96	238.77	396.58	-6.36
31	0.251	1.1644E-05	21.80	238.77	418.38	-7.24
32	0.482	5.3879E-06	10.09	238.77	428.47	-7.65
33	0.742	-2.6669E-07	-0.50	239.26	428.47	-7.63
34	0.986	-4.5576E-06	-8.53	247.80	428.47	-7.28
35	1.170	-6.8012E-06	-12.73	260.53	428.47	-6.77
36	1.250	-6.4027E-06	-11.99	272.51	428.47	-6.29
37	1.195	-3.1941E-06	-5.98	278.49	428.47	-6.04
38	1.068	7.3433E-07	1.37	278.49	429.84	-6.10
39	0.962	3.0835E-06	5.77	278.49	435.62	-6.33
40	0.970	2.0998E-06	3.93	278.49	439.55	-6.49
41	1.132	-2.3134E-06	-4.33	282.82	439.55	-6.32
42	1.401	-8.2160E-06	-15.38	298.20	439.55	-5.70
43	1.720	-1.4113E-05	-26.42	324.62	439.55	-4.63
44	2.035	-1.8852E-05	-35.29	359.91	439.55	-3.21
45	2.289	-2.1477E-05	-40.20	400.12	439.55	-1.59
46	2.428	-2.1155E-05	-39.60	439.72	439.55	0.01
47	2.456	-1.8706E-05	-35.02	474.74	439.55	1.42
48	2.321	-1.3088E-05	-24.50	499.24	439.55	2.41



Remarks:
Length of revetment
= 520 m

Surface area of
lagoon
= 82700 sq. m

Inflow -ve Outflow +ve

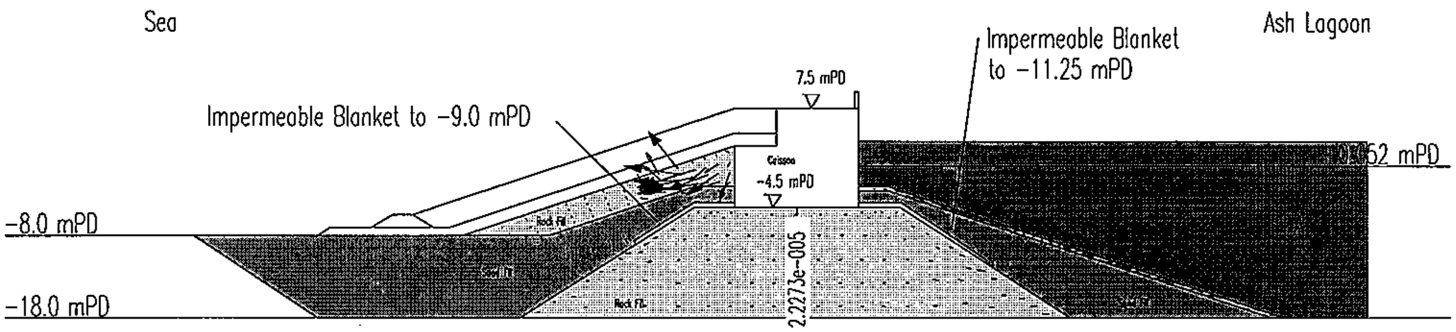
Hongkong Electric Company

Lamma Power Station Ash Lagoon

Spring Tide, initial condition Sea and Lagoon

Water Level = +1.25 mPD

Lagoon full of PFA



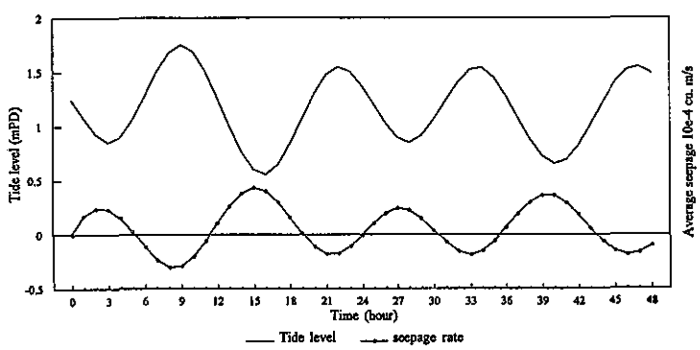
Flux in cu.m/s per m length of seawall

Lamma Power Station Ash Lagoon
Seepage across Caisson and Revetment Seawall

Status of filling: No PFA in lagoon
Tidal cycle: Neap tide

Effective length of seawall = 520 m Lagoon surface area 82700 sq.m

Time hour	Tide level mPD	Flow rate per metre of seawall cu.m/s	Hourly seepage along entire length cu. m/h	Accumulated inflow cu. m	Accumulated outflow cu. m	Accumulated change in lagoon water level mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	1.077	1.7499E-05	32.76	0.00	32.76	-0.40
2	0.925	2.3984E-05	44.90	0.00	77.66	-0.94
3	0.850	2.3366E-05	43.74	0.00	121.40	-1.47
4	0.902	1.5228E-05	28.51	0.00	149.90	-1.81
5	1.062	2.5818E-06	4.83	0.00	154.74	-1.87
6	1.279	-1.1363E-05	-21.27	21.27	154.74	-1.61
7	1.501	-2.3393E-05	-43.79	65.06	154.74	-1.08
8	1.675	-3.0289E-05	-56.70	121.76	154.74	-0.40
9	1.750	-2.9064E-05	-54.41	176.17	154.74	0.26
10	1.686	-2.0010E-05	-37.46	213.63	154.74	0.71
11	1.509	-5.9338E-06	-11.11	224.74	154.74	0.85
12	1.265	1.0288E-05	19.26	224.74	174.00	0.61
13	1.001	2.5785E-05	48.27	224.74	222.27	0.03
14	0.764	3.7693E-05	70.56	224.74	292.83	-0.82
15	0.598	4.3145E-05	80.77	224.74	373.59	-1.80
16	0.552	3.9961E-05	74.81	224.74	448.40	-2.70
17	0.645	2.9846E-05	55.87	224.74	504.27	-3.38
18	0.834	1.5894E-05	29.75	224.74	534.03	-3.74
19	1.068	1.2102E-06	2.27	224.74	536.29	-3.77
20	1.300	-1.1106E-05	-20.79	245.53	536.29	-3.52
21	1.476	-1.7944E-05	-33.59	279.12	536.29	-3.11
22	1.550	-1.7226E-05	-32.25	311.37	536.29	-2.72
23	1.503	-1.0515E-05	-19.68	331.05	536.29	-2.48
24	1.373	-3.9582E-07	-0.74	331.79	536.29	-2.47
25	1.200	1.0529E-05	19.71	331.79	556.00	-2.71
26	1.028	1.9696E-05	36.87	331.79	592.87	-3.16
27	0.897	2.4505E-05	45.87	331.79	638.75	-3.71
28	0.850	2.2655E-05	42.41	331.79	681.16	-4.22
29	0.914	1.4968E-05	28.02	331.79	709.18	-4.56
30	1.059	4.2093E-06	7.88	331.79	717.06	-4.66
31	1.240	-6.8279E-06	-12.78	344.57	717.06	-4.50
32	1.410	-1.5341E-05	-28.72	373.29	717.06	-4.16
33	1.526	-1.8528E-05	-34.68	407.98	717.06	-3.74
34	1.542	-1.4695E-05	-27.51	435.49	717.06	-3.40
35	1.449	-5.5604E-06	-10.41	445.90	717.06	-3.28
36	1.282	6.4809E-06	12.13	445.90	729.19	-3.43
37	1.080	1.9040E-05	35.64	445.90	764.83	-3.86
38	0.882	2.9733E-05	55.66	445.90	820.49	-4.53
39	0.726	3.6176E-05	67.72	445.90	888.21	-5.35
40	0.652	3.6079E-05	67.54	445.90	955.75	-6.17
41	0.690	2.9453E-05	55.14	445.90	1010.89	-6.83
42	0.823	1.8609E-05	34.84	445.90	1045.73	-7.25
43	1.012	5.9683E-06	11.17	445.90	1056.90	-7.39
44	1.218	-6.0539E-06	-11.33	457.23	1056.90	-7.25
45	1.401	-1.5028E-05	-28.13	485.36	1056.90	-6.91
46	1.522	-1.8607E-05	-34.83	520.19	1056.90	-6.49
47	1.549	-1.6390E-05	-30.68	550.87	1056.90	-6.12
48	1.489	-1.0115E-05	-18.94	569.81	1056.90	-5.89



Remarks:
Length of revetment = 520 m

Surface area of lagoon = 82700 sq. m

Inflow -ve Outflow +ve

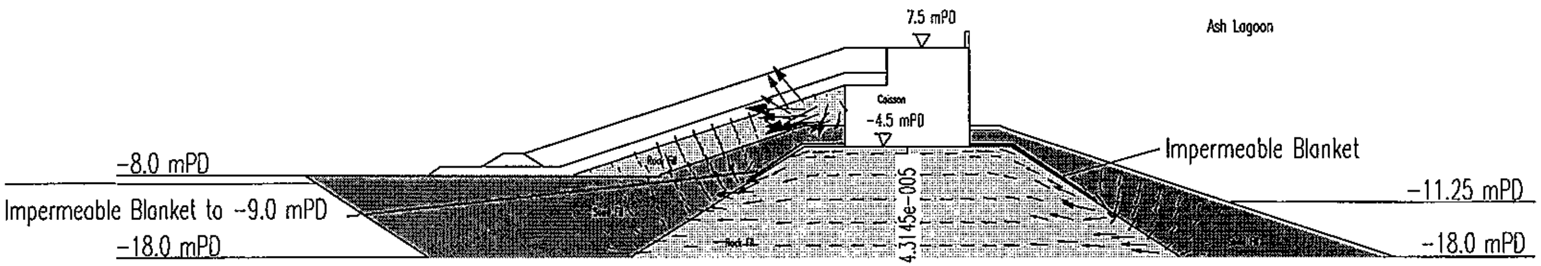
Hongkong Electric Company

Lamma Power Station Ash Lagoon

Neap Tide, initial conditions lagoon and sea

Water Level = +1.25 mPD

No PFA in lagoon



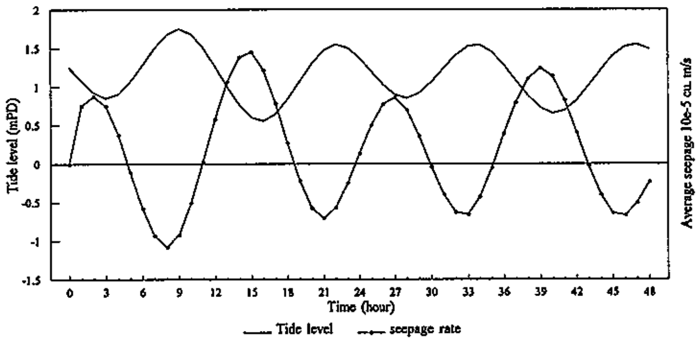
Flux in cu.m/s per m length of seawall

Lamma Power Station Ash Lagoon
Seepage across Caisson and Revetment Seawall

Status of filling: 2m thick of PFA on inner slope of seawall
Tidal cycle: Neap tide

Effective length of seawall = 520 m   Lagoon surface area 82700 sq.m

Time	Tide level	Flow rate per metre of seawall	Hourly seepage along entire length	Accumulated inflow	Accumulated outflow	Accumulated change in lagoon water level
hour	mPD	cu.m/s	cu. m/h	cu. m	cu. m	mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	1.077	7.5194E-06	14.08	0.00	14.08	-0.17
2	0.925	8.7521E-06	16.38	0.00	30.46	-0.37
3	0.850	7.4643E-06	13.97	0.00	44.43	-0.54
4	0.902	3.7063E-06	6.94	0.00	51.37	-0.62
5	1.062	-1.0988E-06	-2.06	2.06	51.37	-0.60
6	1.279	-5.7981E-06	-10.85	12.91	51.37	-0.47
7	1.501	-9.3593E-06	-17.52	30.43	51.37	-0.25
8	1.675	-1.0778E-05	-20.18	50.61	51.37	-0.01
9	1.750	-9.1754E-06	-17.18	67.78	51.37	0.20
10	1.686	-5.0593E-06	-9.47	77.26	51.37	0.31
11	1.509	2.7017E-07	0.51	77.26	51.88	0.31
12	1.265	5.7971E-06	10.85	77.26	62.73	0.18
13	1.001	1.0603E-05	19.85	77.26	82.58	-0.06
14	0.764	1.3801E-05	25.84	77.26	108.41	-0.38
15	0.598	1.4516E-05	27.17	77.26	135.59	-0.71
16	0.552	1.2170E-05	22.78	77.26	158.37	-0.98
17	0.645	7.8001E-06	14.60	77.26	172.97	-1.16
18	0.834	2.6770E-06	5.01	77.26	177.98	-1.22
19	1.068	-2.1529E-06	-4.03	81.29	177.98	-1.17
20	1.300	-5.7142E-06	-10.70	91.98	177.98	-1.04
21	1.476	-7.0470E-06	-13.19	105.17	177.98	-0.88
22	1.550	-5.6491E-06	-10.58	115.75	177.98	-0.75
23	1.503	-2.4926E-06	-4.67	120.42	177.98	-0.70
24	1.373	1.3564E-06	2.54	120.42	180.52	-0.73
25	1.200	5.0189E-06	9.40	120.42	189.92	-0.84
26	1.028	7.6910E-06	14.40	120.42	204.32	-1.01
27	0.897	8.5697E-06	16.04	120.42	220.36	-1.21
28	0.850	6.9888E-06	13.08	120.42	233.44	-1.37
29	0.914	3.6062E-06	6.75	120.42	240.19	-1.45
30	1.059	-3.7416E-07	-0.70	121.12	240.19	-1.44
31	1.240	-3.9831E-06	-7.46	128.57	240.19	-1.35
32	1.410	-6.3300E-06	-11.85	140.42	240.19	-1.21
33	1.526	-6.5585E-06	-12.28	152.70	240.19	-1.06
34	1.542	-4.2793E-06	-8.01	160.71	240.19	-0.96
35	1.449	-4.9525E-07	-0.93	161.64	240.19	-0.95
36	1.282	3.8416E-06	7.19	161.64	247.38	-1.04
37	1.080	7.9358E-06	14.86	161.64	262.24	-1.22
38	0.882	1.1037E-05	20.66	161.64	282.90	-1.47
39	0.726	1.2416E-05	23.24	161.64	306.14	-1.75
40	0.652	1.1384E-05	21.31	161.64	327.45	-2.01
41	0.690	8.2394E-06	15.42	161.64	342.88	-2.19
42	0.823	4.0649E-06	7.61	161.64	350.49	-2.28
43	1.012	-2.7570E-07	-0.52	162.15	350.49	-2.28
44	1.218	-4.0085E-06	-7.50	169.66	350.49	-2.19
45	1.401	-6.3773E-06	-11.94	181.60	350.49	-2.04
46	1.522	-6.6794E-06	-12.50	194.10	350.49	-1.89
47	1.549	-5.0294E-06	-9.42	203.52	350.49	-1.78
48	1.489	-2.3137E-06	-4.33	207.85	350.49	-1.72



Remarks:
Length of revetment
= 520 m

Surface area of lagoon
= 82700 sq. m

Inflow -ve   Outflow +ve

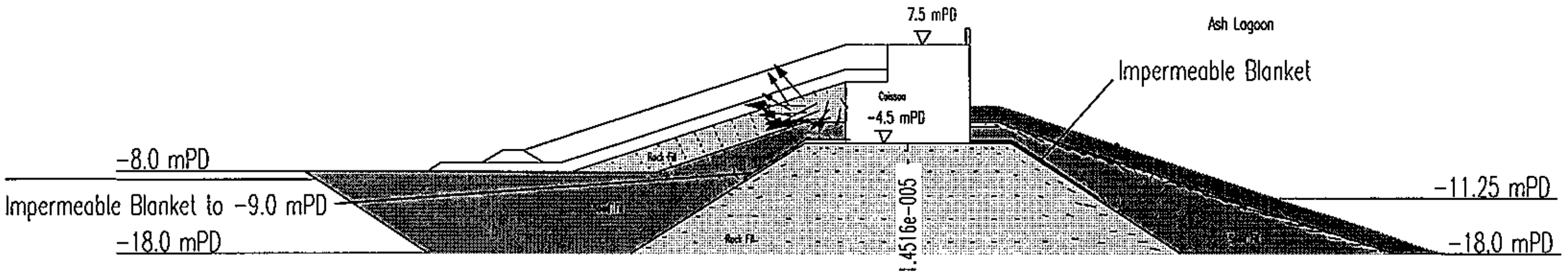
Hongkong Electric Company

Lamma Power Station Ash Lagoon

Neap Tide, initial condition Sea and Lagoon

Water Level at +1.25 mPD

2 metres of PFA on inner slope



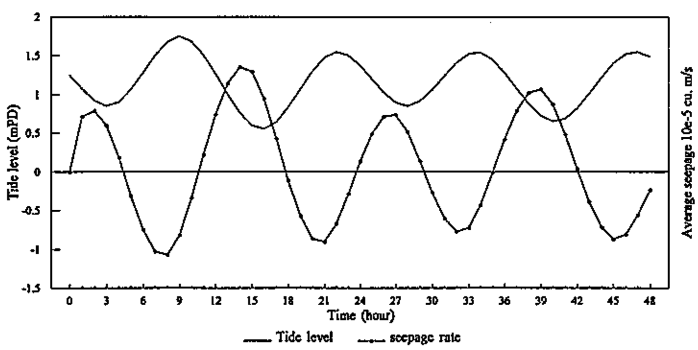
Flux in cu.m/s per m length of seawall

Lamma Power Station Ash Lagoon
Seepage across Caisson and Revetment Seawall

Status of filling: Lagoon full of PFA
Tidal cycle: Neap tide

Effective length of seawall = 520 m   Lagoon surface area 82700 sq.m

Time	Tide level	Flow rate per metre of seawall	Hourly seepage along entire length	Accumulated inflow	Accumulated outflow	Accumulated change in lagoon water level
hour	mPD	cu.m/s	cu. m/h	cu. m	cu. m	mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	1.077	7.1563E-06	13.40	0.00	13.40	-0.54
2	0.925	7.8739E-06	14.74	0.00	28.14	-1.13
3	0.850	5.9766E-06	11.19	0.00	39.32	-1.59
4	0.902	1.7749E-06	3.32	0.00	42.65	-1.72
5	1.062	-3.1128E-06	-5.83	5.83	42.65	-1.48
6	1.279	-7.4584E-06	-13.96	19.79	42.65	-0.92
7	1.501	-1.0278E-05	-19.24	39.03	42.65	-0.15
8	1.675	-1.0732E-05	-20.09	59.12	42.65	0.66
9	1.750	-8.1744E-06	-15.30	74.42	42.65	1.28
10	1.686	-3.3720E-06	-6.31	80.73	42.65	1.54
11	1.509	2.1895E-06	4.10	80.73	46.75	1.37
12	1.265	7.4196E-06	13.89	80.73	60.64	0.81
13	1.001	1.1438E-05	21.41	80.73	82.05	-0.05
14	0.764	1.3500E-05	25.27	80.73	107.32	-1.07
15	0.598	1.2938E-05	24.22	80.73	131.54	-2.05
16	0.552	9.4407E-06	17.67	80.73	149.21	-2.76
17	0.645	4.2830E-06	8.02	80.73	157.23	-3.08
18	0.834	-1.1231E-06	-2.10	82.84	157.23	-3.00
19	1.068	-5.7080E-06	-10.69	93.52	157.23	-2.57
20	1.300	-8.5914E-06	-16.08	109.61	157.23	-1.92
21	1.476	-9.0029E-06	-16.85	126.46	157.23	-1.24
22	1.550	-6.6824E-06	-12.51	138.97	157.23	-0.74
23	1.503	-2.8345E-06	-5.31	144.27	157.23	-0.52
24	1.373	1.3348E-06	2.50	144.27	159.73	-0.62
25	1.200	4.9073E-06	9.19	144.27	168.92	-0.99
26	1.028	7.1444E-06	13.37	144.27	182.29	-1.53
27	0.897	7.3893E-06	13.83	144.27	196.12	-2.09
28	0.850	5.1807E-06	9.70	144.27	205.82	-2.48
29	0.914	1.3816E-06	2.59	144.27	208.41	-2.58
30	1.059	-2.6688E-06	-5.00	149.27	208.41	-2.38
31	1.240	-5.9773E-06	-11.19	160.46	208.41	-1.93
32	1.410	-7.7271E-06	-14.47	174.93	208.41	-1.35
33	1.526	-7.2190E-06	-13.51	188.44	208.41	-0.80
34	1.542	-4.2876E-06	-8.03	196.47	208.41	-0.48
35	1.449	-1.2444E-07	-0.23	196.70	208.41	-0.47
36	1.282	4.2015E-06	7.87	196.70	216.27	-0.79
37	1.080	7.8764E-06	14.74	196.70	231.02	-1.38
38	0.882	1.0226E-05	19.14	196.70	250.16	-2.15
39	0.726	1.0662E-05	19.96	196.70	270.12	-2.96
40	0.652	8.7002E-06	16.29	196.70	286.41	-3.62
41	0.690	4.8469E-06	9.07	196.70	295.48	-3.98
42	0.823	3.3901E-07	0.63	196.70	296.11	-4.01
43	1.012	-3.8982E-06	-7.30	204.00	296.11	-3.71
44	1.218	-7.1242E-06	-13.34	217.33	296.11	-3.18
45	1.401	-8.6993E-06	-16.29	233.62	296.11	-2.52
46	1.522	-8.0926E-06	-15.15	248.77	296.11	-1.91
47	1.549	-5.6308E-06	-10.54	259.31	296.11	-1.48
48	1.489	-2.3468E-06	-4.39	263.70	296.11	-1.31



