PROLINE-CE

WORKPACKAGE T2, ACTIVITY T2.1

SET UP OF PILOT SCECIFIC MANAGEMENT PRACTICES

D.T2.1.4 DESCRIPTIVE DOCUMENTATION OF PILOT ACTIONS AND RELATED ISSUES

PILOT ACTION 1.1: CATCHMENT AREA OF THE VIENNA WATER SUPPLY

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1. Introduction

The Pilot Action Vienna Water decided for is “mountain forests and grassland sites”. The reason for this decision is that Vienna Water wants to continue the research activities regarding the risk assessment in the catchment areas of Vienna’s water supply especially assessing vulnerability and hazards. In PROLINE-CE the main activity lies on the “Zeller Staritzen” (Surface run-off and spring dynamics of Zeller Staritzen). The description for D.T2.1.4 will mainly describe this area. It is planned that the results will be applied to other regions of the catchment and protection zones. This allows for a more detailed description of the selected area and the interpretation of the results for the study.

2. Basic data about pilot action

2.1 Geographical description

The Zeller Staritzen is part of the Hochschwab massif (north-eastern part) which itself is a range in the Eastern Alps (Figure 1). It is situated in Styria. Politically the Zeller Staritzen lay in the community of Mariazell-Gußwerk the largest community in Styria. The Salza river forms the northwest border from Weichselboden to Gußwerk. The north-south border is formed by the Gollradbach from Gußwerk to Wegscheid. The southern border runs from Wegscheid through the Ramertal to Kastenrigel and further to Hintere Höll. There it goes north to Rotmoos which closes the polygon (Figure 2). The elevations range from about 700 m a.s.l. in the valleys up to some 1600m a.s.l. It forms a karstic plateau typical for the Eastern Alps. The vegetation cover consists of different forest types, mountain meadows and areas without vegetation (boulders and gravel). Historically there was iron industry (weapon and tool production) and wood processing industry. A large saw mill is left at Gußwerk. Working places are provided by trade and craft business. A few kilometres north of Gußwerk Mariazell is located. Mariazell is one of Austria’s most prominent pilgrim sites. Pilgrims are the basis for touristic activities in Mariazell and the surroundings. There are just some small villages in the the valleys with diminishing population. In general, it is sparsely populated with few economic activities. Forestry, saw mills, trade business for local demand and supply, mountain pasture, tourism and water supply form the main economic activities.

Figure 1: Geographical map of Austria with the Pilat Area (Zeller Staritzen red coloured)

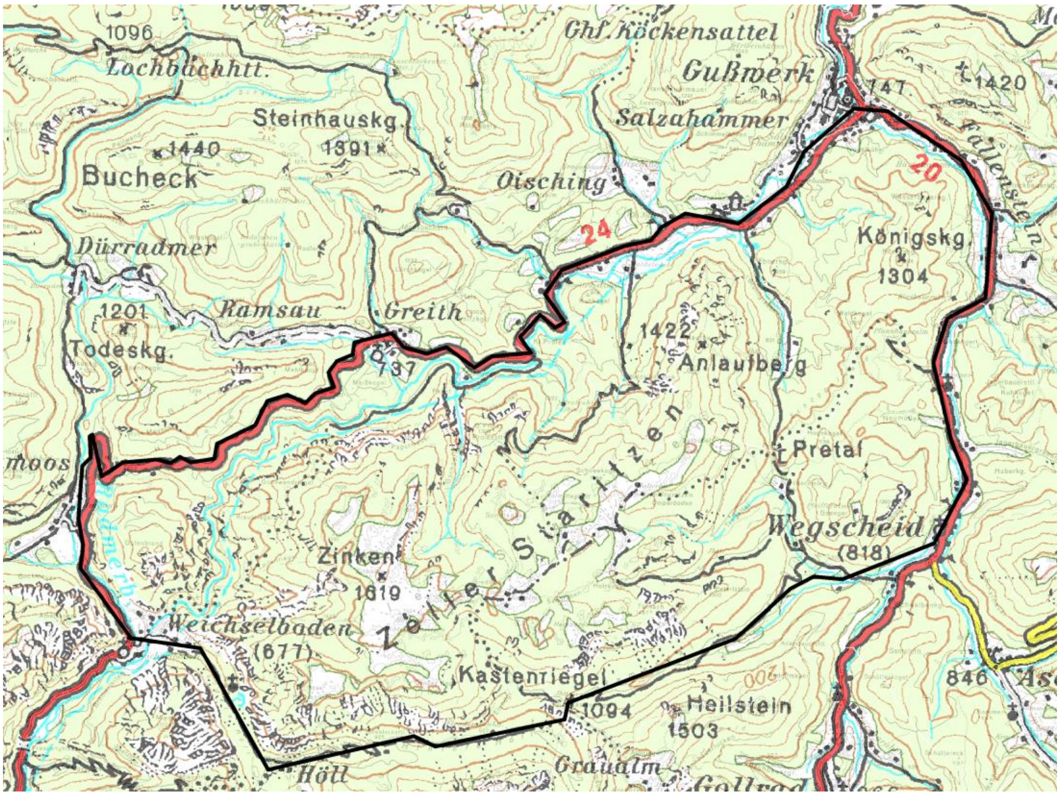

Figure 2: Austria map 200 (ÖK200) – detail Zeller Staritzen

2.2 Geological description

The Zeller Staritzen form the north-western part of the Hochschwab massif. This massif lies in the nappe and overthrust system of the tyrolian and juvavian units of the Northern Calcerous Alps (Figure 3). The series formed by limestones and dolomites belong to the Göller and Mürzalpen nappes the series of the Grauwackenzone at the base of the massif belong to the Noric nappe. The series of the Grauwackenzone were deposited in paleozoic to lower Triassic time and are predominantely siliceous and not permeable. They form the impermeable base of the Hochschwab massiv. The overlaying limestones and dolomites are of Triassic age. The sedimentation facies of the carbonates range from lagoon to reef and fore-reef. The carbonates are more or less intensively fissured and karstified. Detailed geological description is available in the report from Mandl et al. (2002).

