Project no. 505428 (GOCE)

AquaTerra

Integrated Modelling of the river-sediment-soil-groundwater system; advanced tools for the management of catchment areas and river basins in the context of global change

Integrated Project

Thematic Priority: Sustainable development, global change and ecosystems

Deliverable No.: **TREND2.1**

Title: Documented spatial data set containing the subdivision of the basins into groundwater systems and subsystems, the selected locations per subsystem and a description of these sites, available data and projected additional measurements and equipment

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Dissemination Level		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

SUMMARY

The establishment of tools for trends analysis in groundwater is essential for the prediction and evaluation of measures taken within context of the Water Framework Directive and the draft Groundwater Directive. This report describes the spatial data sets which will be used for the purpose of detection, aggregation and extrapolation of temporal trends in groundwater quality. Trend analysis methods will be applied and tested at various scales and in various hydrogeological situations. The report contains a description of the studied sub-basins in TREND 2, including information on hydrogeology, land use and pressures, available data and projected additional measurements. Major differences between the sub-basins and the data sets are described to examine consequences for the work on trend detection. One of the challenges for TREND 2 is to define criteria for the application of various statistical and deterministic trend approaches for a range of hydrogeological conditions, spatial scales and types of groundwater monitoring. An overview of these conditions, scales and monitoring types is provided in the present report.

MILESTONES REACHED

T2.1: Documented spatial data set containing the subdivision of the basins into groundwater systems and subsystems, the selected locations per subsystem for small scale analysis and a description of these sites, available data and projected additional measurements and equipment

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1. Introduction to TREND 2 (TNO)

1.1 Background and objectives

The implementation of the EU Water Framework Directive (2000/60/EU) and the draft Groundwater Directive asks for specific methods to detect the presence of long-term anthropogenically induced upward trends in the concentration of pollutants in groundwater. Specific goals for trend detection have been under discussion during the preparation of the recent draft of the Groundwater Directive. The draft Directive defines criteria for the identification and reversal of significant and sustained upward trends and for the definition of starting points for trend reversal. Figure 1.1 illustrates the trend reversal concept, as communicated by EU Commission Officer Mr. Ph. Quevauviller. The figure shows how the significance of trends is related to threshold concentrations which should be defined by the member states.

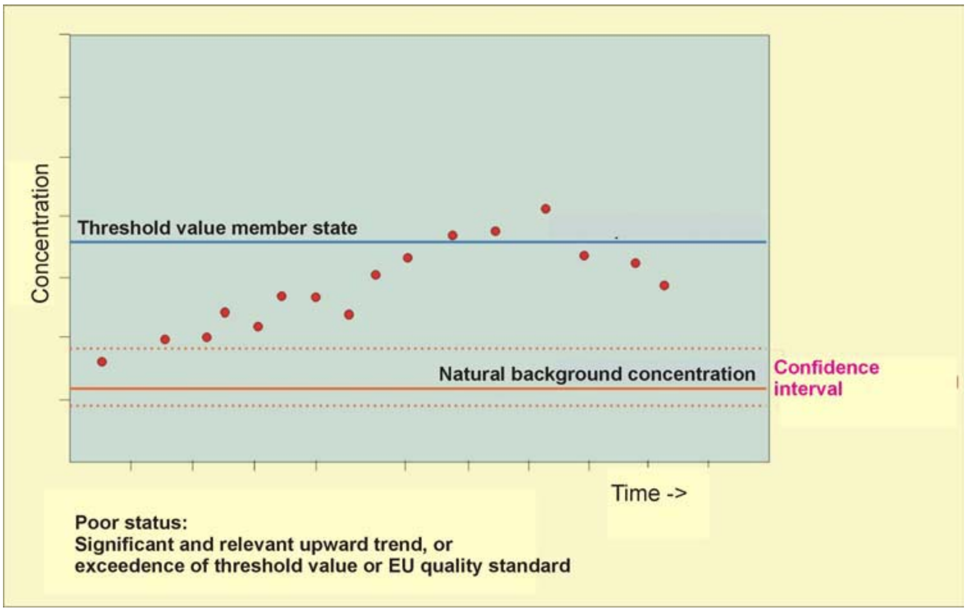

Figure 1.1 Trend reversal concept of the draft EU Groundwater Directive.

Trends should be reversed when concentrations increase up to 75% of the threshold concentration. Member states should reverse trends which present a significant risk of harm to associated aquatic ecosystems, directly dependent terrestrial ecosystems, human health, whether actual or potential, of the water environment, through the program of measures referred to in Article 11 of the Water Framework Directive, in order to progressively reduce pollution of groundwater. Thus, there is a direct link between trends in groundwater and the status and trends in related surface waters. This notion is central to the overall objectives of the AQUATERRA research project.

Working hypothesis 1:
Groundwater quality is of utmost importance to the quality of surface waters. Establishment of trends in groundwater is essential for prediction and evaluation of measures taken within the Framework Directive and the draft Groundwater Directive.

Accordingly, the work package TREND-2 of Aquaterra is dedicated to the following overall objectives.

1 Development of operational methods to assess, quantify and extrapolate trends in groundwater systems. The methods will be applied and tested at various scales and in various hydrogeological situations. The methods applied

should be related to the trend objectives of the Water Framework Directive and draft Groundwater Directive. In addition to the DOW, it is our ambition to link changes in groundwater quality to changes in surface water quality.

2 Linking changes in land use, climate and contamination history to changes in groundwater chemistry. We define a temporal trend as '*a change in groundwater quality over a specific period in time, over a given region, which is related to land use or water quality management',* according to Loftis 1991, 1996.

It should be noted that trends in groundwater quality time series are difficult to detect because of (1) the long travel times involved, (2) possible obscuring or attenuating effect of physical and chemical processes, (3) spatial variability of the subsurface, inputs and hydrological conditions and (4) short-term natural variability of groundwater quality time series. The TREND 2 package is dedicated to the development and validation of methods which overcome many of these problems.

> Working hypothesis 2:
> Detection of trends in groundwater is complicated by spatial variations in pressures, in flow paths and groundwater age, in chemical reactivity of groundwater bodies, and by temporal variations due to climatological factors. Methods for trend detection should be robust in dealing with this inherent variability.

Groundwater pollution is caused by both point and diffuse sources. Large scale groundwater quality, however, is mainly connected to diffuse sources, so that the TREND 2 project will concentrate on trends in groundwater quality connected to diffuse inputs, notably nutrients, metals and pesticides. We will consider a number of large basins in Europe and try to devise a trend monitoring method and network. Although trends in groundwater quality can occur at large scales, linking groundwater quality to land use and contamination history requires analysis at smaller scale, i.e. groundwater subsystems. Thus, the approach zooms in on groundwater system analysis around observation locations. Results will be extended to large scale monitoring.

1.2 General methods used in TREND 2

Research activities within TREND 2 focus on the following issues:

1 *Inventory of monitoring data of different basins and sub-catchments*. The inventory focuses on observation points with existing long time series. The wells should preferably be located in agricultural areas, because pesticides and nutrients are the main concern in trend detection for the Water Framework Directive. Additional information will be collected about historical land use changes and related changes in the input of solutes into the groundwater system.

2 *Development of suitable trend detection concepts.* Trend detection concepts include both statistical approaches (classical parametrical and non-parametrical methods, hybrid techniques) and conceptual approaches (time-depth transformation, age dating)

3 *Methods for trend aggregation for groundwater bodies.* The Water Framework Directive demands that trends for individual points are aggregated on the spatial scale of the groundwater bodies. The project will focus on robust methods for trend aggregation.

4. *Trend extrapolation.* Trend extrapolation will be based on statistical extrapolation methods and on deterministic modelling. Both 1D and 3D model may be applied to predict future changes and to compare these with measured data from time series.
5. *Recommendations for monitoring.* Results from the various case studies will be used to outline recommendations for optimizing monitoring networks for trend analysis

1.3 TREND 2 case studies

The following case studies have been selected for testing the methodologies:

Basin	Contaminants	Institutes
Meuse		
Dommel upper tributaries	Nitrate, sulfate, Ni, Cu, Zn, Cd	TNO/UU
Noord-Brabant region	Nitrate, sulfate, Ni, Cu, Zn, Cd	TNO/UU
Wallonian catchments: • Néblon • Pays Herve • Hesbaye • Floodplain Meuse	Nitrate	Ulg
Brévilles		
Brévilles catchment	Pesticides	BRGM
Elbe		IETU
• Czech subbasins	Nitrate	
• Schleswig-Holstein	Nitrate	

These cases have different spatial scales and different hydrogeological situations. Details on the various cases are provided in the subsequent chapters of this report.

1.4 Version of the report

This is the second, final version of the T2.1 deliverable report, which includes the contribution of IETU regarding the dataset of the Elbe subbasins. The first version of the report was delivered at November 5th 2004, and already included the contributions of BRGM, TNO, UU and ULg. Our IETU collegues unexpectedly encountered great difficulty in collecting a useful data for the Elbe part of the study. These problems have been solved, and we're glad to present the selected data sets in this second version of the report.

1.5 Structure of the report

This report describes the spatial data set of the various cases of TREND 2. The description includes the subdivision of the basins into groundwater systems and subsystems, the selected locations per subsystem and a description of these sites, available data and projected additional measurements and equipment. Chapters 2 to 5 describe the spatial data sets of the Dutch Meuse, the Wallonian Meuse, the Brévilles and the selected Elbe sub-basins, respectively. Chapter 6 gives a brief overview of the various cases, focusing on opportunities and limitations on the integration of methods for trend analysis.

2. Spatial dataset for Meuse NL (TNO)

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2.1 Introduction

The province of Noord-Brabant, in which most of the Dutch Meuse basin is located, has a sandy subsurface which is quite vulnerable to agricultural pollution. This sandy region of the Dutch Meuse basin is shown in yellow and purple in Figure 2.1. In recent history, a large amounts of manure were applied and the transport and fate of this diffuse agricultural pollution front is of concern to those responsible for groundwater quality.

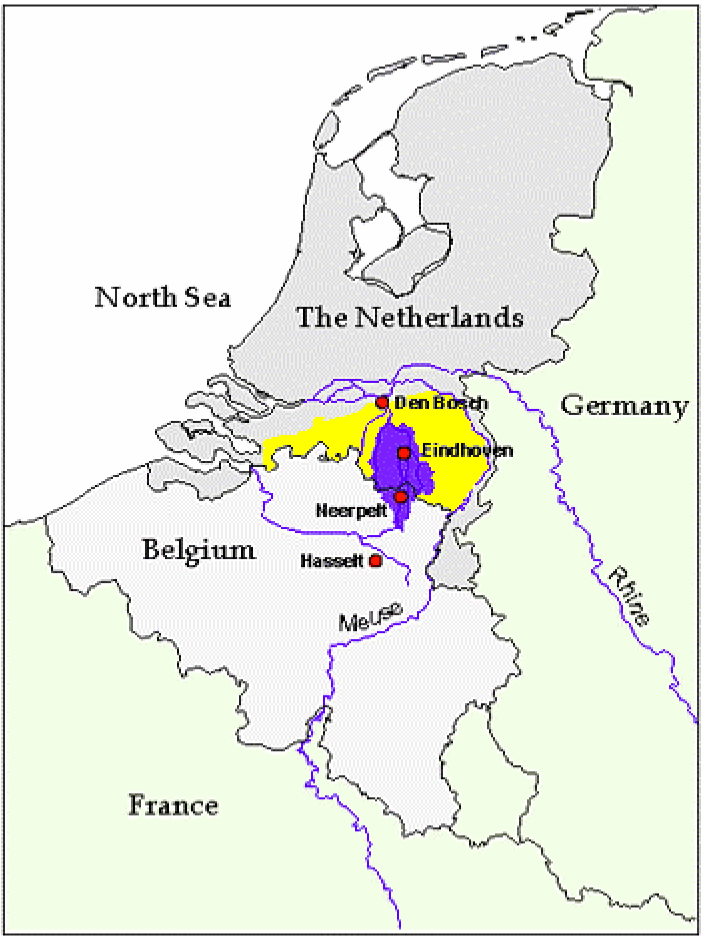

Figure 2.1. Dommel river area (purple), located within the sandy region of Dutch Meuse basin (yellow).

On a smaller spatial scale, zinc ore smelters around the upper tributaries of the Dommel River, named the Kempen region, in the south-east part of Noord-Brabant, have polluted the soil by atmospheric deposition of heavy metals. The extent of the Dommel catchment is shown purple in Figure 2.1. In this area both agricultural and industrial pollution are a possible threat to groundwater quality.

Within the Aquaterra TREND 2 work package we aim to distinguish trends in groundwater quality. First we will use statistical methods to analyse trends on the scale of the province of Noord-Brabant, focussing on areas which are particular vulnerable to diffuse agricultural pollution, namely recharge areas with intensive agricultural land use.

Secondly we will test modelling approaches to trend detection on scale of the upper Dommel tributaries, which are less data demanding but require a smaller scale of interest. Here both agricultural and industrial pollution are considered.

The different requirements for data and scale of statistical methods on the one hand and a modelling approach on the other, lead us to decide that the best results would be obtained if we would consider different scales for different approaches.

For a statistical approach to trend analysis sufficient data (time series) is only available on the scale of the province of Noord-Brabant. The focus is on vulnerable areas where infiltrating water recharges deeper parts of the groundwater body. Here, the vertical component of groundwater flow is important to describe the transport of the diffuse pollution front, and concentration-depth profiles might reveal important temporal trends in groundwater quality.

From studies to the effect of the heavy metal pollution in the Kempen region, measurements are available from a denser monitoring network. The smaller scale allows for more detailed and accurate 3D modelling of groundwater flow, with sufficient measurements to test model results. Also the pollution of heavy metals enables the study of more pollutants than those related to agriculture alone.

This section is set up as follows: first we will give the (physical) geographical background of the area (the Dutch part of the Meuse basin) including geology, hydrology and a concise pollution history. Next the basin is described in terms of (ground)water systems and subsystems. Finally we will give a detailed description of the research locations, considered pollutants and scales, as well as available data and projected sampling.

2.2 Geology

The Netherlands can be divided in two main geological units: Holocene and Pleistocene deposits. The Holocene covers the lower western part with (peri-)marine deposits, as well as the Rhine and Meuse river banks with fluvial clay. Pleistocene glacial till and ice pushed ridges can be found in the north-east of the Netherlands. The Meuse river basin is located in Brabant and Limburg in the south of the Netherlands where Pleistocene fluvial deposits and Pleistocene eolian and fluvio-periglacial deposits can be found.

The subsurface of Noord-Brabant is characterized by an active horst-and-graben structure (Figure 2.2). The west Brabant area is dominated by sandy estuarine deposits with intercalations of clay. The deposits are overlain by a thin cover of eolian sands or local fluvio-periglacial deposits. Beneath the estuarine deposits are older fluvial deposits of the Meuse River.

- West of the Feldbiss Fault is the Kempen High, which extends to the south into Flanders. Older fluvial deposits from the Rhine and Meuse rivers, belonging to the Sterksel Formation are at the surface in this area. The Sterksel Formation consists of medium and coarse sand and some gravel layers and is relatively homogeneous.

- East of the Feldbiss Fault is the Roer Valley Graben. This subsidence area has been filled with a thick series of fluvial sandy and clayey Pleistocene deposits. On top is the Boxtel Formation, which is a terrestrial fine-grained fluvial and eolian sandy deposit that incorporates heterogeneous loam and peat layers. The fluvial deposits of the Sterksel Formation are found below the Boxtel Formation.
- The Peel Horst in the eastern part of the region shows a much thinner series of coarse younger Pleistocene fluvial deposits. Less permeable peri-marine deposits are found below them.

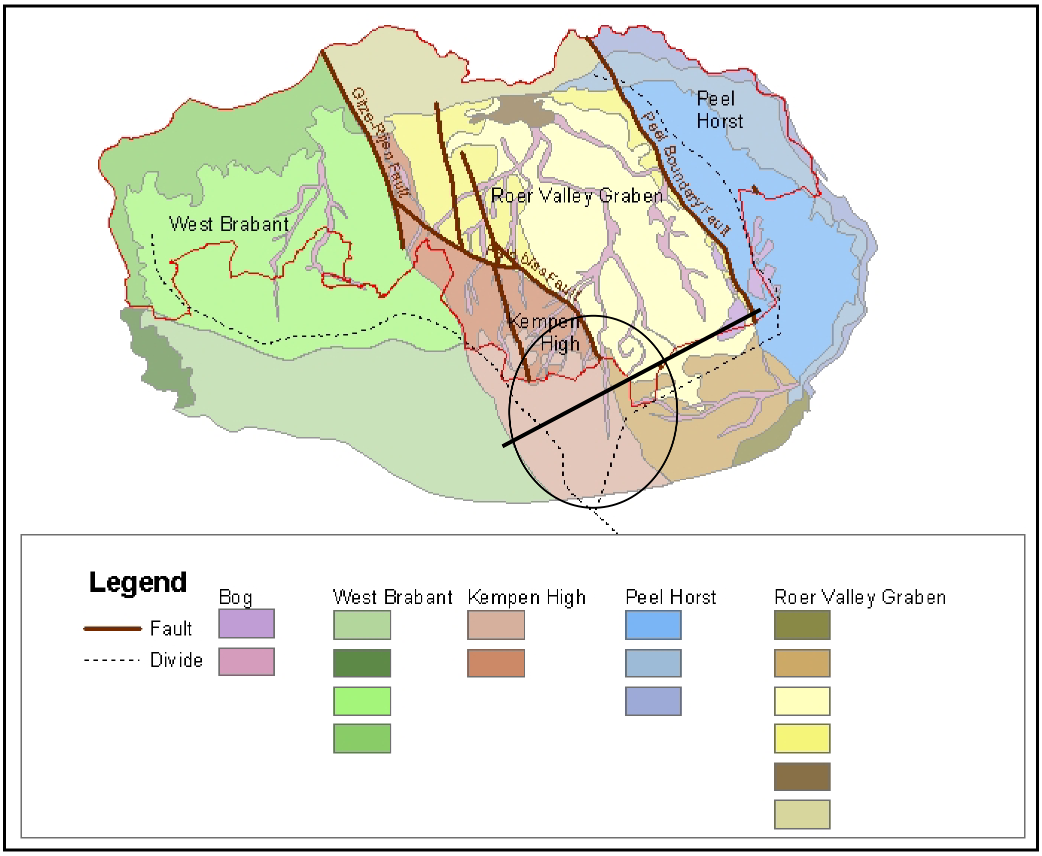

Figure 2.3. Main geological structure of Noord-Brabant, showing the Roer Valley Graben, the Kempen High, the Peel Horst and the West Brabant area. The Dommel sub-catchment is within the circle.

Figure 2.3 shows a hydrogeological cross-section over the upper Dommel catchment. The Kempen High has a higher elevation than the Roer Valley Graben (NL: Centrale Slenk). Part of the upper tributaries of the Dommel, especially the Beekloop-Keersop catchment and the Run catchment, are situated on the Kempen High. Coarse fluvial deposits are present in the first 50 meters of the subsurface (ST and SY codes). These deposits are found at a deeper level in the Roer Valley Graben. The upper 20 m of the subsurface consists of the heterogeneous deposits of the Boxtel Formation (NU code). The Aa catchment is situated in the Roer Valley Graben.

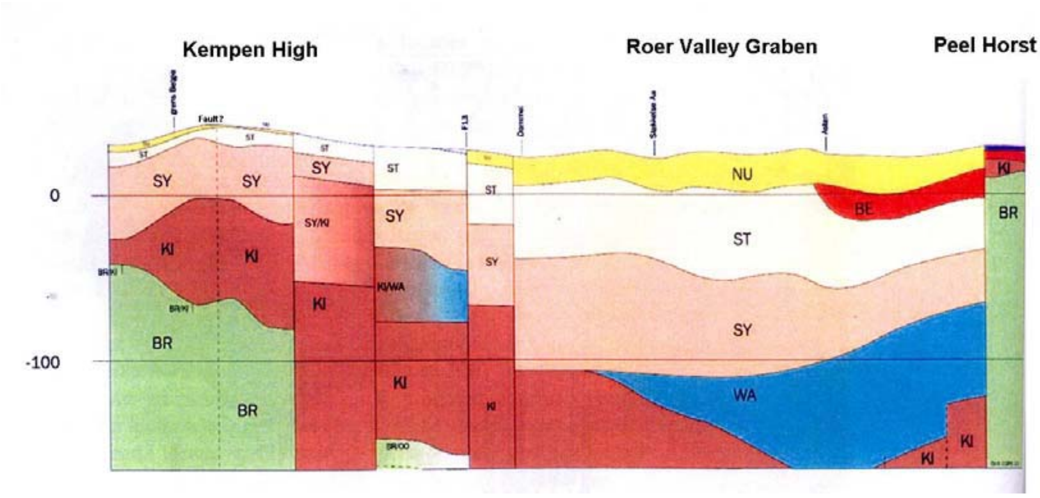

Figure 2.3. Hydrogeological cross-section in the upper Dommel catchment. Location of cross-section shown in Figure 2.2 (Van der Grift, 2004)

2.3 Hydrology

Noord-Brabant is drained by natural streams that developed in equilibrium with groundwater flow. More streams developed in low permeable areas where groundwater recharge contributed little to the drainage, and vice versa. This natural drainage system was expanded in the 20th century to make more land suitable for agriculture. Figure 2.4 shows the main brooks and water courses in Noord-Brabant. The upper Dommel catchment is within the ellipsoid.

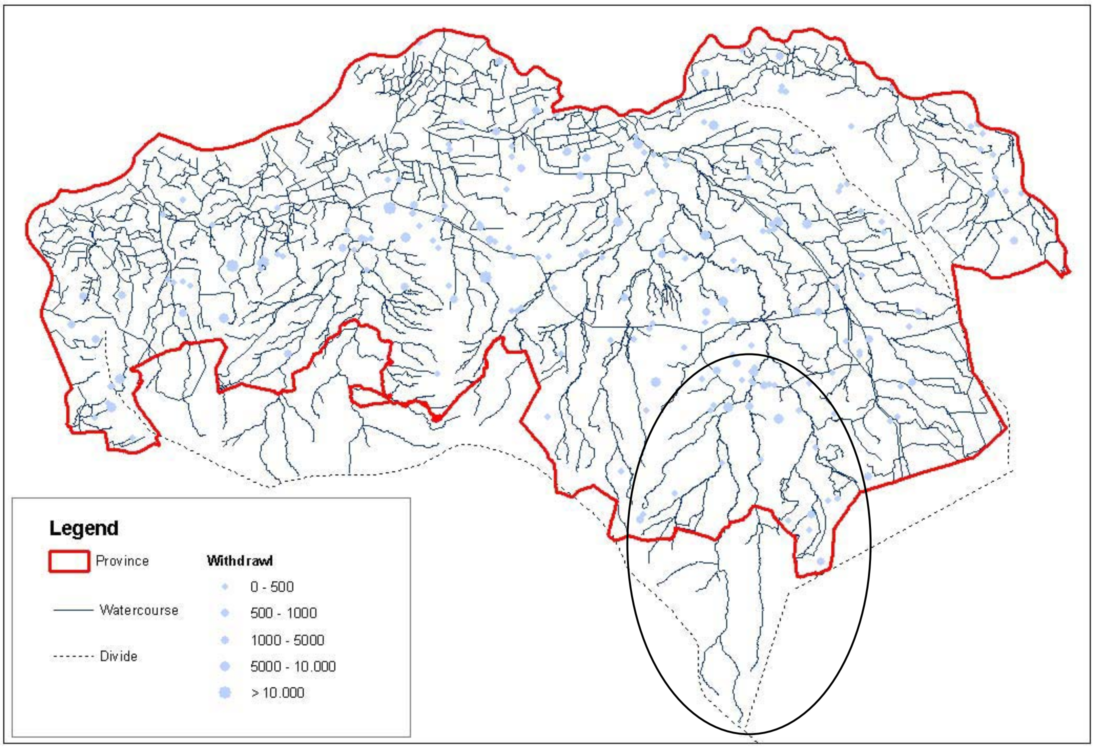

Figure 2.4. Main brooks and water courses in Noord-Brabant.

Besides superficial drainage, pumping is a considerable sink from the groundwater. Several large and deep drinking water pumping stations are in the area, as well as many smaller and shallower installations for irrigation, also shown in Figure 2.4.

2.4 Agriculture and land use

Since 1970 agriculture developed from dairy farming to intensive livestock farming. Exceptionally intensive manure practices lead to large inputs of nitrogen, phosphate and other manure related contaminants since 1970. Manure regulations managed to reduce the input of N in the late 80s which resulted in a nitrogen deposition curve peaking in the mid-80s. Figure 2.5 shows the average estimated amount of N-leaching for the whole of Noord-Brabant.

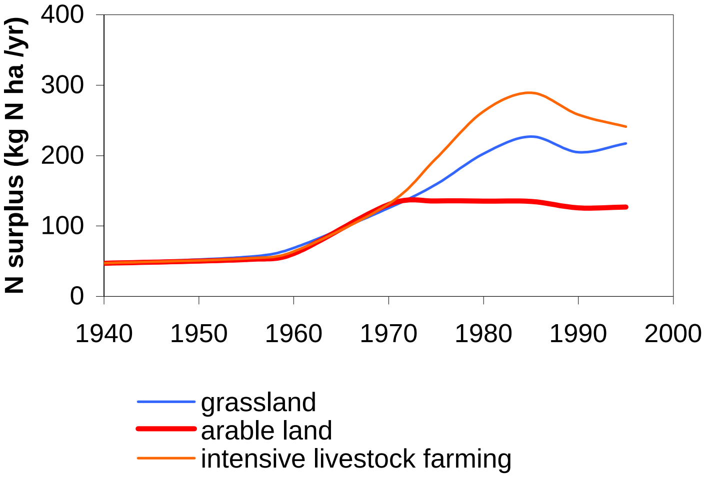

Figure 2.5. The nitrogen surplus over the period 1940-1995 for grassland, arable land and intensive livestock farming areas in Noord-Brabant

2.5 Atmospheric deposition of heavy metals

In the Kempen region, four zinc-ore smelters were active within 10 kilometer from each other. These old pyrometallurgic zinc plants were a major metal emission source and have contaminated the area with the deposition of heavy metals from exhaust fumes (Figure 2.6). This contamination has been ended in the early 70s when one zinc smelter was shut down and the other three changed to a less polluting electrolytic process technology. Nevertheless are the soils in the area heavily contaminated with mainly zinc and cadmium, which have leached to the groundwater and are continuing to do so, even as the deposition has largely ended.

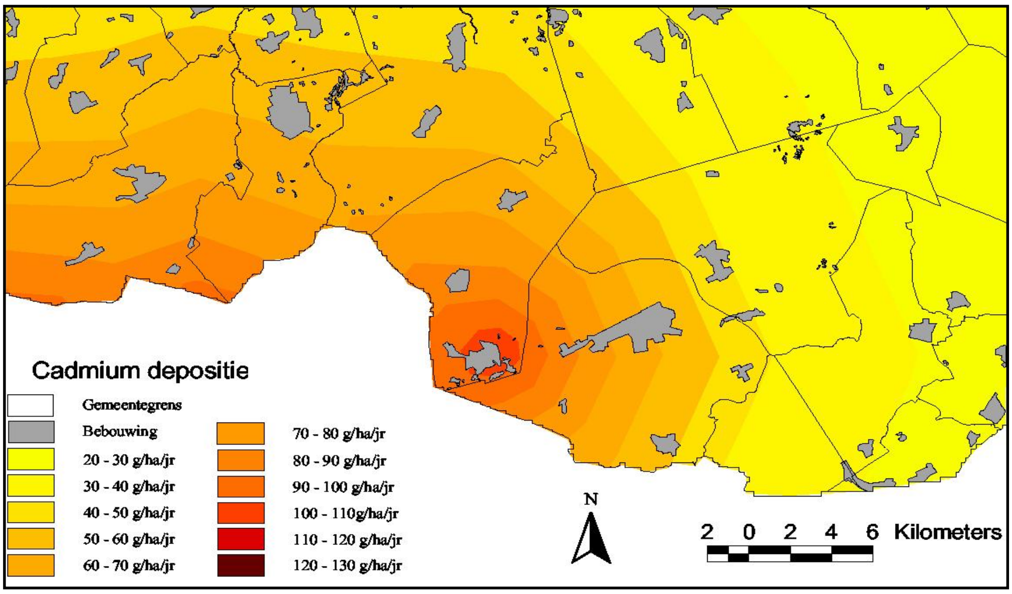

Figure 2.6. Spatial extent of average annual cadmium deposition (gr/ha/y) from 1880 to 1970. (Van der Grift et al., 2004)

2.6 Description of groundwater systems and subsystems

The whole Pleistocene part of Noord-Brabant is considered to be part of one Groundwater Body for the first Dutch national reports on the characterisation for the European Water Framework Directive named *Zand Maas* (Figure 2.7).

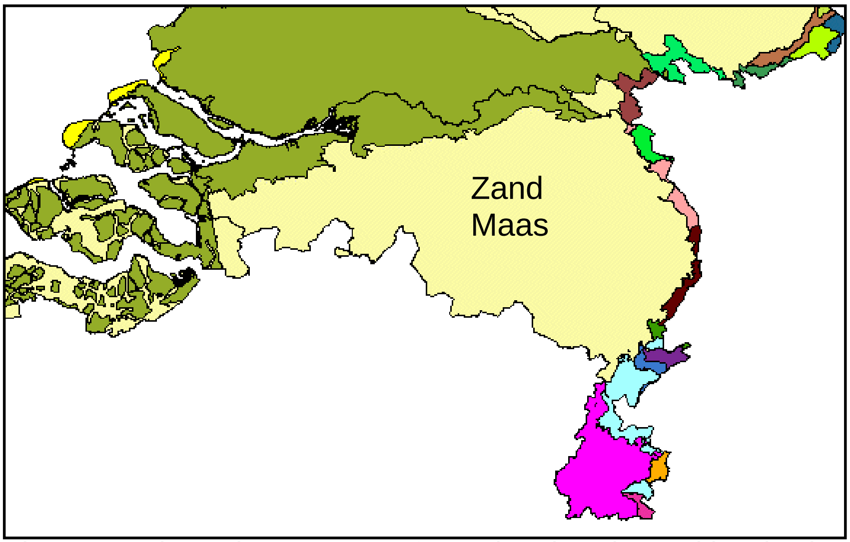

Figure 2.7. The Pleistocene part of Noord-Brabant is considered to be one groundwater body, named Zand Maas

Groundwater systems were mapped as a combination of interconnected groundwater recharge and discharge areas (Figure 2.8). Precipitation in one recharge area will discharge in the same area (horizontally striped), or in a deep discharging area (vertically striped), but not in a neighbouring groundwater system. As a consequence, a lower level groundwater system can be superimposed on a higher level groundwater system (Stuurman et al., 1990).

In Figure 2.8, three main types of groundwater systems are distinguished: river related systems (purple), first order groundwater systems (yellow to red) and (superimposed) lower order groundwater systems (blue). The main groundwater flow direction is South to North, flow directions within the locally discharging systems might deviate from this overall direction.

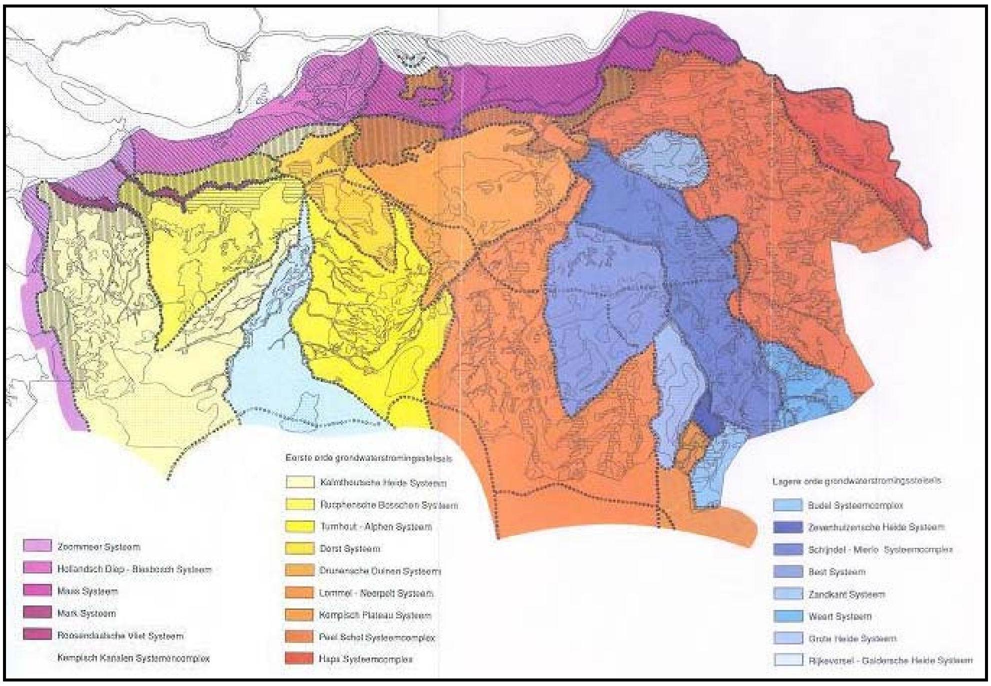

Figure 2.8 Groundwater systems in Noord-Brabant.

Figure 2.9 shows the main water systems in Brabant. (Stuurman et al, 2000) The Dommel system (coloured pink and salmon within the large ellipsoid) is in the south-eastern part of Brabant. A large part of the recharge area is across the border in Flanders. However, smaller tributaries of the Upper Dommel (NL: Boven Dommel), namely the Run, Beekloop-Keersop and Buulder Aa, are completely in Brabant and we will focus on them for our sub-catchment scale analysis.

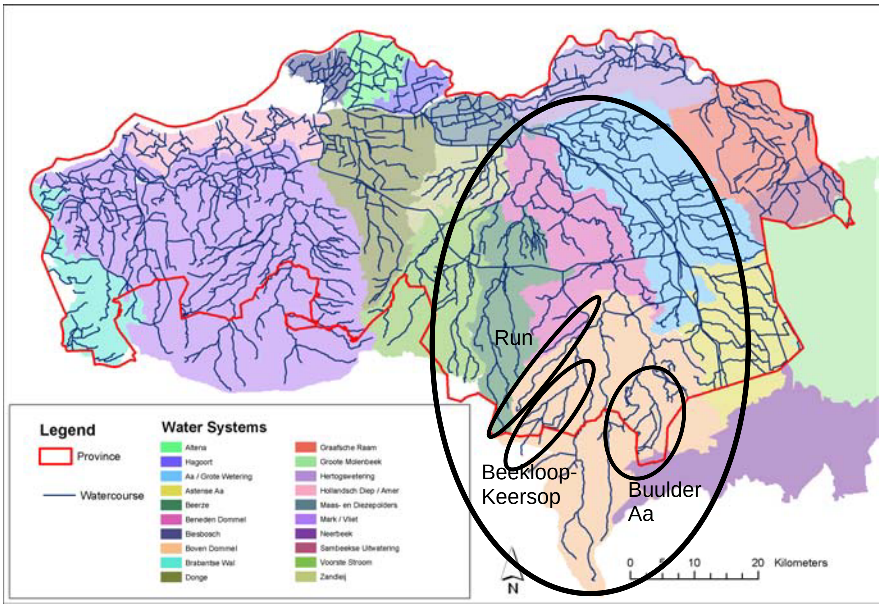

Figure 2.9: Main water systems in the province of Noord-Brabant. The Dommel system is within the large ellipsoid.

2.7 Research variables: agricultural and industrial pollutants

The sandy Brabant area is very vulnerable to pollution by heavy fertilizing practices of intensive livestock farming. TNO/UU will focus on the agriculture related pollutants nitrate and phosphate for the regional scale analysis. For these pollutants well documented time series are available from the provincial authority of Noord-Brabant.

Also the deposition history of these sources will be established in TREND 2 using data from the National Bureau of Statistics.

Besides looking at the separate pollutants, we will also look at the sum of cations and the oxidation capacity. These variables are expected to show a more conservative behaviour and trends are anticipated to be more clearly detectable in the time series and depth profiles of these variables.

The upper Dommel area has also been heavily polluted with heavy metals by zinc ore smelters. For the upper Dommel tributary scale analysis we will focus on both agricultural pollution related variables described above, as well as heavy metals: Cd, Cu, Ni, and Zn.

Analysis	Pollutants
Brabant scale	nitrate, phosphate, SUMCAT, OXC
Dommel scale	nitrate, phosphate, SUMCAT, OXC, Cd, Cu, Ni, Zn

Table 2.1: List of considered pollutants for the different analysis scales.

