CHAPTER 6

EVIDENCES OF DEBRIS FLOW-FLOOD ACTIVITIES IN THE ALLUVIAL FAN

Realizing the parameters and processes that govern flow-flood initiation, transport, and sediment bulking in the area of Nam Ko Yai sub-catchment, the stratigraphic recognition and characteristics of the previous alluvial fan deposits are thus essential for evaluating past flows-floods. A two-step geological evaluation was performed, consisting of an initial delineation of the active depositional area and a subsequent detailed, site-specific analysis of hazards within the active depositional area as suggested by the U.S. National Research Council (1996).

In this chapter, recognition and characterization of the alluvial fan, by defining its activeness as well as the geomorphology and the stratigraphic recognition of the previous alluvial fan deposits were respectively presented as below.

6.1 Recognition and characterization of the alluvial fan

In this part, the activeness of the alluvial fan in the study area was defined as follows.

6.1.1 Defining activeness of the alluvial fan

In this step which was to define an activeness of the alluvial fan, multi-temporal aerial photographs, orthophotographs and Landsat 7 ETM+ imageries were interpreted and integrated with topographic characteristics for preliminary identification of location and morphology. The available multi-temporal low-altitude images of aerial photographs (1:15,000 scale) acquired on 24th December 1974 (Figure 6-1), orthophotograph (1:50,000 scale) acquired on 6th January 1996 (Figure 6-2), and orthophotograph (1:25,000 scale) acquired on 9th January 2002 (Figure 6-3) were used to characterize the Nam Ko Yai canyon mouth and its downstream depositional fan, before and after the 8/11 event. It was obvious that the topographic apex of Nam Ko Yai alluvial fan had only minor

changes between 1974 and 1996. A clear activeness of erosion and deposition was presumed to be caused by the 8/11 flow-flood event (Figure 6-4).

The expanded features of orthophotographs (1:25,000 scale) acquired on 9 January 2002 in Figures 6-4 and 6-5 clearly show the current traces and tracks of debris flood evidenced from the distinctively active alluvial fan deposits. The deposits mainly occurred on the northern bank of the alluvial fan area where the flood severely damaged houses and orchards once existing there as seen in the 1974 aerial photographs and 1996 orthophotographs (Figures 6-2 and 6-3).

Oblique aerial photographs taken after the flood were also the important information sources to characterize the extent of the deposit and validate the analyzed result. The oblique aerial photographs (Figure 6-5) of the severely damaged houses and orchards of Ban Nam Ko Yai perceivably illustrate characteristics and extent of a large volume of the active alluvial fan deposits by the 8/11 flow-flood occurrence. It was noted that the alluvial fan deposit mass on the roads (as seen in Figure 6-5) had been already removed while the debris were still left as in the original manner in the surrounding area. Besides, the fast-moving flow-flood battled and caused damage to houses and other infrastructures during the course of the 8/11 event had also been illustrated as some examples in Figure 6-6.

In the multi-spectral Landsat 7 ETM+ imageries analysis, evidence of the alluvial fan deposit from the 8/11 event were analyzed using NDVI value. NDVI value was also used to detect the depositional locations on the alluvial fan (Figure 6-7). Oblique aerial photographs (in Figure 6-5) of the depositional location in alluvial fan area taken after the event were used to characterize the extent of the deposit and validate analyzed result of NDVI value. It is remarked that the high value of NDVI change (56-107) in Figure 6-7 generally conformed the areas of the most serious damage in Figure 6-5. that covered an area of about 3.49 square kilometers from the total area of about 6.29 square kilometers of the alluvial fan. It is noted that the depositional locations from the 8/11 event cover more than 55 % of the total area of the alluvial fan.

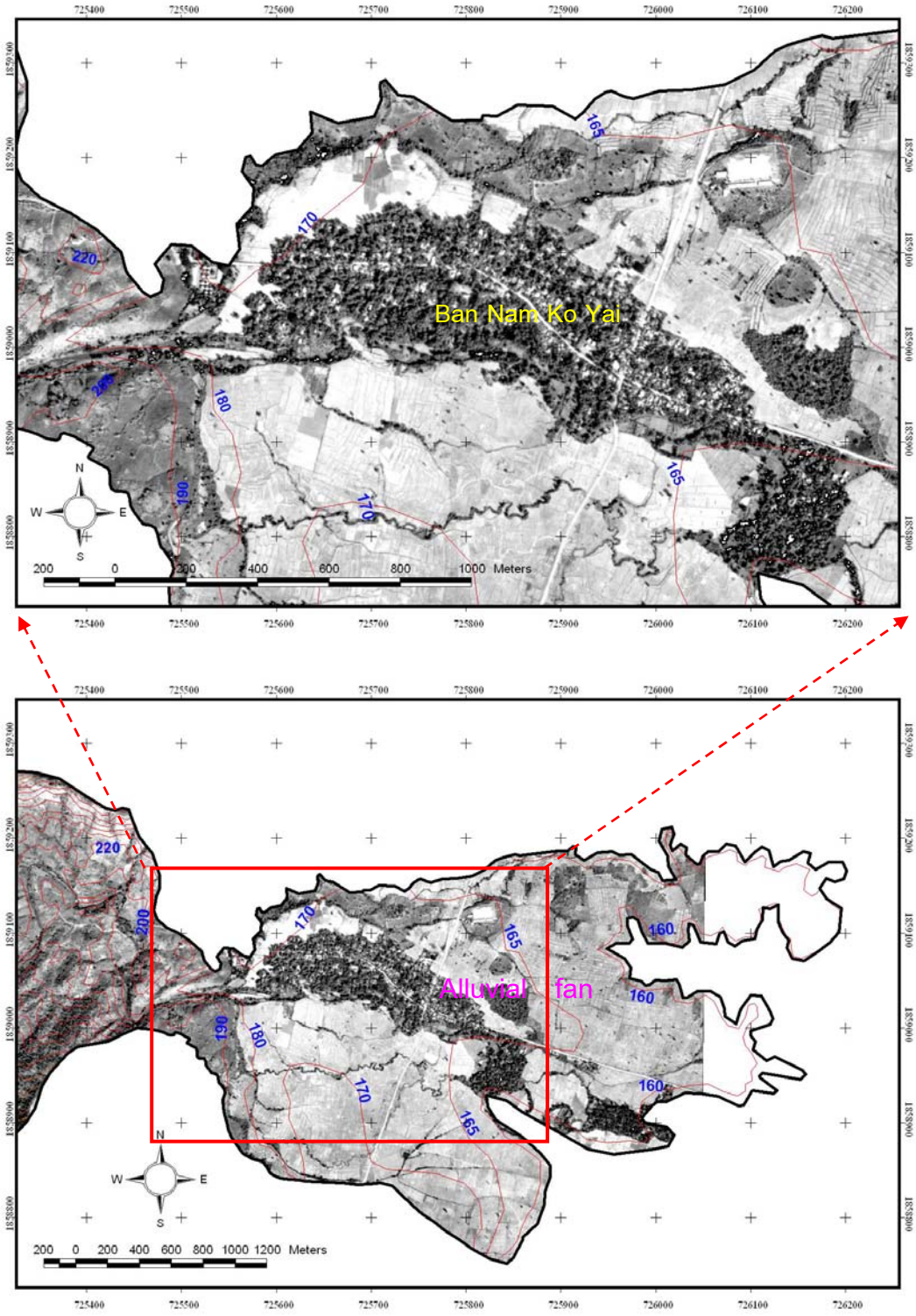


Figure 6-1 Aerial photograph (1:15,000 scale) acquired on 24th December 1974 showing characteristics of the alluvial fan at the canyon mouth of Nam Ko Yai stream with contour intervals (in the solid red-line block).