The range was tectonically formed during five range building phases beginning in the Cretaceous and lasting till the Miocene. These tectonic phases produced the geological structures which determine the drainage and are the preferred locations of karstification. Detailed tectonic description is available in the report from Bauer et al. (2006).

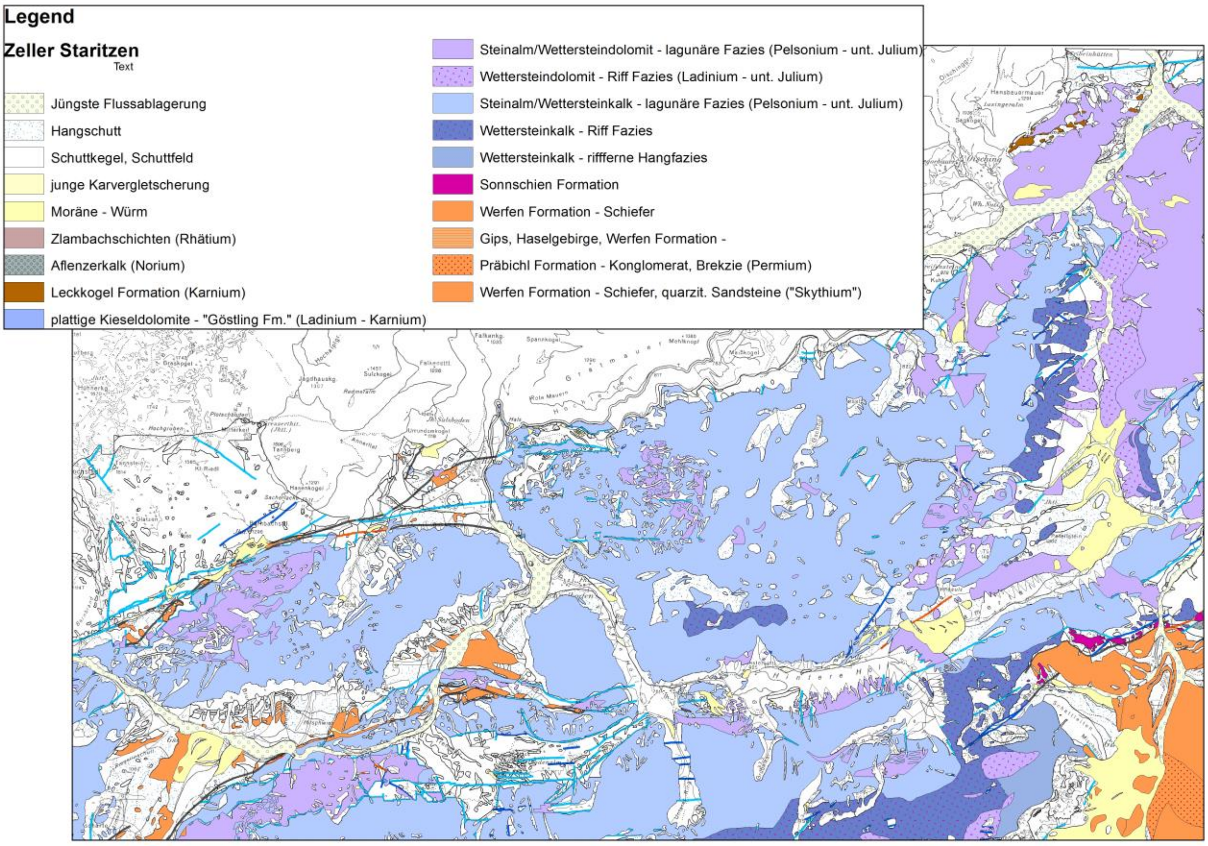

Figure 3: Geological map of Zeller Staritzen (north-western part of Hochschwab)

2.3 Pedology

In Austria, spatially distributed soil data are mostly available for agricultural areas in the lowlands and valleys (Digital soil map – eBod). Coverage in the Alpine areas is poor; no data exist except from regional soil mapping conducted in projects with specific objectives. At the Zeller Staritzen maps of overlying material, soils and debris are available from hydrogeological mapping in a process-oriented way. The idea of process-oriented mapping is that those properties are mapped which describe significant hydrological processes on an area. This is the basis for setting up a hydrological model where spatial structure and parameters can directly be inferred by the mapped processes. Aim of hydrological modelling is the representation of the complex interplay of surface runoff and infiltration in a karstic catchment. The "loose material/soil" type is classified by the type of the material related to its origin (weathering), and in-situ determination of fine grain size fraction as well as incorporating mapping of visible traces of temporary surface runoff or a permanent drainage network.

Figure shows the distribution of the mapped overlaying material at the Zeller Staritzen. Soils with high fraction of coarse material dominate in the region. The dominant hydrological process is direct infiltration (DI) and surface runoff does not occur. Underlying karstified Limestone results often in subsequent deep percolation (DP) and a drainage network is not evident. Increased fraction of fine material is assumed to increase storage capacity and decrease permeability, which supports surface runoff generation. However, soils with high fraction of fine material and areas with fine organic soils (secondary sediments of crystalline) are very rare in the study region. The latter soils are mostly linked to less karstified/less permeable geology and flat morphology. Storage capacity is low and partly water logging and a drainage networks are found.

