02.19 Expected Highest Groundwater Level (EHGL) 2022

Overview

The level of the groundwater surface and the groundwater piezometric surface is relevant to various issues in water management, ecology and structural engineering. This is especially true for its maximum value, the highest value that the groundwater level can reach, which is primarily needed for designing buildings. This value is indispensable as a basis for planning and designing how to waterproof a building against water under pressure or for dimensioning its foundations.

The maximum value is usually determined on the basis of long-term observations of the groundwater level. Currently, at around 2,000 groundwater measuring points in the city of Berlin, groundwater levels (observation well levels) are being measured and represented by groundwater hydrographs (see Figure 1 for an example). The maximum value of such a hydrograph is referred to as the **highest groundwater level**, abbreviated **HGL**. Thus, the HGL refers to a measurement taken in the past.

Groundwater hydrographs of three measuring points in the glacial valley: the highest groundwater level (HGL) was measured at different times: MP 137: 1975, MP 5476: 2002 and MP 8979: 2011.

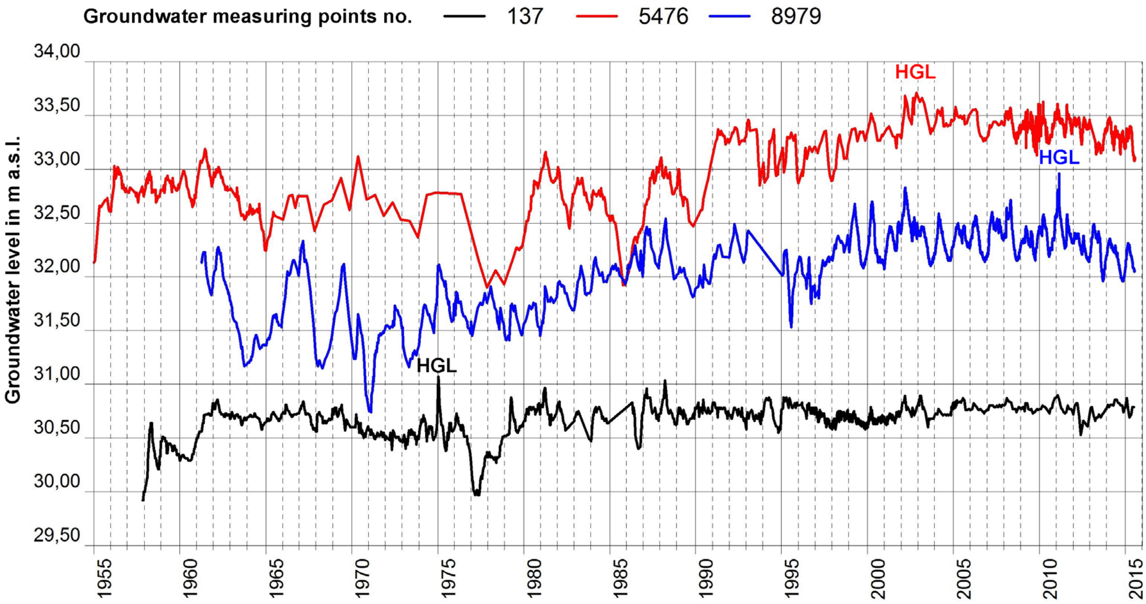

Fig. 1: Groundwater hydrographs of three measuring points in the glacial valley: The highest groundwater level (HGL) was measured at different times: MP 137: 1975, MP 5476: 2002 and MP 8979: 2011

If you need to know the highest groundwater level for a specific location and the observation period is not long enough at any of its groundwater measuring points, an approximate value can be determined by interpolation from the highest groundwater levels of neighbouring measuring points. Such an interpolated value is also referred to as an HGL.

In many cases, knowing the highest groundwater level that occurred in the past is very useful but not always fully satisfactory or sufficient. For instance, if the HGL is to be used for measurements in waterproofing a building against water under pressure, this value observed in the past must of course also not be exceeded in the future, i.e. within the useful life of the building, and must occur only in extremely wet situations. If the observed history of the groundwater level is essentially determined by natural causes (seasonal differences in new groundwater formation, alternation of years with low and high precipitation), it can be assumed to behave similarly in the future. This also applies in the case of anthropogenic interventions with consequences for the groundwater surface, if these are permanent and will thus not change in the future.

In large parts of Berlin, groundwater conditions have not been natural for a long time. The level of the **groundwater surface is subject to artificial influence** due to both permanent and temporary interventions in the groundwater balance.

Permanent measures include:

- rainwater sewerage, which may have the effect of reducing new groundwater formation and thus lowering the groundwater level;
- decentralised rainwater disposal in percolation facilities, which may locally raise the groundwater surface, depending on precipitation events;
- drainages and ditches that were intentionally used to lower the groundwater level locally;
- hydrological construction measures (impoundments, shore revetments, straightening of watercourses), which may lead both to a rise and to a drop in the groundwater level;
- structures protruding into the groundwater, with the effect of impounding the groundwater in the direction of inflow and lowering the same in the direction of outflow.

Temporary measures and those that may vary considerably in their impact include:

- groundwater extractions for the public and private water supply and for keeping water out of construction pits or for remediation, which lower the groundwater surface;
- groundwater replenishments for increasing groundwater availability for the public water supply, which raise the groundwater level in the vicinity of the replenishment facilities;
- repercolation of extracted groundwater, e.g. in the context of groundwater preservation measures for construction purposes, which also raise the groundwater surface – usually only locally.

This multitude of potential artificial measures that affect the groundwater illustrates that in some cases it is difficult even for specialists to judge whether and to what extent an observed (= measured) highest groundwater level (HGL) is anthropogenically influenced and whether such a value can also be used for addressing future issues.

In order to further increase the quality of the HGL value and to make it more readily available to the user, a map has been developed that directly specifies the **"expected highest groundwater level"**, abbreviated **"EHGL"**. This is defined as follows:

The expected highest groundwater level (EHGL) is the maximum that can arise due to weather effects. It can occur after extremely wet periods if the groundwater level is neither lowered nor raised by artificial interventions in the vicinity.

According to this definition and current knowledge, this groundwater level will not be exceeded after very heavy precipitation events if the following geohydraulic conditions apply: the natural conditions (e.g. water permeability of the subsoil) on the one hand and the permanently artificially modified conditions (e.g. impoundments of the watercourses, see above) on the other hand.

Groundwater levels higher than the EHGL can theoretically occur, but only as a result of further artificial interventions. Of course, such interventions (e.g. discharges into the groundwater) are not predictable in the long term. However, they do not need to be taken into account for most questions, as they require permission or approval from the water authorities.