2.8 Research scales: Brabant and upper Dommel area

For the Dutch part of the Meuse basin the analysis concentrates on two spatial scales:

1. The scale of the sandy Pleistocene part of the province of Noord-Brabant. The area covers about 5000 km^2. This area with sandy unconsolidated deposits has been demonstrated to be quite vulnerable for the effects of agricultural diffuse pollution. The trend analysis focuses on the sandy soils with an average highest groundwater level of > 80 cm below surface level. These areas are depicted in Figure 2.10. The area was chosen because of the ample presence of time series data from the provincial monitoring network, which consists of 120 specially designed observation wells. Thirty-six of them are located in the agricultural areas with dry sandy soils and agricultural land use. The time series data cover the period 1984-2004 or 1992-2004 with annual data.

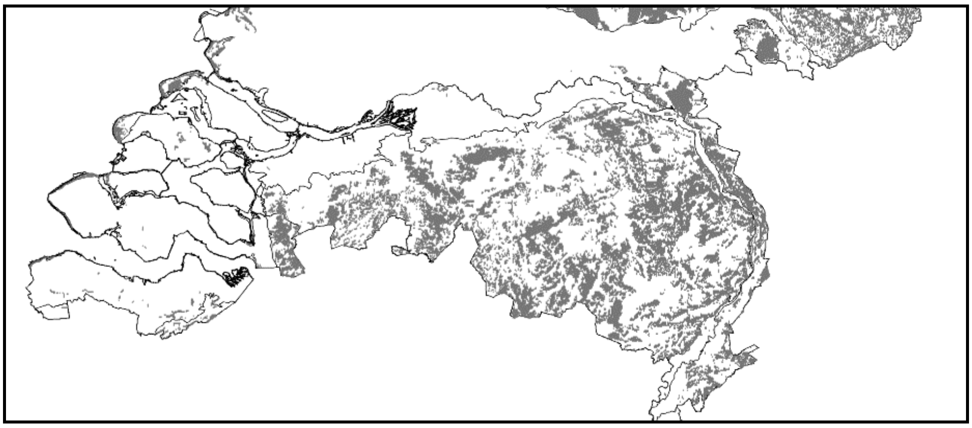

Figure 2.10. Extent of the area with ‚dry sandy soils' in the Noord-Brabant region

2. The scale of the area of the upper tributaries of the Dommel River. The area covers about 500 km^2. The Dommel River is known to be contaminated by the trace metals Zn and Cd, which were released in the atmosphere during zinc production in the Kempen region. Because of the abundant presence of sandy dry soils and abundance of livestock farming, the groundwater resources in the area are also largely contaminated by agricultural inputs. Although many observation wells are available in the area,

only few time series data are available. Here, the aim is to detect trends using concentration-depth profiles, in combination with modern age dating techniques. Reactive transport modelling will be used to extrapolate groundwater quality trends in this area, and to compare them with trends in the surface water of the Dommel tributaries.

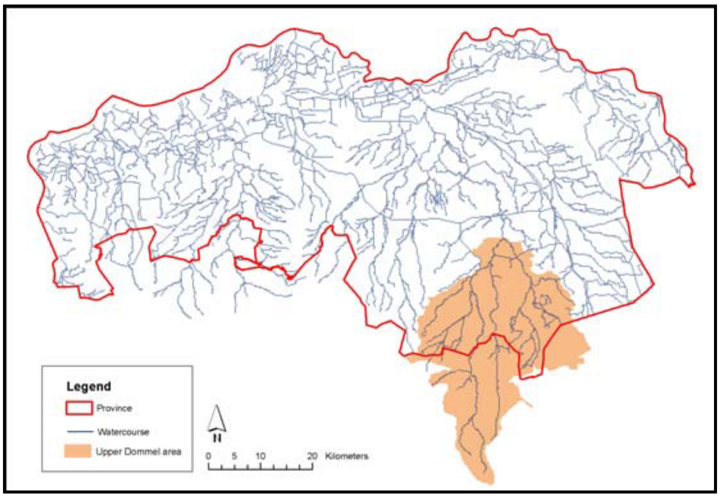

Figure 2.11: Location of the Upper Dommel area.

2.9 Research locations: Noord-Brabant regional scale analysis

For regional scale analysis, 36 wells were selected from the Noord-Brabant provincial groundwater quality network, which are representative for agricultural land use on sandy dry soils. The location of these wells and the area which they represent is shown in Figure 2.12.

The wells of the extensive monitoring network in Brabant all have the same construction. The well construction allows for sampling of groundwater (and head measurements) at several depths, the wells are so called nested wells. These are a series of tubes with various lengths which were installed in a single large diameter borehole. The deepest 1 or 2 meter of the tube is a sampling screen. The bore hole around the sampling screen is filled with a gravel pack after installation. The rest of the bore hole is filled with original material, except at the depth of impermeable layers. Here, bentonite seals are positioned in order to minimize vertical groundwater flow along the tubes.

Table 2.2 provides a brief overview of the data set, indicating time series lengths for each of the wells and additional sampling and analysis efforts which are foreseen. The table shows that time series with annual measurements are available for two specific depth intervals of 5-15 m and 18-25 m depth. Shallower (0-5 m) and intermediate (15-18 m) screens are present, but no longer incorporated in the annual monitoring program. Time series for the uppermost groundwater are available on a few locations from 1991 to 1998. Since then the monitoring of the uppermost groundwater quality is done using temporary open boreholes.

Reference		Location		Screen		Time Series			Sampling	
code	screen	north	east	depth	length	begin	end	n	concentrations*	age
1817	1	51°38'02"	4°57'50"	4	1	1992	1998	7	x	
	2			8	2	1992	2003	10	2004	
	3			~15				0	x	
	4			25	2	1992	2003	10	2004	
1830	1	51°40'16"	5°05'43"	5	1	1991	1998	8	x	
	2			10	2	1991	2003	11	2004	
	3			~15				0	x	
	4			24	2	1991	2003	9	2004	
1829	1	51°37'10"	5°07'36"	3	1	1996	1998	3	x	
	2			9	2	1992	2003	8	2004	
	3			~15				0	x	
	4			24	2	1992	2003	8	2004	
97	1	51°36'17"	5°14'51"	7	2	1980	2003	23	2004	
	2			13	2	1980	1980	1	x	
	3			23	2	1980	2003	21	2004	
1831	1	51°37'51"	5°11'23"	5	1	1991	1998	8	x	
	2			9	2	1991	2003	11	2004	
	3			~15				0	x	
	4			24	2	1991	2003	11	2004	
1868	1	51°40'19"	5°21'09"	4	1	1992	1998	7	x	
	2			9	2	1992	2003	10	2004	
	3			~15				0	x	
	4			19	2	1992	2003	8	2004	
1863	1	51°42'20"	5°36'49"	4	1	1992	1998	7	x	x
	2			10	2	1992	2003	10	2004	x
	3			14		2001	2001	1	2001	
	4			22	2	1992	2003	10	2004	x
1865	1	51°40'29"	5°34'01"	6	2	1992	2003	10	2004	
	2			~15				0	x	
	3			22	2	1992	2003	8	2004	
107	1	51°37'52"	5°57'38"	8	2	1980	2003	23	2004	x
	2			11	2	1980	2001	2	2001	
	3			24	2	1980	2003	21	2004	x
1804	1	51°30'14"	4°23'47"	9	2	1992	2003	10	2004	
	2			~15				0	x	
	3			22	2	1992	2003	8	2004	
1806	1	51°28'54"	4°26'59"	5	2	1992	2003	10	2004	x
	2			14		2001	2001	1	2001	
	3			23	2	1992	2003	10	2004	x
147	1	51°30'39"	4°39'39"	8	2	1980	2003	23	2004	
	2			13	2	1980	1980	1	x	
	3			24	2	1980	2003	21	2004	
1810	1	51°29'29"	4°43'06"	4	2	1991	2003	10	2004	
	2			8		2001	2001	1	2001	
	3			13	2	1992	2003	10	2004	
1809	1	51°28'49"	4°41'35"	6	2	1991	2003	11	2004	
	2			~15				0	x	
	3			19	2	1991	2003	9	2004	
1814	1	51°33'39"	4°42'22"	4	1	1992	1998	6	x	
	2			9	2	1991	2003	11	2004	
	3			~15				0	x	
	4			24	2	1991	2003	9	2004	
1815	1	51°31'29"	4°46'07"	6	2	1991	2003	11	2004	
	2			~15				0	x	
	3			26	2	1992	1998	7	x	
1813	1	51°32'45"	4°44'43"	5	1	1992	1998	7	x	
	2			8	2	1992	2003	10	2004	
	3			~15				0	x	
	4			25	2	1992	2003	8	2004	
1822	1	51°25'10"	4°46'28"	6	2	1991	2003	11	2004	
	2			11	2	1991	1998	8	x	
	3			16	2	1996	2003	6	2004	
	4			23	2	1992	1992	1	x	

151	1	51°31'13"	4°56'25"	6	2	1980	2003	23	2004	
	2			10	2	1980	1980	1	x	
	3			20	2	1981	2003	21	2004	
108	1	51°30'38"	5°08'02"	8	2	1980	2003	23	2004	x
	2			15	2	1980	2001	2	2001	
	3			24	2	1980	2003	20	2004	x
1826	1	51°28'44"	5°04'45"	4	2	1991	2003	10	2004	
	2			12	0	2001	2001	1	x	
	3			21	2	1991	2003	9	2004	
1823	1	51°26'32"	4°54'22"	8	2	1991	2003	10	2004	x
	2			12		2001	2001	1	2001	
	3			18	2	1992	2003	9	2004	x
1833	1	51°33'52"	5°21'31"	8	2	1991	2003	11	2004	x
	2			13		2001	2001	1	2001	
	3			19	2	1991	2003	11	2004	x
1840	1	51°26'39"	5°19'44"	5	1	1994	1998	4	x	x
	2			10	2	1991	2003	11	2004	x
	3			15		2001	2001	1	2001	
	4			25	2	1991	2003	11	2004	x
1853	1	51°31'40"	5°32'45"	6	1	1992	2003	8	2004	
	2			10	2	1992	2003	9	2004	
	3			15		2001	2001	1	2001	
	4			24	2	1992	2003	10	2004	
116	1	51°32'53"	5°44'29"	11	2	1980	2003	23	2004	
	2			17	2	1980	1980	1	x	
	3			25	2	1980	2003	21	2004	
1855	1	51°34'18"	5°36'39"	3	1	1992	1998	7	x	
	2			9	2	1992	2003	10	2004	
	3			~15				0	x	
	4			23	2	1992	2003	10	2004	
1851	1	51°26'31"	5°39'14"	9	2	1992	2003	10	2004	x
	2			12		2001	2001	1	2001	
	3			23	2	1992	2003	10	2004	x
122	1	51°34'10"	5°55'54"	9	2	1980	2003	23	2004	x
	2			13	2	1980	2001	2	2001	
	3			24	2	1980	2003	21	2004	x
1850	1	51°26'23"	5°50'59"	3	2	1992	2002	8	x	
	2			8	0	2001	2003	2	2004	
	3			19	2	1992	2003	8	2004	
124	1	51°17'33"	5°15'32"	9	2	1980	2003	23	2004	x
	2			14	2	1980	1984	2	x	
	3			26	2	1980	2003	20	2004	x
1841	1	51°20'54"	5°17'33"	4	1	1991	1998	8	x	
	2			9	2	1991	2003	11	2004	
	3			~15				0	x	
	4			22	2	1991	2003	11	2004	
1843	1	51°17'06"	5°18'21"	4	1	1991	1998	8	x	x
	2			8	2	1991	2003	11	2004	x
	3			14		2001	2001	1	2001	
	4			23	2	1991	2003	11	2004	x
1844	1	51°16'17"	5°14'35"	5	1	1991	1998	8	x	x
	2			8	2	1991	2003	11	2004	x
	3			~15				0	x	
	4			23	2	1991	2003	11	2004	x
125	1	51°20'33"	5°24'01"	12	2	1980	2003	23	2004	x
	2			17	2	1980	2001	2	2001	
	3			23	2	1980	2003	21	2004	x
1847	1	51°15'22"	5°34'27"	8	2	1991	2003	11	2004	x
	2			~15				0	x	
	3			24	2	1991	2003	11	2004	x
Total number of sampled screens:									**123**	**32**
	Provincial/National monitoring effort								72	
	additional samples								38	
2001	data from 2001sampling to be used for concentration-depth-profile									
2004	incorporated in 2004 Provincial/National monitoring effort									
x	to be sampled in this project									

Table 2.2. Research locations for regional scale trend analysis

Additional sampling is desired to complete the concentration-age-depth profiles of the 36 wells. Therefore the 2004 sampling survey (to be conducted in November and December of 2004 by UU./TNO) will be supplemented with analysis of the intermediate screens.

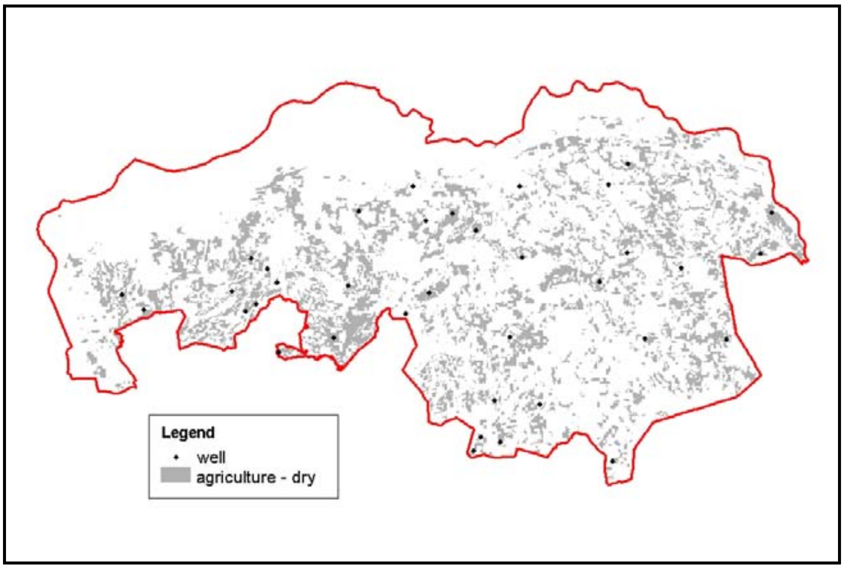

Figure 2.11. Groundwater quality data sets for the regional scale analysis: locations of wells and the extent of agricultural areas on sandy dry soils

Groundwater age dating is foreseen to reconstruct the age-depth profiles. Groundwater age dating will only be done for selected wells in agricultural recharge areas, because trends in those areas are anticipated to be most clearly detected. Depending on costs some *32* groundwater samples from 14 wells will be dated, by either CFC and/or ^{3}H/He methods. The laboratories should still be chosen on basis of analysis of costs and benefits. These wells are shown in Figure 2.12, together with the extent of the agriculture - recharge areas.

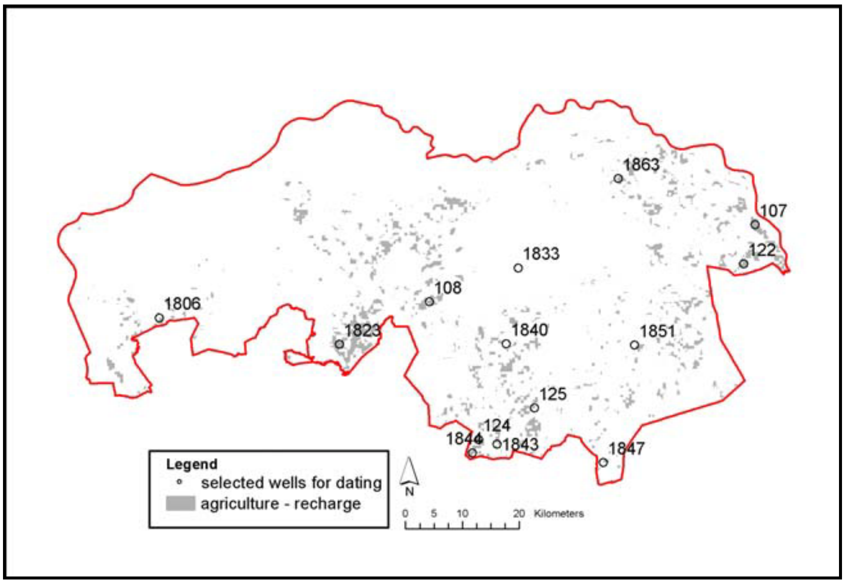

Figure 2.12: Selected wells for groundwater dating in agriculture - recharge areas.

2.10 Research locations: Upper Dommel Tributaries sub-catchment scale analysis

We have chosen 3 groundwater subsystems in the Meuse basin to investigate the trends in groundwater quality at the sub-catchment scale: Beekloop-Keersop, Buulder Aa and Run. These are all tributaries of the Dommel River. The characteristics of the area shown in Figure 2.13 are described in Table 2.3 The table shows the spatial variability in geology, related hydrology, land use and contaminant deposition history.

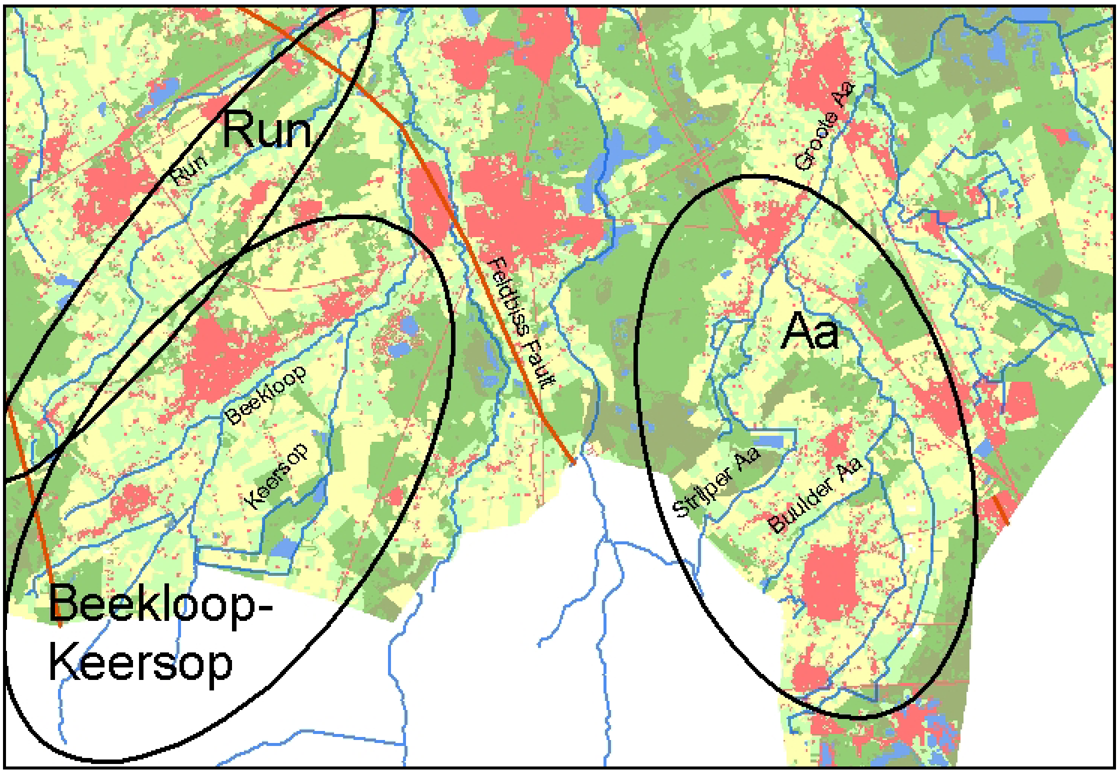

Figure 2.13: Location of the three tributaries for sub-catchment scale analysis, and locations of groundwater quality observation wells

Area	Geology	Land use	Zn/Cd deposition	N-deposition
Beekloop-Keersop	Sterksel: medium/ coarse sand and gravel	agricultural	intermediate	high
Aa	Boxtel: fine sand with loam and peat	mixed	high	intermediate
Run	Sterksel: medium/ coarse sand and gravel	agricultural	intermediate	intermediate

Table 2.3 Description of the three sub-catchments

In a study to the extent of the pollution from the zinc ore smelters in the upper Dommel / Kempen area (NITG 04-181-B), additional groundwater quality samples have been analyzed in 2002 and again in 2003. This study focused on both soil and groundwater pollution and samples were collected from open bore holes (1 m below the phreatic water table) and deeper permanent tubes. The types, locations and depths of the monitoring screens are presented in Table 2.4, together with the land use / hydrology class in which they are located. Also the screens are indicated in which we intend to collect additional samples. Note the two wells with multiple mini-screens providing a detailed concentration-depth profile.

All wells in the upper Dommel area with more than one screen or located in dry agricultural land are presented in Figure 2.14. Of those wells belonging to the provincial monitoring of groundwater quality network (PMG) are time series available. Data from the Kempen study has only been sampled twice (2002 and 2003).

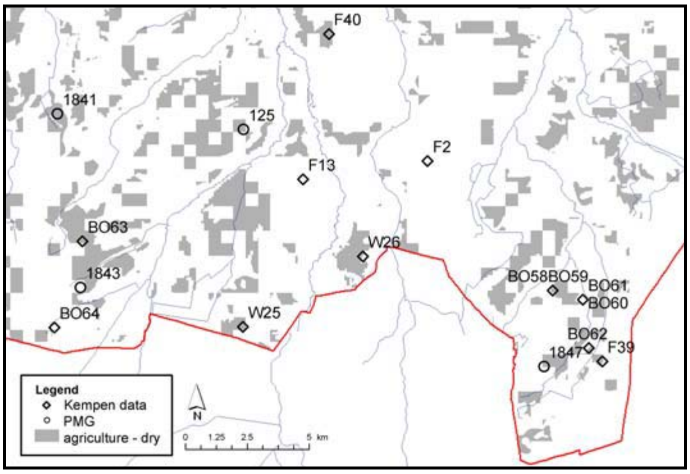

Figure 2.14: Wells of the Kempen study and the Provincial Monitoring network in the Upper Dommel area and the extent of the agricultural dry areas.

Reference				Location		Screen		Time Series			Sampling	
RIVM	screen	type	land	north	east	depth	length	begin	end	n	concentrations	age
BO58	1	g	a-d	51°17'02"	5°34'45"	11	1	2002	2003	2	?	
	2	g	a-d			22	1	2002	2002	1	?	
BO59	1	g	a-d	51°17'02"	5°34'45"	2	0.05	2002	2003	2	?	c
	2	g	a-d			3	0.05	2002	2003	2	?	c
	3	g	a-d			4	0.05	2002	2003	2	?	c
	4	g	a-d			7	0.05	2002	2003	2	?	c
	5	g	a-d			8	0.05	2002	2003	2	?	c
	6	g	a-d			9	0.05	2002	2003	2	?	c
	7	g	a-d			13	0.05	2002	2002	1	?	c
BO60	1	g	n-i	51°16'50"	5°35'48"	8	1	2002	2003	2	?	
	2	g	n-i			20	1	2002	2002	1	?	
BO61	1	g	n-i	51°16'50"	5°35'48"	1	0.05	2002	2003	2	?	c
	2	g	n-i			2	0.05	2002	2003	2	?	c
	3	g	n-i			3	0.05	2002	2003	2	?	c
	4	g	n-i			10	0.05	2002	2003	2	?	c
BO62	1	g	a-d	51°15'46"	5°36'00"	3	1	2002	2003	3	x	t
	2	g	a-d			9	1	2002	2002	1	x	t
BO63		ph	a-d	51°18'07"	5°18'25"		1	2002	2003	2		
	1	g	a-d			7	1	2002	2003	2		
	2	g	a-d			18	1	2002	2003	2		
BO64		ph	n-r	51°16'11"	5°17'29"		1	2002	2003	2		
	1	g	n-r	51°16'15"	5°17'26"	4	1	2002	2003	2	x	t
	2	g	n-r			14	2	2002	2003	2	x	t
F13		ph	n-r	51°19'28"	5°26'08"		1	2002	2003	3		
	1	g	n-r	51°19'28"	5°26'04"	4	1	2002	2003	2		
	2	g	n-r			17	2	2002	2003	2		
F2		ph	n-r	51°19'52"	5°30'25"		1	2002	2003	2		
	1	g	n-r			4	1	2002	2003	2		
	2	g	n-r			32	2	2002	2002	1		
F39		ph	a-d	51°15'29"	5°36'29"		1	2002	2003	2		
F40	1	g	a-d	51°22'37"	5°26'50"	4	1	2002	2003	2		
L19		ph	a-d	51°23'21"	5°48'14"		1	2002	2002	1		
W25		ph	a-d	51°16'19"	5°24'01"		1	2002	2003	2		
W26		ph	a-d	51°17'48"	5°28'04"		1	2002	2003	2		
Type:						Land:						
	g	groundwater					a-d	agricultural - dry				
	ph	phreatic					n-i	natural - intermediate				
							n-r	natural - recharge				
Sampling:						Dating:						
	x	to be sampled in this project					t	optionally to be dated with Tritium/Helium				
	?	optionally to be sampled					c	optionally to be dated with CFC				

Table 2.4. Research locations of tributary scale analysis.

3. Spatial dataset for Meuse BE (ULg)

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3.1 Introduction to the Walloon Meuse basin

The Meuse is the main river in the Walloon part of Belgium. The river drains the northern part of France, where streambed and basin are not very large, flowing through Belgium and the Netherlands to the North Sea. The Meuse basin in the Walloon region is more developed than in France and the network of tributaries is well developed.

The surface of the whole basin is 36.000 Km^2, of which 38.75% is located in the Walloon region (about 14.000 Km^2). This means that 45.7% of Belgium (Haddouchi, 1987) and ¾ of the Walloon region is drained by the Meuse basin (Figure 3.1).

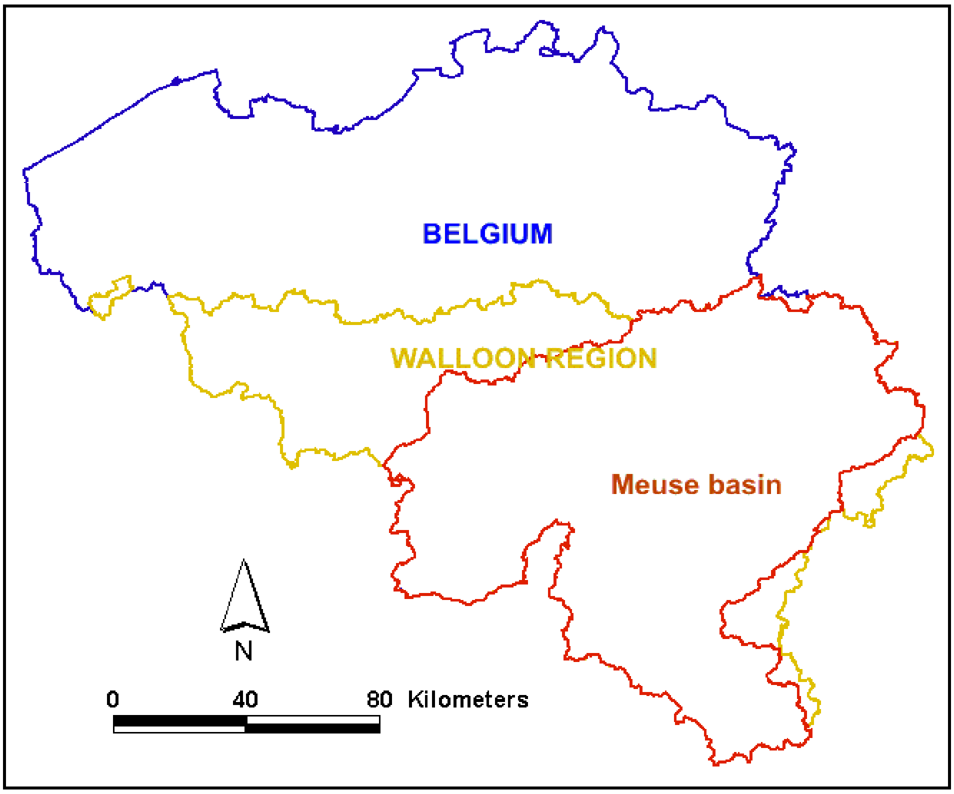

Figure 3.1. Walloon Meuse basin situation.

A total of 182.64 km of the river flows in the Walloon region, which is 20% of the total length of the river (925 km) (Figure 3.2).

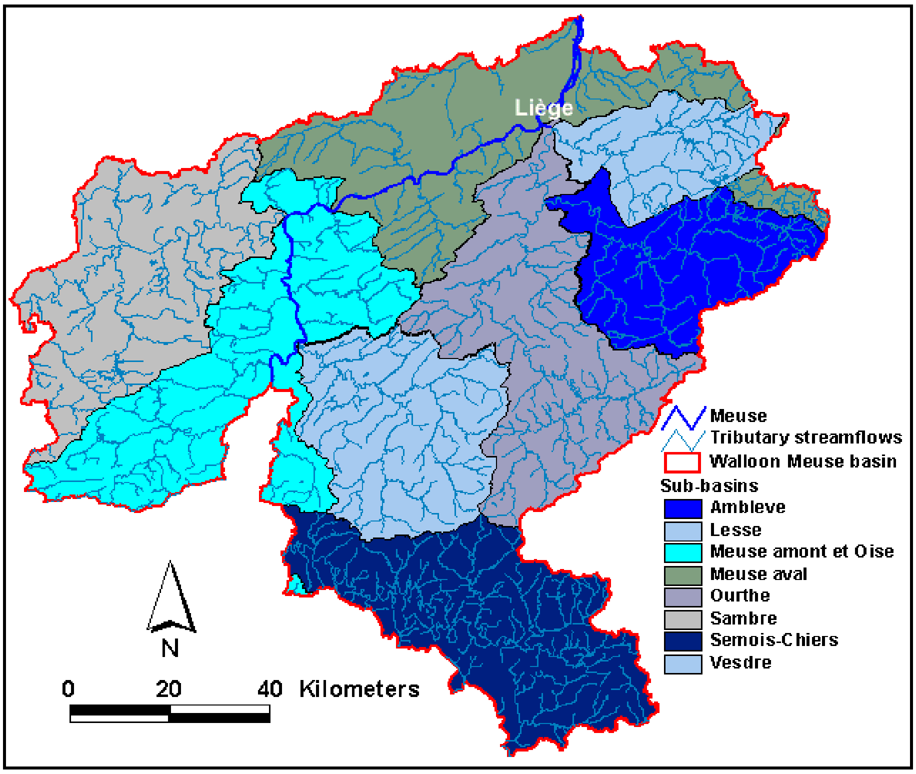

Figure 3.2. Sub-basin division and streamflow network in the Walloon Meuse basin.

3.2 Subdivision of groundwater systems

According to the application of European Water Framework Directive, the aquifers of the Walloon Region have been subdivided in groundwater bodies. This subdivision is based on both hydrogeological and non-hydrogeological criteria. The hydrogeological criteria considered for the groundwater delimitation are:

- geology features
- hydrological basins
- groundwater divide
- hydraulic connexion between geological layers
- surface water and terrestrial ecosystems connexion
- hydrochemical properties (chemical features originated by pollution are not concerned)
- unconfined or confined aquifer

The non-hydrogeological criteria considered for the groundwater delimitation are:

- existence of groundwater catchments (or the possibility that they exist)
- topographical divide between water basins (watershed divide)
- administrative limits

Based on these criteria, 48 groundwater bodies have been delineated in Walloon Region. Among them, 30 are located in the Meuse basin (Figure 3.3). Codes and names of the 30-groundwater bodies located in the Walloon part of the Meuse basin are listed in Table 3.1.

Groundwater body code	Groundwater body name
RWE 051/160	Bruxellian and Landenian sands / Cambro-Silurian bedrock of Brabant
RWE 053/040	Landenian sands / Cretaceous chalk of Hesbaye
RWM 011	North bank Meuse limestone
RWM 012	South bank of the Meuse limestone
RWM 015/011	Shales of the Sambre basin / North bank Meuse limestone
RWM 015/012	Shales of the Sambre basin / South bank Meuse limestone
RWM 016	Shales of the Liège basin
RWM 016/011	Shales of the Liège basin / North bank Meuse limestone
RWM 021	Carboniferous limestone of Dinant synclinorium (Néblon basin)
RWM 022	Devonian limestone of North bank of Dinant synclinorium
RWM 023	Devonian limestone of South bank of Dinant synclinorium
RWM 040	Cretaceous chalk of Hesbaye (Hesbaye)
RWM 041	Chalk and bedrock of Méhaigne
RWM 041/160	Chalk and bedrock of Méhaigne / Cambro-Silurian bedrock of Brabant
RWM 052	Bruxellian and Landenian sands of the Meuse basin
RWM 071	Alluvial plain from Givet to Namur (Alluvial plain)
RWM 072	Alluvial plain from Namur to Lixhe (Alluvial plain)
RWM 073	Alluvial plain downstream of Lixhe (Alluvial plain)
RWM 091	Rhetian conglomerate (upper Trias)
RWM 092/091	Lower Lias (Sinemurian) / Rhetian conglomerates (upper Trias)
RWM 092	Lower Lias (Sinemurian)
RWM 093	Upper Lias (Domerian)
RWM 094	Bajocian – Bathonian limestone (Dogger)
RWM 100	Sandstone and shales of Ardennes massif
RWM 141	Sandstone and limestone of Gueule basin
RWM 142	Sandstone and limestone of Vesdre basin
RWM 151	Aachen and Limburg cretaceous chalk (Pays de Herve)
RWM 151/141	Aachen and Limburg cretaceous chalk / Sandstone and limestone of Gueule basin
RWM 103	Semois, Houille and Viroin sandstone and shales
RWM 102	Roer sandstone and shales

Table 3.1. Groundwater bodies' subdivision in Wallonia situated in the Walloon Meuse basin.

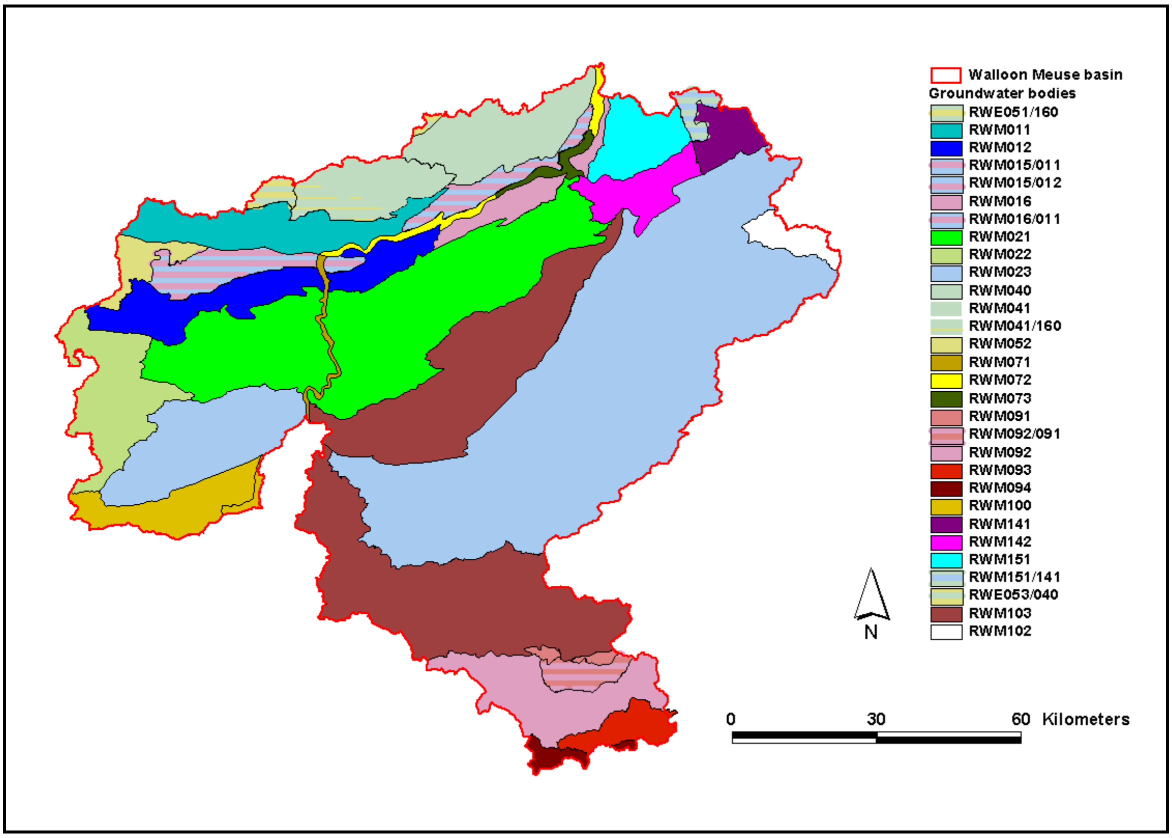

Figure 3.3. Groundwater bodies subdivision in the Walloon Meuse basin.

