CHAPTER 7

DISCUSSION

In this chapter, the results of the study methods as previously mentioned are discussed in three categories. Firstly, the flow-flood susceptibility results are discussed. Secondly, the flow-flood event reconstruction and its potential are proposed and discussed. Finally, the application of FLO-2D simulation results for validation of the suspected natural landslide dam occurrence in the middle of Nam Ko Yai sub-catchment is discussed.

7.1 Debris flow-flood susceptibility results

In this research, a statistical approach to estimating the susceptible flow-flood area using remote sensing technique and the GIS was performed. For the flow-flood susceptibility analysis, the detected scar-scouring locations and the flow-flood related database were constructed for Nam Ko Yai sub-catchment. Using the constructed database, flow-flood susceptibility analysis was done by probability method. It is remarked that the probability method is somewhat simplistic, and the process of input, calculation and output could be understood easily. Moreover, there is no need to convert the database to any other format such as ASCII, as the large amount of data can be processed in the GIS environment quickly and easily.

The relationship of flow-flood and relevant parameters was analyzed for flow-flood susceptibility assessment using the probability method and flow-flood susceptibility map as mentioned above. In Nam Ko Yai sub-catchment, scar-scouring locations detected in multi-temporal aerial photograph and satellite image as well as in field surveys were put into a GIS database. Besides, various maps were constructed from the flow-flood relevant parameters derived from the database as illustrated in Chapter 3. In addition, three-dimensional drape of the interpreted scar-scouring locations through a 1:20,000 base-scale DEM was also illustrated in Figure 7-1 as being concentrated on the western steep slope, along the stream course, and on the alluvial fan below. These generally included 1:20,000 scale digital topographic map of Land Development Department (LDD), 1:20,000 scale soil property map 1:20,000 scale soil property map of LDD, and 1:50,000 scale geological map of Department of Mineral Resources. The significant influencing parameters involved in the flow-flood susceptibility analysis are slope, landform topography, geology, and land cover.

Using the parameters above, probability method was applied to analyze the flow-flood hazard. The analyzed results were used to reconstruct the GIS database, then to maps. The flow-flood susceptibility map and relevant maps as previously proposed in Chapter 4 might be of great help to planners and engineers for choosing suitable locations to implement developments in Nam Ko Yai sub-catchment. Besides, three-dimensional drape of five classes of susceptibility as very high, high, moderate, low, and very low through 1:20,000 base-scale DEM was also illustrated in Figure 7-2 as the flow-flood susceptibility model in the sub-catchment. It was noted that the very high to very low susceptibility was occurred here. In general, the middle part of Nam Ko Yai stream channel and its adjacent banks had a very high to high flow-flood susceptibility whereas the lower downstream part of the stream had a high flow-flood susceptibility. Whereas the western and northern steep-cliff areas had a low to moderate flow-flood susceptibility whereas the main other parts else of the sub-catchment have in general very low flow-flood susceptibility.

These results can be used as basic data to assist slope management and land use planning. But the method used in this part is valid for generalized planning and assessment purposes only, as it may be less useful at the site-specific scale where local geological and geographic heterogeneities prevail. For the method to be more generally applied, more flow-flood data that are not available in the study area will be needed. Accurate distribution of rainfall that could be combined with a hydrological model of stream flow is one of the most important data needed for an accurate possibility analysis in the sub-catchment.