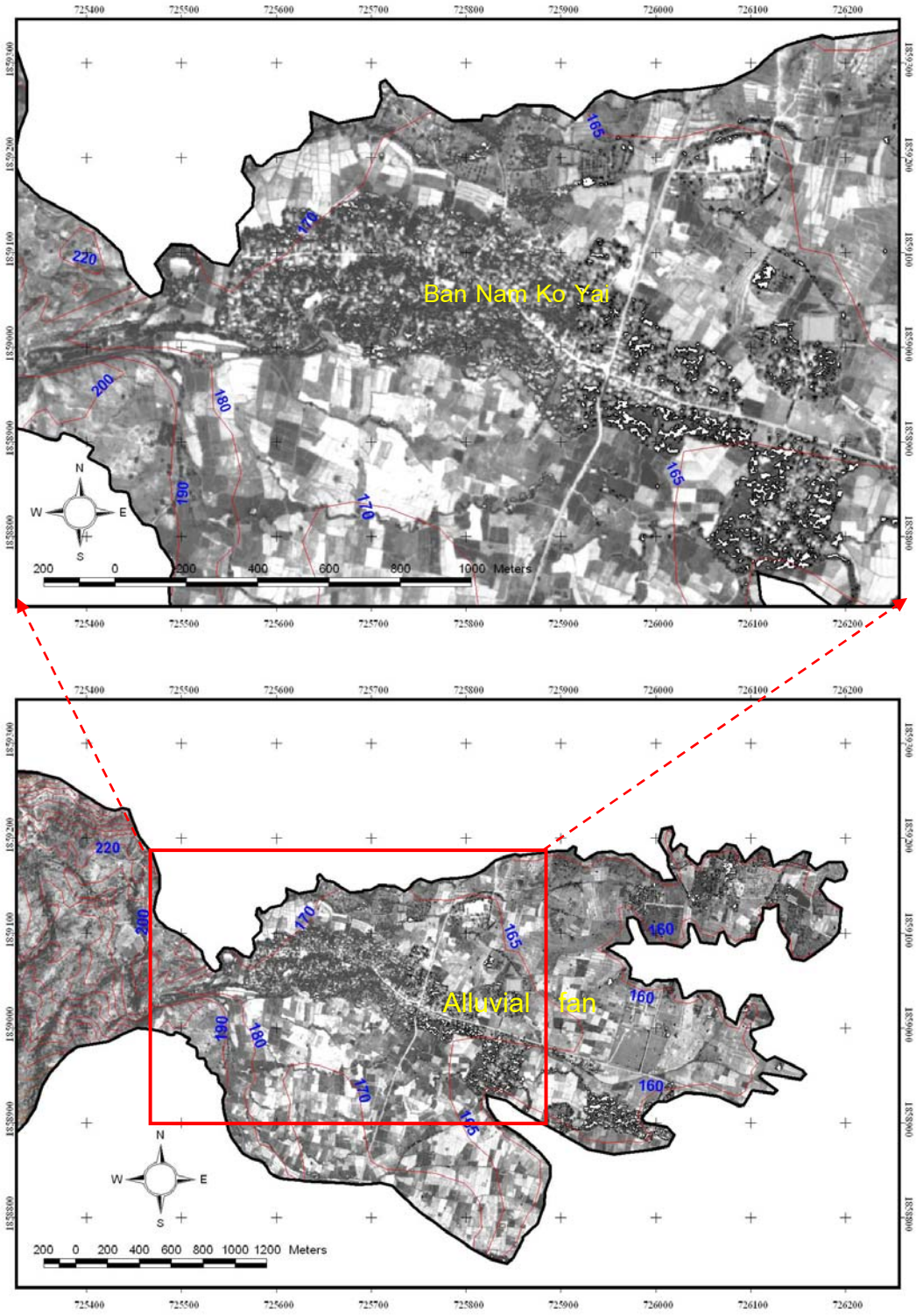


Figure 6-2 Orthophotograph (1:50,000 scale) acquired on 6th January 1996 showing characteristics of the alluvial fan at the canyon mouth of Nam Ko Yai stream without significant change in land cover.