The definition of the expected highest groundwater level thus essentially corresponds to the definition of the "design groundwater level" (*Bemessungsgrundwasserstand*) for waterproofing buildings according to the BWK guidelines, Bulletin BWK-M8 (2009; BWK Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau e.V.).

The term "expected highest groundwater level" is used here instead of the term "design groundwater level" because the EHGL map is made available also for other questions besides that of the required waterproofing of buildings.

In this context, it should also be noted that the responsibility of determining design groundwater levels for construction measures generally lies with the constructor or their specialised planner or surveyor. In some cases, individuals are unable to determine these by themselves, or only with great effort, based on groundwater investigations at the construction site or in its immediate vicinity only. Berlin's groundwater conditions are extremely complex and strongly influenced by humans; therefore, the State of Berlin is sharing groundwater level information with the public.

The Geological Survey working group ("*Landesgeologie*") of the Senate Department for the Environment, Urban Mobility, Consumer Protection and Climate Action has been providing information on the groundwater for decades, including the highest groundwater level (HGL), which is determined by specialists on the basis of the available groundwater level data. As the HGL, according to its definition (see above), is not necessarily an uninfluenced groundwater level, the aim is to develop a city-wide map of the EHGL, which is more conclusive regarding future matters (e.g. waterproofing of buildings). Accessing the map through the Internet allows the user to obtain the EHGL for their site of interest. Thus, waiting periods previously caused by written inquiries can be avoided.

The EHGL map is available for four areas of Berlin (see Figure 2).

- In geological terms, these are the **area of the Berlin glacial valley** and the area of the **Panke valley**. Both are characterised by subsoil that is predominantly composed of sands with high water conductivity near the surface and their groundwater surface that is generally located just below ground (depths to groundwater of a few metres, sometimes even less than one metre) (SenStadtUm).
- Furthermore, the EHGL map was developed for the areas connecting to the glacial valley in the South, i.e. the **Teltow Plateau** and the **Nauen Plate** west of the Havel. In the eastern part, the plateau is covered by relatively thick boulder marl or boulder clay of the ground moraine, which are also partly responsible for confined groundwater conditions. The western part is predominantly characterised by thick sand sequences. Boulder marl and meltwater sands are equally represented in the Nauen Plate area. South of the glacial valley, the area is characterised by groundwater surface levels found at depths that are usually much greater than 10 m, in some parts of the Grunewald and on the Wannsee peninsula even greater than 20 m. By contrast, surface waters, such as the Havel and the Grunewald lakes, but also the Rudower Fließ area, the southern part of Lichtenrade and the former Karolinenhöhe sewage farms feature low depths to groundwater.
- The section of the **Barnim Plateau** north of the glacial valley and south-east of the Panke valley was added to the EHGL map as part of this update. In this area, the extensive boulder clay formations of the ground moraines of the Weichselian and Saalian Glaciations, which are often interspersed with meltwater sands, mainly determine the hydrogeological conditions. The aquifer in this area is generally covered and largely confined. It is also artesian in some areas. Its hydraulic gradient is comparatively high. The depth to groundwater can measure up to several tens of metres. As cover sands are often deposited on top of ground moraine sediments, stratum water commonly occurs.

A map on groundwater levels titled "Expected highest groundwater level (EHGL)" is published here covering each area. The methodological approach was not the same across all areas, however.

Fig. 2: Area of validity of the EHGL map for the glacial valley, the Panke valley, the Teltow Plateau and the Nauen Plate, as well as the section of the Barnim Plateau adjacent to the south-east of the Panke valley.

Statistical Base

The EHGL maps for the Berlin glacial valley, the Teltow Plateau and the Nauen Plate, which were developed using numerical groundwater flow models (see Methodology), have an extraordinarily comprehensive statistical base.

The geological sections from the State Geological Service were available for capturing the hydrogeological structure of the main aquifer in the Berlin glacial valley. Additionally, numerous deeper **boreholes** from the database of the State Geological Service were evaluated.

The configuration data of over 1,300 **groundwater measuring points** and their groundwater level data were used for calibrating and verifying the groundwater models. Moreover, information on the **groundwater withdrawals** of all Berlin waterworks, on **groundwater replenishments** and on other groundwater extractions (unwatering, private water supply plants, remediation) was available.

The surface waters, which are the receiving waters for groundwater, determine essential hydraulic conditions. A multitude of data – mostly **gauge heights** – and information on the state of development of the water bodies was used in this regard.

Data on new groundwater formation taken from the map of the Environmental Atlas (SenStadtUm 2012) was integrated into the model.

The hydrographs of about 2,200 groundwater measuring points were evaluated for the Berlin glacial valley area to check the plausibility of the computed EHGL map. For the Teltow Plateau and the Nauen Plate areas, it was about 1,100.

Moreover, a very comprehensive pool of further hydrogeological, water management, geographical and historical sources of information was used.

The hydrographs of about 150 further groundwater measuring points were evaluated to develop the EHGL map for the Panke valley. Comprehensive data on the geology of the Panke valley aquifer that is available to the Senate Department was also used. Gauge heights were available for the Panke and some of its tributaries.

The EHGL map draws on the statistical base used for the current groundwater isoline plans, which comprises 98 measuring points. After a statistical analysis of the groundwater levels at 43 representative measuring points, this data was used for the area of the Barnim Plateau south-east of the Panke valley.

Methodology

The current map was developed in individual sections corresponding to the different geological units of Berlin, in the following order:

1. Glacial valley
2. Panke valley
3. Teltow Plateau and Nauen Plate,
4. Barnim Plateau to the south-east of the Panke valley

whereby different methodologies were applied in part.

Glacial valley

For the area of the **Berlin glacial valley**, the EHGL map was developed using a numerical **groundwater flow model**. This was necessary, as the groundwater surface has been influenced by humans for a long time, in some cases heavily. This means that an EHGL map cannot be calculated based on measured groundwater levels only, according to the EHGL definition mentioned earlier.

A numerical model allows the spatially discrete simulation of groundwater levels considering geohydraulic conditions. These include new groundwater formation, which is a function of precipitation among other things, and the water levels of the surface waters. Both are subject to natural and also artificially induced fluctuations. For example, in our climate area, new groundwater formation occurs mainly in the winter half of the year, with the result that the highest groundwater levels within a year usually occur in the spring. Often, relatively high water levels of the surface waters (here the Spree, the Havel and their tributaries) further contribute to the high groundwater levels during this time. Particularly high groundwater levels are observed when the amount of precipitation is significantly higher than the long-term mean for several consecutive years. During these extremely wet periods, it is expected that the groundwater will rise to the highest groundwater level in the area under observation.

Beginning in 2003, a numerical groundwater flow model has been developed, which, shall be available permanently for the entire area of Berlin for addressing water management questions at the state level. By 2008, this model had reached a stage which enabled it to be used to create an EHGL map for the area of the Berlin glacial valley. This map was subsequently used by the Senate Department's specialists for groundwater advice and has thus thoroughly proved itself in practice.

