EFFECTS OF DEBRIS-FLOW CONTROL WORKS ON ENVIRONMENT AND CONSEQUENCES FOR LAND-USE PLANNING CASE STUDY "MURBACH", TYROL, AUSTRIA

Joerg Heumader[1*]

ABSTRACT

The torrent "Murbach" is one of the most dangerous debris-flow torrents in the Oetz Valley. 1762 a village located on its cone was destroyed almost totally by a series of debris flows. The destroyed houses and farms were not rebuilt on the same site, but on a safer place not on the debris cone. Combined technical control works have been installed in three building periods between 1954 and 2005. In the paper the effects of these control works on environment and the consequences for future land-use and development on the protected debris cone are discussed. Despite the fact, that the control works will bring safety up to the design event of 150-years probability, to the author`s opinion some restrictions for future development are nevertheless necessary.

Key words: Debris-flow control, Environment, Land-use restrictions, Near-nature control

INTRODUCTION

Debris-flow torrents are responsible for sediment disasters with severe property and infrastructure damages and often also for injured and killed people. Debris-flow dynamics require massive technical counter measures on the one hand, on the other the assessment of residual risks despite implemented defense works is problematic in such cases and the influence of defense works on environment is often criticized as negative in public opinion. The above problems and found solutions for an individual debris-flow torrent are described and discussed in the paper.

DESCRIPTION OF THE CATCHMENT AND PAST SEDIMENT DISASTERS

The catchment basin of the torrent "Murbach", community Umhausen, district Imst/Tyrol, has an area of 3,8 km². Its headwater reach is very steep and reaches up to almost 3000 m a.s.l., steep flanks characterize also the middle reach. On the bottom of the Oetz valley (1000 m a.s.l.) a very large debris cone is an indicator of this torrent's activities.

1 Professor, Federal Service for Torrent and Avalanche Control, Austria (*Corresponding Author; Tel: +43-2-82261010, e-mail: joerg.heumader@cni.at)

The climatic conditions are continental; the average precipitation is only 710 mm per year. The maximum thunderstorm rainfall is recorded with 96 mm per hour 1966.
The bedrocks are foliated gneiss and schist. In parts of the headwater reach and in the middle reach they are covered with thick veneers of glacial deposits. These relict deposits are the sources for heavy debris flows. "Murbach" means "debris-flow torrent" and it can be characterized exactly with this word. The design event for hazard zoning is based on a debris flow with 70.000 m³ volume. There are practically no negative human activities (e.g. deforestation) in this watershed.

In the period from the 9th to the 11th of July in the year 1762 a series of debris flows, coming down from the basin for 40 hours damaged 68 houses and farm buildings, which had been built on the southern sector of the debris cone. Only one house in this part of the village "Umhausen" has withstood this catastrophe. 9 persons and a lot of livestock were killed (Fig. 1 and 2).

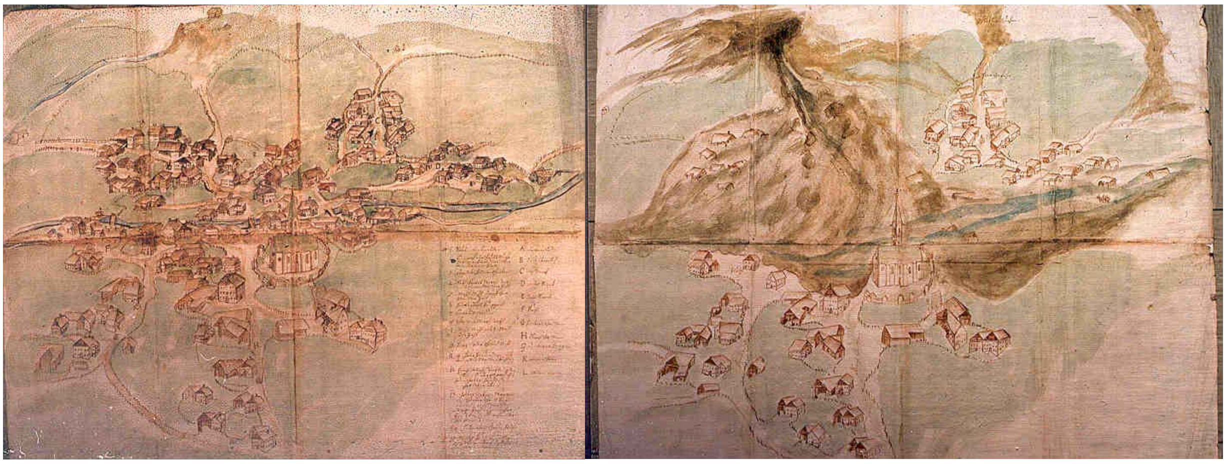

Fig. 1 and 2: The village of Umhausen before and after the catastrophe of 1762.