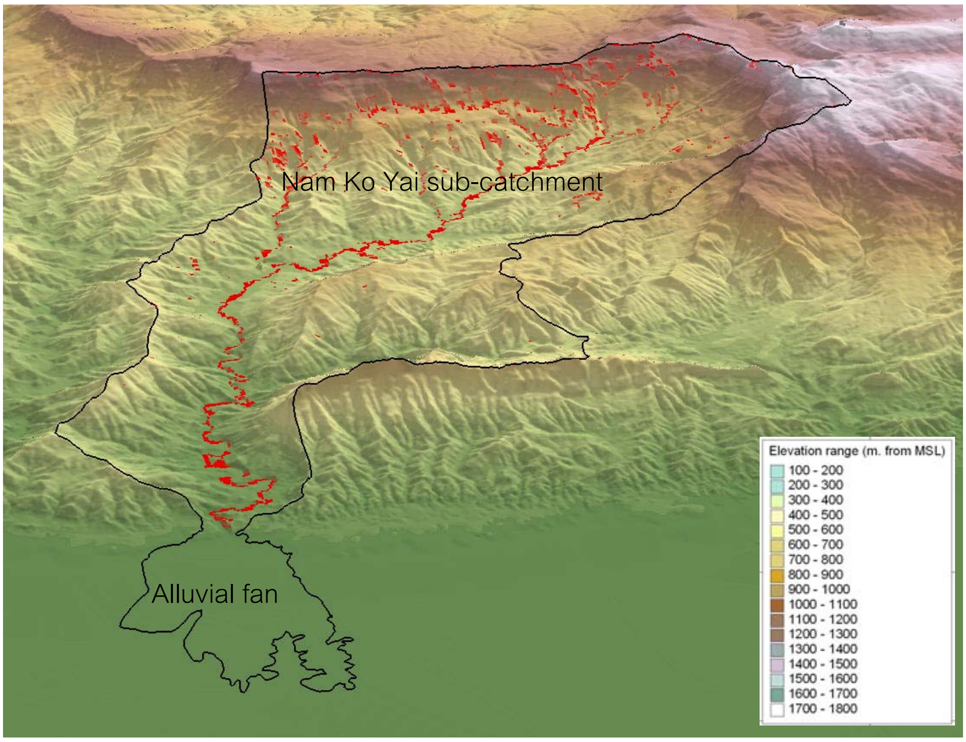

Figure 7-1 Three-dimensional drape of the interpreted scar-scouring locations (grouped in red color) through a 1:20,000 base-scale DEM in Nam Ko Yai sub-catchment.

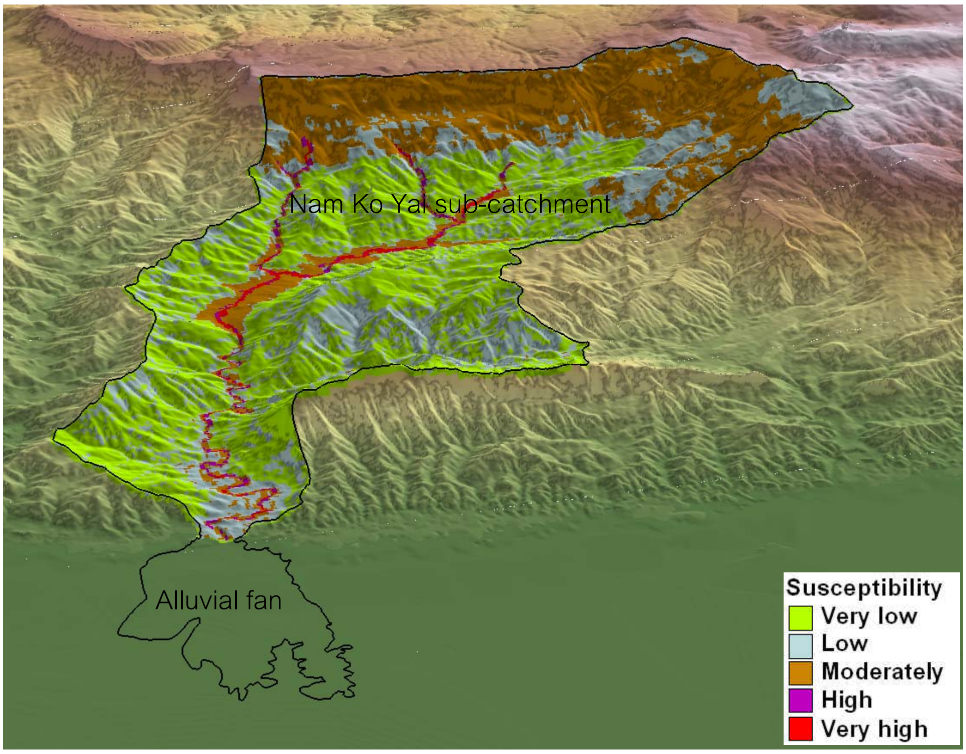

Figure 7-2 Three-dimensional drape of five classes susceptibility of very high, high, moderate, low, and very low, through a 1:20,000 base-scale DEM in Nam Ko Yai sub-catchment. Very high to very low susceptibility was noted here.

7.2 Debris flow-flood event reconstruction and its potential

In this discussed topic, three-dimensional drape of false color composite of Landsat 7 ETM+ (R=5, G=4, B=3) acquired before and after the 8/11 flow-flood occurrence through a 1:20,000 base-scale DEM in Nam Ko Yai sub-catchment and its alluvial fan as modeled in Figure 7-3 and 7-4 are mainly used to illustrate and be referred to with the flow-flood event reconstruction as follow.

The debris flow probably began as shallow circular landslides, on the western and northern steep mountain slopes of Nam Ko Yai sub-catchment after a continuous heavy rainfall period for at least 10 days (before 8/11) that the weakened material with the increasing weight set, thus became highly movable down-slope. The colluvial soil and rock debris of Pw Formation and Pk Formation flew down the forest-covered 30° (or steeper) slopes during the peak of heavy rainfall as previously mentioned in Chapter 4. This could be the potential primary source area for the debris (Figure 7-4).

