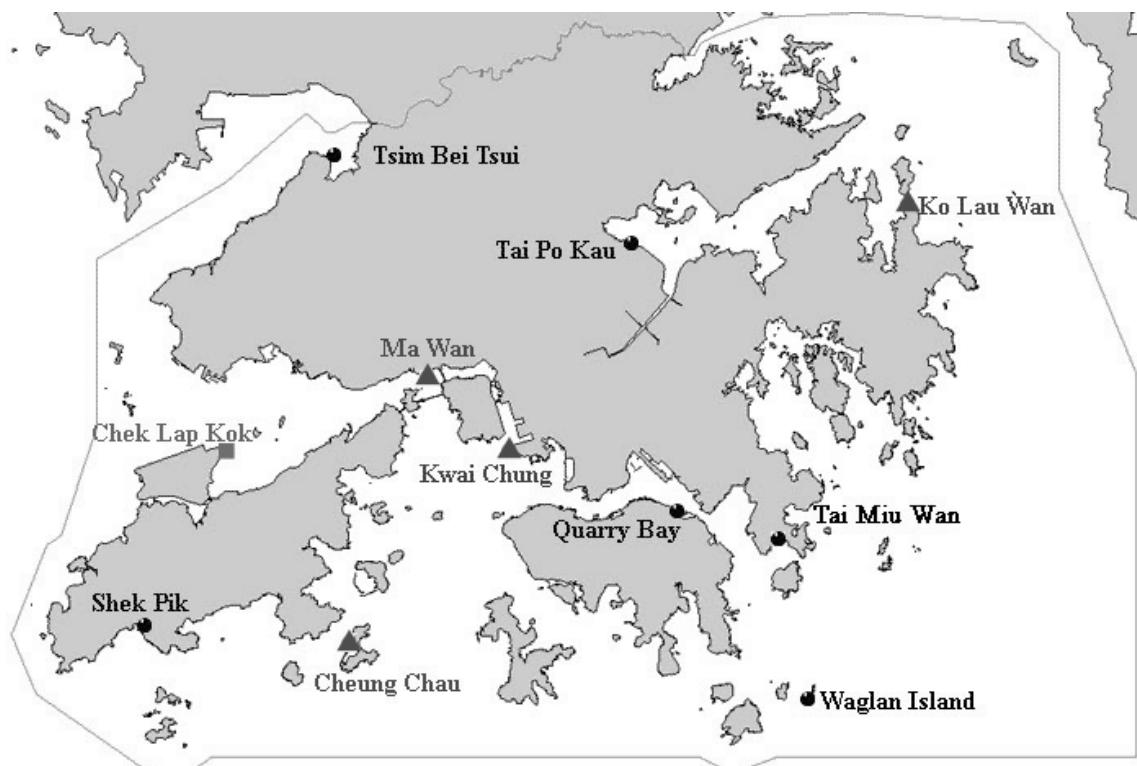


Tide reporting and applications in Hong Kong, China

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1. Tide Gauge Network in Hong Kong

Eleven tide gauge stations are installed in Hong Kong. Six of them are managed by the Hong Kong Observatory (HKO), four by the Hong Kong Marine Department (HKMD) and one by the Hong Kong Airport Authority (HKAA). Figure 1 shows the locations of these eleven stations. The HKO tide gauge station at Quarry Bay is registered at the core network of the Global Sea Level Observing System (GLOSS). An overview of the data availability of HKO tide gauge stations is shown in Table 1.



Tide Gauge Stations managed by:

● Hong Kong Observatory ▲ Hong Kong Marine Department ■ Hong Kong Airport Authority

Figure 1 Locations of tide gauge stations in Hong Kong

Table 1 Operation periods and data availability at HKO tide gauge stations

Station Name	Latitude	Longitude	Operation Period	Data Availability in 2005
North Point/ Quarry Bay [#] (GLOSS station)	22°18'N 22°17'N	114°13'E 114°13'E	1954-1985 since 1986	100%
Tai Po Kau	22°27'N	114°11'E	since 1963	100%
Tsim Bei Tsui	22°29'N	114°01'E	since 1974	93%
Waglan Island	22°11'N	114°18'E	since 1976	86%
Shek Pik	22°13'N	113°54'E	since 1997	99%
Tai Miu Wan	22°16'N	114°17'E	since 1994	78%

Tide gauge station at Quarry Bay (has been operating since 1986) is about 500 metres east of the North Point tide gauge station (closed in 1986).

