# TWO LARGE-SCALE LANDSLIDE DAMS AND OUTBURST DISASTER IN THE SHINANO RIVER, CENTRAL JAPAN

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## ABSTRACT

Large landslides or debris flows due to heavy rainfall, earthquakes often block mountain rivers to form landslide dams. Dammed water inundates the upstream area and the downstream area is flooded by surges when the landslide dam breaks. As many as 19 landslide dams have been formed in the last 500 years in the northern region of Nagano Prefecture in central Japan, all except one having broken. Seven were formed when the Zenkoji Earthquake occurred in 1847. This abundance is likely because of the geotectonic background of this area which is located at the western end of the major tectonic line, “Fossa Magna” .

In the midstream and upstream areas of the Shinano River, two large-scale landslide dams were formed about 160 and 250 years ago, respectively. The Tobata landslide occurred June 24, 1757 due to heavy rain. The Mt. Iwakura landslide occurred May 8, 1847 due to the Zenkoji Earthquake. Information on the formation and subsequent bursting of these landslide dams remains in detail in historical records such as old documents and picture maps.

**Keywords:** Shinano River, Landslide Dam, Tobata Landslide, Zenkoji Earthquake, Mt. Iwakura Landslide, Old Documents, Picture Maps

## INTRODUCTION

Major flooding damage may occur in the downstream area, if a large-scale landslide dam bursts due to the build-up of water behind the landslide dam. Researchers such as Schuster (1986) and Tabata et al. (2002) have collected data on landslide dam cases and performed related analyses. As a recent example in Japan, large-scale landslide dams were formed in the Imo River, tributary of the Shinano River, when the Niigata-Ken Chuetsu (Mid-Niigata) Earthquake occurred on Oct. 23, 2004. Various measures were taken to prevent the bursting of these dams.

Fig.1 shows the distribution of landslide dams in the northern region of Nagano Prefecture, in central Japan, and Table 1 shows the list of landslide dams in this area. As many as 19 landslide dams have been formed in the last 500 years in area, all but one having broken. Of this number, seven were formed when the Zenkoji Earthquake occurred in 1847.