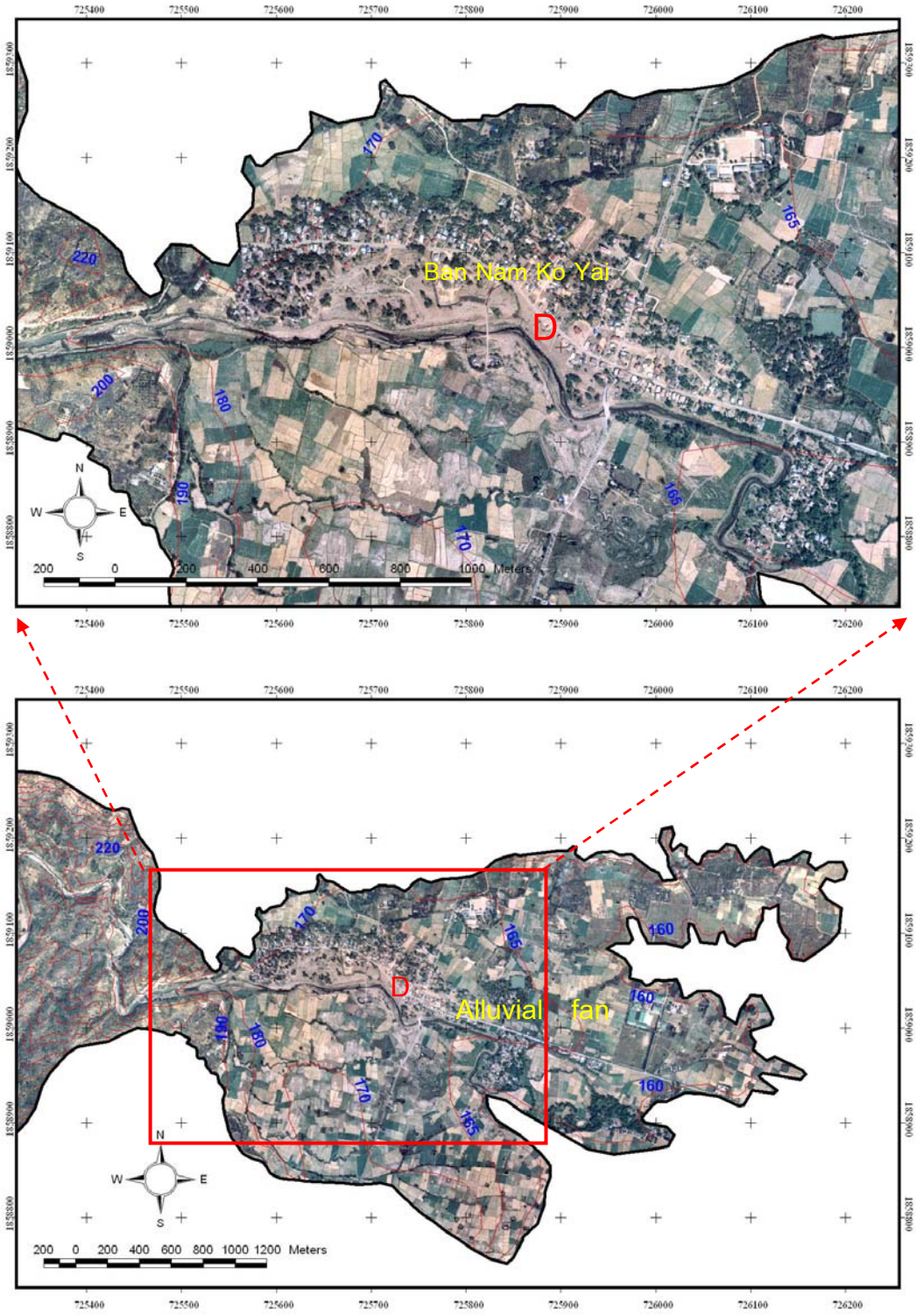


Figure 6-3 Orthophotograph (1:25,000 scale) acquired on 9th January 2002 (after the 8/11 flow-flood occurrence) showing the distinctive active alluvial fan deposit. The main area on the northern bank of Nam Ko Yai stream with populated settlement of Ban Nam Ko Yai (brown color zone surrounding the D location) was strongly damaged.

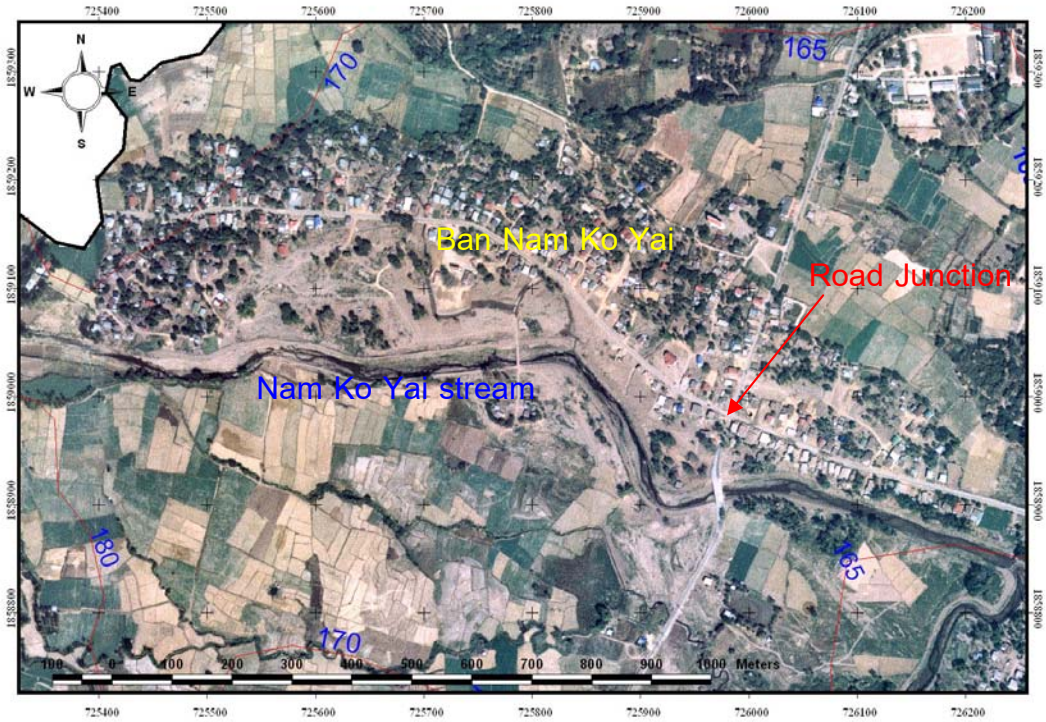


Figure 6-4 Expanded features of orthophotograph (1:25,000 scale) acquired on 9th January 2002 (after the 8/11 flow-flood occurrence) showing the clear traces and tracks of flow-flood from the evidences of the distinctively active alluvial fan deposit (in brown color area) that mainly covered and severely damaged houses and orchards in the northern bank of Nam Ko Yai stream. (Note: the road-junction location in this figure will be used to refer to the same location in Figure 6-5)

According to the oblique aerial photographs of the severely damaged settlement area (Figure 6-5), they illustrate characteristics and extent of a large volume of an active alluvial fan deposit. The ground visit was also conducted to investigate and record the flow-flood levels in this area. The flood levels were established from the mud traces on house walls and trees. It was found that the highest level of the flow-flood, 190-200 cm above ground surface, was located in the most severely damaged zone at locations A and B (Figure 6-8). It was also noted that these were the two locations facing the straight course of Nam Ko Yai stream before the channel changed its direction abruptly southerly further downstream. Here, the flood jumped over-bank to destroy houses and orchards and claim lives.

Figure 6-5 Two oblique aerial photographs perceivably illustrating the characteristics and extension of a large volume of deposited sediments as evidences of 8/11 incidence.

Figure 6-6 Four photographs showing some examples of seriously structural damage of houses and other infrastructures in Ban Nam Ko Yai (in the area between A and B in Figure 6-5) battled and caused by the fast-moving 8/11 flow-flood.