2. Instrumentation

For HKO tide gauge network, float-type gauges are used at Quarry Bay and Tai Po Kau while pneumatic-type gauges are installed at Shek Pik and Tai Miu Wan, and a pressure sensor is used at Tsim Bei Tsui. Acoustic tide gauges are installed at the tide gauge stations managed by HKMD and HKAA. These instruments measure the sea level with an accuracy of 1 cm.

With the assistance of the Hong Kong Civil Engineering and Development Department (CEDD), tide gauge benchmarks were installed at HKO tide gauge stations for monitoring land settlement at the stations. The heights of tide gauge benchmarks were measured at half-yearly intervals by precise levelling, a land surveying technique based on trigonometric calculations, against the Hong Kong survey benchmark ^{Note 1}.

In cooperation with the Hong Kong Lands Department, Global Positioning System (GPS) geodetic measurements are conducted at the Quarry Bay, Shek Pik and Tai Po Kau tide gauge stations at half-yearly intervals for monitoring crustal movement. A GPS receiver was installed at the Shek Pik tide gauge station in February 2006 for continuous measurement.

^{Note 1} The datum of Hong Kong survey benchmark is called the Principal Datum (PD), which is about 0.88 metre below the Yellow Sea Datum. Tide heights are measured in metres above Chart Datum, which is 0.146 metre below the Principal Datum.

3. Acquisition and Processing of Tide Data

All HKO tide gauges take 128 samples per second to derive the 1-second average data which are used to compute the 1-minute average sea level. A microprocessor-based electronic package developed by HKO staff digitizes 1-minute average sea level and transmits the data through modem and a minilink (a type of commercial data circuit operating at 2400 baud) to the HKO Headquarters for display and archival by the main computer system. The 1-minute data are quality controlled and further processed to derive the hourly sea levels and the monthly mean sea levels. 1-minute data recorded at Quarry Bay and Shek Pik tide gauge stations are transmitted to the University of Hawaii Sea Level Center (UHSLC), the Japan Meteorological Agency (JMA) and the Pacific Tsunami Warning Centre (PTWC) on a real-time basis for tsunami monitoring. For long-term mean sea level monitoring, hourly sea level data and monthly mean sea level data recorded at Quarry Bay tide gauge station are sent to UHSLC on a monthly interval, and monthly mean sea level data for all HKO tide gauge stations are sent to the Permanent Service for Mean Sea Level Centre (PSMSL) on an annual basis. Details are shown in Table 2.

Table 2 Dissemination of data recorded by HKO tide gauge stations

Organizations	Tide Gauge Station	Date Type	Frequency of Dissemination
University of Hawaii Sea Level Center, Japan Meteorological Agency, Pacific Tsunami Warning Centre	Quarry Bay and Shek Pik	1-minute sea level data	10-minute interval
University of Hawaii Sea Level Centre	Quarry Bay	Hourly sea level data and monthly mean sea level data	Monthly
Permanent Service for Mean Sea Level	All HKO tide gauge stations	Monthly mean sea level data	Annual

4. Applications of Tide Data

4.1 Tidal Prediction

Prediction of the astronomical tides at various tide gauge stations up to two years ahead is conducted by HKO using harmonic analysis method. Hourly tide data were analysed to determine harmonic constants for tidal prediction. Predicted tides are made available in the annual publication "Tide Tables for Hong Kong" and HKO's homepage (http://www.weather.gov.hk/tide/estation_select.htm).

