

#### 7.2.5.4.3 *Analysis based on flood data in the watershed, both surveyed and recorded in literature*

There is a great deal of literature on rainfall and floods in the San-Hua region over the past 2,600 years. The region is in the heartland of China, and since 770 B.C., nine dynasties have had their capitals located in Luoyang, an ancient city in the region. Since 1953, many flood surveys for the main rivers and tributaries in the region have been carried out, yielding a great deal of valuable data. Based on this record, extraordinary floods occurred in the San-Hua region in 184 B.C., and 223, 271, 722, 1482, 1553 and 1761 A.D.

According to the available literature, these historical floods can be categorized into two types, similar to those from recent years. The longitudinal type storms feature longer durations, higher intensities and wider storm areas. For example, the flood of 1761 was similar to 1958 and 1982. Its characteristics were as follows (for details see Wang G., 1999, pp. 112–113):

- (a) Precipitation duration was approximately 10 days.
- (b) The within-storm burst associated with the storm was approximately 5 days.
- (c) The 5-day storm had two peaks, with the smaller one preceding the larger one. The information was obtained from an extensive historical study.
- (d) The storm area was spatially distributed along a meridional, elongated, narrow region. From an extensive literature review, the synoptic situation was categorized as a longitudinal midsummer type in terms of the circulation type, and north–south shear lines in terms of the storm weather system.

Analysis based on available literature shows that the peak flood for the 1761 Yellow River event was about 30 000 m<sup>3</sup>/s in Heigangkou and rose to 32 000 m<sup>3</sup>/s in Huayuankou, of which 26 000 m<sup>3</sup>/s was from the San-Hua region. The recurrence period for an event of this magnitude was estimated to be in excess of 400 years.

#### 7.2.5.4.4 *Analysis based on data on extraordinary floods in similar neighbouring watersheds*

According to flood data observed along the Haihe River, a neighbouring watershed, extraordinary floods in the Haihe River watershed have characteristics similar to those in the San-Hua region. An

example is the catastrophic cloudburst on the Haihe River on 1–10 August 1975. Its circulation type was the longitudinal midsummer type; the storm weather system was a northerly trough and a southerly vortex followed by north–south shear lines; the storm area was distributed like a longitudinal belt. The precipitation duration was 10 days, with most of the rainfall falling in 7 days (3–9 August).

#### 7.2.5.4.5 *Analysis based on watershed characteristics*

With a watershed area of 41 615 km<sup>2</sup>, the San-Hua region is located at 110–114° E and 34–37° N, and is between the two main plateaus of China. The terrain varies greatly in the watershed: there are mountains in the north, west and south and an opening in the east that acts like a funnel. The Yellow River runs through from west to east. The main river branches in the region include the Yihe River and the Luohe River in the south and the Qinhe River in the north.

The terrain in the San-Hua region favours moisture inflow from the south-east. The funnel-like ascending terrain in the region assists with the formation of intense, large storms. The shape of the watershed in the San-Hua region looks like a butterfly flying eastward (Figure 7.2). Storms formed by north–south shear lines can cover the entire watershed, thus facilitating the formation of large floods.

Meanwhile, the observed data show that centres of storms formed by north–south shear lines occur mostly in mountainous areas, where conditions for runoff yield and concentration further facilitates the formation of large floods.

#### 7.2.5.4.6 *Analysis based on the synoptic situation*

Generally speaking, the basic characteristic of the longitudinal midsummer type system is that meridional circulations dominate in mid- and high-latitude regions in Asia, such that southerly flow (warm and wet) and northerly flow (cold and dry) interchange, leading to storms with large areas, high intensities and long durations.

Specifically in this situation, the east of northern China and the Sea of Japan are both under the influence of stable subtropical anticyclones and the eastward movement of westerly troughs is hampered (between 850 hPa and 700 hPa). There is strong southerly flow bringing warm, moist air on the west side of subtropical anticyclones. Influenced by such circulation, north–south shear lines appear frequently in the San-Hua region. To the east of the