TECHNICAL OBSERVATIONS OF LARGE OBJECTS – MONITORING OF LARGE OBJECTS AND LAKES IN EXPLOTATION AREA OF VELENJE COAL MINE

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ABSTRACT

The influence area of mining in the exploitation area of Velenje Coal Mine (VCM) is subject to constant changes of the surface. The size and the location of the influence area is changing according to the location and the size of the mining panel in the excavation caves of the mine. As a consequence of the coal excavation in the mine three lakes (Lake Škale, Lake Velenje, Lake Družmirje) were formed through different time. The measurement of the depths, lake sizes, the seaside of the lakes, the area between the lakes and the observation of the total area are carried out according to the regular annual monitoring of the exploitation area, required by the State Mining Act. The area between the Lake Škale and the Lake Velenje is now stable and rehabilitated area, where the installed observation points are observed once a year. The same measurements are also carried out on the southern seaside of the Lake Družmirje, which represents the security dike, which protects the city Šoštanj from high water. The area between the Lake Velenje and the Lake Družmirje is the subsidence rehabilitation area, where the geodetic monitoring is carried out twice a year. Nearby the production area of VCM, are also infrastructural facilities of VCM and the villages Pesje, Šoštanj, Škale, and Gaberke. In these areas and on the production area observation networks of VCM are established for displacement monitoring. With permanent monitoring of displacements of terrain and facilities we are able to determine displacements and the impacts that the excavation of the coal has on production area, its vicinity and the facilities within the production area.

1. Introduction

Velenje Coal Mine has been operating for more than 135 years. The annual output is approximately 4 million tons of lignite coal, which is excavated in three pits with an average of two coalfaces. The thickness of the coal seam in the deposit is from 20 m to 160 m in depth up to 500 meters. Underground coal excavation using Velenje Mining Method (VMM) is the main reason for surface subsidence in exploitation area. Exploitation area of Velenje Coal Mine is located in the Šaleška Valley between the city of Velenje and the town of Šoštanj (Picture 1).

Picture 1 Exploitation area of Velenje Coal Mine (red line)

Subsidence of the surface occur shortly after excavation. After finishing coal excavation on one coalface surface subsidence is finished at 90 % in approximately 3 months. There are three lakes in the exploration area of Velenje Coal Mine that have formed as a result of underground mining. Lake Škale was formed before the Second World War, Lake Velenje began to emerge in 1960 and Lake Družmirje in 1975. Since the terrain of Šaleška Valley falls in the direction from east to west Lakes were formed at different altitudes. At the beginning natural barriers between the lakes were created due to excavation in different parts of the mine (pit Škale, pit Pesje, pit Preloge). In order to avoid overflows higher-level lakes in the low-lying lake, terrain between the lakes is maintained at a constant height. The area between Lake Velenje and Lake Družmirje is called the active subsidence remediation area (ASRA). The area between Lake Škale and Lake Velenje is in stable state. Under the lakes and the area ASRA exploitation of the coal continues and causing subsidence of the ground. To prevent leakage of water from Lake Družmirje into River Paka on the southern part of Lake Družmirje there was built the embankment Šoštanj. The area of the embankment has been stable since 1975. Technical observations of areas between lakes, lakes and the area of influence is carried out in the context of monitoring the exploitation area of Velenje Coal Mine, quite a few decades. To determine the coordinates of the starting points of each observation network we perform GPS (Global Positioning System) measurements of the

