Flooding Problem in Hong Kong

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1. Introduction

1.1 Climatic Factors of Hong Kong

Hong Kong is located at the southern coast of China, with the climate being sub-tropical and tending towards temperate for nearly half the year. Since the territory is on the track of tropical cyclones, it can experience very heavy and prolonged rainstorms at times. Rainfall duration ranges from short bursts of a few minutes to long and heavy downpours of several hours or even days. With an annual average rainfall of about 2,200 mm, Hong Kong receives the highest precipitation among cities in the Pacific Rim.

Hong Kong has a relatively distinct wet season in the summer when the weather is hot and humid and about 80% of the rain falls between May and September. The distribution of rainfall over the year is very uneven and is shown in Figure 1, which indicates the distribution of clock-hourly rainfall for over a hundred years of record. The wettest month is August, when rain occurs about four days out of seven and the average monthly rainfall in the urban area in Kowloon is about 400 mm. It is during the summer months of July to September that Hong Kong is most likely to be affected by tropical cyclones and heavy rain may last for several days.

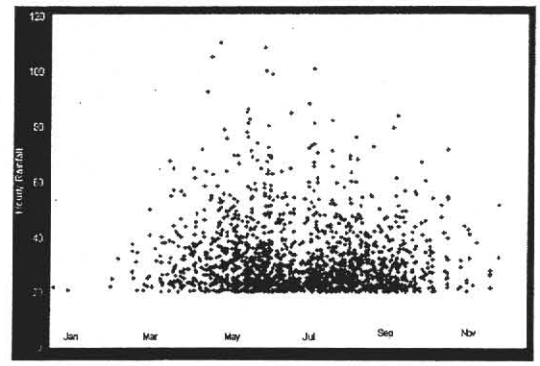


Fig. 1 Distribution of clock hourly rainfall over time (1884-1998) - rainfall below 20 mm/hr not shown for clarity

Notwithstanding Hong Kong's relatively small land area of approximately 1,100 km2, the distribution of rainfall in the territory is uneven. The mean annual rainfall ranges from around 1,300 mm at Waglan Island on the south-eastern corner of Hong Kong, to more than 3,000 mm near Tai Mo Shan, which is its highest peak and located in the middle of the territory. Besides the noticeable spatial distribution of precipitation, the temporal variation of the rainfall is also high.

1.2 The Flooding Problem

During heavy rainstorms, flooding in the rural low-lying areas and natural flood-plains in the northern part of the territory and in parts of the older urban areas is not uncommon.

Fig. 2 Flooding during Typhoon Brenda in 1989

To quote an example, the heavy rain brought about by Typhoon Brenda in 1989 flooded 1,170 hectares of land. Over the years, intensive development associated with urban development has taken place in the flood-plains. This has turned large areas of natural ground into hard paved areas and rainwater which formerly was retained now quickly becomes surface flows. The extension of built-up areas in close proximity to the major watercourses has also reduced their flood carrying capacity and has further aggravated the flooding problem. In the old urban areas, flooding occurs because stormwater drainage systems built decades ago to older protection standards are becoming inadequate due to aging of the systems and the expansion of the built-up urban area.

As general standards of living have risen, public expectations of levels of service and protection against flooding have also increased. The Government has long realised the need for a strategy for flood prevention in Hong Kong to tackle the flooding problem and to meet the public expectation.

Fig. 3 Flooding in Mong Kok in 1997

1.3 Strategic Studies

To provide a long-term solution against the flooding problem, the Government decided that a comprehensive strategy was needed and the "Territorial Land Drainage and Flood Control Strategy Study – Phase I" was commissioned in November 1988. A broadbrush strategy, with appropriate balance between the town planning, engineering and organisational aspects was developed for the whole territory. The study gave due consideration to using non-structural measures in parallel with conventional structural measures and also identified the need for major river training schemes and the introduction of legislation and management measures. The Government endorsed the strategy in 1990.

In September 1989, the Government established the Drainage Services Department (DSD) to take up the overall responsibility of providing an efficient approach to resolving both the flooding

and sewage problems in Hong Kong. Since then, a number of further studies on flood prevention strategy have been conducted by DSD. The "Territorial Land Drainage and Flood Control Strategy Study – Phase II" began in 1991 and was completed in 1993. The study provided Government with the more concrete plans and tools needed to make the strategy effective in the 5 most flood prone basins in the north New Territories. The principal output from the study was a Basin Management Plan for each of the basins. It provides a rational framework for managing the drainage systems in each basin, implementing structural and non-structural flood loss mitigation measures and responding to requests for development.