The debris flow continued further over the central undulated valley area to the main channel of Nam Ko Yai stream. As the sub-catchment plain was extensively deforested during the last decade with only few trees left on its overbank flat land, the large quantity of plant debris observed to be carried further with the water flow must have come from the upslopes with only a small amount from the overbanks. The debris flow was capable of exerting tremendous lateral forces on obstruction in the flow path, as evidenced from the impact of entrained, large boulders in the highest velocity along the main channels of the first order and second order sub-catchments in the steep slope areas.

These high velocity flows severely snapped off a large number of trees from hillsides and over channels, and mixed with re-eroded soils of the detached-landslides at the steep banks down along the main channels to the central area of moderate -to-

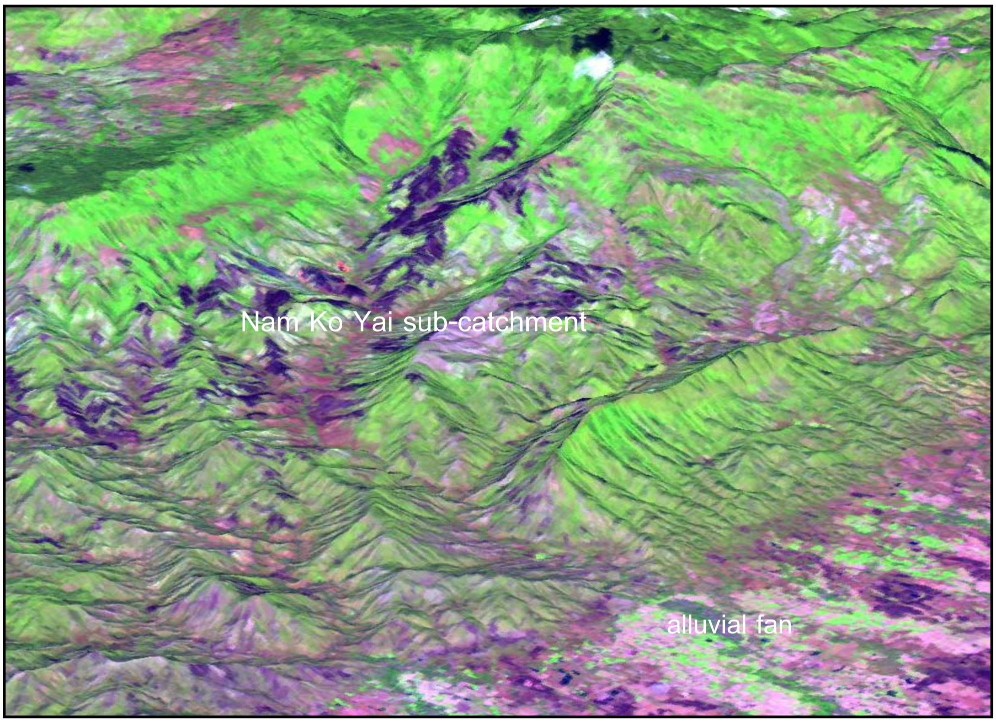

Figure 7-3 Three-dimensional drape of false color composite of Landsat 7 ETM+ (R=5, G=4, B=3) acquired on 5th January 2001 through a 1:20,000 base-scale DEM illustrating the general characteristics before the 8/11 flow-flood occurrence in Nam Ko Yai sub-catchment and its alluvial fan.