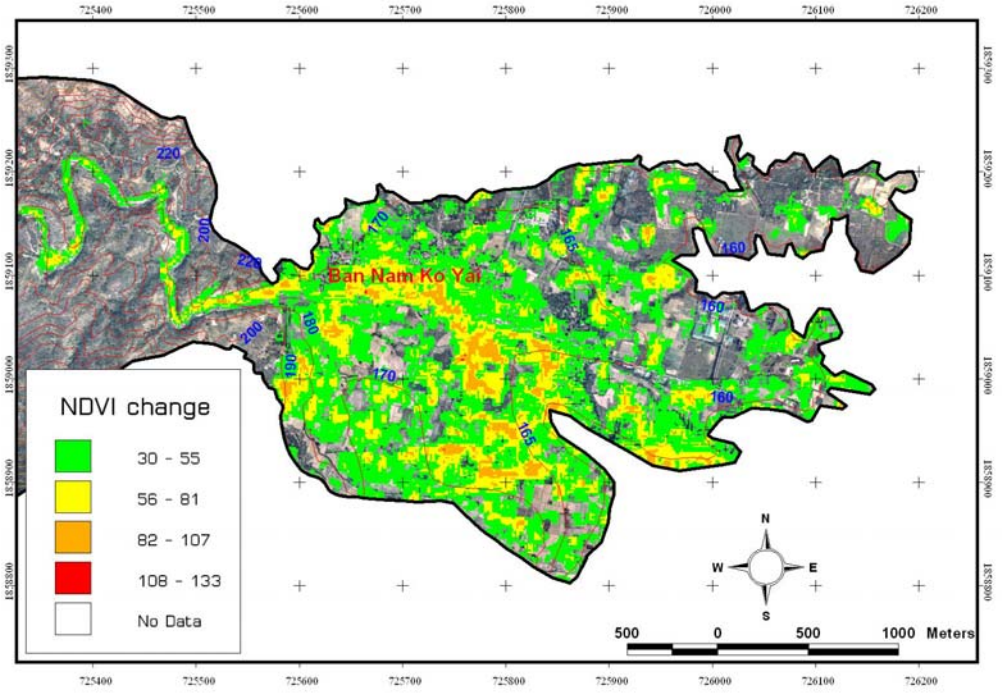
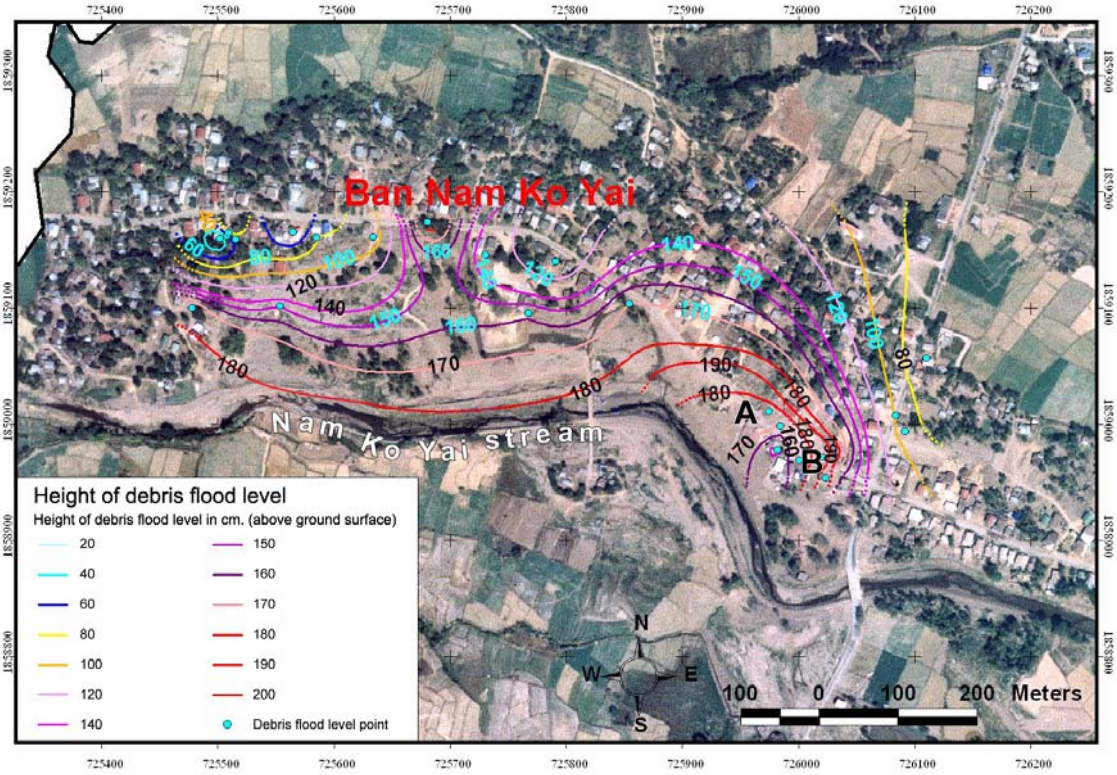


Figure 6-7 Detection change of NDVI value in the depositional location of the alluvial fan (expanded from Figure 3-21) overlain on the orthophotograph (1:25,000 scale) acquired on 9th January 2002 (as shown in Figure 6-3).



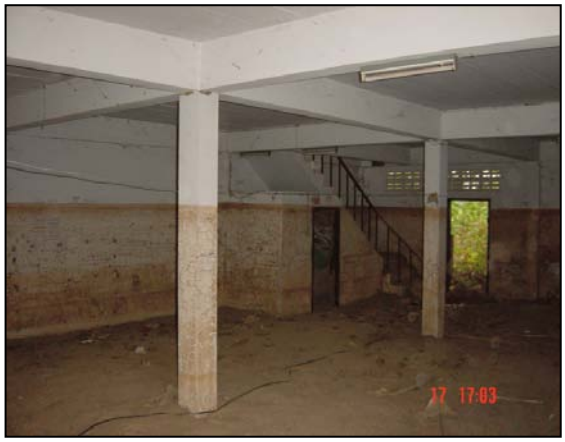


Figure 6-8 Height map of the flow-flood levels detected from the mud traces on the trees and house walls (as illustrating in the attached photographs below the map) in the severely damaged area of Ban Nam Ko Yai after the fast-moving 8/11 flow-flood

6.1.2 Defining geomorphology, local subsurface geology, and stratigraphic recognition of the alluvial fan

In this step, a subsequent detailed and site-specific analysis of the hazard within the active depositional area was characterized. The detailed fan evaluations in this step, namely; geomorphological mapping, resistivity survey and sedimentary sequence study, were used to investigate and describe:

a) geomorphology of the alluvial fan,

b) local subsurface geology of the previous alluvial fan deposits, and

c) stratigraphic recognition of the previous alluvial-fan deposits.

Besides, evidence and relationship between the sedimentary sequences and the flow-flood occurrence in the alluvial fan was presented. The above detailed fan evaluations in this step were respectively presented as below.

6.1.2.1 Geomorphology of the alluvial fan

As the criteria of an alluvial fan in terms of morphology are that it must have a fan shape, either partially or fully extended, the multi-temporal aerial images (Figures 6-1 to 6-4) and oblique aerial photographs (Figure 6-5) clearly illustrated the typical morphology of an alluvial-fan landform where the village is situated. The landform is a section of stream gradient where long-term channel migration and sediment accumulation became markedly less confined than upstream. Below, gradients of the lower part of the older alluvial fan are gentler than those at the fan apex, as was noted from the wider spacing of contour lines in Figures 6-1 to 6-4, and 6-7. The topographic apex of this active alluvial fan was located at the point where the flow in the stream channel become unconfined and less certain, and thus was coincident with the hydrological apex.

6.1.2.2 Local subsurface geology of the previous alluvial fan deposits

According to the resistivity survey in the alluvial fan along the lines NK 01 – NK 05 (as shown in Figure 6-9) to identify the local subsurface geology (thickness and depth of the previous alluvial fan deposits), the results revealed four sedimentary units at a total depth of less than 100 m below ground surface (Figure 6-10). The lowest unit was semi-unconsolidated sediments or weathered rocks of at least 70 m thick to the west with the bed top be noted at a depth of about 30 m below ground surface, and much thinner, less than 10 m to the east, with the bed top be noted at the depth of about 80 m below ground surface.