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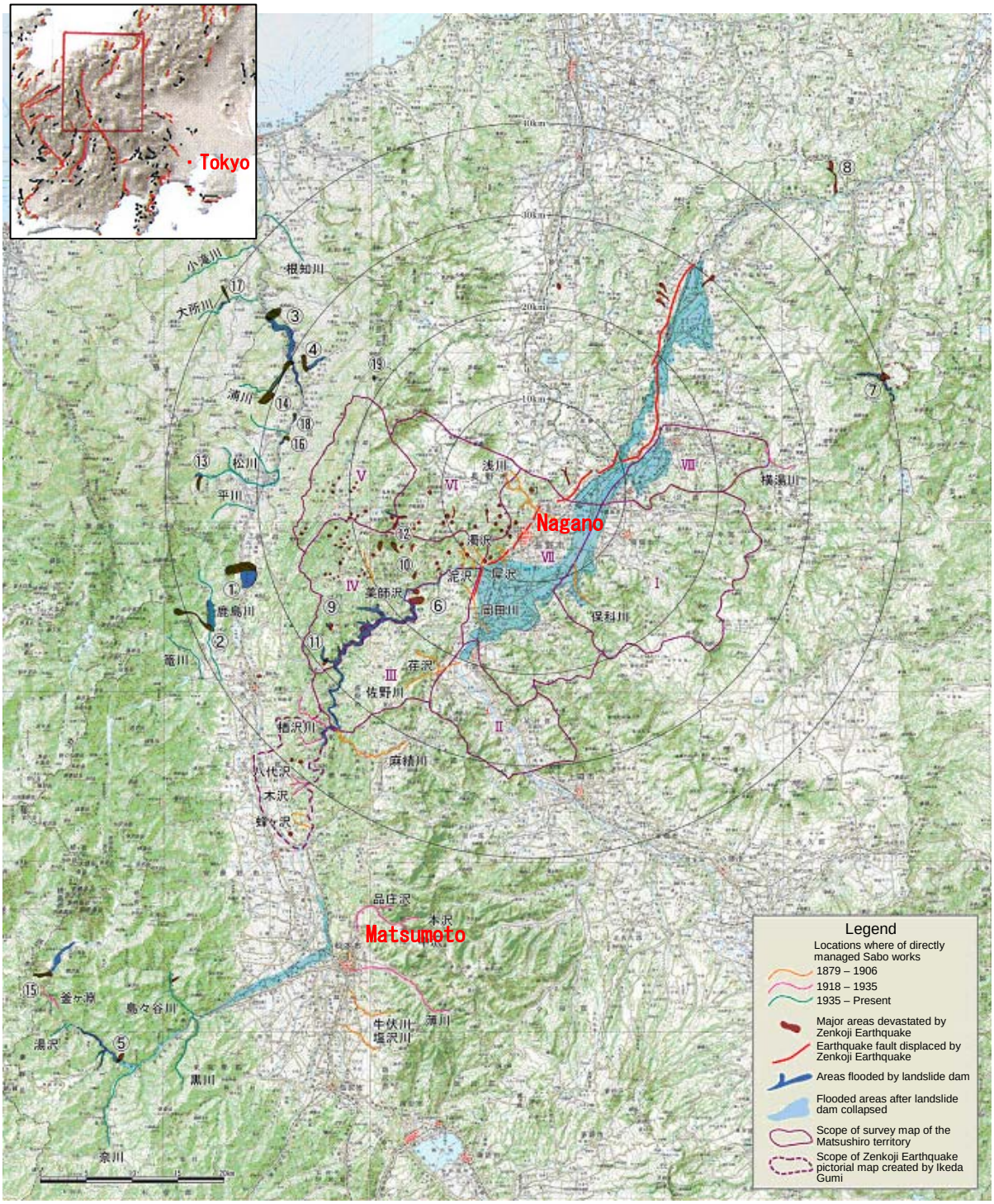


**Fig.1 Distribution of landslide dams in the northern region of Nagano Prefecture in central Japan (Mori et al, 2007)**

This abundance is likely because of the geotectonic background of this area which is located at the western end of the Fossa Magna, Japan's central graben belt (Geologocal Survey of Japan, 1995). The Shinano River, which is the longest river in Japan, runs through the mountainous region of central Japan and flows into the Sea of Japan. In the midstream and upstream areas of the Shinano River, two large-scale landslide dams were formed about 160 and 250 years ago. Information on the formation and subsequent bursting of these landslide dams remains in detail in historical records such as old documents and picture maps.

**Table 1 List of Landslide Dams in Northern Nagano Prefecture (Mori, et al, 2007)**

| No. | Landslide Dam | Date Formed | Cause | Failure Timing |
|---|---|---|---|---|
| (1) | Aoki Lake | 30,000 years ago | Unknown | Continuing today |
| (2) | Kashima River | 1441 | Heavy Rain | 3 days later |
| (3) | Mt. Manaita | 1502? | Essa Earthquake | Unknown |
| (4) | Mt. Shimizu | 1502? | Essa Earthquake | Unknown |
| (5) | Mt. Tobata Landslide | 1757 | Heavy Rain | 54 hours later |
| (6) | Mt. Iwakura | 1847 | Zenkoji Earthquake | 19 days later |
| (7) | Kiriake | 1847 | Zenkoji Earthquake | Gradually failed |
| (8) | Mt. Amamizu | 1847 | Zenkoji Earthquake | A few days later |
| (9) | Yanakubo Lake | 1847 | Zenkoji Earthquake | Continuing today |
| (10) | Ikari | 1847 | Zenkoji Earthquake | 16 days later |
| (11) | Somuro | 1847 | Zenkoji Earthquake | Gradually failed |
| (12) | Oyasawa | 1847 | Zenkoji Earthquake | Unknown |
| (13) | Garagara Sawa | 1891 | Heavy Rain | Gradually failed |
| (14) | Mt. Hieda | 1911 | Heavy Rain | 3 days later |
| (15) | Lake Taisho | 1915 | Eruption | Continuing today |
| (16) | Mt. Kazahari | 1939 | Snowmelting Flood | Gradually failed |
| (17) | Mt. Akahage | 1967 | Snowmelting Flood | 101 days later |
| (18) | Mt. Kozuchi | 1971 | Heavy Rain | Gradually failed |
| (19) | Susobana River | 1997 | Snowmelting Flood | Did not fail due to countermeasures |