4.2 Real-time Monitoring of Storm Surges and Tsunamis

Real-time monitoring of storm surges and tsunamis is necessary for HKO to issue advisory of sea flooding during the passages of tropical cyclones and to operate its tsunami warning service respectively. To fulfill operational requirements, both the measured sea level and the predicted astronomical tides are displayed in the same graph so that their difference can be easily visualized (Figure 2).

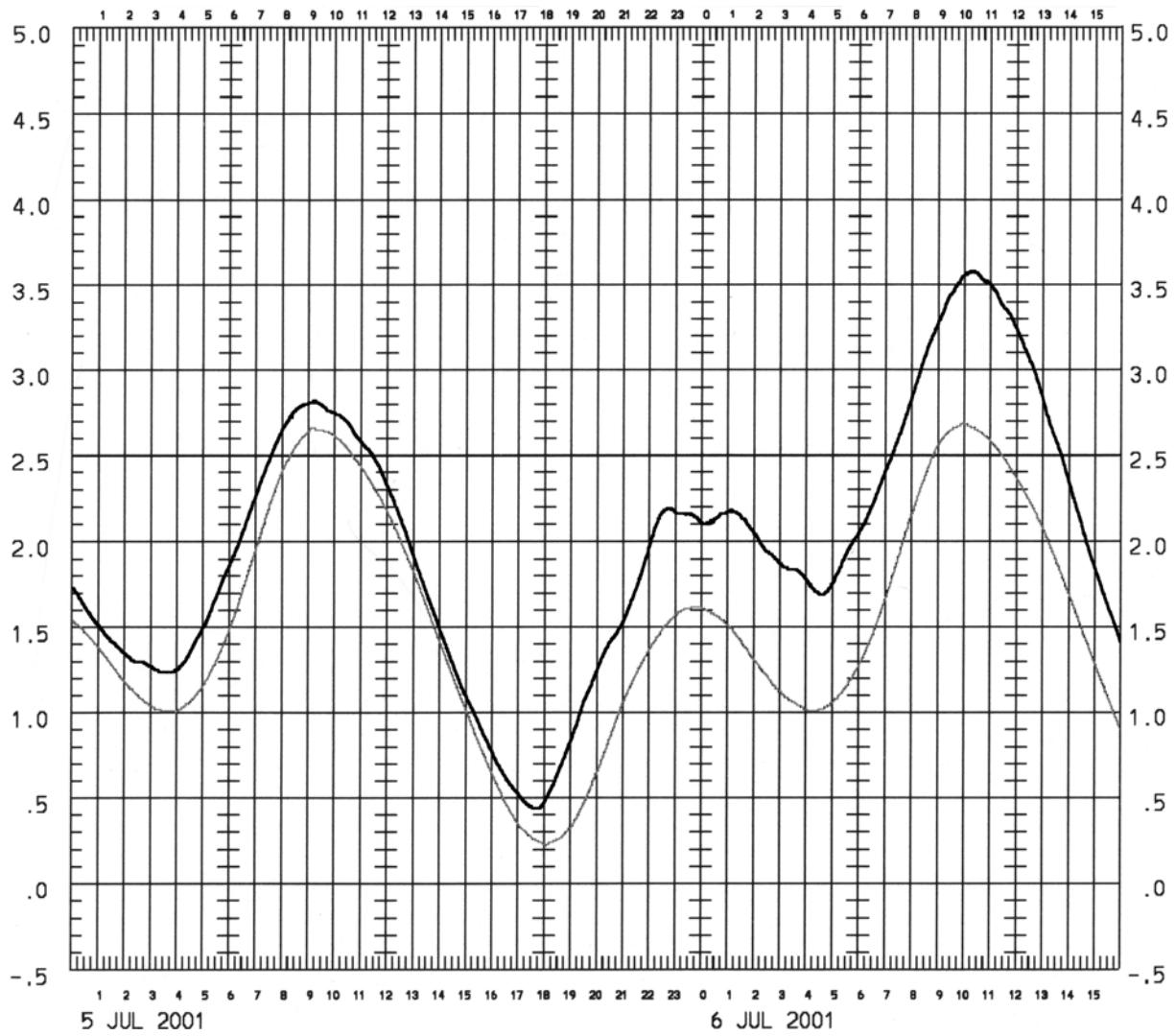


Figure 2 Anomalous sea level rise recorded at the Tsim Bei Tsui tide gauge station on 5-6 July 2001 caused by storm surges during the passage of Typhoon Utor. (blue line is measured sea level and green line is predicted astronomical tide level).