The development of the EHGL map for the Berlin glacial valley is described in Limberg, Hörmann & Verleger (2010) and is summarised here:

The numerical model, for which the software system MODFLOW was used, is designed to encompass the entire area of Berlin (Figure 3).

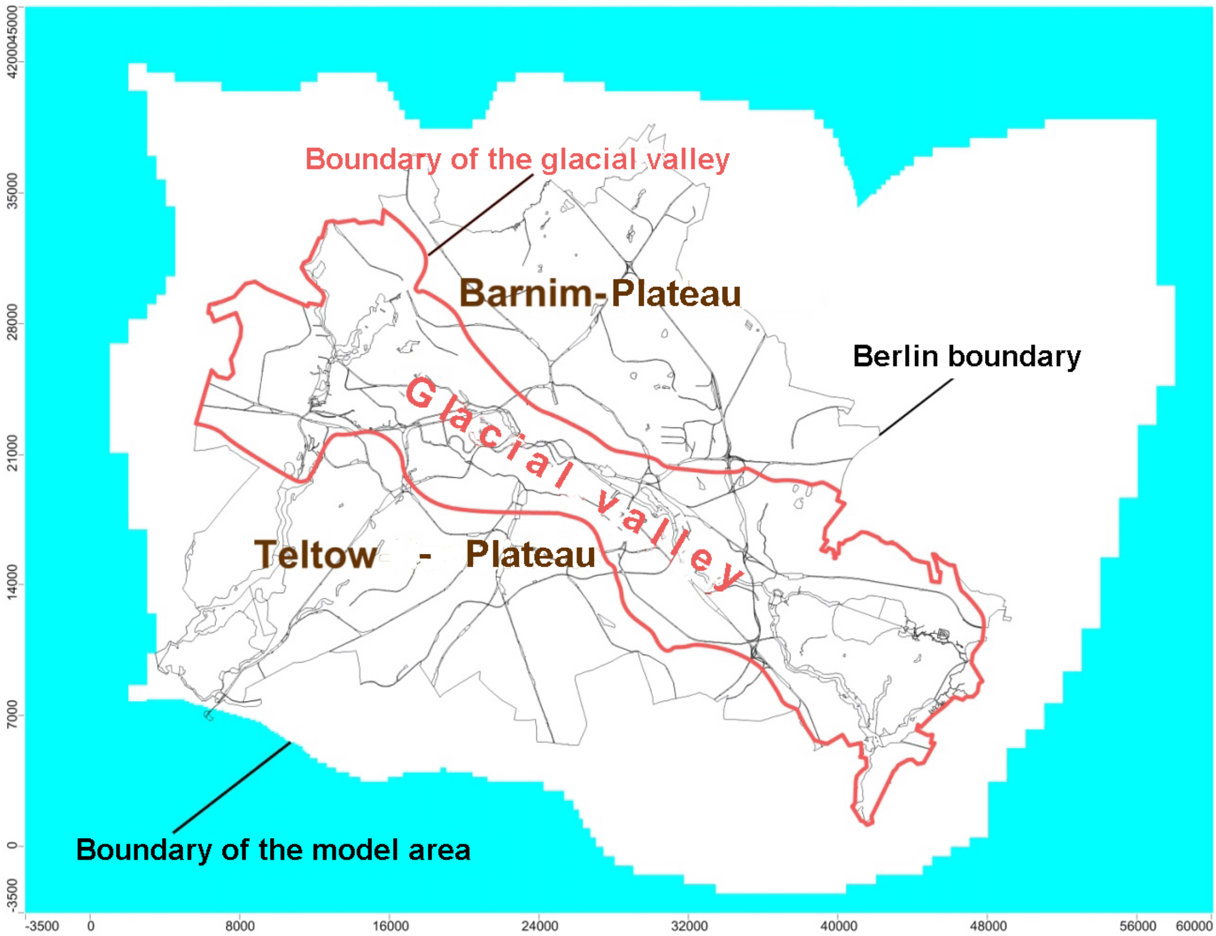

Fig. 3: Area of the groundwater flow model for developing the EHGL map for the Berlin glacial valley

The area of the Berlin glacial valley is divided vertically into several model layers, of which the uppermost represents the – here usually unconfined – main aquifer, for which the highest groundwater level is to be calculated.

Horizontally, the model is divided into rectangular cells. The cell size varies between 50 x 50 and 100 x 100 metres.

Further modelling occurred in the following steps:

- **Model calibration**
  After the known or estimated geohydraulic conditions (levels of receiving waters, groundwater extractions, groundwater feeds, etc.) had been specified, the model was essentially calibrated by varying a given distribution of the water conductivity using hydraulically stationary calculations. The mean values of the data with respect to groundwater use and the groundwater levels of the year 2004 were selected for this purpose. The year 2004 may be regarded as climatically average.
- **Model verification**
  Model verification here refers to a test of the model as to whether it can represent a known load situation of the groundwater that deviates from the calibration period (e.g. altered groundwater extractions) with respect to the actually observed groundwater heights with sufficient accuracy. In this case, the groundwater levels for the year 2001, which differ from the year 2004 in particular with respect to the distribution of groundwater withdrawal, were calculated using the model. The deviations of the model-calculated groundwater levels from the observed ones were found to be relatively small. Thus, the model reached an important quality milestone.
- **Model simulation of the expected highest groundwater level and plausibility test**
  After verification, different model simulations for calculating the highest groundwater level were performed. In summary, three types of hydraulic conditions had to be modified accordingly for this purpose. Those that form the basis for the model calibration and the verification apply to climatically average years and a specific groundwater load. The three conditions are:

- *groundwater use*
  According to the EHGL definition, neither groundwater extractions nor feeds into the groundwater occur in this scenario. This is true both for the waterworks and for other extractions, such as for personal water supply, remediation or construction.
- *height of the receiving waters for groundwater*
  The water levels of the receiving waters for the so-called HGL case were defined through evaluation of the gauge heights.
- *new groundwater formation*
  When the highest groundwater level occurs, the new groundwater formation must be significantly higher than the long-term mean. For estimation purposes, guideline model simulations were carried out followed by plausibility tests based on selected groundwater level measurements. As a result, in case of HGL, the new groundwater formation was set up to 15% higher than the long-term annual mean, depending on its level specific to the location.

The completion of this preliminary EHGL map was followed by an intensive plausibility test using the data of about 2,200 groundwater measuring points and various other sources of data and information (for the locations of the groundwater measuring points used for the plausibility test, see Fig. 4). The map only required minor modifications subsequently.