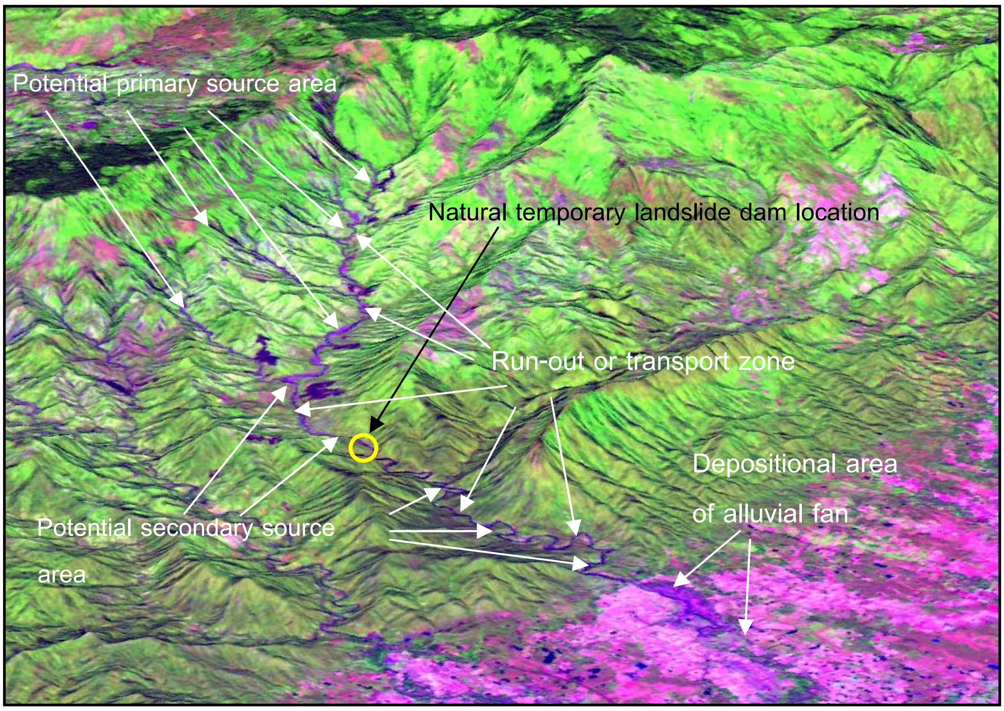

Figure 7-4 Three-dimensional drape of false color composite of Landsat 7 ETM+ (R=5, G=4, B=3) acquired on 21st November 2001 through a 1:20,000 base-scale DEM showing distinguish characteristics after 8/11 flow-flood occurrence in Nam Ko Yai sub-catchment, and the depositional area of alluvial fan.

gentle slope. This could be the potential secondary source area (Figure 7-4) where debris incorporated into the primary debris flows to form a significant volume through the run-out or transport zone as previously mentioned in Chapter 5.

With supporting study results on the soil engineering properties as previously mentioned in Chapter 5, the highly weathered rocks of Ls Formation with its thick residual or colluvial soils appeared to influence the slope failures on the hillsides and debris flows in the channels. These almost undrained clayey soils with increasing load pressure and less internal shear strength would have caused the mass movement beyond the critical load pressure.

Additionally, the previously-mentioned physical nature of the source area and run-out zone to the flow-flood occurrence, the amount and intensity of precipitation falling, steep hill slopes and long-running sinusoidal stream channel were key factors as well. Ten days of continuous rainfall to the cumulative peak on 8/11 triggered the severe flow-flood in these zones of weak materials as mentioned in Chapter 4.

During the flow- flood processes, a temporary natural landslide dam might have built up somewhere in the causeway of this stream, most probably near Tad Fa waterfall. The temporary natural landslide dam could have been formed when debris of plant remains, trees, soils and boulders both from several previous and this 8/11 events were locked at this specific location, forming a reservoir upstream as previously mentioned in Chapter 5. Then another powerful flow-flood might followed to break the dam, perhaps with surges up to 10 m high, to send water and debris flowing further down to destroy the village on the alluvial fan.

After this serious debris flow-flood occurrence in the year 2001 that completely traversed and removed the former sediments along the channels together with almost-entirely wiping out of trees, it should take many more years to let the parameter conditions to build up again. The plant debris and sediments are reduced at present.

This last conclusive remark was noted from a fact that the relative higher amount of rainfall in the following year 2002 in this same area did not resulting a serious flow-flood event except a mild flash flood occurring for only a few hours overbanks.

7.3 FLO-2D simulation results for validation of the suspected temporary landslide dam occurrence

To validate the suspected temporary landslide dam occurrence, some justification must be employed. Here an FLO-2D simulation technique was used.

In general, the FLO-2D is a simple volume conservation model that distributes a flood hydrograph over a system of square grid elements (FLO-2D Users Manual, 2003). It implements the Diffusive Hydrodynamic Model (DHM) created by Hromadka and Yen (1987), which is a simple numerical approach with a finite difference scheme that permits modification of the grid element attributes. FLO-2D software model allows the user to delineate flood hazards and designing flood mitigation. Details can be added to the simulation by turning on or off switch for various components such as street, sediment transport, culverts and many others. Channel flow is one-dimentional, with the channel geometry represented either by natural, rectangular or trapezoidal cross sections, whereas overland flow is modeled two-dimensionally and channel overbank flow is computed when the channel capacity is exceeded. When the flow overtops the channel, it will disperse to other overland grid elements based on topography, roughness and obstructions. Besides, FLO-2D software model also allows to route hyperconcentrated sediment flows as a fluid continuum by predicting viscous and yield stresses as function of sediment concentration is employed and sediment volumes are tracked through the system. As sediment concentration changes for a given grid element, dilution effects, flow cessation and remobilization of deposits are simulated (FLO-2D Users Manual, 2003). It is noted that the later ability of FLO-2D software model cannot firstly be applied in the sub-catchment area because of the lack of sediment-flow data recorded from the 8/11 flow-flood event.