3.3 General nitrate survey network

In the Walloon region, the nitrate survey network contains 957 observation points. Among these points, 752 are located in the Walloon Meuse basin (Figure 3.4). Pumping/control wells (boreholes and traditional wells), piezometers and springs are considered among these observation points. This network provides a spatial and temporal representation of nitrate contents. Nevertheless, many blanks exist in the available data sets, compromising in some regions the chances to perform a reliable trend analysis. The monitoring data are provided by the Wallloon government and Wallonian water supply companies.

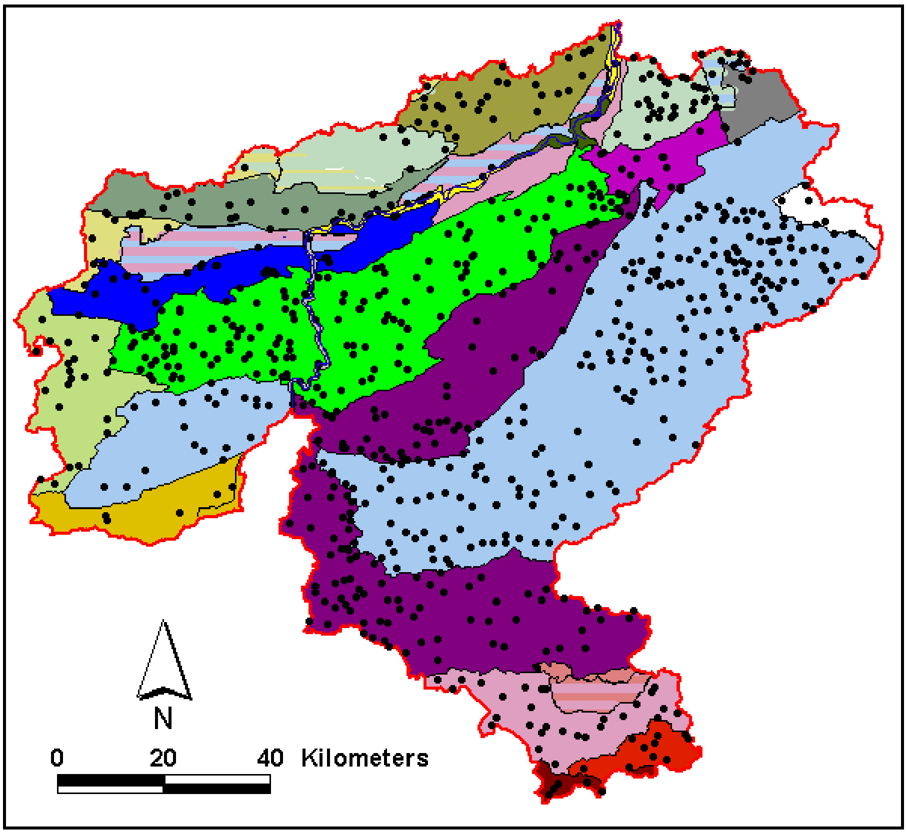

Figure 3.4. Nitrate survey network in Walloon Meuse basin.

3.4 Groundwater bodies pre-selected for trend analysis in the frame of WP TREND 2

Four groundwater bodies have been pre-selected for the TREND 2 investigations: the Cretaceous chalk of Hesbaye (RWM 040), the Aachen and Limburg cretaceous chalk (RWM 151), the alluvial plain of the river Meuse (RWM 071 - RWM 073) and the Néblon basin which is a sub-basin of the Dinant synclinorium (RWM 021) (Figure 3.5). From now, these groundwater bodies will be referred as *Cretaceous of Hesbaye* for the RWM 040, *Cretaceous of Pays de Herve* for the RWM 151, *Alluvial plain* for the RWM 071 - RWM 073 and *Néblon basin*.

These groundwater bodies are representative of various hydrogeological contexts of Walloon Region. Furthermore, an initial characterization has already been performed in the scope of the European Water Framework Directive implementation.

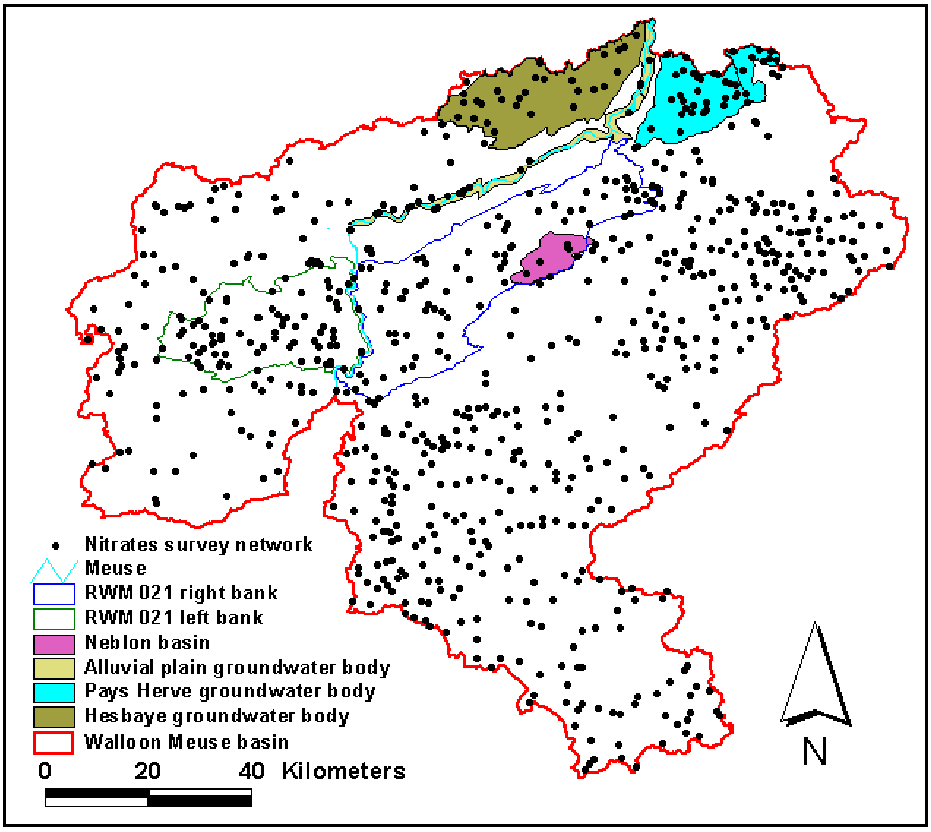

Figure 3.5. Location of groundwater bodies pre-selected for TREND 2: Cretaceous chalk of Hesbaye (RWM 040); Cretaceous chalk of Pays Herve (RWM 021); alluvial plain of the river Meuse (RWM 072 and RWM 073); Néblon basin (part of the synclinorium of Dinant–RWM 021).

Because groundwater quality data are still awaited, it is possible that the choice will be updated if interesting datasets become available.

3.4.1 The Cretaceous chalk of Hesbaye (RWM 040)

The Hesbaye chalk groundwater body is located North-West from Liège. The Geer River, tributary of the Meuse down-stream from Liège, drains the chalk aquifer. This groundwater body has a total area of 440 Km^2.

The Hesbaye aquifer has been investigated for years (Brouyère et al., 2004a, 2004b; Dassargues & Monjoie 1993; Hallet 1999). It is a fissured, dual-porosity aquifer. The large porosity of the chalk provides it with a large water storage capacity. The intense fissure network drains groundwater stored in the chalk. The mean annual pumping rate is of 25 millions of m^3/year (pumped out by galleries and pumping wells) for supplying the cities of Liège and its suburbs, as well as an important number of little villages in the Hesbaye region.

The CILE water company (Intercommunal Water Company of Liège) owns more than 40 km of galleries for pumping groundwater from the aquifer. The SWDE (Walloon Society of Water Distribution) owns several wells located in this zone. In the nitrate survey network, 27 observation points are located in the chalk aquifer (Figure 3.6). Supplementing, nitrate datasets are also available at 5 other observation points not included in the network. The new monitoring network, defined following the regulations of the EU Water Directive, contains 14 points.

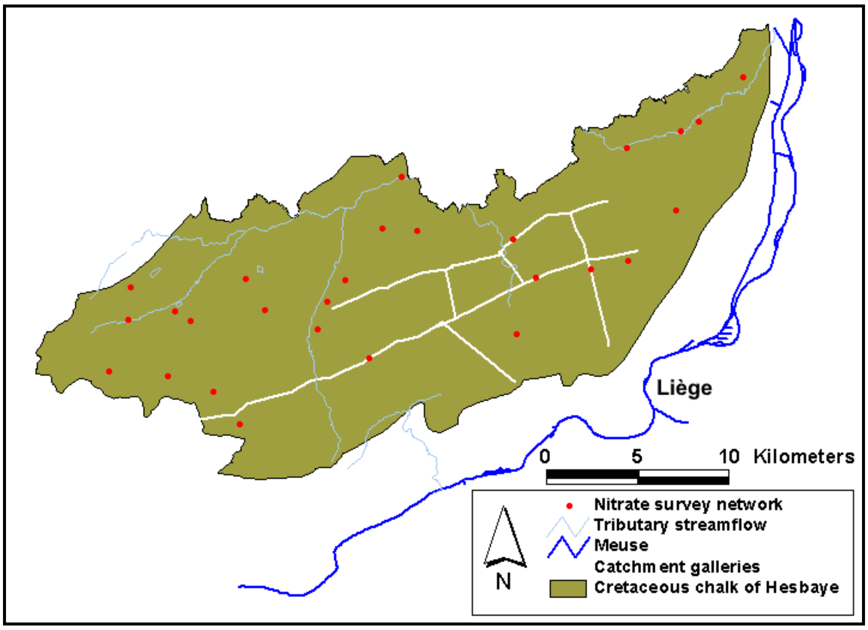

Figure 3.6. Nitrate survey network in cretaceous chalk of Hesbaye groundwater body.

The Hesbaye is a rural territory: 85% used for permanent and seasonal meadowlands; 10 % of land for residential use; 5% for industries, quarries….

3.4.2 The Aachen and Limburg cretaceous chalk (RWM 151) - Cretaceous chalk of Pays de Herve

The groundwater body of Pays de Herve is located North-East from Liège close to the border with Germany. It has a surface of 285 km^2. Major problems are encountered in this groundwater body because nitrate contents are very high.

Three aquifers are located in this body:

- **a.** Fissured shale/sandstone aquifer (low capacity)
- **b.** Cretaceous chalk and sandy aquifer
- **c.** Quaternary aquifers

Among these aquifers, the most important is the cretaceous chalk because the sandstone/shale aquifer has a low permeability and the quaternary aquifers are very local.

The cretaceous aquifers (Gulpen chalk and Aachen sands) are the main groundwater resources, with a mean pumping rate of 12 million of m^3/year from the chalk aquifer. The nitrate survey network contains 38 observation points (Figure 3.7). Supplementing, nitrate datasets are also available at 21 other observation points not included in the network. In this groundwater body, nitrate concentrations are, in some locations, close to or higher than 40 mg/l. The new monitoring network defined following the regulations of the EU Water Directive contains 9 points.

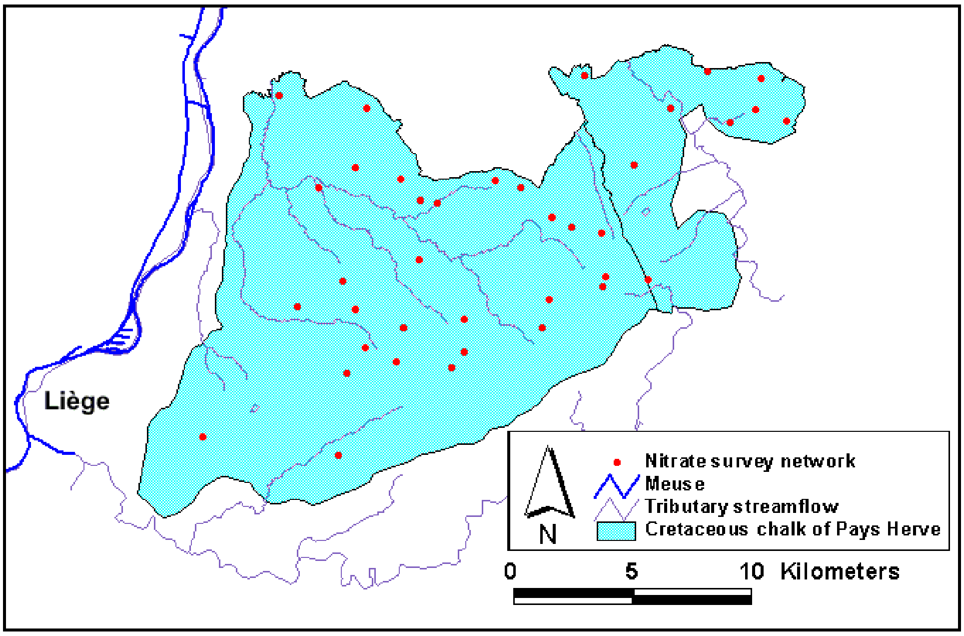

Figure 3.7. Nitrate survey network in cretaceous chalk of Pays Herve groundwater body.

Land use is similar to that in the Hesbaye region: more than 80 % of the territory used for permanent and seasonal meadowlands, 10% of forests and 10% for residential and industrial activities.

3.4.3 The Néblon basin (sub-basin of the Dinant synclinorium RWM 021)

This basin, with an area of 65 km^2, is located South-East from Liège in the synclinorium of Dinant (succession of Devonian sandstone and shales and Carboniferous limestones) (groundwater body RWM 021), on the right bank of the Meuse river (Figure 3.3). This basin has been investigated recently for the evaluation of groundwater vulnerability (Popescu et al., 2004).

The geology of the basin is characterized by sequences of anticlines and synclines oriented North-East / South-West. The platform is formed by Palaeozoic formations, from low Devonian (Praguian) in the basis to middle Carboniferous formations (Namurian) in the bottom. Low limestone Carboniferous formations (Turnesian and Visean) are at the surface in 75 % of the area. (Figure 3.8) Tertiary and Quaternary deposits are filling paleokarsts developed in the Carboniferous limestone and in the river valleys.

The main aquifer in this basin is located in the Carboniferous limestone, with more than 500 meters thickness of folded and karstified limestone.

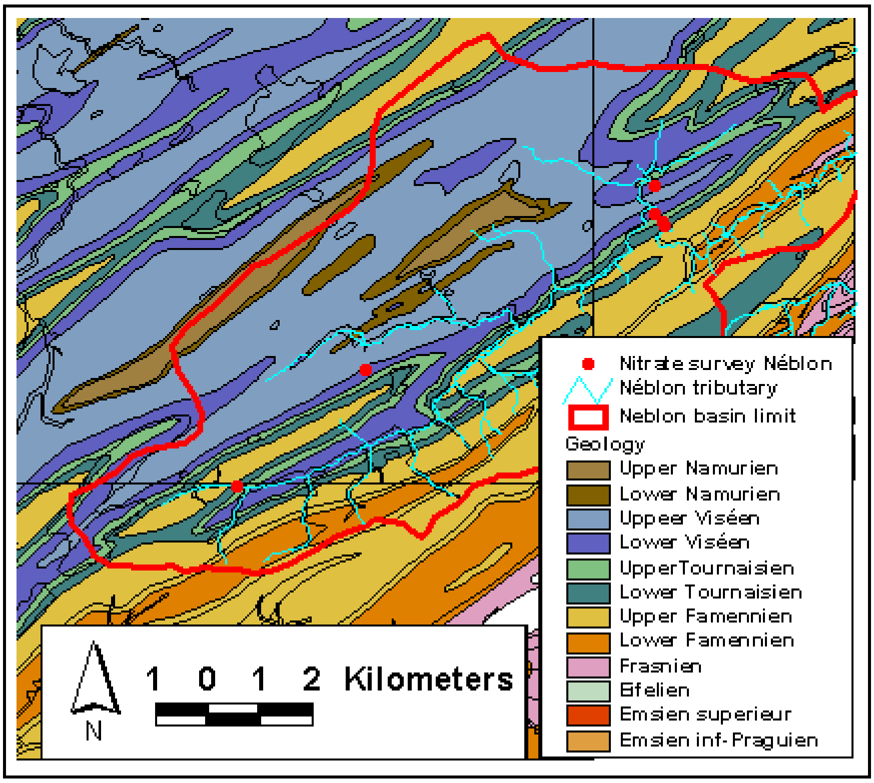

Figure 3.8. Nitrate survey network in Néblon basin. Geology is showed, together with the Néblon streamflow.

Nitrate concentrations in groundwater have been monitored since 1979, showing a total increase of 5 mg/l during the last 10 years. The nitrate survey network contains 6 observation points in the Néblon basin (Figure 3.8). The new monitoring network, defined following the regulations of the EU Water Directive, contains 5 points.

About 50 % of the basin is used for permanent meadows, 25 % by seasonal meadows; in 24 % we find forests and 1% for residential and industrial land uses.

3.4.4 The Alluvial plain groundwater body (RWM 071 - RWM 073)

Because of the important industrial activities, especially between Namur and Liège, various types of contaminants affect the alluvial plain of the Meuse River. The groundwater body has an area of 125 km^2 and a length of 80 km.

The „classical“ geology of the alluvial plain is made of gravel bodies embedded in old, meandering channels of the river filled with clay, silt and sandy sediments. From bottom to top of the alluvial layer, a gradation is often observed with well sorted aquifer gravels at the bottom overlain by sandy to loamy gravels of lower hydraulic conductivity.

Nitrate concentration has been monitored for years. The nitrate survey network contains 24 observation points (Figure 3.9). Supplementing, nitrate datasets are also available at 23 other observation points not included in the network. The new monitoring network, defined following the regulations of the EU Water Directive, contains 13 points. At a first glance, nitrate concentrations are relatively low and there are no significant variations. Locally, concentrations close to 40 mg/l may be observed. Other contaminants (industrial etc) are present but the availability and continuity of datasets have to be confirmed.

In the alluvial plain, land use is distributed as follows: 40% for residential and industrial activities; the Meuse streamflow, permanent and seasonal meadowlands and forests represent 60% of the land.

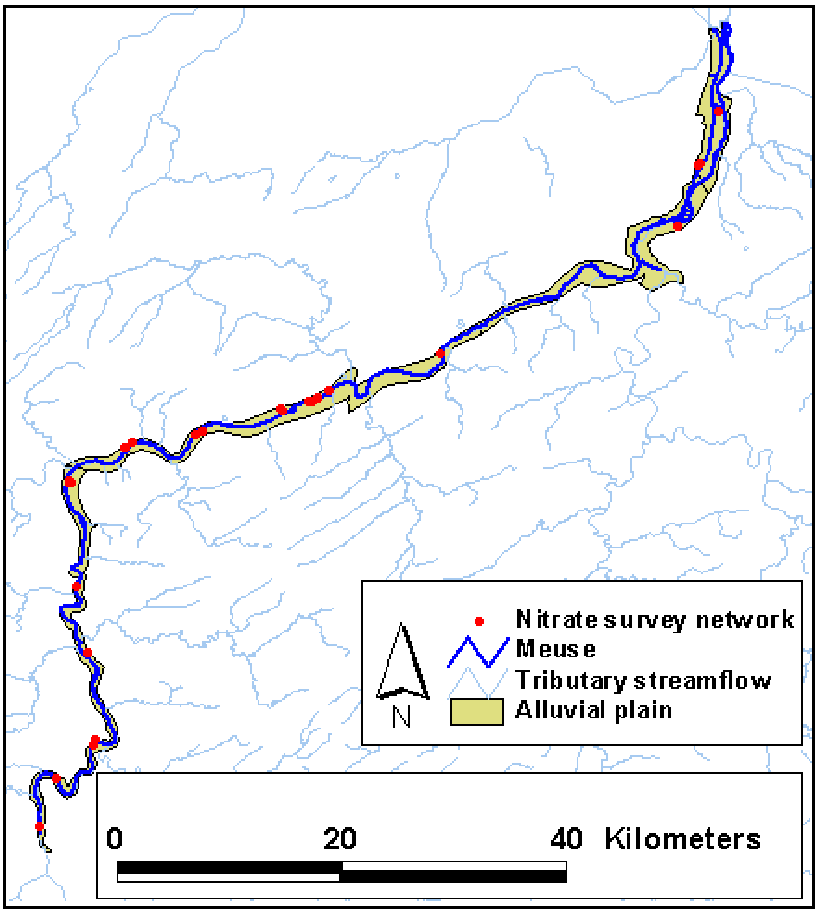

Figure 3.9. Nitrate survey network in alluvial plain groundwater body.

Table 3.2 summarizes the nitrate survey network observation points for the pre-selected groundwater bodies. In Tables 3.3, 3.4, 3.5 and 3.6 (at the end of this section) overall observation points with nitrate data are documented (in red are the points not included in the new monitoring network for nitrates).

	Observation points from the nitrate survey network	**Other observation points** (with nitrate data sets)	**Total of observation points**
Cretaceous chalk of Hesbaye (RWM 040)	27	5	32
Aachen and Limburg cretaceous chalk (RWM 151) – Pays Herve-	38	21	59
Néblon basin (RWM 021)	6	0	6
Alluvial plain (RWM 071 - RWM 073)	24	23	47

Table 3.2. Summary of observation points in the pre-selected groundwater bodies.

Table 3.3. Available data of nitrate survey network for Cretaceous chalk of Hesbaye (RWM 040)

Code	Latitude (N)	Longitude (E)	Type of observation point	Pumping / control point	Time series		Number of data samples	Sampling time step (monthly, seasonal...)	Extension of completed time series (years)
					Start	End[*]			
3388001	55° 44' 07.65"	005° 23' 18.38"	Borehole	Pumping (water supply)	1994	2003	126	+/- Irregular	1994 – 2003
3465001	50° 45' 36.56"	005° 37' 05.45"	Traditional well	Pumping (water supply)	1994	2003	123	Bimonthly	1994 – 1998
								Monthly	2000 – 2003
3466001	50° 46' 53.24"	005° 39' 08.74"	Borehole	Pumping (water supply)	1958	2002	101	Annual, Seasonal…	
3467001	50° 44' 53.53"	005° 33' 42.79"	Borehole	Pumping (water supply)	1994	2002	131	+/- Seasonal	1994 – 2002
3468001	50° 45' 20.13"	005v36' 13.17"	Borehole	Pumping (water supply)	1994	2003	123	+/- Seasonal (weekly for 2003)	1994 – 1998
									2000 – 2003
4125001	50° 41' 01.31"	005° 10' 43.42"	Borehole	Pumping (agriculture)	2003	2003	1	Annual	-
4126007	50° 40' 17.07"	005° 12' 46.01"	Traditional well	Pumping (agriculture)	2003	2003	1	Annual	-
4128005	50° 40' 04.37"	005° 10' 34.80"	Borehole	Pumping (industrial)	1992	2003	14	Annual	1996 – 2000
4128024	50° 38' 33.37"	005° 09' 41.78"	Borehole	Pumping (agriculture)	2003	2003	1	Annual	-
4135004	50° 41' 13.69"	005° 16' 03.43"	Borehole	Pumping (water supply)	1958	2002	75	Annual	1970 – 1984
								Seasonal	1990 – 2002
4135006	50° 40' 18.36"	005° 16' 55.50"	Borehole	Pumping (water supply)	1976	2002	57	Annual	1976 – 1979
								Seasonal / Annual	1986 – 2002
4136001	50° 40' 32.75"	005° 19' 48.71"	Borehole	Pumping (water supply)	1957	2002	223	Annual	1976 – 1984
								Annual	1986 – 1990
								Annual / Seasonal	1991 – 2002
4137002	50° 40' 00.97"	005° 13' 27.48"	Borehole	Pumping (agriculture)	2003	2003	1	Annual	-
4139009	50° 39' 43.57"	005° 19' 20.72"	Traditional well	Control	2003	2003	1	Annual	-
4142001	50° 42' 31.16"	005° 23' 59.11"	Borehole	Pumping (industrial)	2003	2003	1	Annual	-
4142003	50° 42' 37.82"	005° 22' 24.44"	Borehole	Pumping (water supply)	1957	2000	245	Annual	1965 – 1974
								Biannual	1976 – 1988
								Monthly	1989 – 2002
4144004	50° 41' 10.22"	005° 20' 39.45"	Borehole	Pumping (water supply)	1998	2002	14	Seasonal	1998 – 2002
4147001	50° 38' 50.62"	005° 21' 43.97"	Traditional well	Pumping (water supply)	1990	2002	112	Annual	1990 – 1993
								Seasonal	1994 – 2002

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[*] For most of these points, data will be available for 2004 at the beginning of 2005.

Code	Latitude (N)	Longitude (E)	Type of observation point	Pumping / control point	Time series		Number of data samples	Sampling time step (monthly, seasonal...)	Extension of completed time series (years)
					Start	End*			
4163003	50° 38' 25.09"	005° 12' 22.02"	Traditional well	Pumping (agriculture)	1997	1997	1	Annual	-
4171004	50° 37' 55.84"	005° 14' 29.79"	Borehole	Pumping (agriculture)	1998	1998	1	Annual	-
4172004	50° 36' 59.03"	005° 15' 42.71"	Traditional well	Control	2003	2003	1	Annual	-
4211001	50° 42' 15.21"	005° 28' 24.00"	Traditional well	Pumping (water supply)	1990	2002	116	Annual	1990 – 1992
								Monthly	1993 – 2002
4215001	50° 41' 09.52"	005° 29' 23.90"	Traditional well	Pumping (water supply)	1991	2002	234	Weekly	1991 – 1993
								Monthly	1994 – 2002
4216005	50° 41' 21.72"	005° 31' 56.59"	Traditional well	Pumping (water supply)	1998	2002	347	Weekly	1988 – 1993
								Monthly	1994 – 2002
4217007	50° 39' 30.80"	005° 28' 29.57"	Borehole	Control	2003	2003	2	Annual	-
4222001	50° 43' 02.03"	005° 35' 56.04"	Borehole	Pumping (particular)	2003	2003	1	Annual	-
4224005	50° 41' 36.85"	005° 33' 41.23"	Traditional well	Pumping (agriculture)	2003	2003	1	Annual	-
4128004	50° 40' 13.16"	005° 10' 32.66"	Borehole	Pumping (industrial)	1992	2002	9	Irregular	-
4135001	50° 41' 10.11"	005° 16' 06.42"	Borehole	Pumping (water supply)	1957	2002	35	Annual	1987 – 1992
								Seasonal	1994 – 1996
								Irregular	1997 – 2002
4135007	50° 40' 35.15"	005° 16' 39.88"	Borehole	Pumping (water supply)	1976	2002	54	Biannual	1976 – 1978
								Annual	1987 – 1989
								Seasonal / Bimonthly	1993 – 2002
4219004	50° 39' 08.44"	005° 32' 43.91"	Gallery with well	Pumping (water supply)	1982	2002	1648	Annual / Twice per year	1982 – 1987
								Twice per week	1988 – 1993
								Twice per month	1994 – 2002
4251001	50° 38' 07.88"	005° 28' 22.07"	Gallery with well	Pumping (water supply)	1982	2002	1383	Annual	1982 – 1985
								Biannual	1986 – 1987
								Three per week	1990 – 1992
								Twice per week	1993
								Weekly	1994 – 2002

∉# For most of these points, data will be available for 2004 at the beginning of 2005.

∉#

Table 3.4. Available data of nitrate survey network for Aachen and Limburg Cretaceous chalk *-Pays d'Herve-* (RWM 151)

Code	Latitude (N)	Longitude (E)	Observation point type	Observation / Pumping point	Time series		Number of data samples	Sampling time step (monthly, seasonal...)	Extension of completed time series (years)
					Start	End*			
3478006	50° 44' 45.92"	005° 43' 50.71"	Traditional well	Pumping (water supply)	1986	2003	4	Irregular	-
3558004	50° 45' 03.46"	005° 54' 37.68"	Traditional well	Pumping (particular)	1999	2002	2	Irregular	-
3558017	50° 41' 32.64"	005° 55' 09.01"	Traditional well	Pumping (agriculture)	2002	2003	2	Annual	2002 – 2003
3558024	50° 44' 17.64"	005° 57' 39.82"	Spring	Pumping (agriculture)	2003	2003	1	Annual	-
3559001	50° 45' 06.20"	005° 59' 00.10"	Spring	Pumping (camping)	2002	2002	1	Annual	-
3559003	50° 43' 56.79"	005° 59' 47.14"	Spring	Pumping (water supply)	1994	2000	16	Biannual Seasonal	1994 – 1996 1997 – 2000
3559004	50° 44' 12.24"	006° 00' 39.71"	Drain	Pumping (water supply)	1990	2000	31	Irregular	1990 – 2000
3567002	50° 43' 57.70"	006° 01' 46.53"	Spring	Pumping (water supply)	1995	2000	5	Annual	1998 – 2000
3567003	50° 44' 55.42"	006° 00' 53.72"	Drain	Pumping (water supply)	1990	2002	32	Annual Seasonal	1990 – 1993 1994 – 2002
4232004	50° 44' 25.41"	005° 46' 57.84"	Borehole	Pumping (agriculture)	1986	2003	6	Irregular	2002 – 2003
4233004	50° 42' 39.38"	005° 45' 11.17"	Spring	Control	1986	2003	5	Irregular	2002 – 2003
4233005	50° 43' 05.64"	005° 46' 31.68"	Spring	Control	2003	2003	2	Biannual	-
4235002	50° 40' 02.33"	005° 44' 21.74"	Traditional well	Control	1986	2003	4	Irregular	-
4236001	50° 40' 36.28"	005° 46' 00.02"	Gallery	Pumping (water supply)	1985	2002	282	Irregular Weekly / Twice per month	1985 – 1988 1989 - 2002
4239001	50° 38' 30.80"	005° 46' 04.45"	Spring	Pumping (water supply)	1982	2003	268	Annual Twice per month	1982 – 1984 1989 - 1998
4239006	50° 39' 05.88"	005° 46' 45.61"	Spring	Pumping (particular)	2002	2003	3	Biannual	2002 – 2003
4241005	50° 42' 19.90"	005° 48' 47.34"	Spring	Control	2003	2003	2	Biannual	-
4241006	50° 42' 50.21"	005° 48' 06.87"	Spring	Control	2003	2003	2	Biannual	-
4242012	50° 42' 15.28"	005° 49' 23.28"	Traditional well	Pumping (particular)	1986	2003	5	Irregular	2002 – 2003
4242029	50° 42' 45.38"	005° 51' 26.98"	Traditional well	Control	1986	2003	4	Irregular	2002 – 2003
4243010	50° 41' 54.10"	005° 53' 23.19"	Spring	Pumping (agriculture)	1986	2003	4	Irregular	2002 – 2003
4243011	50° 42' 34.61"	005° 52' 16.95"	Spring	Pumping (agriculture)	1986	2003	5	Irregular	2002 – 2003
4244002	50° 41' 01.33"	005° 48' 43.30"	Spring	Control	2002	2003	2	Annual	2002 – 2003
4246007	50° 40' 04.96"	005° 53' 14.58"	Spring	Control	1986	2003	5	Irregular	2002 – 2003
4247003	50° 38' 44.90"	005° 47' 49.74"	Gallery with well	Pumping (industrial)	1986	2003	4	Irregular	2002 – 2003

Code	Latitude (N)	Longitude (E)	Observation point type	Observation / Pumping point	Time series		Number of data samples	Sampling time step (monthly, seasonal...)	Extension of completed time series (years)
					Start	End*			
4247031	50° 39' 56.98"	005° 46' 24.83"	Traditional well	Pumping (agriculture)	1986	2003	5	Irregular	2002 – 2003
4247088	50° 39' 31.81"	005° 48' 04.91"	Spring	Control	2002	2003	3	Biannual	2002 – 2003
4248003	50° 39' 41.58"	005° 50' 15.22"	Traditional well	Pumping (agriculture)	2002	2003	2	Annual	2002 – 2003
4248006	50° 38' 37.16"	005° 49' 45.07"	Borehole	Pumping (particular)	2002	2003	3	Biannual	2002 – 2003
4248007	50° 38' 57.18"	005° 50' 14.71"	Borehole	Pumping (particular)	1986	2003	3	Irregular	-
4249056	50° 39' 27.95"	005° 52' 58.11"	Spring	Control	1986	2003	5	Irregular	2002 – 2003
4271003	50° 37' 09.91"	005° 40' 55.25"	Traditional well	Control	1986	2003	5	Irregular	2002 – 2003
4273003	50° 36' 40.03"	005° 45' 42.85"	Traditional well	Pumping (particular)	2002	2002	1	Annual	-
4311006	50° 41' 41.25"	005° 54' 05.08"	Borehole	Pumping (water supply)	1986	2003	6	Irregular	2002 – 2003
4312003	50° 43' 02.33"	005° 56' 19.78"	Traditional well	Pumping (agriculture)	1986	2003	5	Irregular	2002 – 2003
4314008	50° 40' 33.82"	005° 55' 16.14"	Borehole	Pumping (industrial)	1986	2003	6	Irregular	2002 – 2003
4315002	50° 40' 29.86"	005° 56' 44.25"	Spring	Pumping (industrial)	1986	2002	4	Irregular	-
4318003	50° 40' 20.15"	005° 55' 07.14"	Traditional well	Pumping (particular)	1999	2002	2	Irregular	-
3478002	50° 43' 52.28"	005° 43' 56.55"	Drain	Pumping (water supply)	1980	1994	8	Annual	1980 – 1985
3557003	50° 44' 16.82"	005° 55' 03.75"	Borehole	Pumping (agriculture)	2003	2003	1	Annual	-
3559002	50° 45' 03.35"	006° 00' 42.51"	Drain	Pumping (water supply)	1990	2002	33	Annual	1990 – 1993
								Seasonal	1994 – 2002
4233002	50° 42' 07.47"	005° 46' 16.34"	Traditional well	Pumping (agriculture)	2002	2002	1	Annual	-
4238003	50° 38' 26.70"	005° 44' 05.72"	Traditional well	Pumping (industrial)	1986	2002	3	Irregular	-
4242004	50° 41' 50.12"	005° 50' 33.96"	Borehole	Pumping (agriculture)	2002	2002	1	Annual	-
4242018	50° 41' 49.84"	005° 50' 55.76"	Traditional well	Pumping (industrial)	1986	1999	2	Irregular	-
4242047	50° 41' 52.53"	005° 49' 30.73"	Traditional well	Control	1986	1999	2	Irregular	-
4243005	50° 42' 11.19"	005° 51' 47.92"	Borehole	Pumping (industrial)	2000	2002	3	Annual	2000 – 2002
4245003	50° 40' 34.79"	005° 50' 26.41"	Borehole	Pumping (agriculture)	2002	2002	1	Annual	-
4246006	50° 40' 12.13"	005° 52' 08.08"	Traditional well	Pumping (agriculture)	1986	1999	2	Irregular	-
4247001	50° 39' 25.66"	005° 48' 43.99"	Gallery	Pumping (water supply)	1984	1992	48	Irregular	1986 – 1992
4247082	50° 38' 49.29"	005° 48' 40.28"	Traditional well	Pumping (industrial)	1986	1999	2	Irregular	-

Code	Latitude (N)	Longitude (E)	Observation point type	Observation / Pumping point	Time series		Number of data samples	Sampling time step (monthly, seasonal...)	Extension of completed time series (years)
					Start	End*			
4247083	50° 39' 21.56"	005° 47' 13.78"	Borehole	Control	2001	2003	5	Biannual	2001 – 2003
4248004	50° 39' 07.29"	005° 51' 30.28"	Borehole	Pumping (agriculture)	2002	2002	1	Annual	-
4249054	50° 39' 50.78"	005° 53' 47.23"	Traditional well	Pumping (industrial)	1986	2003	5	Irregular	2002 – 2003
4271001	50° 37' 01.03"	005° 41' 07.31"	Gallery with well	Pumping (industrial)	1991	2001	5	Irregular	-
4273001	50° 37' 50.15"	005° 46' 20.04"	Borehole	Pumping (agriculture)	2002	2002	1	Annual	-
4311002	50° 43' 22.85"	005° 54' 30.21"	Borehole	Pumping (industrial)	2002	2002	1	Annual	-
4312001	50° 42' 50.11"	005° 56' 37.72"	Gallery with well	Pumping (water supply)	1988	1988	1	Annual	-
4314001	50° 41' 16.84"	005° 55' 28.87"	Gallery with well	Pumping (water supply)	1991	1991	1	Annual	-

Table 3.5. Available data of nitrate survey network for the Néblon basin (sub-basin of the Dinant synclinorium RWM 021)

Code	Latitude (N)	Longitude (E)	Observation point type	Observation / Pumping sites	Time series		Number of data samples	Sampling time step (monthly, seasonal...)	Extension of completed time series (years)
					Start	End[*]			
4888002	50° 23' 21.50"	005° 22' 41.97"	Spring	Pumping (water supply)	1995	2003	29	Seasonal	1995 – 2003
4954004	50° 25' 11.97"	005° 27' 18.41"	Gallery	Pumping (water supply)	1993	2002	156	Bimonthly Bimonthly	1993 – 1996 1999 – 2002
4954005	50° 24' 49.24"	005° 27' 26.50"	Spring	Pumping (water supply)	1983	2001	170	Annual +/- Monthly	1983 – 1987 1988 – 2001
4954006	50° 24' 47.94"	005° 27' 26.98"	Spring	Pumping (water supply)	1979	2002	187	Annual Monthly	1979 – 1987 1988 – 2002
4954009	50° 24' 55.14"	005° 27' 18.02"	Spring	Pumping (water supply)	1979	2002	191	Annual Monthly	1979 – 1987 1988 – 2002
5441002	50° 22' 11.36"	005° 20' 36.49"	Spring	Pumping (water supply)	1990	2000	26	Biannual Irregular	1990 – 1992 -

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[*] For most of these points, data will be available for 2004 at the beginning of 2005.