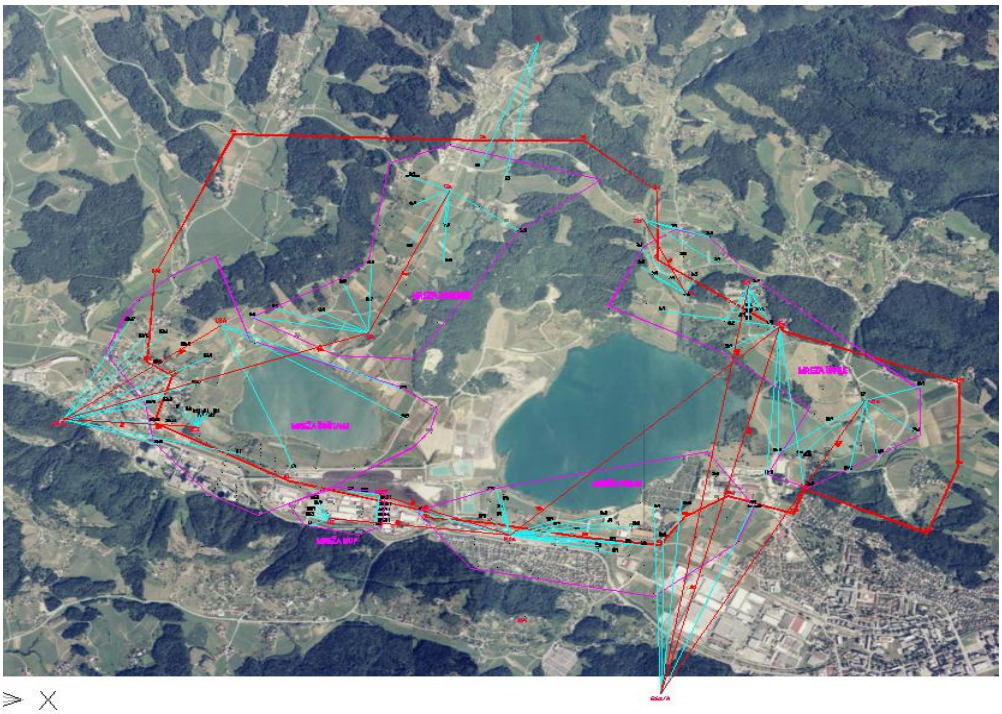
baseline observation network. Observations of the exploration area of Velenje Coal Mine will be presented below.

2. Observation of the exploitation area

Observation of terrain and object deformation in the exploitation area of Velenje Coal Mine includes measurements of observation networks, measuring shapes and depths of lakes and measurements of changes in the active remediation area PSU. Observation of the embankment in Šoštanj and areas between the lakes are also included in observation network measurements.

2.1 Observation networks

Observation networks of Velenje Coal Mine consist of more than 300 measurement points from which exploitation area of Velenje Coal Mine is observed. The base or starting observation network consists of 18 major observation points from which 3 are stabilized outside the exploitation area. To determine the coordinates of base points of each observation network GPS measurements are carried out. Each observation network includes at least one observation point, which is part of base observation network and each observation network has a different number of observation points. Observation networks are shown in Picture 2.



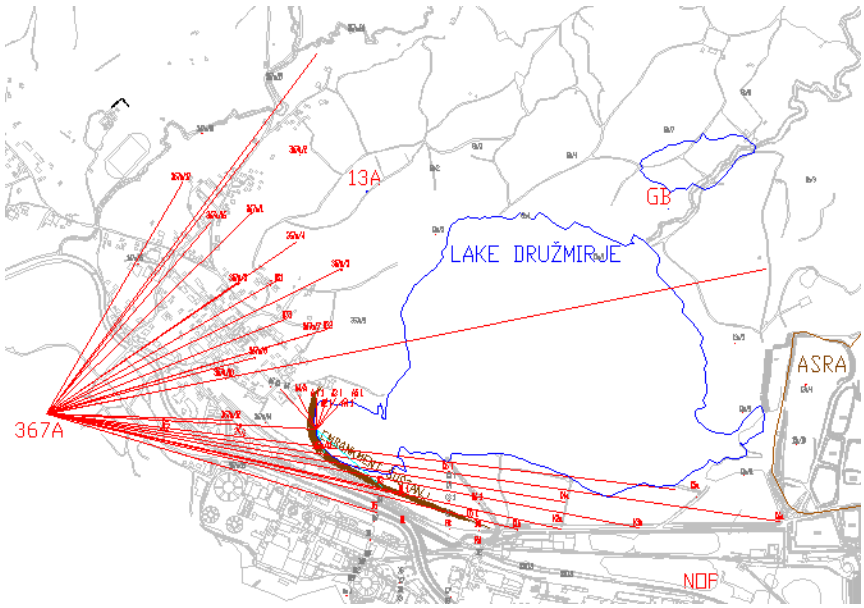
Picture 2 Observation networks of VCM

Observation networks are designed to observe essential parts of the exploitation area and are constantly optimized and supplemented. Frequency of observations depends mainly on the location and type of observed object or space within the exploitation area.