Areas with bare rock show a significant extent in the area. This class contains also areas with very thin soil layers, where the influence on the infiltration characteristics can be neglected. On these areas the properties of geology (size of cracks, fissures) are dominant. Low permeable dolomitic areas, for example, are assumed to contribute immediately to surface runoff at rainfall events.

Forest is the dominant vegetation type in the region and hence, water flow is influenced by interception and storage in the forest soils showing a thin humus layer, loosened by roots and overlaid by mulch.

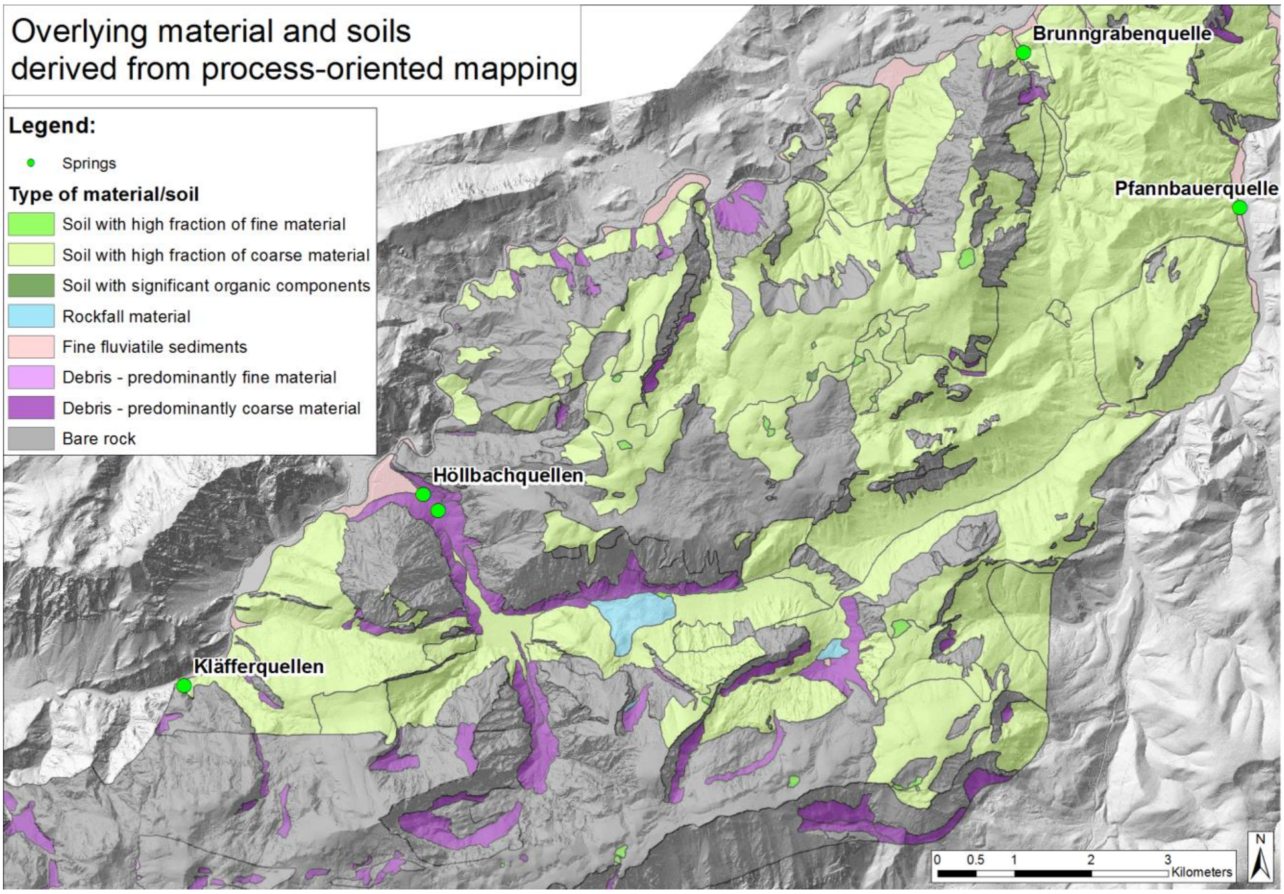

Figure 4: Mapped process-oriented types of overlying loose material and soils at the Zeller Staritzen

2.4 Climate characteristics

The Zeller Staritzen catchment in the Northern Calcareous Alps in Styria reaches altitudes up to 1619 m a.s.l and shows therefore a clear Alpine climate with cold winters with high and long term snow cover (October – May in the high altitudes) and cool summers. Figure 5 shows the spatial distribution of the meteorological stations located in the Zeller Staritzen region. In Weichselboden (WB) and in Brunngraben (BG), both, the Vienna Water Works, MA31, and the Hydrographic Service of Styria, HD, operate stations. Edelboden (EB) is operated by the MA31 since 2009 and located at the highest altitude in the area at 1350 m a.s.l. **Error! Reference source not found.** lists the stations with their mean annual precipitation in the years 2009–2016. In this period the recordings of the available stations overlap. First, the altitude dependence of the precipitation can be seen. The station Edelboden (EB) shows the highest values that are relevant for the Zeller Staritzen area with a mean annual value of 1828 mm. Additional gradients are indicated by the relative differences: precipitation in Weichselboden (WB) is higher than in

Gollrad/Wegscheid (GW) or Seewiesen (SW), although WB is located at lower altitude, which indicates a Northwest-Southeast gradient; precipitation in WB is also higher than in GW, which indicates also a West–East gradient. These gradients are consistent with the general atmospheric conditions of moist air flow from Northwest to Southeast. Combined with orographic effects these conditions induce significant precipitation during frontal events induced by low-pressure systems coming from the Atlantics.