Table 3.6. Available data of nitrate survey network for Alluvial plain groundwater body (RWM 071 – RWM 073)

Code	Latitude (N)	Longitude (E)	Observation point type	Observation / Pumping sites	Time series		Number of data samples	Sampling time step (monthly, seasonal...)	Extension of completed time series (years)
					Start	End*			
3477005	50° 44' 15.84"	005° 40' 58.45"	Unknown	Pumping (water supply)	1987	2002	66	Annual	1987 – 1992
								Monthly	1994 – 1996
								Bimonthly	1997 – 2002
4223004	50° 41' 50.23"	005° 39' 27.14"	Borehole	Pumping (water supply)	1994	2002	66	Bimonthly	1994 – 2002
4226008	50° 41' 45.81"	005° 37' 44.69"	Borehole	Pumping (water supply)	1994	2002	65	Bimonthly	1994 – 2002
4228005	50° 38' 51.63"	005° 37' 40.04"	Borehole	Pumping (industrial)	1995	1997	2	Annual	-
4748017	50° 28' 48.43"	004° 56' 31.39"	Borehole	Pumping (water supply)	1994	2002	65	Monthly / Seasonal	1994 – 2002
4748019	50° 28' 37.07"	004° 56' 03.86"	Borehole	Pumping (water supply)	1994	2002	81	+/- Monthly	1994 – 2002
4773002	50° 26' 58.17"	004° 51' 53.84"	Borehole	Pumping (water supply)	1994	2002	70	Monthly	1994 – 1997
								Bimonthly	1999 – 2002
4773006	50° 26' 55.31"	004° 51' 49.20"	Borehole	Pumping (water supply)	1994	2002	70	Monthly	1994 – 1997
								Bimonthly	1999 – 2002
4773008	50° 26' 54.85"	004° 51' 58.47"	Borehole	Pumping (water supply)	1994	2001	40	Monthly	1994 – 1995
								Irregular	-
4817004	50° 29' 12.31"	005° 01' 19.83"	Traditional well	Pumping (water supply)	1994	2002	49	Seasonal	1994 – 2002
4818001	50° 29' 21.04"	005° 01' 50.39"	Traditional well	Pumping (water supply)	1994	2002	30	+/- Seasonal	1995 – 2002
4824009	50° 30' 20.05"	005° 07' 49.07"	Borehole	Pumping (water supply)	1995	2000	28	Seasonal	1995 – 2000
4824010	50° 30' 18.97"	005° 07' 55.80"	Borehole	Pumping (water supply)	1994	2000	23	Seasonal	1994 – 1997
4825003	50° 30' 54.96"	005° 10' 34.46"	Traditional well	Pumping (water supply)	1991	1999	48	Bimonthly	1991 – 1999
4825007	50° 30' 40.68"	005° 09' 52.39"	Traditional well	Pumping (water supply)	1991	1998	39	Bimonthly / Seasonal	1991 - 1997
4825015	50° 30' 44.42"	005° 10' 08.85"	Traditional well	Pumping (water supply)	1992	1999	9	Irregular	-
4826001	50° 31' 14.37"	005° 11' 26.62"	Borehole	Pumping (water supply)	1994	2000	30	Seasonal	1994 – 1998
								Monthly	1999
4841002	50° 32' 59.80"	005° 19' 51.48"	Borehole	Pumping (water supply)	1995	2002	11	Irregular	1995 – 1998 2000 - 2002
5333001	50° 21' 55.45"	004° 52' 24.02"	Traditional well	Pumping (water supply)	1999	2000	4	Irregular	1999 – 2000
5347001	50° 18' 42.52"	004° 53' 06.96"	Borehole	Pumping (water supply)	1994	2002	24	Bimonthly	1996 – 2002
5379002	50° 12' 38.86"	004° 50' 41.03"	Borehole	Pumping (water supply)	1994	2002	43	Bimonthly / Seasonal	1994 - 2002
5384001	50° 14' 17.33"	004° 53' 31.33"	Borehole	Pumping (water supply)	1996	2002	50	Irregular	1996 – 2002

Code	Latitude (N)	Longitude (E)	Observation point type	Observation / Pumping sites	Time series		Number of data samples	Sampling time step (monthly, seasonal...)	Extension of completed time series (years)
					Start	End*			
5384003	50° 14' 31.88"	004° 53' 35.02"	Unknown	Pumping (water supply)	1994	2002	26	+/- Seasonal	1994 – 2002
5832001	50° 10' 24.31"	004° 49' 29.18"	Borehole	Pumping (water supply)	1995	2002	25	Seasonal	1995 – 2002
3477004	50° 44' 16.44"	005° 41' 02.55"	Borehole	Pumping (water supply)	1986	2002	47	Annual Annual Bimonthly	1986 – 1987 1991 – 1992 1997 – 2002
4223012	50° 41' 51.79"	005° 39' 26.63"	Borehole	Pumping (water supply)	1994	2002	68	Monthly / Bimonthly	1994 – 2002
4226032	50° 41' 47.27"	005° 39' 22.32"	Borehole	Pumping (water supply)	1994	2002	69	Monthly / Bimonthly	1994 – 2002
4228007	50° 38' 52.18"	005° 37' 36.74"	Borehole	Pumping (industrial)	1995	1997	2	Irregular	-
4228010	50° 38' 49.15"	005° 37' 35.54"	Borehole	Pumping (industrial)	1995	1997	2	Irregular	-
4228016	50° 38' 49.49"	005° 37' 30.92"	Borehole	Pumping (industrial)	1995	1997	2	Irregular	-
4748005	50° 28' 34.48"	004° 56' 04.85"	Borehole	Pumping (water supply)	1994	2002	80	Monthly Monthly	1994 – 1997 1999 – 2002
4748018	50° 28' 48.43"	004° 56' 31.39"	Borehole	Pumping (water supply)	1994	2002	54	Bimonthly	1996 – 2002
4773010	50° 26' 55.10"	004° 51' 52.29"	Borehole	Pumping (water supply)	1994	2002	70	Bimonthly Bimonthly	1994 – 1997 1999 – 2002
4773012	50° 26' 54.20"	004° 51' 55.43"	Borehole	Pumping (water supply)	1994	2002	67	Bimonthly Bimonthly	1994 – 1997 1999 – 2002
4773019	50° 26' 54.05"	004° 51' 57.30"	Borehole	Pumping (water supply)	1994	2002	61	Bimonthly Bimonthly	1994 – 1997 2000 – 2002
4773023	50° 26' 54.82"	004° 51' 57.15"	Borehole	Pumping (water supply)	1999	2001	5	Biannual	1999 – 2001
4779007	50° 22' 58.33"	004° 52' 12.34"	Surface water	-	1999	2002	314	Twice per week Weekly	1999 – 2001 2002
4820998	50° 30' 55.16"	005° 10' 34.05"	Unknown	Pumping (water supply)	2000	2002	3	Irregular	-
4824002	50° 30' 19.14"	005° 07' 54.79"	Borehole	Pumping (water supply)	1994	1998	36	Bimonthly	1994 – 1998
4824005	50° 30' 20.46"	005° 07' 45.62"	Borehole	Pumping (water supply)	1994	1996	4	Irregular	-
4824012	50° 30' 17.54"	005° 07' 51.46"	Borehole	Pumping (water supply)	1994	2000	11	Seasonal	1994 – 1996
4824014	50° 30' 19.03"	005° 07' 46.97"	Borehole	Pumping (water supply)	1994	1999	31	Bimonthly	1994 – 1999
4824016	50° 30' 21.32"	005° 07' 48.23"	Borehole	Pumping (water supply)	1995	2000	6	Irregular	-
4825011	50° 30' 44.20"	005° 10' 14.90"	Traditional well	Pumping (water supply)	1991	1999	37	Seasonal	1991 – 1999
4826004	50° 31' 11.01"	005° 11' 21.03"	Borehole	Pumping (water supply)	1994	1999	32	Seasonal Monthly	1994 – 1998 1999

Code	Latitude (N)	Longitude (E)	Observation point type	Observation / Pumping sites	Time series		Number of data samples	Sampling time step (monthly, seasonal...)	Extension of completed time series (years)
					Start	End*			
4841003	50° 33' 00.91"	005° 19' 51.30"	Borehole	Pumping (water supply)	1994	1997	10	+/- Seasonal	1994 – 1997
5384002	50° 14' 19.03"	004° 53' 34.42"	Borehole	Pumping (water supply)	1994	2002	62	Bimonthly	1994 – 1996
								Seasonal / Bimonthly	1998 – 2002

4. Spatial dataset for Brévilles (BRGM)

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4.1 General context

The Brévilles catchment is situated within the vicinity of the village of Montreuil-sur-Epte (France), some 70 km west of Paris, on the border of the Normandie and Ile-de-France regions (see Figure 4.1). The catchment was first instrumented in 1999 as part of the FP5 European project PEGASE (EVK1-CT1999-00028) and represents a fairly small (2.8-km^2) study area dominated by agricultural activities. Monitoring and characterisation activities in the catchment have concentrated on the transfer of agricultural contaminants (mainly pesticides) through the hydrogeological system. It should be noted that there is no surface waters in the catchment. The outlet of the system is a spring (the 'Brévilles' spring) which was used by the 350 inhabitants of the village for drinking water purposes until atrazine was found in concentrations exceeding legal thresholds.

In an effort to reduce contamination of the spring, farmers replaced atrazine by acetochlor for controlling weeds in maize. First applications of acetochlor on the catchment in May 2000 coincided with the start of the pesticide monitoring exercise, thereby providing a unique opportunity to study pesticide detections in a context of product substitution.

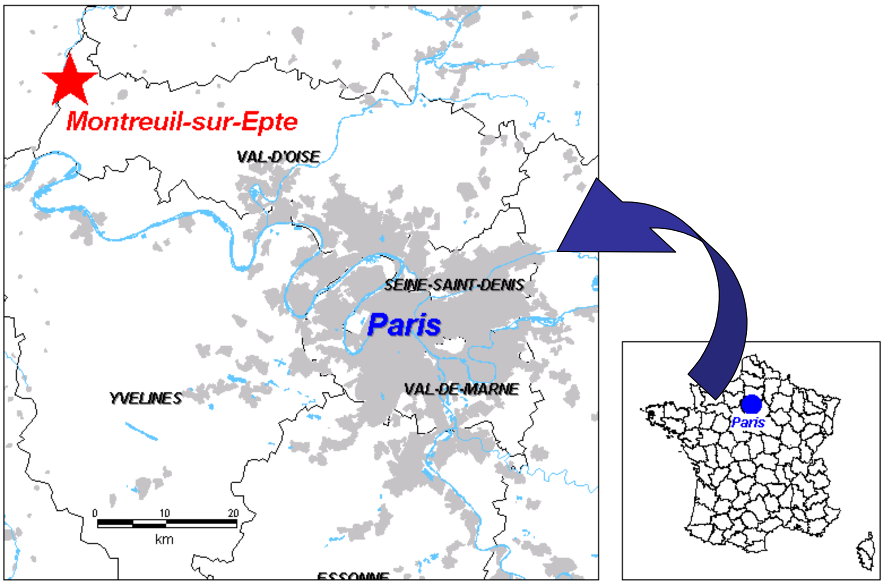

Figure 4.1. Map showing the location of the Brévilles study area

Additional factors supporting the selection of this particular catchment at the start of the PEGASE project included: i) the small size of the hydrogeological catchment; ii) the small number of farmers on the catchment; and iii) the sandy nature of the geological material of the aquifer, which suggested that the aquifer was porous and homogeneous and therefore represented a relatively simple hydrogeological case.

A significant amount of characterisation activities were undertaken in the catchment since it was first instrumented and the main characteristics of the basin are briefly described below.

4.2 Geology and geometry of the aquifer

Figure 4.2 shows geographical information on the catchment together with the location of the seven piezometers and the spring which were used for monitoring purposes. Table 4.1 provides basic information on the piezometers.

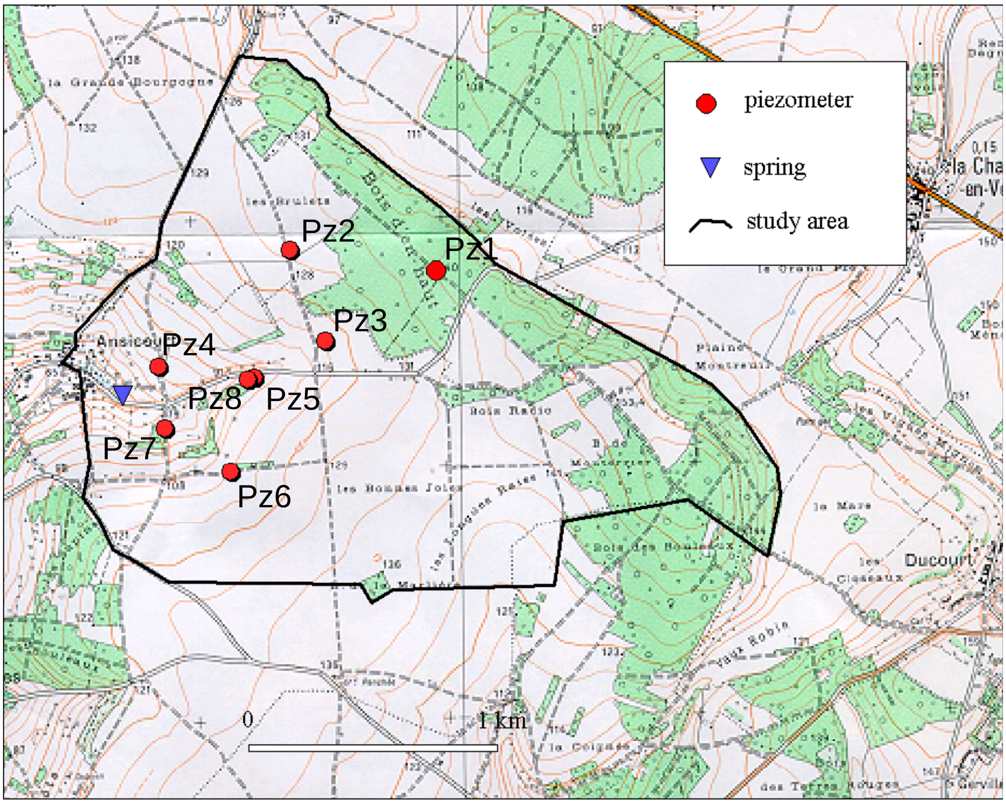

Figure 4.2. Map showing the location of the seven piezometers and of the spring

Piezometer	north	east	Z ground (m NGF)	Screen depth (m bgl)	Pumping depth (m bgl)
Pz1	40°13'14"	1°48'08"	137.0	22.6 to 40.2	-
Pz2	40°13'18"	1°47'45"	131.4	39.5 to 51.3	42
Pz3	40°13'06"	1°47'51"	123.2	33.0 to 44.8	38
Pz4	40°13'03"	1°47'23"	95.3	17.9 to 26.7	18
Pz5	40°13'01"	1°47'39"	105.7	13.0 to 31.0	20
Pz6	40°13'50"	1°47'35"	117.3	27.9 to 39.1	32
Pz7	40°13'55"	1°47'24"	89.3	11.2 to 22.7	14
Pz8	40°13'01"	1°47'38"	103.4	17.1 to 28.9	21

Table 4.1. Selected characteristics of the eight piezometers on the Brévilles study area (bgl: below ground level)

Delineation of the geometry of the aquifer was based on geophysical and geological data. The hydrogeological basin of the spring was determined on the basis of i) geophysical investigations using Protonic Magnetic Resonance; ii) a substratum map (the structure of the anticline was studied in detail for a gas storage project in 2001); and, iii) a piezometric map.

Montreuil-sur-Epte is located on the left bank of the Epte Valley, at the foot of a tilted plateau composed of tertiary material: a carbonaceous formation from Lutetian age, locally overlaid by lacustrine limestones and sandstones from Bartonian age. Quaternary sediments are present in the form of silts on the plateau and colluvions at the foot of hills. The spring basin is part of a plateau, tilted westwards, which forms an independent hydrogeological system, delineated on the western side by the Epte Valley, on the north and south by two tributaries of the Epte River, and on the east by a crest line. The top of the Sparnacian clays is showing a depression, centred 1 km SE of Montreuil, *i.e.* approximately 500 m south of the hydrometric station. Within the hydrogeological basin, the dips of the layers converge towards this depression. The fault system breaks the slope on the west flank of the anticline. The top of the Cuise sands shows the same pattern. The bottom of the Lutetian formation is not an impervious layer, although it may be semi-pervious by places, where green clays are accumulated. The hydrogeological basin is limited by a fault, direction NW-SE, on its eastern boundary. The throw of this fault being around 20 m, the upper compartment raises sparnacian clays in front of Cuise sands, thus constituting a hydrogeological barrier. Information about the stratigraphy for the eight piezometers drilled on the site is presented graphically in Figure 4.3 while Figure 4.4 gives the results obtained in terms of delineation of topographic (i.e. surface) and hydrogeological basins.

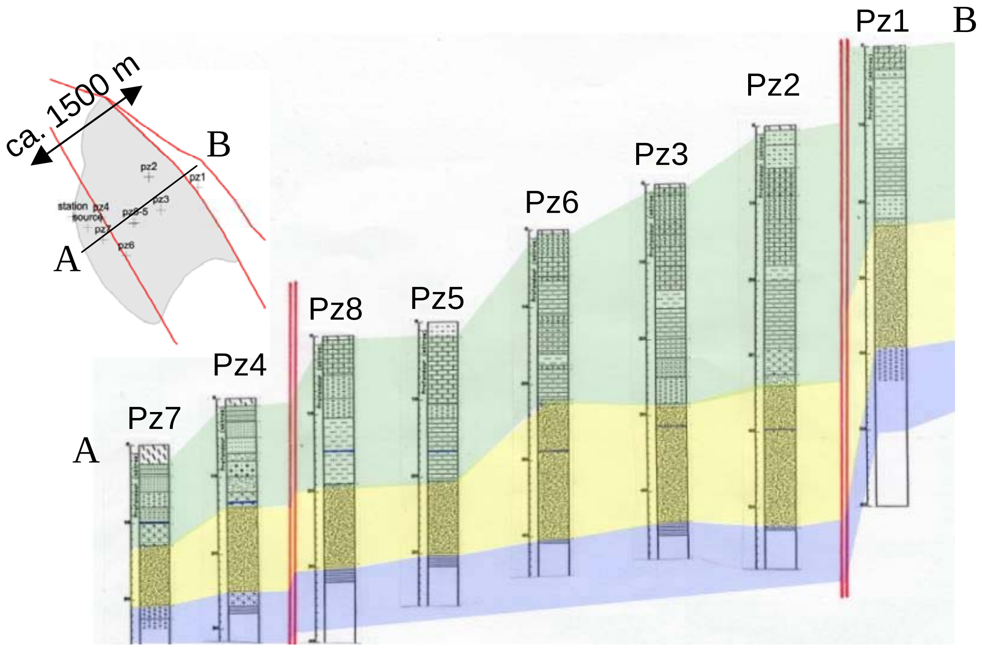

Figure 4.3. Schematic diagram [not to scale] showing the stratigraphy for the eight piezometers (black marks against the logs represent 10 m in length; green: Lutecian limestone; yellow: upper part of the Cuise sands; blue: lower part of the Cuise sands ; altitude of top of Pz1: 137 m above sea level; altitude of top of Pz7: 89.2 m above sea level)

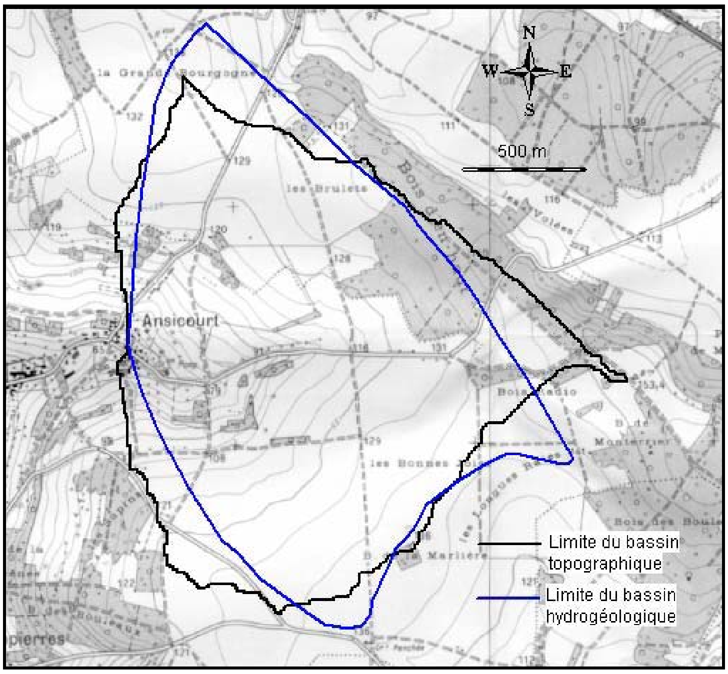

Figure 4.4. Map showing the delineation of topographic (black line) and hydrogeological (blue line) basins at Brévilles

4.3 Soils

A detailed soil map consisting of 25 soil classes was built on the basis on 270 auger samples and nine soil pits (Figure 4.5). In addition, a simplified soil map with four classes was also drawn for modelling purposes. The four classes were Luvisol (the deepest soils), Calcosol and Calcisol (shallower stony and calcareous or calcic soils) and Colluvisol (remanied soils). The dominant units in the area were Luvisol and Calcosol/Calcisol.

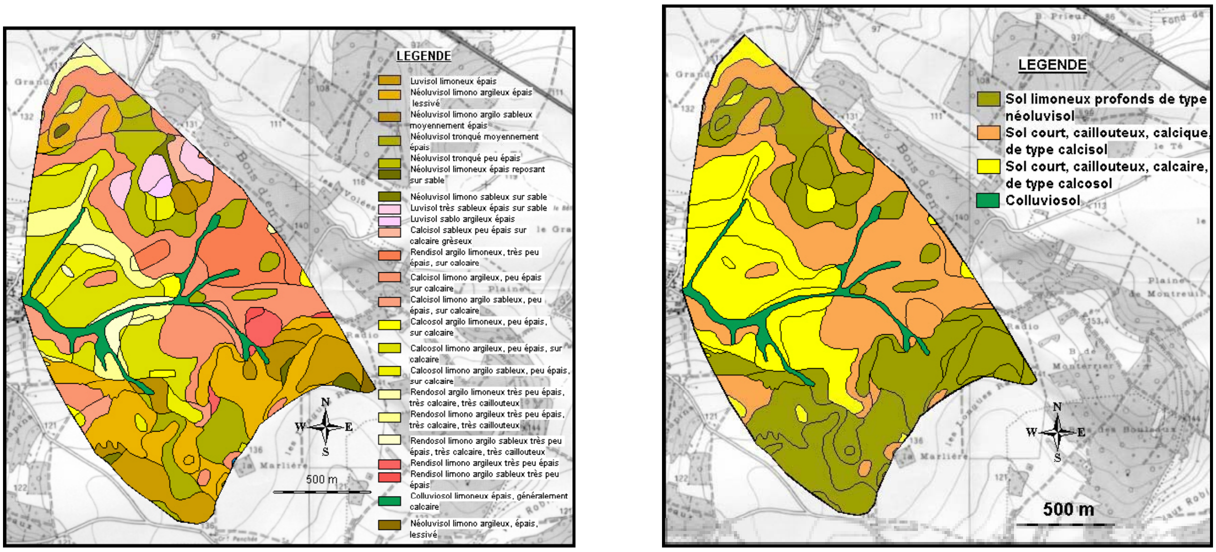

Figure 4.5. Soil maps for the Brévilles catchment (left: comprehensive; right: simplified).

Fifteen representative horizons were distinguished based on grain size distribution, percentage of stones and topographic position in the landscape. Hydraulic properties for each of the 15 horizons were determined in the laboratory (Figure 4.6).

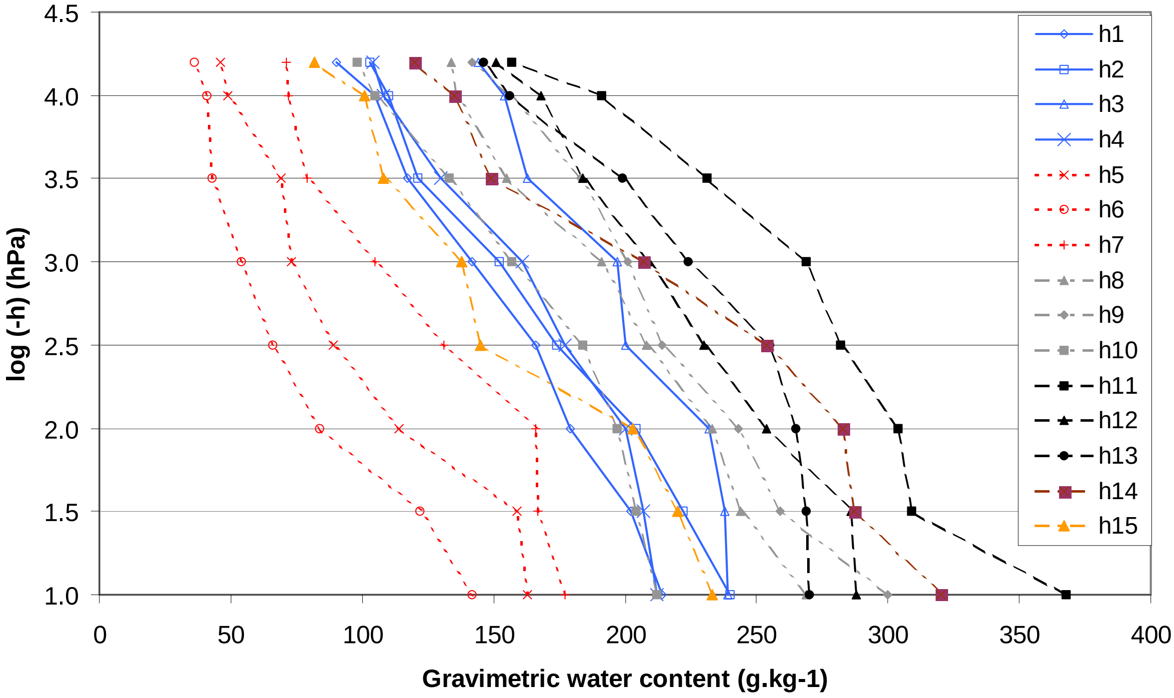

Figure 4.6. Water retention properties for 15 soil horizons representative of soil diversity throughout the catchment. Y-axis: water tension.

4.4 Unsaturated zone

Samples of the unsaturated zone (>30 m in some instances) were retrieved during drilling campaigns (8 piezometers and 6 specific drilling exercises). Samples were taken every 50 cm and described from a geological perspective. Hydraulic properties were measured in the laboratory or estimated through the determination of porosity distributions through injections of mercury (Figure 4.7). Geophysical measurements (Protonic magnetic resonance which allows the location of the top of the water table) were performed throughout the catchment to help building a piezometric map of the area.

Figure 4.7 shows that some of the water retention curves obtained for unsaturated materials (here Lutetian limestone) were characterised by a high variability between triplicates and between samples taken at various depths. The velocity of the water could thus vary significantly within a given vertical profile and between several points located throughout the basin. The variability was found to be smaller in the Cuise sands.

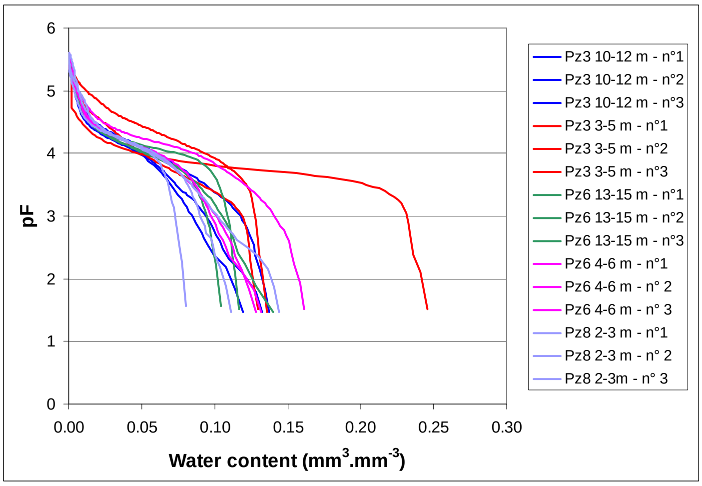

Figure 4.7. Selection of triplicate water retention curves obtained for limestone samples originating from the unsaturated zone. pF = water tension.

4.5 Saturated zone

Eight piezometers, seven of which were situated in the suspected hydrogeological catchment area, were drilled and instrumented. Monitoring for piezometric levels and water quality took place on a two-week basis from the winter of 2000. Pumping tests in the piezometers provided estimates of the transmissivity of the aquifer, but did not allow the computation of its storage coefficient. Transmissivities in the vicinity of the spring were larger by about an order of magnitude compared to those estimated for the upstream area. For a specific piezometer, the permeability appeared to be higher in the upper part of the aquifer compared to the lower formations.

Piezometric heads in the piezometers have increased continuously since monitoring started in February 2001 (Figure 4.8). Variations reached 1.4 m in the upper part of the basin and ca. 20 cm near the spring. The increase was particularly noticeable at the start of the monitoring period (between February and September 2001).

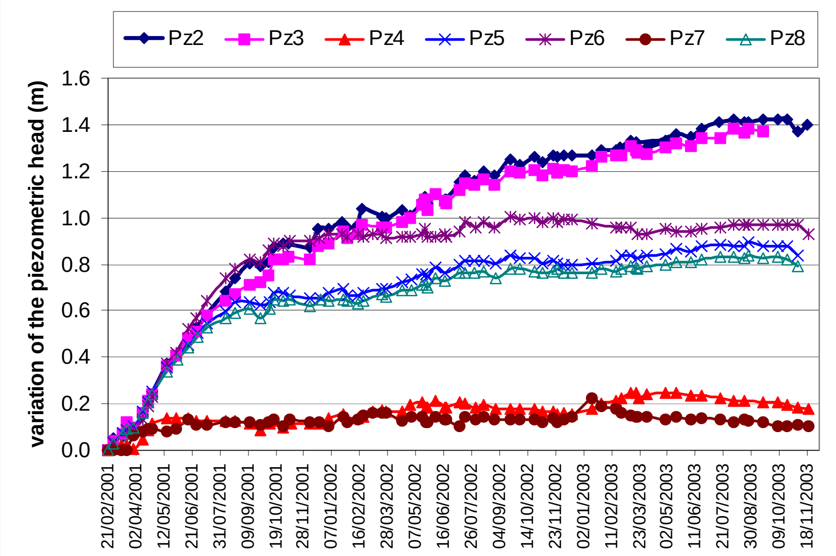

Figure 4.8. Variation of the piezometric head in the various piezometers since monitoring began in February 2001.

4.6 Water quality data

Sampling campaigns were conducted on a monthly basis in seven piezometers from March 2001 and twice a month at the spring from October 1999 (EU PEGASE project, BRGM). The pesticides atrazine and its metabolites DEA and DIA, isoproturon and its metabolites monomethyl- and didesmethyl-isoproturon, chlortoluron, acetochlor and its metabolites ESA and OA were analysed in samples collected using HPLC-MS(-MS) and GC-MS(-MS) (Dagnac et al., 2002). In addition, samples were analysed for major anions and cations as they can providevaluable information on the mechanisms leading to aquifer recharge.

Atrazine and deethylatrazine (DEA) were systematically detected at the spring even though the last application of atrazine in the catchment occurred in April 1999. The time series of concentrations at the spring (Figure 4.9) showed significant variations of atrazine and deethylatrazine concentrations over rather shorts periods of time especially at the beginning of the study. Isoproturon and chlortoluron were detected on a few occasions only and detections were made at the time of application (end of February).

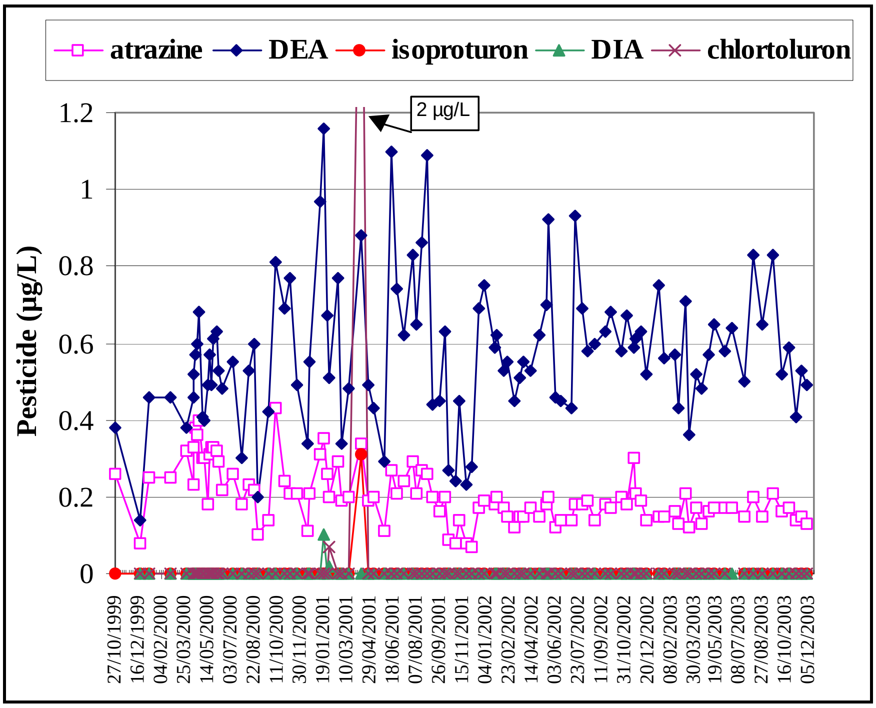

Figure 4.9. Pesticide concentrations at the Brévilles spring

Figure 4.10 presents data on pesticide concentrations in the seven piezometers. Pesticides concentrations were found to be very variable between the various piezometers. For instance, no detection was made in Pz4 whereas concentrations up to several µg/l were noted in Pz5. Trends were found to vary between the different piezometers. To date, acetochlor and its two metabolites have not been detected in groundwater except in one sample at the spring and another piezometer sample. Concentrations were very low and these detections could not be confirmed after a second analysis.