## LANDSLIDE DAM FORMED IN 1757

At the Azusa River, three dams – the Nagawado, Midono, and Inekoki Dams – were completed in 1969 by a power generation company and have since been producing hydropower. The Nagawado Dam is an arch dam, 155 m high, having Lake Azusa with a total storage capacity of 123 millions $m^3$ as the dam lake. Fig. 2 shows the location of the Nagawado Dam and Tobata Landslide at upstream section of the Azusa River.

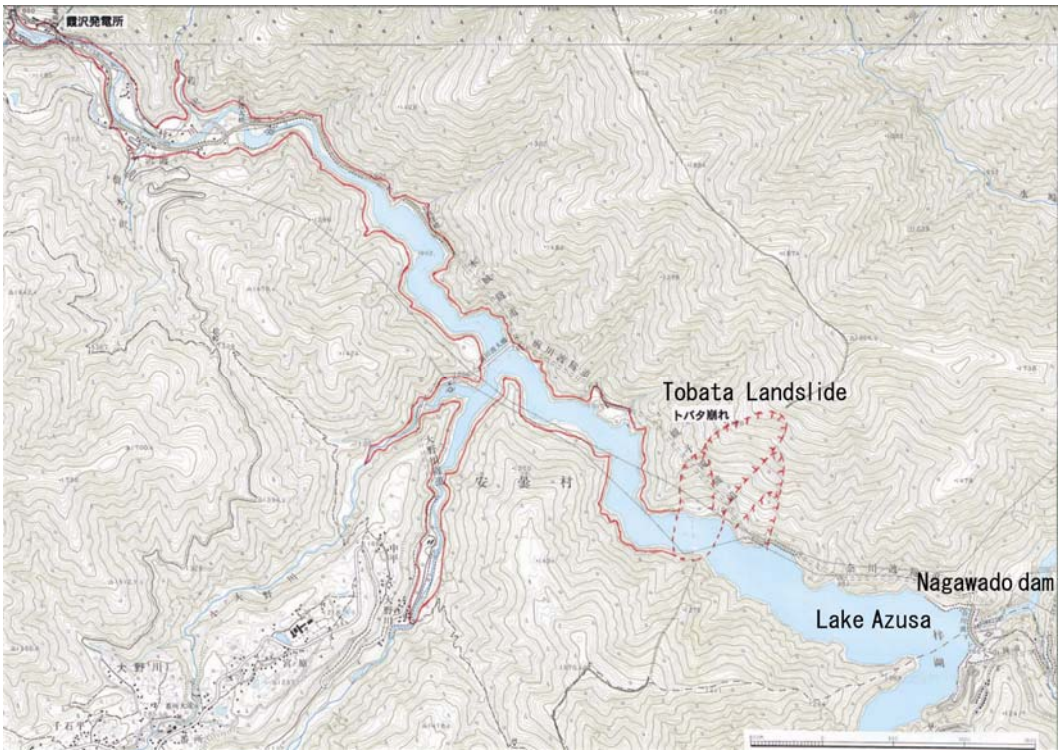


