

**Investigation Report on
Flooding in the New Territories
and Tsuen Wan in June 2001**

EXECUTIVE SUMMARY

Drainage Services Department

14 September 2001

1. BACKGROUND

An investigation was carried out by the Drainage Services Department (DSD) at the instruction of the Secretary for Works to investigate the causes of flooding in the New Territories and Tsuen Wan which occurred in June 2001, and to assess whether construction works in the vicinities of the affected areas had aggravated the flooding situation.

2. SCOPE OF INVESTIGATION

2.1 The investigation was based on the hydraulic performance of the drainage system under the prevailing rainfall and tide conditions, and included an assessment of the effect of any construction activities in the vicinity of the flooding locations.

As far as is compatible with producing appropriate conclusions, the engineering investigation was limited to describing the immediate physical conditions and factual events which were directly related to the actual causes of the flooding. It was considered that it is outside the scope of such an engineering investigation to speculate about or comment upon the circumstances that may have given rise to the physical conditions or on the background that may have led up to the events as they occurred.

The intention was not to investigate into the contractual or legal responsibilities of any of the parties involved and the material facts proffered were compiled by independent teams in DSD who are not involved in the work contracts relating to the flooding incidents. As such the observations and conclusions drawn from the flooding investigations were prepared in the exercise of DSD's responsibilities on the control of flooding in Hong Kong as distinct from in its capacity as Employer under some of the works contracts involved.

In any event, any explicit or implied criticisms of or adverse comments on the contractors and/or Employers and/or other parties made under such administrative capacity should not be construed as admissions of liability on the part of the contractor and/or Employer of the works contracts concerned or of other parties.

2.2 METHODOLOGY

In recent years, a series of consultancy studies have been undertaken by DSD to produce Drainage Master Plans (DMPs) covering much of the territory. These DMPs include a comprehensive assessment of the existing drainage systems and form a good basis for this investigation into the flooding events in June this year. The following DMPs are relevant :

DMP Study	Completion Date
Yuen Long, Kam Tin, Ngau Tam Mei & Tin Shui Wai	10/1998
Tsuen Wan, Kwai Chung & Tsing Yi	7/1999
Northern New Territories	10/1999

The investigation was generally carried out based on the following methodology with appropriate amendments to suit individual incidents.

- (a) Determination of the flood extent and flood water level.
- (b) Collection of relevant information and reports from Resident Engineers of the construction works in the vicinity.
- (c) Site inspection by the investigation teams.
- (d) Interview with the local people.
- (e) Collection of hydrometric data.
- (f) Study of the site characteristics.
- (g) Comparison with historic flood events.
- (h) Comparison with the base-line flooding scenario.

Computer hydraulic models have been used to establish a base-line scenario to compare with the measured flood levels on site. These computer models, namely MIKE 11 models¹, were built up and calibrated under the various DMP Studies. Basic parameters such as topographical data, river geometry, land use and other boundary conditions had been scrutinised and agreed upon by both DSD and the

¹ MIKE 11, developed by DHI Water & Environment, is a professional engineering software package for simulating flows in estuaries, rivers, irrigation channels and other water bodies.

consultants of the DMP Studies as the best available information or approximations during the building-up of the models.

As some of the construction works under investigation generally involve a lot of temporary works including complicated river diversion works, it is not feasible to assess the effect of individual temporary works and then to aggregate their theoretical combined effects. Instead, a base-line scenario of flooding levels was first computed with hydraulic models using the actual rainfall data and tide levels of the events in June 2001 combined with a practical assessment of the topography and drainage conditions of the particular areas that could have prevailed had the construction works under the particular contracts not been in progress.

Comparisons were then made to relate the computed base-line flood levels to the actual flood levels measured on site. Through this comparison, an assessment to indicate the possible effects of construction activities was made. It must be emphasized that the amount of flood level difference calculated should not be taken as the exact values due to the inherent limitations of hydraulic modelling techniques such as problems in simulating debris being washed down by the storms and deviation of local flood paths due to construction works or temporary blockage. In addition to the above limitations, the possible variation of model parameters, the diverse rainfall data over a large catchment area and the accuracy of the boundary condition water levels may also affect the accuracy of the computed water level difference.

Nevertheless, even though the effects of the above mentioned problems may give rise to some uncertainties, the validity of this approach of assessment using the results of hydraulic models to compare the actual event is considered to be acceptable as a practical means of establishing the relative impacts of the flooding events. Under the relevant DMPs, the hydraulic models had already been validated and calibrated using actual rainfall and flood water data from previous events.