Remarks:
Length of revetment
= 520 m

Surface area of
lagoon
= 82700 sq. m

Inflow -ve   Outflow +ve

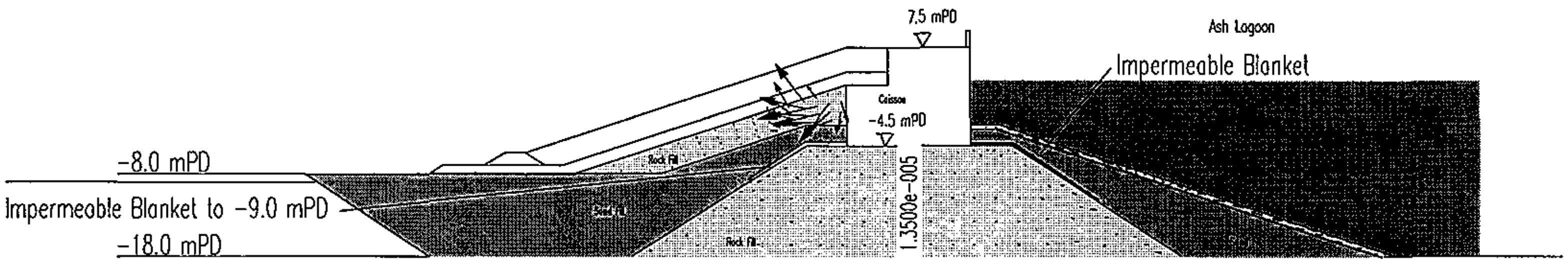
Hongkong Electric Company

Lamma Power Station Ash Lagoon

Neap Tide, initial condition Sea and Lagoon

Water Level = +1.25 mPD

Lagoon full of PFA



Flux in cu.m/s per m length of seawall

APPENDIX D

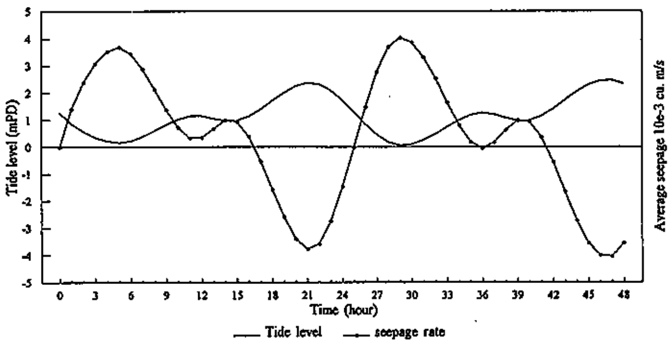
SEEPAGE, NORTHERN PERIMETER

Lamma Power Station Ash Lagoon
Seepage across Northern Perimeter Seawall

Status of filling: No PFA in lagoon
Tidal cycle: Spring tide

Effective length of seawall = 290 m   Lagoon surface area 82700 sq.m

Time	Tide level	Flow rate per metre of seawall	Hourly seepage along entire length	Accumulated inflow	Accumulated outflow	Accumulated change in lagoon water level
hour	mPD	cu.m/s	cu. m/h	cu. m	cu. m	mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	0.854	1.39050E-03	1451.68	0.00	1451.68	-17.55
2	0.556	2.38130E-03	2486.08	0.00	3937.76	-47.61
3	0.344	3.06850E-03	3203.51	0.00	7141.27	-86.35
4	0.205	3.50860E-03	3662.98	0.00	10804.25	-130.64
5	0.146	3.68180E-03	3843.80	0.00	14648.05	-177.12
6	0.214	3.43160E-03	3582.59	0.00	18230.64	-220.44
7	0.377	2.86730E-03	2993.46	0.00	21224.10	-256.64
8	0.593	2.13060E-03	2224.35	0.00	23448.45	-283.54
9	0.819	1.36490E-03	1424.96	0.00	24873.40	-300.77
10	1.013	7.15480E-04	746.96	0.00	25620.37	-309.80
11	1.132	3.28470E-04	342.92	0.00	25963.29	-313.95
12	1.136	3.41630E-04	356.66	0.00	26319.95	-318.26
13	1.046	6.70980E-04	700.50	0.00	27020.45	-326.73
14	0.957	9.79220E-04	1022.31	0.00	28042.76	-339.09
15	0.969	9.29550E-04	970.45	0.00	29013.21	-350.82
16	1.128	3.72420E-04	388.81	0.00	29402.02	-355.53
17	1.388	-5.26490E-04	-549.66	549.66	29402.02	-348.88
18	1.696	-1.57750E-03	-1646.91	2196.57	29402.02	-328.97
19	1.998	-2.59180E-03	-2705.84	4902.40	29402.02	-296.25
20	2.238	-3.38330E-03	-3532.17	8434.57	29402.02	-253.54
21	2.362	-3.76910E-03	-3934.94	12369.51	29402.02	-205.96
22	2.317	-3.57050E-03	-3727.60	16097.11	29402.02	-160.88
23	2.087	-2.74530E-03	-2866.09	18963.21	29402.02	-126.23
24	1.726	-1.48870E-03	-1554.20	20517.41	29402.02	-107.43
25	1.294	-1.62760E-05	-16.99	20534.40	29402.02	-107.23
26	0.850	1.46820E-03	1532.80	20534.40	30934.82	-125.76
27	0.456	2.76180E-03	2883.32	20534.40	33818.14	-160.63
28	0.172	3.67210E-03	3833.67	20534.40	37651.81	-206.98
29	0.052	4.02800E-03	4205.23	20534.40	41857.04	-257.83
30	0.093	3.85670E-03	4026.39	20534.40	45883.43	-306.52
31	0.251	3.30270E-03	3448.02	20534.40	49331.45	-348.21
32	0.482	2.51050E-03	2620.96	20534.40	51952.42	-379.90
33	0.742	1.62710E-03	1698.69	20534.40	53651.11	-400.44
34	0.986	8.03460E-04	838.81	20534.40	54489.92	-410.59
35	1.170	1.92590E-04	201.06	20534.40	54690.98	-413.02
36	1.250	-5.28800E-05	-55.21	20589.61	54690.98	-412.35
37	1.195	1.62080E-04	169.21	20589.61	54860.20	-414.40
38	1.068	6.15160E-04	642.23	20589.61	55502.42	-422.16
39	0.962	9.77390E-04	1020.40	20589.61	56522.82	-434.50
40	0.970	9.34120E-04	975.22	20589.61	57498.04	-446.29
41	1.132	3.61570E-04	377.48	20589.61	57875.52	-450.86
42	1.401	-5.66530E-04	-591.46	21181.06	57875.52	-443.71
43	1.720	-1.65710E-03	-1730.01	22911.08	57875.52	-422.79
44	2.035	-2.71730E-03	-2836.86	25747.94	57875.52	-388.48
45	2.289	-3.55730E-03	-3713.82	29461.76	57875.52	-343.58
46	2.428	-3.99070E-03	-4166.29	33628.05	57875.52	-293.20
47	2.456	-4.04710E-03	-4225.17	37853.22	57875.52	-242.11
48	2.321	-3.54730E-03	-3703.38	41556.60	57875.52	-197.33



Remarks:
Length of seawall
= 290 m

Surface area of
lagoon
= 82700 sq. m

Inflow -ve   Outflow +ve

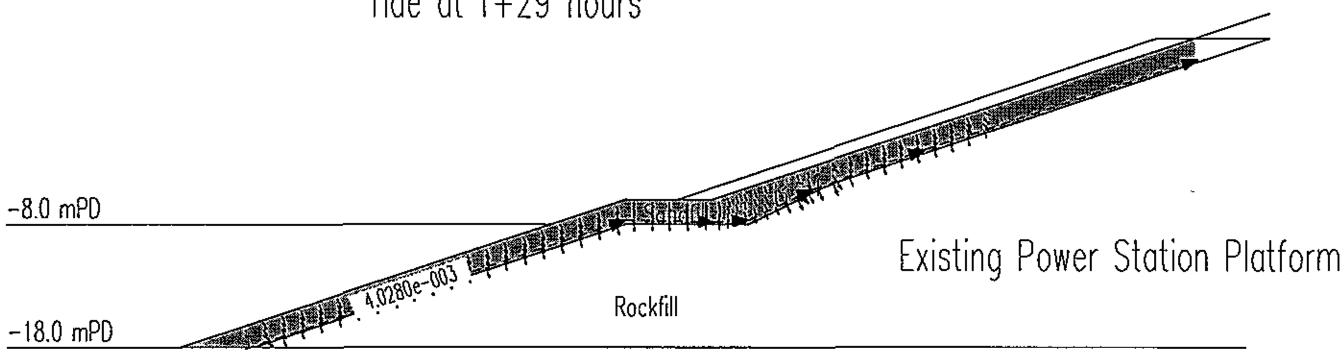
Hongkong Elecric Company

Lamma Power Station Ash Lagoon

Initial condition water level +1.25 mPD

Spring Tide   No PFA in lagoon

Tide at T+29 hours



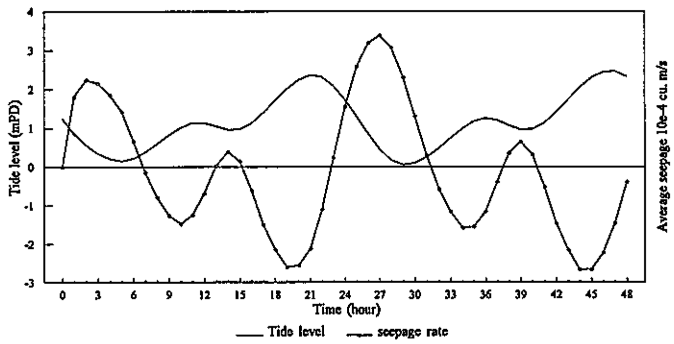
Lamma Power Station Ash Lagoon
Seepage across Northern Perimeter Seawall

Status of filling: 2m thick of PFA on inner slope of seawall
Tidal cycle: Spring tide

Effective length of seawall = 290 m

Lagoon surface area 82700 sq.m

Time hour	Tide level mPD	Flow rate per metre of seawall cu.m/s	Hourly seepage along entire length cu. m/h	Accumulated inflow cu. m	Accumulated outflow cu. m	Accumulated change in lagoon water level mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	0.854	1.80740E-04	188.69	0.00	188.69	-2.28
2	0.556	2.24150E-04	234.01	0.00	422.71	-5.11
3	0.344	2.15210E-04	224.68	0.00	647.38	-7.83
4	0.205	1.84420E-04	192.53	0.00	839.92	-10.16
5	0.146	1.40960E-04	147.16	0.00	987.08	-11.94
6	0.214	6.55360E-05	68.42	0.00	1055.50	-12.76
7	0.377	-1.48480E-05	-15.50	15.50	1055.50	-12.58
8	0.593	-7.97310E-05	-83.24	98.74	1055.50	-11.57
9	0.819	-1.26220E-04	-131.77	230.51	1055.50	-9.98
10	1.013	-1.47690E-04	-154.19	384.70	1055.50	-8.11
11	1.132	-1.24810E-04	-130.30	515.00	1055.50	-6.54
12	1.136	-6.83740E-05	-71.38	586.39	1055.50	-5.67
13	1.046	1.82180E-06	1.90	586.39	1057.40	-5.70
14	0.957	3.86590E-05	40.36	586.39	1097.76	-6.18
15	0.969	1.48790E-05	15.53	586.39	1113.30	-6.37
16	1.128	-6.10620E-05	-63.75	650.14	1113.30	-5.60
17	1.388	-1.50110E-04	-156.71	806.85	1113.30	-3.71
18	1.696	-2.14330E-04	-223.76	1030.61	1113.30	-1.00
19	1.998	-2.60560E-04	-272.02	1302.64	1113.30	2.29
20	2.238	-2.56420E-04	-267.70	1570.34	1113.30	5.53
21	2.362	-2.12570E-04	-221.92	1792.26	1113.30	8.21
22	2.317	-1.09430E-04	-114.24	1906.51	1113.30	9.59
23	2.087	2.34350E-05	24.47	1906.51	1137.76	9.30
24	1.726	1.55320E-04	162.15	1906.51	1299.92	7.33
25	1.294	2.57850E-04	269.20	1906.51	1569.11	4.08
26	0.850	3.18090E-04	332.09	1906.51	1901.20	0.06
27	0.456	3.38580E-04	353.48	1906.51	2254.68	-4.21
28	0.172	3.07530E-04	321.06	1906.51	2575.74	-8.09
29	0.052	2.30300E-04	240.43	1906.51	2816.17	-11.00
30	0.093	1.30050E-04	135.77	1906.51	2951.94	-12.64
31	0.251	2.93340E-05	30.62	1906.51	2982.57	-13.01
32	0.482	-5.79520E-05	-60.50	1967.01	2982.57	-12.28
33	0.742	-1.16810E-04	-121.95	2088.96	2982.57	-10.81
34	0.986	-1.58270E-04	-165.23	2254.19	2982.57	-8.81
35	1.170	-1.54610E-04	-161.41	2415.60	2982.57	-6.86
36	1.250	-1.15780E-04	-120.87	2536.48	2982.57	-5.39
37	1.195	-3.91040E-05	-40.82	2577.30	2982.57	-4.90
38	1.068	3.50340E-05	36.58	2577.30	3019.14	-5.34
39	0.962	6.46670E-05	67.51	2577.30	3086.65	-6.16
40	0.970	3.11600E-05	32.53	2577.30	3119.19	-6.55
41	1.132	-5.26790E-05	-55.00	2632.30	3119.19	-5.89
42	1.401	-1.47540E-04	-154.03	2786.33	3119.19	-4.02
43	1.720	-2.16200E-04	-225.71	3012.04	3119.19	-1.30
44	2.035	-2.67360E-04	-279.12	3291.17	3119.19	2.08
45	2.289	-2.66910E-04	-278.65	3569.82	3119.19	5.45
46	2.428	-2.23610E-04	-233.45	3803.27	3119.19	8.27
47	2.456	-1.45940E-04	-152.36	3955.63	3119.19	10.11
48	2.321	-3.96230E-05	-41.37	3997.00	3119.19	10.61



Remarks:
Length of seawall
= 290 m

Surface area of
lagoon
= 82700 sq. m

Inflow -ve Outflow +ve

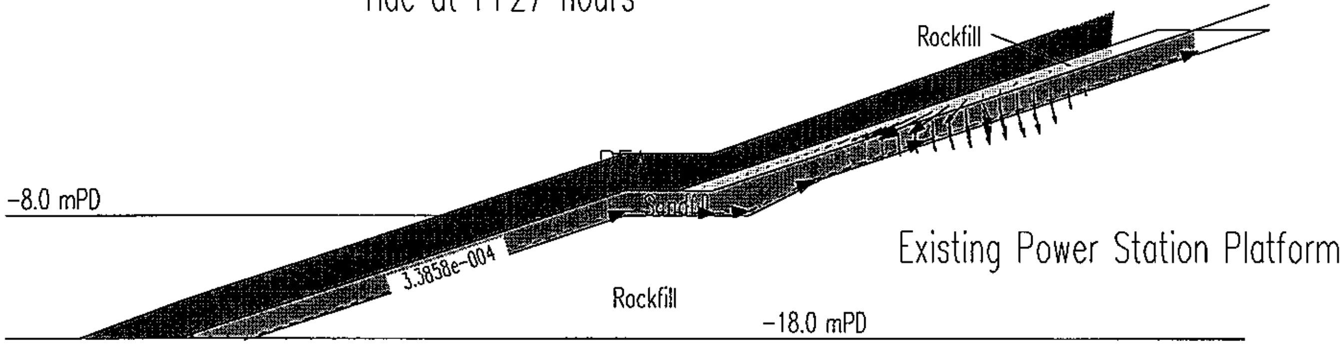
Hongkong Elecric Company

Lamma Power Station Ash Lagoon

Initial condition water level +1.25 mPD

Spring Tide 2m of PFA in lagoon

Tide at T+27 hours

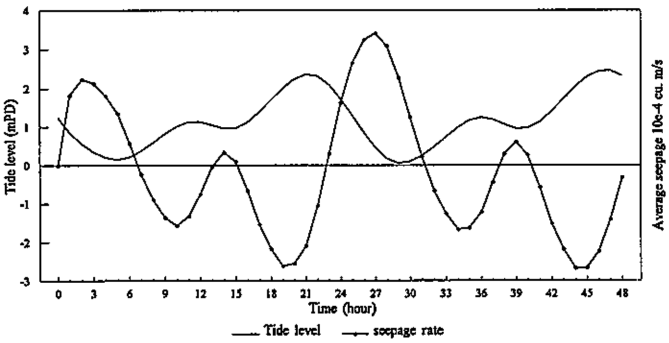


Lamma Power Station Ash Lagoon
Seepage across Northern Perimeter Seawall

Status of filling: Lagoon full of PFA
Tidal cycle: Spring tide

Effective length of seawall = 290 m   Lagoon surface area 82700 sq.m

Time	Tide level	Flow rate per metre of seawall	Hourly seepage along entire length	Accumulated inflow	Accumulated outflow	Accumulated change in lagoon water level
hour	mPD	cu.m/s	cu. m/h	cu. m	cu. m	mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	0.854	1.82260E-04	190.28	0.00	190.28	-7.67
2	0.556	2.23250E-04	233.07	0.00	423.35	-17.06
3	0.344	2.12500E-04	221.85	0.00	645.20	-26.01
4	0.205	1.79840E-04	187.75	0.00	832.96	-33.57
5	0.146	1.34550E-04	140.47	0.00	973.43	-39.24
6	0.214	5.75430E-05	60.07	0.00	1033.50	-41.66
7	0.377	-2.39630E-05	-25.02	25.02	1033.50	-40.65
8	0.593	-8.93570E-05	-93.29	118.31	1033.50	-36.89
9	0.819	-1.35670E-04	-141.64	259.95	1033.50	-31.18
10	1.013	-1.56500E-04	-163.39	423.33	1033.50	-24.59
11	1.132	-1.32630E-04	-138.47	561.80	1033.50	-19.01
12	1.136	-7.51270E-05	-78.43	640.23	1033.50	-15.85
13	1.046	-4.09520E-06	-4.28	644.51	1033.50	-15.68
14	0.957	3.32430E-05	34.71	644.51	1068.21	-17.08
15	0.969	9.72890E-06	10.16	644.51	1078.36	-17.49
16	1.128	-6.59110E-05	-68.81	713.32	1078.36	-14.71
17	1.388	-1.54330E-04	-161.12	874.44	1078.36	-8.22
18	1.696	-2.17410E-04	-226.98	1101.41	1078.36	0.93
19	1.998	-2.61960E-04	-273.49	1374.90	1078.36	11.95
20	2.238	-2.55720E-04	-266.97	1641.87	1078.36	22.71
21	2.362	-2.09630E-04	-218.85	1860.72	1078.36	31.53
22	2.317	-1.04440E-04	-109.04	1969.76	1078.36	35.93
23	2.087	2.99050E-05	31.22	1969.76	1109.58	34.67
24	1.726	1.62440E-04	169.59	1969.76	1279.17	27.84
25	1.294	2.64630E-04	276.27	1969.76	1555.45	16.70
26	0.850	3.23510E-04	337.74	1969.76	1893.19	3.09
27	0.456	3.41810E-04	356.85	1969.76	2250.04	-11.30
28	0.172	3.08020E-04	321.57	1969.76	2571.61	-24.26
29	0.052	2.27930E-04	237.96	1969.76	2809.57	-33.85
30	0.093	1.25080E-04	130.58	1969.76	2940.15	-39.11
31	0.251	2.23720E-05	23.36	1969.76	2963.51	-40.05
32	0.482	-6.61680E-05	-69.08	2038.84	2963.51	-37.27
33	0.742	-1.25400E-04	-130.92	2169.76	2963.51	-31.99
34	0.986	-1.66510E-04	-173.84	2343.59	2963.51	-24.99
35	1.170	-1.61990E-04	-169.12	2512.71	2963.51	-18.17
36	1.250	-1.22010E-04	-127.38	2640.09	2963.51	-13.04
37	1.195	-4.42890E-05	-46.24	2686.33	2963.51	-11.17
38	1.068	3.05740E-05	31.92	2686.33	2995.43	-12.46
39	0.962	6.05240E-05	63.19	2686.33	3058.62	-15.01
40	0.970	2.70820E-05	28.27	2686.33	3086.89	-16.15
41	1.132	-5.66340E-05	-59.13	2745.45	3086.89	-13.76
42	1.401	-1.51040E-04	-157.69	2903.14	3086.89	-7.41
43	1.720	-2.18130E-04	-227.73	3130.87	3086.89	1.77
44	2.035	-2.68130E-04	-279.93	3410.79	3086.89	13.06
45	2.289	-2.65590E-04	-277.28	3688.07	3086.89	24.23
46	2.428	-2.23001E-04	-232.81	3920.88	3086.89	33.62
47	2.456	-1.40190E-04	-146.36	4067.24	3086.89	39.51
48	2.321	-3.21070E-05	-33.52	4100.76	3086.89	40.87