**Fig. 2 Nagawado Dam and Tobata Landslide upstream in the Azusa River**

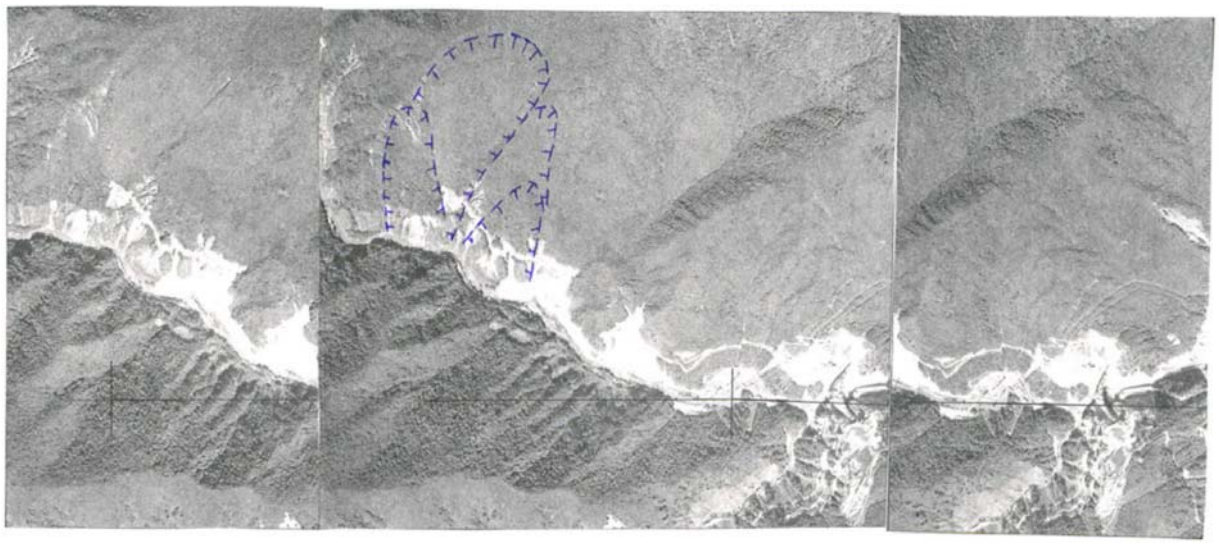

**Photo 1 Tobata Landslide before impounding of Lake Azusa (Photographed on Sept. 20, 1968)**

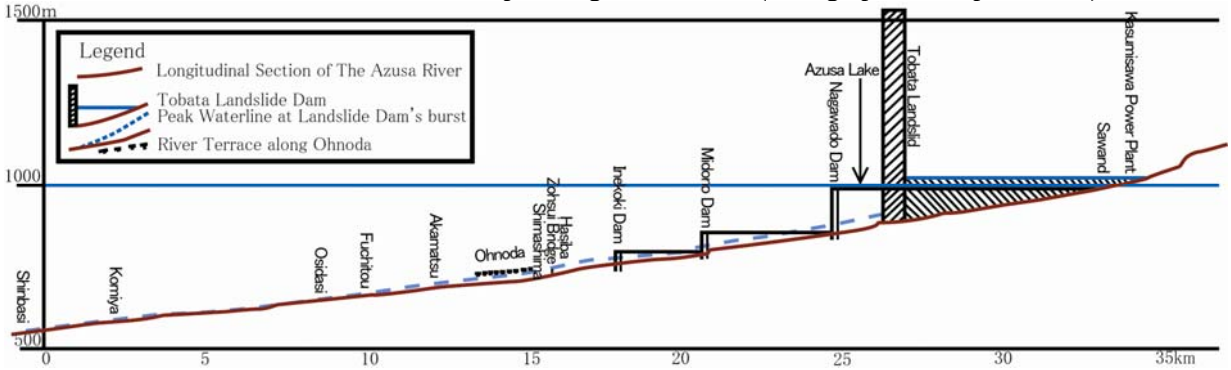


**Fig. 3 Longitudinal section of the Azusa River and Location of Tobata Landslide, Hydropower dam reservoir**

Photo 1 shows the Tobata Landslide before impounding of Lake Azusa. Fig. 3 shows the longitudinal section of the Azusa River in the upstream of Shinano River and the location of Tobata Landslide, hydropower dam reservoirs.