These modifications included the introduction of the representation of **riparian strips** along some of the surface waters. In these areas, which are separately designated on the map, EHGL values are stipulated that were not directly calculated using the large-scale groundwater flow model. This was necessary because in some riparian areas, strong short-term increases in the water levels of the receiving waters can lead to a rise in the groundwater surface close to the shore, which cannot be covered with sufficient certainty by the map derived from a hydraulically stationary calculation. Separate EHGL values were also established for individual areas for which the modelled map may show values that are too unreliable due to a relatively low model discretisation, e.g. in the vicinity of locks and in some riparian areas along the Tegeler See. These EHGL values were determined based on maximum gauge heights measured for the surface waters, and in some cases approximative hydraulically non-stationary calculations.

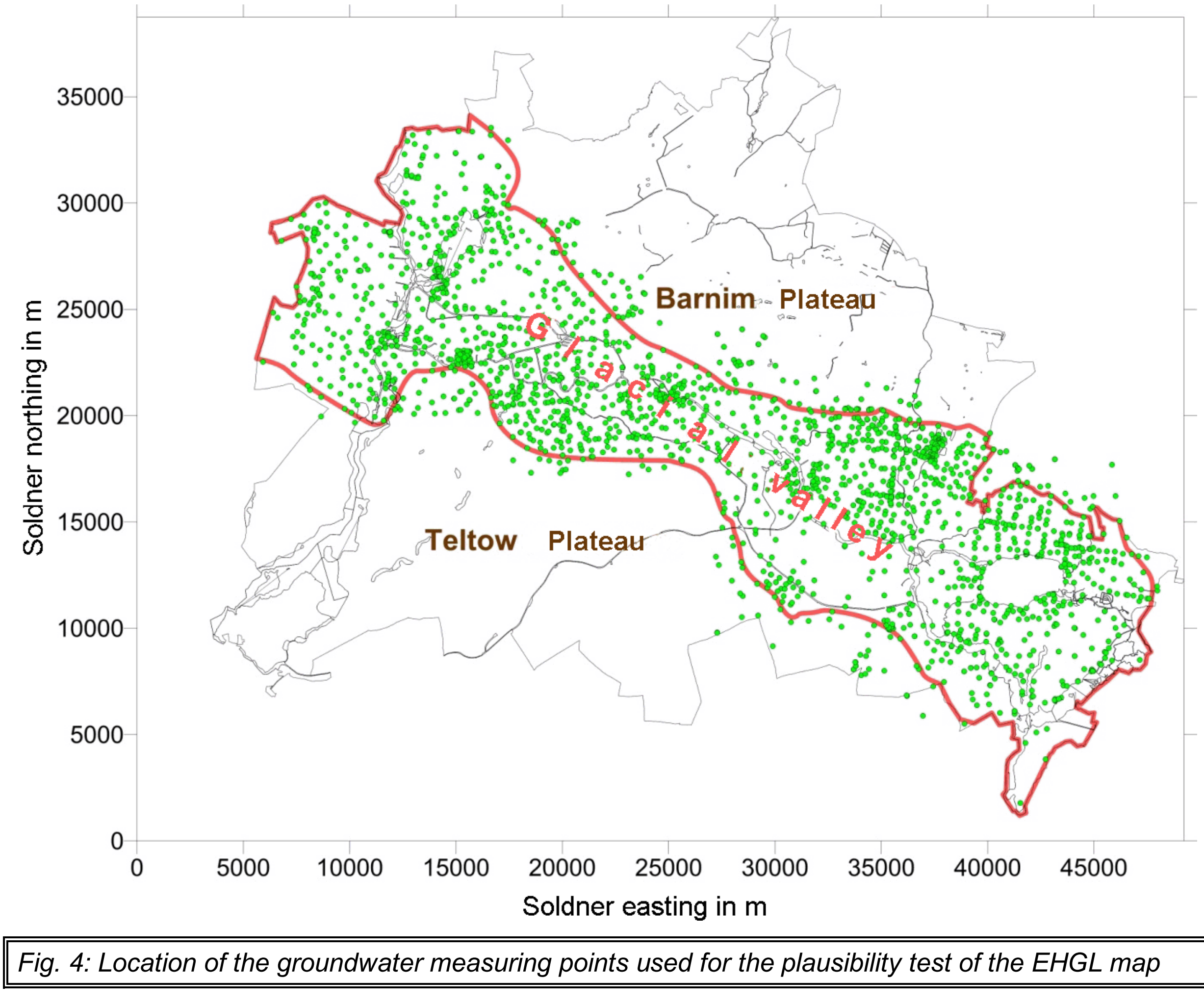

Fig. 4: Location of the groundwater measuring points used for the plausibility test of the EHGL map

The methodology of the EHGL map also includes its ongoing review, particularly after very high groundwater levels have been observed. After the map was completed, such extremely high groundwater levels were recorded in the period from 2008 to 2011. The map passed the test very successfully based on this groundwater level data. Only minimal changes were carried out subsequently. The published map is now set up such that the HGL that applies at the individual measuring points, i.e. which is regarded as uninfluenced, is at least 10 cm lower than the EHGL shown.

Panke valley

The EHGL map in the area of the Panke valley was originally going to be developed using the same methodology as that used for the glacial valley, i.e. using a numerical groundwater simulation model. Thus, a separate groundwater model was first created for this area, which is generally available for questions of water management and has already been used. However, when preparing this model, it became apparent that the required hydrological and hydrogeological data is relatively sparse in some areas. The calculation of a preliminary EHGL map and its critical evaluation led to the assessment that in these areas the model does not yet meet the particularly high quality requirements set out for an EHGL model.

The anthropogenic influence on the groundwater in the Panke valley is relatively small, in contrast to the Berlin glacial valley. Therefore, more directly measured HGL values can be taken into account in developing the EHGL map in this case. The EHGL map for the area of the Panke valley does not only include the Panke valley in the strict sense, as defined on the geological map of Berlin, but also a small adjacent part of the glacial valley. This is a transition area between the two geological units, which hydrogeologically rather belongs to the Panke valley with its relatively shallow uppermost aquifer.

The methodological approach is described in Hörmann & Verleger (2016) and is summarised here as follows:

1. Hydrograph analysis

All hydrographs of the 135 groundwater measuring points from the Senate Department's archive that are installed in the Panke valley aquifer (GWL 1.2 according to the aquifer nomenclature of Limberg & Thierbach 2002) were checked for suitability for the present purpose. This included in particular an assessment of the groundwater levels with respect to potential artificial influence and potential data errors. The essential result of this investigation was that the groundwater levels are significantly more often and usually also more strongly influenced before 1990 than after. An essential cause for this is the operation of the sewage farms in the northern part of the Panke valley, which was ended in the 1980s and caused a significant rise in the groundwater level locally. The highest groundwater levels measured during the operation of the sewage farms do not count as expected highest groundwater levels. As a result of this hydrograph analysis, only measurements since 1990 have been used to determine EHGL values.