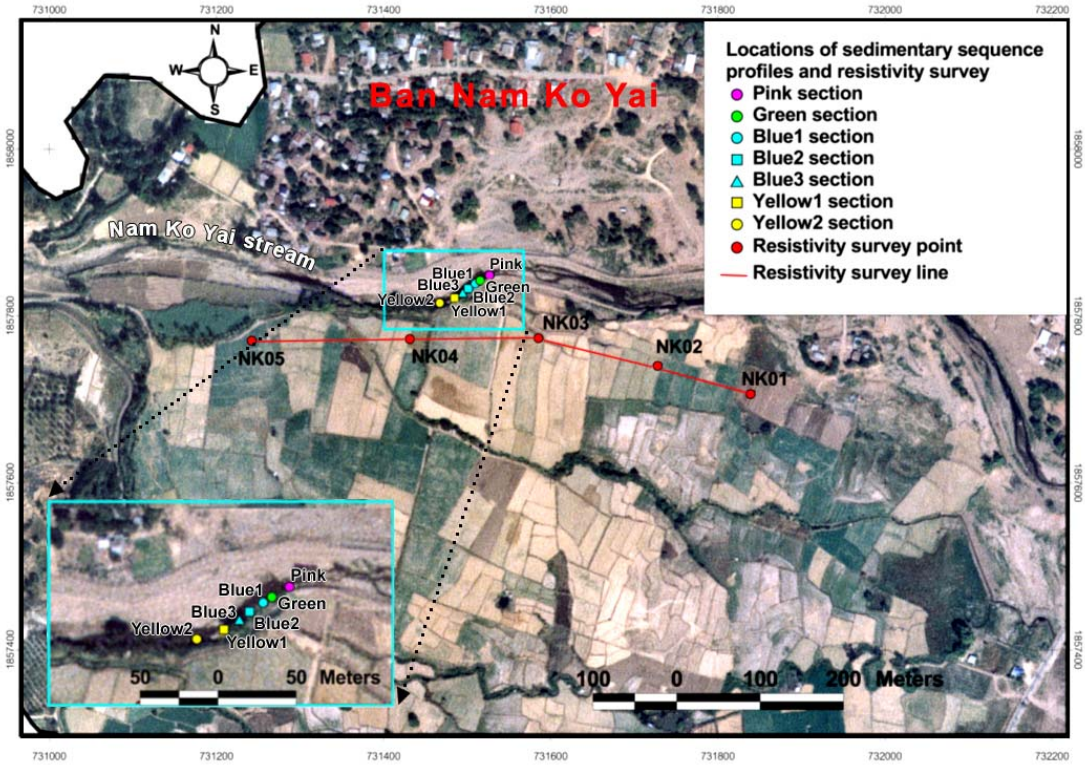


Figure 6-9 Location map of the seven measured stratigraphic profiles and a line of five resistivity survey points used for investigating the stratigraphic recognition and local subsurface geology of the previous alluvial fan deposits.

The overlying second unit was semi-unconsolidated sediments with trapped water in the bed openings. Thickness was 25-70 m and increased to the east. Its shallow horizon was 5 m below ground surface in the west to about 10-20 m to the west. These two lower units are never exposed near the site, but are at surface in the surrounding hills.

The third unit was unconsolidated sediments with trapped water. Thickness was in the range of 5-30 m. The thickest part of this third unit was near the NK 03 line in the central part, where the depth to the top of the unit was from a few meters down to 15 m below ground surface further to the east. The fourth and uppermost unit was of unconsolidated sediments with a thickness of a few meters in the west to 10 m in the east. The fourth unit was commonly exposed on the ground surface along all survey lines, except in the east where it was completely covered by recent topsoils.

6.1.2.3 Stratigraphic recognition of the previous alluvial-fan deposits

A detailed field study of the previous alluvial fan deposits was conducted along a 5x70 m eroded bank (Figure 6-9) of Nam Ko Yai stream near where the resistivity survey had been performed. According to the information from the local people, this eroded bank of Nam Ko Yai stream was just strongly eroded by the 8/11 flow-flood to allow the previously buried sedimentary deposits of alluvial fan be well exposed. Seven stratigraphic profiles, from east to west; zones Pink, Green, Blue1, Blue2, Blue3, Yellow1, and Yellow2 (marked by the flag colors); were studied to reveal sedimentary sequences in both terms of vertical and lateral stratigraphic correlation. The stratigraphic profiles as mentioned above are actually illustrated in Figure 6-11. The photographs of much closer illustration of the stratigraphic characteristics of their lateral and vertical correlation of the seven stratigraphic profiles are also presented in Figures 6-11 and 6-12.