2.3 WEATHER EFFECT

In early June, a trough of low pressure brought torrential rain to the South China coastal areas. The rain bands affected Hong Kong and periods of heavy rainfall occurred in various areas of the territory from the 5th to the 13th of June 2001. The most severe rainfall occurred in the morning of 9.6.2001 resulting in flooding in the New Territories.

The periods of heavy rainfall generally occurred in the morning which coincided with the high tide on those dates. In the morning of 9.6.2001, the heavy rain occurred around 8:00 am with the tide level at 1.35 mPD rising to a peak of 2.65 mPD at 10:40 am. From the drainage point of view, this was undesirable because the rising tide prevented the stormwater runoff from discharging quickly to the sea. The rate of dissipation of the flood was also deferred by the rising tide.

The rainfall in early June was heavy and prolonged, with the Amber rainstorm signal hoisted on 9 consecutive days. The smaller yet prolonged rainfall at the beginning of June had increased the catchment soil saturation and therefore increased the volume of flood water generated in the subsequent severe rainstorms on 9.6.2001.

Heavy rainfall also occurred near the end of June 2001, in particular from the 23rd to the 27th. The tide was not high during the rainstorms on these days, but the heavy rains still brought about flooding to various parts of Hong Kong. It is also important to note that June 2001 has been the wettest month of June in the hundred years record of the Hong Kong Observatory.

3. MAJOR FLOODING EVENTS

- 3.1** During the periods of heavy rain in June 2001, although very intense rainfall had occurred over the urban areas of Kowloon and Hong Kong Island, it was generally for only shorter periods of time and flooding in these areas was mostly limited to localized ponding. In the New Territories, however, the very intense rainfall persisted for a longer period which, together with the high tide, resulted in extensive flooding in the low-lying areas of Northern and North-western New Territories. Serious flooding also occurred at Belvedere Garden in Tsuen Wan and in Kau Lung Hang near Tai Po.

The most extensive flood occurred on 9.6.2001 when DSD received 130 flooding complaints. On the other days, the rainfall was more localised and flooding was more limited in extent.

On the 7th, 9th, 11th, 12th, 23rd and the 24th of June 2001, flooding occurred in the North-western New Territories in the low-lying areas and blackspots which are susceptible to flooding such as Ngau Tam Mei and Kam Tin.

In the Northern New Territories, flooding occurred in the low-lying areas and blackspots on the 9th, 10th and the 27th of June 2001. The areas worst hit by flooding were in the floodplains of the River Indus near Fu Tei Au, Tin Ping Shan, and the Ganges Basin.

There were other areas of flooding including Fat Yip Lane near Belvedere Garden in Tsuen Wan (9.6.2001, 11.6.2001, 12.6.2001, 23.6.2001 and 27.6.2001) and Kau Lung Hang in Tai Po (9.6.2001, 10.6.2001, 12.6.2001 and 27.6.2001)

3.2 CAUSES OF FLOODING

3.2.1 Principal Causes

In the New Territories, the flooding incidents that occurred in June 2001 were mainly in the low-lying areas of known flood risk, e.g. the River Indus floodplain and Ngau Tam Mei area. The river channels in these areas are inadequate to convey the flood flow under heavy rain and have long been recognized as flood-prone. They have been classified as flooding blackspots and large scale drainage improvement works are being implemented to solve the flooding problem. Before the completion of these improvement measures, flooding will still occur under adverse weather.

The basic cause of the flooding in June 2001 was the inadequacy of drainage capacity under the effects of heavy rainfall. In some cases, the heavy rain was coupled with high tide, or with the tide rising during the subsidence of the flood flow. The high tide prevented the smooth discharge of flood flow to the sea and created a backing-up of the flood water.

Furthermore, the prolonged rainfall also aggravated the situation. The preceding rainfall saturated the catchment and reduced the infiltration into the soil. The stormwater runoff was increased, and a larger flood volume was generated.

Under such adverse circumstances, the flooding blackspots would be flooded even if no construction activities were in their vicinity. However, on the River Indus floodplain and areas in Ngau Tam Mei and Kam Tin, construction of river improvement works were being actively carried out. These construction projects unavoidably involved temporary works and

flow diversions, some of which could have different degrees of impact on the capacity of the drainage systems. Details of individual locations are discussed and summarized below.

3.2.2 Tin Ping Shan and Sheung Shui

Flooding occurred in the Tin Ping Shan and Fu Tei Au areas in Sheung Shui in June 2001. The most severe flood occurred on 9.6.2001, and there was also flooding to similar areas on 10.6.2001 and 27.6.2001 but to a lesser extent.