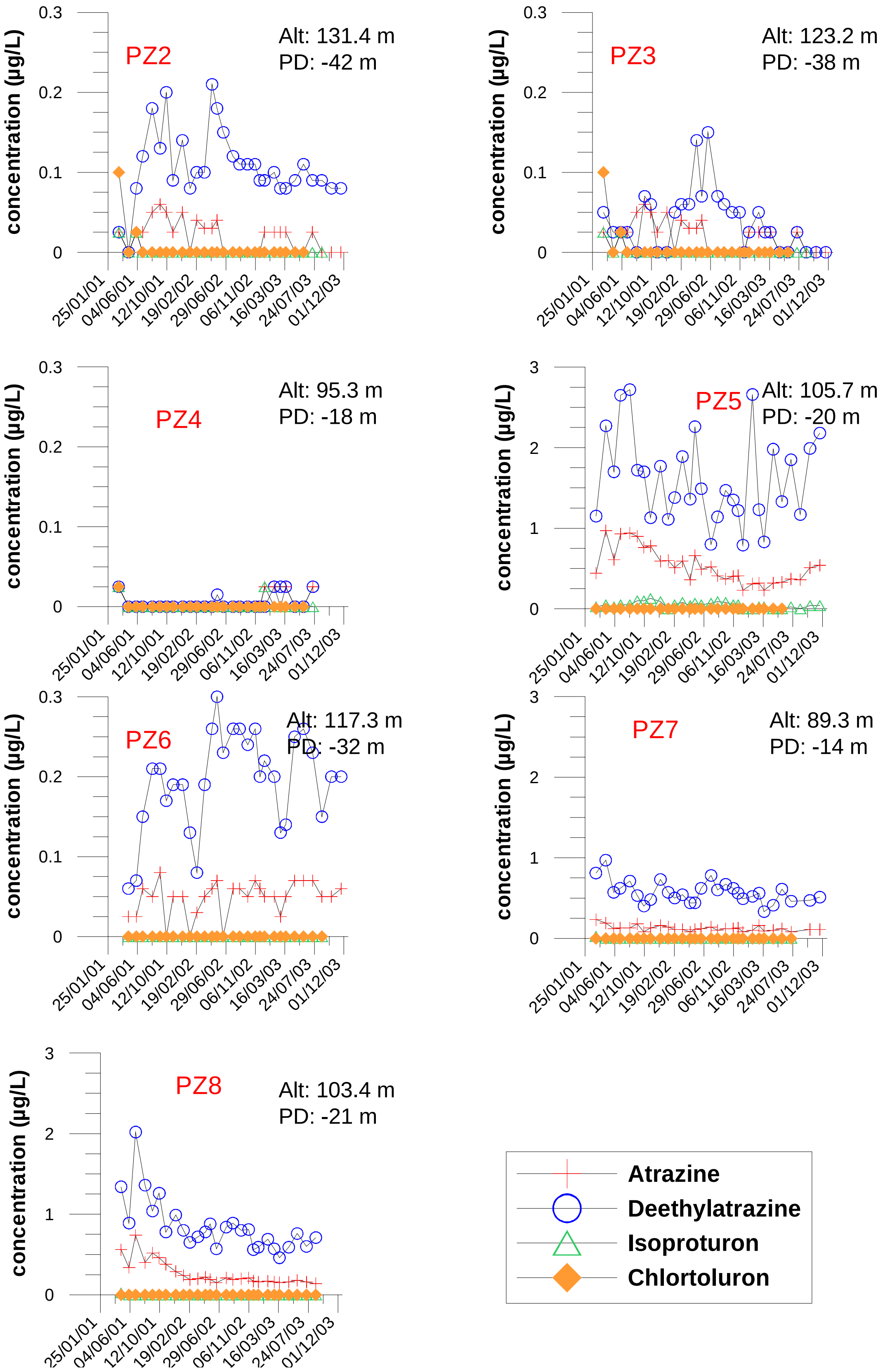

Figure 4.10. Pesticide concentrations found in the seven piezometers over a period of three years starting January 2001 (Alt: altitude ; PD: pumping depth)

4.7 Discussion

The aim of the present section was to provide a general description of the Brévilles study site for TREND 2 partners and has therefore focussed on the main aspects of the dataset available for use within the work package. It should be noted that additional data have been collected at the site and can be used in future modelling activities. These include information on meteorology, on the sorption and degradation properties of soil and subsoil materials with regard to a number of pesticides (in particular acetochlor and atrazine), on the conductivity and oxygenation of ground water, and on land use. In addition, a dye tracing experiment was performed and topographical information is available in the form of a digital terrain model.

Additional characterisation efforts which will be undertaken within the scope of Aquaterra on the Brévilles catchment include the drilling of eight additional piezometers (three of them being nested to attempt to obtain concentration-depth relationships), further geophysical surveys, tracer injection characterisation, batch laboratory experiments for atrazine and its metabolites, and monitoring of piezometer levels and pesticide concentrations in piezometers and at the spring. It is also intended to perform additional groundwater age determinations in the piezometers to help understand the hydrogeological and geochemical functioning of the catchment.

One of the tasks identified in the work package TREND 2 consisted in subdividing the groundwater system under study into more manageable subsystems. There is no such need for subdivision for the Brévilles aquifer as the basin is only 2.8 km^2 and can be considered as a whole in terms of functioning. The splitting of a large area into smaller subdivisions is most appropriate for the large water basins considered within the context of TREND 2 (e.g. the Meuse basin).

The Brévilles dataset is unique in Europe in that very few research projects have attempted to i) investigate pesticide fluxes from the soil surface to and in groundwater (the vast majority of projects have focused on the root zone), and, ii) monitor pesticide dynamics on a two-week to one-month temporal resolution over five years. Most research efforts to be undertaken in the near future within the context of the work package TREND 2 on the Brévilles dataset will focus on pesticide concentration time series at the Brévilles spring and in the various piezometers scattered across the catchment. The water quality datasets will be analysed using ‘classical’ time series statistics and will also be used to develop innovative statistical approaches for time series analysis and forecasting.

5. Spatial Dataset for Elbe Basin (IETU)

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5.1 Introduction to the Elbe Basin

Elbe is one of the main rivers of Europe, that drains water from the territory of four countries: Germany, Czech, Austria and Poland. The boundaries of the main Elbe watersheds are presented along with political boundaries in Fig. 5.1.

Fig. 5.1 Main watersheds in Elbe Basin [source: LANU]

The German and Czech part comprises about 99% of total Elbe Basin area. Only 1% is governed by Austria and Poland (Table 5.1).

Table 5.1 The area of Elbe Basin within state boundaries

State	Watersheds	Area [km^2]	Area [%]
Germany	Tide-Elbe; Middle Elbe-Elde; Havel; Saale; Mulde Elbe-Black Elster	97175	65,54
Czech	Upper Elbe; Ohre/Eger; Vltava/Moldau	49933	33,68
Austria	Vltava/Moldau	921	0,62
Poland	upper Elbe (sources)	239	0,16
Total		**148 268**	**100**

Source – EUROCAT

The springs of Elbe River are located in the Karkonosze Mountains (Giant Mountains) at the level of 1386,3 m above see level (Fig. 5.2)

Fig. 5.2 The Elbe springs in Karkonosze Mountains [source: http://www.pla.cz]

5.2 Elbe Basin division

Czech part of the Elbe Basin is composed of 5 watersheds:

- Upper Elbe
- Vltava (Moldau) – divided into Lower and Upper Moldau and Beraun
- Ohre (Eger) and Lower Elbe

German part of the Elbe Basin is divided into 5 major watersheds:

- Mulde-Elbe-Schwartze Elster and Eger
- Saale
- Havel
- Middle Elbe/Elde
- Tide Elbe

The table below presents areas of the main watersheds of the Elbe Basin.

Table 5.2 Area of major watershed of the Elbe Basin

Watershed Name	Acronim	State	State / Land (in Germany)	Area [km^2]	Area [%]
Upper and Middle Elbe	HSL	Czech Republic	**Czech Republic**	14976	10
Upper Moldau	HVL	Czech Republic	**Czech Republic**	11986	8
Beraun	BER	Czech Republic	**Czech Republic**	8872	6
Lower Moldau	DVL	Czech Republic	**Czech Republic**	4530	3
Eger and Lower Elbe	ODL	Czech Republic	**Czech Republic**	9569	6
Mulde-Elbe-Schwarze Elster	MES	Germany	**Sachsen,** Brandenburg, Sachsen-Anhalt, Thuringen	18738	13
Saale	SAL	Germany	**Sachsen-Anhalt,** Bayern, Niedersachsen, Sachsen, Thuringen	24167	16
Havel	HAV	Germany	**Brandenburg,** Berlin, Vorpomern, Sachsen, Sachsen-Anhalt	23860	16
Mittlere Elbe/Elde	MEL	Germany	**Sachsen-Anhalt,** Brandenburg, Mecklenburg, Vorpomern, Niedersachsen, Schleswig-Holstein	16551	11
Tideelbe	TEL	Germany	**Schleswig-Holstein,** Hamburg, Niedersachsen, Sachsen-Anhalt	15921	11

Source: Zusammenfassender Bericht der Flussgebietsgemeinschaft Elbe über die Analysen nach Artikel 5 der Richtlinie 2000/60/EG (A-Bericht) http://www.wasser.sh/de/fachinformation/

Each of the mentioned watersheds is governed by a separate water management body responsible for coordination of activities of the local authorities (Czech Republic) or a land government (Germany).

5.3 Basic groundwater network

5.3.1 Czech Republic

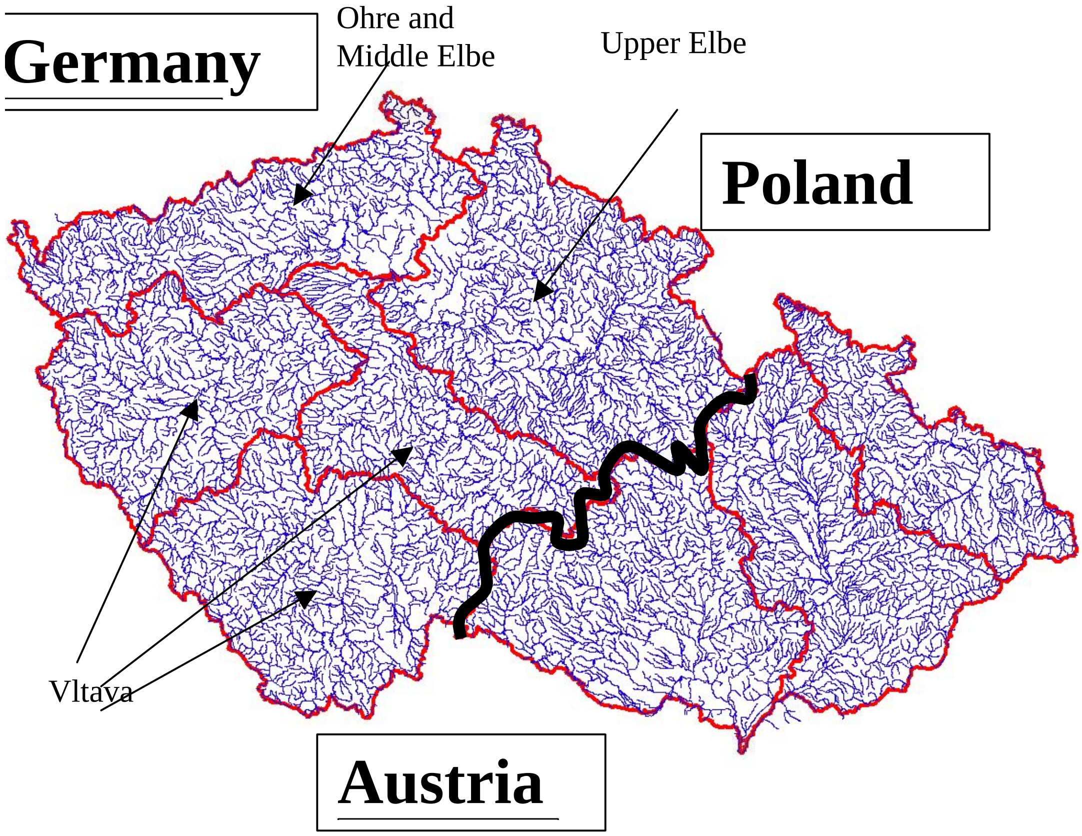

Fig. 5 3 The river network of the Czech Elbe Watershed

Data on the organization of the water management authorities, distinguished watersheds and hydrogeological units are available at http://www.povodi.cz/ [1].
Monitoring of groundwater level and quality has been conducted by the Czech Hydrometeorological Institute (CHMU) – Department of Hydrology since 1984.
Monitoring data are published yearly in yearbooks and since 2003 they have been publicly available free of charge also in English at http://hydro.chmi.cz/ojv/default.php?lng=ENG. Details of data handling can be found in Annex I.
The groundwater quality network is a part of the state groundwater network. Monitoring comprises observations in springs, shallow and deep boreholes. The springs monitoring points are spread all over the country within geological structures. These are the only observation points within the boundaries of the old crystalline structures. Shallow boreholes monitor the quality of Quaternary, porous aquifers. Deep boreholes monitor the quality of groundwater within the recognized hydrogeological structures with deeper water cycling (sediments of Upper

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[1] order of ministry for land use from 13.06.2002 about water management regions – effective since 13.06.2004

Cretaceous aquifer of Czech Cretaceous Basin, Tertiary aquifer as well as limestone of southern Czech basins). The development of groundwater quality monitoring network started in 1984 and was originally composed of 138 monitoring points at springs. Two years later the network was enlarged by 121 shallow boreholes and in 1991 another 192 deep boreholes were added. Since 2002 the GW monitoring network is composed of 463 monitoring points. The sampling is made twice a year (spring and late summer/early winter).

Data were copied from the web page and after conversion from html, integrated into MS Access database.

Sampling of surface water and groundwater as well as analytical works are provided for CHMI in external accredited laboratories. CHMI tests the data, stores it in the national database, presents and makes assessment of the water quality data.

At present the description of borehole profiles is not available. This lack of information could be a reason of eventual cancellation the Czech part of Elbe Basin as a research object within TREND2.

The monitored parameters included:

- physic-chemical parameters (pH, dissolved oxygen, silicon, dissolved carbon, main anions and main cations);
- heavy metals
- aromatic compounds, alkenes, alkynes;
- polycyclic aromatic hydrocarbons (PAHs);
- pesticides and chlorinated pesticides;
- chlorinated benzenes and phenols;
- PCB (polychlorinated biphenyls);
- radioactivity

5.3.2 Germany

The German Elbe Watershed was selected based on data availability as well as data completeness. A regional set of data from Schleswig-Holstein was selected that represents right part of Tide-Elbe Watershed.

The monitoring data as well as other environmental data are available on the official internet web pages of the Schleswig-Holstein Government. Data are shared by Environmental Office of Schleswig-Holstein State[2]. Details of data handling can be found in Annex I.

The groundwater monitoring scheme consists of 3 types:

- basic or reference monitoring network
- user related monitoring
- emission related monitoring.

Basic monitoring is divided into:

- baseline measuring points that should describe natural groundwater conditions
- trend measuring points that should determine the trend of groundwater quality during longer periods, they provide a basis for the identification of the impact of hazardous substances, check the groundwater policy

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[2] The data included into report were provided by this office thanks to the assistance of dr. Henning Holthusen and his colleagues from Dezernat 44 - Grundwasserhydrologie, Grundwasserschutz, Landesamt für Natur und Umwelt Schleswig-Holstein

The basic frequency is twice a year with monitoring program changing in time (full and short).
The trend monitoring network provides, among others data, on nitrogen, phosphor, pesticides and heavy metals contamination factors.
The groundwater monitoring network was thoroughly developed based on extensive geological and hydrogeological studies.

The selection of the location of the measurement point was made independently from the theoretical availability or actually existing use of groundwater (for instance preferred use in water protection areas or water reservation areas). The installation of monitoring points was carried out at sites which represent:

- a typical agricultural use as well as
- natural spatial environment particularly soil and climate conditions.

For this, data from Schleswig-Holstein Statistic State Office on livestock units, areas under maize cultivation, cereal and colza as well as on grassland areas and on tree nurseries have been considered and combined with the general (overview) hydrogeological map of Schleswig-Holstein in 1:200 000 scale. Areas with sandy covers and with good infiltration potential for rainfall water in connection with high number of livestock with corresponding impact of manure matter represent there a comparatively high hazard potential for groundwater. Areas with loamy and clayey covers in connection with pure tillage comprise comparatively small hazard potential.

Subsequently 40 areas with various groundwater hazard potential have been mapped paying attention to approximately equal distribution in State (Land). After marking these areas on the maps in 1:25000 scale, real use of a particular agricultural compartment has been surveyed at the site. At qualified sites, groundwater flow direction has been investigated by test boreholes and by installation of small monitoring points. Test boreholes also have provided information about geological layers structure. The installation of permanent groundwater monitoring points for routine, regular sample collection has been carried out on the direction of groundwater flow from agricultural areas.

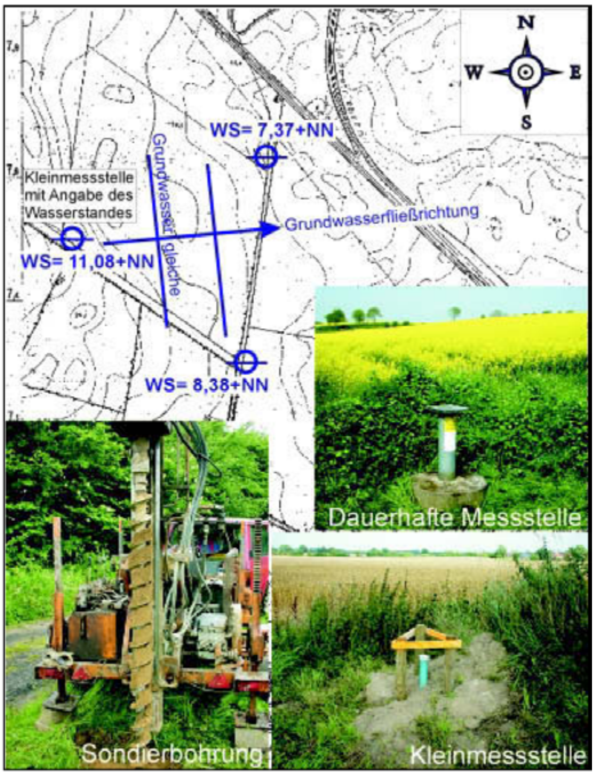

Fig. 5 4 Construction of a monitoring point (MP) from test boreholes throughout small monitoring point up to permanent monitoring point

Source: *Beobachtung der Grundwasserbeschaffenheit in Schleswig-Holstein Trendmessnetz 1995 – 2000-* Steinmann F.; http://www.umweltdaten.landsh.de/nuis/wafis/gw/trend/trendmessnetz95_00.pdf

As a result of the conducted investigations illustrated in Fig. 5 4, it should be warranted, that the water in water sample taken at given monitoring points originating from the inside of the mapped area is newly formed (not stagnated water).

Fig. 5 5 presents schematically a path of a conservative substance, i.e.: a substance that does not react in the zone between surface up to filtered sphere of the monitoring point under ideal conditions. Figure 3 presents the going westwards geographical classification of natural landscapes of Schleswig-Holsteins with Eastern Hügelland (hilly country), Lower Geest, Upper Geest as well as Marsh.

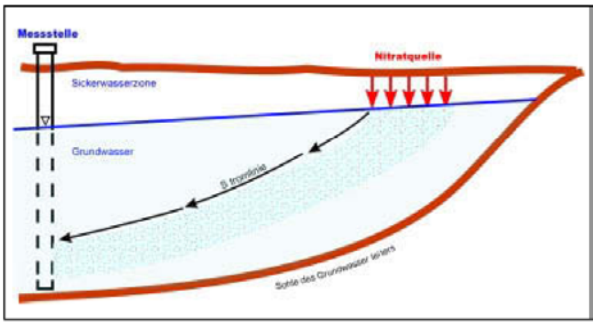

Fig. 5 5 Idealized diagram of migration of nitrate in a porous aquifer

Source: *Beobachtung der Grundwasserbeschaffenheit in Schleswig-Holstein Trendmessnetz 1995 – 2000-* Steinmann F.; http://www.umweltdaten.landsh.de/nuis/wafis/gw/trend/trendmessnetz95_00.pdf

It is evident that the monitoring points are, to some extent, regularly distributed all over the State. Marshes at western coastline represent an exception where groundwater at shallow depth is already salty and because the clay-rich groundwater cover practically eliminates the possibility of any hazard due to leaching of fertiliser/manure.

The adjustment of the measurement network is ongoing due to the fact that on one hand there are still gaps in the monitoring network in some parts of the State, on the other hand some monitoring points have to be eliminated because of inefficient productivity (of water) for water sampling, external influence (from the outside of an area unit) or because of the cancellation of the licence agreement.

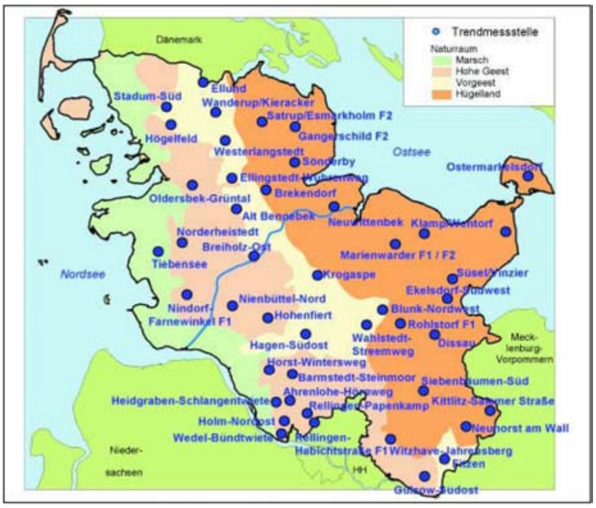

Fig. 5 6 The location of trend MPs within natural regions of Schleswig-Holsteins

Source: *Beobachtung der Grundwasserbeschaffenheit in Schleswig-Holstein Trendmessnetz 1995 – 2000-* Steinmann F.; http://www.umweltdaten.landsh.de/nuis/wafis/gw/trend/trendmessnetz95_00.pdf

Careful sampling is a fundamental requirement for determination of groundwater quality. It has to be guaranteed, that the property of chemically analysed water reflects the real status of the aquifer water and is not affected by a sojourn at the monitoring point or sampling activity.

Fig. 5 7 Photo of sampling process at Klamp/Wentorf MP

Sampling is carried out by the use of an underwater pump, which is hung over a support made of several connected tubs installed in groundwater monitoring point. By speed control, delivery rate of the pump can be adjusted specifically to the hydraulic capacity of the monitoring point. Then the water extracted by tube support (linkage) and hose system is pumped into a container. In which water conductivity, acidity (pH value) and temperature are continuously measured.

Source: Source: *Beobachtung der Grundwasserbeschaffenheit in Schleswig-Holstein Trendmessnetz 1995 – 2000-* Steinmann F.; http://www.umweltdaten.landsh.de/nuis/wafis/gw/trend/trendmessnetz95_00.pdf

The overflow from this container is taken out by a hose to a distant place (from a monitoring point) so that no “short circuit” would take place i.e. once pumped and measured the water is removed from the site (Fig. 5 7). In a monitoring point itself other hydro-chemical conditions govern than in the aquifer. Therefore the proper sample is not taken until:

Þ the monitoring point volume - MPV (amount of water filling the tubes plus extent of hydraulic effective ring) is exchanged at least two-three times and

Þ electrical conductivity and pH value reach extensive (long time) stability.

Basically, the requirement of adjusted stability is essential also for temperature, however it is possible that at shallowly built and less productive monitoring points, as a result of heat emission from the pump, a slight warming of the extracted water may appear (< 1 Centigrade). The filling of particular sampling vessel is carried out by a special adjustable sampling hose, which is carried into vessel bottom. This helps avoiding swirls generation during filling of the vessel.

The change of the quality of the extracted water during pumping at monitoring point is presented in Figure 5. The change of pH values and electrical conductivity against the frequency of the monitoring point volume *(*MPV*)* exchange are presented for two monitoring points. At *Fitzen* monitoring point 12 MPV have to be exchanged to obtain the constant value, while at *Tiebensee* monitoring point the constant value has been obtained already after about two MPV exchanges. Because of the different hydraulic productivity, the measurement process required at Tiebensee monitoring point about 50 minutes, while at the Fitzen monitoring point only 20-25 minutes.

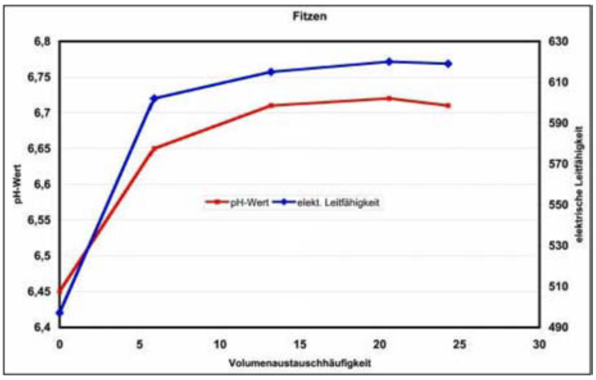

Fig. 5 8 Change of the pH value and electrical conductivity during sampling process at Fitzen MP

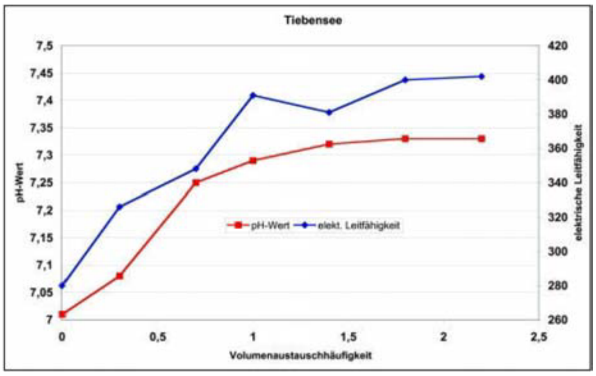

Fig. 5 9 Change of the pH value and electrical conductivity during sampling process at Tiebensee MP

The information about MPV characteristic is included into description of monitoring point as a separate from data quality files.

Series of dissolved substances are determined in samples of the groundwater. In addition to the already mentioned parameters i.e. temperature, pH value, electric conductivity, the so called organoleptic parameters are determined i.e. colouring, turbidity and smell/odour. The pH value and electric conductivity are determined once more in laboratory. The comparison of results of both groups gives a clue about a possible modification during transport or possible storage before the analysis in a laboratory. In addition an analysis of biocatalysts pesticides and their metabolites is conducted.

The following table presents information on chemical methods and related determination limits applied for water samples analysis.

Table 5.3 The list of parameters and their LOD[3]

Parameter	Unit	Detection limit	Preparation	Method
Water quality basic parameters				
Temperature	°C		no	DIN 38404-C4
Reaction	pH		no	DIN 38404 C5
Electrical conductivity at 25°C	mS/m		no	DIN 38404-C8
Suspended matter	mg/l	1	Filtration on 0,45µm membrane filter	DIN 38409-H 2-2
Total dissolved oxygen	mg/l O_2	0,2	no	DIN 38408-G21
Oxygen-saturation index (inland water)	%		no	DIN 38404-G23
Oxygen- saturation index (Coast water)	%		no	According to Weiss4)
Salt content	psu		no	In situ electric conductivity, recalculated according to UNESCO-Definition5)
Nutrition substances				
Ammonium-N	mg/l N	0,01	Filtration on 0,45µm membrane filter	CFA 3) , Salicylate-method
Nitrite-N	mg/l N	0,001	Filtration on 0,45µm membrane filter	CFA 3) , Sulfanilamide and N-1-Naphtyl-ethylen-diamin-dihydrochlorid
Nitrate-N	mg/l N	0,05	Filtration on 0,45µm membrane filter	CFA 3) , Sulfanilamide and N-1-Naphtyl-ethylen-diamin-dihydrochlorid to reduction with Cadmium
Total-Nitrogen	mg/l N	0,05	Pressure oxide digestion with $K_2S_2O_8$ in PTFE-flask according to Koroleff1)	Nitrogen determination - CFA 3)
o-Phosphate-P	mg/l P	0,005	Filtration on 0,45µm membrane filter	CFA 3) , Phosphor molybdenum blue-method
Total-Phosphor	mg/l P	0,05	Pressure oxide digestion with $K_2S_2O_8$ in PTFE-flask according to Koroleff1)	Phosphor determination (CFA) 3)
Silicate	mg/l SiO_2	0,2	Filtration on 0,45µm membrane filter	CFA 3) eg. FIA 2) , Siliceous molybdenum blue-method
Total factors (parameters)				
TOC	mg/l C	0,5	Homogenisation with Ultraturax	DIN 38409-H3-1
DOC	mg/l C	0,5	Filtration on 0,45µm membrane filter	
BOD 5	mg/l O_2		Saturation with oxygen to ca. 200%	DIN 38409-H52
UV-Absorption	1/m		no	DIN 38404-C1 bzw. C3
AOX	µg/l Cl		Addition of 1ml HNO_3 for 1l	DIN EN 1485-H14

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[3] According to information provided by Mr Thorkild Petenati and Mr Wolters from Landesamt für Natur und Umwelt des Landes Schleswig-Holstein

Parameter	**Unit**	**Detection limit**	**Preparation**	**Method**
			sample	(Säulenmethode)
Acidity, anions and cations				
Acid capacity	mmol/l		Homogenisation	DIN 38409-H7-1-2 (Titroprocessor)
Chloride	mg/l Cl	10	no	DIN 38405-D1-2
Sulfate	mg/l SO_4	0,5	Filtration with 0,45µm membrane filter	Turbimetric Method (FIA) 2)
Potassium Sodium Calcium Magnesium	mg/l	0,1 0,06 0,05 0,02	acidification with HNO_3 (5ml/l)	ICP-AES
Mercury	µg/l	0,001	Addition of HNO_3 (pH 2; 5ml for 1l Probe), 2h UV-exposure	AAS, cold vapours
Cadmium Lead Manganese Copper	µg/l	0,02 0,2 1 0,5		AAS
Chrom	µg/l	0,2		AAS
Nickel	µg/l	0,5		AAS
Eisen	µg/l	1		ICP-AES
Zinc	µg/l	1		Inverse voltammetry
Arsenic	µg/l	0,2		AAS, hygrogen method
Chlorinated hydrocarbons	ng/l	0,05		GC-ECD according to DIN 38407-F2
Pesticide (PSM), different herbicides and insecticides	ng/l	0,05		GC-MSD or HPLC according to DIN-Norm

1) Report of the Baltic Intercalibration Workshop, März 1977 – Kiel
2) FIA = Flow Injection Analyser
3) CFA = Continuous Flow Analyser
4) Weiss, R. F., Deep Sea Research 17 (1970) 721 – 735
5) practical salinity unit (dimension less)
6) NUSCH, E. A. (1980): Comparison of different methods for chlorophyll and phaeopigment determination, Arch. Hydrobiol. Beih. 14, 14 – 36

5.4 Research variables and scales

In recent history, a large amounts of nitrogen compounds were introduced into the soil– water system from atmosphere and by agricultural practices resulting in contamination of ground water bodies. Preventive measures undertaken by the EU require, among others, developing methods of groundwater chemical status calculation and presentation which take into account problems of spatially and temporally robust extrapolation of the monitoring results.

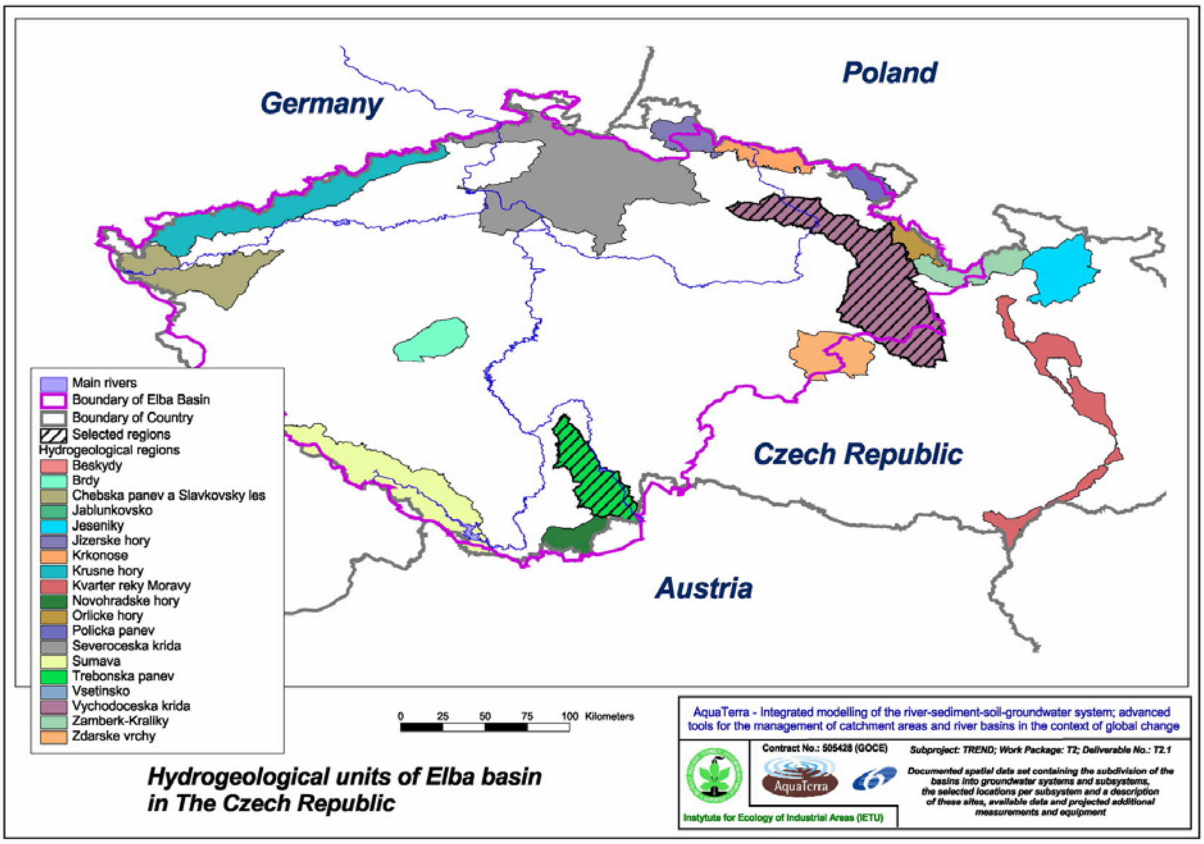
Within the AquaTerra Trend 2 work package an attempt is made to distinguish trends in groundwater quality. At first different statistical methods will be used to identify trends within one observation well. Selected method will be applied for the thoroughly selected groups of wells to estimate impact of selected grouping variables on the trend character at regional scale. Focus will be made on areas which are particularly vulnerable to diffuse agricultural pollution, i.e. recharge areas with intensive agricultural land use.
Secondly selected statistical approaches will be tested to trend detection on the scale of the Schleswig-Holstein watershed.

The trends of nitrogen compounds will be analysed based on such monitoring parameters as ammonium nitrogen, nitrate nitrogen as well as nitrite nitrogen.

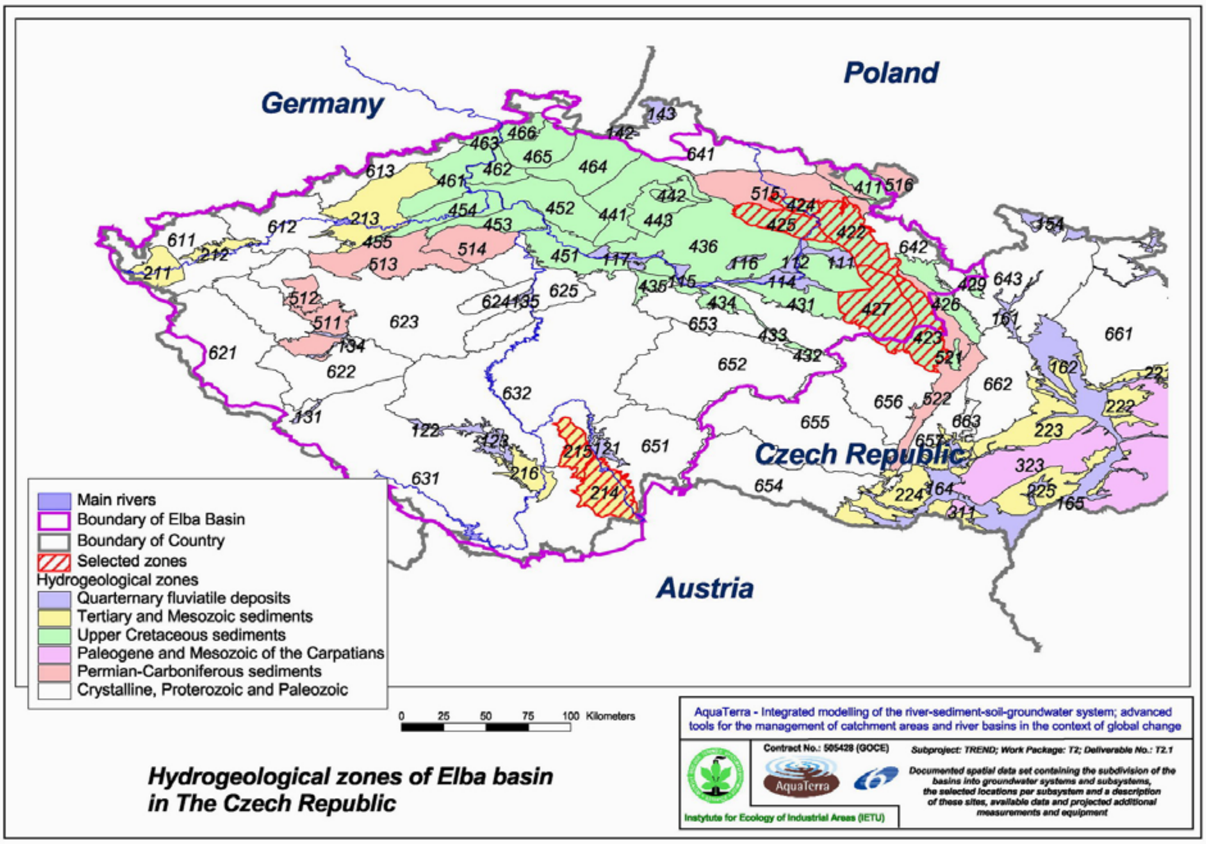
The established trends will be compared with the history of the nitrogen fertilizers use and history of nitrogen compounds deposition. The collection of additional data is necessary to complete this task.