2. Determining the EHGL values

The highest groundwater level (HGL) was extracted for every single groundwater measuring point that was recognised as suitable. To determine the EHGL, an increment was added to the HGL:

EHGL = HGL + increment

The increment was determined based on various considerations for estimating the reliability of the recording of highest groundwater levels. In particular, the frequency of measurements and the observation duration of the groundwater measuring points were taken into account. The minimum increment added to the HGL is 0.3 m. This value applies to measuring points that capture the period from 2007 to 2012 well through frequent measurements. In Berlin, the highest groundwater levels under the currently prevailing geohydraulic conditions (cf. EHGL definition) were generally observed in this period (see example Fig. 5).

HGL values of groundwater measuring points that do not cover periods of generally high groundwater levels and/or have a lower measuring frequency were incremented by 0.5 m or 0.7 m.

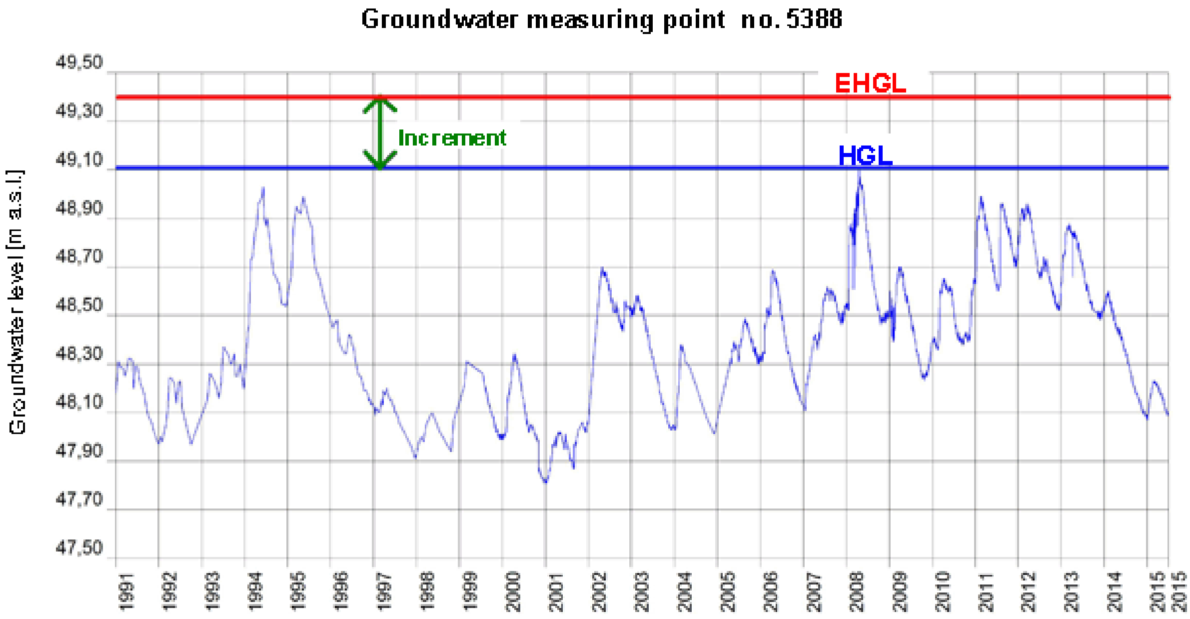

Fig. 5: Example of a hydrograph from the Panke valley with HGL, EHGL and increment

3. Calculation of the EHGL map

On the basis of 105 suitable groundwater measuring points and their EHGL values as sample values, the distribution of the EHGL was calculated using the software system SURFER, without taking bodies of water into account, and was represented in the form of lines of equal EHGL. The calculation method is the same as the one used for the current groundwater isolines map (Hannappel, Hörmann & Limberg 2007).

In addition, the following should be noted in general:

Since the EHGL map has been made available for different applications, the expected highest groundwater levels include **no application-specific blanket safety increments, as are required e.g. in the regulations relevant for the construction of buildings**. The increments added to the HGL (0.3 to 0.7 m, see Methodology), which differ across the area of the Panke valley in some cases, were chosen solely due to the varying quality of recording the highest groundwater levels and the relatively large natural amplitude of the groundwater graph here, compared to the glacial valley. In the glacial valley, the values shown in the EHGL map are **at least 0.1 m higher than the highest measured groundwater levels that have been determined to be relevant**. In the area of the cone of depression of the Berlin waterworks, however, the EHGL is predominantly much higher than the HGL, which registers on a metre scale.

Thus, the EHGL estimates have been determined using computational methods based on comprehensive data and various other sources of information. According to current knowledge, they are on the "safe side" – in the sense that they will most likely not be exceeded. Another consequence is that they may not necessarily reach the maximum height specified.

The methodology for the development of the map also includes an ongoing review, i.e. a comparison with the current groundwater levels. A comprehensive check of the map, which is based on the data prior to 2007, was carried out in 2013, after extremely high groundwater levels had been recorded in Berlin in 2008 and 2011. **The result demonstrated that even in times of extreme precipitation the EHGL values were not exceeded**.

Teltow Plateau and Nauen Plate

The development of an EHGL map for the areas of the Teltow Plateau and the Nauen Plate began in 2013. In 2017, it was completed for these two hydrogeological units and is published here for the first time together with the EHGL maps for the glacial valley and the Panke valley.

The method used to develop this map is essentially the same as that used for the glacial valley map, i.e. the map was created based on a numerical groundwater flow model (Hörmann & Verleger 2020). As was the case for the glacial valley, the use of a simulation model was required here because of the long-term anthropogenic influence on the groundwater levels, especially by the Beelitzhof, Tiefwerder and Kladow waterworks. The main differences are listed below:

The existent four-layer groundwater model for Berlin was used for further vertical differentiation. The model is now divided into eight layers. This was necessary to accommodate the hydrogeological layer structure of the Teltow Plateau and the Nauen Plate that is considerably more complex than that of the glacial valley. Figure 6 shows a North-South section through the model, as it currently exists for the entire Berlin area. The model layers L 1 to L 6 represent the main aquifer, which is locally differentiated into the aquifers GWL 2.1, GWL 2.2 and GWL 2.3, which are hydraulically separated from each other – especially in the plateau areas – by layers of boulder marl with low water conductivity.