Since 1996, the Government has further commissioned eight stormwater drainage master plan (DMP) studies covering all the flood prone areas of the territory. These DMP studies comprehensively examine the adequacy of the existing drainage systems and develop short and long term drainage improvement measures to meet current standards and future needs. Implementation of these measures will follow upon completion of each DMP study.

2. Flood Prevention Strategy

The above-mentioned studies provided a framework for the Government to progressively and systematically formulate an effective flood prevention strategy. The strategy needs to consider both technical and management options, expressed through structural and non-structural measures. In developing the strategy, a number of constraints and objectives have been considered, including social and economic pressures, financial and legal constraints, geographical and environmental conditions, institutional and management constraints and development plans. The strategy comprises many components and the following major items will be discussed in the subsequent sections:

(i) New flood protection standards for the public stormwater drainage systems;

(ii) Long-term structural measures;

(iii) Short-term improvement and management measures;

(iv) Land use management and legislation;

(v) Planned preventive approach to maintenance.

2.1 The Organisational Set-up of DSD

An effective and efficient institutional arrangement is the key for implementing successfully the flood prevention strategy. The DSD is a multi-disciplinary department charged with the overall responsibility of resolving both flooding and sewage problems. It is responsible for, among other things, the planning, design and construction of new stormwater drainage facilitities and their

subsequent operation and maintenance. DSD now consists of a workforce of 1900 which has grown from 1400 since its establishment in 1989. The organisational set-up is shown in Appendix 1.

2.2 Flood Protection Standards

One of the major components of the strategy is a set of flood protection standards for the planning and design of the public stormwater drainage systems. Factors such as land use development scenarios, economic growth, socio-economic needs, consequences of flooding and benefit-cost analysis of flood mitigation measures have been considered in developing the standards. As a result, there are different standards for various elements of the drainage systems. All new stormwater facilities have to be designed to withstand a severe flood event which will occur about once within the period stated below:

	years
Urban drainage trunk systems	200
Urban drainage branch systems	50
Main river and rural drainage channels	50
Flood protection bunds for villages	200
Village drainage	10
Intensively used agricultural land	2-5
Fallow or disused land	flooding accepted

The definition of flood events is based on the combination of rainfall intensity and tide levels.

It is recognised that it will not be always possible or practical to upgrade the existing drainage systems, especially those within the old urban areas, to the current standards. In these special circumstances, a pragmatic approach is necessary in order to determine the best possible flood protection levels that can be achieved having regard to the constraints imposed by the existing highly intensive development.

2.3 Long-term Structural Measures

2.3.1 River Training Works and Village Flood Pumping Schemes

To achieve the flood protection standards and to prevent major flooding, very large scale civil engineering works are required.

Fig. 4 Regulation of Shenzhen River

A comprehensive programme for these long term structural measures is already in hand in the New Territories to implement improvements to the primary

drainage network. The works, estimated to cost HK$10.8 billion, include widening and training of 110 km of major rivers and the implementation of village flood pumping schemes for low-lying flood prone villages. The latter are necessary where the villages are so low-lying that flood water cannot effectively be drained by gravity to the primary drainage network. These schemes involve the construction of bunds around existing villages and pumping of stormwater from within the bunded area to an outside channel during rainstorms. To date, 25 flood pumping schemes have been constructed and have proven to work well. Two more schemes are under construction.

Fig. 5 Village flood pumping scheme at Chuk Yuen Tsuen, Yuen Long

With the increasing public awareness of environmental protection, it is our policy to incorporate environmental friendly features into our drainage improvement and flood control projects as far as possible. These efforts have culminated into large tracts of green banks, rich reed ponds, preserved meanders, and mangrove habitat over the years.

2.3.2 Urban Area Drainage

In Hong Kong, most of the utilities such as electric cables, telephone lines, TV cables, fuel gas pipes, water pipes, etc., are all laid underground beneath the public roads and pedestrian footways. In view of the disruption caused and the numerous constraints in carrying out road opening works in old urban areas such as the lack of space, traffic and utility diversion problems, innovative improvement options are now being considered to minimise these effects. The options include the following:

(i) the application of no-dig technology to eliminate road opening works;

(ii) the provision of underground storage tanks for flood water to reduce peak flows and hence reduce the amount and extent of drainage improvement works in highways;

(iii) pumping of flood water from low-lying areas;

(iv) tunnel systems to collect rain water from upland areas for discharge directly into the sea. By employing this method, less rain water would enter the old drainage systems within urbanised districts and therefore, the flood protection level of the systems could be improved with much less requirement for the construction of conventional drainage works.