The major floodplains in Sheung Shui are the Lo Wu areas near the confluence with the Shenzhen River, the Fu Tei Au and Ho Sheung Heung areas at the Lower Indus, the Tin Ping Shan area to the upstream of Man Kam To Road, and the Kwan Tei area at the Upper Indus. They are flood prone and have been classified as major flooding blackspots in the North District. With some of the drainage improvement projects and rehabilitation works largely completed, the flooding situation in Lo Wu, Ho Sheung Heung and Kwan Tei has been improved. However, for the Tin Ping Shan and Fu Tei Au areas where the construction of major drainage improvement works are yet to be completed, heavy rainfall will still cause severe flooding.

The most serious flooding occurred on 9.6.2001. From computer modelling analysis of the drainage system, it is concluded that the heavy rainfall coupled with the rising tide on 9.6.2001 morning would have caused severe flooding to the Fu Tei Au and Tin Ping Shan floodplains even if no construction activities were taking place. This is because the existing rivers have insufficient capacity to cope with the flood water arising on that day. There have been nine flooding events in Tin Ping Shan since 1996. It is noted that both the rainfall and the high tide conditions on 9.6.2001 were more severe than in any of the eight other events.

Having reviewed the conditions on site, it was considered that works under the following two contracts of the Territory Development Department (TDD) may have had the potential to aggravate the flooding situation on 9.6.2001:

- (a) Contract No. FL 20/97: Shek Wu Hui Development Package 4 – River Training in Area 30B; and

- (b) Contract No. FL 23/99: Main Drainage Channels for Fanling, Sheung Shui and Hinterland – River Training Works for Upper River Indus.

Investigations were carried out using computer modelling to assess the possible effects of the works. A base-line scenario was therefore established whereby the depth of flooding was calculated by computer modelling assuming that none of the works under Contract No. FL 20/97 and Contract No. FL 23/99 had been in existence. These theoretical base-line flood levels were then compared with actual flood levels recorded on site. It is found that the actual flood levels in the Tin Ping Shan area on 9.6.2001 were slightly higher than the situation simulated in the base-line scenario. The increase in flood depth was generally less than 120 mm.

Having regard to the limitations of the methodology in carrying out such investigations, it is not possible to conclude whether or not this relatively small increase in depth of flooding, as compared with the base-line scenario, was solely attributable to the contract works on site. It is possible to conclude, however, that if there was an adverse effect, it would not have been significant.

Although these two contracts still have substantial temporary works, stockpiles, local channel widening, by-pass channels and flow diversions on site, it is noted that, since the start of the works, improvements to the drainage system have been carried out under the contracts. It is considered that these factors, taking an overall view of the contract works, may have largely mitigated any potential adverse effects of the current works.

3.2.3 Ngau Tam Mei, Yuen Long

In the Ngau Tam Mei area, the only significant flooding during June 2001 was the 9.6.2001 event.

In the morning of 9.6.2001, a heavy rainstorm occurred in the North and Northwest New Territories including Ngau Tam Mei. Flooding occurred in the low-lying areas in Ngau Tam Mei including Wai Tsai Tsuen and Yau Tam Mei Tsuen. In a small low-lying part of Wai Tsai Tsuen between Ngau Tam Mei Road and the existing watercourse, about twenty village houses were flooded to a depth of up to 1.5 m. In Yau

Tam Mei Tsuen, flood depth was about 0.5 m to 1 m. A total area of about 4 ha along the existing watercourses in Ngau Tam Mei was inundated.

The hydraulic performance of the existing drainage system in Ngau Tam Mei is poor. Flooding would occur in a rainstorm with a return period of less than 2 years, and Wai Tsai Tsuen and Yau Tam Mei Tsuen are both listed as flooding blackspots.

The rainstorm in Ngau Tam Mei on 9.6.2001 had a return period of 1-5 years at lower catchment and a return period of up to 30 years at upper catchment. Based on mathematical modelling analysis, flooding would be expected in the low-lying areas of Wai Tsai Tsuen and Yau Tam Mei Tsuen even without any construction works in the vicinity.

After examining the situation in the area and not having found any other potential causes, it is concluded that:

- (a) DSD's Contract No. DC/98/10: Construction of Main Drainage Channels for Ngau Tam Mei, Phase 1 (Contract E); and
- (b) TDD's Contract No. YL48/99: Main Drainage Channel for Ngau Tam Mei, Phase 2

may have aggravated the flooding by causing an increase in flood depths of up to 750mm in a small low-lying part of Wai Tsai Tsuen between Ngau Tam Mei Road and the existing watercourse and in the downstream portion of Yau Tam Mei Tsuen near Castle Peak Road. It should be noted that as a result of the works carried out prior to 9.6.2001, the flood risk and the flood damage in the downstream areas of Chuk Yuen Tsuen and Yau Mei San Tsuen have been reduced in comparison to previous years.