In the early morning of June 24, 1757, a landslide occurred on the left bank of the Azusa River due to torrential downpours in the rainy season (estimated sediment movement: 10 millions $m^3$), forming a large-scale landslide dam in the river. From the historical records, old topographical maps, and aerial photos, it is estimated that the water height and water volume reached 150 m and 98 millions $m^3$, respectively.

Around 10 a.m. on the third day (54 hours later), this landslide dam burst and its water flooded the Matsumoto-Daira, alluvial fan, up to the confluence with the Narai River in the upstream of Shinano River. As the Zousui Bridge (height from water level 14.4 m; length 34.2 m) located 12 km downstream was washed away by the flood, it is estimated that the flood height of the peak flow was 20 m. According to calculation using Manning's formula, it is estimated that the flood water run down the river in a concentrated path with a velocity of 12 m/s and a peak flow of 27,000 $m^3$/s. When the dam burst, local people were quickly ordered to evacuate and no casualties were caused during this flood. The lords ruling the areas (Matsumoto feudal clans) at the time and local people collaborated together to watch, report, and quickly evacuate from the site. Although houses and arable land were carried away, casualties were few because people evacuated to a safe place quickly.

LANDSLIDE DAM FORMED IN 1847

Due to the Zenkoji Earthquake on May 8, 1847, a large-scale landslide (estimated sediment movement: 20 million $m^3$) occurred at Mt. Iwakura in the midstream section of the Shinano River (Sai River) and a large landslide dam was formed due to the blockage of the river. Although the river blockage height was 70 m, the water build-up reached as much as 300 millions $m^3$, making it the largest landslide dam recorded in Japan. Fig. 4 shows the Mt. Iwakura landslide dam and Outburst flood area.