Implementation of all these plans could cost about HK$6.5 billion.

Fig 6 Kai Tak Transfer Tunnel

Upon completion of these extensive long term structural measures, major flooding problems within the territory will be resolved. These structural measures are one of the fundamental components of the flood prevention strategy.

2.4 Short-term Improvement and Management Measures

Large-scale structural improvement projects often take many years to complete. Apart from the need to carry out design and construction, we also need time for public consultation, land resumption and clearance, assessment of environmental, traffic and utilities impacts and for procedural requirements under relevant ordinances. Hence short term improvement and management measures are put in place in the interim. These include local drainage improvement works, first aid measures, public information, flood warning systems and flood shelters.

2.4.1 Local Drainage Improvement Works

Local drainage improvement projects consist mainly of the improvement of local channels and village drains, and are implemented under the Rural Public Works programme managed by the Home Affairs Department. These works will alleviate the local flooding situation in flood prone rural areas.

2.4.2 First Aid Measures

Under the eight DMP studies, the existing local flooding blackspots within the study areas are being investigated. First aid measures will be designed and implemented quickly so as to provide immediate relief at these blackspots. These could include the addition of road gullies, road side channels, and the clearance of obstructions in channels and pipes.

2.4.3 Public Information, Flood Warning Systems and Flood Shelters

Apart from constructing new drainage facilities, the Government has put in place non-structural measures to help tackle the flooding problem. One of the measures is to provide the public with better information to minimize public inconvenience and flood losses. Forecasts of typhoons, rainstorms and floods are disseminated to the public as

quickly as possible. The Hong Kong Observatory will broadcast rainstorm warnings and make a special flood announcement for the flood prone Northern New Territories when the situation warrants. An Amber rainstorm warning signal will be issued when heavy rain exceeding 30 mm in an hour has fallen or is expected to fall generally over the territory. Similarly, a Red or Black warning signal will be issued when more than 50 or 70 mm of rain has fallen or is forecast to fall in an hour respectively. These warnings are aimed to give ample time for public to take proper and precautionary actions and also for the officials of the relevant Departments to get prepared for flooding hazards. Pamphlets are distributed from time to time to promote public awareness of flooding hazards and to advise on the steps which can be taken to reduce flood losses.

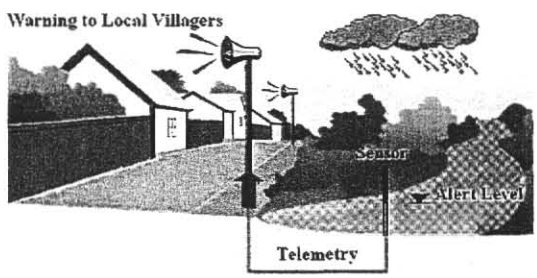


Fig. 7 Village flood warning system

As interim measures to minimize flood losses before the long term improvement works are completed, local flood warning systems have been installed at flood prone villages to inform the villagers when flood water reaches a predetermined alert level. The warnings are disseminated through flood sirens or through automatic telephone calls to the village representatives. Flood shelters will also be made available during emergencies to provide an adequate safety net for the majority of flood affected residents.

2.5 Land Use Management and Legislation

2.5.1 Land Use Management

In the past, spontaneous development in the New Territories has sometimes occurred, usually with no regard to the adverse impact on the drainage systems in the areas. The filling of fishponds and low lying areas within the flood plains to form large paved storage yards has increased surface flows and blocked drainage paths. To address this problem, land use management measures are now in place to ensure that the current flooding situation will not deteriorate due to further development and urbanisation in the New Territories' floodplain. Development control is enforced through the Outline Zoning Plans (OZPs), the Town Planning Ordinance and the Drainage Impact Assessment requirements. All development requiring a change in the land use specified in the OZPs or other Government development plans will need to seek approval from the Town Planning Board. If the project will significantly affect the drainage situation, private developers or the proponents of public projects, such as reclamation and highway projects, will need to conduct a

Drainage Impact Assessment to demonstrate that, with their proposed mitigation measures, the flooding risk to the area concerned would not be increased. These management measures are a significant element in determining the need, scope and timing for the structural measures to be implemented, and in allowing development in the floodplain to proceed in a proper and controlled manner whilst the long term structural measures are being implemented.