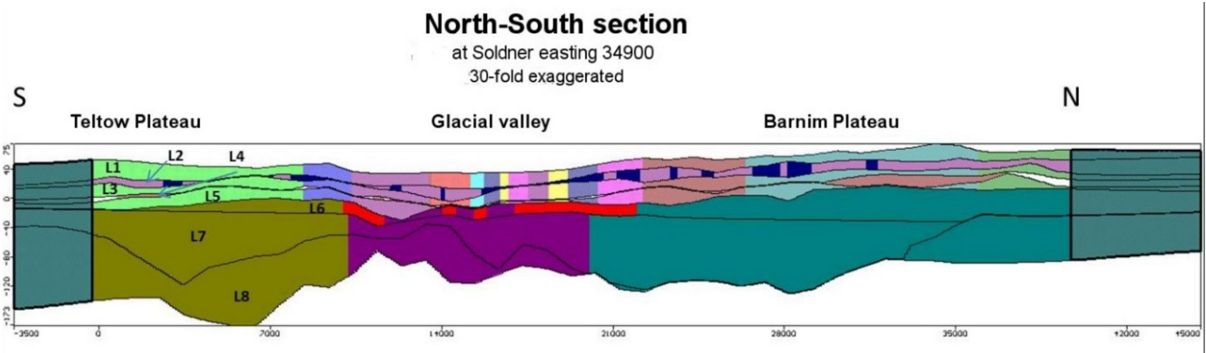

Fig. 6: Section of the numerical groundwater flow model for the State of Berlin

The year 2001 was used for calibration and the year 2004 for verification, based on their advantageous data on the observed groundwater levels.

As for the glacial valley area, the EHGL simulation was carried out following the calibration and verification process. Data from about 1,100 groundwater measuring points was used to implement the plausibility test and a required recalibration of the EHGL model.

Based on the plausibility test of the Teltow Plateau and the Nauen Plate map, identifying riparian strips separately along individual bodies of water turned out to be superfluous here, in contrast to the glacial valley. Essentially, only a small area on the Nauen Plate west of Kladow was subsequently modified on the model-calculated map, i.e. where a hydrogeological anomaly was taken into account by indicating areas with the same EHGL values based on the highest groundwater levels observed.

Barnim Plateau south-east of the Panke valley

In the course of developing the numerical groundwater flow model for the Barnim Plateau, it emerged that the required hydrogeological data is relatively poor in some areas. Furthermore, it became clear that the complexity of the hydrogeological conditions, which are highly intricate in some parts, could not always be mapped with sufficient accuracy. A very strict analysis of the calculated EHGL map revealed that one section of the EHGL model does not yet meet the particularly high quality requirements set out for an EHGL model.

Similar to the Panke valley, HGL measurements were therefore initially used to develop the EHGL map. Groundwater levels from the year 2000 were used for this purpose. This is possible, as anthropogenic influence has become rather insignificant as a factor, following the cessation of water pumping at the Buch waterworks and the levelling of sewage farms in the 1990s.

The EHGL map for the area of the Barnim Plateau southeast of the Panke valley does not only include the plateau as presented on the geological map of Berlin, but also a small adjacent area, where the Panke valley transitions to the glacial valley (see Fig. 2). The area of the Barnim Plateau west of the Panke valley, however, is not included in these maps. On the one hand, the main aquifer does not cover a large area here. On the other hand, further analyses of the hydrogeological situation would be necessary to be able to provide reliable information on the EHGL.

The following steps were taken to calculate the EHGL map in the area of the Barnim Plateau located south-east of the Panke valley:

1. Hydrograph analysis

A statistical analysis was carried out for the groundwater levels of 43 representative groundwater measuring points, which the main aquifer filters (GWL 2.1, GWL 2.2, GWL 2) according to the aquifer nomenclature of Limberg & Thierbach (2002). Only data from the year 2000 and later was included in this evaluation. Prior to the year 2000, artificial groundwater recharge in the area of former sewage farms and the groundwater lowering by the Buch waterworks may have had a hydraulic impact on groundwater levels.

Initially, the data sets were checked for data errors. Furthermore, it was a prerequisite for use that the measurement series not contain any considerable measurement gaps and cover at least 80 % of the observation period. The groundwater level measured on day 15 of each month was used for evaluation.

The aim of the evaluation was to determine the month with the highest groundwater levels in the observation period and to determine the maximum groundwater increase during the winter half of the year and caused by heavy precipitation events in the summer respectively.

On the Barnim Plateau, the highest groundwater levels were measured in the winter of 2012 (23 groundwater measuring points) and the winter of 2011 (16 groundwater measuring points). In the winter months of 2008, maximum values were recorded at 3 groundwater measuring points and at 1 measuring point in 2002. February 2012 was the month with the highest groundwater levels with 21 peak values. In the winter of 2011, the highest groundwater levels were also recorded in February with 13 peak values. Figure 7 reveals that the measuring points that recorded maximum values in the winter of 2012 (highlighted in pink) are located in the southern section of the Barnim Plateau and in the north-west (Frohnau/Hermsdorf), while the measuring points that recorded maximum values in the winter of 2011 (highlighted in blue) are mainly located in the north and the east.

Figure 8 illustrates the difference in water levels between the two peak levels of winter 2012 and 2011. The groundwater levels recorded at the northern and eastern groundwater measuring points (highlighted in blue in Figure 7) in the winter of 2012 read up to 0.44 m below the maximum water levels in 2011. The median is 0.10 m lower than that of the water levels of 2011. In the southern groundwater measuring points (highlighted in pink in Figure 7), the 2012 water levels were 0.17 m higher on average than the 2011 water levels.

The highest groundwater increases across all groundwater measuring points investigated on the Barnim Plateau within a month is 0.39 m and can be attributed to heavy precipitation events that occurred in June/July 2017. When investigating groundwater increases across several months, the winter months from November 2010 to February 2011 stand out in particular, with an increase of 0.47 m in three months.