5.5 Description data set Czech part of Elbe basin

The area is divided into hydrogeological regions (Figure 5.8). The most important groundwater bodies are located in the Upper Cretaceous aquifers – mainly within the boundaries of Upper Elbe watershed (zones 442, 441, 451, 424, 423, 425, 411, 427) and Ohre watershed (zones 466, 463, 465, 466, 461, 454, 453, 452)
The smaller watersheds located in the tertiary and cretaceous sediments are located in the Ohre Watershed (hydrogeological zone number 211) and in the southern part of the Vltava watershed (hydrogeological zones 214, 215, 216).



Hydrogeological units of Elba basin
in The Czech Republic



Hydrogeological zones of Elba basin
in The Czech Republic

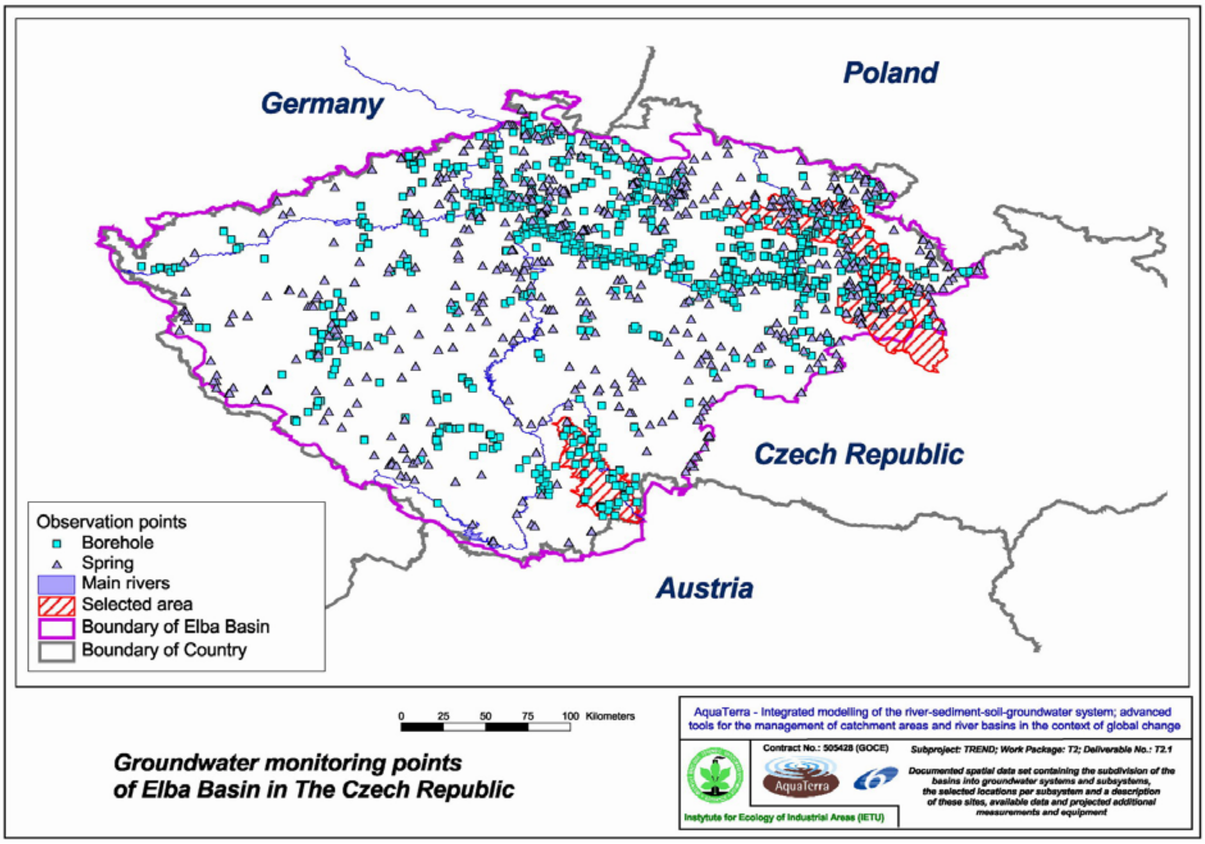


Figure 5.8 Hydrogeological units, hydrogeological zones and monitoring points in the Czech part of the Elbe basin

The data set presented in Table 5.4 allows on the nitrogen trend calculation. It should be noted that this data set does not give a possibility of further trend analysis. This is the result of the mentioned earlier lack of detail description of the monitoring points. Based on available data it is possible to make a preliminary selection of two porous hydrological regions: 1) Trebonska panev (area 875 sq. km, 30 observation points) 2) Vychodoceska krida (area 2260 sq. km, 48 observation points). In both regions the main aquifers are formed from Cretaceous sandstones, locally covered by Quaternary loams and sands. Bedrocks of the regions are formed from Proterozoic and Paleozoic crystalline rocks (granitite, metamorphic, vulcanite). One of these two regions will be selected depending on possibility of data completion

Table 5.4 Available data from groundwater quality Czech monitoring network

No	***Point ID***	***Type of point***	***WGS84 DMS***		***Ammonium, Nitrate, Nitrite***		***Number of data samples***
					Time series		
			Latitude (N)	***Longitude (E)***	***Start***	***End***	
1	VP0007	borehole	50 25 35	015 49 29	1966-06-02	2004-04-16	27
2	VP0011	borehole	50 34 31	016 10 22	1966-04-15	2004-04-17	40
3	VP0026	borehole	50 20 56	016 07 37	1966-03-20	2004-04-18	40
4	VP0031	borehole	50 20 48	015 58 18	1966-03-03	2004-04-15	41
5	VP0094	borehole	50 16 17	015 49 22	1985-06-18	2004-04-15	39
6	VP0114	borehole	50 00 06	016 27 27	1982-06-29	2004-04-20	40
7	VP0119	borehole	50 00 27	016 12 35	1982-06-24	2004-04-26	38
8	VP0129	borehole	50 08 48	016 03 46	1982-06-17	2004-04-19	40

No	***Point ID***	***Type of point***	***WGS84 DMS***		***Ammonium, Nitrate, Nitrite***		***Number of data samples***
			Latitude (N)	***Longitude (E)***	***Time series***		
					Start	***End***	
9	VP0131	borehole	50 16 25	016 03 03	1982-06-16	2004-04-15	40
10	VP0141	borehole	50 12 06	015 56 44	1982-06-15	2004-04-27	40
11	VP0201	borehole	49 52 30	016 16 00	1991-10-24	2004-04-26	26
12	VP0203	borehole	49 55 07	016 12 07	1985-06-13	2004-04-24	39
13	VP0210	borehole	49 59 02	016 04 26	1985-06-13	2004-04-23	39
14	VP0254	borehole	49 45 29	015 47 40	1985-11-21	2004-04-25	36
15	VP0261	borehole	49 57 29	015 57 22	1985-06-11	2004-04-26	39
16	VP0265	borehole	49 58 44	015 50 40	1985-06-12	2004-04-23	39
17	VP0302	borehole	50 10 56	015 49 09	1985-06-25	2004-04-27	39
18	VP0314	borehole	50 10 41	015 46 42	1957-05-29	2004-04-27	40
19	VP0326	borehole	50 03 16	015 40 32	1982-07-21	2004-04-27	40
20	VP0341	borehole	50 03 27	015 28 58	1982-07-15	2004-04-27	40
21	VP0342	borehole	50 02 34	015 28 36	1982-07-15	2004-04-27	40
22	VP0362	borehole	49 41 29	015 47 57	1985-07-17	2004-04-25	39
23	VP0409	borehole	50 17 36	015 29 44	1985-06-19	2004-04-15	39
24	VP0458	borehole	50 03 37	015 10 53	1985-05-28	2004-04-28	38
25	VP0459	borehole	50 03 40	015 09 35	1985-05-31	2004-04-28	38
26	VP0469	borehole	50 13 08	015 07 32	1985-05-29	2004-04-28	38
27	VP0476	borehole	50 06 12	015 02 45	1988-04-26	2004-04-28	36
28	VP0478	borehole	50 06 12	015 02 45	1988-04-26	2004-04-28	37
29	VP0479	borehole	50 06 12	015 02 45	1988-06-28	2004-04-28	36
30	VP0480	borehole	50 07 17	014 59 09	1988-04-25	2004-05-19	37
31	VP0481	borehole	50 07 17	014 59 09	1988-04-25	2004-05-19	37
32	VP0482	borehole	50 07 17	014 59 09	1988-04-25	2004-04-28	37
33	VP0484	borehole	50 08 17	015 03 24	1988-04-27	2004-04-26	37
34	VP0485	borehole	50 08 17	015 03 24	1988-04-27	2004-04-26	38
35	VP0486	borehole	50 08 17	015 03 24	1988-04-27	2004-04-26	37
36	VP0511	borehole	50 10 08	014 48 32	1985-06-01	2004-04-26	38
37	VP0627	borehole	50 20 35	014 51 47	1991-05-30	2004-04-28	25
38	VP0635	borehole	50 34 36	015 07 00	1966-10-08	2004-05-04	40
39	VP0644	borehole	50 32 42	015 04 14	1966-09-25	2004-05-04	40
40	VP0651	borehole	50 33 30	014 58 40	1966-11-08	2004-05-04	10
41	VP0655	borehole	50 29 33	014 56 11	1966-11-09	2004-04-28	40
42	VP0672	borehole	50 12 34	014 44 55	1969-11-16	2004-04-17	39
43	VP0684	borehole	50 14 00	014 35 17	1991-03-27	2004-05-17	27
44	VP0685	borehole	50 12 38	014 34 12	1991-04-17	2004-04-26	27
45	VP0690	borehole	50 17 14	014 36 26	1991-03-27	2004-05-17	27
46	VP0692	borehole	50 18 22	014 35 24	1991-04-21	2004-04-26	27
47	VP0697	borehole	50 16 27	014 33 02	1985-05-22	2004-05-19	39
48	VP0699	borehole	50 16 41	014 30 35	1985-05-21	2004-05-19	37
49	VP0709	borehole	50 33 13	015 02 17	1991-05-30	2004-05-04	27
50	VP0714	borehole	50 12 06	014 42 19	1988-11-24	2004-04-27	33
51	VP0715	borehole	50 12 06	014 42 20	1988-11-24	2004-04-27	33
52	VP0717	borehole	50 12 08	014 37 21	1988-12-06	2004-04-27	31
53	VP0718	borehole	50 12 08	014 37 21	1988-12-06	2004-04-27	31
54	VP0719	borehole	50 12 08	014 37 21	1988-12-06	2004-04-27	31
55	VP0814	borehole	48 52 51	014 40 36	1967-08-09	2004-05-24	39
56	VP0901	borehole	48 58 21	014 27 53	1967-08-30	2004-05-21	20
57	VP0903	borehole	49 00 25	014 27 20	1967-09-13	2004-05-18	39
58	VP1009	borehole	49 01 04	014 49 33	1967-06-27	2004-05-25	39

No	Point ID	Type of point	WGS84 DMS		Ammonium, Nitrate, Nitrite		Number of data samples
			Latitude (N)	Longitude (E)	Time series		
					Start	End	
59	VP1014	borehole	49 11 47	014 42 52	1975-07-30	2004-05-24	41
60	VP1103	borehole	49 16 00	014 56 22	1967-10-23	2004-05-18	40
61	VP1109	borehole	49 15 55	013 55 24	1967-11-01	2004-05-18	37
62	VP1117	borehole	49 09 30	014 08 05	1985-06-25	2004-05-18	37
63	VP1308	borehole	49 36 22	015 33 48	1968-04-26	2004-05-17	38
64	VP1324	borehole	49 50 35	014 40 55	1968-03-11	2004-04-22	4
65	VP1326	borehole	49 45 24	015 02 31	1968-04-20	2004-05-17	39
66	VP1567	borehole	49 45 45	013 17 03	1968-01-04	2004-04-08	38
67	VP1570	borehole	49 44 52	013 20 12	1968-01-22	2004-04-07	39
68	VP1576	borehole	49 38 45	013 15 39	1967-12-07	2004-04-08	40
69	VP1585	borehole	49 24 10	013 15 29	1968-01-23	2004-04-08	40
70	VP1601	borehole	49 58 50	013 21 38	1968-02-07	2004-04-07	40
71	VP1605	borehole	49 49 15	013 23 18	1968-01-27	2004-04-07	40
72	VP1614	borehole	49 53 44	013 58 43	1968-02-14	2004-04-08	40
73	VP1617	borehole	49 54 48	013 59 05	1968-02-07	2004-04-08	39
74	VP1626	borehole	49 58 18	014 22 18	1969-12-15	2004-04-08	39
75	VP1708	borehole	50 16 53	014 20 06	1985-10-24	2004-07-29	36
76	VP1721	borehole	50 29 12	014 24 09	1988-04-22	2004-06-25	37
77	VP1723	borehole	50 27 56	014 21 54	1988-04-21	2004-06-24	37
78	VP1724	borehole	50 27 56	014 21 54	1988-04-21	2004-06-24	37
79	VP1725	borehole	50 27 56	014 21 54	1988-04-21	2004-06-24	37
80	VP1801	borehole	50 06 24	012 23 20	1968-03-07	2004-04-07	6
81	VP1805	borehole	50 06 33	012 27 35	1968-03-21	2004-04-07	15
82	VP1813	borehole	50 13 31	012 50 15	1985-06-13	2004-04-07	39
83	VP1819	borehole	50 21 27	013 28 52	1991-11-05	2004-04-06	21
84	VP1823	borehole	50 13 22	013 28 56	1985-06-11	2004-04-06	39
85	VP1831	borehole	50 22 17	013 43 18	1985-06-10	2004-04-06	39
86	VP1838	borehole	50 24 17	014 05 44	1985-05-14	2004-06-25	39
87	VP1847	borehole	50 27 58	014 08 06	1996-06-04	2004-06-25	17
88	VP1851	borehole	50 26 19	014 10 25	1988-04-20	2004-06-22	37
89	VP1852	borehole	50 26 19	014 10 25	1988-04-20	2004-06-22	37
90	VP1853	borehole	50 26 19	014 10 25	1988-04-20	2004-06-22	37
91	VP1866	borehole	50 29 41	013 42 33	1968-05-08	2004-04-06	40
92	VP1873	borehole	50 39 13	013 59 59	1968-05-20	2004-06-22	21
93	VP1903	borehole	50 20 55	014 27 01	1996-06-05	2004-06-24	17
94	VP1919	borehole	50 29 07	014 16 46	1991-04-16	2004-06-17	27
95	VP1922	borehole	50 30 06	014 17 08	1985-05-13	2004-06-17	39
96	VP1942	borehole	50 42 36	014 47 52	1967-03-15	2004-06-16	38
97	VP1955	borehole	50 40 23	014 30 30	1966-12-23	2004-06-17	40
98	VP1994	borehole	50 48 32	014 28 43	1966-12-05	2004-06-14	40
99	VP7004	borehole	50 25 03	015 58 49	1991-11-28	2004-04-16	26
100	VP7005	borehole	50 25 04	015 58 49	1991-11-28	2004-04-16	26
101	VP7008	borehole	50 29 45	016 16 29	1991-10-03	2004-04-17	26
102	VP7012	borehole	50 24 26	015 48 00	1991-12-04	2004-04-16	26
103	VP7013	borehole	50 27 02	015 46 07	1991-12-04	2004-04-16	26
104	VP7014	borehole	50 24 28	015 53 12	1991-11-29	2004-04-18	26
105	VP7015	borehole	50 20 28	015 47 24	1991-10-09	2004-04-15	26
106	VP7016	borehole	50 34 01	016 12 13	1991-10-02	2004-04-17	26
107	VP7017	borehole	50 35 21	016 05 06	1991-12-09	2004-04-17	26
108	VP7018	borehole	50 23 18	016 06 12	1992-03-30	2004-04-18	25

No	**Point ID**	**Type of point**	**WGS84 DMS**		**Ammonium, Nitrate, Nitrite**		**Number of data samples**
			Latitude (N)	**Longitude (E)**	**Time series**		
					Start	**End**	
109	VP7019	borehole	50 23 18	016 06 12	1991-12-10	2004-04-18	26
110	VP7020	borehole	50 18 26	015 57 31	1991-12-10	2004-04-15	26
111	VP7021	borehole	50 28 01	015 54 17	1992-03-24	2004-04-16	25
112	VP7203	borehole	50 06 59	016 19 58	1991-12-04	2004-04-23	26
113	VP7204	borehole	50 04 15	016 26 46	1987-11-26	2004-04-19	26
114	VP7205	borehole	50 04 15	016 26 46	1987-12-06	2004-04-19	26
115	VP7207	borehole	50 07 04	016 24 24	1991-12-03	2004-04-20	26
116	VP7208	borehole	50 05 32	016 10 04	1988-03-30	2004-04-19	27
117	VP7210	borehole	49 48 59	016 24 12	1991-11-20	2004-04-25	26
118	VP7213	borehole	49 48 25	016 30 20	1988-09-01	2004-04-27	26
119	VP7214	borehole	49 48 25	016 30 21	1991-10-31	2004-04-27	26
120	VP7215	borehole	50 01 31	016 21 54	1988-08-24	2004-04-19	27
121	VP7216	borehole	50 01 31	016 21 53	1988-08-11	2004-04-19	27
122	VP7217	borehole	49 50 33	016 30 22	1988-12-07	2004-04-24	27
123	VP7218	borehole	49 50 33	016 30 22	1988-09-08	2004-04-24	28
124	VP7219	borehole	49 55 28	016 26 10	1988-11-15	2004-04-25	27
125	VP7221	borehole	50 04 13	016 19 35	1991-12-04	2004-04-23	25
126	VP7222	borehole	50 12 36	016 11 27	1991-11-27	2004-04-18	25
127	VP7223	borehole	50 13 01	016 16 18	1991-11-27	2004-04-18	26
128	VP7224	borehole	50 11 09	016 12 45	1991-11-27	2004-04-18	26
129	VP7225	borehole	50 07 26	016 10 32	1991-06-21	2004-04-19	27
130	VP7226	borehole	50 17 36	016 11 34	1991-12-03	2004-04-18	26
131	VP7303	borehole	49 48 28	016 21 13	1991-11-05	2004-04-24	26
132	VP7304	borehole	49 48 28	016 21 13	1991-11-05	2004-04-24	26
133	VP7305	borehole	49 54 28	016 12 43	1989-11-27	2004-04-24	27
134	VP7307	borehole	49 57 17	016 15 07	1991-10-17	2004-04-25	26
135	VP7308	borehole	49 58 52	016 10 20	1989-10-26	2004-04-23	26
136	VP7409	borehole	50 26 49	015 34 57	1991-11-21	2004-04-16	26
137	VP7410	borehole	50 24 59	015 28 06	1991-11-19	2004-04-16	26
138	VP7411	borehole	50 18 42	015 43 26	1991-12-05	2004-04-15	26
139	VP7412	borehole	50 20 19	015 36 03	1991-11-28	2004-04-15	26
140	VP7500	borehole	50 36 02	015 00 26	1987-12-11	2004-05-18	31
141	VP7501	borehole	50 36 01	015 00 26	1987-12-15	2004-05-18	30
142	VP7502	borehole	50 41 06	015 00 49	1988-01-17	2004-05-04	29
143	VP7503	borehole	50 41 06	015 00 51	1987-12-17	2004-05-04	29
144	VP7506	borehole	50 38 23	014 57 22	1987-12-06	2004-05-19	30
145	VP7508	borehole	50 38 23	014 57 22	1987-12-11	2004-05-19	31
146	VP7510	borehole	50 38 55	014 55 29	1988-07-29	2004-05-20	31
147	VP7511	borehole	50 27 02	014 48 53	1990-12-18	2004-05-06	36
148	VP7512	borehole	50 27 02	014 48 56	1990-12-18	2004-05-06	36
149	VP7513	borehole	50 39 46	014 54 15	1988-08-29	2004-05-20	31
150	VP7514	borehole	50 29 35	014 57 44	1987-11-23	2004-04-29	31
151	VP7515	borehole	50 29 03	015 00 15	1987-11-24	2004-04-29	31
152	VP7516	borehole	50 29 31	015 07 52	1990-12-20	2004-05-11	28
153	VP7517	borehole	50 24 35	014 59 11	1987-11-12	2004-05-20	31
154	VP7518	borehole	50 24 35	014 59 11	1987-11-05	2004-05-20	31
155	VP7519	borehole	50 18 37	014 51 21	1987-11-02	2004-04-29	29
156	VP7520	borehole	50 17 37	014 47 18	1988-06-30	2004-04-29	30
157	VP7523	borehole	50 31 33	014 49 49	1990-05-16	2004-05-20	33
158	VP7524	borehole	50 24 18	014 50 51	1991-03-28	2004-05-11	32

No	Point ID	Type of point	WGS84 DMS		Ammonium, Nitrate, Nitrite		Number of data samples
			Latitude (N)	Longitude (E)	Time series		
					Start	End	
159	VP7525	borehole	50 25 10	014 40 19	1990-09-25	2004-05-17	33
160	VP7526	borehole	50 19 54	014 45 03	1991-05-07	2004-05-17	33
161	VP7603	borehole	48 50 25	014 46 00	1990-05-07	2004-05-26	28
162	VP7614	borehole	49 02 43	014 19 43	1988-08-19	2004-05-18	28
163	VP7615	borehole	48 59 26	014 26 06	1988-08-08	2004-05-21	28
164	VP7616	borehole	49 01 11	014 24 45	1988-08-01	2004-05-18	28
165	VP7617	borehole	48 47 50	014 50 12	1989-10-29	2004-05-26	21
166	VP7618	borehole	48 47 52	014 50 13	1990-04-06	2004-05-26	21
167	VP7620	borehole	48 52 52	014 40 36	1990-06-18	2004-05-24	24
168	VP7621	borehole	48 52 52	014 40 37	1990-06-25	2004-05-24	24
169	VP7622	borehole	49 03 35	014 31 14	1989-11-23	2004-05-28	28
170	VP7700	borehole	48 52 04	014 51 26	1990-06-04	2004-05-27	24
171	VP7707	borehole	49 09 09	014 42 20	1991-05-18	2004-05-25	27
172	VP7708	borehole	48 57 21	014 50 26	1990-04-29	2004-05-26	24
173	VP7709	borehole	48 57 22	014 50 27	1990-04-22	2004-05-26	24
174	VP7710	borehole	48 57 22	014 50 28	1990-05-06	2004-05-26	28
175	VP7711	borehole	48 55 54	014 54 56	1990-05-15	2004-05-25	28
176	VP7712	borehole	48 55 16	014 41 35	1990-07-24	2004-05-27	24
177	VP7713	borehole	48 55 15	014 41 36	1990-07-15	2004-05-27	24
178	VP7714	borehole	49 04 08	014 45 44	1989-05-21	2004-05-17	31
179	VP7715	borehole	49 01 05	014 40 29	1990-04-02	2004-05-27	28
180	VP7716	borehole	49 04 11	014 37 41	1990-03-15	2004-05-19	28
181	VP7717	borehole	49 04 31	014 40 46	1990-03-25	2004-05-19	28
182	VP7718	borehole	49 07 06	014 36 00	1990-03-25	2004-05-19	28
183	VP7719	borehole	49 08 06	014 38 41	1990-04-02	2004-05-19	28
184	VP7720	borehole	49 15 10	014 34 55	1989-11-02	2004-05-20	28
185	VP7721	borehole	49 15 17	014 37 01	1989-10-16	2004-05-20	28
186	VP7722	borehole	49 13 15	014 33 57	1990-02-20	2004-05-25	28
187	VP7723	borehole	49 13 33	014 38 06	1990-01-14	2004-05-20	30
188	VP7724	borehole	49 12 08	014 39 29	1990-01-23	2004-05-20	27
189	VP7726	borehole	49 11 07	014 37 04	1990-05-17	2004-05-21	28
190	VP7727	borehole	49 11 08	014 37 03	1990-05-24	2004-05-21	28
191	VP7728	borehole	49 11 08	014 37 02	1990-05-31	2004-05-24	28
192	VP8200	borehole	50 27 36	014 18 47	1990-09-19	2004-05-12	33
193	VP8206	borehole	50 26 08	014 14 41	1990-10-01	2004-05-12	33
194	VP8209	borehole	50 35 46	014 18 30	1991-04-20	2004-05-13	33
195	VP8212	borehole	50 20 26	014 36 20	1990-03-26	2004-05-11	35
196	VP8213	borehole	50 28 40	014 33 24	1990-05-23	2004-05-11	35
197	VP8214	borehole	50 24 33	014 26 41	1987-12-14	2004-05-13	35
198	VP8215	borehole	50 24 34	014 26 41	1989-12-05	2004-05-13	35
199	VP8218	borehole	50 32 12	014 23 35	1990-01-12	2004-05-12	35
200	VP8219	borehole	50 28 52	014 25 55	1991-04-28	2004-05-12	33
201	VP8220	borehole	50 33 05	014 12 38	1990-02-20	2004-05-13	31
202	VP8221	borehole	50 33 05	014 12 37	1990-02-13	2004-05-13	30
203	VP8411	borehole	50 39 13	014 00 01	1991-04-23	2004-06-22	32
204	VP8413	borehole	50 45 18	014 53 38	1988-08-16	2004-06-10	30
205	VP8414	borehole	50 45 18	014 53 38	1988-08-23	2004-06-17	30
206	VP8415	borehole	50 47 38	014 50 30	1988-07-14	2004-06-09	31
207	VP8416	borehole	50 47 38	014 50 30	1988-07-21	2004-06-09	30
208	VP8417	borehole	50 45 28	014 47 06	1988-09-20	2004-06-09	30

No	***Point ID***	***Type of point***	***WGS84 DMS***		***Ammonium, Nitrate, Nitrite***		***Number of data samples***
			Latitude (N)	***Longitude (E)***	***Time series***		
					Start	***End***	
209	VP8418	borehole	50 45 28	014 47 06	1988-09-25	2004-06-09	30
210	VP8419	borehole	50 34 08	014 42 40	1988-09-13	2004-06-23	35
211	VP8420	borehole	50 34 08	014 42 39	1988-09-08	2004-06-23	35
212	VP8423	borehole	50 32 57	014 39 57	1988-06-23	2004-06-23	30
213	VP8424	borehole	50 32 57	014 39 57	1988-06-28	2004-06-23	30
214	VP8425	borehole	50 35 55	014 26 50	1990-11-18	2004-06-25	28
215	VP8428	borehole	50 49 22	014 32 58	1996-06-10	2004-06-15	16
216	VP8429	borehole	50 48 11	014 22 15	1997-11-30	2004-06-09	14
217	VP8431	borehole	50 51 18	014 25 55	1990-05-08	2004-06-17	34
218	VP8434	borehole	50 41 37	014 12 56	1981-11-18	2004-06-08	34
219	VP8435	borehole	50 41 36	014 12 56	1989-04-10	2004-06-08	33
220	VP8436	borehole	50 41 37	014 12 55	1989-04-17	2004-06-08	35
221	VP8439	borehole	50 46 25	014 43 25	1990-11-13	2004-06-09	28
222	VP8440	borehole	50 46 25	014 43 25	1988-10-21	2004-06-09	30
223	VP8443	borehole	50 42 18	014 39 22	1991-04-13	2004-06-21	27
224	VP8444	borehole	50 42 18	014 39 24	1991-04-13	2004-06-21	27
225	VP8445	borehole	50 41 53	014 41 34	1991-04-13	2004-06-21	27
226	VP8446	borehole	50 45 37	014 35 43	1989-03-07	2004-06-08	35
227	VP8447	borehole	50 45 38	014 35 44	1989-03-21	2004-06-08	35
228	VP8448	borehole	50 45 36	014 35 44	1989-03-13	2004-06-08	35
229	VP8449	borehole	50 41 26	014 33 28	1991-05-29	2004-06-22	29
230	VP8450	borehole	50 41 25	014 33 30	1989-11-21	2004-06-22	31
231	VP8452	borehole	50 39 05	014 32 22	1989-11-28	2004-06-22	31
232	VP8453	borehole	50 39 06	014 32 21	1988-11-08	2004-06-22	31
233	VP8455	borehole	50 48 37	014 10 49	1991-04-25	2004-06-15	33
234	VP8456	borehole	50 48 37	014 10 49	1991-04-25	2004-06-15	33
235	VP8460	borehole	50 50 43	014 32 11	1989-01-31	2004-06-15	30
236	VP8462	borehole	50 51 22	014 21 19	1989-04-24	2004-06-14	35
237	VP8501	borehole	50 55 24	014 24 10	1989-02-07	2004-06-17	36
238	VP8503	borehole	50 52 46	014 22 53	1990-05-03	2004-06-17	35
239	VP8505	borehole	50 49 09	014 06 58	1996-06-10	2004-06-16	17
240	PB0464	spring	49 09 52	015 18 47	1984-10-25	2004-04-16	45
241	PB0472	spring	49 02 01	015 12 44	1989-03-21	2004-04-16	33
242	PP0021	spring	50 30 36	016 11 09	1961-12-06	2004-04-17	45
243	PP0026	spring	50 28 35	015 44 03	1973-11-08	2004-04-16	38
244	PP0049	spring	50 08 55	016 31 15	1969-09-19	2004-04-20	29
245	PP0051	spring	50 03 14	016 22 06	1969-07-28	2004-04-23	44
246	PP0052	spring	50 12 38	016 27 36	1969-09-19	2003-10-21	47
247	PP0053	spring	50 09 33	016 09 54	1967-11-16	2004-04-19	38
248	PP0063	spring	50 01 12	016 26 22	1969-09-11	2004-04-20	47
249	PP0091	spring	49 53 02	016 15 59	1974-11-14	2004-04-26	42
250	PP0111	spring	50 05 57	015 35 44	1974-10-09	2004-04-28	27
251	PP0114	spring	49 40 32	015 50 25	1969-03-05	2004-04-25	42
252	PP0115	spring	49 45 31	015 43 58	1974-11-15	2004-04-25	41
253	PP0121	spring	49 46 21	015 44 12	1969-03-04	2004-04-25	41
254	PP0148	spring	49 54 12	015 48 47	1971-12-09	2004-04-23	42
255	PP0157	spring	50 30 31	015 34 52	1984-10-03	2004-04-16	40
256	PP0160	spring	50 22 28	015 33 50	1972-12-08	2004-04-15	41
257	PP0164	spring	50 21 56	015 05 54	1968-11-07	2004-04-28	41
258	PP0190	spring	50 43 27	015 26 16	1969-10-29	2004-05-18	42

No	***Point ID***	***Type of point***	***WGS84 DMS***		***Ammonium, Nitrate, Nitrite***		***Number of data samples***
					Time series		
			Latitude (N)	***Longitude (E)***	***Start***	***End***	
259	PP0191	spring	50 42 40	015 19 21	1969-09-12	2004-05-18	42
260	PP0197	spring	50 36 27	015 09 47	1975-09-26	2004-05-18	41
261	PP0210	spring	50 31 31	015 08 24	1974-06-03	2004-05-18	43
262	PP0227	spring	50 27 47	015 05 43	1974-06-04	2004-05-11	41
263	PP0232	spring	50 17 03	014 38 29	1975-08-06	2004-05-17	41
264	PP0257	spring	49 13 05	015 19 41	1970-12-04	2004-05-27	42
265	PP0261	spring	49 22 46	014 51 33	1970-11-12	2004-05-27	42
266	PP0267	spring	49 16 49	015 01 17	1974-06-03	2004-05-27	24
267	PP0271	spring	49 20 35	014 55 38	1974-12-09	2004-05-27	29
268	PP0275	spring	49 18 03	014 27 03	1971-11-10	2004-05-20	42
269	PP0277	spring	49 24 37	014 16 09	1970-11-18	2004-05-20	41
270	PP0284	spring	49 05 20	013 47 08	1970-10-16	2004-05-24	42
271	PP0285	spring	49 03 59	013 38 02	1971-09-16	2004-05-24	42
272	PP0291	spring	49 35 26	014 35 36	1970-11-13	2004-05-20	42
273	PP0292	spring	49 45 58	014 19 33	1970-10-28	2004-04-05	43
274	PP0293	spring	48 59 14	013 46 07	1970-10-15	2004-05-24	44
275	PP0300	spring	49 18 31	013 42 59	1972-11-22	2004-05-24	42
276	PP0301	spring	49 17 41	013 51 18	1972-11-22	2004-05-24	42
277	PP0319	spring	49 25 00	015 21 21	1969-02-12	2004-05-27	41
278	PP0320	spring	49 24 22	015 18 21	1967-02-16	2004-05-27	41
279	PP0327	spring	49 36 21	015 16 53	1969-02-12	2004-05-27	35
280	PP0331	spring	49 45 23	014 40 35	1978-04-21	2004-05-20	42
281	PP0346	spring	49 29 56	014 50 09	1969-12-05	2004-05-27	43
282	PP0359	spring	49 41 19	015 35 53	1974-10-14	2004-05-27	42
283	PP0360	spring	49 26 56	012 46 57	1987-09-29	2004-04-08	21
284	PP0367	spring	49 27 54	012 58 56	1972-02-01	2004-04-08	42
285	PP0368	spring	49 43 04	013 23 06	1972-02-01	2004-04-08	41
286	PP0378	spring	49 32 13	013 30 50	1977-07-05	2004-04-08	41
287	PP0379	spring	49 42 11	013 31 26	1977-07-05	2004-04-05	41
288	PP0401	spring	49 55 51	014 06 57	1977-09-20	2004-04-05	41
289	PP0402	spring	49 53 09	014 06 49	1966-03-04	2004-04-05	44
290	PP0407	spring	49 52 12	013 26 27	1977-04-25	2004-04-07	41
291	PP0427	spring	50 06 27	014 12 28	1977-05-30	2004-04-06	41
292	PP0434	spring	50 19 34	014 02 00	1968-10-30	2004-04-06	43
293	PP0437	spring	50 25 04	014 34 43	1991-04-29	2004-07-05	27
294	PP0446	spring	50 32 24	014 32 44	1974-02-14	2004-07-05	29
295	PP0456	spring	50 29 48	014 29 20	1974-08-08	2004-07-05	42
296	PP0462	spring	50 24 44	014 27 05	1966-02-03	2004-07-05	24
297	PP0466	spring	50 24 23	014 26 43	1974-02-14	2004-07-05	42
298	PP0469	spring	50 32 53	014 27 32	1970-10-06	2004-07-05	29
299	PP0477	spring	50 34 13	014 14 33	1974-08-15	2004-07-05	27
300	PP0490	spring	49 59 26	012 33 05	1984-10-23	2004-04-08	40
301	PP0491	spring	50 08 50	012 32 30	1984-10-23	2004-04-07	40
302	PP0496	spring	50 24 13	013 47 31	1976-07-26	2004-04-06	42
303	PP0498	spring	50 23 07	014 07 27	1974-05-31	2004-07-05	29
304	PP0513	spring	50 15 15	013 20 22	1975-02-13	2004-04-06	21
305	PP0525	spring	50 44 25	014 01 47	1977-06-30	2004-06-22	27
306	PP0531	spring	50 46 27	014 46 52	1969-03-21	2004-07-11	42
307	PP0533	spring	50 47 30	014 40 19	1969-03-21	2004-07-29	22
308	PP0535	spring	50 44 29	014 36 07	1966-01-01	2004-07-29	27

No	Point ID	Type of point	WGS84 DMS		Ammonium, Nitrate, Nitrite		Number of data samples
			Latitude (N)	Longitude (E)	Time series		
					Start	End	
309	PP0539	spring	50 35 34	014 29 03	1968-11-07	2004-07-05	27
310	PP0540	spring	50 40 06	014 21 58	1976-03-24	2004-07-29	38
311	PP0542	spring	50 48 13	014 29 19	1984-10-22	2004-06-14	38
312	PP0552	spring	50 52 45	014 15 38	1992-03-28	2004-06-14	26
313	PP0565	spring	50 38 36	013 32 37	1973-09-20	2004-04-06	44
314	PP0570	spring	50 57 33	014 20 16	1984-10-22	2004-06-15	40
315	PP0574	spring	50 28 34	013 02 18	1984-10-23	2004-04-06	40
316	PP0668	spring	49 46 52	015 47 25	1974-10-04	2004-04-16	38
317	PP0744	spring	50 33 06	015 22 47	1970-11-22	2004-05-18	42
318	PP0753	spring	49 16 07	013 22 54	1977-09-29	2004-05-24	41
319	PP0754	spring	49 04 25	013 38 53	2001-04-10	2004-05-24	7
320	PP0766	spring	49 40 17	015 28 01	1998-04-17	2004-05-27	12
321	PP0782	spring	49 51 43	012 52 51	1977-05-04	2004-04-08	41
322	PP0784	spring	49 51 32	012 32 52	1997-09-24	2004-04-08	14
323	PP0789	spring	49 49 43	012 47 05	1986-03-12	2004-04-08	37
324	PP0823	spring	50 46 32	014 03 34	1994-11-10	2004-06-22	20
325	PP0845	spring	48 48 33	014 18 48	1974-10-23	2004-05-20	42
326	PP0847	spring	48 45 07	014 23 28	1978-08-15	2004-05-20	9
327	PP0848	spring	48 44 36	014 24 34	1978-08-14	2004-05-20	40
328	PP0850	spring	48 42 55	014 42 41	1986-03-11	2004-05-20	37
329	PP0852	spring	49 08 00	014 24 59	1971-11-02	2004-05-20	41
330	PP0872	spring	49 41 41	013 58 26	1972-11-29	2004-04-05	42
331	PP0873	spring	49 41 09	013 41 05	1977-04-25	2004-04-05	41
332	PP0874	spring	49 47 01	013 38 27	1977-04-25	2004-04-05	41
333	PP0880	spring	49 57 25	013 14 47	1974-12-11	2004-04-07	42
334	PP0883	spring	49 54 06	013 45 08	1977-05-02	2004-04-05	41

5.6 Description data set German Elbe Watershed

5.6.1. Available monitoring points

As it was mentioned in point 5.3.2 the Shleswig-Holstein groundwater monitoring network (basic and trend) is based on specially designed set of observation points. The trend network as a new one (15 years) is still under development. For trend analysis we will use data from both networks selected by boundaries of groundwater bodies in concern.