There is a Government's policy on afforestation and restoring vegetative cover which is implemented by the Agriculture, Fisheries and Conservation Department and the Leisure and Cultural Services Department. Although afforestation is intended to achieve various environmental objectives, it will continue to form one of the components of the land use management measures as increased afforestation has the potential to reduce stormwater flows and erosion.

2.5.2 Legislation

In the New Territories, many of the natural watercourses lie within private land. In the past, some flooding incidents have been caused by the lack of maintenance of the sections of main watercourses which lie within private land. The Government experienced great difficulty in obtaining the necessary consent from landowners to gain access and to carry out maintenance works to these watercourses. To overcome this problem, the Land Drainage Ordinance was enacted in 1994 empowering the Government to carry out maintenance, remove obstructions such as illegal structures encroaching upon the river channels, and to gain access into private land for maintaining these designated main watercourses. Maintenance works under the Land Drainage Ordinance are on-going and there has been a definite improvement in the overall situation.

Fig. 8 Desilting works under Land Drainage Ordinance

2.6 Planned Preventive Approach to Maintenance

2.6.1 Preventive Maintenance

The drainage systems will not continue to function properly without a well-planned, on-going preventive maintenance programme of inspection, desilting and repair. This forms a vital part of flood hazard management. The Government ensures that problematic road gullies, stormwater intakes, drains and watercourses are inspected on a regular basis especially before and during the

rainy season. Under this preventive maintenance programme, about 1600 km (60% of total) of drains and watercourses are inspected and 500 km are desilted in 2004, about HK$110 million was spent on such maintenance works. Extensive closed circuit television surveys have been employed for existing drains where man-entry inspections are not possible. Timely repairs to the drains will be carried out before major problems arise. Regular desilting and dredging of tidal channels are conducted so that their flood carrying capacities would not be adversely affected by sediment washed down from the upstream areas. A special programme of inspecting flood control installations including flood water pumping stations and flood warning systems, is conducted throughout the year to ensure that they would be fully operational in times of rainstorm. Coordinated efforts amongst relevant departments are in place to keep the streets clean in order to prevent rubbish from blocking road side gullies and catchpits.

Computer models have been developed and continuously upgraded so as to provide quantitative information on the risk of flooding, impacts of development and the performance of various flood loss mitigation options. A computerised stormwater drainage asset inventory and management system is also being developed in DSD. The system will provide an accurate up-to-date record of the inventory and the hydraulic and structural performance of DSD's drainage assets. All these technological developments will serve as a useful management tool to identify deficiencies, and to derive action plans and maintenance schedules for the drainage systems, thereby reducing flood hazards.

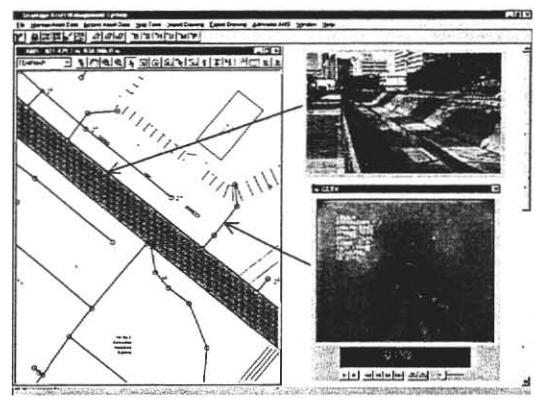


Fig. 9 Drainage Asset Management System

2.6.2 Flood Hazard Management

Flooding will continue to be a problem until the long-term measures have been completed. Having said that, there will still be flood hazards that need to be managed. For example, the intensity of rainstorm may be so extreme as to exceed those allowed for in the design of the drainage system or a tree could fall down during a typhoon, blocking an inlet and causing flooding. It is inevitable that flooding risks will still remain even after all the measures have been implemented.