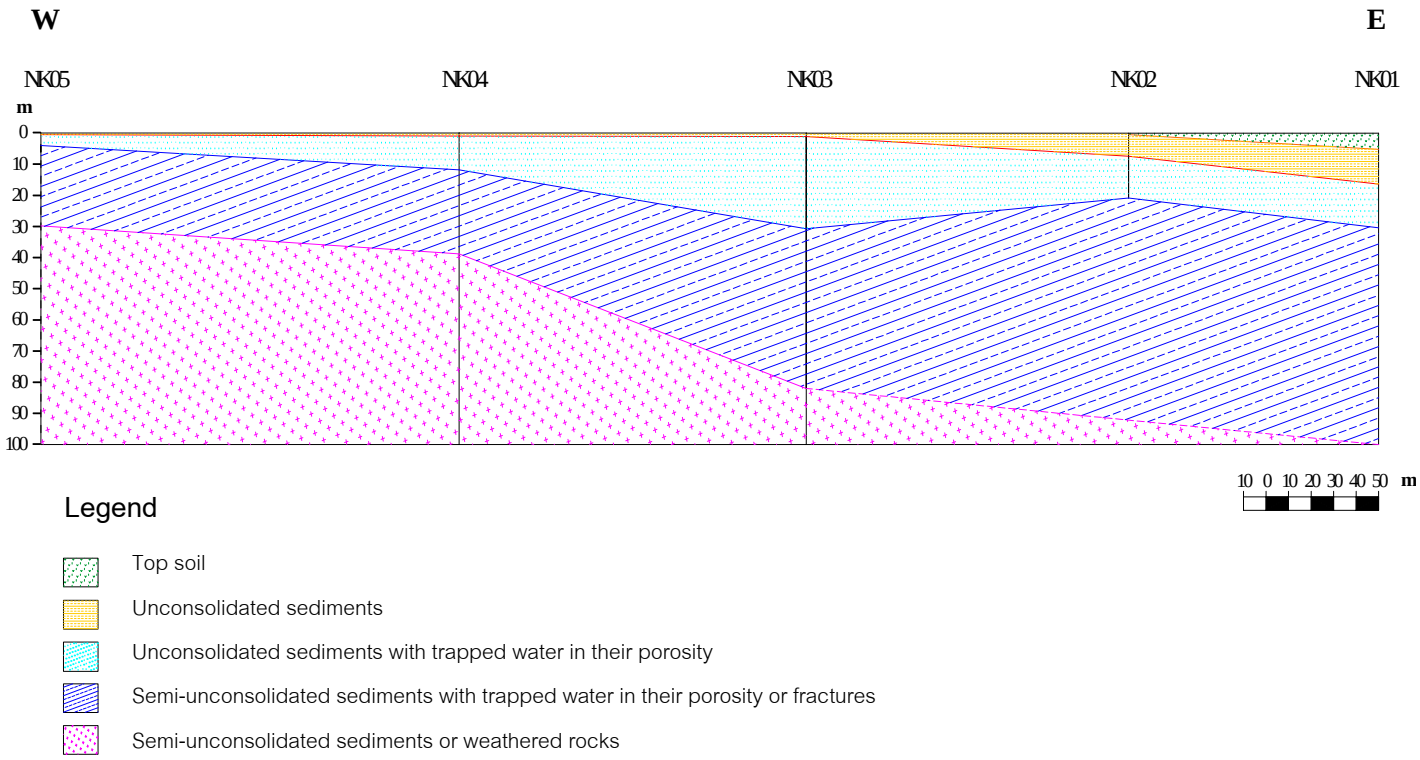


Figure 6-10 Cross-section of the resistivity survey interpreted from the five survey points (NK 01 – NK 05 as shown in Figure 5-9) that revealed four sedimentary units lying less than 100 m below ground surface.

In the observed stream-bank profiles, the lowest sedimentary unit of the previous alluvial fan deposits was a debris flow unit of floating texture, unsorted, and un-stratified material that was exposed in the stream-bed only in the lowest part of the zone Green (Figure 6-13). The coarse-grained fluvial unit of clast-supported texture and fining-upward graded bedding was transitionally deposited on top of the debris flow unit, especially in the middle part of the zone Green, and extended westward (upstream) beyond the zone Yellow2 (Figure 6-14). This coarse-grained fluvial unit was the thickest in the western part and became thinner to the east.

The uppermost part of this eroded-bank profile was a fine-grained fluvial and debris flood unit that was dominantly deposited to form a sharp contact on top of the coarse-grained fluvial unit (as shown in Figures 6-12 to 6-15). The uppermost unit is thicker to the east, especially in the eastern part of the zone Pink. The representative sedimentary and stratigraphic characteristics in completely detailed vertical succession are shown in the zone Green (Figure 6-13) and are from bottom to top the debris flow unit, the coarse-grained fluvial unit, and the fine-grained fluvial and debris flood unit, respectively.

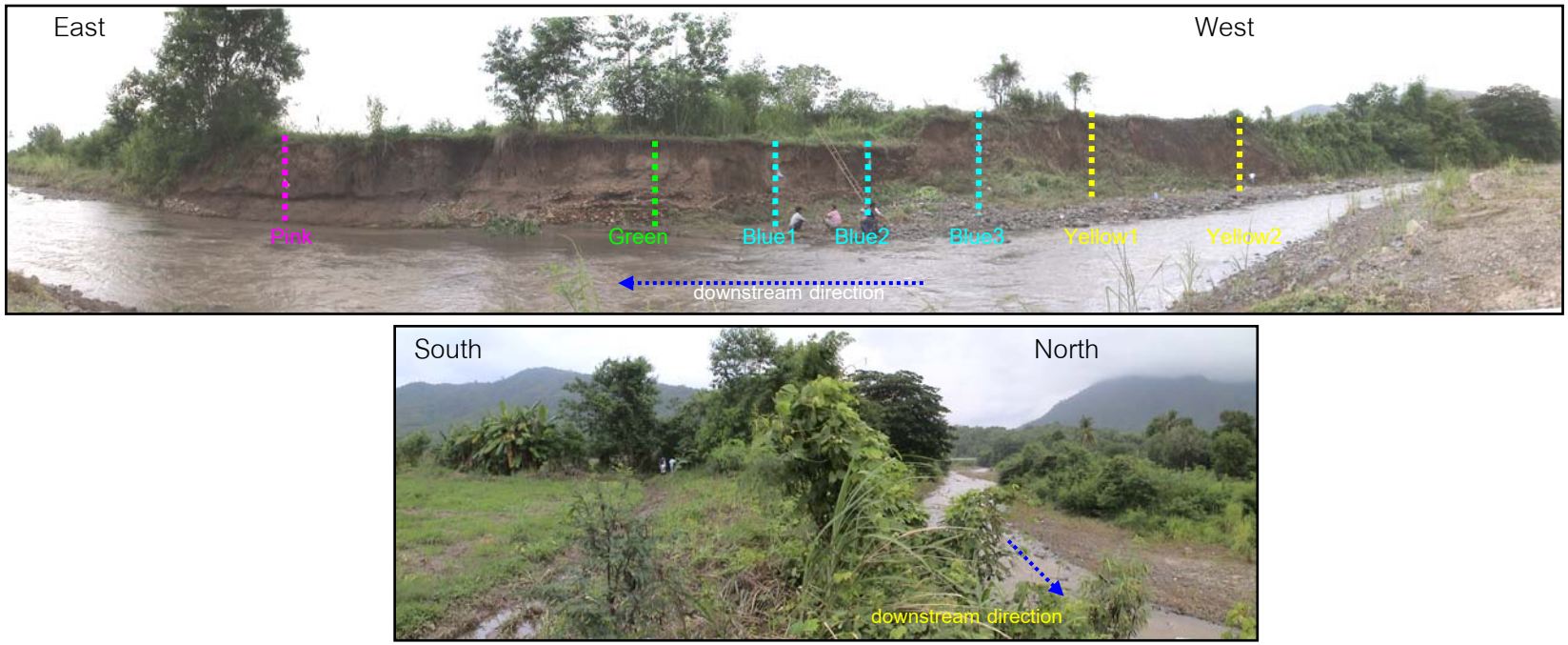


Figure 6-11 Photographs illustrating the actual location of the seven measured stratigraphic profiles (zones Pink, Green, Blue1, Blue2, Blue3, Yellow1 and Yellow2) along the eroded-bank of Nam Ko Yai stream.