A description of the monitoring points is presented in Table 5.5. The newly established monitoring points in trend network are presented without coordinates (described as “nowy_x”). Some of points (mainly from the basic network) are designed as nested measurement points. The screens are described in columns SCREEN. The number of screens is provided in column “No”. The next two columns contain the elevation of upper and lower edge of a screen in meters above see level. Next column presents data on depth of the lower edge of screen in meters below ground level. The column “length” presents a length of a screen. The coordinates are presented as geographic longitude and latitude. Coordinates are calculated for GCS_WGS84.

The count of measurements in time series is presented in column “CNT”. The starting year of measurements is in column “START” and the last year of measurements is in column “END”. The attributes in column “BASIC” or “TREND” identify the monitoring network of each measurement point. The following three columns provide information on selected watersheds and their order.

TIDE-ELBE watershed (second order) and the BILLE-KRUCKAU watershed (third order) is selected as the study area.

Table 5.5 Location of the monitoring points in Schleswig-Holstein

NAME	MP_ID	No	SCREEN upper edge [m asl]	lower edge [m asl]	lower edge [m ugl]	length	Longitude WGS84	Latitude WGS84	CNT	START	END	TREND	BASIC	WATERSHED_2	WATERSHED_3	WATATERSHED_4
ACHTRUP-TETTWANG	10L54001003 / 1281	1	-3,85	-8,85	20,00	5,00	9° 3' 32"	54° 48' 39"	12	1986	2000	FALSE	TRUE	EIDER		
ACHTRUP-TETTWANG	10L54001004 / 1282	2	-114,85	-119,85	131,00	5,00	9° 3' 32"	54° 48' 39"	6	1986	1989	FALSE	TRUE	EIDER		
ACHTRUP-TETTWANG	10L54001005 / 1283	3	-181,85	-186,85	198,00	5,00	9° 3' 32"	54° 48' 39"	12	1986	2000	FALSE	TRUE	EIDER		
AHRENLOHE-HÖRNWEG	10L56048009 / 3928	1	8,44	5,44	5,15	3,00	9° 45' 1"	53° 42' 33"	18	1995	2004	TRUE	FALSE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU
ALT BENNEBEK	10L59001002 / 5242	1	1,98	-1,02	4,00	3,00	9° 26' 54"	54° 22' 15"	18	1995	2004	TRUE	FALSE	EIDER		
BARMISSEN	10L57002001 / 6065	1	17,32	12,32	31,15	5,00	10° 10' 36"	54° 12' 39"	33	1986	2004	FALSE	TRUE	TIDE-ELBE		
BARMISSEN	10L57002002 / 6066	2	-67,03	-72,03	115,45	5,00	10° 10' 36"	54° 12' 39"	25	1986	2003	FALSE	TRUE	TIDE-ELBE		
BARMSTEDT-STEINMOOR	10L56002033 / 3935	1			20,00	5,00	9° 45' 55"	53° 48' 4"	11	1995	1999	TRUE	FALSE	TIDE-ELBE	BILLE-KRUCKAU	KRUCKAU
BLUNK-NORDWEST	10L60010014 / 3921	1	36,36	33,36	6,10	3,00	10° 17' 48"	54° 1' 11"	18	1995	2004	TRUE	FALSE	SCHLEI/TRAVE		
BOCKHORN-FORSTNAUS	10L60014023 / 3798	1	35,19	32,19	5,20	3,00	10° 5' 40"	53° 55' 22"	27	1993	2003	FALSE	TRUE	TIDE-ELBE		
BOHMSTEDTER FORS	10L54012001 / 1291	1	6,20	3,20	9,00	3,00	9° 5' 41"	54° 34' 27"	5	1996	2000	FALSE	TRUE	EIDER		
BORGHORSTHÜTTEN	10L58121001 / 6028	1	-16,36	-22,36	47,00	6,00	10° 3' 16"	54° 26' 8"	7	1986	1991	FALSE	TRUE	SCHLEI/TRAVE		
BORGHORSTHÜTTEN	10L58121002 / 6029	2	-99,30	-105,30	130,00	6,00	10° 3' 16"	54° 26' 8"	7	1986	1991	FALSE	TRUE	SCHLEI/TRAVE		
BREIHOLZ-OST	10L58029002 / 6227	1			4,00	3,00	9° 32' 56"	54° 12' 30"	10	1999	2004	TRUE	FALSE	TIDE-ELBE		
BREKENDORF	10L58030001 / 6100	1	21,46	19,46	7,00	2,00	9° 37' 19"	54° 26' 12"	18	1995	2004	TRUE	FALSE	EIDER		
BROKREIHE	10L61006001 / 3463	1	-18,98	-23,98	24,00	5,00	9° 27' 23"	53° 53' 0"	18	1991	2003	FALSE	TRUE	TIDE-ELBE		
DISSAU	nowy 8	1							8	2001	2004	TRUE	FALSE			
EKELSDORF-SÜDWEST	nowy 7	1							8	2001	2004	TRUE	FALSE			
ELLERHOOP-WIEREN	10L56014001 / 3932	1	7,46	5,46	6,10	2,00	9° 47' 38"	53° 43' 52"	0			TRUE	FALSE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU

ELLERHOOP-WIEREN	10L56014002 / 3933	2	0,52	-2,48			9° 47' 23"	53° 43' 50"	2	1995	1995	TRUE	FALSE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU
ELLINGSTEDT-WUHRENWEG	10L59023003 / 5241	1	13,31	10,31	4,00	3,00	9° 25' 20"	54° 28' 38"	18	1995	2004	TRUE	FALSE	EIDER		
ELLUND-WILMKJERWEG	10L59119003 / 5251	1	24,26	21,26	4,50	3,00	9° 15' 17"	54° 48' 32"	8	2001	2004	TRUE	FALSE	EIDER		
FARGEMIEL	10L55022002 / 4618	1	2,90	-1,10	12,00	4,00	11° 1' 40"	54° 16' 35"	18	1995	2004	TRUE	FALSE	SCHLEI/TRAVE		
FELM	10L58051001 / 6022	1					10° 2' 44"	54° 24' 40"	0			FALSE	TRUE	TIDE-ELBE		
FELM	10L58051002 / 6023	2					10° 2' 44"	54° 24' 40"	0			FALSE	TRUE	TIDE-ELBE		
FELM	10L58051003 / 6024	3					10° 2' 44"	54° 24' 40"	0			FALSE	TRUE	TIDE-ELBE		
FITZEN	10L53029005 / 4624	1	15,77	12,77	3,50	3,00	10° 38' 14"	53° 29' 54"	18	1995	2004	TRUE	FALSE	Middle-ELBE/ELDE		SCHAALSEE-DELVEN
GANGERSCHILD	10L59095001 / 5238	1	18,61	15,61	4,00	3,00	9° 47' 57"	54° 39' 9"	10	1995	2004	TRUE	FALSE	SCHLEI/TRAVE		
GANGERSCHILD	10L59095002 / 5239	2	14,19	12,19	7,50	2,00	9° 47' 57"	54° 39' 9"	10	1995	1999	TRUE	FALSE	SCHLEI/TRAVE		
GARDINGBEO	10L54036002 / 1285	1	-2,95	-7,95	10,00	5,00	8° 46' 23"	54° 19' 49"	7	1986	1990	FALSE	TRUE	EIDER		
GARDINGBEO	10L54036003 / 1286	2	-26,95	-31,95	34,00	5,00	8° 46' 23"	54° 19' 49"	7	1986	1990	FALSE	TRUE	EIDER		
GÖNNEBEK	10L60026001 / 3475	1	-155,52	-160,52	205,70	5,00	10° 10' 30"	54° 2' 19"	18	1991	2003	FALSE	TRUE	TIDE-ELBE		
GROßHANSDORF	10L62023001 / 4428	1	6,86	2,86	48,15	4,00	10° 17' 54"	53° 39' 22"	25	1986	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	ALSTER
GROßHANSDORF	10L62023002 / 4429	2	-149,14	-154,14	205,15	5,00	10° 17' 54"	53° 39' 22"	25	1986	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	ALSTER
GROßHANSDORF	10L62023003 / 4430	3	-201,23	-206,23	257,15	5,00	10° 17' 54"	53° 39' 22"	25	1986	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	ALSTER
GROßHANSDORF	10L62023004 / 4431	4	-275,23	-280,23	331,15	5,00	10° 17' 54"	53° 39' 22"	25	1986	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	ALSTER
GÜLZOW-SÜDOST	10L53047012 / 4625	1	23,77	20,77	4,00	3,00	10° 31' 8"	53° 26' 25"	18	1995	2004	TRUE	FALSE	Middle-ELBE/ELDE		SCHAALSEE-DELVEN
HAGEN-SÜDOST	10L60031007 / 3924	1	17,48	14,48	7,00	3,00	9° 50' 44"	53° 56' 21"	18	1995	2004	TRUE	FALSE	TIDE-ELBE		
HANDEWITT	10L59119002 / 5233	1	33,58	30,58	6,00	3,00	9° 20' 43"	54° 44' 36"	5	1996	2000	FALSE	TRUE	EIDER		
HASLOH	10L56021001 / 3730	1	5,24	3,24	15,00	2,00	9° 53' 29"	53° 42' 1"	18	1991	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU
HASLOH	10L56021002 / 3731	2	-126,76	-131,76	150,00	5,00	9° 53' 29"	53° 42' 1"	18	1991	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU
HASLOH	10L56021003 / 3732	3	-168,76	-173,76	192,00	5,00	9° 53' 29"	53° 42' 1"	18	1991	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU

HAVETOFTLOIT	10L59038001 / 5208	1	24,23	20,23	22,00	4,00	9° 33' 57''	54° 39' 21''	21	1986	2000	FALSE	TRUE	EIDER		
HAVETOFTLOIT	10L59038002 / 5209	2	3,25	-1,75	44,00	5,00	9° 33' 57''	54° 39' 21''	21	1986	2000	FALSE	TRUE	EIDER		
HAVETOFTLOIT	10L59038003 / 5210	3	-28,76	-32,76	75,00	4,00	9° 33' 57''	54° 39' 21''	16	1986	1991	FALSE	TRUE	EIDER		
HAVETOFTLOIT	10L59038004 / 5211	4	-72,83	-77,83	120,00	5,00	9° 33' 57''	54° 39' 21''	21	1986	2000	FALSE	TRUE	EIDER		
HEDEHUSUM / FÖHR BEO	10L54143002 / 1260	1	-28,25	-33,25	40,10	5,00	8° 24' 54''	54° 42' 21''	7	1986	1991	FALSE	TRUE	KUSTE (COAST)		
HEIDGRABEN-SCHLANGENTWIETE	10L56023008 / 8282	1			5,00	2,00	9° 40' 12''	53° 42' 13''	8	2001	2004	TRUE	FALSE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU
HEIDMOOR	10L60037001 / 3760	1					9° 50' 42''	53° 50' 14''	0			FALSE	TRUE	TIDE-ELBE		
HEIDMOOR	10L60037002 / 3761	2					9° 50' 42''	53° 50' 14''	0			FALSE	TRUE	TIDE-ELBE		
HÖGELFELD	10L54045001 / 1293	1	8,10	5,10	4,20	3,00	9° 3' 49''	54° 39' 44''	18	1995	2004	TRUE	FALSE	EIDER		
HOHENFIERT	10L61042008 / 3923	1	19,40	16,40	6,00	3,00	9° 37' 38''	53° 59' 48''	18	1995	2004	TRUE	FALSE	TIDE-ELBE		
HOLM-NORDOST	10L56028009 / 3929	1	7,29	4,29	4,10	3,00	9° 42' 59''	53° 38' 20''	18	1995	2004	TRUE	FALSE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU
HORST	10L61044014 / 3669	1	-22,30	-27,30	37,00	5,00	9° 37' 16''	53° 49' 3''	18	1991	2003	FALSE	TRUE	TIDE-ELBE		
HORST	10L61044015 / 3670	2	-184,30	-189,30	199,00	5,00	9° 37' 16''	53° 49' 3''	18	1991	2003	FALSE	TRUE	TIDE-ELBE		
HORST-WINTERSWEG	10L61044023 / 3930	1	9,33	6,33	7,10	3,00	9° 37' 53''	53° 49' 1''	18	1995	2004	TRUE	FALSE	TIDE-ELBE		
KESDORF / RASTPLATZ	10L55041001 / 4619	1	40,40	36,40	11,00	4,00	10° 38' 37''	54° 3' 50''	1	1995	1995	TRUE	FALSE	SCHLEI/TRAVE		
KITTLITZ HINTERM SEE	10L53062002 / 4621	1	43,82	40,82	5,00	2,00	10° 54' 19''	53° 39' 37''	1	1995	1995	TRUE	FALSE	Middle-ELBE/ELDE		SCHAALSEE-DELVEN
KITTLITZ-SALEMER STR.	10L53062002 / 4645	1	38,40	36,40	4,60	2,00	10° 54' 22''	53° 39' 43''	18	1995	2004	TRUE	FALSE	Middle-ELBE/ELDE		SCHAALSEE-DELVEN
KLAMP / WENTORF	10L57035002 / 6105	1			6,00	3,00	10° 32' 58''	54° 16' 43''	18	1995	2004	TRUE	FALSE	SCHLEI/TRAVE		
KLEIN BENNEBEK	10L59050002 / 5212	1	-9,56	-14,56	24,00	5,00	9° 27' 41''	54° 24' 27''	12	1986	2000	FALSE	TRUE	EIDER		
KLEIN BENNEBEK	10L59050003 / 5213	2	-27,55	-32,55	42,00	5,00	9° 27' 41''	54° 24' 27''	12	1986	2000	FALSE	TRUE	EIDER		
KROGASPE	10L58091002 / 6101	1	24,22	21,22	6,00	3,00	9° 55' 11''	54° 8' 31''	18	1995	2004	TRUE	FALSE	TIDE-ELBE		
KROPP	10L59053002 / 5234	1			4,10	3,00	9° 30' 60''	54° 23' 32''	5	1996	2000	FALSE	TRUE	EIDER		
KRUMSTEDT	10L51063006 / 2472	1			26,00	5,00	9° 11' 52''	54° 4' 23''	5	1996	2000	FALSE	TRUE	TIDE-ELBE		

KRUMSTEDT	10L51063007 / 2473	2			71,00	5,00	9° 11' 52"	54° 4' 23"	5	1996	2000	FALSE	TRUE	TIDE-ELBE	
LABENZ	10L53079001 / 4462	1					10° 31' 5"	53° 42' 55"	5	1997	2000	FALSE	TRUE	SCHLEI/TRAVE	
LABENZ	10L53079002 / 4463	2					10° 31' 5"	53° 42' 55"	5	1997	2000	FALSE	TRUE	SCHLEI/TRAVE	
LABENZ	10L53079003 / 4464	3					10° 31' 5"	53° 42' 55"	5	1997	2000	FALSE	TRUE	SCHLEI/TRAVE	
LANGENLEHSTENER HEIDE	10L53080001 / 4616	1	26,55	23,55	6,10	3,00	10° 46' 22"	53° 30' 21"	17	1993	2003	FALSE	TRUE	Middle-ELBE/ELDE	SCHAALSEE-DELVEN
LANGWEDEL	10L58094001 / 6000	1	-39,76	-44,76	80,00	5,00	9° 57' 11"	54° 13' 44"	25	1986	2003	FALSE	TRUE	TIDE-ELBE	
LANGWEDEL	10L58094002 / 6001	2	-124,72	-129,72	165,00	5,00	9° 57' 11"	54° 13' 44"	25	1986	2003	FALSE	TRUE	TIDE-ELBE	
LANGWEDEL	10L58094003 / 6002	3	4,80	-0,20	35,50	5,00	9° 57' 11"	54° 13' 44"	25	1986	2003	FALSE	TRUE	TIDE-ELBE	
LEEZEN-NORD	10L60053001 / 3927	1	23,35	21,35	3,00	2,00	10° 14' 54"	53° 52' 41"	2	1995	1995	TRUE	FALSE	SCHLEI/TRAVE	
LENTFÖRDEN	10L60054010 / 3653	1	20,89	17,89	10,00	3,00	9° 51' 55"	53° 52' 13"	29	1991	2003	FALSE	TRUE	TIDE-ELBE	
LENTFÖRDEN	10L60054011 / 3654	2	-14,11	-19,11	47,00	5,00	9° 51' 55"	53° 52' 13"	18	1991	2003	FALSE	TRUE	TIDE-ELBE	
LENTFÖRDEN	10L60054012 / 3655	3	-77,26	-82,26	110,15	5,00	9° 51' 55"	53° 52' 13"	18	1991	2003	FALSE	TRUE	TIDE-ELBE	
LENTFÖRDEN	10L60054013 / 3656	4	-137,26	-142,26	170,15	5,00	9° 51' 55"	53° 52' 13"	18	1991	2003	FALSE	TRUE	TIDE-ELBE	
LENTFÖRDEN	10L60054014 / 3657	5	-158,26	-163,26	191,15	5,00	9° 51' 55"	53° 52' 13"	18	1991	2003	FALSE	TRUE	TIDE-ELBE	
LÜTAU	10L53087005 / 4513	1	18,91	15,91	14,15	3,00	10° 33' 21"	53° 25' 32"	7	1986	1990	FALSE	TRUE	Middle-ELBE/ELDE	SCHAALSEE-DELVEN
LÜTAU	10L53087006 / 4514	2	-4,25	-10,25	40,15	6,00	10° 33' 21"	53° 25' 32"	25	1986	2003	FALSE	TRUE	Middle-ELBE/ELDE	SCHAALSEE-DELVEN
LÜTAU	10L53087007 / 4515	3	-47,15	-52,15	82,15	5,00	10° 33' 21"	53° 25' 32"	25	1986	2003	FALSE	TRUE	Middle-ELBE/ELDE	SCHAALSEE-DELVEN
LÜTAU	10L53087008 / 4516	4	-120,55	-129,55	159,15	9,00	10° 33' 21"	53° 25' 32"	25	1986	2003	FALSE	TRUE	Middle-ELBE/ELDE	SCHAALSEE-DELVEN
MARIENWARDER	10L57046004 / 6103	2	10,99	7,99	5,00	3,00	10° 22' 41"	54° 14' 32"	18	1995	2004	TRUE	FALSE	SCHLEI/TRAVE	
MARIENWARDER	10L57046005 / 6104	1	29,39	26,39	24,00	3,00	10° 22' 41"	54° 14' 32"	18	1995	2004	TRUE	FALSE	SCHLEI/TRAVE	
NEBEL / AMRUM BEO	10L54085010 / 1256	3	-51,61	-56,61	66,50	5,00	8° 20' 52"	54° 38' 49"	14	1986	2000	FALSE	TRUE	KUSTE (COAST)	
NEBEL / AMRUM BEO	10L54085011 / 1257	2	-28,31	-33,31	43,50	5,00	8° 20' 52"	54° 38' 49"	13	1986	2000	FALSE	TRUE	KUSTE (COAST)	
NEBEL / AMRUM BEO	10L54085021 / 1284	1	-2,80	-7,80	18,00	5,00	8° 20' 52"	54° 38' 49"	13	1986	2000	FALSE	TRUE	KUSTE (COAST)	

NEUHORST AM WALL	10L53057001 / 4622	1	28,57	25,57	10,00	3,00	10° 45' 56''	53° 36' 31''	18	1995	2004	TRUE	FALSE	SCHLEI/TRAVE		
NEUWITTENBEK	nowy 6	1							8	2001	2004	TRUE	FALSE	SCHLEI/TRAVE		
NIENBÜTTEL-NORD	10L61076003 / 3922	1	37,05	34,05	4,10	3,00	9° 25' 17''	54° 2' 24''	18	1995	2004	TRUE	FALSE	TIDE-ELBE		
NIENJAHN	10L58085003 / 3455	1	5,01	0,01	32,00	5,00	9° 36' 56''	54° 3' 15''	7	1986	1991	FALSE	TRUE	TIDE-ELBE		
NIENJAHN	10L58085004 / 3456	2	-95,49	-100,49	132,50	5,00	9° 36' 56''	54° 3' 15''	7	1986	1991	FALSE	TRUE	TIDE-ELBE		
NINDORF-FARNEWINKEL	10L51078001 / 2481	1	-164,21	-169,21	175,00	5,00	9° 9' 18''	54° 4' 43''	22	1986	2004	TRUE	TRUE	TIDE-ELBE		
NINDORF-FARNEWINKEL	10L51078002 / 2482	2	-28,21	-33,21	39,00	5,00	9° 9' 18''	54° 4' 43''	7	1986	1990	FALSE	TRUE	TIDE-ELBE		
NINDORF-FARNEWINKEL	10L51078003 / 2483	3	-2,30	-7,30	13,00	5,00	9° 9' 18''	54° 4' 43''	7	1986	1990	FALSE	TRUE	TIDE-ELBE		
NORDBÜTTEL	10L61020002 / 3428	1	-22,40	-25,40	25,00	3,00	9° 14' 2''	53° 54' 40''	7	1986	1991	FALSE	TRUE	TIDE-ELBE		
NORDERHEISTEDT-NORDWEST	10L51080002 / 2052	1	1,20	-0,80	4,20	2,00	9° 7' 39''	54° 15' 21''	18	1995	2004	TRUE	FALSE	EIDER		
OLDERSBEK-GRÜNTAL	10L54096004 / 1294	1	10,65	7,65	6,20	3,00	9° 11' 21''	54° 27' 15''	18	1995	2004	TRUE	FALSE	EIDER		
OSTERMARKELSDORF	10L55005005 / 4522	1	5,08	-2,22	7,70	3,00	11° 10' 4''	54° 27' 58''	22	1987	2004	TRUE	TRUE	SCHLEI/TRAVE		
RELLINGEN-HABICHTSTR.	10L56043007 / 3708	1			12,00	4,00	9° 53' 28''	53° 37' 56''	8	2001	2004	TRUE	FALSE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU
RELLINGEN-PAPENKAMP	10L56043016 / 8283	1			9,50	3,00	9° 51' 1''	53° 39' 52''	8	2001	2004	TRUE	FALSE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU
RIEPSDORF / FINKENBUS	10L55036001 / 4523	1	-21,65	-24,65	34,00	3,00	10° 58' 7''	54° 14' 11''	12	1987	2000	FALSE	TRUE	SCHLEI/TRAVE		
ROHLSTDORF	10L60069001 / 3472	1	21,69	16,69	14,00	5,00	10° 23' 53''	53° 58' 17''	22	1986	2004	TRUE	TRUE	SCHLEI/TRAVE		
ROHLSTDORF	10L60069002 / 3473	2	-25,33	-31,33	62,00	6,00	10° 23' 53''	53° 58' 17''	12	1986	2000	FALSE	TRUE	SCHLEI/TRAVE		
ROHLSTDORF	10L60069003 / 3474	3	-74,26	-85,26	116,00	11,00	10° 23' 53''	53° 58' 17''	12	1986	2000	FALSE	TRUE	SCHLEI/TRAVE		
SACHSENWALD-VIERTHE	10L53105018 / 4544	1	-34,25	-44,25	89,15	10,00	10° 21' 29''	53° 33' 18''	17	1991	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	BILLE
SACHSENWALD-VIERTHE	10L53105019 / 4545	2	22,75	16,75	28,15	6,00	10° 21' 29''	53° 33' 18''	17	1991	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	BILLE
SACHSENWALD-VIERTHE	10L53105020 / 4546	3	-4,25	-9,25	54,15	5,00	10° 21' 29''	53° 33' 18''	17	1991	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	BILLE
SATRUP/ESMARKHOLM	10L59071004 / 5237	2	26,54	25,54	13,8	1,00	9° 36' 6''	54° 40' 16''	18	1995	2004	TRUE	FALSE	EIDER		
SCHLUTUP	10L03008001 / 4417	1			30,00	5,00	10° 47' 44''	53° 52' 48''	4	1997	2000	FALSE	TRUE	SCHLEI/TRAVE		
SCHLUTUP	10L03008002 /	2			236,00	5,00	10° 47' 44''	53° 52' 48''	4	1997	2000	FALSE	TRUE	SCHLEI/TRAVE		

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SCHMALFELD-NORD	10L60073002 / 3373	1	-10,58	-15,58	37,30	5,00	9° 59' 9"	53° 53' 27"	0			FALSE	TRUE	TIDE-ELBE		
SCHMALFELD-NORD	10L60073003 / 3374	2	-118,58	-123,58	145,30	5,00	9° 59' 9"	53° 53' 27"	7	1986	1991	FALSE	TRUE	TIDE-ELBE		
SCHNEIDERSHOOP	10L58026001 / 6054	3	3,40	-0,60	12,00	4,00	9° 47' 41"	54° 19' 47"	25	1986	2003	FALSE	TRUE	TIDE-ELBE		
SCHNEIDERSHOOP	10L58026002 / 6062	2	-40,65	-44,65	56,00	4,00	9° 47' 41"	54° 19' 47"	25	1986	2003	FALSE	TRUE	TIDE-ELBE		
SCHNEIDERSHOOP	10L58026003 / 6063	1	-98,56	-103,56	115,00	5,00	9° 47' 41"	54° 19' 47"	25	1986	2003	FALSE	TRUE	TIDE-ELBE		
SEESTERMÜHE	10L56045001 / 3726	1	-15,83	-20,83	23,00	5,00	9° 33' 42"	53° 42' 10"	13	1991	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	KRUCKAU
SEESTERMÜHE	10L56045002 / 3727	1		-16,52	19,00		9° 32' 27"	53° 41' 57"	0			FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	KRUCKAU
SEESTERMÜHE	10L56045003 / 3728	1		-16,57	19,00		9° 32' 57"	53° 41' 60"	0			FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	KRUCKAU
SETH-ECKHOLM	nowy 5	1							5	2002	2004	TRUE	FALSE			
SIEBENBÄUMEN	10L53118001 / 4465	2	-33,80	-41,80	80,00	8,00	10° 31' 26"	53° 44' 9"	6	1987	1989	FALSE	TRUE	SCHLEI/TRAVE		
SIEBENBÄUMEN	10L53118002 / 4466	3	-95,80	-104,80	143,00	9,00	10° 31' 26"	53° 44' 9"	6	1987	1991	FALSE	TRUE	SCHLEI/TRAVE		
SIEBENBÄUMEN	10L53118003 / 4620	1			5,40	2,00	10° 31' 26"	53° 44' 9"	18	1995	2004	TRUE	FALSE	SCHLEI/TRAVE		
SÖNDERBY	10L58137002 / 6226	1			6,00	3,00	9° 47' 36"	54° 31' 50"	10	1999	2004	TRUE	FALSE	SCHLEI/TRAVE		
ST. MICHAELISDON	10L51097021 / 2362	1	10,32	7,32	9,80	3,00	9° 9' 43"	54° 0' 5"	17	1993	2004	FALSE	TRUE	TIDE-ELBE		
STADUM-SÜD	10L54125002 / 1292	1	4,20	1,20	5,20	3,00	9° 2' 13"	54° 43' 26"	17	1995	2004	TRUE	FALSE	EIDER		
STRANDE / NEUBÜLK	10L58157001 / 6102	1	9,14	6,14	13,00	3,00	10° 8' 12"	54° 27' 27"	2	1995	1995	TRUE	FALSE	SCHLEI/TRAVE		
SÜDERLÜGUMFELD	10L54131001 / 1290	1					8° 57' 34"	54° 52' 49"	5	1996	2000	FALSE	TRUE	EIDER		
SÜSEL / KESDORF	10L55041008 / 4612	1			67,00	5,00	10° 38' 54"	54° 3' 48"	5	1996	2000	FALSE	TRUE	SCHLEI/TRAVE		
SÜSEL / KESDORF	10L55041009 / 4613	2			90,00	5,00	10° 38' 54"	54° 3' 48"	5	1996	2000	FALSE	TRUE	SCHLEI/TRAVE		
SÜSEL / VINZIER	nowy 4	1							8	2001	2004	TRUE	FALSE			
TANGSTEDER FORST	10L62076008 / 4617	1		31,35	10,10		10° 3' 27"	53° 43' 12"	26	1993	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	ALSTER
TIEBENSEE	10L51075004 / 2051	1			4,20	3,00	8° 59' 56"	54° 13' 29"	18	1995	2004	TRUE	FALSE	EIDER		
TIEBENSEE (GRABEN)	nowy 3	1							4	2002	2004	TRUE	FALSE			
TORNESCH	10L56048003 /	1	3,26	0,26	14,00	3,00	9° 42' 43"	53° 42' 46"	18	1991	2003	FALSE	TRUE	TIDE-ELBE	BILLE-	PINNAU

	3587														KRUCKAU	
TORNESCH	10L56048004 / 3588	2	-68,78	-72,78	87,00	4,00	9° 42' 43''	53° 42' 46''	18	1991	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU
TORNESCH	10L56048005 / 3589	3	-90,89	-95,89	110,00	5,00	9° 42' 43''	53° 42' 46''	18	1991	2003	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU
TRAPPENKAMP	10L60068003 / 3800	1		16,79	27,00		10° 12' 4''	54° 1' 42''	18	1991	2003	FALSE	TRUE	TIDE-ELBE		
TRAPPENKAMP	10L60068004 / 3801	2		-151,21	195,00		10° 12' 4''	54° 1' 42''	18	1991	2003	FALSE	TRUE	TIDE-ELBE		
TRAVENBRÜCK-SCHLAMERSDORF	nowy 2	1							5	2002	2004	TRUE	FALSE			
TREIA-NORDERBROK	10L59092002 / 5214	1	-4,66	-9,66	27,00	5,00	9° 17' 45''	54° 31' 19''	12	1986	2000	FALSE	TRUE	EIDER		
TREIA-NORDERBROK	10L59092003 / 5215	2	-114,68	-119,68	137,00	5,00	9° 17' 45''	54° 31' 19''	12	1986	2000	FALSE	TRUE	EIDER		
WAHLSTEDT-STREEMWEG	10L60092002 / 3925	1			4,10	3,00	10° 12' 3''	53° 58' 8''	18	1995	2004	TRUE	FALSE	TIDE-ELBE		
WANDERUP/KIERACKER	10L59174004 / 5235	1	27,30	24,30	4,00	3,00	9° 19' 42''	54° 42' 20''	18	1995	2004	TRUE	FALSE	EIDER		
WAPELFELD	10L58167003 / 3461	1	-57,54	-63,54	83,50	6,00	9° 35' 45''	54° 4' 39''	18	1991	2003	FALSE	TRUE	TIDE-ELBE		
WAPELFELD	10L58167004 / 3462	2	-154,55	-159,55	179,50	5,00	9° 35' 45''	54° 4' 39''	18	1991	2003	FALSE	TRUE	TIDE-ELBE		
WEDEL-BÜNDTWIETE	10L56050015 / 3934	1			17,10	3,00	9° 41' 58''	53° 35' 42''	18	1995	2004	TRUE	FALSE	TIDE-ELBE	BILLE-KRUCKAU	PINNAU
WESTERBORSTEL-SÜDWEST	10L51131001 / 2107	1					9° 14' 43''	54° 12' 56''	5	1997	2000	FALSE	TRUE	EIDER		
WESTERBORSTEL-SÜDWEST	10L51131002 / 2108	2					9° 14' 43''	54° 12' 56''	5	1997	2000	FALSE	TRUE	EIDER		
WESTERLANGSTEDT	10L59138002 / 5240	1	12,90	9,90	4,00	3,00	9° 23' 0''	54° 36' 23''	18	1995	2004	TRUE	FALSE	EIDER		
WILSTEDT-LOHEWEG	nowy 1	1							5	2002	2004	TRUE	FALSE			
WITSUM / FÖHR BEO	10L54158002 / 1258	1	-6,54	-11,54	20,20	5,00	8° 26' 10''	54° 42' 11''	7	1986	1991	FALSE	TRUE	KUSTE (COAST)		
WITZHAVE-JAHRENSBERG	10L62086003 / 4623	1	25,00	22,00	5,00	3,00	10° 19' 40''	53° 34' 16''	18	1995	2004	TRUE	FALSE	TIDE-ELBE	BILLE-KRUCKAU	BILLE
WOHLTORF	10L53133001 / 4447	1	19,78	17,78	14,60	2,00	10° 17' 13''	53° 30' 52''	7	1987	1991	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	BILLE
WOHLTORF	10L53133002 / 4448	2	-40,04	-42,04	74,50	2,00	10° 17' 13''	53° 30' 52''	6	1987	1991	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	BILLE
WOHLTORF	10L53133003 / 4449	3	-76,18	-81,18	113,50	5,00	10° 17' 13''	53° 30' 52''	6	1987	1991	FALSE	TRUE	TIDE-ELBE	BILLE-KRUCKAU	BILLE

Source: Schleswig-Holstein Ministry of Environment

5.6.2. Hydrogeological regions in the selected German Elbe Watershed[4]

The Quaternary groundwater bodies in Bille-Kruckau watershed are located in sand and gravel layers representing three water bearing horizons. The shallow – L1 horizon exist in El11 and El12 GW body. The deeper horizon - L2 can be found in nearly all GW bodies. The deepest (Quaternary) L3 horizon is observed in El13, El14, El15 and El16 groundwater bodies.The Tertiary horizons (L5, L6) are found in N8 groundwater body.

Presented below data describe the officially established groundwater bodies within boundaries of BILLE-KRUCKAU watershed numbered from El-11 to El-17 (shallow horizons) and N-8 related to the deeper horizons of upper and lower brown coal sands. The location of this groundwater bodies is presented on Figure 5.9.