In this discussion, flow-2d simulation was preliminary applied to numerical model of channel flow conditions in terms of water height from the channel floor (hereafter will be conveniently used as *water height*) calculated from the rainfall intensity during 1st to 10th August 2001 before 8/11 flow-flood event with two scenarios . Firstly, the flow-2d simulation was back analyzed in the condition of the channel topography without a temporary landslide dam (hereafter will be conveniently used as *the condition without dam*). Secondly, the flow-2d simulation was back analyzed in the condition of the channel topography with a temporary landslide dam (hereafter will be conveniently used as *the condition with dam*) that was 10 m high from the channel floor at the location in the central part of the sub-catchment (referred to Figure 7-4). This is conducted to first numerical validating the possibility of the occurrence of a suspected temporary landslide dam in the location as previously mentioned as one of the most important causes of the 8/11 flow-flood event.

There are two important steps to start a simulation with FLO-2D: obtaining the topographic data base and developing the flood hydrograph. For the first step, the 50 m. cell size DTM available for the sub-catchment, that is probably not accurate enough for a highly detailed analysis, but it can be sufficient for a preliminary validation of the suspected landslide dam occurrence. The second step arises from the fact that each flood simulation requires an inflow flood hydrograph on a rainfall data that previously extrapolated in Chapter 3.

Finally, the FLO-2D model created accurate representations of the first- and secondary scenario as shown in Figures 7-5 to 7-9. The details of these two scenarios in the sub-catchment during 9th to 11th August 2001 (before 8/11 event) are discussed below.

From the simulation with FLO-2D model in the condition of the sub-catchment without dam, it revealed that the water height was apparent at first and increased up to 0.5 - 1.0 m along the stream channels throughout the upper and middle parts of the sub-catchment at 8 p.m. on 9th August 2001 (about 31 hours before the 8/11 event) while the rainfall accumulation was more than 100 mm as modeled in Fig 7-5. At 3 a.m. on 10th

August 2001(about 24 hours before the 8/11 event), the water height in the condition without dam was generally increased up to 0.5 - 2.0 m along the stream channels further down in the middle part of sub-catchment while the rainfall accumulation was approximately 120 mm as modeled in Fig 7-6. It is noted that the water height in the further down of middle part along the channels was locally increased to 3.0 – 4.5 m. At 3 a.m. on 11th August 2001 (0.5 hour before the 8/11 event) the water height in the condition without dam was generally increased up to 1.0 - 3.0 m along the stream channels in the upper and middle parts, and significantly increased up to 1.0 - 10.0 m in the further down of lower part of sub-catchment while the rainfall accumulation was more than 140 mm as modeled in Figure 7-7.

From the simulation with FLO-2D model in the proposed condition of nearly 10 m height landslide dam occurrence at the location near Tad Fa waterfall (referred to Figure 7-4), it is noted that the water height was generally increased up to 1.0 - 3.0 m along the channels upstream from this location at 3 a.m. on 10th August 2001 (about 24 hours before the 8/11 event) while the rainfall accumulation was approximately 110 mm as modeled in Figure 7-8. It is noted that the water height along the channels in the proposed dam location was significant increased up to 5.0 – 12.0 m and less increased further down from this location. At 3 a.m. on 11th August 2001 (about 0.5 hour before the 8/11 event) the water height in the condition with dam was generally increased up to 1.0 - 3.0 m along the stream channels in the upper part of sub- catchment, 1.0 - 5.0 m in the middle part upstream from the dam location, 5.0 – 12.0 m in the proposed dam location, and still increased up to 1.0 - 10.0 m in the lower part further down from the proposed dam location while the rainfall accumulation was more than 140 mm as modeled in Figure 7-9.