4.3 Monitoring of Long-term Sea-level Changes

In 2004, HKO published results of a study on long-term sea level change in Hong Kong. The study revealed that taken overall, the mean sea level in Hong Kong Victoria Harbour had risen at an average rate of 2.3 millimetres per year during the 50 years from 1954 to 2003 (Figure 3). Indeed, the rising trend was particularly prominent in the last decade or so. This coincides with the period of most rapid rise in the global average temperatures since instrumental measurement of air temperatures began. It suggests that global warming might be an important factor in the sea level change in Hong Kong.

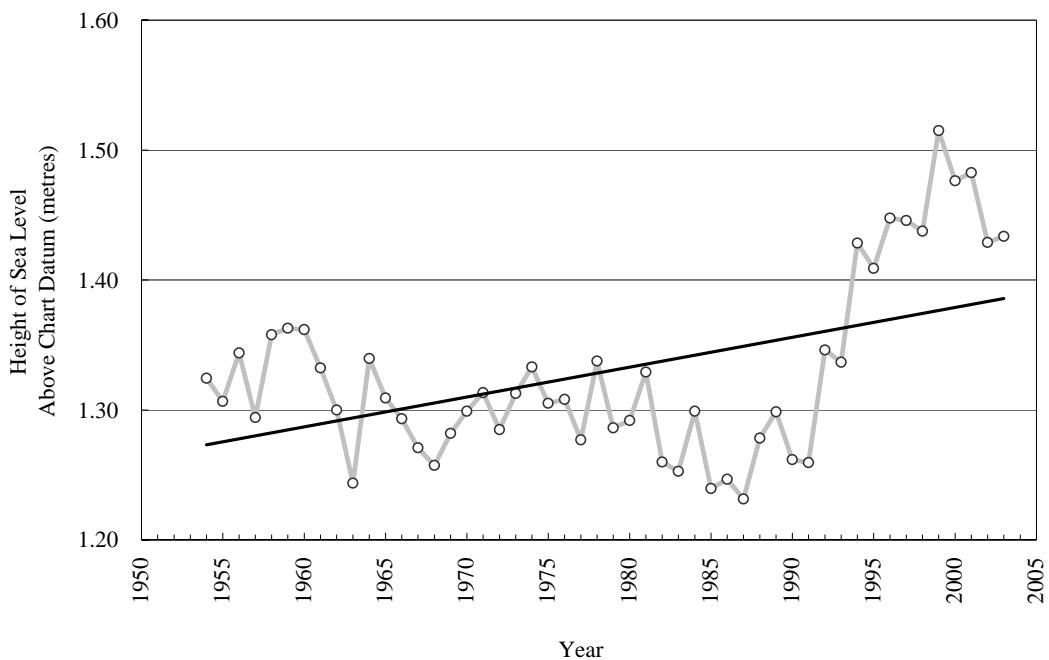


Figure 3 Annual mean sea level at North Point/Quarry Bay (1954-2003)

4.4 Coastal Engineering Design

HKO compiles extreme sea level statistics for various tide gauge stations based on tidal records. The results are summarised in the Hong Kong Port Works Manual published by CEDD and the Stormwater Drainage Manual published by the Hong Kong Drainage Services Department (DSD). The extreme sea level statistics provide useful guidance for engineers in the design of marine structures and stormwater drainage system in Hong Kong.