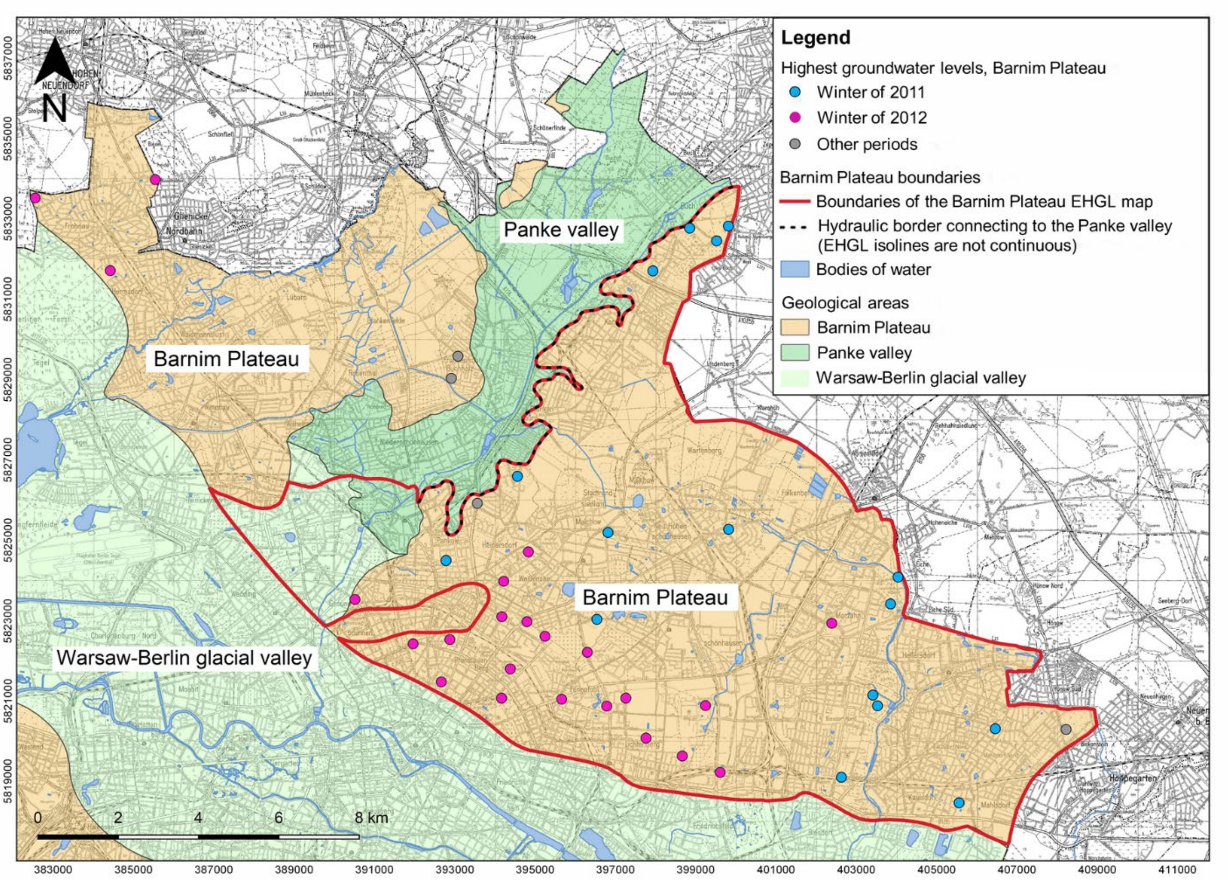

Fig. 7: Distribution pattern of groundwater measuring points by highest groundwater level (blue: winter of 2011; pink: winter of 2012)

2. Defining EHGL values and calculating the EHGL map

The hydrograph analysis demonstrated that the overall highest groundwater levels were measured in February 2012. Hence, this date was chosen as the basis for calculating the EHGL map. In order to account for the influence of heavy precipitation events and persistent phases of precipitation in winter, these water levels were raised by 0.5 m. Figure 7 illustrates that the highest groundwater levels were measured in the winter of 2011 (highlighted in blue) in the northern and eastern sections of the Barnim Plateau. They were up to 0.44 higher than those measured in February 2012 (cf. Figure 8). To account for this, the water levels of February 2012 were raised by an additional 0.4 m for these groundwater measuring points.

Barnim Plateau EHGL = groundwater level (February 2012) + heavy precipitation increment (0.5 m) + increment in the north and east (0.4 m)

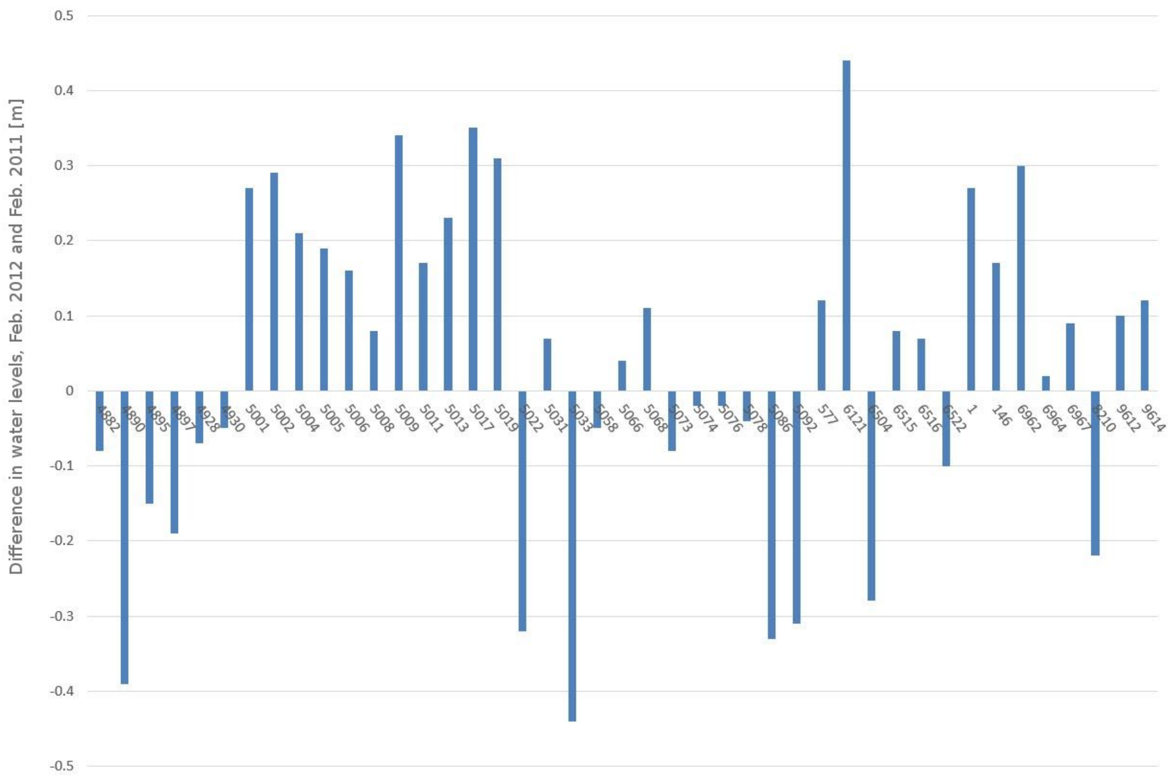

Fig. 8: Difference in water levels between February 15, 2012 and February 15, 2011 at 43 representative groundwater measuring points. Positive values indicate that the water level was higher in the winter of 2012 than in the winter of 2011 (corresponds to the groundwater measuring points highlighted in pink in Fig. 7)

Based on this evaluation, EHGLs were calculated for all groundwater measuring points available on the Barnim Plateau. Furthermore, a groundwater equation map was created using the SURFER software system. The calculation methodology and the number of groundwater measuring points used are the same as those used for the current groundwater levels map (Hannappel, Hörmann & Limberg 2007).