Mean temperatures based on the period 2006-2016 range from 7.5°C at the station Weichselboden HD (WB) in the valley to 5.5°C at the station Edelboden (EB) in high altitudes. For evaporation values, regionalised potential evaporation amounts according to PENMAN are published in the Hydrological Atlas of Austria, edited by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management. Values between 500 are 600 mm per year are reported for the Zeller Staritzen Area.

Table 1: Meteorological stations (with abbreviations for Figure 5) in the Zeller Staritzen area and mean annual precipitation (MAP) in the period 2009 – 2016.

Station	Altitude [m a.s.l.]	MAP [mm]
Weichselboden-HD (WB)	680	1595
Gollrad-Wegscheid (GW)	850	1471
Seewiesen (SW)	980	1506
Brunngraben-HD (BG)	710	1405
Edelboden (EB)	1350	1828

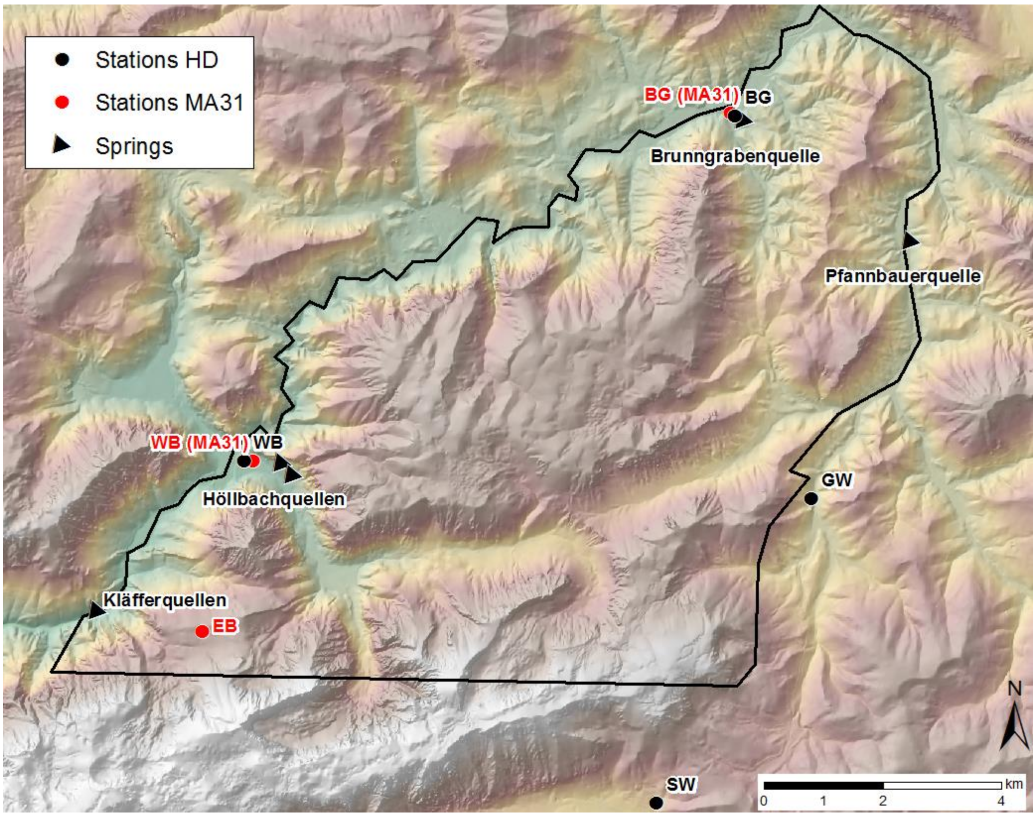

Figure 5: Location of available meteorological stations in the study region Zeller Staritzen (abbreviations according to Error! Reference source not found.**). The black polygon shows the study area. Triangles denote the main springs.**

2.5 Hydrology

Four important springs of the Vienna Water Works (MA31) are located in the Zeller Staritzen region. They drain the most part of the Hochschwab-Zeller Staritzen karst massif. There are no rivers or creeks in the region, where permanent surface runoff can leave the catchment. Hydrological measures of rivers in the wider region (e.g., river Salza) are not comparable and also highly uncertain due to the karstic character of their catchments in the Northern Calcareous Alps.

Location of the springs is indicated in the Figure 5**Error! Reference source not found.** (black triangles). **Error! Reference source not found.** lists the springs with their mean annual discharge in the period 2000–2012. The Kläffer Springs are located in the West, outside the current study area. Their catchment was included into the previous study of Stadler et al. (2015). A comparison between the springs can only be made by specific discharges, when the exact catchment areas are known, which is not the case. Estimations of catchment boundaries exist from geological studies, but uncertainties are assumed to be large. In general, the Kläffer springs are supposed to have the largest catchment, followed by the Höllbach springs and the Pfannbauern and Brunngraben springs.