After this enormous disaster the damaged houses were not rebuilt on the same place, but on a new site, called "Neudorf" (that means "New Village"). Only after the second-world-war new houses were built again on the southern fringe of the debris cone.

DEBRIS FLOW DEFENSE WORKS

A combination of defense measures has been planned and constructed by the Austrian Federal Service for Torrent and Avalanche Control (Fig. 3).

In the middle reach two sections have been consolidated by chains of check dams made of reinforced concrete. It is estimated, that roughly 30.000 m³ of erodible moraine material are consolidated by these check dams.

At the valley outlet a gravity dam with large holes made of concrete masonry functions as a sort of debris-flow breaker; its storage capacity is 5.000 m³ (Fig. 4).

On the uppermost part of the debris cone a deflecting earth dam, protected on the waterside slope by a revetment of dry-laid boulders, shall keep off debris flows from the partly settled southern fringe of the debris cone as an additional second barrier.

On the northern sector of the uppermost part of the debris cone a debris-flow retention basin has been built. It reaches upstream almost to the debris-flow breaker, it is bordered to the north by the mountainside and to the south by an earth dam, whose waterside slope is protected by dry-laid boulders. The basin's outlet is a dam, made of reinforced concrete with steel bars closing its opening, supported on the left by an angular retaining wall and fixed on the right to a natural rock outcrop by prestressed anchors. The retention capacity of the basin is 40.000 m³ at minimum, depending on the aggradation grade (Fig. 5).

Because a farmland reallocation and consolidation operation has been started on the debris cone, it was possible to build a totally new channel downstream the retention basin, located in as great a distance from the settled area as possible. The new channel runs on the northern border of the cone in the depression, where the two debris-flow cones of the "Murbach" and of its neighbor torrent to the north meet.

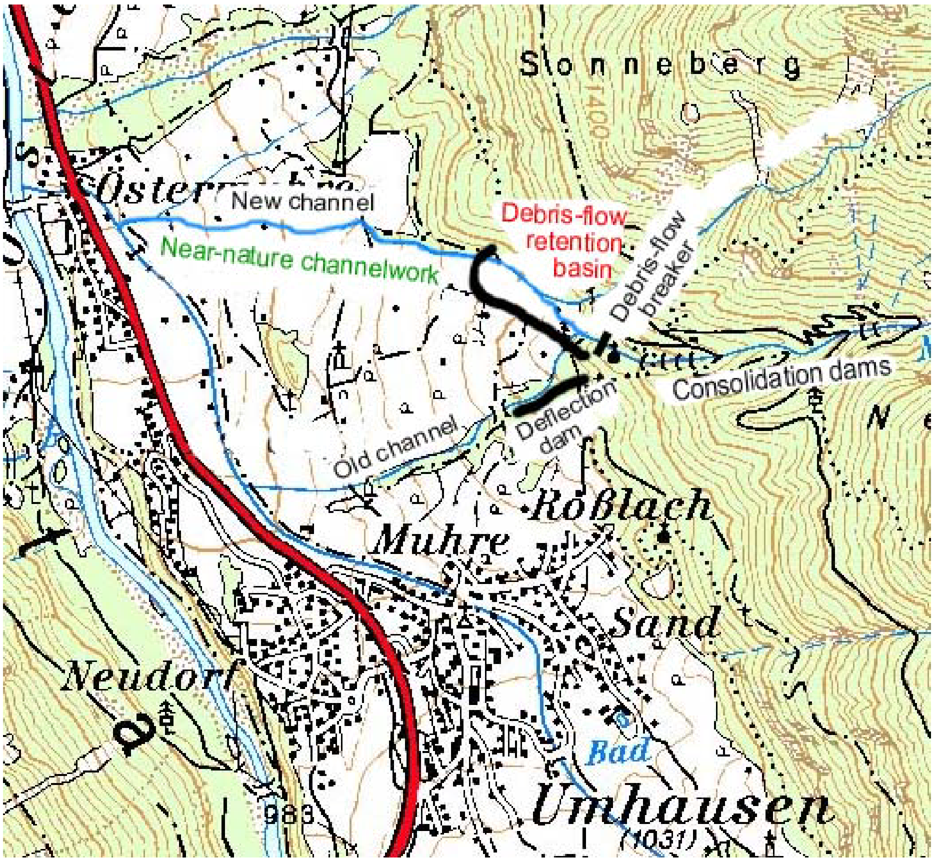

Fig 3: Overview map of the debris-flow cone of the torrent „Murbach“ and its surroundings with defense works.