2.1.1 Observation network Šoštanj-Družmirje-TEŠ

Observation network Šoštanj-Družmirje-TEŠ was established in 1973. The network consists of profiles B, C, D and X, which are arranged in a north-south direction. Profile A, which extends in an east-west direction I am also part of the observation network (Picture 3). A lot of observation points in this network was destroyed during increasing of lake Družmirje. In

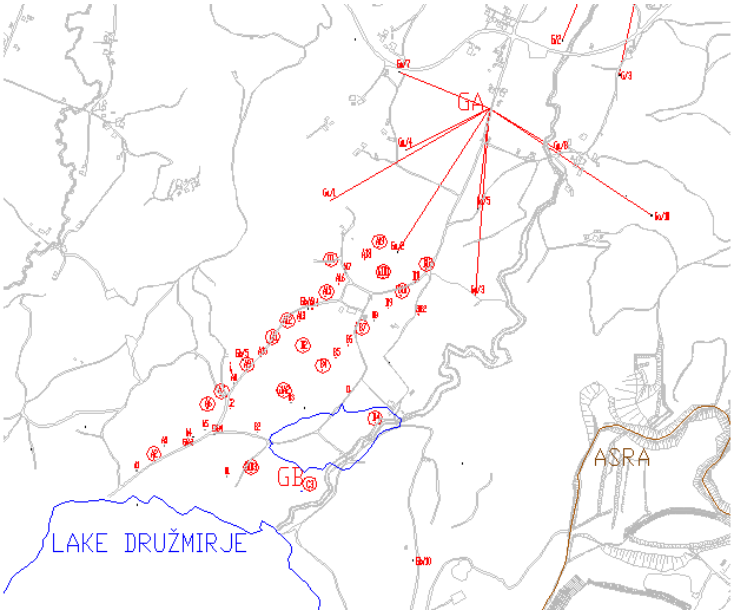
1989 observation network was supplemented and extended, due to submerged and destroyed points. New points were installed in the area of town Šoštanj and village Gaberke. Observation network Šoštanj-Družmirje-TEŠ is measured once a year.



Picture 3 Observation network Šoštanj-Družmirje-TEŠ (A1,367a/1, …in red are observation points)

2.1.2 Observation network Gaberke

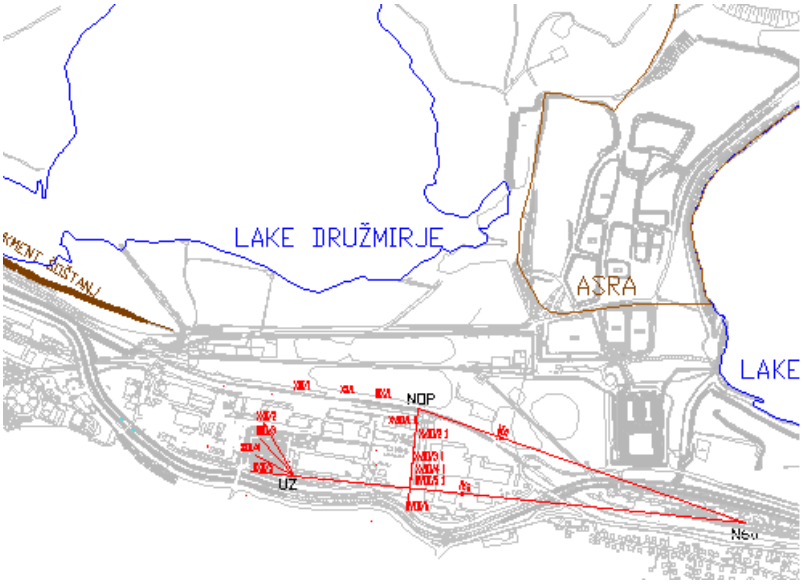
Observation network Gaberke was established in 1988 (Picture 4). Observation network had three main points Gb, Ga and G, but the point Gb has been destroyed due to excavation of G plates in the northwest of the pit Preloge. The base points of the network are GPS points 367a and Ga. Observation network Gaberke is measured once a year.