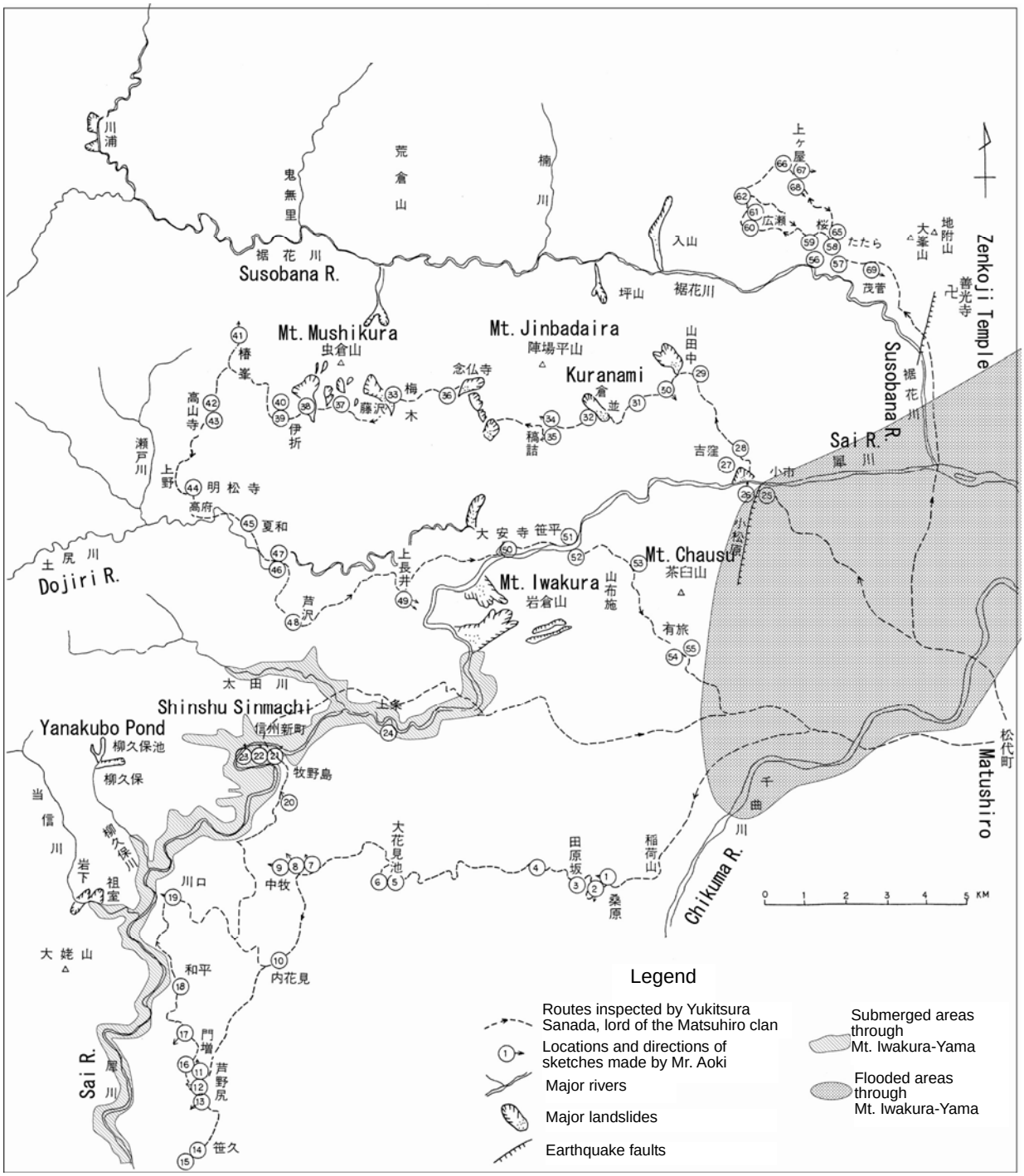


**Fig. 4 Mt. Iwakura landslide dam, outburst flood area and sketch points of painter Sekkei Aoki (Zenkoji Earthquake Disaster Study Group, 1994)**


**Fig. 5 Large-scale Earthquake Disaster Map after 3 months of the earthquake**
**(Sanada Museum in Nagano City)**


**Fig. 6 Mt. Iwakura landslide dam sketched by Sekkei Aoki after 2 years of the earthquake**
**(Sanada Museum in Nagano City)**


**Fig. 7 Mt. Iwakura landslide dam mapped by Matsushiro Clan after 5 years of the earthquake (Kyoto University Museum in Kyouto City)**

The water level reached its maximum on 16 days after the landslide; because of abundant water supply from melted snow (average flow rate: 254 $m^3/s$). The water gradually began to overflow from the dam top, eroding the 1000 m long debris masses. The landslide dam finally collapsed on the 19 th day. The resulting flood flow, reaching a height of 21 m and a peak flow of 34,000 $m^3/s$, caused serious damage to areas in the downstream section which are known today as Nagano City (Zenkoji-Daira) and Iiyama City in Nagano Prefecture.

Immediately after the earthquake, Yukitsura Sanada, who was lord of the Matsushiro feudal clan at the time, ordered his men to draft a “Large-Scale Earthquake Disaster Map” (see to Fig. 5) and reported the state of damage to the Edo feudal government that was ruling Japan at that time. With support from this feudal government, the Matsushiro clan started a disaster restoration effort. Two years later, the lord himself made an inspection tour of his territory and ordered the renowned painter Sekkei Aoki to make 67 sketches of the earthquake damage (see to Fig. 6). After about four to five years when the first stage of restoration work ended, the lord also ordered the preparation of a land survey map, and eight large-size maps (1/6000 scale) collectively called the “Survey Map of the Matsushiro Territory” were completed (see to Fig. 7).

## Conclusion

In our report, the formation and bursting of the two landslide dams and the resulting flooding, which were vividly depicted in the aforementioned maps and drawings, are very introduced. Historical records on landslide dams and associated floods will be connected more and they will be documented. These informations are taken into account when disaster prevention plans or warning and evacuation system are made in each area.

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