The Figure shows the mean monthly discharge of the four springs in the period 2000 to 2012. The discharge is normalised by the mean discharge in the corresponding period in order to analyse the four springs together in one plot. The Kläffer springs (KL) show the most pronounced seasonality, i.e. discharge dynamics during the year. Recharge area of the Kläffer springs consists of intensely karstified Limestone without significant vegetation cover (Hochschwab plateau). On average, KL shows the peak in May, after the main snow melt period. Due to the high altitudes of the corresponding recharge areas the snow melt occurs late. Winter low flow is also significant. At the two springs, Pfannbauern and Brunngraben, the discharge is almost equally distributed over the year. Main parts of the catchments of the two springs are located in dolomitic geology. Water storage and residence times are large due to the low permeabilities in the small fracture system which is typical for a Dolomite karst spring. The fourth spring, the Höllbachquellen group, shows a behaviour which lays between these two. The catchment consists of Limestones and Dolomite. In addition, a porous aquifer affects the dynamics at the spring. The hydrogeology in the spring catchments is described in the following section 2.6.

Table 2: Mean values of discharge in the period 2000 – 2012 at the four springs in the area. Note that the Kläffer springs are located outside of the region of the current study.

Spring	Mean annual discharge 2000-2012 [l/s]
Kläffer (KL)	5570
Höllbach (HO)	616
Pfannbauern (PF)	306
Brunngraben (BR)	328

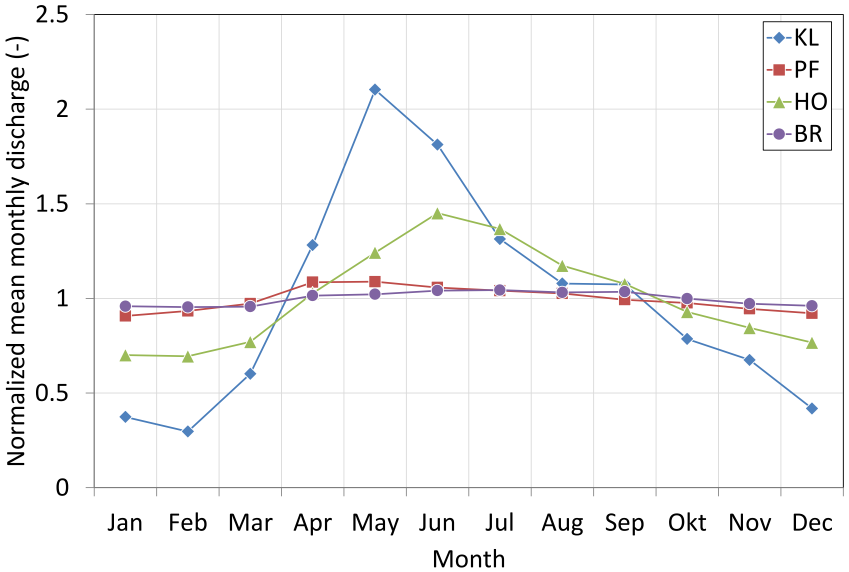

Figure 6: Mean monthly discharge of the four springs in the study region, normalised by the mean discharge in the period 2000 to 2012.

2.6 Hydrogeology

Figure shows the compilation of data regarding hydrogeology and main tectonic vaults in the investigation area Zeller Staritzen. The hydrogeological map is taken from Stadler & Strobl (1997), but uncertain areas and boundaries were checked during the process-oriented mapping in previous studies and described above. Vaults and lineaments are available from Decker et al. (2006) with partially estimated water conductivities and from Stadler & Strobl (1997) without conductivities. It is clear, that, because these structures are estimations made in different studies with different methods, they do not overlap. However, consistently, both data sources indicate subsurface flow directions towards the main springs, from which catchment boundaries were roughly estimated. These boundaries are subject to revision within the current study with the use of water balance modelling.

The lineament structure indicates that the South-Western part drains towards the Kläffer springs; it consists mainly of karstified Limestone of the Hochschwab massif. In the Zeller Staritzen, the estimated catchments of the Pfannbauern and Brunngraben springs in the north-east are dominated by Limestone (karstified aquifer) and also to a high degree by Dolomite (fissured aquifer). The estimated catchment area of the Höllbach springs consists of Limestone but also includes a larger area of porous aquifer. It is likely, that karst water from the Limestone areas recharges this aquifer which would lead to a temporary storage of this groundwater component. In the South-Eastern part (Aflenzer Staritzen) a connection towards the Kläffer springs was confirmed by a tracer experiment (Speläologisches Institut, 1972). However, geologic and tectonic data in this area suggest, that there are different draining directions in different depths, i.e. that the upper karst level drains to the North towards the Höllbach springs and the lower karst level drains to the South and hence, towards the Kläffer springs. It is assumed, that the catchments of the Kläffer and the Höllbach springs are overlapping.

In the Northern part local temporary surface runoff occurs ("Gschödinggraben") which flows directly into the river Salza, the Northern border of the Zeller Staritzen catchment. Also, exfiltrating subsurface flow is observed at the "Wasserloch". Catchments of these two draining systems are assumed to be small (Stadler & Strobl, 1997), and actual discharge data are not available in both cases. So, they are not included into the map.

Regarding processes on the surface, based on the hydrogeological rating, at areas with a high degree of karstification direct infiltration (DI) and subsequent deep percolation (DP) into the karst system dominate. Only temporary surface flow is possible with short flow lengths either at (i) steep slopes with parallel stratification and (ii) when very high intensities occur so that the infiltration capacity of the fissures and cracks is exceeded ("Infiltration Excess"). This was confirmed during the process-oriented mapping when very rarely significant traces of surface runoff were found on these areas. On the other hand, the Dolomite is generally less karstified; the cracks and fissures are smaller and hence, the permeability of these areas is much lower than Limestone. Surface runoff is much more likely. As depths and permeabilities of the debris increase subsurface flow towards a local draining network at the interface to the underlying Dolomite occur. Often local springs originate at the intersection of the debris and the underlying impermeable rock but water flow infiltrates again. Springs with significant discharges were also mapped.