Picture 4 Observation network Gaberke (A1, B1,GA, …in red are observation points)

2.1.3 Observation network NOP

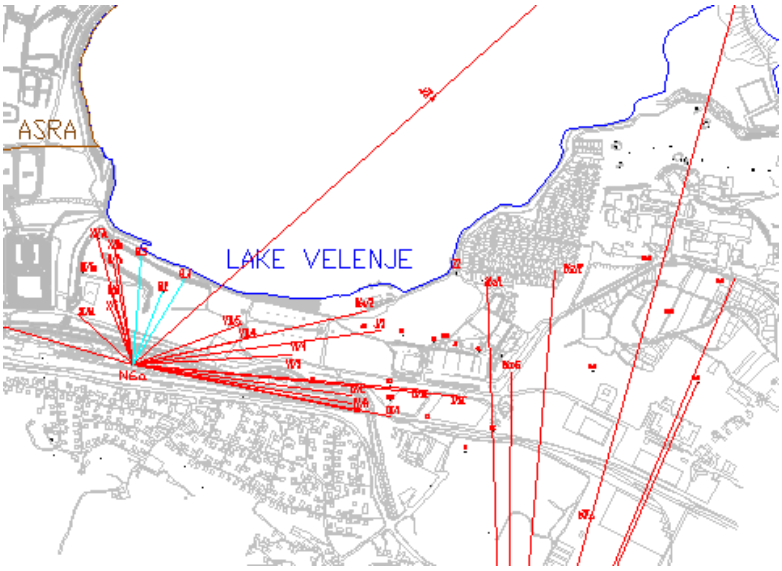
Observation network NOP was established in 1987 and supplemented in 1989. The network is located so that there are two profiles in the north-south direction and a profile in east-west direction (Picture 5). Observation network NOP has two main points marked as NOP and UZ. Observation network NOP is measured once a year.



Picture 5 Observation network NOP (UZ, N6a, …in red are observation points)

2.1.4 Observation network Pesje

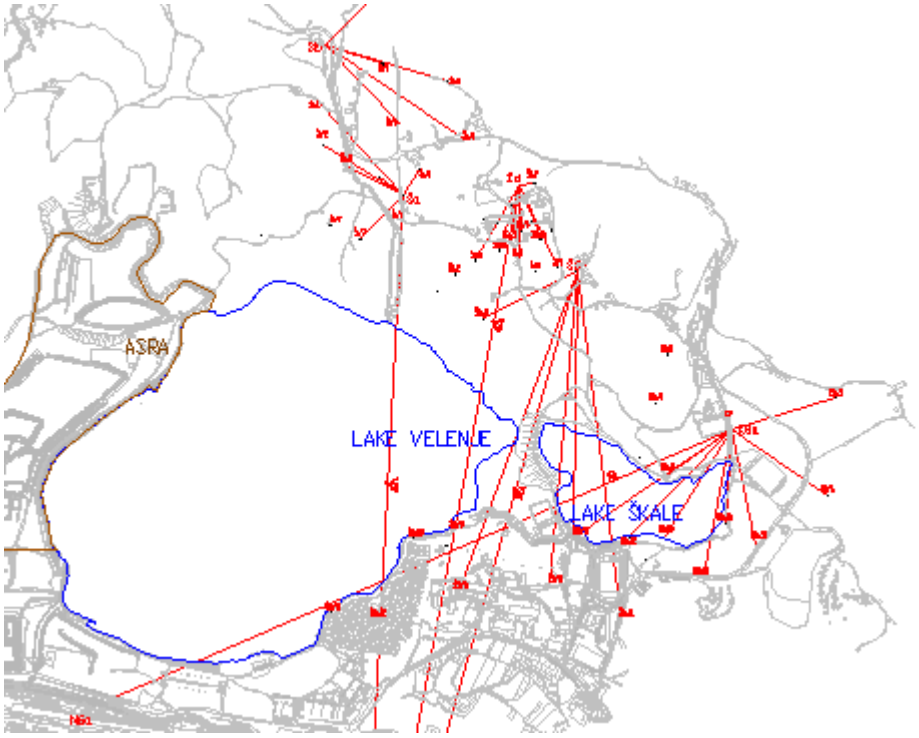
Observation network Pesje was established in 1980 and later supplemented in 1984 and in 1989. An observation network consists of fifteen measurement profiles oriented in the north-south. The network has been updated with two new measurement profiles in 1989 (Picture 6). In 1991, the network has been updated with new profile J. Observation network Pesje is measured once a year.