2.6.3 Emergency Planning

The Government has contingency plans in place to manage flood hazards. In

addition to flood warning and flood shelters mentioned above, DSD has set up a 24-hour hotline so that flooding complaints can be dealt with by our direct labour force or our contractors as soon as possible. We have publicized our performance pledge and every effort is made to ensure that complaints received in the morning are investigated on the same day or the next morning for those received after 1 pm. Complaints received are recorded by the computerised Drainage Complaints Information System so that data could be retrieved and analysed later for resolving the problem. An Emergency and Storm Damage Organisation is in place to handle emergency and flooding problems outside office hours. An Emergency Control Centre overseen by senior professionals is activated when the situation warrants in order to coordinate emergency clearance of blocked drains and watercourses throughout the territory, to handle the large number of complaints and reports of flooding, and to disseminate information within the Government and to the public. Crucial hydraulic structures, such as the facilities within the flood pumping station and the inflatable dams at major channels constructed for stormwater quality improvement, are closely monitored by telemetry and video surveillance for visual monitoring of important electrical, mechanical and civil components.

The DSD has installed more than 40 automated gauging stations at rivers and channels throughout the territory to monitor the real time flooding situation round the clock and collect the hydrological data. Most of these stations are equipped with ultrasonic probes to measure the water depth in channel with great precision, and transmit the data to the control center immediately via the advanced GPRS (General Packet Radio Service) wireless data transmission technology. To make use of renewable energy and to reduce the installation and operation costs, many of the stations are powered by solar cells. With this real-time flood data, officers manning the Flood Monitoring and Reporting System can quickly analyse the flooding situation and, when necessary, alert the Emergency Control Centre and other departments, such as Fire Services Department, Hong Kong Police Force, the Home Affairs Department, etc. to prepare for rescue, evacuation and the opening of flood shelters if necessary.