Remarks:
Length of seawall = 290 m

Surface area of lagoon = 82700 sq. m

Inflow -ve   Outflow +ve

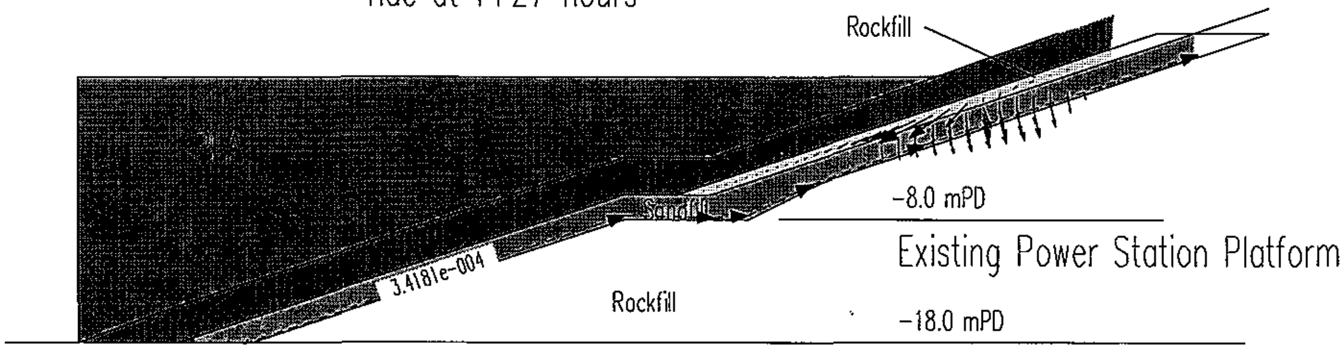
Hongkong Elecric Company

Lamma Power Station Ash Lagoon

Initial condition water level +1.25 mPD

Spring Tide   Lagoon full of PFA

Tide at T+27 hours



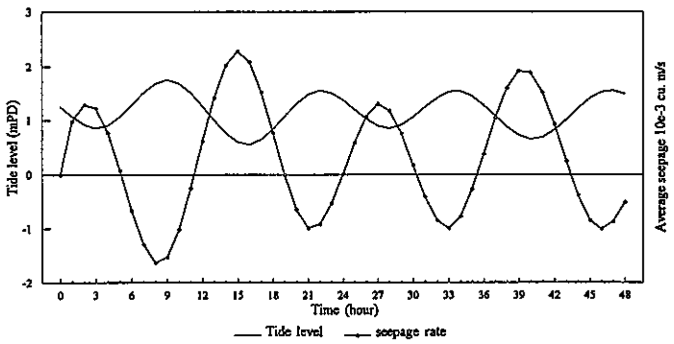
Lamma Power Station Ash Lagoon
Seepage across Northern Perimeter Seawall

Status of filling: No PFA in lagoon
Tidal cycle: Neap tide

Effective length of seawall = 290 m

Lagoon surface area 82700 sq.m

Time	Tide level	Flow rate per metre of seawall	Hourly seepage along entire length	Accumulated inflow	Accumulated outflow	Accumulated change in lagoon water level
hour	mPD	cu.m/s	cu. m/h	cu. m	cu. m	mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	1.077	9.79050E-04	1022.13	0.00	1022.13	-12.36
2	0.925	1.28690E-03	1343.52	0.00	2365.65	-28.61
3	0.850	1.21950E-03	1273.16	0.00	3638.81	-44.00
4	0.902	7.61220E-04	794.71	0.00	4433.52	-53.61
5	1.062	7.71610E-05	80.56	0.00	4514.08	-54.58
6	1.279	-6.62040E-04	-691.17	691.17	4514.08	-46.23
7	1.501	-1.28630E-03	-1342.90	2034.07	4514.08	-29.99
8	1.675	-1.62610E-03	-1697.65	3731.72	4514.08	-9.46
9	1.750	-1.52690E-03	-1594.08	5325.80	4514.08	9.82
10	1.686	-1.01500E-03	-1059.66	6385.46	4514.08	22.63
11	1.509	-2.50440E-04	-261.46	6646.92	4514.08	25.79
12	1.265	6.10290E-04	637.14	6646.92	5151.22	18.09
13	1.001	1.41600E-03	1478.30	6646.92	6629.53	0.21
14	0.764	2.01940E-03	2108.25	6646.92	8737.78	-25.28
15	0.598	2.27630E-03	2376.46	6646.92	11114.24	-54.02
16	0.552	2.07760E-03	2169.01	6646.92	13283.25	-80.25
17	0.645	1.52110E-03	1588.03	6646.92	14871.28	-99.45
18	0.834	7.71420E-04	805.36	6646.92	15676.64	-109.19
19	1.068	-7.25190E-06	-7.57	6654.49	15676.64	-109.09
20	1.300	-6.48720E-04	-677.26	7331.75	15676.64	-100.91
21	1.476	-9.88560E-04	-1032.06	8363.81	15676.64	-88.43
22	1.550	-9.20100E-04	-960.58	9324.39	15676.64	-76.81
23	1.503	-5.37930E-04	-561.60	9885.99	15676.64	-70.02
24	1.373	1.31020E-05	13.68	9885.99	15690.32	-70.19
25	1.200	5.93000E-04	619.09	9885.99	16309.41	-77.67
26	1.028	1.06770E-03	1114.68	9885.99	17424.09	-91.15
27	0.897	1.30340E-03	1360.75	9885.99	18784.84	-107.60
28	0.850	1.18260E-03	1234.63	9885.99	20019.48	-122.53
29	0.914	7.57080E-04	790.39	9885.99	20809.87	-132.09
30	1.059	1.77400E-04	185.21	9885.99	20995.07	-134.33
31	1.240	-4.07070E-04	-424.98	10310.97	20995.07	-129.19
32	1.410	-8.47560E-04	-884.85	11195.83	20995.07	-118.49
33	1.526	-9.96070E-04	-1039.90	12235.72	20995.07	-105.92
34	1.542	-7.66880E-04	-800.62	13036.35	20995.07	-96.24
35	1.449	-2.62530E-04	-274.08	13310.43	20995.07	-92.92
36	1.282	3.83940E-04	400.83	13310.43	21395.91	-97.77
37	1.080	1.04470E-03	1090.67	13310.43	22486.57	-110.96
38	0.882	1.59530E-03	1665.49	13310.43	24152.07	-131.10
39	0.726	1.91370E-03	1997.90	13310.43	26149.97	-155.25
40	0.652	1.88400E-03	1966.90	13310.43	28116.86	-179.04
41	0.690	1.51260E-03	1579.15	13310.43	29696.02	-198.13
42	0.823	9.25890E-04	966.63	13310.43	30662.65	-209.82
43	1.012	2.52020E-04	263.11	13310.43	30925.76	-213.00
44	1.218	-3.79710E-04	-396.42	13706.85	30925.76	-208.21
45	1.401	-8.40710E-04	-877.70	14584.55	30925.76	-197.60
46	1.522	-1.00730E-03	-1051.62	15636.17	30925.76	-184.88
47	1.549	-8.64230E-04	-902.26	16538.42	30925.76	-173.97
48	1.489	-5.12440E-04	-534.99	17073.41	30925.76	-167.50



Remarks:
Length of seawall
= 290 m

Surface area of
lagoon
= 82700 sq. m

Inflow -ve Outflow +ve

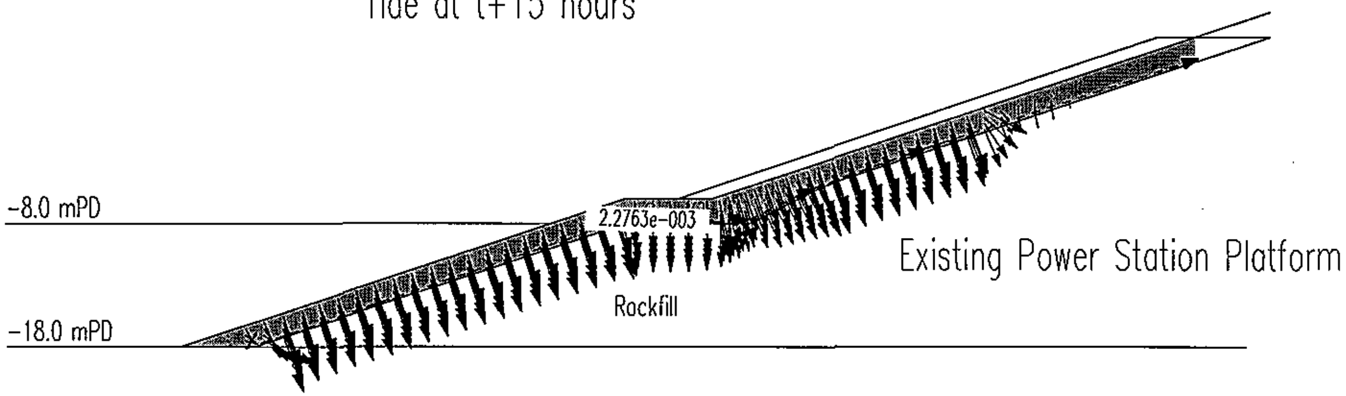
Hongkong Elecric Company

Lamma Power Station Ash Lagoon

Initial condition water level +1.25 mPD

Neap Tide   No PFA in lagoon

Tide at t+15 hours

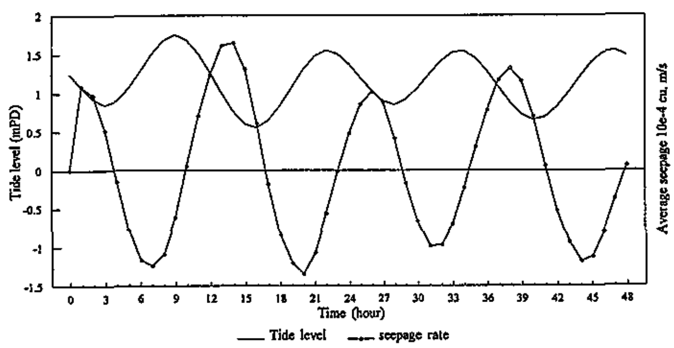


Lamma Power Station Ash Lagoon
Seepage across Northern Perimeter Seawall

Status of filling: 2m thick of PFA on inner slope of seawall
Tidal cycle: Neap tide

Effective length of seawall = 290 m   Lagoon surface area 82700 sq.m

Time hour	Tide level mPD	Flow rate per metre of seawall cu.m/s	Hourly seepage along entire length cu. m/h	Accumulated inflow cu. m	Accumulated outflow cu. m	Accumulated change in lagoon water level mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	1.077	1.08540E-04	113.32	0.00	113.32	-1.37
2	0.925	9.73310E-05	101.61	0.00	214.93	-2.60
3	0.850	5.20730E-05	54.36	0.00	269.29	-3.26
4	0.902	-1.51810E-05	-15.85	15.85	269.29	-3.06
5	1.062	-7.69350E-05	-80.32	96.17	269.29	-2.09
6	1.279	-1.16510E-04	-121.64	217.81	269.29	-0.62
7	1.501	-1.24120E-04	-129.58	347.39	269.29	0.94
8	1.675	-1.09270E-04	-114.08	461.46	269.29	2.32
9	1.750	-6.17550E-05	-64.47	525.94	269.29	3.10
10	1.686	5.22450E-06	5.45	525.94	274.75	3.04
11	1.509	7.07010E-05	73.81	525.94	348.56	2.14
12	1.265	1.23700E-04	129.14	525.94	477.70	0.58
13	1.001	1.61280E-04	168.38	525.94	646.08	-1.45
14	0.764	1.64750E-04	172.00	525.94	818.08	-3.53
15	0.598	1.31430E-04	137.21	525.94	955.29	-5.19
16	0.552	6.08450E-05	63.52	525.94	1018.81	-5.96
17	0.645	-1.88190E-05	-19.65	545.58	1018.81	-5.72
18	0.834	-8.35240E-05	-87.20	632.78	1018.81	-4.67
19	1.068	-1.20210E-04	-125.50	758.28	1018.81	-3.15
20	1.300	-1.34420E-04	-140.33	898.62	1018.81	-1.45
21	1.476	-1.06700E-04	-111.39	1010.01	1018.81	-0.11
22	1.550	-5.67360E-05	-59.23	1069.24	1018.81	0.61
23	1.503	-1.60130E-06	-1.67	1070.92	1018.81	0.63
24	1.373	4.80300E-05	50.14	1070.92	1068.96	0.02
25	1.200	8.54610E-05	89.22	1070.92	1158.18	-1.06
26	1.028	1.01920E-04	106.40	1070.92	1264.58	-2.34
27	0.897	8.81130E-05	91.99	1070.92	1356.57	-3.45
28	0.850	4.14500E-05	43.27	1070.92	1399.85	-3.98
29	0.914	-1.70090E-05	-17.76	1088.67	1399.85	-3.76
30	1.059	-6.65050E-05	-69.43	1158.10	1399.85	-2.92
31	1.240	-9.81770E-05	-102.50	1260.60	1399.85	-1.68
32	1.410	-9.67720E-05	-101.03	1361.63	1399.85	-0.46
33	1.526	-6.99240E-05	-73.00	1434.63	1399.85	0.42
34	1.542	-2.32630E-05	-24.29	1458.92	1399.85	0.71
35	1.449	3.04400E-05	31.78	1458.92	1431.63	0.33
36	1.282	7.85130E-05	81.97	1458.92	1513.59	-0.66
37	1.080	1.17190E-04	122.35	1458.92	1635.94	-2.14
38	0.882	1.32160E-04	137.98	1458.92	1773.91	-3.81
39	0.726	1.16030E-04	121.14	1458.92	1895.05	-5.27
40	0.652	7.02080E-05	73.30	1458.92	1968.35	-6.16
41	0.690	5.86520E-06	6.12	1458.92	1974.47	-6.23
42	0.823	-5.23930E-05	-54.70	1513.62	1974.47	-5.57
43	1.012	-9.30120E-05	-97.10	1610.72	1974.47	-4.40
44	1.218	-1.18050E-04	-123.24	1733.97	1974.47	-2.91
45	1.401	-1.12210E-04	-117.15	1851.11	1974.47	-1.49
46	1.522	-7.98130E-05	-83.32	1934.44	1974.47	-0.48
47	1.549	-3.76830E-05	-39.34	1973.78	1974.47	-0.01
48	1.489	6.14930E-06	6.42	1973.78	1980.89	-0.09



Remarks:
Length of seawall
= 290 m

Surface area of lagoon
= 82700 sq. m

Inflow -ve   Ouflow +ve

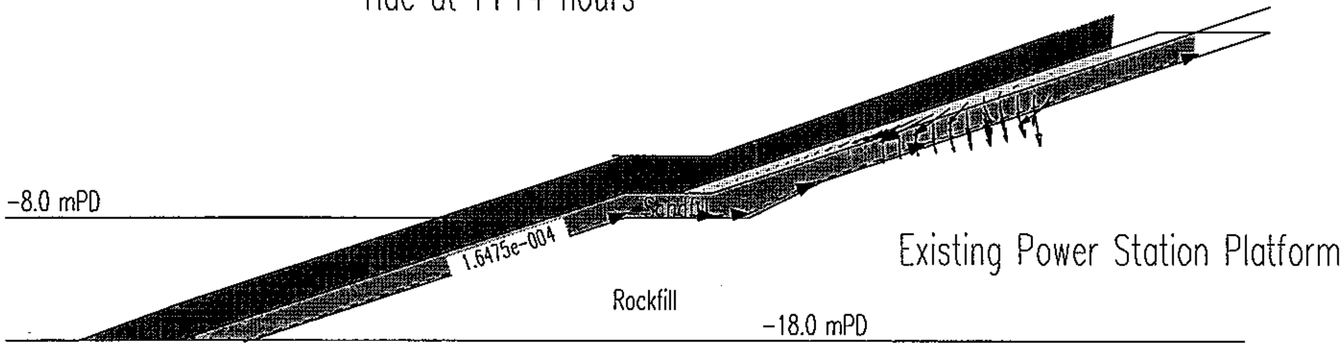
Hongkong Elecric Company

Lamma Power Station Ash Lagoon

Initial condition water level +1.25 mPD

Neap Tide   2m of PFA in lagoon

Tide at T+14 hours



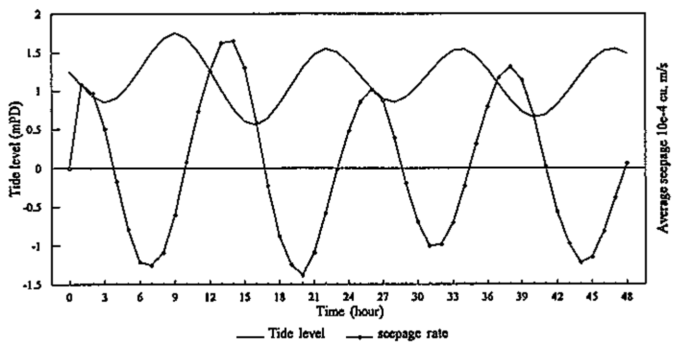
Lamma Power Station Ash Lagoon
Seepage across Northern Perimeter Seawall