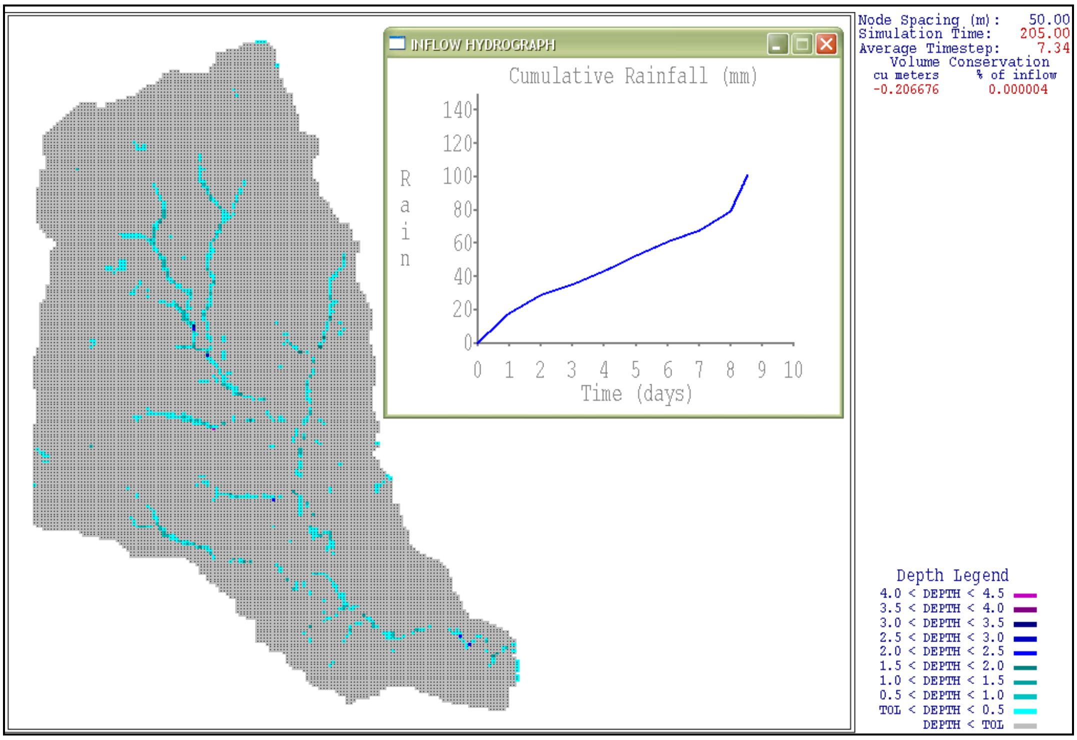

Figure 7-5 FLO-2D simulation results of the channel flow conditions of water height from the condition without dam while the rainfall accumulation was more than 100 mm at 8 p.m. on 9th August 2001 (about 31 hours before the 8/11 event).

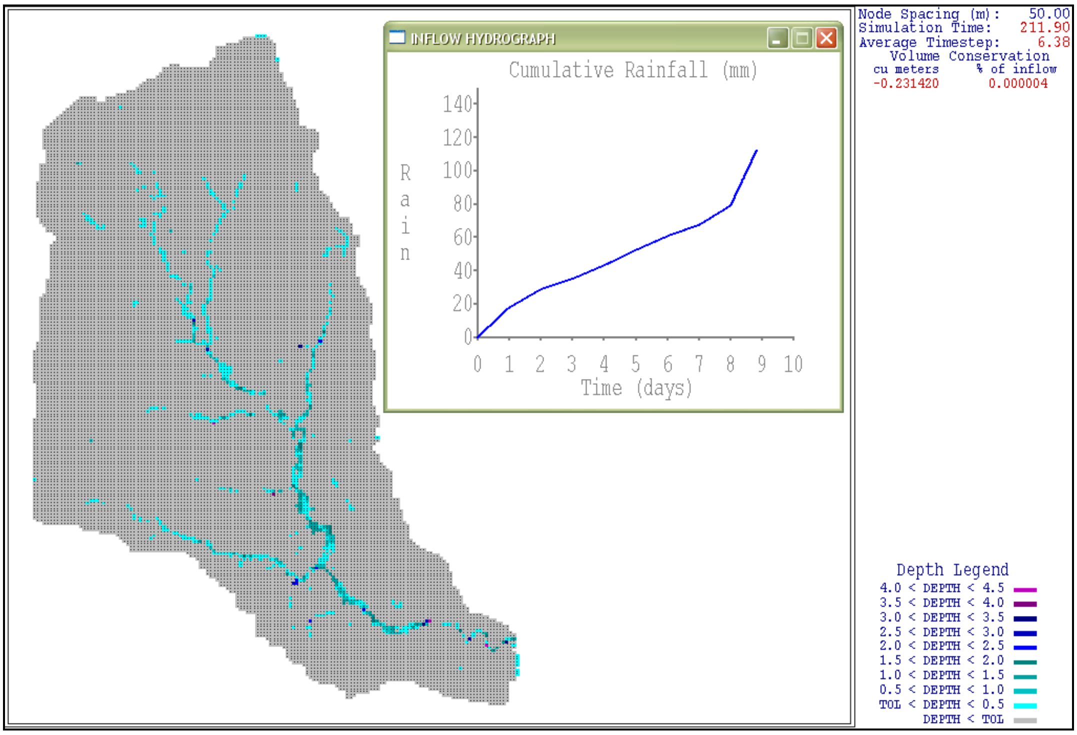

Figure 7-6 FLO-2D simulation results of the channel flow conditions of water height from the condition without dam while the rainfall accumulation was 120 mm at 3 a.m. on 10th August 2001 (about 24 hours before the 8/11 event).