(Note: locations of the seven stratigraphic profiles are referred to in Figure 6-9)

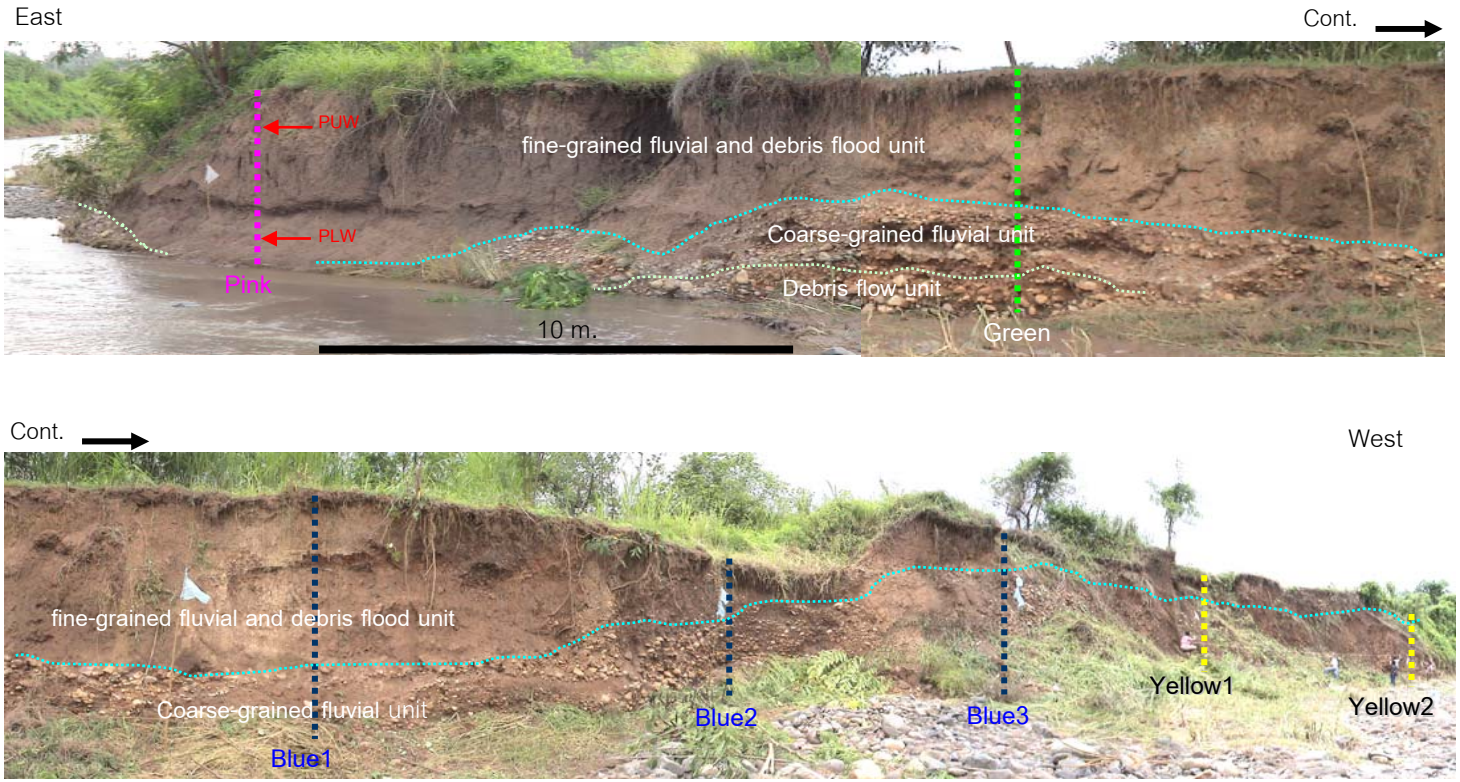
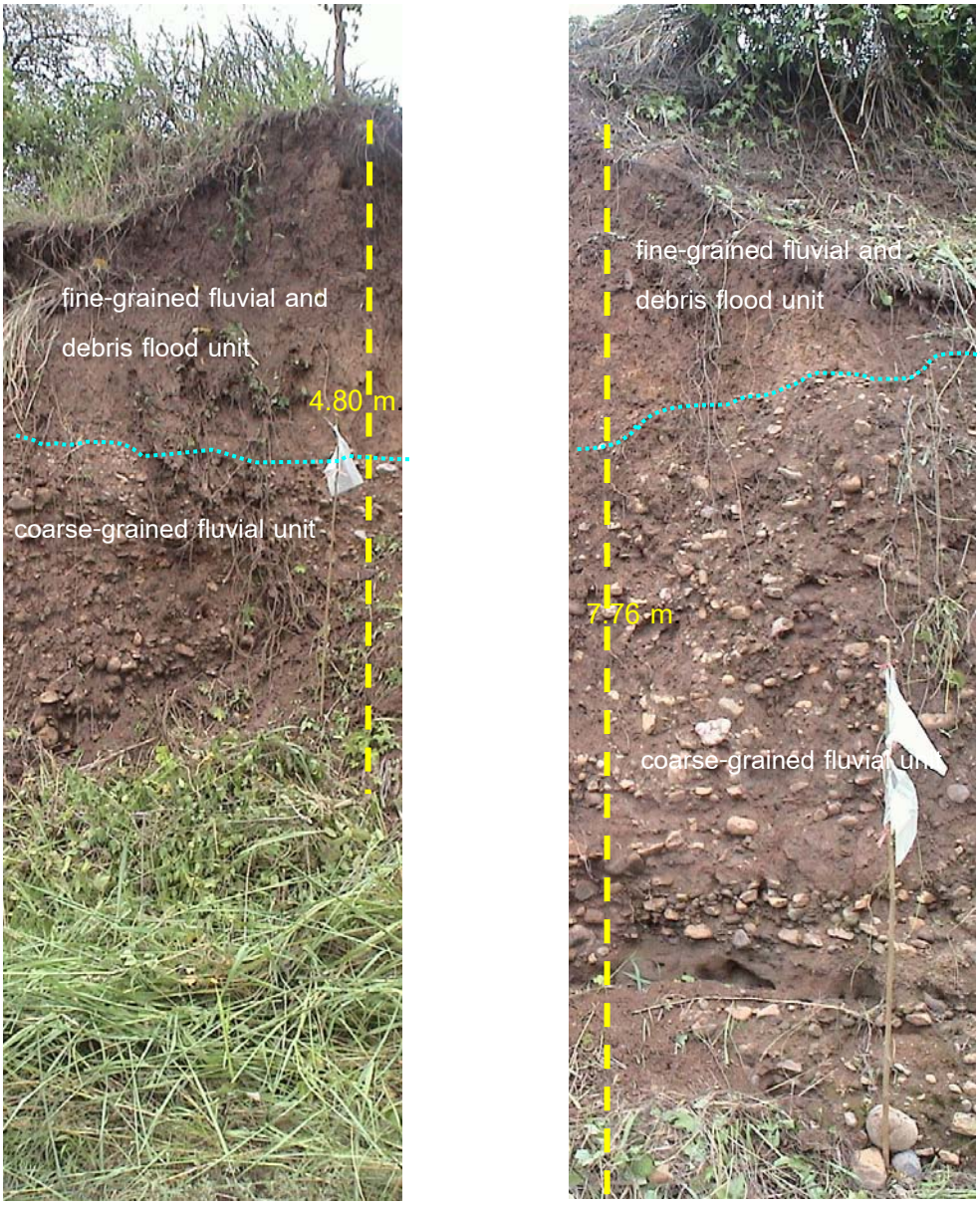


Figure 6-12 Photographs illustrating lateral and vertical stratigraphic characteristics of three sedimentary units (debris flow unit, coarse-grained fluvial unit, and fine-grained fluvial and debris flow unit) of the previous alluvial fan that well exposed along the eroded-bank of Nam Ko Yai stream. (Note: locations of the seven stratigraphic profiles referred to Figures 6-9 and 6-11)

Figure 6-13 Photographs illustrating detailed sedimentary and stratigraphic characteristics in vertical and lateral succession of three sedimentary units (debris flow unit, coarse-grained fluvial unit, and fine-grained fluvial and debris flow unit) of the previous alluvial fan deposits at the zone Green.