Status of filling: Lagoon full of PFA
Tidal cycle: Neap tide

Effective length of seawall = 290 m

Lagoon surface area 82700 sq.m

Time	Tide level	Flow rate per metre of seawall	Hourly seepage along entire length	Accumulated inflow	Accumulated outflow	Accumulated change in lagoon water level
hour	mPD	cu.m/s	cu. m/h	cu. m	cu. m	mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	1.077	1.08260E-04	113.02	0.00	113.02	-4.56
2	0.925	9.64360E-05	100.68	0.00	213.70	-8.61
3	0.850	5.04520E-05	52.67	0.00	266.37	-10.74
4	0.902	-1.73470E-05	-18.11	18.11	266.37	-10.01
5	1.062	-7.92280E-05	-82.71	100.82	266.37	-6.67
6	1.279	-1.21420E-04	-126.76	227.59	266.37	-1.56
7	1.501	-1.25180E-04	-130.69	358.27	266.37	3.70
8	1.675	-1.09180E-04	-113.98	472.26	266.37	8.30
9	1.750	-6.05150E-05	-63.18	535.44	266.37	10.84
10	1.686	7.31010E-06	7.63	535.44	274.01	10.54
11	1.509	7.31130E-05	76.33	535.44	350.34	7.46
12	1.265	1.25810E-04	131.35	535.44	481.68	2.17
13	1.001	1.62500E-04	169.65	535.44	651.33	-4.67
14	0.764	1.64640E-04	171.88	535.44	823.22	-11.60
15	0.598	1.29790E-04	135.50	535.44	958.72	-17.06
16	0.552	5.78000E-05	60.34	535.44	1019.06	-19.49
17	0.645	-2.28650E-05	-23.87	559.31	1019.06	-18.53
18	0.834	-8.79960E-05	-91.87	651.18	1019.06	-14.83
19	1.068	-1.24440E-04	-129.92	781.09	1019.06	-9.59
20	1.300	-1.37890E-04	-143.96	925.05	1019.06	-3.79
21	1.476	-1.09080E-04	-113.88	1038.93	1019.06	0.80
22	1.550	-5.79970E-05	-60.55	1099.48	1019.06	3.24
23	1.503	-1.99800E-06	-2.09	1101.56	1019.06	3.33
24	1.373	4.80610E-05	50.18	1101.56	1069.24	1.30
25	1.200	8.54350E-05	89.19	1101.56	1158.43	-2.29
26	1.028	1.01420E-04	105.88	1101.56	1264.31	-6.56
27	0.897	8.68750E-05	90.70	1101.56	1355.01	-10.22
28	0.850	3.94600E-05	41.20	1101.56	1396.21	-11.88
29	0.914	-1.95210E-05	-20.38	1121.94	1396.21	-11.05
30	1.059	-6.91390E-05	-72.18	1194.12	1396.21	-8.15
31	1.240	-1.00490E-04	-104.91	1299.03	1396.21	-3.92
32	1.410	-9.84010E-05	-102.73	1401.77	1396.21	0.22
33	1.526	-7.06800E-05	-73.79	1475.56	1396.21	3.20
34	1.542	-2.32250E-05	-24.25	1499.80	1396.21	4.18
35	1.449	3.09620E-05	32.32	1499.80	1428.53	2.87
36	1.282	7.90580E-05	82.54	1499.80	1511.07	-0.45
37	1.080	1.17280E-04	122.44	1499.80	1633.51	-5.39
38	0.882	1.31380E-04	137.16	1499.80	1770.67	-10.92
39	0.726	1.14130E-04	119.15	1499.80	1889.82	-15.72
40	0.652	6.71860E-05	70.14	1499.80	1959.96	-18.55
41	0.690	1.95560E-06	2.04	1499.80	1962.00	-18.63
42	0.823	-5.67660E-05	-59.26	1559.07	1962.00	-16.24
43	1.012	-9.73080E-05	-101.59	1660.66	1962.00	-12.15
44	1.218	-1.21770E-04	-127.13	1787.78	1962.00	-7.02
45	1.401	-1.15010E-04	-120.07	1907.85	1962.00	-2.18
46	1.522	-8.15280E-05	-85.12	1992.97	1962.00	1.25
47	1.549	-3.83980E-05	-40.09	2033.06	1962.00	2.86
48	1.489	6.14930E-06	6.42	2033.06	1968.42	2.61



Remarks:
Length of seawall = 290 m

Surface area of lagoon = 82700 sq. m

Inflow -ve Outflow +ve

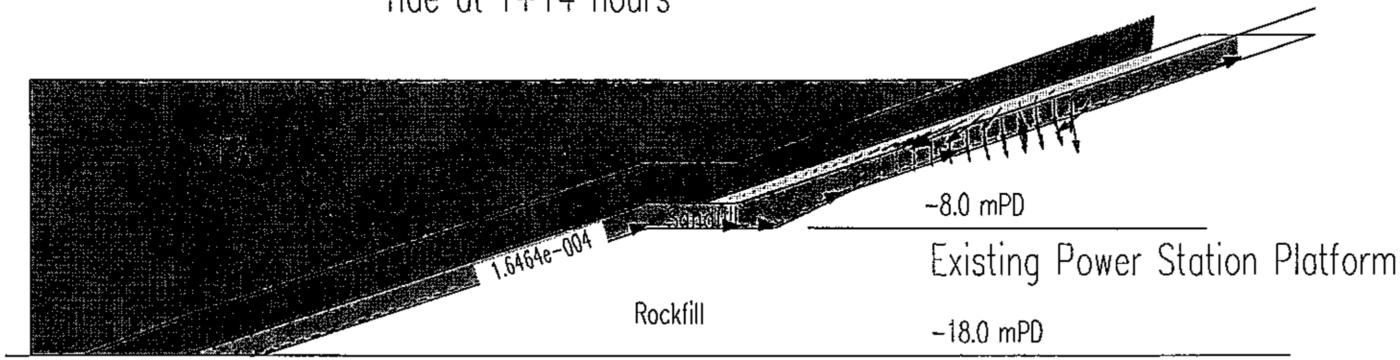
Hongkong Elecric Company

Lamma Power Station Ash Lagoon

Initial condition water level +1.25 mPD

Neap Tide   Lagoon full of PFA

Tide at T+14 hours



APPENDIX E

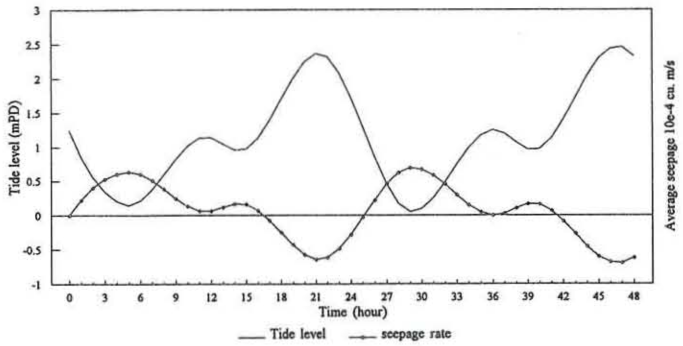
SEEPAGE, EAST WHARF SECTION

Lamma Power Station Ash Lagoon
Seepage across Eastern Wharf Seawall

Status of filling: No PFA in lagoon
Tidal cycle: Spring tide

Effective length of seawall = 160 m   Lagoon surface area 82700 sq.m

Time hour	Tide level mPD	Flow rate per metre of seawall cu.m/s	Hourly seepage along entire length cu. m/h	Accumulated inflow cu. m	Accumulated outflow cu. m	Accumulated change in lagoon water level mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	0.854	2.23170E-05	12.85	0.00	12.85	-0.16
2	0.556	4.05020E-05	23.33	0.00	36.18	-0.44
3	0.344	5.27700E-05	30.40	0.00	66.58	-0.81
4	0.205	6.03800E-05	34.78	0.00	101.36	-1.23
5	0.146	6.37220E-05	36.70	0.00	138.06	-1.67
6	0.214	6.01780E-05	34.66	0.00	172.72	-2.09
7	0.377	5.12420E-05	29.52	0.00	202.24	-2.45
8	0.593	3.84380E-05	22.14	0.00	224.38	-2.71
9	0.819	2.48230E-05	14.30	0.00	238.68	-2.89
10	1.013	1.35410E-05	7.80	0.00	246.48	-2.98
11	1.132	6.67990E-06	3.85	0.00	250.33	-3.03
12	1.136	6.48950E-06	3.74	0.00	254.06	-3.07
13	1.046	1.17270E-05	6.75	0.00	260.82	-3.15
14	0.957	1.69710E-05	9.78	0.00	270.59	-3.27
15	0.969	1.62910E-05	9.38	0.00	279.98	-3.39
16	1.128	7.05220E-06	4.06	0.00	284.04	-3.43
17	1.388	-7.50260E-06	-4.32	4.32	284.04	-3.38
18	1.696	-2.48580E-05	-14.32	18.64	284.04	-3.21
19	1.998	-4.29880E-05	-24.76	43.40	284.04	-2.91
20	2.238	-5.72340E-05	-32.97	76.37	284.04	-2.51
21	2.362	-6.42530E-05	-37.01	113.38	284.04	-2.06
22	2.317	-6.16710E-05	-35.52	148.90	284.04	-1.63
23	2.087	-4.87160E-05	-28.06	176.96	284.04	-1.29
24	1.726	-2.79800E-05	-16.12	193.08	284.04	-1.10
25	1.294	-2.88180E-06	-1.66	194.74	284.04	-1.08
26	0.850	2.20220E-05	12.68	194.74	296.72	-1.23
27	0.456	4.58320E-05	26.40	194.74	323.12	-1.55
28	0.172	6.20880E-05	35.76	194.74	358.89	-1.98
29	0.052	6.89100E-05	39.69	194.74	398.58	-2.46
30	0.093	6.69720E-05	38.58	194.74	437.15	-2.93
31	0.251	5.83930E-05	33.63	194.74	470.79	-3.34
32	0.482	4.55820E-05	26.26	194.74	497.04	-3.66
33	0.742	2.95090E-05	17.00	194.74	514.04	-3.86
34	0.986	1.50790E-05	8.69	194.74	522.73	-3.97
35	1.170	4.50190E-06	2.59	194.74	525.32	-4.00
36	1.250	3.28900E-08	0.02	194.74	525.34	-4.00
37	1.195	3.02610E-06	1.74	194.74	527.08	-4.02
38	1.068	1.02620E-05	5.91	194.74	532.99	-4.09
39	0.962	1.66920E-05	9.61	194.74	542.61	-4.21
40	0.970	1.62420E-05	9.36	194.74	551.96	-4.32
41	1.132	6.79170E-06	3.91	194.74	555.87	-4.37
42	1.401	-8.21000E-06	-4.73	199.47	555.87	-4.31
43	1.720	-2.62150E-05	-15.10	214.57	555.87	-4.13
44	2.035	-4.52850E-05	-26.08	240.65	555.87	-3.81
45	2.289	-6.01710E-05	-34.66	275.31	555.87	-3.39
46	2.428	-6.80340E-05	-39.19	314.50	555.87	-2.92
47	2.456	-6.95220E-05	-40.04	354.54	555.87	-2.43
48	2.321	-6.20740E-05	-35.75	390.29	555.87	-2.00



Remarks:
Length of seawall = 160 m

Surface area of lagoon = 82700 sq. m

Inflow -ve   Outflow +ve

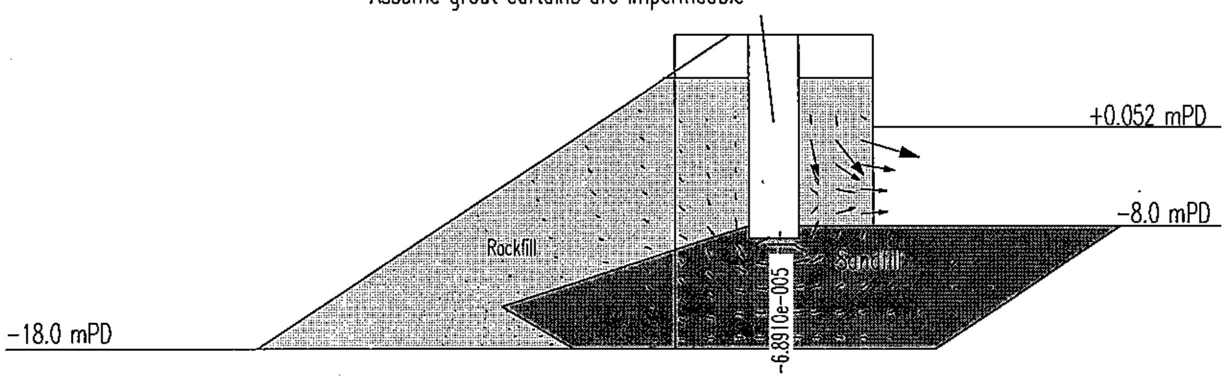
Hongkong Electric Company

Lamma Power Station Ash Lagoon

No PFA in lagoon   Spring Tide

Initial condition water level +1.25 mPD

Tide at T+29



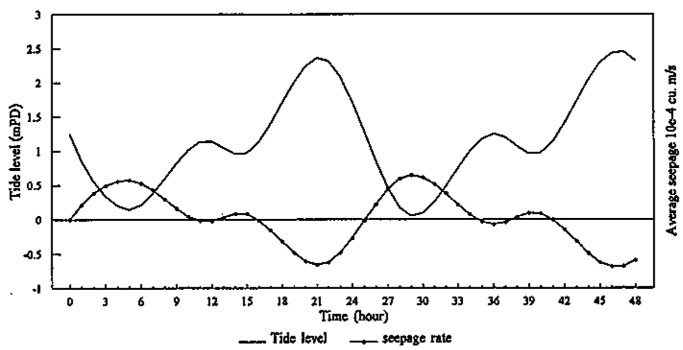
Flux in cu.m/s per metre length of seawall

Lamma Power Station Ash Lagoon
Seepage across Eastern Wharf Seawall

Status of filling: 2m thick of PFA on inner slope of seawall
Tidal cycle: Spring tide

Effective length of seawall = 160 m Lagoon surface area 82700 sq.m

Time	Tide level	Flow rate per metre of seawall	Hourly seepage along entire length	Accumulated inflow	Accumulated outflow	Accumulated change in lagoon water level
hour	mPD	cu.m/s	cu. m/h	cu. m	cu. m	mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	0.854	2.14540E-05	12.36	0.00	12.36	-0.15
2	0.556	3.84670E-05	22.16	0.00	34.51	-0.42
3	0.344	4.94120E-05	28.46	0.00	62.98	-0.76
4	0.205	5.56140E-05	32.03	0.00	95.01	-1.15
5	0.146	5.75660E-05	33.16	0.00	128.17	-1.55
6	0.214	5.28560E-05	30.45	0.00	158.61	-1.92
7	0.377	4.30830E-05	24.82	0.00	183.43	-2.22
8	0.593	2.98220E-05	17.18	0.00	200.61	-2.43
9	0.819	1.60680E-05	9.26	0.00	209.86	-2.54
10	1.013	4.88850E-06	2.82	0.00	212.68	-2.57
11	1.132	-1.76860E-06	-1.02	1.02	212.68	-2.56
12	1.136	-1.83670E-06	-1.06	2.08	212.68	-2.55
13	1.046	3.32700E-06	1.92	2.08	214.59	-2.57
14	0.957	8.38000E-06	4.83	2.08	219.42	-2.63
15	0.969	8.61750E-06	4.96	2.08	224.38	-2.69
16	1.128	-1.36570E-06	-0.79	2.86	224.38	-2.68
17	1.388	-1.52400E-05	-8.78	11.64	224.38	-2.57
18	1.696	-3.14500E-05	-18.12	29.76	224.38	-2.35
19	1.998	-4.80240E-05	-27.66	57.42	224.38	-2.02
20	2.238	-6.05710E-05	-34.89	92.31	224.38	-1.60
21	2.362	-6.59070E-05	-37.96	130.27	224.38	-1.14
22	2.317	-6.18750E-05	-35.64	165.91	224.38	-0.71
23	2.087	-4.79320E-05	-27.61	193.52	224.38	-0.37
24	1.726	-2.68060E-05	-15.44	208.96	224.38	-0.19
25	1.294	-1.98370E-06	-1.14	210.10	224.38	-0.17
26	0.850	2.20580E-05	12.71	210.10	237.09	-0.33
27	0.456	4.44920E-05	25.63	210.10	262.72	-0.64
28	0.172	5.91570E-05	34.07	210.10	296.79	-1.05
29	0.052	6.44030E-05	37.10	210.10	333.89	-1.50
30	0.093	6.10770E-05	35.18	210.10	369.07	-1.92
31	0.251	5.14420E-05	29.63	210.10	398.70	-2.28
32	0.482	3.79660E-05	21.87	210.10	420.57	-2.54
33	0.742	2.16640E-05	12.48	210.10	433.04	-2.70
34	0.986	7.31750E-06	4.21	210.10	437.26	-2.75
35	1.170	-2.97270E-06	-1.71	211.81	437.26	-2.73
36	1.250	-7.13390E-06	-4.11	215.92	437.26	-2.68
37	1.195	-4.01920E-06	-2.32	218.24	437.26	-2.65
38	1.068	3.10120E-06	1.79	218.24	439.05	-2.67
39	0.962	9.28110E-06	5.35	218.24	444.39	-2.73
40	0.970	8.70280E-06	5.01	218.24	449.40	-2.80
41	1.132	-5.09290E-07	-0.29	218.53	449.40	-2.79
42	1.401	-1.48270E-05	-8.54	227.07	449.40	-2.69
43	1.720	-3.16870E-05	-18.25	245.32	449.40	-2.47
44	2.035	-4.92150E-05	-28.35	273.67	449.40	-2.12
45	2.289	-6.23890E-05	-35.94	309.61	449.40	-1.69
46	2.428	-6.85030E-05	-39.46	349.07	449.40	-1.21
47	2.456	-6.83210E-05	-39.35	388.42	449.40	-0.74
48	1.49	-5.94830E-05	-34.26	422.68	449.40	-0.32



Remarks:
Length of seawall = 160 m

Surface area of lagoon = 82700 sq. m

Infow -ve Outflow +ve

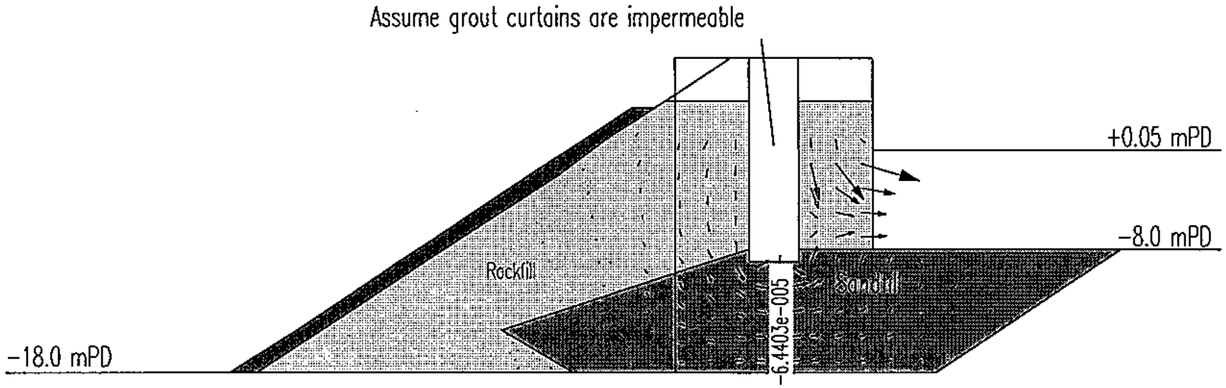
Hongkong Electric Company

Lamma Power Station Ash Lagoon

2m PFA in lagoon   Spring Tide

Initial condition water level +1.25 mPD

Tide at T+29



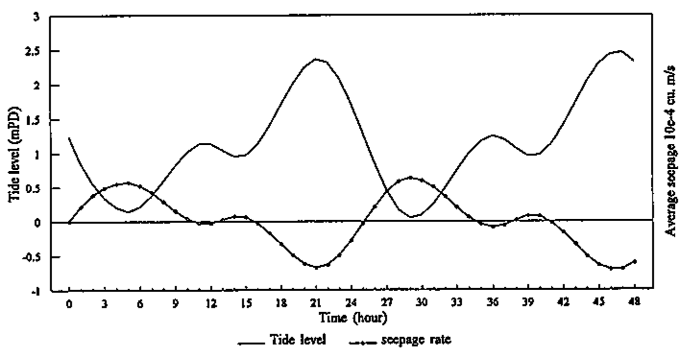
Flux in cu.m/s per metre length of seawall