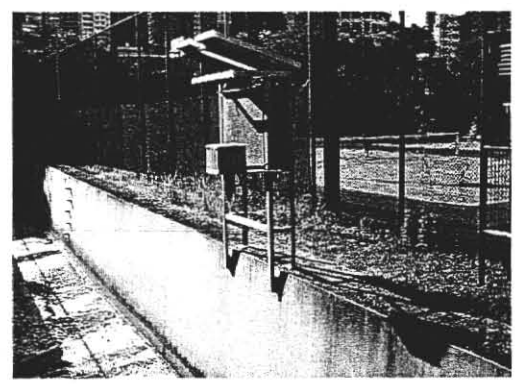


Fig. 10 Wireless gauging station

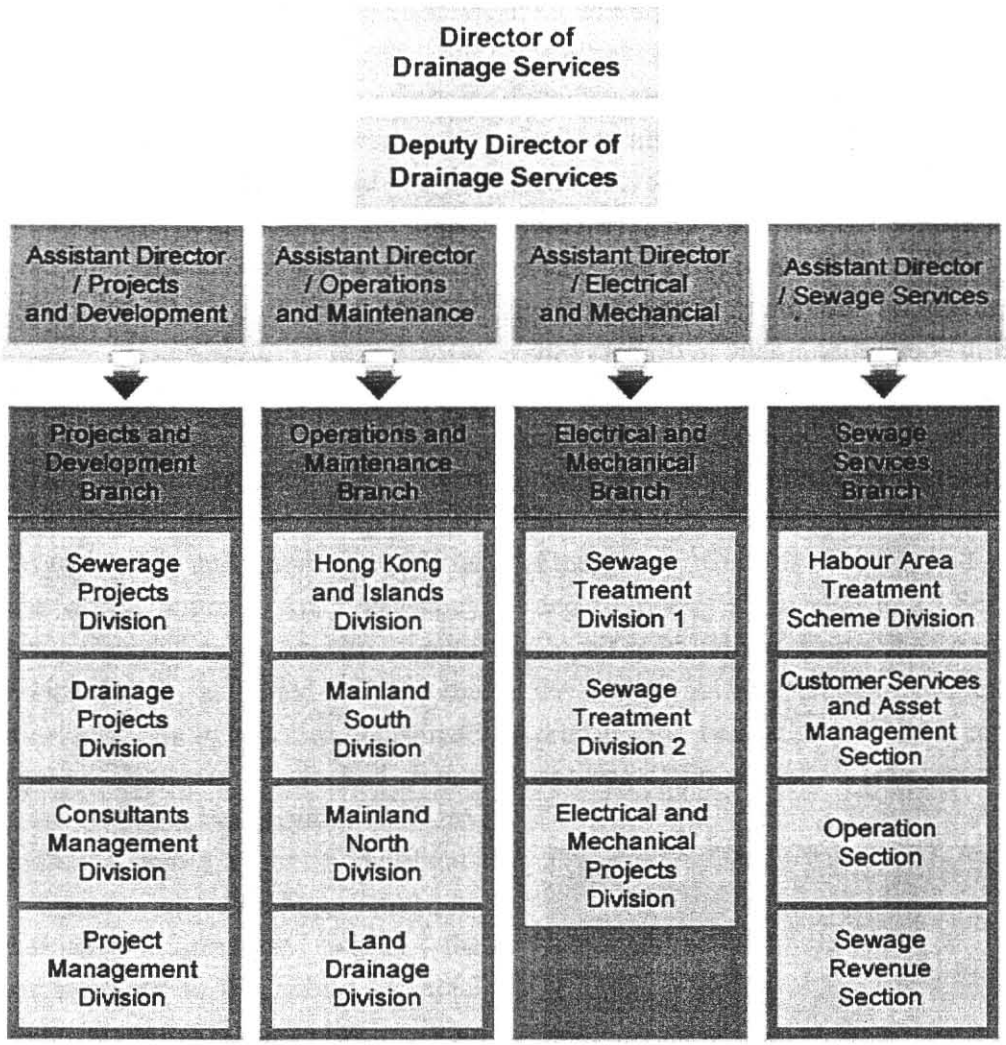
3. Conclusion

Hong Kong has a comprehensive strategy in place to tackle flooding problems. The

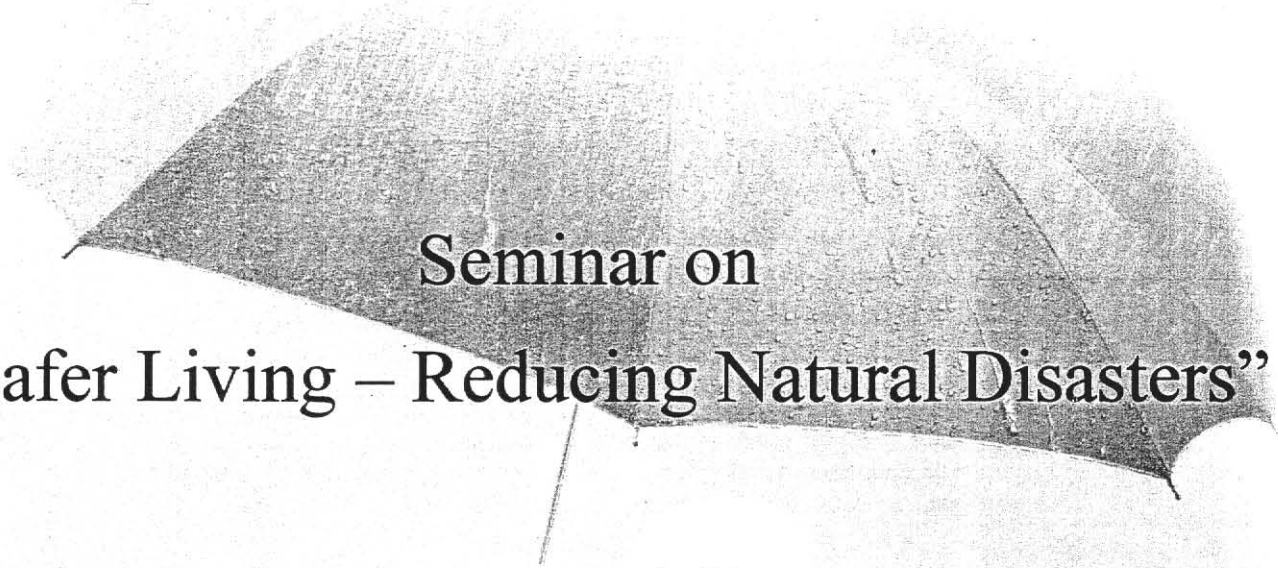
strategy consists of long-term structural measures, short-term improvement and management measures, land use management and legislation, and a planned, preventive approach to maintenance. Many of the long-term measures are well under-way although the benefits may not be immediately apparent until further work has been completed. With the comprehensive flood prevention strategy in place, there is no doubt that the drainage system is being better planned to meet future demands and that the Government is well on its way to providing good flood protection standards for the benefits of the community.

Appendix I

DSD HEADQUARTERS



Reducing
Natural Disasters
防天災 保平安
Safer Living 晴天行動



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