3.2.4 Kam Tin

Flooding incidents were reported in the Kam Tin area at Tsat Sing Kong and Tai Kong Po. Major flooding was reported on 9.6.2001 and minor incidents were also reported on the 11th, 12th, 23rd and 24th of June 2001. This investigation has only focused on the major flooding incident on 9.6.2001.

Tsat Sing Kong and Tai Kong Po are relatively low-lying on the northern side of the Kam Tin River. Both villages are flooding blackspots and susceptible to flooding. The existing river and tributaries near the villages do not have adequate drainage capacity to convey the flow under the severe rainstorm event on 9.6.2001 and it was verified by the mathematical model that overflow would occur at these watercourses. The area would be subject to flooding even if there was not any construction works along the Kam Tin River or blockage of drainage facilities.

Within the general area, there is a works site for a DSD contract for the construction of Main Drainage Channels for Yuen Long and Kam Tin Stage II – Kam Tin San Tsuen to Wang Toi Shan Section (Contract D: No. DC/98/04).

The flooding in Tsat Sing Kong was very local at a temporary pipe bridge constructed by the contractor. There was no flooding at the Tsat Sing Kong village upstream but vehicular access was disrupted. The flooding situation in Tsat Sing Kong was alleviated as compared with previous flooding incidents with similar rainfall intensity. This was mainly due to the partial commissioning of the main drainage channel under the contract and a substantial increase in flood storage provided in the drainage channel. The construction works had not aggravated the flooding situation in the area.

The flooding at Tai Kong Po was mainly due to the inadequate capacity of the existing watercourse combined with blockage of an existing box culvert caused by large amounts of soil, debris, boulders and vegetation being washed down from immediately upstream. This box culvert is outside the works site of the DSD contract. The construction works had no adverse impact on the hydraulic performance of the existing watercourse and had not aggravated the flooding situation in the area.

3.2.5 Pok Wai, Yuen Long

During the severe rainstorm in the early morning of 7.6.2001, Pok Wai was flooded covering an area of about 3 ha to a depth of about 500 – 900 mm. About twenty houses and several vehicles were flooded. Firemen were called in for rescue, but no casualties or injuries were reported.

Pok Wai village is low-lying and is a well-known flooding blackspot which would have been flooded under this sort of heavy rainfall. A flood pumping scheme is being implemented by DSD under Contract No. DC/98/12 titled "Village Flood Protection Works for Pok Wai and Stormwater Intercepting Drain for Wang Chau" to permanently resolve the flooding problem. The project commenced in October 1999 and is now scheduled for completion in August 2002. During construction, the contract requires the contractor to provide interim flood protection measures to increase the flood protection level at Pok Wai.

The contractor has formed an earth embankment to prevent ingress of floodwater from outside the village and provided on site a number of temporary pumps for discharging stormwater collected from within the village to the nearby channels. However, it is evident that part of the temporary embankment was not maintained at the correct height to protect the village from ingress of floodwater. Furthermore, the contractor did not operate the temporary pumps at the early stage of the rainstorm. If the protective embankment had been maintained to the required level and the pumps were put into operation at 4:00 am that morning, the flood depth would have been reduced to about 100 mm and confined to the car park area.

After the incident, it has been reported that the contractor has maintained the protective embankment to the required level. The contractor has arranged his duty staff to be on site at all times to deal with emergency situations and to ensure that the pumps are always readily operable. The contractor has also provided more pumps to increase the flood protection level of the village. With these improvement measures, there were no further flooding incidents at Pok Wai during the subsequent rainstorms in June 2001.

3.2.6 Belvedere Garden, Tsuen Wan

On 9.6.2001, heavy rain fell in Tsuen Wan resulting in very large quantities of muddy water flowing down a streamcourse from the upland catchment above Belvedere Garden. Some of the water overshot from the streamcourse, thus flooding adjacent areas. However, the majority of the flow continued down the streamcourse but could not enter the underground drainage system because the drainage catchpit at Fat Yip Lane next to Belvedere Garden was blocked. Large amounts of boulders and debris which had been washed down from the streamcourse had caused the blockage. The floodwater carrying mud

and debris overflowed to flood parts of Castle Peak Road opposite to Belvedere Garden and also ran down the steep Lai Chi Road with high velocity to eventually flood Hoi On Road.

The same location flooded again during the heavy rain events on the 11th, 12th, 23rd & 27th June 2001.