Lamma Power Station Ash Lagoon
Seepage across Eastern Wharf Seawall

Status of filling: Lagoon full of PFA
Tidal cycle: Spring tide

Effective length of seawall = 160 m   Lagoon surface area 82700 sq.m

Time	Tide level	Flow rate per metre of seawall	Hourly seepage along entire length	Accumulated inflow	Accumulated outflow	Accumulated change in lagoon water level
hour	mPD	cu.m/s	cu. m/h	cu. m	cu. m	mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	0.854	2.14310E-05	12.34	0.00	12.34	-0.50
2	0.556	3.84200E-05	22.13	0.00	34.47	-1.39
3	0.344	4.93260E-05	28.41	0.00	62.89	-2.53
4	0.205	5.54740E-05	31.95	0.00	94.84	-3.82
5	0.146	5.73600E-05	33.04	0.00	127.88	-5.15
6	0.214	5.25810E-05	30.29	0.00	158.16	-6.38
7	0.377	4.27370E-05	24.62	0.00	182.78	-7.37
8	0.593	2.94050E-05	16.94	0.00	199.72	-8.05
9	0.819	1.55770E-05	8.97	0.00	208.69	-8.41
10	1.013	4.32250E-06	2.49	0.00	211.18	-8.51
11	1.132	-2.40770E-06	-1.39	1.39	211.18	-8.46
12	1.136	-2.54270E-06	-1.46	2.85	211.18	-8.40
13	1.046	2.56240E-06	1.48	2.85	212.66	-8.46
14	0.957	7.56020E-06	4.35	2.85	217.01	-8.63
15	0.969	6.73940E-06	3.88	2.85	220.89	-8.79
16	1.128	-2.31230E-06	-1.33	4.18	220.89	-8.73
17	1.388	-1.62640E-05	-9.37	13.55	220.89	-8.36
18	1.696	-3.25400E-05	-18.74	32.29	220.89	-7.60
19	1.998	-4.91090E-05	-28.29	60.58	220.89	-6.46
20	2.238	-6.15980E-05	-35.48	96.06	220.89	-5.03
21	2.362	-6.69080E-05	-38.54	134.60	220.89	-3.48
22	2.317	-6.28530E-05	-36.20	170.80	220.89	-2.02
23	2.087	-4.88850E-05	-28.16	198.96	220.89	-0.88
24	1.726	-2.77380E-05	-15.98	214.94	220.89	-0.24
25	1.294	-2.88800E-06	-1.66	216.60	220.89	-0.17
26	0.850	2.11820E-05	12.20	216.60	233.09	-0.66
27	0.456	4.36300E-05	25.13	216.60	258.23	-1.68
28	0.172	5.82830E-05	33.57	216.60	291.80	-3.03
29	0.052	6.34780E-05	36.56	216.60	328.36	-4.50
30	0.093	6.01110E-05	34.62	216.60	362.98	-5.90
31	0.251	5.04350E-05	29.05	216.60	392.03	-7.07
32	0.482	3.69160E-05	21.26	216.60	413.30	-7.93
33	0.742	2.05630E-05	11.84	216.60	425.14	-8.41
34	0.986	6.15390E-06	3.54	216.60	428.69	-8.55
35	1.170	-4.19860E-06	-2.42	219.02	428.69	-8.45
36	1.250	-8.41110E-06	-4.84	223.87	428.69	-8.26
37	1.195	-5.33160E-06	-3.07	226.94	428.69	-8.13
38	1.068	1.76230E-06	1.02	226.94	429.70	-8.17
39	0.962	7.91590E-06	4.56	226.94	434.26	-8.36
40	0.970	7.30330E-06	4.21	226.94	438.47	-8.53
41	1.132	-1.95750E-06	-1.13	228.06	438.47	-8.48
42	1.401	-1.63290E-05	-9.41	237.47	438.47	-8.10
43	1.720	-3.32070E-05	-19.13	256.60	438.47	-7.33
44	2.035	-5.06750E-05	-29.19	285.79	438.47	-6.15
45	2.289	-6.37830E-05	-36.74	322.52	438.47	-4.67
46	2.428	-6.98680E-05	-40.24	362.77	438.47	-3.05
47	2.456	-6.96520E-05	-40.12	402.89	438.47	-1.43
48	2.321	-6.08030E-05	-35.02	437.91	438.47	-0.02



Remarks:
Length of seawall = 160 m

Surface area of lagoon = 82700 sq. m

Inflow -ve   Outflow +ve

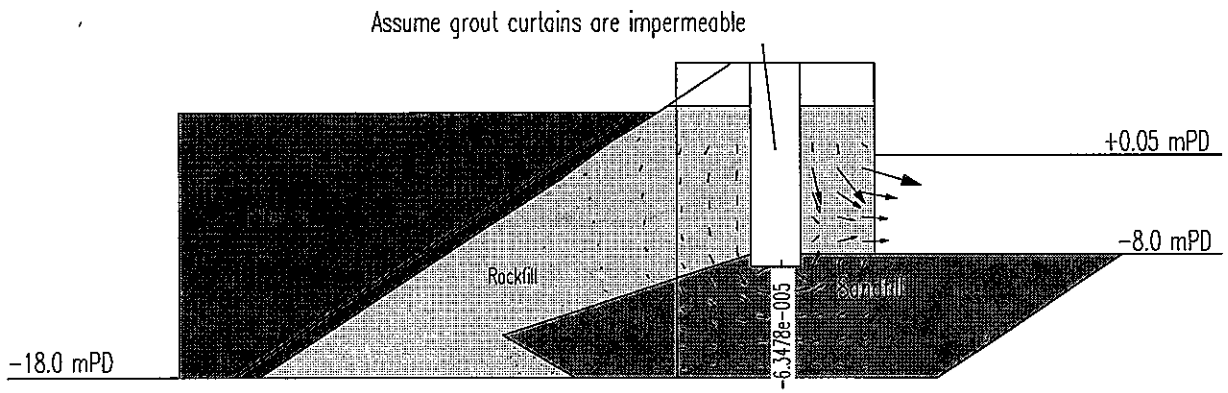
Hongkong Electric Company

Lamma Power Station Ash Lagoon

Lagoon full of PFA   Spring Tide

Initial condition water level +1.25 mPD

Tide at T+29



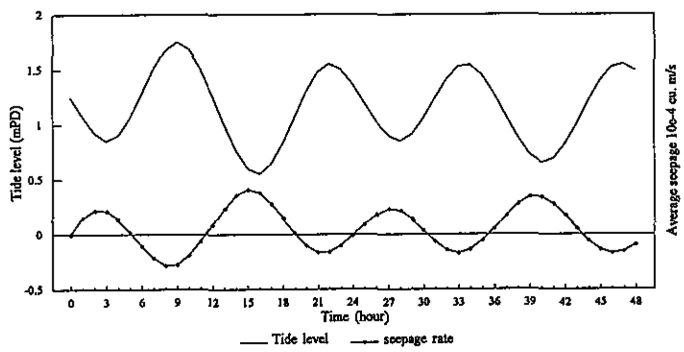
Flux in cu.m/s per metre length of seawall

Lamma Power Station Ash Lagoon
Seepage across Eastern Wharf Seawall

Status of filling: No PFA in lagoon
Tidal cycle: Neap tide

Effective length of seawall = 160 m   Lagoon surface area 82700 sq.m

Time	Tide level	Flow rate per metre of seawall	Hourly seepage along entire length	Accumulated inflow	Accumulated outflow	Accumulated change in lagoon water level
hour	mPD	cu.m/s	cu. m/h	cu. m	cu. m	mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	1.077	1.51540E-05	8.73	0.00	8.73	-0.11
2	0.925	2.18390E-05	12.58	0.00	21.31	-0.26
3	0.850	2.13270E-05	12.28	0.00	33.59	-0.41
4	0.902	1.36890E-05	7.88	0.00	41.48	-0.50
5	1.062	2.07440E-06	1.19	0.00	42.67	-0.52
6	1.279	-1.04590E-05	-6.02	6.02	42.67	-0.44
7	1.501	-2.13870E-05	-12.32	18.34	42.67	-0.29
8	1.675	-2.81540E-05	-16.22	34.56	42.67	-0.10
9	1.750	-2.74620E-05	-15.82	50.38	42.67	0.09
10	1.686	-1.88020E-05	-10.83	61.21	42.67	0.22
11	1.509	-5.96270E-06	-3.43	64.64	42.67	0.27
12	1.265	8.82080E-06	5.08	64.64	47.75	0.20
13	1.001	2.32980E-05	13.42	64.64	61.17	0.04
14	0.764	3.56120E-05	20.51	64.64	81.68	-0.21
15	0.598	4.07430E-05	23.47	64.64	105.15	-0.49
16	0.552	3.76320E-05	21.68	64.64	126.83	-0.75
17	0.645	2.80000E-05	16.13	64.64	142.96	-0.95
18	0.834	1.47870E-05	8.52	64.64	151.47	-1.05
19	1.068	1.24650E-06	0.72	64.64	152.19	-1.06
20	1.300	-9.93310E-06	-5.72	70.36	152.19	-0.99
21	1.476	-1.62690E-05	-9.37	79.73	152.19	-0.88
22	1.550	-1.58740E-05	-9.14	88.88	152.19	-0.77
23	1.503	-9.96070E-06	-5.74	94.62	152.19	-0.70
24	1.373	-8.29090E-07	-0.48	95.09	152.19	-0.69
25	1.200	9.17510E-06	5.28	95.09	157.48	-0.75
26	1.028	1.78820E-05	10.30	95.09	167.78	-0.88
27	0.897	2.31240E-05	13.32	95.09	181.10	-1.04
28	0.850	2.13530E-05	12.30	95.09	193.40	-1.19
29	0.914	1.40420E-05	8.09	95.09	201.48	-1.29
30	1.059	4.00420E-06	2.31	95.09	203.79	-1.31
31	1.240	-6.01850E-06	-3.47	98.56	203.79	-1.27
32	1.410	-1.38250E-05	-7.96	106.52	203.79	-1.18
33	1.526	-1.69250E-05	-9.75	116.27	203.79	-1.06
34	1.542	-1.36880E-05	-7.88	124.16	203.79	-0.96
35	1.449	-5.50420E-06	-3.17	127.33	203.79	-0.92
36	1.282	5.42880E-06	3.13	127.33	206.92	-0.96
37	1.080	1.70720E-05	9.83	127.33	216.75	-1.08
38	0.882	2.79130E-05	16.08	127.33	232.83	-1.28
39	0.726	3.41680E-05	19.68	127.33	252.51	-1.51
40	0.652	3.40060E-05	19.59	127.33	272.10	-1.75
41	0.690	2.76800E-05	15.94	127.33	288.04	-1.94
42	0.823	1.73960E-05	10.02	127.33	298.06	-2.06
43	1.012	5.52980E-06	3.19	127.33	301.25	-2.10
44	1.218	-5.34930E-06	-3.08	130.41	301.25	-2.07
45	1.401	-1.35570E-05	-7.81	138.22	301.25	-1.97
46	1.522	-1.69980E-05	-9.79	148.01	301.25	-1.85
47	1.549	-1.52340E-05	-8.77	156.78	301.25	-1.75
48	1.489	-9.63900E-06	-5.55	162.33	301.25	-1.68



Remarks:
Length of seawall = 160 m

Surface area of lagoon = 82700 sq. m

Inflow -ve   Outflow +ve

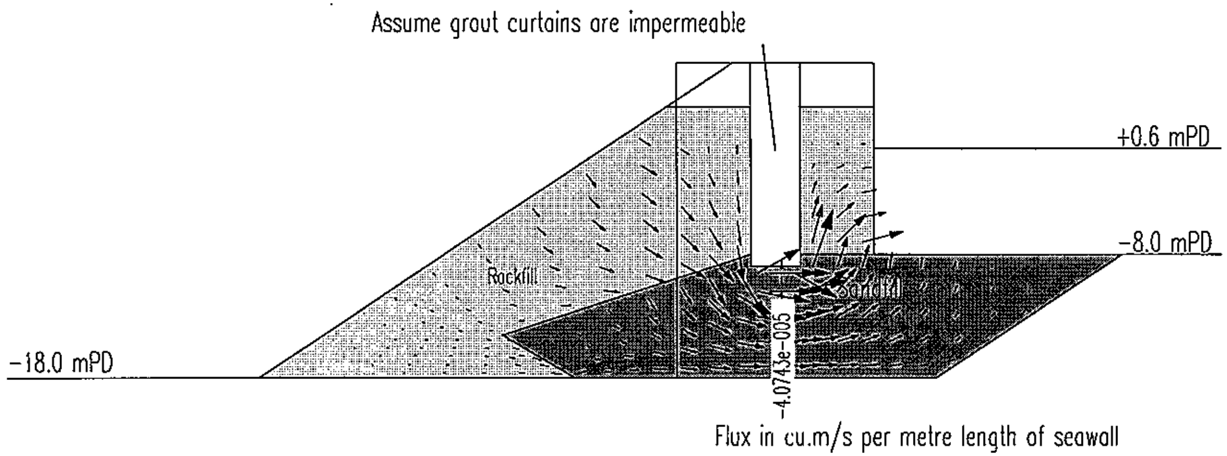
Hongkong Electric Company

Lamma Power Station Ash Lagoon

No PFA in lagoon   Neap Tide

Initial condition water level +1.25 mPD

Tide at T+15

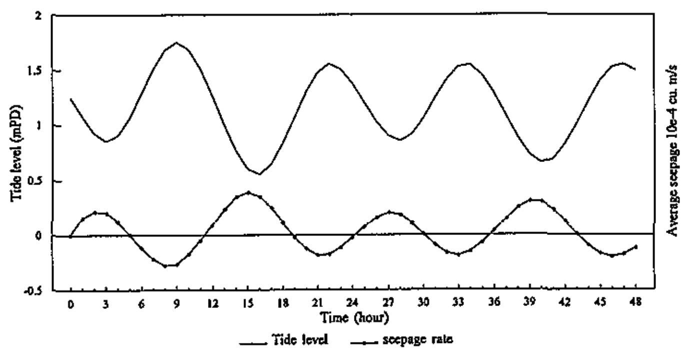


Lamma Power Station Ash Lagoon
Seepage across Eastern Wharf Seawall

Status of filling: 2m thick of PFA on inner slope of seawall
Tidal cycle: Neap tide

Effective length of seawall = 160 m Lagoon surface area 82700 sq.m

Time	Tide level	Flow rate per metre of seawall	Hourly seepage along entire length	Accumulated inflow	Accumulated outflow	Accumulated change in lagoon water level
hour	mPD	cu.m/s	cu. m/h	cu. m	cu. m	mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	1.077	1.55820E-05	8.98	0.00	8.98	-0.11
2	0.925	2.15100E-05	12.39	0.00	21.36	-0.26
3	0.850	2.02660E-05	11.67	0.00	33.04	-0.40
4	0.902	1.22710E-05	7.07	0.00	40.11	-0.48
5	1.062	6.96280E-07	0.40	0.00	40.51	-0.49
6	1.279	-1.14590E-05	-6.60	6.60	40.51	-0.41
7	1.501	-2.17670E-05	-12.54	19.14	40.51	-0.26
8	1.675	-2.78160E-05	-16.02	35.16	40.51	-0.06
9	1.750	-2.65320E-05	-15.28	50.44	40.51	0.12
10	1.686	-1.75970E-05	-10.14	60.58	40.51	0.24
11	1.509	-4.84520E-06	-2.79	63.37	40.51	0.28
12	1.265	9.47890E-06	5.46	63.37	45.97	0.21
13	1.001	2.31790E-05	13.35	63.37	59.32	0.05
14	0.764	3.44910E-05	19.87	63.37	79.19	-0.19
15	0.598	3.86440E-05	22.26	63.37	101.44	-0.46
16	0.552	3.47770E-05	20.03	63.37	121.48	-0.70
17	0.645	2.47250E-05	14.24	63.37	135.72	-0.87
18	0.834	1.14590E-05	6.60	63.37	142.32	-0.95
19	1.068	-1.81800E-06	-1.05	64.42	142.32	-0.94
20	1.300	-1.25210E-05	-7.21	71.63	142.32	-0.85
21	1.476	-1.83230E-05	-10.55	82.18	142.32	-0.73
22	1.550	-1.75130E-05	-10.09	92.27	142.32	-0.61
23	1.503	-1.14090E-05	-6.57	98.84	142.32	-0.53
24	1.373	-2.34220E-06	-1.35	100.19	142.32	-0.51
25	1.200	7.36250E-06	4.24	100.19	146.56	-0.56
26	1.028	1.56030E-05	8.99	100.19	155.55	-0.67
27	0.897	2.03220E-05	11.71	100.19	167.25	-0.81
28	0.850	1.81860E-05	10.48	100.19	177.73	-0.94
29	0.914	1.07660E-05	6.20	100.19	183.93	-1.01
30	1.059	8.90750E-07	0.51	100.19	184.44	-1.02
31	1.240	-8.74680E-06	-5.04	105.23	184.44	-0.96
32	1.410	-1.60370E-05	-9.24	114.47	184.44	-0.85
33	1.526	-1.86340E-05	-10.73	125.20	184.44	-0.72
34	1.542	-1.50740E-05	-8.68	133.88	184.44	-0.61
35	1.449	-6.83190E-06	-3.94	137.82	184.44	-0.56
36	1.282	3.87010E-06	2.23	137.82	186.67	-0.59
37	1.080	1.50150E-05	8.65	137.82	195.32	-0.70
38	0.882	2.51400E-05	14.48	137.82	209.80	-0.87
39	0.726	3.06190E-05	17.64	137.82	227.44	-1.08
40	0.652	2.97920E-05	17.16	137.82	244.60	-1.29
41	0.690	2.30540E-05	13.28	137.82	257.87	-1.45
42	0.823	1.26690E-05	7.30	137.82	265.17	-1.54
43	1.012	1.00570E-06	0.58	137.82	265.75	-1.55
44	1.218	-9.44060E-06	-5.44	143.26	265.75	-1.48
45	1.401	-1.70860E-05	-9.84	153.10	265.75	-1.36
46	1.522	-1.99770E-05	-11.51	164.60	265.75	-1.22
47	1.549	-1.77950E-05	-10.25	174.85	265.75	-1.10
48	1.489	-1.19750E-05	-6.90	181.75	265.75	-1.02

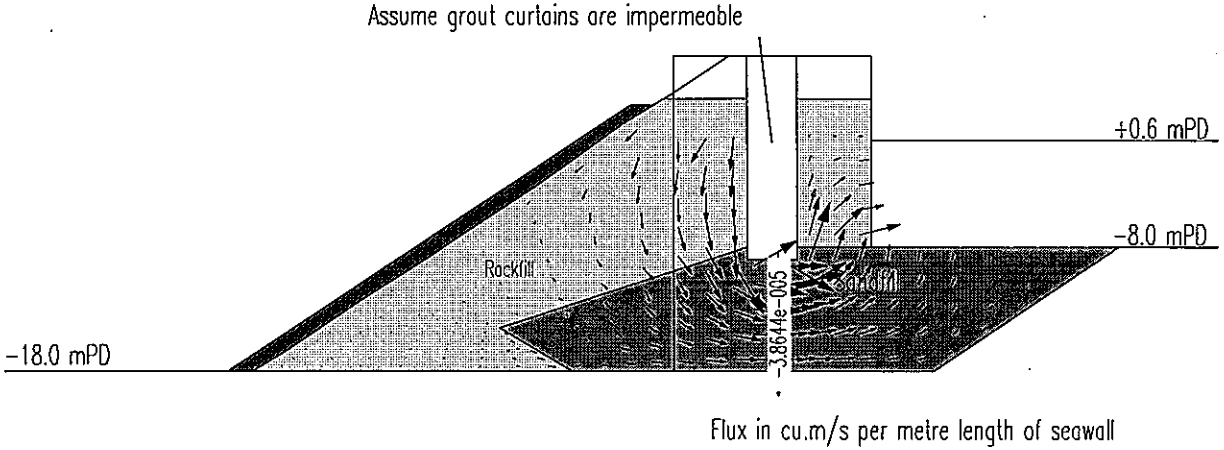


Remarks:
Length of seawall
= 160 m

Surface area of
lagoon
= 82700 sq. m

Inflow -ve Outflow +ve

Hongkong Electric Company
Lamma Power Station Ash Lagoon
2m PFA in lagoon Neap Tide
Initial condition water level +1.25 mPD
Tide at T+15