(Note: location of the zone Green referred to Figures 6-9 and 6-11)



Zone Yellow1 Zone Yellow2

Figure 6-14 Photographs illustrating detailed sedimentary and stratigraphic characteristics in vertical succession of two sedimentary units (coarse-grained fluvial unit, and fine-grained fluvial and debris flow unit) of the previous alluvial fan deposits at the zones Yellow1 and Yellow2.

(Note: location of the zones Yelow1 and Yellow2 referred to Figures 6-9 and 6-11)

Zone Blue1 Zone Blue2 Zone Blue3

Figure 6-15 Photographs illustrating detailed sedimentary and stratigraphic characteristics in vertical succession of the fine-grained fluvial and debris flood unit that overlay with the sharp contact manner on top of the coarse-grained fluvial unit at the zones Blue1, Blue2 and Blue3.

(Note: location of the zones Yelow1 and Yellow2 referred to Figures 6-9 and 6-11)

With respected to the resistivity survey results as previous mentioned, the overall interpreted subsurface characteristics of these survey lines generally conformed to the normal alluvial fan deposits. The third sedimentary sequences unit repeated in the resistivity survey should be the same as the previous alluvial fan deposits in this eroded bank profile as evidenced from the depth and thickness variation from the west to the east. The upper part of the third unit is clearly of the previous fan deposits composing of the coarse-grained fluvial unit, debris flow unit, and fine-grained fluvial and debris flood unit.

Significant evidences of the previous flows-floods found in the uppermost fine-grained fluvial and debris flood unit were two preserved wooden debris fragments, one at the lower part (location PLW) and the other at the upper part (location PUW) of the Pink section (Figures 6-16 and 6-17). It is noted that the PLW sample of the lower location was charcoal characteristic with fibrous texture whereas the sample of the upper location (PUW) was the pale brown wood with rather complete wooden texture (as shown in Figure 6-17). These preserved wooden debris were dated by radiocarbon dating method to have absolute ages of deposition between 2,618+/- 35 before present and post-1950, respectively.

From these radioactive dating results, it is strongly confirmed that this is an active alluvial fan and the debris flow-flood processes had occurred at least twice before the recent 8/11disastrous event.

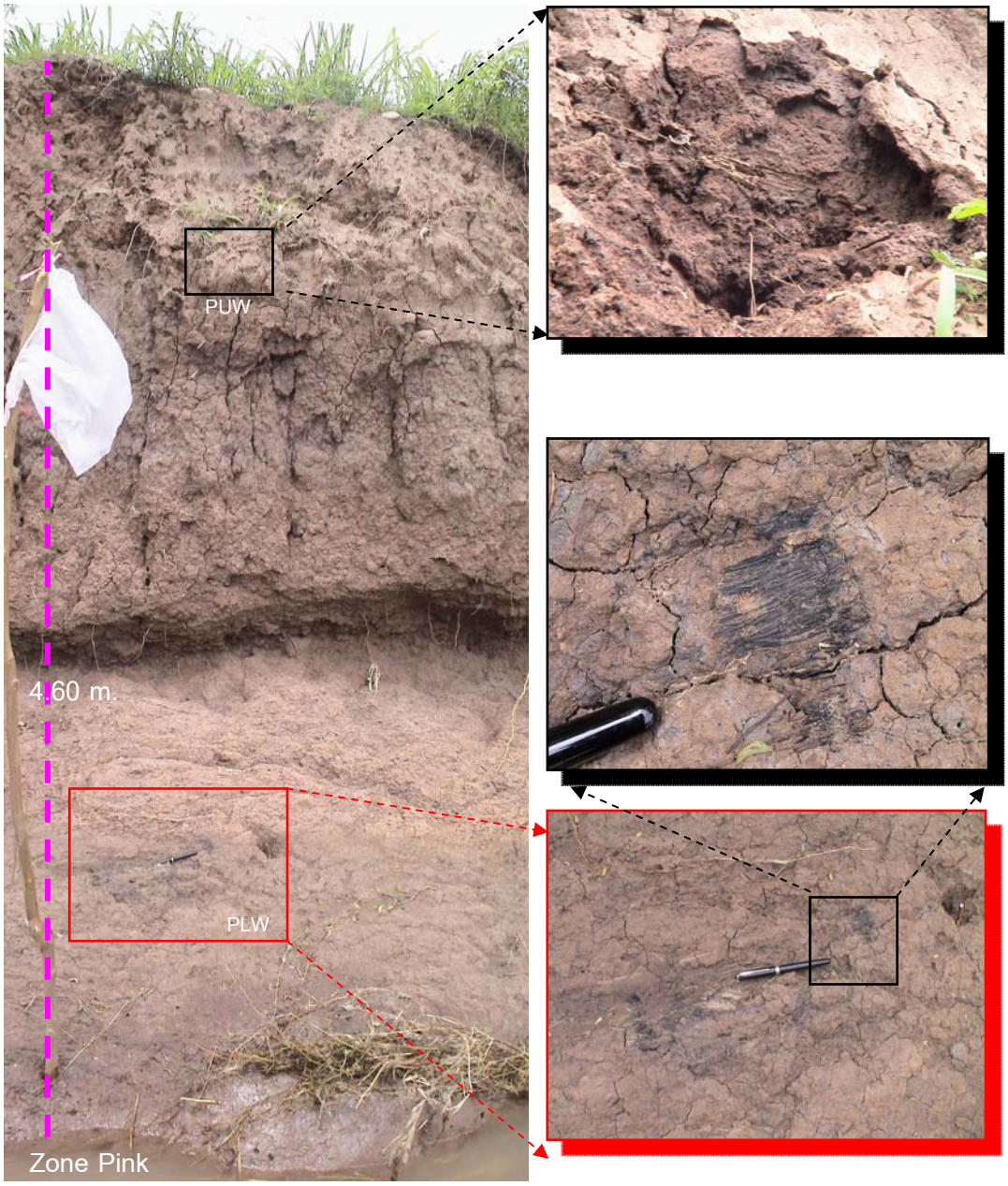


Figure 6-16 Photographs illustrating the general characteristics in the uppermost fine-grained fluvial and debris flood unit at the zone Pink (referred to Figures 6-9 and 6-11) and the preserved large wood debris at the lower part (PLW) and at the upper part (PUW) locations.

Figure 6-17 Closed-up photographs of the collected wood debris samples from the preserved locations at PLW and PUW (as shown in Figure 6-16) illustrating their general characteristics of charcoal characteristic with fibrous texture and pale brown wood with rather complete wooden texture, respectively.