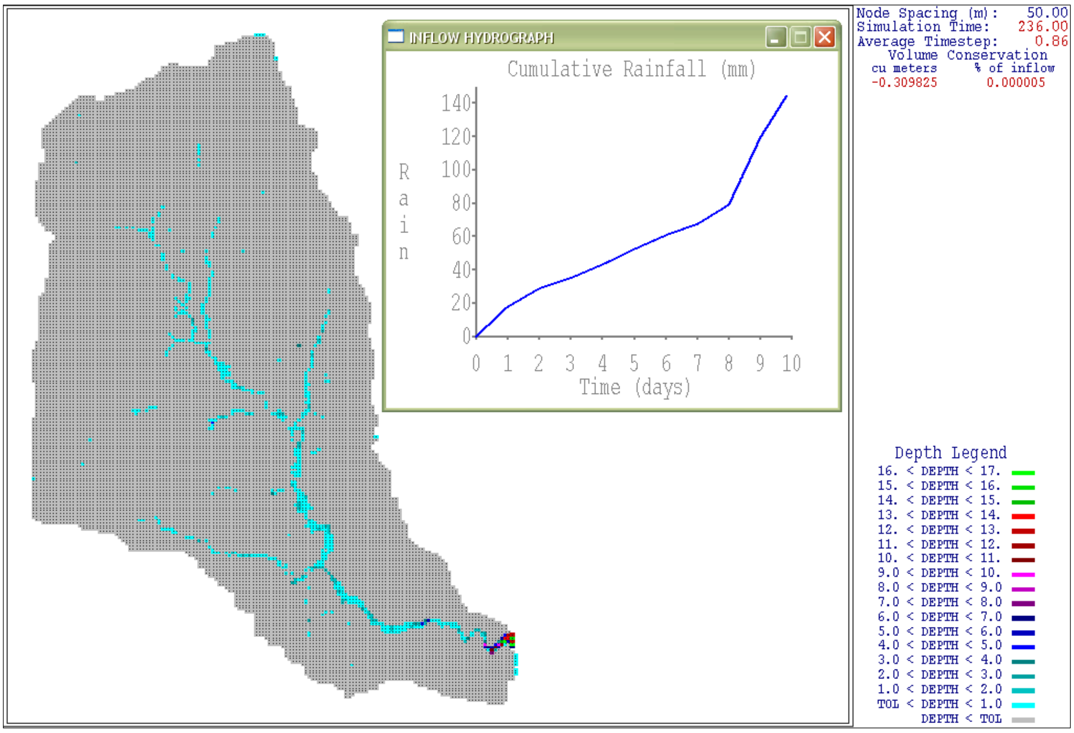

Figure 7-7 FLO-2D simulation results of the channel flow conditions of water height from the condition without dam while the rainfall accumulation was more than 140 mm at 3 a.m. on 11th August 2001 (0.5 hour before the 8/11 event).