The drainage catchpit at Fat Yip Lane is located at the toe of a small, steep, largely natural catchment in Ha Fa Shan above Belvedere Garden. There are three main streams flowing down the catchment which eventually enter the catchpit.

In the upstream section of the catchment, there is a catchwater which was built along the mid-level of Ha Fa Shan to collect rainfall from the catchment. It cuts across many natural streams running down the hillside and was designed to intercept the flow and convey the water to the Tai Lam Chung Reservoir. But in the case of severe rainstorms, the design allows for excessive flow to overflow from the catchwater to the stormwater drainage system by a series of specially designed overflow weirs at appropriate locations along the catchwater. There are two such overflow weirs along the section of catchwater above Belvedere Garden which, if the flow in the catchwater exceeds its carrying capacity, will discharge water to one of the streams and eventually to the drainage catchpit at Fat Yip Lane.

The flooding incidents at Belvedere Garden were due to a combination of factors as summarized in the following paragraphs.

There was a substantial rise in water level along a section of the catchwater above Belvedere Garden. As a result, very large and exceptional quantities of water were discharged from the catchwater's overflow weirs to the natural streamcourse leading to the underground drainage system at Fat Yip Lane.

In this connection it was reported that erosion debris had been deposited in the catchwater and it is noted that there was temporary steel decking and struts over the catchwater associated with slope upgrading works in progress at the time under Civil Engineering Department's Contract No. GE/99/18 – "10 Year Extended Landslip Preventive Measure Project, Phase I, Package A – Ground Investigation and Landslip Preventive Works for Slope in Hong Kong Island South, Kowloon and the New Territories – Batch A – Tai Lam Chung Catchwater".

When the very large and exceptional flow from the catchwater ran down the natural streamcourse, erosion occurred. Such a large flow would have carried with it any boulders and debris in its path to eventually block the downstream underground drainage system.

Due to the blockage of the drainage catchpit, the majority of the flow could not enter the underground drainage system but found its way along the roads, causing flooding.

The relatively short time intervals between the successive heavy rainstorms in June 2001, which did not allow sufficient time for the complete clearance and desilting of the downstream stormwater drainage system, may have also contributed to aggravate the situation.

If there had been no such large flow from the catchwater and the catchpit had not been blocked, it is considered that the drain at Fat Yip Lane as well as the downstream box culvert should have had sufficient capacity to cater for the rainstorms on the 9th, 11th, 12th and 27th June 2001. There may have been some minor flooding on 23.6.2001 when the rainstorm exceeded a 60-year return period and the capacity of the drainage system would have been exceeded.

3.2.7 Kau Lung Hang and Yuen Leng, Tai Po

Flooding occurred in the Kau Lung Hang catchment in Tai Po (River Indus Basin) during very heavy rainstorms in June 2001. The most severe flood occurred on 9.6.2001 and to a lesser extent on 10.6.2001, 12.6.2001 and 27.6.2001. Flooding was concentrated mainly in the following areas which are generally considered to be flooding blackspots:

- (a) Main access road adjacent to the railway;
- (b) Yuen Leng Village;
- (c) Road under the railway at Kau Lung Hang; and
- (d) Kiu Tau.

The flooding occurred because of the insufficient capacity of the main drainage networks to cope with the very heavy rainfall that occurred on each of these occasions and the relatively low-lying topography of some of the areas within the catchment. There were no major construction or development works in the vicinity of the Kau Lung Hang catchment.

3.2.8 Other Areas

There were other areas in the North District, Lok Ma Chau and San Tin reported by the media to be flooded during the heavy rainstorms in June 2001. A total of eight areas were investigated and most of them were found to be either previously identified flooding blackspots or areas known to be susceptible to flooding.

For the flooding at Ta Kwu Ling, Man Kam To, Ma Tso Lung, Ping Kong, Lok Ma Chau, Ki Lun Tsuen and Luk Mei Tsuen in San Tin, the causes were due to the heavy rainfall that had occurred, the low-lying topography of the locations, and the inadequate flood conveyance capacity of the local and/or downstream drainage systems.

For the flooding case at Hang Tau in Sheung Shui, the recorded rainfall exceeded the capacity of the drainage system. According to the local villagers, the flood extent was less than that experienced in the past, indicating that the recently completed drainage rehabilitation works had helped in mitigating the effects of flooding. As for the flooding case at Ha Pak Tsuen in Sheung Shui Wai, the flooding was found to be minor and localised, and was probably caused by temporary blockage of internal village drains.

None of the eight flooding cases mentioned above were related to construction activities in the vicinity of the flooded areas.