EFFECTS ON ENVIRONMENT, LANDSCAPE AND RECREATION

Debris-flow retention basin

Despite the fact, that the retention basin will be filled up by the next debris-flow, nature-orientated planning has been done for the period before that event. Considering environmental and landscape aspects the dam's outer slope has been afforested with groups of conifers (*Larix decidua*) and some broadleaf tree species. Willow cuttings (*Salix sp.*) and alder plants (*Alnus* *sp*.) have been planted into the gaps between the dry-laid stones of the revetment of the inner slope. The basin's bottom has been structured and left to natural revegetation (Fig. 5). The basin's outlet's opening reaches down to the torrent bottom and is no barrier for migrating fish. Because of the special outlet construction of the basin only the earth dam can be seen from the opposite mountainside.

Fig. 4: At the valley outlet a gravity dam, made of concrete masonry, functions as a debris-flow breaker.

Fig. 5: The debris-retention basin has been structured, but otherwise left to natural regeneration.

Near-nature channel

Permanent environment and landscape-orientated control measures are only possible downstream the debris-flow retention basin, where the torrent reach has changed as result of the implemented debris-flow defense works from a debris-flow reach to a section with flood runoff transporting only suspended load and some bedload.

Planning had to take into account the energy surplus of the water runoff downstream the retention basin, which would have resulted in severe depth and lateral erosion problems.
When setting out the channel's centerline it was tried to integrate existing stone rows, bush and tree groups etc. The channel has an open, natural bottom with varying width fixed by low sills made of boulders founded on timber logs. The banks with varying slope inclinations, steeper in the outer curves, gently inclined in the inner curves, are protected by revetments of dry-laid stones, founded on timber logs (Fig. 6 and 7).

The gaps in the stone pavement were planted with willow cuttings (*Salix sp.*), the upper edge and strips of varying width on both banks with groups of bushes and trees.

The torrent's alluvial cone is a steep "debris-flow cone", showing typical morphology and landforms, like debris lobes and levees, stone heaps and large boulders deposited by debris flows.

Fig. 6 and 7: Near-nature channel under and just after construction without water running.

It has been cultivated by livestock farmers since centuries for the production of hay, in former times also flax and corn have been grown.

The cultivation resulted in typical landscape elements, like heaps and rows of stones picked up on the cultivated land. These stone heaps are partly stocked by several species of bushes and some trees, they are habitats for small mammals, lizards, birds and insects. Unproductive areas covered by coarse-grained debris deposits remained uncultivated and developed naturally.

Parallel to some sections of the channel new stone rows were deposited, copying the stone heaps of former times. Large excavated boulders were deposited near the channel as impressive debris-flow indicators.

Three channel widenings with gently inclined slopes have been designed as water-playgrounds for children, several picnic places and information boards have been installed (Fig. 8).

Fig. 8: Channel widenings as playing grounds for children.

People like to walk along the man-made stream and of course children love playing in the stream bed and on the banks.

The step-pool-structure of the new channel is very positive for water-life, even two fish species (*Salmo trutta f. fario* and *Salvelinus fontinalis*) live here now (Fig. 9).

Fig. 9: Step-pool-structures and densely planted banks as good habitats for life inside and outside the water.

CONSEQUENCES FOR LAND-USE AND DEVELOPMENT PLANNING

The torrent defense works have been designed for a debris-flow event with a recurrence probability of 150 years, according to the rules of hazard zoning in Austria.
The sediment disaster of 1762 most probably had been one of lower probability according to the historical descriptions. Therefore we can not be sure, if our technical defense works will prevent damages on the whole protected cone in the future.

These considerations led to the conclusion to develop further only the already partly settled southern sector of the cone, which is additionally protected by the deflection dam as second barrier, but to restrict the use of the other sectors to agriculture including rural buildings (farmsteads, stables, barns, haystacks). The development of these sectors for housing and touristic buildings is forbidden by the land-use and development authorities (Fig. 10).