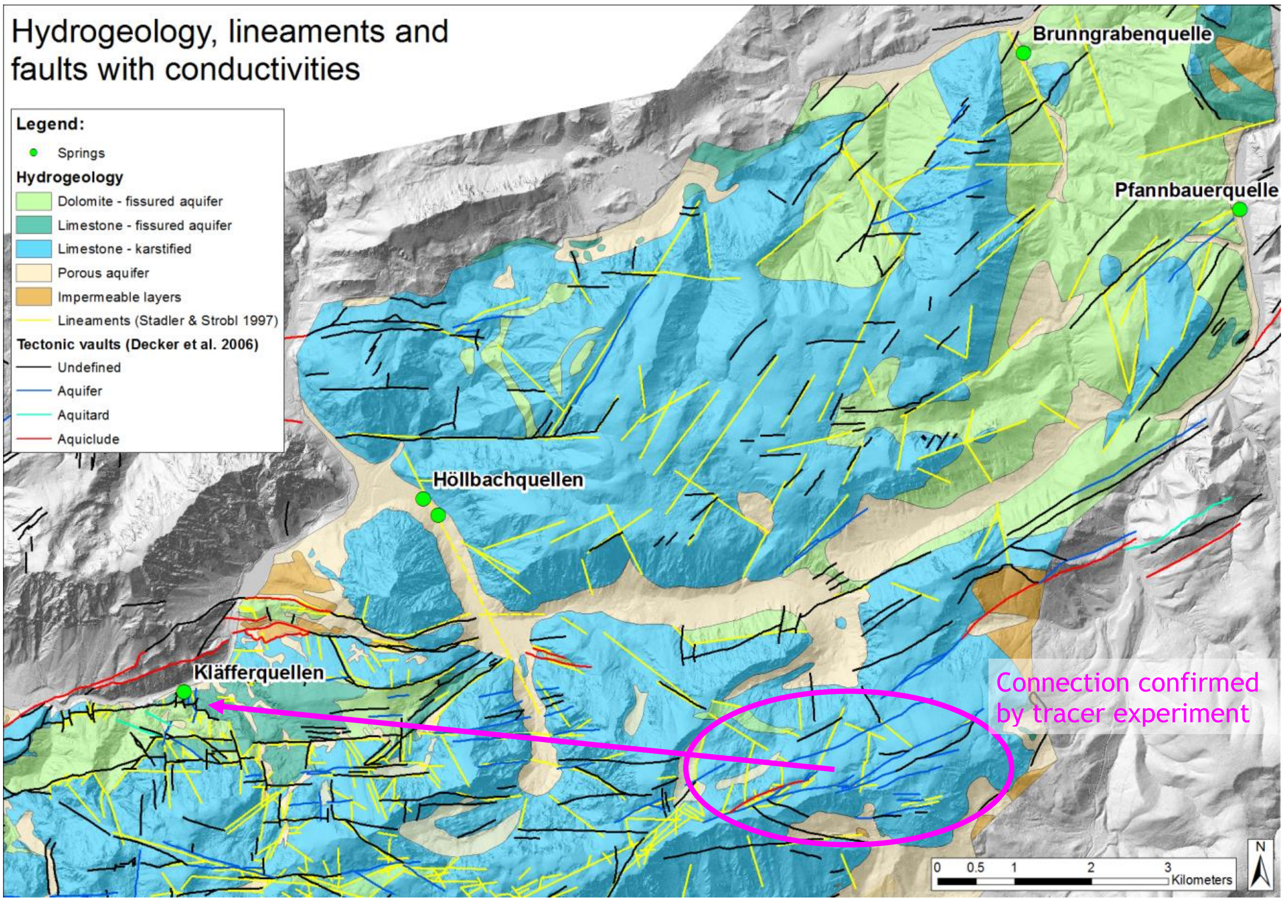

Figure 7: Hydrogeological map with information on tectonic vaults of Zeller Staritzen.

2.7 Land use

The main land use activities in the Zeller Staritzen area are forestry and mountain pasture.

The total area of the Zeller Staritzen sums up to 65.34 km². 74% (48.35 km²) of the area are forested and 18% (11.76 km²) are dedicated as pastures. The rest (~8%;5 km²) are rocky area.

The forests are owned by the Austrian Federal Forests and the City of Vienna. The forests of Vienna are explicitly dedicated as “Water Protection Forests” and managed by the Vienna Forest Department (MD 49).

The pastures are managed by associations of farmers. There are two herders in the summer time. The pasture starts at 1st June and ends on 20th September. 320 cattle are allowed. There is no more milk or cheese production. There is no shelter for the animals even during bad weather conditions.

Tourism is just hiking in summer and free skiing in winter. There are no mountain huts in the area. Therefore, tourism is practiced very extensively and poses no problem in the Zeller Staritzen.