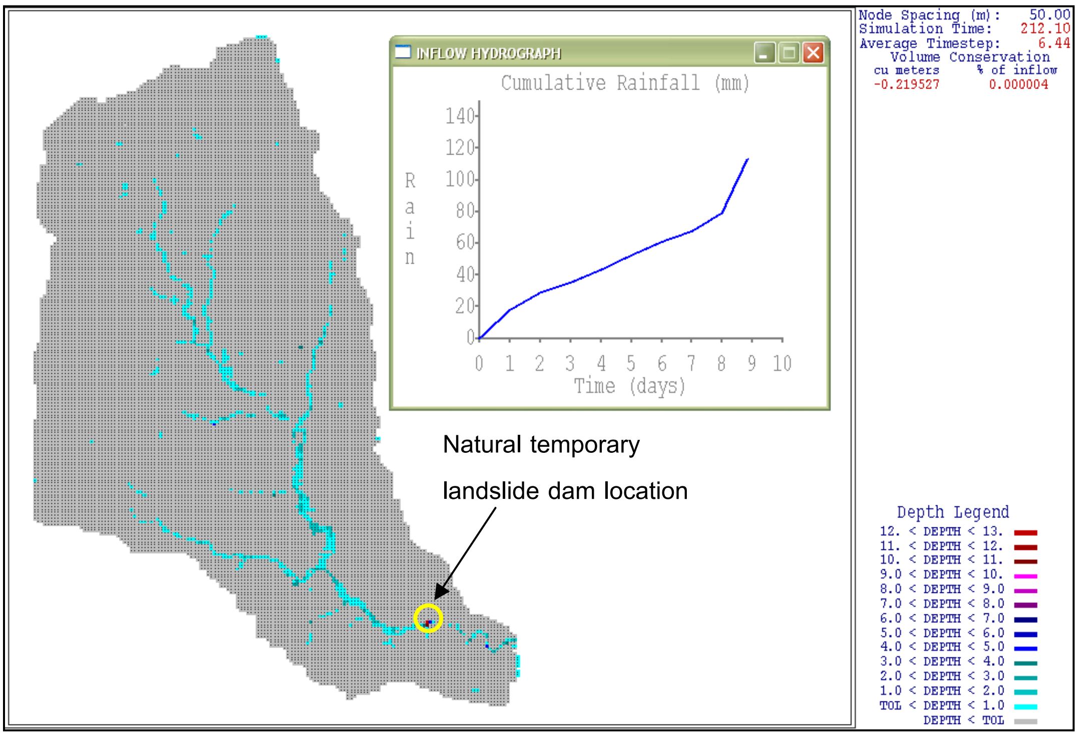

Figure 7-8 FLO-2D simulation results of the channel flow conditions of water height from the condition with dam while the rainfall accumulation was 120 mm at 3 a.m. on 10th August 2001 (about 24 hours before the 8/11 event).

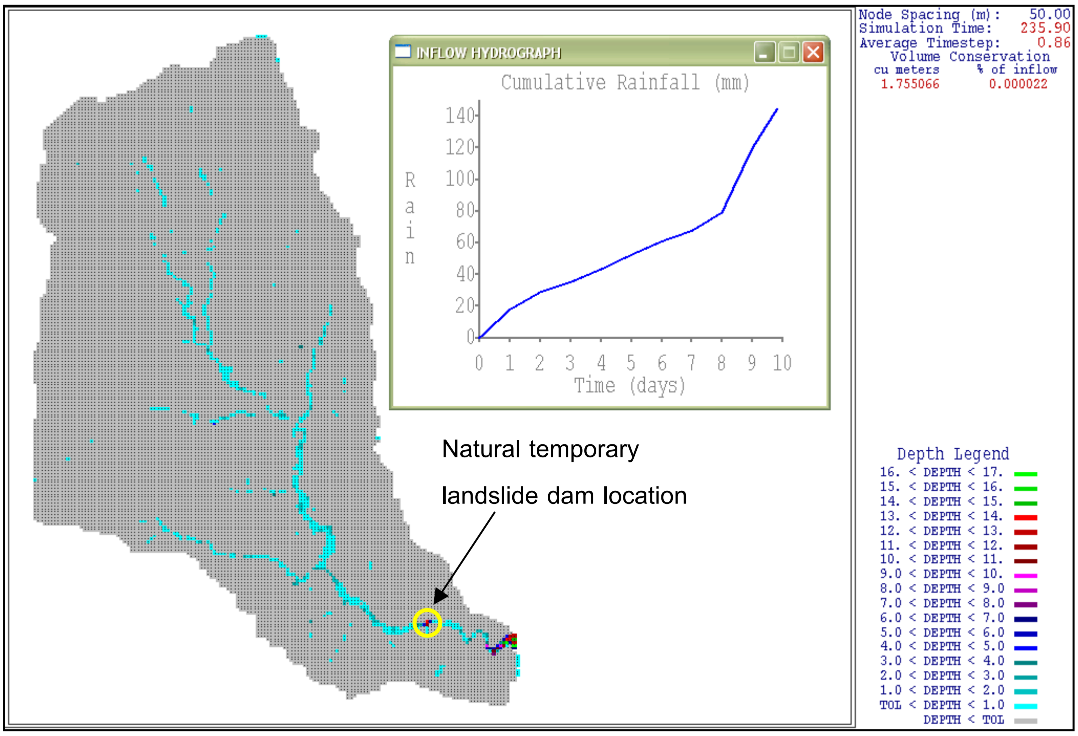

Figure 7-9 FLO-2D simulation results of the channel flow conditions of water height from the condition with dam while the rainfall accumulation was more than 140 mm at 3 a.m. on 11th August 2001 (0.5 hour before the 8/11 event).

In conclusion according to the first scenario, the flow-2d simulation was back analyzed in the condition without dam, the channel flow conditions of water height had some significant increasing values in the middle and further lower parts of the sub-catchment during 9th to 11th August 2001 (before 8/11 event). Whereas, the channel flow conditions in terms of water height had much more increasing values compared to the condition with dam, especially in the middle part of the sub-catchment next to the suspected location of temporary landslide dam.

Although the calculated values from the proposed FLO-2D model above have only some significant to validate the possibility of occurrence of natural landslide dam before the 8/11 flow-flood event, the simulated concept of the landslide dam occurrences can be useful to predict the past and future events in the other locations in the sub-catchment in order to propose the better hazard- and risk mapping in the further studies.