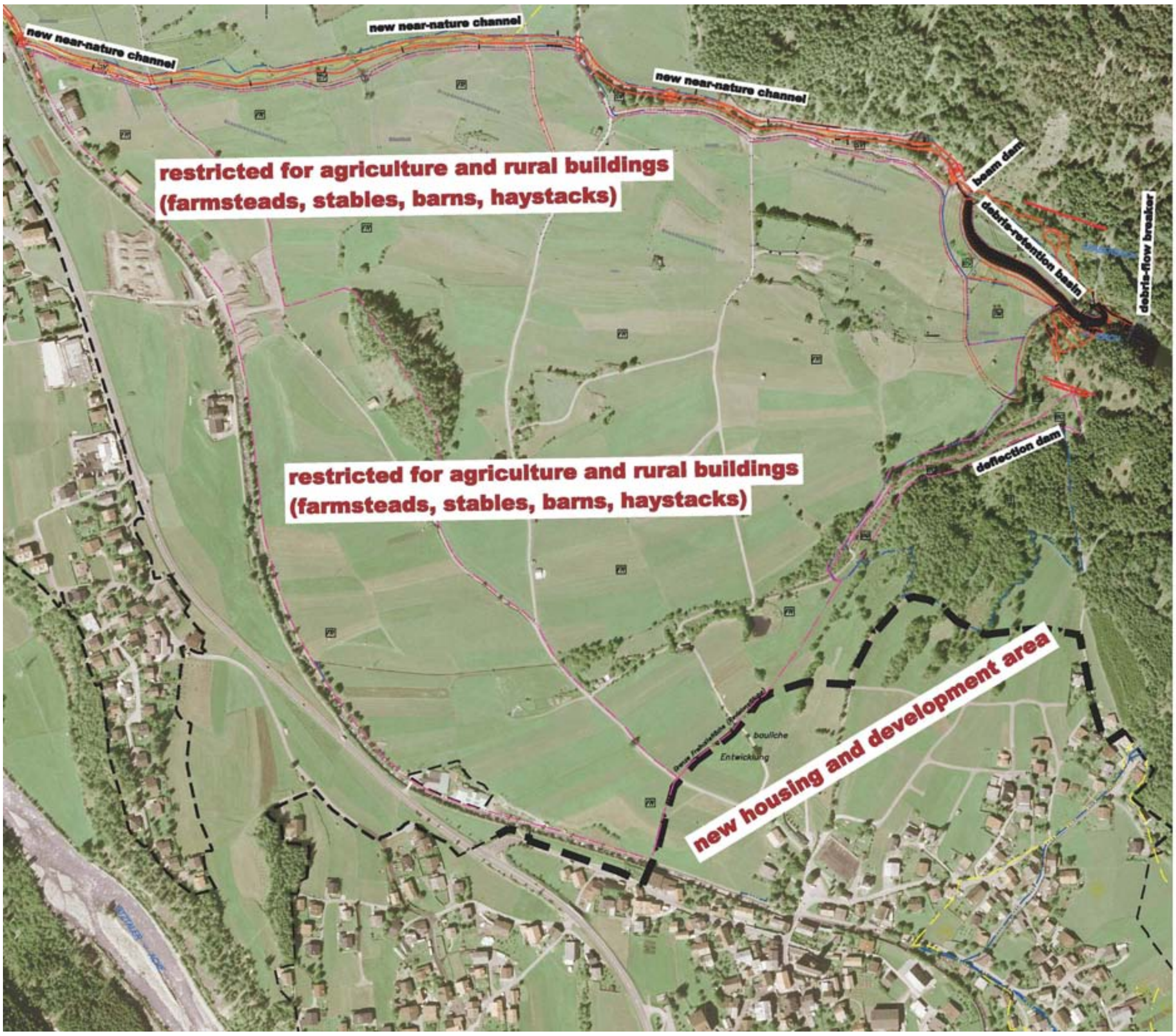

Fig. 10: Hazard Zone and Development Map of the debris cone Murbach, Umhausen, Tyrol, with areas restricted for agriculture and rural buildings on the northern sector and for housing and touristic development on the southern sector.

CONCLUSIONS

The case study “Murbach” shows that when planning and implementing torrent control works not only safety for people, buildings and infrastructure is to be reached as main goal, but that environment, landscape and recreation are also important aspects.

These aspects have to be taken into account in the planning procedure. Even in case of debris-flow torrents there are some possibilities to reach these additional goals, especially when erosion and debris transport can be reduced or stopped by technical consolidation and/or retention works (Heumader 2004).

Debris-flows, rapid landslides and snow avalanches may bring not only heavy damages, but endanger also human lives.

In these cases therefore residual risks after the implementation of defense works require careful considerations and some precautious restrictions for future developments may be necessary, of course depending on the individual situation.

REFERENCES

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