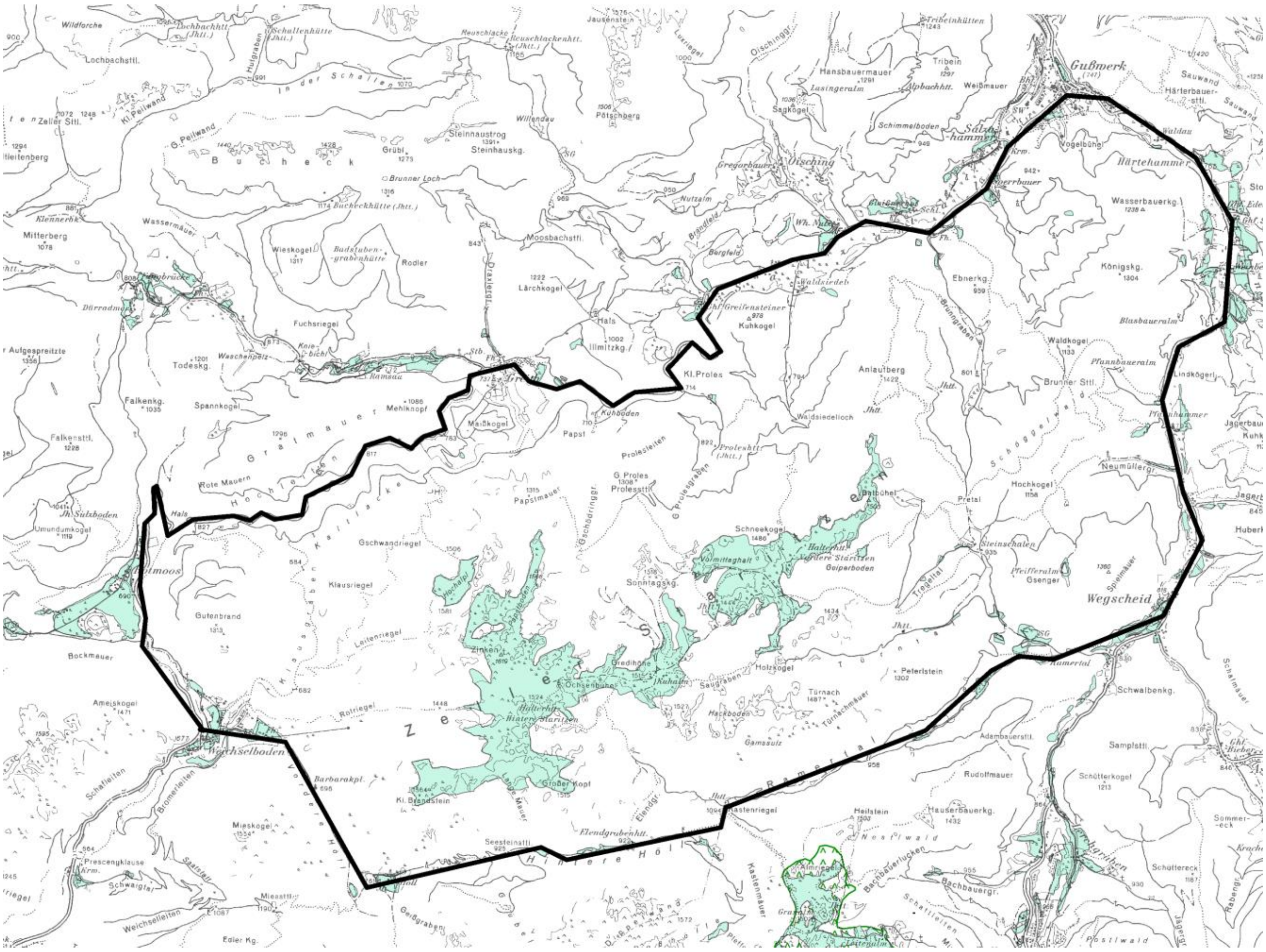

Figure 8: Zeller Staritzen pastures (light green)

3. Water supply in the pilot action

3.1 Drinking water sources

Drinking water source is karst aquifer of Hochschwab massive and drinking water is taken form karst springs. The location of the springs is shown in Figure 4. The mean annual discharge of the relevant springs is shown in Table 2.

Pfannbauernquelle: typical spring with a dolomitic recharge area. The discharge ratio (Q_{max}/Q_{min}) is 1.4 a value showing good buffering properties. The spring water has a relatively long residence time (21 years). Due to the long residence time there are very seldom contaminations detected. Nevertheless, some sites with high vulnerability have been located.

Brunngrabenquellen: dolomite is dominant in the recharge area but some influence of limestone is evident. Also, a small contribution comes from a little porous aquifer in a valley south to the springs. The buffering properties are still quite good. The residence time of 10 years and the discharge ratio of 1.6 show also a well buffered reservoir.

Höllbachquellen: Limestone dominates in the recharge area. The Höllbachquellen drain the western part of the Zeller Staritzen. There is also some influence from the partly porous aquifer of the so called “Hintere Höll”. The residence time of 1.7 Years and the discharge ration of 4.0 show a difference to the Pfannbauern- and Brunngrabenspring. Detailed analyses show that there are different parts of the recharge area with distinctly different hydrological properties. Protection measures have to take these differences into account.

Kläfferquelle: the Kläfferspring is the spring in the whole Hochschwab area (of which Zeller Staritzen is part) with the highest discharge (>5000 l/s). the catchment area is accordingly large. But in the whole Hochschwab area catchments are not strictly separated. Due to intensive tectonics hydraulic effective connections exist which allows for transportation of contaminants. Kläfferspring is a typical limestone karstspring with a discharge ratio of 40 and a residence time of 0.7 years. There are different discharge components which relate to the geological different properties. Generally, the reservoir is well mixed.

Detailed description of springs is available in not published report from Stadler (2006).

3.2 Drinking water protection

The whole area is protected (Figure 9) by law (BGBl. 345/1973). This decree is based on the Austrian water Law, which is the national adaptation of the Water Framework Directive.

The protection decree states that within the protection area only those activities are allowed which do not have impact on drinking water (not just for the City of Vienna but in general).