5. Real-time Tide Data On-line

HKO cooperates with HKMD to operate a webpage displaying real-time 1-minute average tide data collected from the tide gauge network in Hong Kong. The real-time tide information is updated every minute and is available at <http://www.hko.gov.hk/tide/marine/hko.htm> for access by the public (Figure 4).

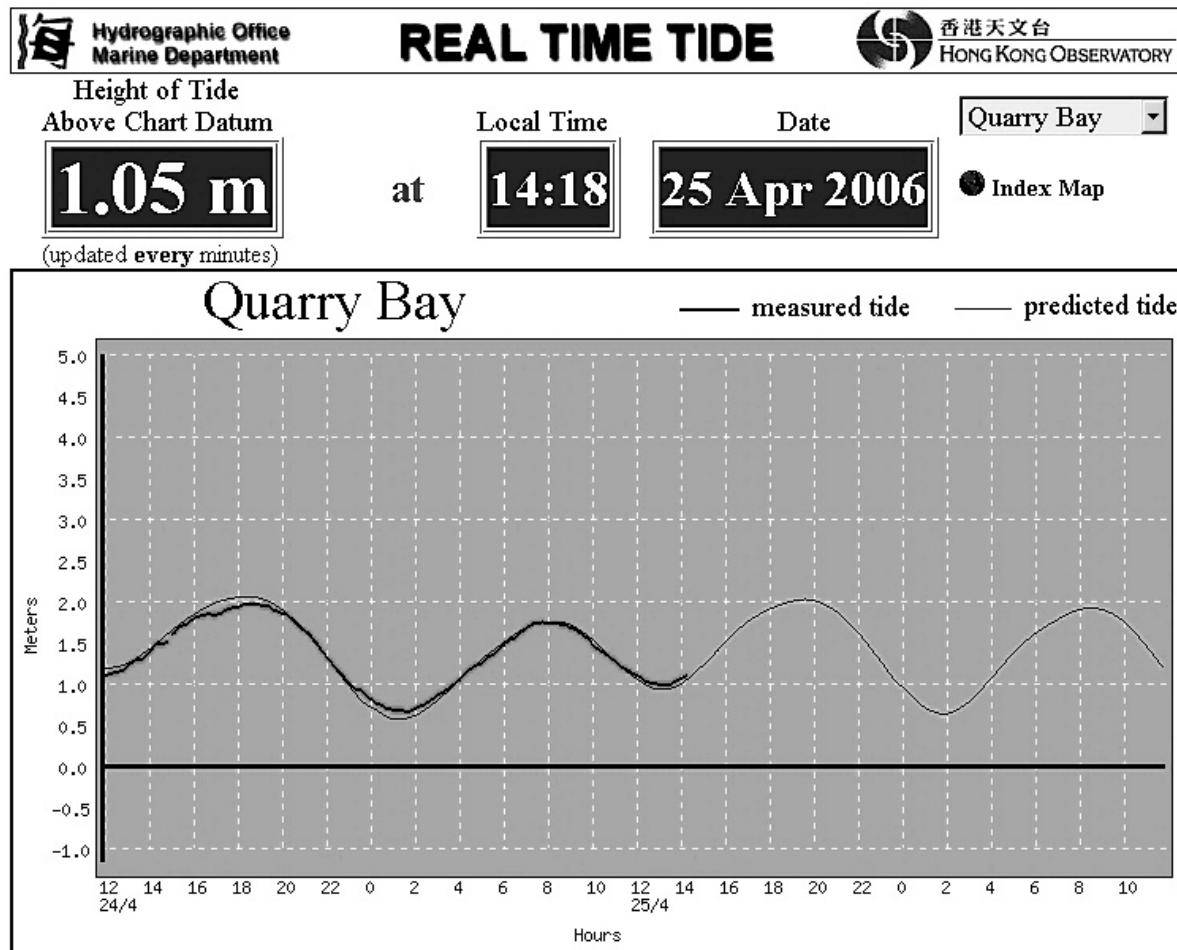


Figure 4 Real-time tide information displayed at HKO website