3. Adjustments to match the glacial valley and the Panketal EHGL maps

The Barnim Plateau EHGL map connects directly to the glacial valley EHGL map in the south and was manually adjusted to match the existing map in the area of transition.

The Panke valley aquifer is the uppermost aquifer in its area. Hydraulically, it is largely separated from the main aquifer. The EHGLs of the Panketal aquifer are thus mapped in the area of the Panketal valley. As a result, the transition between the Panketal and the Barnim Plateau is not smooth. It is rather characterised by misaligned EHGL isolines, resulting from two hydraulically separated aquifers “colliding” on this map. In the southwest, in the area of transition to the glacial valley, however, the Panketal aquifer is no longer hydraulically separate from the main aquifer. From the isoline situated 42 m above sea level, the EHGL isolines of the Panktetal aquifer start to align with the hydrographs of the Barnim Plateau and the glacial valley EHGLs. In this area, the EHGLs determined for the Barnim Plateau are above those of the Panketal aquifer, bar a few exceptions (e.g. north-east of the Schäfersee). The Barnim Plateau EHGLs are therefore presented on the current map. This modification was necessary, as it was the only option to adjust the Barnim Plateau EHGL map to the already existing glacial valley and Panke valley EHGL maps in a hydrogeologically sound way.

Map description

The EHGL map (2021) covers about 90 % of the area of the State of Berlin. The expected highest groundwater level is represented by lines of equal height in metres above sea level. The difference in height between groundwater isolines is 0.1 m. Thus, the map shows the distribution of the observation well levels in the EHGL case. In the areas of the glacial valley and the Panke valley, the uppermost groundwater is predominantly unconfined, in the area of the plateaus it is mostly confined or covered. It is evident from the course of the contour lines that the Spree and the Havel and their tributaries form the receiving waters for the groundwater close to the surface. The groundwater flow direction lies perpendicular to the contour lines from the higher to the lower level. The EHGL varies between about 61.9 m above sea level on the state border of the north of the Barnim Plateau and 30.1 m above sea level where the Lower Havel exits the state area in the southeast. The closer clustering of the contour lines in the Panke valley, the Teltow Plateau and the Nauen Plate as well as in the south-eastern section of the Barnim Plateau shows that, as expected, the height gradient of the groundwater is larger here than in the glacial valley. Thus, the course of the EHGL isolines paint a plausible picture for the case that neither groundwater extractions nor artificial groundwater replenishments occur. In particular, this map provides realistic EHGL values in the area of the large cones of depression of the Berlin waterworks, which could hitherto only be estimated very roughly without the modelled groundwater levels (cf. current groundwater levels maps, on which the cones of depression are visible).

On the digital map, you can display the EHGL value for a specific location by a mouse click.

In the vicinity of the shores of the Spree, the upper Havel and the Tegeler See, there are lateral riparian strips (see also Methodology). These areas are marked with different colours according to the EHGL value and can also be displayed by a mouse click.

A user can therefore easily access an EHGL value relevant to their question.

The following should be noted:

The map value applies to the groundwater level of the uppermost aquifer. In the area of the glacial and Panke valley, the uppermost aquifer is predominantly unconfined. Thus, the map value generally specifies the height of the groundwater surface here, which is relevant, for example, for dimensioning waterproofing for buildings.

However, in some places – often in the plateau areas – overlying layers with low water conductivity, such as boulder clay and boulder marl, clay, silt and organic soils, cause the groundwater to be confined. In these cases, the map does not specify the height of the groundwater surface, but rather that of the piezometric surface of the confined groundwater.

In these cases, shallow groundwater (in the sense of the groundwater definition of DIN 4049) may form – possibly only temporarily – above the confining layers. This stratum water is also water under pressure in a constructional sense and must be taken into account in relevant contexts.

Due to the scale and the rather heterogeneous sedimentation conditions in certain situations, the two possible deviations from the usual hydrogeological configuration that were mentioned cannot be represented at all or not fully in the Geological Outline provided. However, they can be revealed in the course of soil investigations, which are a prerequisite for all construction activity. In addition, the strata log sheets from the database of the State Geological Service (only in German) can be accessed on the Internet for each individual case.

It should also be noted that the EHGL may be above ground level. In this case, the formation of groundwater ponds cannot be ruled out.

Near surface waters, in addition to high groundwater levels, short-term local flooding may occur, which cannot be inferred from the EHGL map. Information in this regard is available under Hochwasser (floods, only in German).

Current water levels of the Berlin State monitoring network of surface waters and the groundwater can be researched in the water portal of the Senate Department. Furthermore, State-wide analysis results are provided as part of groundwater isoline plans for the main aquifer and the Panketal aquifer for the month of May.

Should the current groundwater level be only slightly lower than the value of the EHGL map, or even slightly higher, which is very unlikely in the glacial valley but cannot be entirely ruled out, this may be due to the different statistical bases of the maps. In these cases, more detailed information may be requested from the State Geology Working Group.

In the Panke valley, in particular in its northern part, the groundwater measuring points are sometimes relatively far apart considering the heterogeneity of the aquifer and the predominantly large natural groundwater gradient. As a result, the EHGL map is more fraught with uncertainty here than in the area of the glacial valley. This also applies to areas in the immediate vicinity of surface waters (the Panke and its small tributaries). While this was accounted for by the above-mentioned increments, localised deviations of the map value from an actually occurring highest groundwater level cannot be entirely excluded. If new investigations (drillings, groundwater level measurements) yield results in such areas that clearly contradict the EHGL value of the map (current groundwater level is higher than the map value or lower within the metre range), the EHGL should be modified locally by an expert. In such cases, please notify the State Geology Working Group.

The hydrogeological conditions in the area of the Teltow Plateau, the Nauen Plate and the Barnim Plateau are considerably more complicated than those in the glacial valley and the Panke valley. Therefore, the mathematical EHGL estimate, applying the methods described above is fraught with somewhat higher uncertainties. To be on the safe side, the map was thus developed to indicate EHGL values that are rather higher than those that may actually occur. This was deemed a reasonable approach in construction planning. It should also be noted here that the probability of locally occurring stratum water atop confined layers at heights above the indicated EHGL values is greater than in the glacial valley. Should you detect contradictions to the map in the framework of future investigations (e.g. a soil investigations), please also inform the above-mentioned authority.

It is envisaged that the map will continue to be checked and possibly modified based on the results of the Berlin State Geology Working Group and new scientific findings. The intent is to recognise and take into account possible changes in the hydrological conditions that cannot currently be foreseen (e.g. due to general changes in the climate) as soon as possible.

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