Following activities require an approval by the federal Water Authority:

- Storage and transport of mineral oils and similar persistent or difficult degradable materials
- Construction and/or change of buildings which waste water amount may lead to groundwater contamination
- Construction of lifts and cable cars
- Construction of facilities for mass traffic beyond hiking tourism

- Excavations of more than 3m
- Construction of quarries and gravel pits
- Deposition, usage and transport of radioactive and potentially water contaminating materials
- Forest clearings of more than 1500m²; clear cuts of more than 10.000m²
- Construction of cemeteries
- Construction of airports and landings of airplanes or helicopters

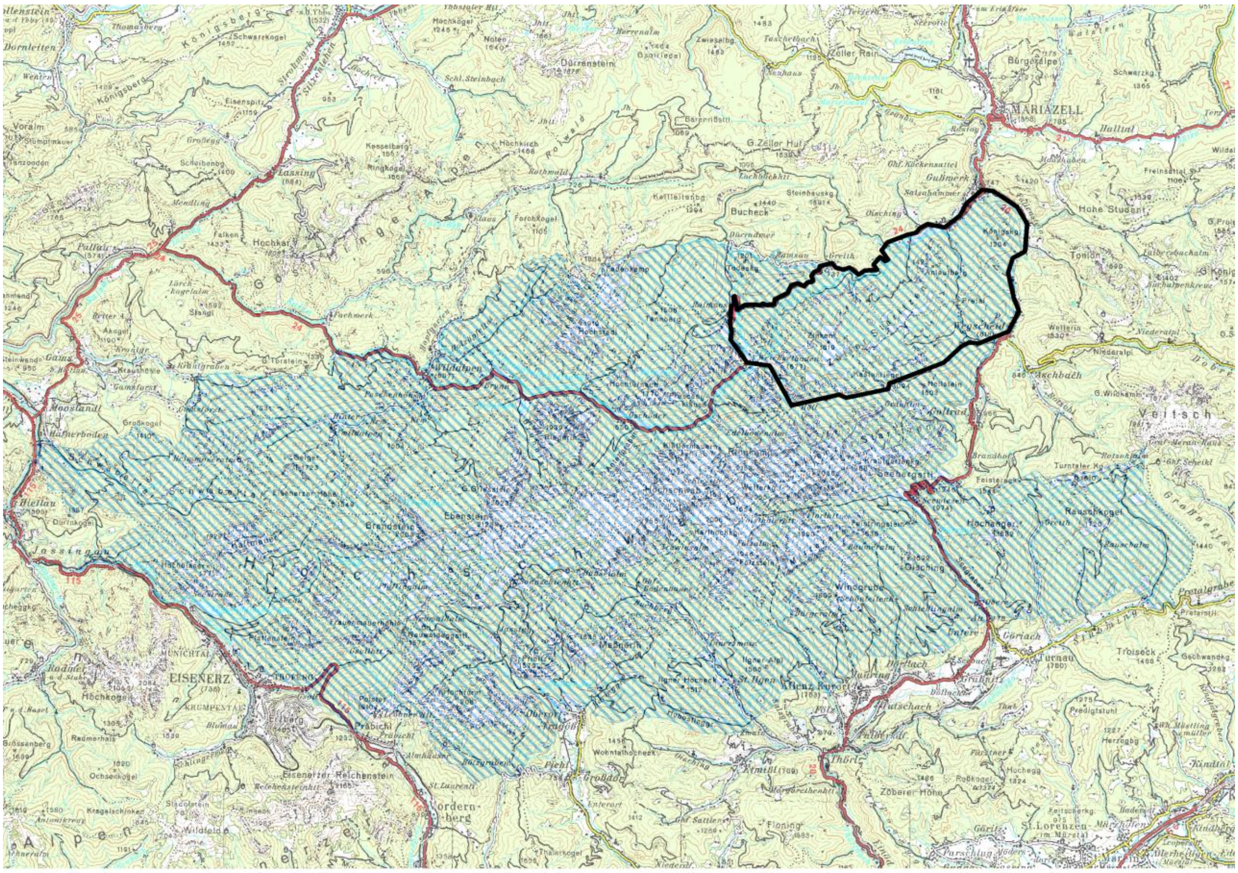

Figure 9: Protection area of Hochschwab (shaded) with Zeller Staritzen (surrounded black)

4. Main identified problems / conflicts

Vienna water as water supplier wants to minimize the risk for the groundwater quality and quantity. The risk is in our definition a product of the factors hazard and vulnerability. Hazards are all activities or (natural) processes which have the potential to afflict groundwater. Activities are land use activities. Vulnerability is a dimensionless value which depends on parameters describing the natural environment (in this case the karst system).

The goal is to list and describe the hazards (land use activities) and assess the vulnerability of the system. Consequently, we try to estimate the risk.

Hazards are potential problems/conflicts. It depends on the (estimated) risk if potential problems become real problems. A hazard on site X is the same hazard on the site Y. Depending on the vulnerability in X and Y there will be a risk in X or Y or there will be no or a different risk and consequently a problem.

The main (potential) problems are due to three main land use activities:

(1) Forestry and associated activities (hunting, road constructing, …).

(2) Mountain pasture: the impacts are enhanced erosion and microbial contamination potential due to faeces. There are various measures to reduce the risk: no pasture, reduction of animals, managing animal movements by fencing, erection of drinking facilities, protecting highly sensible spots (sink holes, dolines, creeks …).

(3) Tourism: impacts are not appropriate disposure of faecal waste, waste water and waste, construction of touristic facilities. Since the hazard is a point hazard the reduction of risks is not very difficult.

5. References

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