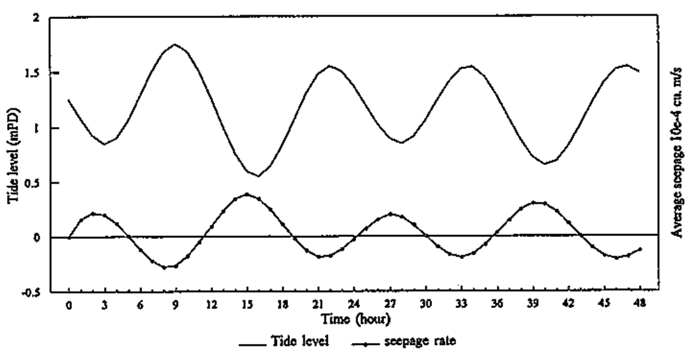


Lamma Power Station Ash Lagoon
Seepage across Eastern Wharf Seawall

Status of filling: Lagoon full of PFA
Tidal cycle: Neap tide

Effective length of seawall = 160 m Lagoon surface area 82700 sq.m

Time	Tide level	Flow rate per metre of seawall	Hourly seepage along entire length	Accumulated inflow	Accumulated outflow	Accumulated change in lagoon water level
hour	mPD	cu.m/s	cu.m/hr	cu.m	cu.m	mm
0	1.250	0.0000E+00	0.00	0.00	0.00	0.00
1	1.077	1.5589E-05	8.98	0.00	8.98	-0.36
2	0.925	2.1502E-05	12.39	0.00	21.36	-0.86
3	0.850	2.0239E-05	11.66	0.00	33.02	-1.33
4	0.902	1.2224E-05	7.04	0.00	40.06	-1.61
5	1.062	6.3365E-07	0.36	0.00	40.43	-1.63
6	1.279	-1.1529E-05	-6.64	6.64	40.43	-1.36
7	1.501	-2.1837E-05	-12.58	19.22	40.43	-0.85
8	1.675	-2.7877E-05	-16.06	35.28	40.43	-0.21
9	1.750	-2.6579E-05	-15.31	50.59	40.43	0.41
10	1.686	-1.7628E-05	-10.15	60.74	40.43	0.82
11	1.509	-4.8623E-06	-2.80	63.54	40.43	0.93
12	1.265	9.4679E-06	5.45	63.54	45.88	0.71
13	1.001	2.3164E-05	13.34	63.54	59.22	0.17
14	0.764	3.4460E-05	19.85	63.54	79.07	-0.63
15	0.598	3.8587E-05	22.23	63.54	101.30	-1.52
16	0.552	3.4688E-05	19.98	63.54	121.28	-2.33
17	0.645	2.4601E-05	14.17	63.54	135.45	-2.90
18	0.834	1.1304E-05	6.51	63.54	141.96	-3.16
19	1.068	-1.9975E-06	-1.15	64.69	141.96	-3.11
20	1.300	-1.2717E-05	-7.32	72.02	141.96	-2.82
21	1.476	-1.8529E-05	-10.67	82.69	141.96	-2.39
22	1.550	-1.7725E-05	-10.21	92.90	141.96	-1.98
23	1.503	-1.1626E-05	-6.70	99.59	141.96	-1.71
24	1.373	-2.5669E-06	-1.48	101.07	141.96	-1.65
25	1.200	7.1263E-06	4.10	101.07	146.07	-1.81
26	1.028	1.5349E-05	8.84	101.07	154.91	-2.17
27	0.897	2.0045E-05	11.55	101.07	166.45	-2.64
28	0.850	1.7880E-05	10.30	101.07	176.75	-3.05
29	0.914	1.0434E-05	6.01	101.07	182.76	-3.29
30	1.059	5.3769E-07	0.31	101.07	183.07	-3.31
31	1.240	-9.1137E-06	-5.25	106.32	183.07	-3.09
32	1.410	-1.6411E-05	-9.45	115.78	183.07	-2.71
33	1.526	-1.9012E-05	-10.95	126.73	183.07	-2.27
34	1.542	-1.5453E-05	-8.90	135.63	183.07	-1.91
35	1.449	-7.2125E-06	-4.15	139.78	183.07	-1.74
36	1.282	3.4845E-06	2.01	139.78	185.08	-1.83
37	1.080	1.4618E-05	8.42	139.78	193.50	-2.17
38	0.882	2.4722E-05	14.24	139.78	207.74	-2.74
39	0.726	3.0169E-05	17.38	139.78	225.12	-3.44
40	0.652	2.9303E-05	16.88	139.78	241.99	-4.12
41	0.690	2.2527E-05	12.98	139.78	254.97	-4.64
42	0.823	1.2106E-05	6.97	139.78	261.94	-4.92
43	1.012	4.1378E-07	0.24	139.78	262.18	-4.93
44	1.218	-1.0051E-05	-5.79	145.57	262.18	-4.70
45	1.401	-1.7703E-05	-10.20	155.77	262.18	-4.29
46	1.522	-2.0599E-05	-11.87	167.63	262.18	-3.81
47	1.549	-1.8420E-05	-10.61	178.24	262.18	-3.38
48	1.489	-1.2604E-05	-7.26	185.50	262.18	-3.09



Remarks:
Length of seawall = 160 m

Surface area of lagoon = 82700 sq. m

Inflow -ve Outflow +ve

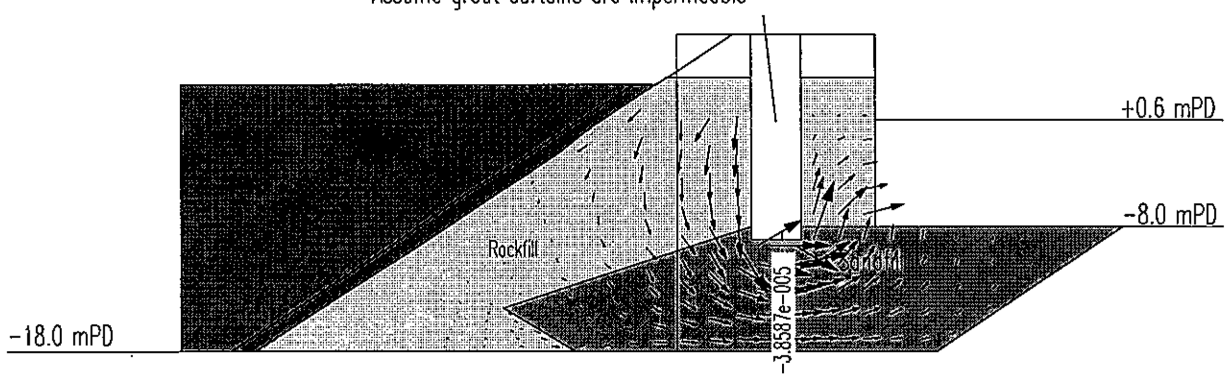
Hongkong Electric Company

Lamma Power Station Ash Lagoon

Lagoon full of PFA   Neap Tide

Initial condition water level +1.25 mPD

Tide at T+15



Flux in cu.m/s per metre length of seawall

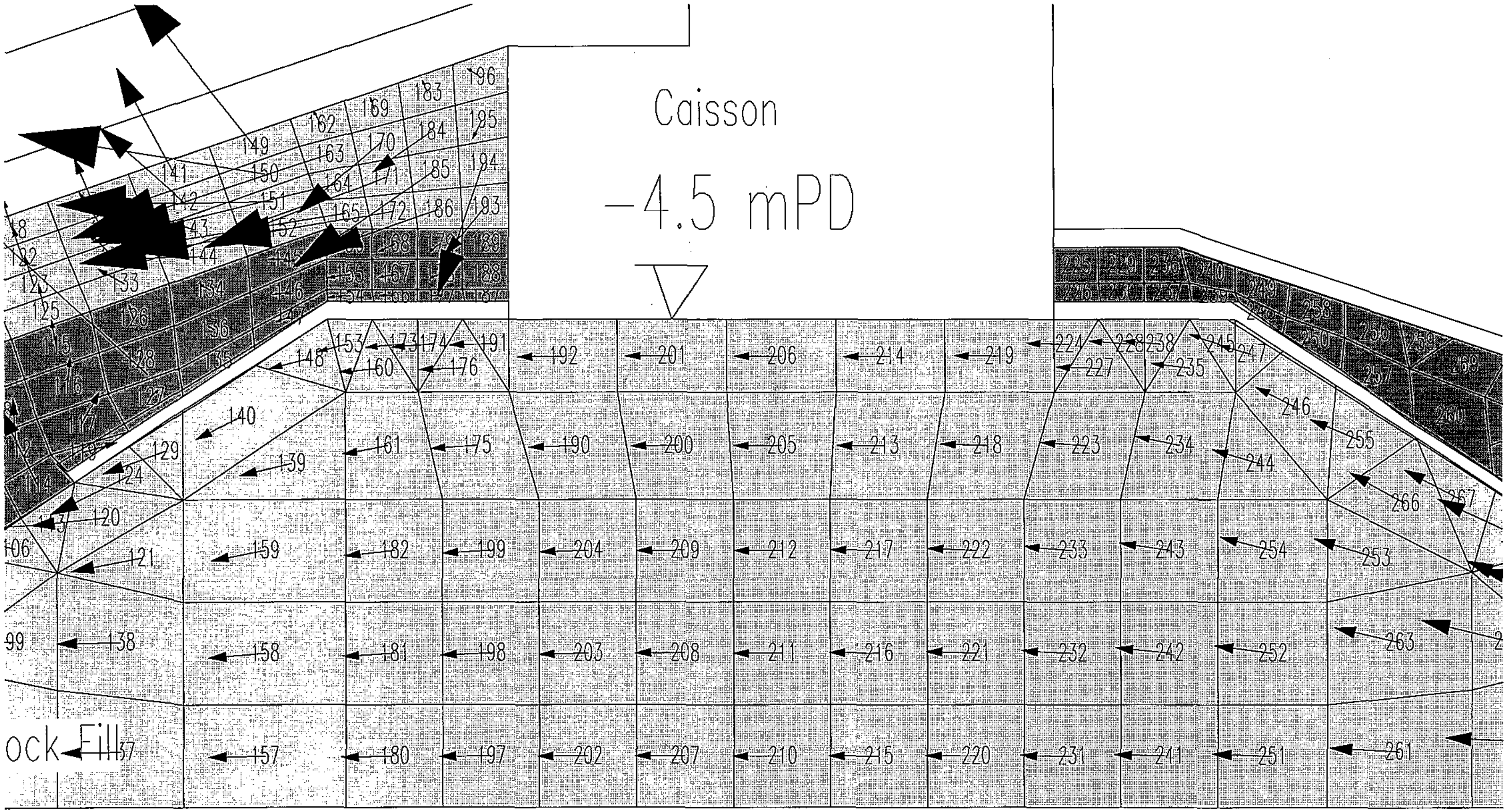
APPENDIX F

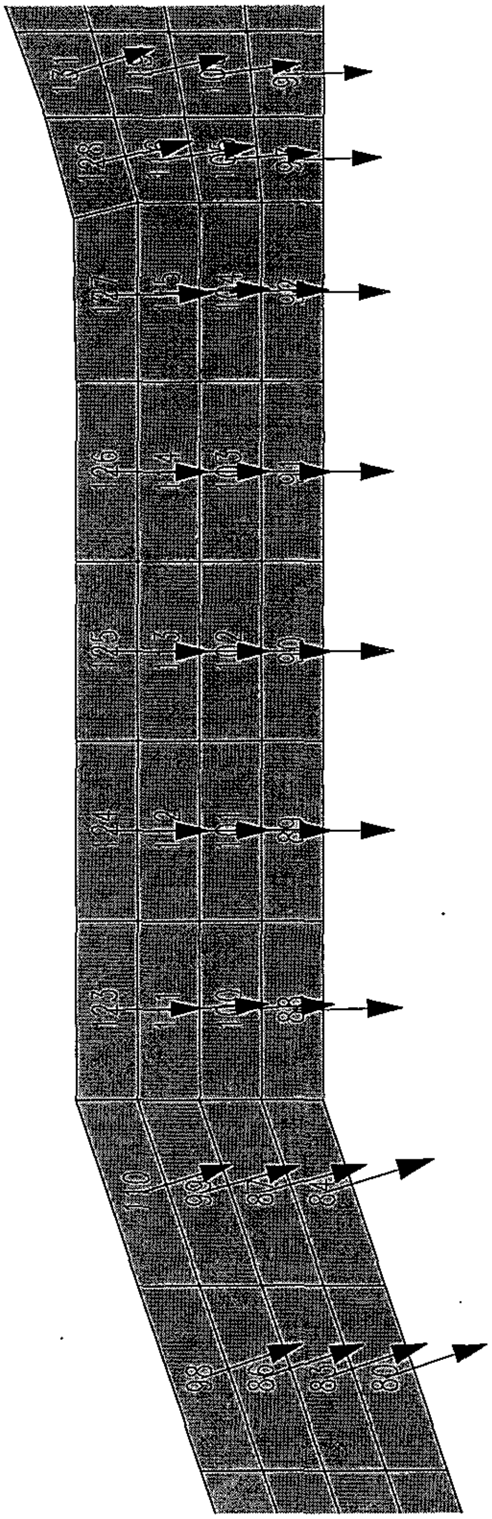
MAXIMUM SEEPAGE VECTORS

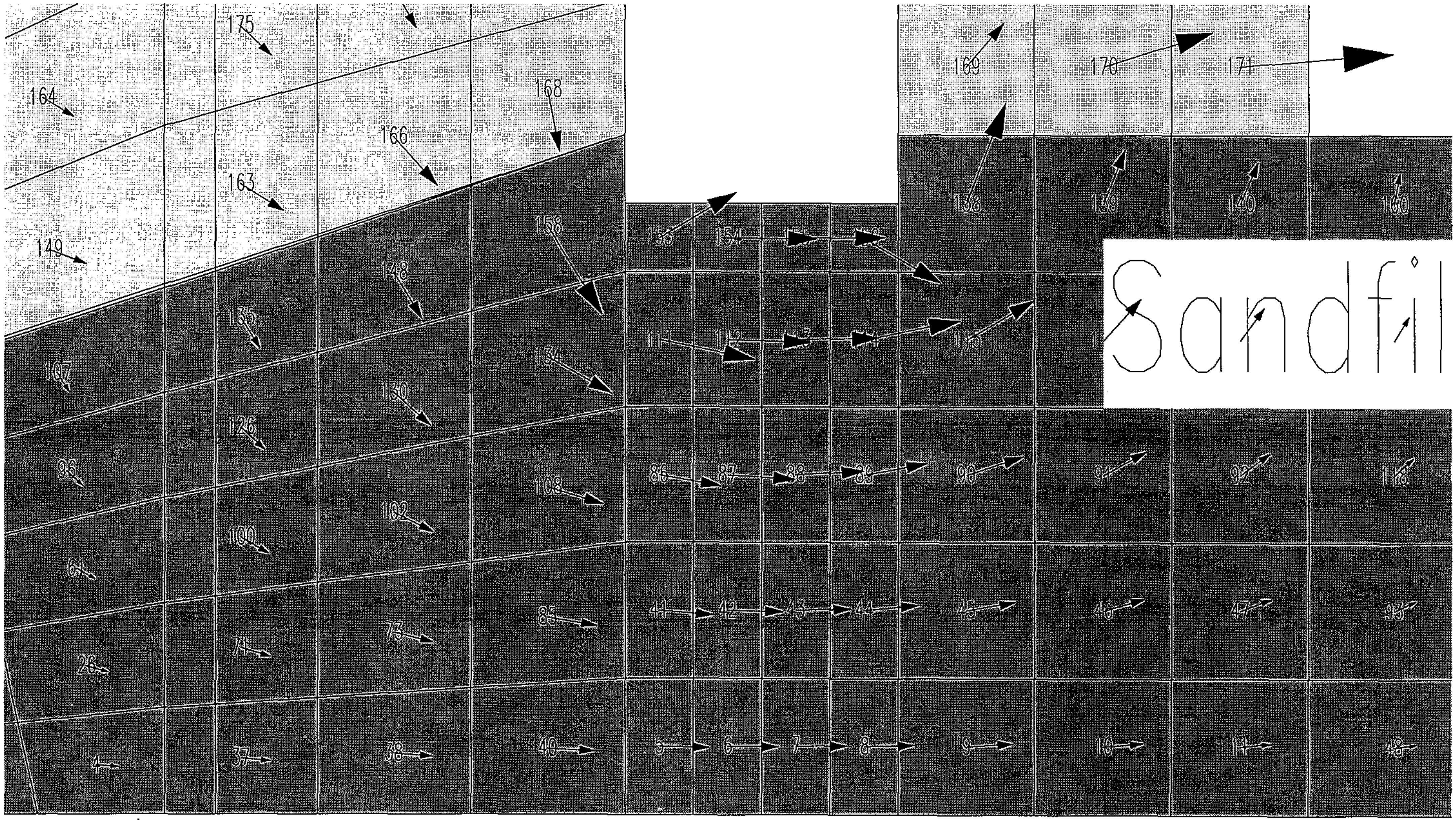
Seepage across lagoon perimeter
Maximum velocity vectors - maximum head difference across perimeter

Spring Tides - no PFA in lagoon

Analysis Section	Time hours	Element No	Resultant Velocity m/s
Revetment with Caisson	T + 29	212	1.500E-09
Northern Perimeter	T + 29	125	1.670E-08
Eastern Wharf	T + 29	155	2.000E-09