Picture 6 Observation network Pesje (GL2, VI/3, …in red are observation points)

2.1.5 Observation network Škale

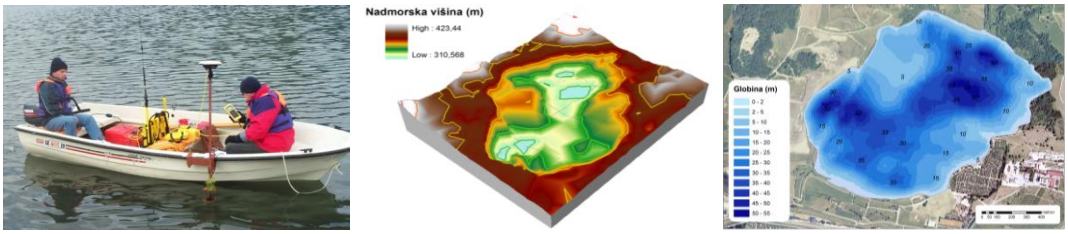
Observation network Škale was established in 1989 (Picture 7). Basic points of the network are GPS points K8a, Ša, ŠB, ŠD and Š5a. Basic points serve to measure other points of the network. Observation network Škale is measured once a year.



Picture 7 Observation network Škale (N6a, G, …in red are observation points)

2.2 Observation of lakes

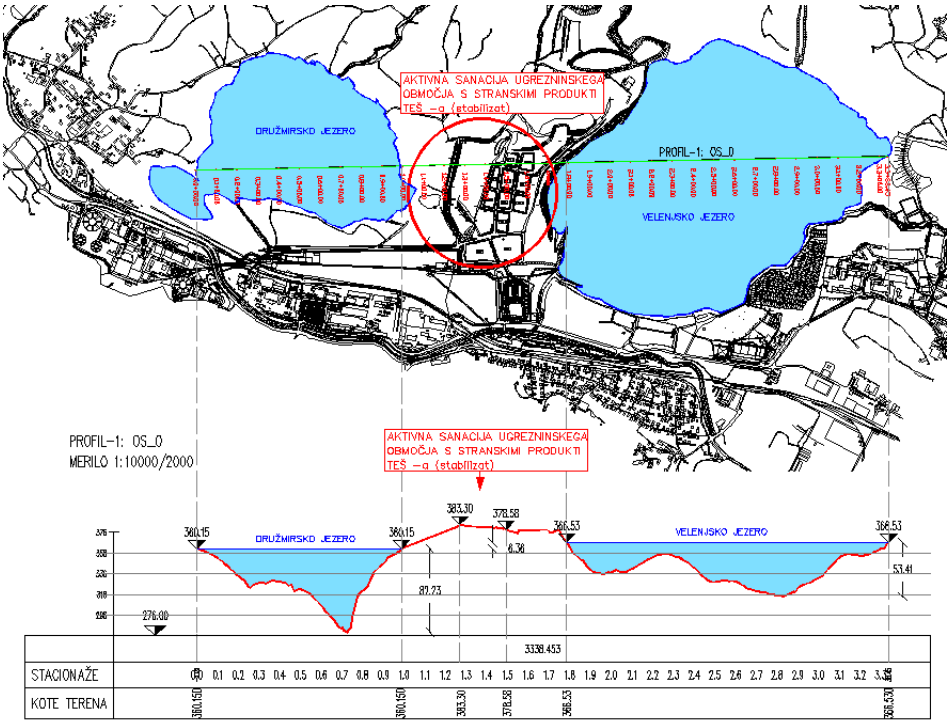
Measurements of the depth of the lakes and their shape are used for determining the effects of underground coal mining on the enlargement of the lakes and changes of the bottom of the lakes. Such measurements are carried out once a year. The first measurements of lakes were made in 1960. Since 1975, measurements of all three lakes have been carried out annually (Picture 8). To measure the depth of the lakes at known location sonar Reason Sound 110 in combination with GNSS receiver is used since 2010. Measurements are carried out on the lines of square grid of 25 m by 25 m. The depth of the lake is measured every 5 meters. Model of the bottom of the lakes is made out of measured data. With this model we can monitor changes that appear as a result of underground coal mining. The shape of the surface of the lake is measured by GNSS measurements.



Picture 8 Field work (left), 3D model of the bottom of the lake (middle), bathymetric map of Lake Velenje (right)

2.3 Observation of active subsidence remediation area

The active subsidence remediation area (ASRA) lies between Velenje Lake and Družmirje Lake. In this area emerging subsidence is in-filled with by-products of TEŠ. Most of the ASRA area lies above the pit Pesje of VCM (Picture 9).