Caisson
-4.5 mPD
ock Fill



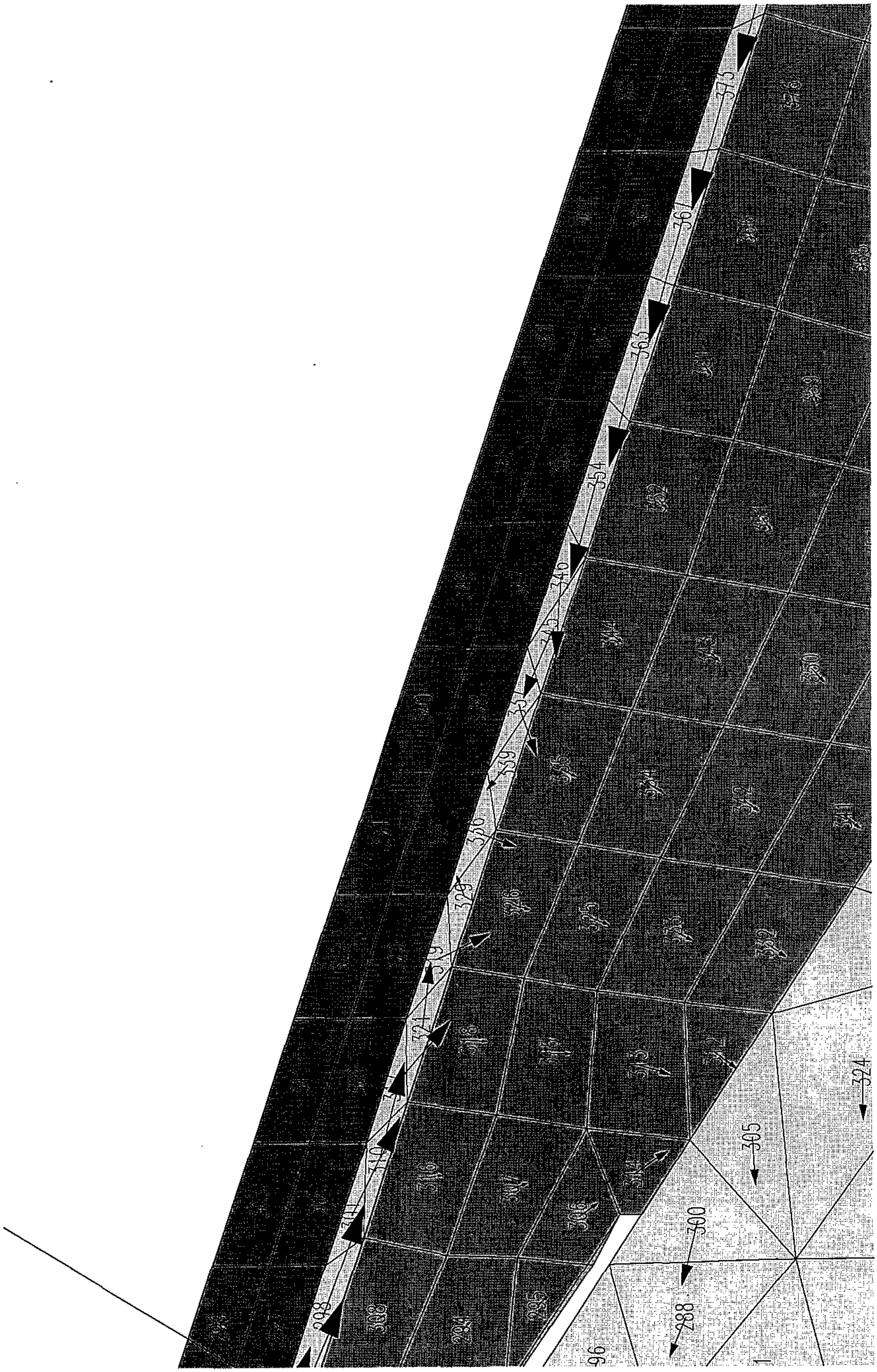


Sandfil

Seepage across lagoon perimeter
Maximum velocity vectors - maximum head difference across perimeter

Spring Tides - 2 metres of PFA in lagoon

Analysis Section	Time hours	Element No	Resultant Velocity m/s
Revetment with Caisson	T + 29	338	1.300E-10
Northern Perimeter	T + 27	244	1.250E-10
Eastern Wharf	T + 29	79	2.700E-11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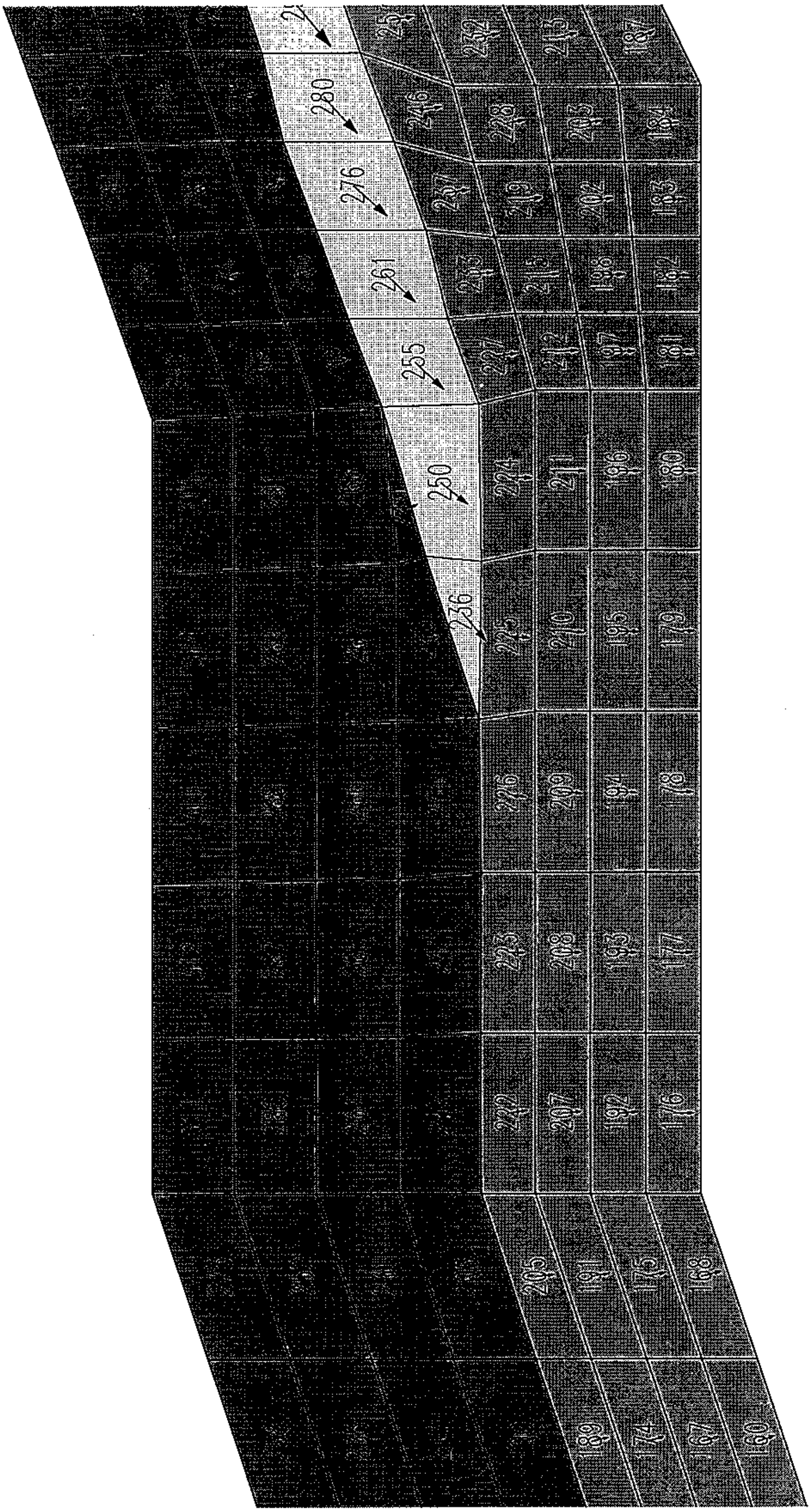
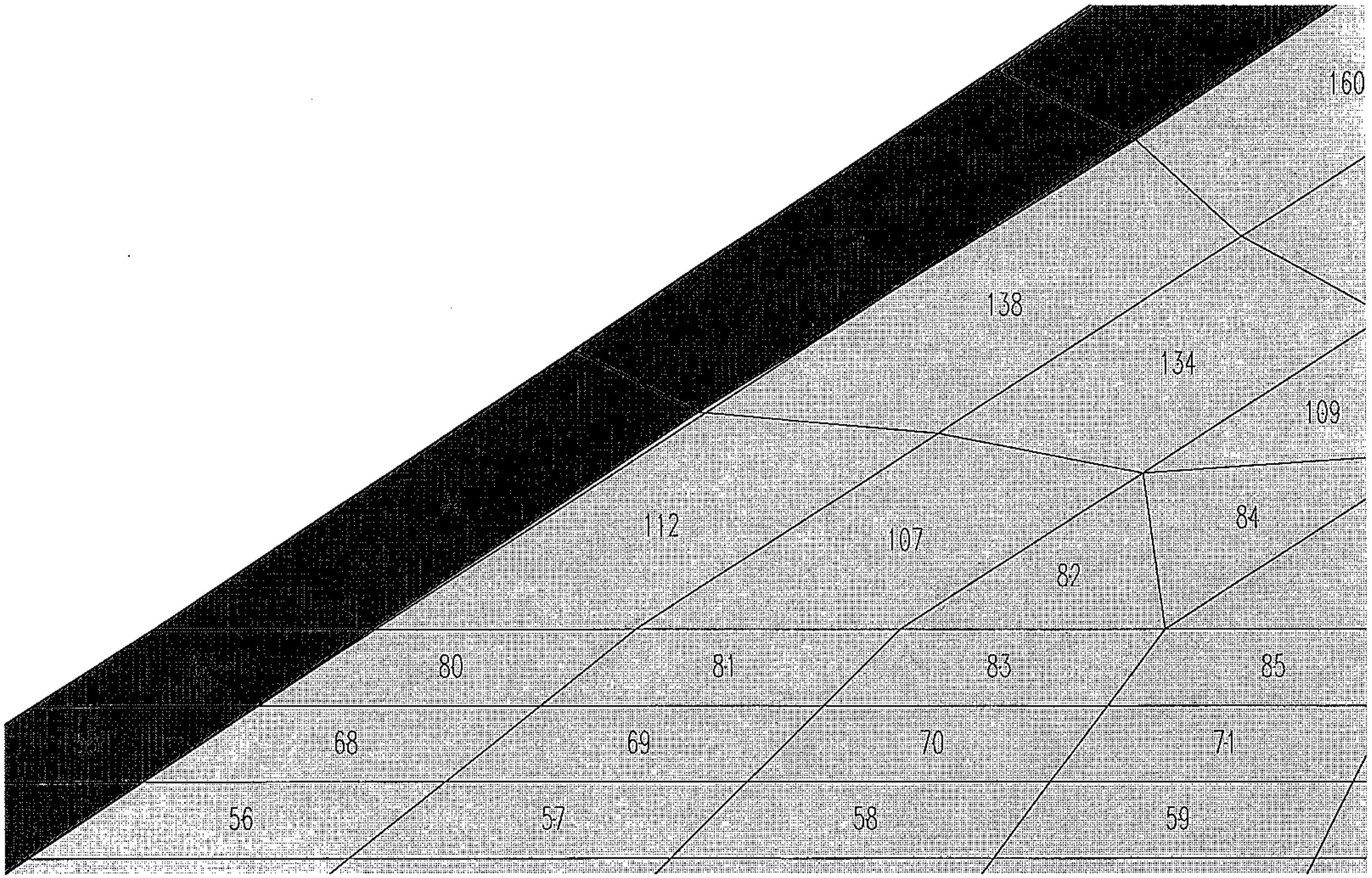
354
324
305
300
288
96




160
138
134
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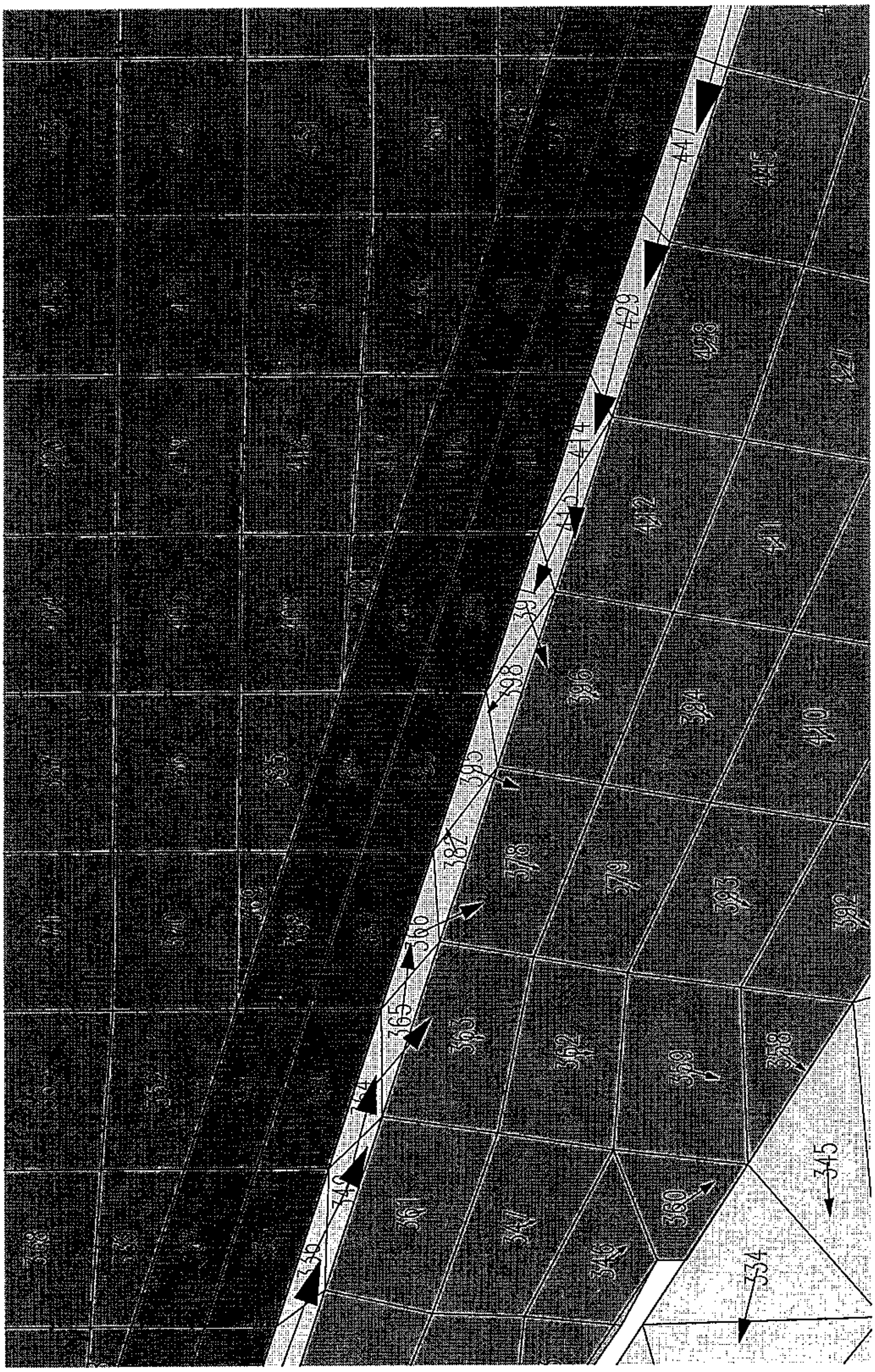
112
107
82
84
80
81
83
85
68
69
70
71
56
57
58
59

Seepage across lagoon perimeter
Maximum velocity vectors - maximum head difference across perimeter

Spring Tides - lagoon full of PFA

Analysis Section	Time hours	Element No	Resultant Velocity m/s
Revetment with Caisson	T + 28	383	1.050E-10
Northern Perimeter	T + 27	371	1.420E-10
Eastern Wharf	T + 29	199	2.700E-11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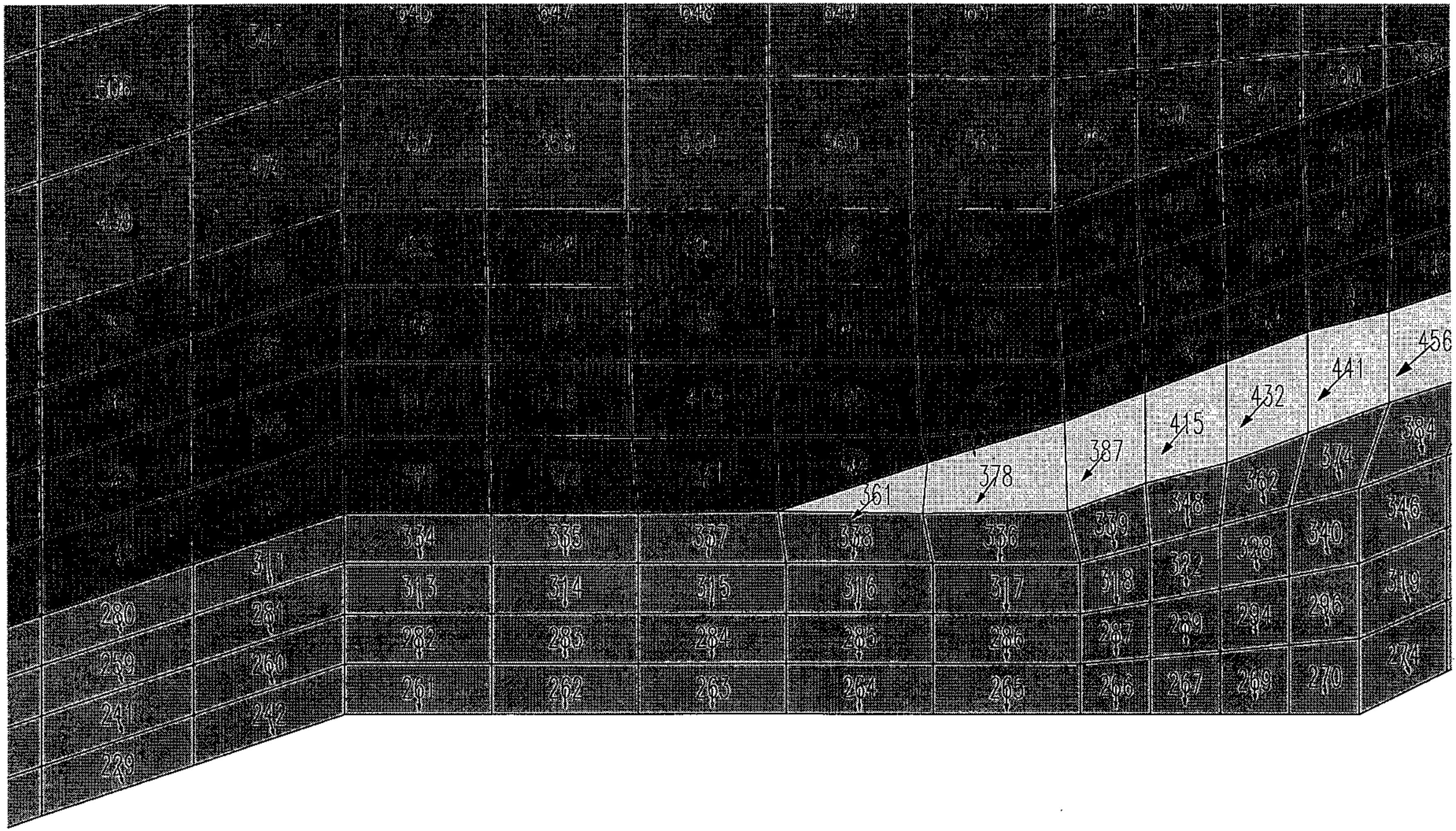
334
365
360
429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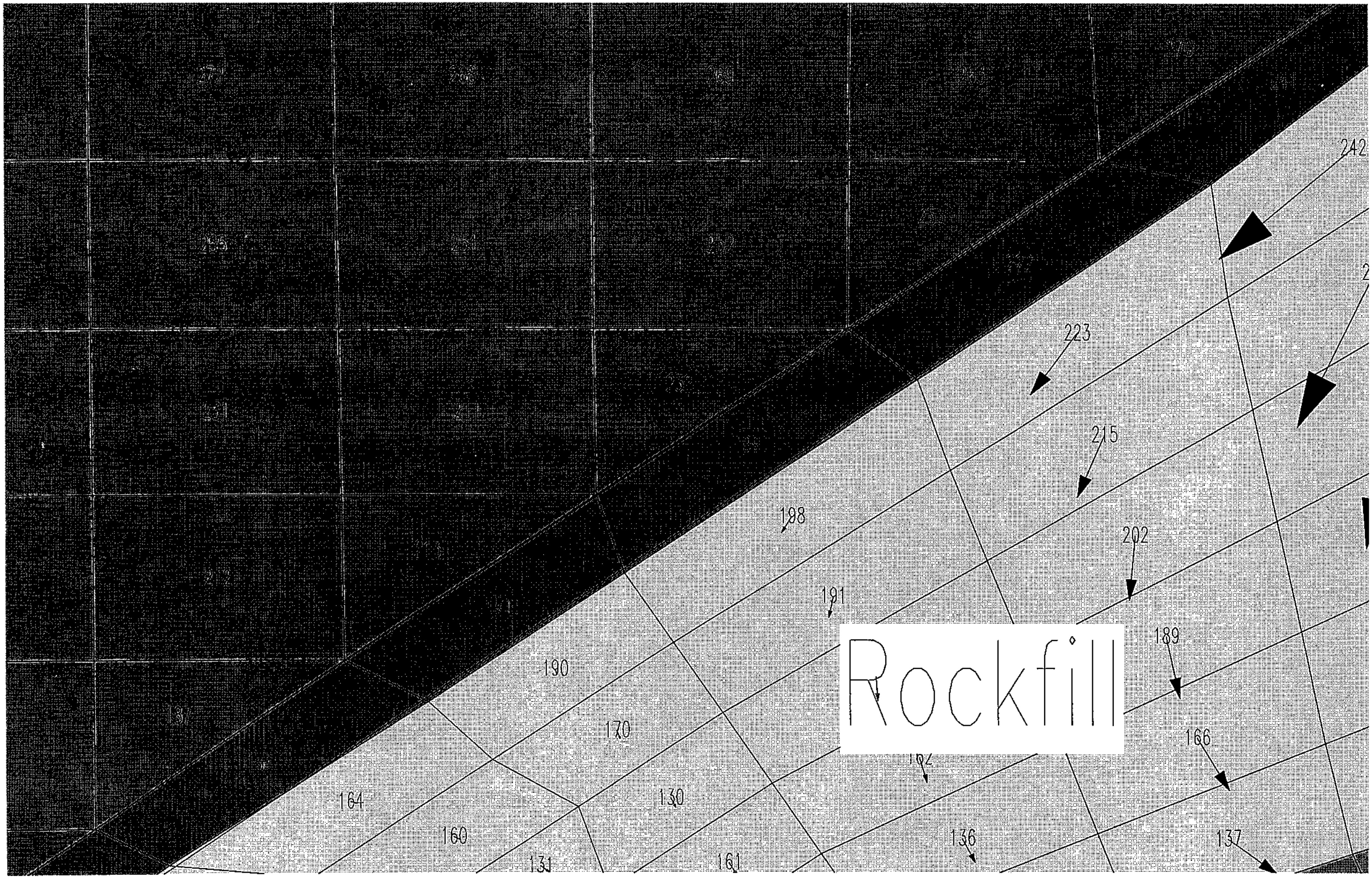
387
415
432
441
456


Rockfill
242
223
215
202
189
166
137
136
191
198
161
130
170
190
160
164

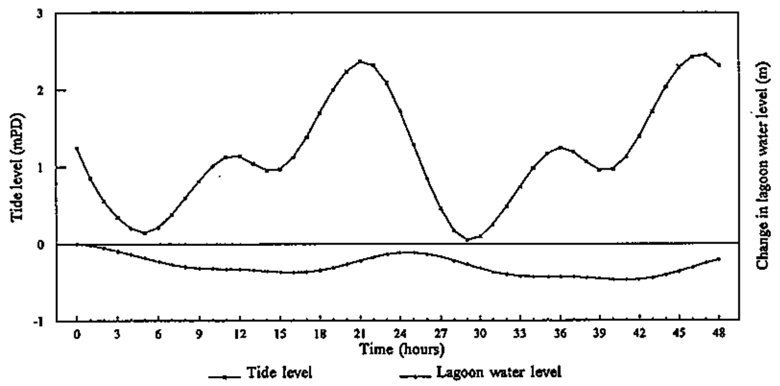
APPENDIX G

TRANSIENT WATER LEVELS IN THE LAGOON

Lamma Power Station Ash Lagoon
Initial condition water level in sea and lagoon at +1.25 mPD

Status of filling:No PFA in lagoon
Tidal cycle: Spring tide

Time	Tide level	Change in water level due to			
		Caisson with revetment	Eastern wharf	Northern perimeter	Total
hours	mPD	mm	mm	mm	mm
0	1.250	0.00	0.00	0.00	0.00
1	0.854	-0.55	-0.16	-17.55	-18.26
2	0.556	-1.52	-0.44	-47.61	-49.58
3	0.344	-2.79	-0.81	-86.35	-89.94
4	0.205	-4.25	-1.23	-130.64	-136.12
5	0.146	-5.79	-1.67	-177.12	-184.58
6	0.214	-7.24	-2.09	-220.44	-229.77
7	0.377	-8.46	-2.45	-256.64	-267.55
8	0.593	-9.38	-2.71	-283.54	-295.63
9	0.819	-9.99	-2.89	-300.77	-313.64
10	1.013	-10.32	-2.98	-309.80	-323.10
11	1.132	-10.48	-3.03	-313.95	-327.46
12	1.136	-10.64	-3.07	-318.26	-331.97
13	1.046	-10.93	-3.15	-326.73	-340.81
14	0.957	-11.34	-3.27	-339.09	-353.70
15	0.969	-11.73	-3.39	-350.82	-365.94
16	1.128	-11.90	-3.43	-355.53	-370.86
17	1.388	-11.71	-3.38	-348.88	-363.97
18	1.696	-11.09	-3.21	-328.97	-343.26
19	1.998	-10.04	-2.91	-296.25	-309.20
20	2.238	-8.66	-2.51	-253.54	-264.71
21	2.362	-7.10	-2.06	-205.96	-215.12
22	2.317	-5.61	-1.63	-160.88	-168.13
23	2.087	-4.44	-1.29	-126.23	-131.96
24	1.726	-3.78	-1.10	-107.43	-112.31
25	1.294	-3.71	-1.08	-107.23	-112.02
26	0.850	-4.27	-1.23	-125.76	-131.27
27	0.456	-5.38	-1.55	-160.63	-167.56
28	0.172	-6.89	-1.98	-206.98	-215.85
29	0.052	-8.56	-2.46	-257.83	-268.86
30	0.093	-10.18	-2.93	-306.52	-319.63
31	0.251	-11.58	-3.34	-348.21	-363.12
32	0.482	-12.65	-3.66	-379.90	-396.21
33	0.742	-13.36	-3.86	-400.44	-417.67
34	0.986	-13.73	-3.97	-410.59	-428.29
35	1.170	-13.84	-4.00	-413.02	-430.86
36	1.250	-13.85	-4.00	-412.35	-430.19
37	1.195	-13.85	-4.02	-414.40	-432.27
38	1.068	-14.11	-4.09	-422.16	-440.36
39	0.962	-14.51	-4.21	-434.50	-453.22
40	0.970	-14.90	-4.32	-446.29	-465.51
41	1.132	-15.07	-4.37	-450.86	-470.29
42	1.401	-14.85	-4.31	-443.71	-462.87
43	1.720	-14.20	-4.13	-422.79	-441.11
44	2.035	-13.10	-3.81	-388.48	-405.39
45	2.289	-11.65	-3.39	-343.58	-358.61
46	2.428	-10.00	-2.92	-293.20	-306.11
47	2.456	-8.31	-2.43	-242.11	-252.85
48	2.321	-6.81	-2.00	-197.33	-206.14

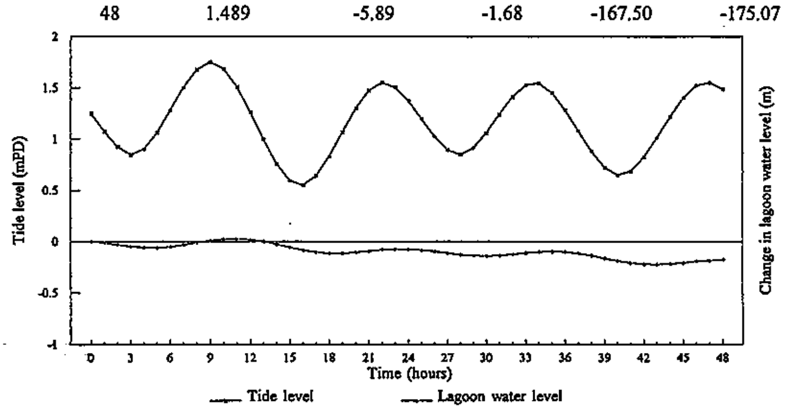


Water level	
max	0.00
min	-470.29
diff	470.29

Lamma Power Station Ash Lagoon
Initial condition water level in sea and lagoon at +1.25 mPD

Status of filling:No PFA in lagoon
Tidal cycle: Neap tide

Time	Tide level	Change in water level due to			
		Caisson with revetment	Eastern wharf	Northern perimeter	Total
hours	mPD	mm	mm	mm	mm
0	1.250	0.00	0.00	0.00	0.00
1	1.077	-0.40	-0.11	-12.36	-12.86
2	0.925	-0.94	-0.26	-28.61	-29.80
3	0.850	-1.47	-0.41	-44.00	-45.87
4	0.902	-1.81	-0.50	-53.61	-55.92
5	1.062	-1.87	-0.52	-54.58	-56.97
6	1.279	-1.61	-0.44	-46.23	-48.28
7	1.501	-1.08	-0.29	-29.99	-31.37
8	1.675	-0.40	-0.10	-9.46	-9.96
9	1.750	0.26	0.09	9.82	10.17
10	1.686	0.71	0.22	22.63	23.56
11	1.509	0.85	0.27	25.79	26.90
12	1.265	0.61	0.20	18.09	18.90
13	1.001	0.03	0.04	0.21	0.28
14	0.764	-0.82	-0.21	-25.28	-26.31
15	0.598	-1.80	-0.49	-54.02	-56.31
16	0.552	-2.70	-0.75	-80.25	-83.70
17	0.645	-3.38	-0.95	-99.45	-103.78
18	0.834	-3.74	-1.05	-109.19	-113.98
19	1.068	-3.77	-1.06	-109.09	-113.92
20	1.300	-3.52	-0.99	-100.91	-105.41
21	1.476	-3.11	-0.88	-88.43	-92.41
22	1.550	-2.72	-0.77	-76.81	-80.30
23	1.503	-2.48	-0.70	-70.02	-73.20
24	1.373	-2.47	-0.69	-70.19	-73.35
25	1.200	-2.71	-0.75	-77.67	-81.14
26	1.028	-3.16	-0.88	-91.15	-95.19
27	0.897	-3.71	-1.04	-107.60	-112.36
28	0.850	-4.22	-1.19	-122.53	-127.95
29	0.914	-4.56	-1.29	-132.09	-137.94
30	1.059	-4.66	-1.31	-134.33	-140.30
31	1.240	-4.50	-1.27	-129.19	-134.97
32	1.410	-4.16	-1.18	-118.49	-123.82
33	1.526	-3.74	-1.06	-105.92	-110.71
34	1.542	-3.40	-0.96	-96.24	-100.60
35	1.449	-3.28	-0.92	-92.92	-97.13
36	1.282	-3.43	-0.96	-97.77	-102.16
37	1.080	-3.86	-1.08	-110.96	-115.89
38	0.882	-4.53	-1.28	-131.10	-136.90
39	0.726	-5.35	-1.51	-155.25	-162.12
40	0.652	-6.17	-1.75	-179.04	-186.95
41	0.690	-6.83	-1.94	-198.13	-206.91
42	0.823	-7.25	-2.06	-209.82	-219.14
43	1.012	-7.39	-2.10	-213.00	-222.49
44	1.218	-7.25	-2.07	-208.21	-217.53
45	1.401	-6.91	-1.97	-197.60	-206.48
46	1.522	-6.49	-1.85	-184.88	-193.22
47	1.549	-6.12	-1.75	-173.97	-181.84
48	1.489	-5.89	-1.68	-167.50	-175.07

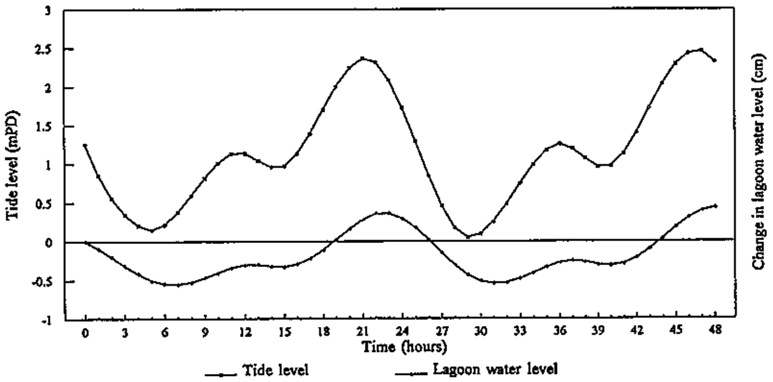


Water level	
max	26.90
min	-222.49
diff	249.40

Lamma Power Station Ash Lagoon
Initial condition water level in sea and lagoon at +1.25 mPD

Status of filling:Lagoon full of PFA
Tidal cycle: Spring tide

Time	Tide level	Change in water level due to			
		Caisson with revetment	Eastern wharf	Northern perimeter	Total
hours	mPD	mm	mm	mm	mm
0	1.250	0.00	0.00	0.00	0.00
1	0.854	-0.76	-0.50	-7.67	-8.93
2	0.556	-1.89	-1.39	-17.06	-20.34
3	0.344	-3.17	-2.53	-26.01	-31.71
4	0.205	-4.49	-3.82	-33.57	-41.88
5	0.146	-5.71	-5.15	-39.24	-50.10
6	0.214	-6.65	-6.38	-41.66	-54.68
7	0.377	-7.21	-7.37	-40.65	-55.23
8	0.593	-7.39	-8.05	-36.89	-52.32
9	0.819	-7.23	-8.41	-31.18	-46.82
10	1.013	-6.85	-8.51	-24.59	-39.95
11	1.132	-6.41	-8.46	-19.01	-33.88
12	1.136	-6.12	-8.40	-15.85	-30.36
13	1.046	-6.08	-8.46	-15.68	-30.21
14	0.957	-6.22	-8.63	-17.08	-31.93
15	0.969	-6.30	-8.79	-17.49	-32.58
16	1.128	-6.08	-8.73	-14.71	-29.53
17	1.388	-5.43	-8.36	-8.22	-22.01
18	1.696	-4.37	-7.60	0.93	-11.04
19	1.998	-2.97	-6.46	11.95	2.52
20	2.238	-1.39	-5.03	22.71	16.29
21	2.362	0.14	-3.48	31.53	28.20
22	2.317	1.36	-2.02	35.93	35.27
23	2.087	2.01	-0.88	34.67	35.80
24	1.726	2.00	-0.24	27.84	29.59
25	1.294	1.32	-0.17	16.70	17.85
26	0.850	0.08	-0.66	3.09	2.50
27	0.456	-1.56	-1.68	-11.30	-14.54
28	0.172	-3.36	-3.03	-24.26	-30.65
29	0.052	-5.03	-4.50	-33.85	-43.39
30	0.093	-6.36	-5.90	-39.11	-51.37
31	0.251	-7.24	-7.07	-40.05	-54.37
32	0.482	-7.65	-7.93	-37.27	-52.84
33	0.742	-7.63	-8.41	-31.99	-48.02
34	0.986	-7.28	-8.55	-24.99	-40.82
35	1.170	-6.77	-8.45	-18.17	-33.39
36	1.250	-6.29	-8.26	-13.04	-27.58
37	1.195	-6.04	-8.13	-11.17	-25.35
38	1.068	-6.10	-8.17	-12.46	-26.73
39	0.962	-6.33	-8.36	-15.01	-29.70
40	0.970	-6.49	-8.53	-16.15	-31.16
41	1.132	-6.32	-8.48	-13.76	-28.56
42	1.401	-5.70	-8.10	-7.41	-21.20
43	1.720	-4.63	-7.33	1.77	-10.19
44	2.035	-3.21	-6.15	13.06	3.69
45	2.289	-1.59	-4.67	24.23	17.97
46	2.428	0.01	-3.05	33.62	30.57
47	2.456	1.42	-1.43	39.51	39.50
48	2.321	2.41	-0.02	40.87	43.25

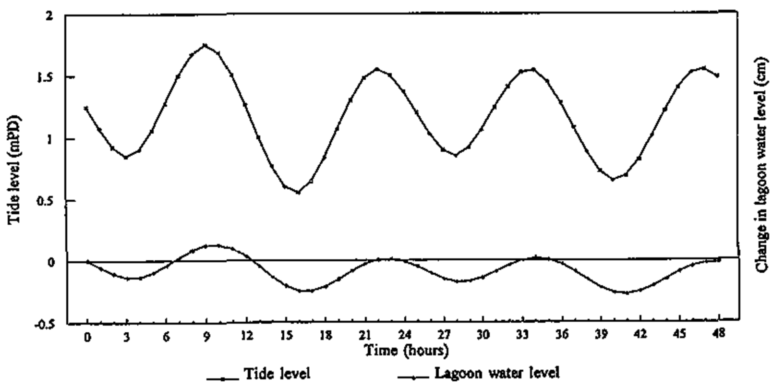


Water level	
max	43.25
min	-55.23
diff	98.48

Lamma Power Station Ash Lagoon
Initial condition water level in sea and lagoon at +1.25 mPD

Status of filling:Lagoon full of PFA
Tidal cycle: Neap tide

Time	Tide level	Change in water level due to			
		Caisson with revetment	Eastern wharf	Northern perimeter	Total
hours	mPD	mm	mm	mm	mm
0	1.250	0.00	0.00	0.00	0.00
1	1.077	-0.54	-0.36	-4.56	-5.46
2	0.925	-1.13	-0.86	-8.61	-10.61
3	0.850	-1.59	-1.33	-10.74	-13.65
4	0.902	-1.72	-1.61	-10.01	-13.34
5	1.062	-1.48	-1.63	-6.67	-9.79
6	1.279	-0.92	-1.36	-1.56	-3.85
7	1.501	-0.15	-0.85	3.70	2.70
8	1.675	0.66	-0.21	8.30	8.75
9	1.750	1.28	0.41	10.84	12.54
10	1.686	1.54	0.82	10.54	12.89
11	1.509	1.37	0.93	7.46	9.76
12	1.265	0.81	0.71	2.17	3.69
13	1.001	-0.05	0.17	-4.67	-4.55
14	0.764	-1.07	-0.63	-11.60	-13.30
15	0.598	-2.05	-1.52	-17.06	-20.63
16	0.552	-2.76	-2.33	-19.49	-24.58
17	0.645	-3.08	-2.90	-18.53	-24.51
18	0.834	-3.00	-3.16	-14.83	-20.99
19	1.068	-2.57	-3.11	-9.59	-15.27
20	1.300	-1.92	-2.82	-3.79	-8.53
21	1.476	-1.24	-2.39	0.80	-2.83
22	1.550	-0.74	-1.98	3.24	0.53
23	1.503	-0.52	-1.71	3.33	1.10
24	1.373	-0.62	-1.65	1.30	-0.97
25	1.200	-0.99	-1.81	-2.29	-5.10
26	1.028	-1.53	-2.17	-6.56	-10.26
27	0.897	-2.09	-2.64	-10.22	-14.94
28	0.850	-2.48	-3.05	-11.88	-17.41
29	0.914	-2.58	-3.29	-11.05	-16.93
30	1.059	-2.38	-3.31	-8.15	-13.83
31	1.240	-1.93	-3.09	-3.92	-8.94
32	1.410	-1.35	-2.71	0.22	-3.84
33	1.526	-0.80	-2.27	3.20	0.12
34	1.542	-0.48	-1.91	4.18	1.78
35	1.449	-0.47	-1.74	2.87	0.66
36	1.282	-0.79	-1.83	-0.45	-3.07
37	1.080	-1.38	-2.17	-5.39	-8.94
38	0.882	-2.15	-2.74	-10.92	-15.81
39	0.726	-2.96	-3.44	-15.72	-22.12
40	0.652	-3.62	-4.12	-18.55	-26.28
41	0.690	-3.98	-4.64	-18.63	-27.25
42	0.823	-4.01	-4.92	-16.24	-25.17
43	1.012	-3.71	-4.93	-12.15	-20.79
44	1.218	-3.18	-4.70	-7.02	-14.90
45	1.401	-2.52	-4.29	-2.18	-8.99
46	1.522	-1.91	-3.81	1.25	-4.47
47	1.549	-1.48	-3.38	2.86	-2.00
48	1.489	-1.31	-3.09	2.61	-1.79



Water level	
max	12.89
min	-27.25
diff	40.15

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