Picture 9 The active subsidence remediation area (ASRA)

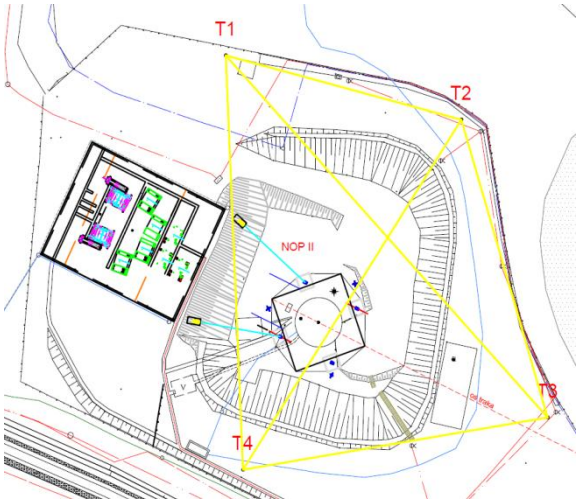
With the filling of subsidence the initial state of the terrain is maintained. This prevents water flow from Lake Velenje into Družmirje Lake. Due to the dynamics of the remediation activities, measurements are carried out at least twice a year using the conventional GNSS measurement method.

2.4 Observation of other large objects in the exploitation area

In the exploitation area of Velenje Coal Mine and its close vicinity we can find important large objects that are not observed within observation networks. These large objects are the site of the new export shaft NOP2 and cooling tower of Unit 4 TEŠ.

2.4.1 Observation network NOP2

New shaft NOP2 is located near the excavation field, making this area potential subject of ground subsidence. The baseline network has been stabilized near future Shaft NOP2 (Picture 10).

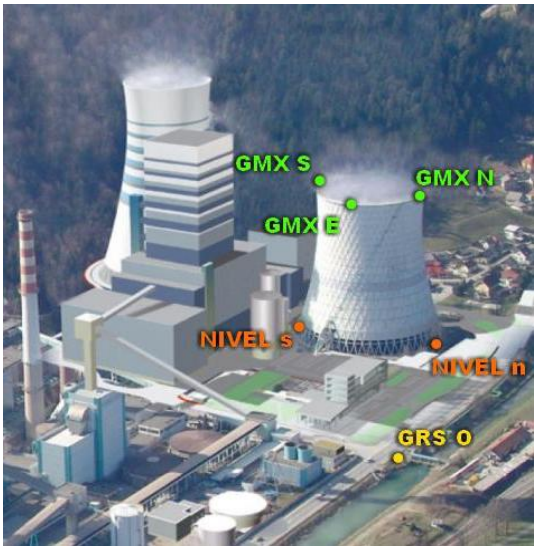


Picture 10 Baseline network NOP2

Around the construction site points are placed in quadrangle in a position that visibility between points is assured. Basic local observation network consist of four control points (T1, T2, T3, T4) located in the area of the main observation network of VCM. Measurement of the internal stability of the network is carried out once a month. Measurements to determine the movements of the external stability of the network are carried out every 6 months.

2.4.2 Monitoring of cooling tower of Unit 4 TEŠ

Observation of the cooling tower of Unit 4 TEŠ was launched in 2011. The reason for the establishment of observation is that a large construction site for new Unit 6 TEŠ is near Unit 4 TEŠ and near exploitation area of VCM. Monitoring system includes 6 points. One point is used as a reference point. Reference point consists of GNSS receiver and tilt sensor. Three observation points are equipped with GPS receivers. There are also two observation points equipped with tilt sensors. Observation points are linked directly to the central computer. Central computer collects observation data from observation points. Continuous monitoring is possible by accessing a central computer via the internet. Picture 11 shows the observation points and reference point of automatic GNSS monitoring system.



Picture 11 The continuous GNSS monitoring system points

3. Summary

Underground coal exploitation in Velenje Coal Mine causes subsidence of the area above pits of Velenje Coal Mine. Good knowledge of the effects on the surface caused by coal excavation is essential for planning and optimizing remediation of degraded areas and restoration degraded areas to their original condition. In the exploitation area of monitoring networks are established so that terrain changes can be constantly monitored. The observations are carried out at more than 300 points. Observations of the exploitation area of VCM are also carried out by observing the changes in the three lakes. And large object such as shaft NOP2, cooling tower of Unit 4 TEŠ and an area of active surface subsidence remediation. Measurements of minor observation networks provide data to determine changes in the exploitation area of VCM. This ensures control of existing facilities and the basis for the preparation and remediation of degraded areas.

4. References

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