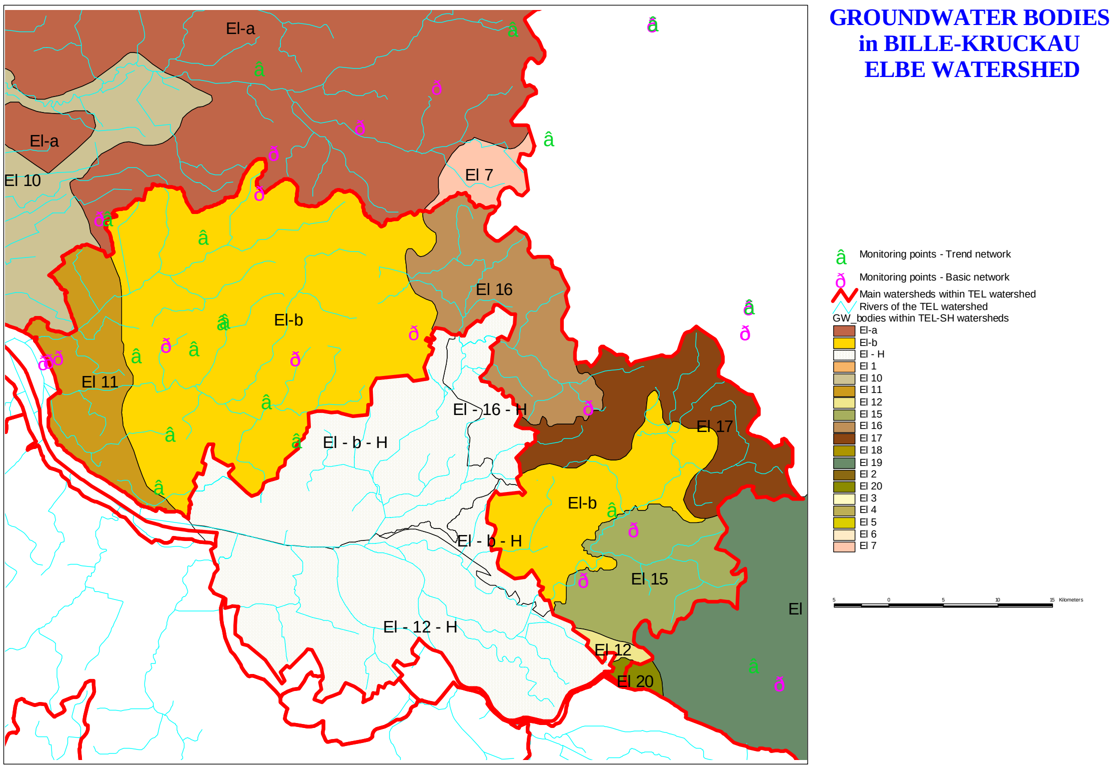

Figure 5.9 Groundwater bodies in the Bille-Kruckau Elbe watershed

The tables 5.6 below summarize some important aspects of these groundwater bodies.

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[4] Bericht über die Umsetzung der Anhänge II, III und IV der Richtlinie 2000/60/EG im Koordinierungsraum Tideelbe (B-Bericht), Anhang B – Daten; Anhang B 3.6 Teileinzugsgebiet Bille/Krückau Beschreibung der Grundwasserkörper/-gruppen; 2004; Herausgeber: Behörde für Stadtentwicklung und Umwelt der Freien und Hansestadt Hamburg Niedersächsisches Umweltministerium Ministerium für Umwelt, Naturschutz und Landwirtschaft des Landes Schleswig-Holstein; Vorlage zur Elbe-Ministerkonferenz am 9. Dezember 2004

Table 5.6: aspects of groundwater bodies in Bille-Kruckau

Aquifer	El11
Name	Krückau Marsch Nord
Reporting year	2004
Area	138,6 km^2
Catchment basin part	Bille / Krückau
Horizon (geological stratum)	L1 (sand and gravels) , L2 (sand and gravels)
Type of the aquifer	I
Characterisation of cover layers	Protection function[5]: G 65% - M 8% - U 27%
Land use	LW[6]: 95%, FW: 1%, SV: 3%, W: 1%, R: 0%
Abandoned hazardous sites (AHS) and landfills (point sources)	1 AHS (Nr. 96)
Part of area with potential endangering (land) use upon average and unfavourable cover	32%
Chemical state: present emission data for nitrate and PSM	NO_3^- > 25 mg/l: , >50 mg/l, PSM: > 0,1 µg/l
Groundwater-dependant surface waters and land ecosystems	Present/
Groundwater withdrawal	Sum of extraction: 0,9 Millions m^3/a, conurbation No
Water state time-variation curve with a noticeable decreasing trend	No
Indication of increasing noticeable salinisation	No
Other anthropological impacts	No
"at risk" concerning the chemical status	No
"at risk" concerning the quantitative status	No
Exception of the groundwater state (II;2.4)	No
Exception of the chemical state (II;2.5)	No

Aquifer	El12
Name	Bille Marsch / Niederung Geesthacht
Reporting year	2004
Area	9,8 km^2
Catchment basin part	Bille/ Krückaur
Horizon (geological stratum)	L1 (sand and gravels)
Type of the aquifer	I
Characterisation of cover layers	Protection function: M 4% - U 95% (areas-%)
Land use	LW: 68%, FW: 14%, SV: 18%, W: 5%, R: 5%
Abandoned hazardous sites (AHS) and landfills (point sources)	1 AHS
Part of area with potential endangering (land) use upon average and unfavourable cover	85,6%
Chemical state: present emission data for nitrate and PSM	NO_3^- > 25 mg/l: , >50 mg/l, PSM: > 0,1 µg/l
Groundwater-dependant surface waters and land ecosystems	present
Groundwater withdrawal	Sum of extraction 92865 m^3/a, conurbation No
Water state time-variation curve with a noticeable decreasing trend	No
Indication of increasing noticeable salinisation	No
Other anthropological impacts	No

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[5] G: good (favourable), M: medium U: unfavourable

[6] LW: field / grassland, FW: Forest / groves, SV: residential / transportation area, W: Water, R: other

Aquifer	El12
“at risk” concerning the chemical status	Yes
“at risk” concerning the quantitative status	No
Exception of the groundwater state (II;2.4)	No
Exception of the chemical state (II;2.5)	No

Aquifer	El13,14
Name	Krückau Altmoränengeest Nord/ Bille Altmoränengeest Mitte
Reporting year	2004
Area	633,7 km^2 + 166,7 km^2
Catchment basin part	Bille/ Krückaur
Horizon (geological stratum)	L2 (sand and gravels) ,L3 (sand and gravels)
Type of the aquifer	I
Characterisation of cover layers	Protection function G 15% – M 48% - U 37%
Land use	LW: 72%, FW: 10%, SV: 18%, W: 0%, R: 0%
Abandoned hazardous sites (AHS) and landfills (point sources)	17 AHS
Part of area with potential endangering (land) use upon average and unfavourable cover	76%
Chemical state: present emission data for nitrate and PSM	NO_3^- : 2 > 25 mg/l, 3 >50 mg/l, PSM: > 0,1 µg/l
Groundwater-dependant surface waters and land ecosystems	present
Groundwater withdrawal	Sum of extraction 38,8 million m^3/a, conurbation Yes
Water state time-variation curve with a noticeable decreasing trend	No
Indication of increasing noticeable salinisation	No
Other anthropological impacts	No
“at risk” concerning the chemical status	Yes
“at risk” concerning the quantitative status	No
Exception of the groundwater state (II;2.4)	No
Exception of the chemical state (II;2.5)	No

Aquifer	El15
Name	Bille Altmoränengeest
Reporting year	2004
Area	139,6 km^2
Catchment basin part	Bille/ Krückaur
Horizon (geological stratum)	L2 (sand and gravels) ,L3 (sand and gravels)
Type of the aquifer	I
Characterisation of cover layers	Protection function G 17% – M 60% - U 23%
Land use	LW: 42%, FW: 50%, SV: 8%, W: 0%, R: 0%
Abandoned hazardous sites (AHS) and landfills (point sources)	1 AHS (Nr. 90)
Part of area with potential endangering (land) use upon average and unfavourable cover	40,8%
Chemical state: present emission data for nitrate and PSM	NO_3^- > 25 mg/l, >50 mg/l, PSM: > 0,1 µg/l
Groundwater-dependant surface waters and land ecosystems	present
Groundwater withdrawal	Sum of extraction 1,7 million m^3/a, conurbation No
Water state time-variation curve with a noticeable decreasing trend	No
Indication of increasing noticeable salinisation	No
Other anthropological impacts	No
“at risk” concerning the chemical status	No

“at risk” concerning the quantitative status	No
Exception of the groundwater state (II;2.4)	No
Exception of the chemical state (II;2.5)	No

Aquifer	El16
Name	Alster Östl. Hügelland Nord
MSCOde	
Inserted at	
Inserted by	
River catchment code	
Reporting year	2004
Area	185,3 km^2
Catchment basin part	Bille/ Krückaur
Horizon (geological stratum)	L2 (sand and gravels) ,L3 (sand and gravels)
Type of the aquifer	I
Characterisation of cover layers	Protection function G 15% – M 70% - U 15%
Land use	LW: 77%, FW: 9%, SV: 13%, W: 1%, R: 0%
Abandoned hazardous sites (AHS) and landfills (point sources)	0 AHS
Part of area with potential endangering (land) use upon average and unfavourable cover	76%
Chemical state: present emission data for nitrate and PSM	NO_3^- > 25 mg/l, >50 mg/l, PSM: > 0,1 µg/l
Groundwater-dependant surface waters and land ecosystems	present
Groundwater withdrawal	Sum of extraction 22,9 million m^3/a, conurbation Yes
Water state time-variation curve with a noticeable decreasing trend	No
Indication of increasing noticeable salinisation	No
Other anthropological impacts	No
“at risk” concerning the chemical status	Yes
“at risk” concerning the quantitative status	No
Exception of the groundwater state (II;2.4)	No
Exception of the chemical state (II;2.5)	No

Aquifer	El17
Name	Bille Östl. Hügelland
Reporting year	2004
Area	176,6 km^2
Catchment basin part	Bille/ Krückaur
Horizon (geological stratum)	L2 (sand and gravels)
Type of the aquifer	I
Characterisation of cover layers	Protection function G 80% – M 16% - U 2%
Land use	LW: 77%, FW: 19%, SV: 3%, W: 0,5%, R: 0,5%
Abandoned hazardous sites (AHS) and landfills (point sources)	0 AHS
Part of area with potential endangering (land) use upon average and unfavourable cover	14%
Chemical state: present emission data for nitrate and PSM	NO_3^- > 25 mg/l, >50 mg/l, PSM: > 0,1 µg/l
Groundwater-dependant surface waters and land ecosystems	present
Groundwater withdrawal	Sum of extraction 8,4 million m^3/a, conurbation No
Water state time-variation curve with a noticeable decreasing trend	No
Indication of increasing noticeable salinisation	No

Other anthropological impacts	No
“at risk” concerning the chemical status	No
“at risk” concerning the quantitative status	No
Exception of the groundwater state (II;2.4)	No
Exception of the chemical state (II;2.5)	No

Aquifer	N8
Name	Nordsee 8
Reporting year	2004
Area	2215 km^2
Catchment basin part	Stör, Bille - Krückau, Mittelelbe
Horizon (geological stratum)	L5 and L6 2 (upper and lower brown coal sands)
Type of the aquifer	I
Characterisation of cover layers	
Land use	
Abandoned hazardous sites (AHS) and landfills (point sources)	
Part of area with potential endangering (land) use upon average and unfavourable cover	
Chemical state: present emission data for nitrate and PSM	
Groundwater-dependant surface waters and land ecosystems	
Groundwater withdrawal	Sum of extraction 15,5 million m^3/a, conurbation No
Water state time-variation curve with a noticeable decreasing trend	No
Indication of increasing noticeable salinisation	No
Other anthropological impacts	No
“at risk” concerning the chemical status	No
“at risk” concerning the quantitative status	No
Exception of the groundwater state (II;2.4)	No
Exception of the chemical state (II;2.5)	No

5.6.3 Geology[7] of the German Elbe watershed

Landscape forms and water network

The geographical classification of natural landscapes of Schleswig-Holstein is determined by processes of the glacial (Pleistocene) and postglacial periods (Holocene). There can be distinguished four major natural regions: *Eastern Hügelland (hilly country); Vorgeest; High Geest; Marsch.* The study area situated in south-eastern part of Schleswig-Holstein covers area of 1300 square kilometres of essential parts of *Eastern Hügelland* and *High Geest*. *The Eastern Hügelland* was shaped by processes during advances of a glacier of the last glacial period. Different phases of following glacier transgression and regression left distinct abrasive relief of ground moraine and terminal moraine landscape. The region of the *High Geest* owes its origins to the Vistula glaciation and preceding the Saale glacial period. Subsequent denudation and sedimentation levelled the relief to the form of smooth, evened, plateau-kind landscape, about 40 metres above sea level (NN).

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[7] Nutzbares Grundwasserdargebot in Südost-Holstein - HGN Hydrogeologie GmbH; 2002 - Landesamt für Natur und Umwelt des Landes Schleswig-Holstein; www.lanu-sh.de

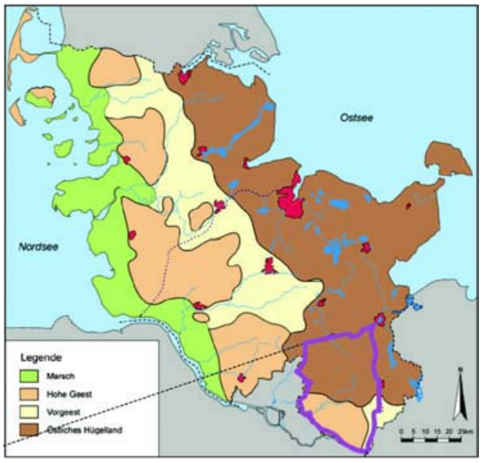

Fig. 5 10 Geographical classification of natural landscapes and the location of the study area

This landscape, between Bergedorf and Lauenburg, is bordered by line of terminal moraines which build nearby Geesthacht (over 90m NN) a cliff of the southern, adjacent lowland of the Elba valleys. Essentially, present, dense water network was developed already during the last glacier period. Most of the streams widened the valleys, which were formed throughout melted water masses of glaciers of the Vistula glaciation. The largest stream of the study area is the Bille. It's catchment area is 335 sq. km and constitutes a quarter of the total study area.

Geological structure

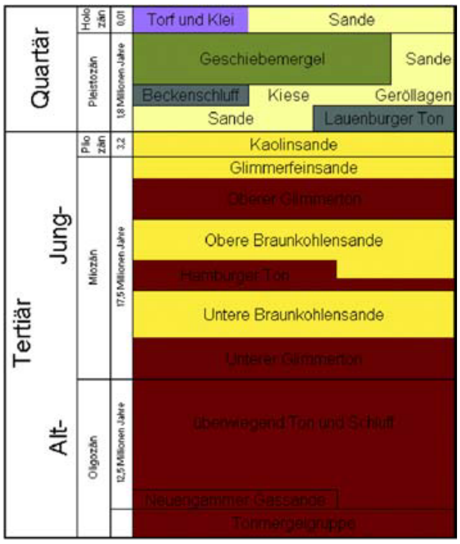

Fig. 5 11 Hydrogeological strata series

The groundwater used for drinking water supply is extracted from the sandy and gravely stratums, which were developed in different accumulation conditions during late, geological periods (Tertiary and Quaternary). Diagram of strata series presents Fig. 5 11. Depending on the cover and separation of the aquifer by solid strata, like for instance clay or boulder clay, frequently several useful multi-aquifer formation are developed in depth range between 10m and 300m beneath the terrain surface. These aquifer systems feature local hydraulic connections.

Exchange of the groundwaters in natural conditions is greater and faster in upper multi-aquifer formations than in lower ones. However, through the high groundwater exploitation, exchange of the groundwaters from lower water-bearing horizons is accelerated.

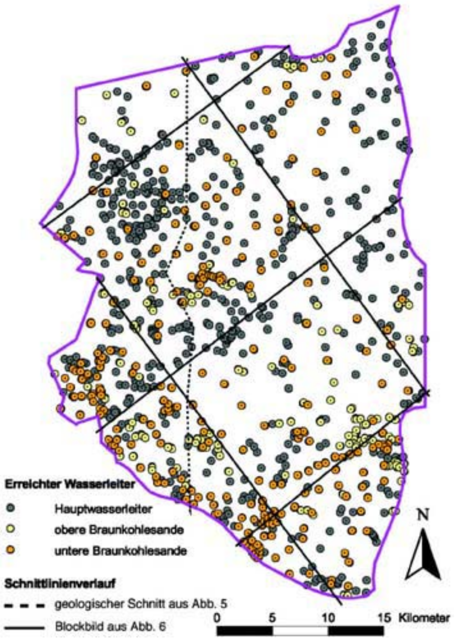

Fig. 5 12 Drilling density

The geology of Bille region was recognized based on data from geological archive concerning about 1100 drillings. Locations of the drillings is presented on Fig. 5 12.

The geological structure as well as depth and thickness of rock layers were substantially determined by tectonic movements and subsurface movements of salt deposits.

Massive rock salt formations of North Germany (700÷1000m) were deposited in Perm (Zechstein). In the following Triassic and Cretaceous, this salt formations were covered with 4000m thick rock deposits. The roof pressure and difference in thickness between salt and above deposited rock masses led to movements and development of salt deposits of *Hohenhorn*, *Juliusburg*, *Siek-Witzhave* und *Sülfeld* as well as cushion-shaped bulge of *Nusse-Eckhorst* (Fig. 5 13).

Between depressive zones located in North-western part of the study area arise *Ahrensburger* and *Oldesloer Trog*, which in southeaster direction merge into plane *Trittauer Mulde*.

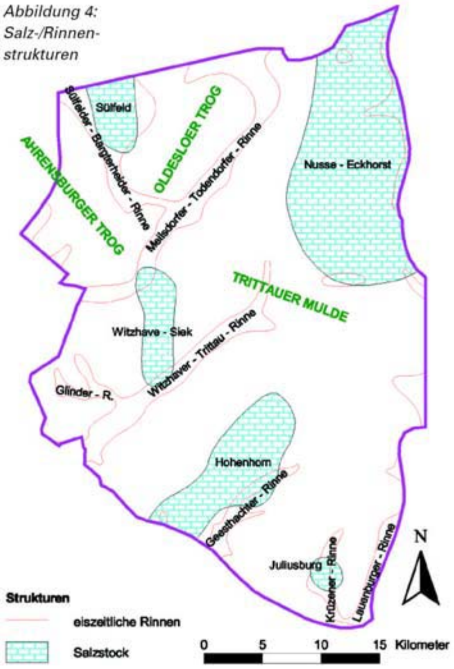

Fig. 5 13 Salt and gully structures

During their subsidence these areas were filled with sediments. In southern part of the study area analogous subsidence areas were not developed. There, processes of the salt deposits formation, were completed already at the beginning of Tertiary. In addition to salt deposits there are glacial gullies and other significant subsurface geological structural elements. In contrast to salt deposits these geological forms are quite young. The cause of their development, apart from abrasion, primarily by glacial ice, is a sub glacial erosion caused by the melted waters (fluvioglacial waters). Such developed, partly less as 1 km width and up to several tens of kilometres long concave forms often reach depth of 300m below see level, and in individual cases even 350m below see level (Fig. 5 13, Fig. 5 14). Typical sediment materials filling gullies are coarse grained fluvioglacial sands. Above them often follows massive horizons of slit and clay, so called Lauenburger clay.

From the viewpoint of the water management important are the Tertiary and Quaternary sediments (Fig. 5 11). In the old Tertiary predominate minor-porous sediments, in which appear local sandy inclusions with highly mineralised groundwater (e.g. *Neuengammer Gas* sands on Oligocene basement). The late Tertiary encompasses massive clay and sand horizons, which are common in vast fragments of the study area and only in northern-east, over the *Nusse-Eckhorst* salt structure, are not found. The floor of the late Tertiary sediment series, usable for water extraction is built of *the silt-reach grey-brown to black-brown lower micaceous clay* (*Unteren Glimmerton – UGT*). The wide spread UGT clays reaches the thickness between 10 and more than 50m. Exceptions are regions of deeper glacial gullies and flank regions of salt deposits (Fig. 5 13, Fig. 5 14). Above UGT clays follow the lower brown coal sands (*Unteren Braunkohlensande - UBKS*). They are widely spread almost over the whole study area. They are not found over the elevations of the young salt rock structures in central and northern part of the area. UBKS are characterised by dichotomy. A light-brow up to grey, fine sandy of lower zone passes above into a brown up to grey, middle to coarse grained sand. These upper segments of UBKS are discontinued in various degree, mostly by the thin layers of partly humous silt, layers of clay and lignite. In northern *Ahrensburger* and *Oldesloer Trog*, thickness of the UBKS exceed 200m and the lowest bottom of these sands reaches depth of about 900 to 1000m beneath sea level. In southern part of the study area the bottom of the UBKS reaches the level of 150n beneath see level (NN) at thickness of about 100m. In the extent of the glacial gullies, throughout deep erosion, the sands are completely removed.

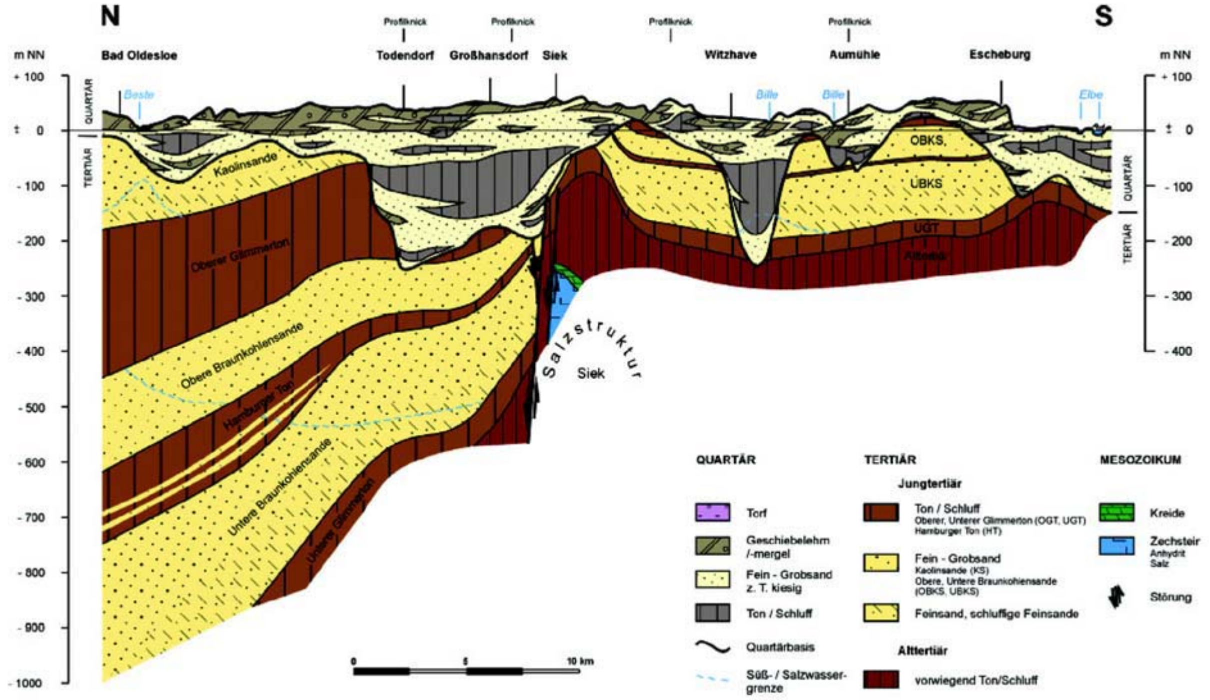

Fig. 5 14 Geological profile (cross-section line on Fig. 5 12)

The UBKS sands are covered by the Hamburg clays (*Hamburger Ton - HT*). The HT clays are in form of dark-brown up to black-brown, firm and fat clays. At its bottom, the HT clays create, almost in the whole area, a sharp edge with underneath deposited sands. The thickness of HT clays oscillate considerably. In southern part of the study area the HT clays build a 2-10m layer. The bottom of this layer is located at depth of about 0m NN in the area of *Raum Geesthacht* and up to 150m below NN (sea level) in *Trittauer Mulde* (syncline). In the North (*Ahrensburger* and *Oldesloer Trog*) this layer reaches more than 100m of thickness and in subsided basin a depth of 700m below sea level (Fig. 5 13). In deeper glacial gullies the HT clays are eroded. The OBKS sands are widely spread over the whole investigated area. Only over the salt deposits of *Siek, Sülfeld* and *Nusse-Eckhorst*, and partly over glacial gullies

occur voids. South of the line *Escheburg - Schwarzenbeck - Büchen* the OBKS sands are frequently eroded outside of the gully extents. The thickness of the sands decreases from circa 60m to 25m. On the base of the thorough investigations, it was proved that in the synclinal zone of the salt deposit structures, thickness of the OBKS sands reaches maximum 175m and depth of 500m below sea level.
The upper micaceous clays (*Obere Glimmerton - OGT)*, a dark grey to brown clay, build a cover of the OBKS sands. Silt contents in OGT clays increase noticeable partly in "suspended" layers. The name of the clays result from high mica contents, which are typical for them. In northwest synclinal zones the OGT, clays overlay completely the OBKS sands and reach there thickness of more than 200m. The bottom of the clays reaches there the depth of about 500m below sea level. In the south, the OGT clays are deposited at shallower depth and as a result of glacial (Pleistocene) erosion they are fragmented. Here the OGT clays build the last element of Tertiary stratigraphic sequence. In the central region of Ahrensburger and Oldesloer Troges, in northwest follow micaceous fine sands (*Glimmerfeinsande - GFS*) of latest Miocene. They reaches there with thickness if about 40 metres. The GFS sands are superimposed by kaolin sands (Kaolinsanden - KS) of Pliocene (the usual thickness of the KS sands is between 40 and 70m, maximum up to 150m).

The major part of the Bille Kruckau watershed, is located within the hydrogeological region of the unconsolidated sediments[8] in North Germany. These sedimentary rocks originate from transport and sedimentation of the products of mechanical and chemical weathering and are formed as clastic and chemical sediments. The clastic sediments in form of sands, silts and clay represent both Quaternary and Tertiary formations. There are also large areas of organic sediments in a form of peat.

The Bille Kruckau watershed spans over sander and high terraces region and moraine region as well as marsh region.

Table 5.7 Hydrogeological regions of Bille Kruckau

Hydrogeological regions of Bille Kruckau	
Sub regions	**Hydrogeological description**
Costal region ("Marsch") – represented by Nord Marsch Kruckau – El-11	
Costal marsh (Quaternary clay and silt)	Low-permeability confining layer, usually overlying a saline
Region of unconsolidated rocks – represented by El-b, El-16	
Sandur and high terraces (Quaternary sandy geest, alluvial loam and peat's)	Pore water aquifers, usually high yield, sometimes subdivided by aquicludes
Moraines (Quaternary boulder clay, sand and moraines)	usually aquitards (locally variations in permeability)

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[8] Hydrologische Atlas Deutschlands

Table 5.8 General hydrogeological profile of costal marsh region

Lithology	No of aquifer	Thicknessa		k		
		Min	max	min	frequently	max
silty clay		0,7	2	1E-07	3E-07	1E-06
silty sand	L1	0	5	1E-06	3E-06	3E-06
Peat	L 10	0	5	1E-05	1E-05	1E-05
Silty clay		0	2	1E-07	3E-07	3E-07
Sand	L 2	5	30	1E-04	3E-04	3E-04

Table 5.9 General hydrogeological profile of sandur region

Lithology	No of aquifers	Thickness		k		
		Min	max	min	frequently	max
Sand	L 1	2	20	1E-03	3E-04	1E-03
boulder clay (marl)		0	100	1E-05	3E-06	3E-07
Sand	L 2	5	50	1E-03	1E-04	1E-04

Table 5.10 General hydrogeological profile of moraine region

Lithology	No of aquifers	Thickness		k		
		min	max	min	frequently	max
Sand	L 1	1	5	1E-05	3E-04	1E-03
boulder marl (marl)		0	10	1E-07	3E-06	3E-06
silty clay		0	5	1E-06	1E-06	1E-05
boulder marl (marl)		0	10	1E-07	3E-06	3E-06
Sand	L 2	1	10	1E-05	3E-04	3E-03
boulder marl		0	10	1E-07	1E-06	1E-06
Sand	L 2	5	100	1E-05	1E-04	1E-03

The *coastal regio*n is characterized by the influence of the North Sea. This influence of the see is distinct especially in western part of the Bille Kruckau watershed, on the right bank of Elbe.

In El-11 sub-GW (Krückau Marsch Nord) the first water bearing horizon (L1) is located in fine and middle sands (Heidegraben – more than 5 m thick) or coarse, medium and fine sands with gravels (Seestermuhe – more than 10 m thick) covered with thick layer of clays and loams or thin layer of sands. It is assessed that this sub-GW is unprotected (permeable covering layers) on the area of about 37km^2.

Major part of the central and eastern part of Bille Kruckau watershed is located within the extent of the region of unconsolidated rocks (sand, gravel, boulder clay).

In El-13 and El-14 sub-GW (El-b) the first L1 horizon is located in a layer of fine, middle and coarse sand as well as gravels. The thickness is changed over sub-bodies from 2m to 20m and more. This horizon is covered frequently with loams, clays and loamy silts and boulder marls. The thickness of the this covering layers vary highly from nearly 0 (Holm-Nordost) up to more than 10 m (Barmsted). The next water bearing horizon (L2) is located in sand and gravel layer and is covered with layers of clays and boulder loams of varying thickness (Hasloh up to 100m). L2 aquifer is located similarly as L3 in deposits of Pleistocene age.
One of the properties of the groundwater occurrence is its potential yield. High yield groundwater occurrences are due to the following factors:

- sufficient precipitation;
- aquifer thickness,
- favorable relief and surface water condition

These conditions lead to variability in potential groundwater yield. In most part of Bille Kruckau potential yield is between 15 and 40 l/s, sometimes exceeding 40 l/s. Only small part of Bille Kruckau watershed is represented by aquifers with potential yield between 5 and 15 l/s.

5.7 DISCUSSION

The aim of the section 5 was to provide a general description of available datasets related to groundwater quality within Elbe Basin which could be useful for statistical analysis of the nitrogen trends. Presented data for Schleswig-Holstein will be selected by boundaries of Bille-Kruckau watershed.
Simultaneously data on precipitation, groundwater level as well as nitrogen load input to the soil will be completed and analysed.
The nitrogen trends at each monitoring point will be analysed using moving average method. Obtained for each monitoring point curves will be further analysed to find parameters of similarity.

The collected data from the Czech Republic at present state of completion allow only on typical statistical analysis of trends at point and on calculation of trends similarity. Further analysis of the similarity parameters require collection of additional data including detail description of monitoring points. Therefore, we propose to primarily focus on the complete German data set for trend analysis, and extend the Czech data set only when it is possible within the allocated budget ans time frame.

6. Discussion

This discussion is meant to briefly summarise the characteristics of the various study areas, to highlight apparent differences between the study sites and to examine the consequences for the work on trend detection.

6.1 Hydrogeology

Table 6.1 summarizes some main hydrogeological characteristics of the selected sub-basins. It shows that a wide range of hydrogeological situations was selected. This has major consequences for the type of wells used to collect monitoring data (see below). Moreover, a completely different age distribution and chemical reactivity is anticipated between the various types of aquifers.

Sub-basin	**Hydrogeological characteristics**	**Unsaturated zone**
Dommel/Brabant	Unconsolidated Plesitocence deposits; fine to medium coarse sands, loam	Shallow (1-5 m)
Wallony-Hesbaye	Cretaceous chalk, fissured, dual porosity aquifer	Thick
Wallony-Pays de Herve	Cretaceous chalk and sands, fissured	Thick
Wallony-Néblon	Carboniferous limestone, folded karstified	Thick
Wallony-Meuse alluvial plain	Unconsolidated deposits; gravels, sands and clays	Shallow (1-5 m)
Brévilles	Lutecian limestone over Cuise sands, limestone fissured	Thick (> 30 m sometimes)
Elbe-Czech part	Upper Cretaceous, Tertiary (sand, sandstones)	Unknown
Elbe-SH-Bille-Kruckau	Quaternary sand and gravels, glacial ground and terminal moraine deposits	Shallow (1-5 m)

Table 6.1 Summary of hydrogeological characteristics of the selected sub-basins

6.2 Spatial scales

The spatial extents of the selected sub-basins are summarised in Table 6.2. The spatial extents range from 2.5 km^2 to 5000 km^2. This reflects the large range of scales encountered in the delineation of groundwater bodies throughout Europe. The Brévilles catchment is quite small in this respect, but is well suited for the deterministic approaches and for the testing of the tools developed. The Brabant region is quite large, but contains a well developed regional monitoring system which is useful for trend detection at a regional scale.

Sub-basin	**Spatial scale**
Dommel/Brabant	500/5000 km^2
Wallony-Hesbaye	440 km^2
Wallony-Pays de Herve	285 km^2
Wallony-Néblon	65 km^2
Wallony-Meuse alluvial plain	125 km^2
Brévilles	2.5 km^2
Elbe-Czech part	875 or 2260 km^2
Elbe-SH-Bille-Kruckau	1450 km^2

Table 6.2 Summary of spatial scale of the selected sub-basins

6.3 Identity and role of stakeholders

One interesting aspect of the contrast in the various groundwater systems considered within TREND 2 is the number of stakeholders involved in water quality issues and their involvement with regard to the protection of water resources. In the small Brévilles agricultural catchment, the main stakeholders are the farmers and the inhabitants of the village of Montreuil-sur-Epte who have seen the closure of the Brévilles spring as a source of drinking water for their personal consumption due to the presence of pesticides in the spring. In the case of the Meuse, a large number of stakeholders which may have conflicting interest with regard to water quality issues coexist. These include for instance the water boards, drinking water supply companies, provincial authorities, the industry, farmers, state agencies and Nature Protection NGOs. Another interesting aspect with regard to the Meuse is the trans-national nature of the river. Transboundary water quality issues are managed by the International Scheldt and Meuse Commission which is based on international treaties. Recently, this also includes the competency of the Water Framework Directive and the Commission has a coordinating task for the transboundary river basin management plans. Although stakeholders are varied on the different groundwater systems considered, they share the same need for information on past, present and future trends in water quality to support their activities with regard to the management of water resources.

6.4 Types of monitoring

Quite different monitoring systems exist in the selected sub-basins (Table 6.3). The Brabant and Dommel sub-basins have nested observation wells at specific depths which are dedicated to groundwater quality monitoring. Monitoring data in the Wallonian catchment originate from the Wallonian nitrate survey network. Both pumping wells, springs and galleries are used for nitrate monitoring. Monitoring in the Brévilles catchment is done in piezometers and in the Brévilles spring itself. The monitoring of the German right Tide-Elbe watersheds is based on specially designed observation wells. The Czech ground water quality monitoring is based on wells and springs. At present the status of the Czech wells is not known.

Sub-basin	Observation wells	Pumping wells	Others	Typical screen lengths	Typical monitoring depths - SL
NL Dommel	X	X [b]		2 m	10, 25 m
NL Brabant	X				
Wallony-Hesbaye	X	X	Galleries	10-30 m	20-40 m [a]
Wallony-Pays de Herve	X	X	Galleries, springs	10-30 m	20-40 m [a]
Wallony-Néblon	X		Galleries, springs	10-30 m	20-40 m [a]
Wallony-Meuse alluvial plain	X	X		5-15 m	5-15 m
Brévilles	X		Spring	10-20 m	14-42 m
Elbe-Czech part	?	?	Spring	?	?
Elbe Schleswig-Holstein	x			3-5 m	4,5 – 47 m

Table 6.3 Summary of monitoring systems in the selected sub-basins. SL = Surface Level. [a] = exact lengths and depths not yet known, [b] = not yet certain

There are important differences between the monitoring systems used that are relevant for trend analysis. Probably the most important aspect is the difference in travel time (groundwater age) for samples which are taken from a pumping well, spring or gallery and for samples which are taken from monitoring screens which are not pumped.

For pumping wells, springs and galleries the sample reflects a mix of travel times which could best be described using the complete travel time frequency distribution. Young and very old groundwater are mixed because of the converging flow field. The average travel time, or characteristic time, is often counted in decades.

Samples from observation wells have more or less fixed travel time from the earth surface to the screen. Deeper screens generally exhibit older water than shallow screens, due to the slow vertical groundwater flow component. When short screens are applied, only limited mixing is anticipated. Observation wells with large screen length take an intermediate position relative to short screened wells and pumping wells.

These differences in monitoring types have large consequences for the groundwater age as deduced from modern tracers (tritium-helium, CFC) and for the spatial and temporal variability within the resulting data sets. One of the hypotheses of the WP TREND 2 is that different statistical and deterministic approaches should be applied for different types of monitoring data. One of the important contributions of the TREND 2 work package would be to develop criteria for the use of trend tools for these different types of monitoring systems. This includes the statistical and deterministic tools and concepts. An example is the possible combined use of groundwater age dating, spatial aggregation of data, concentration-depth analyses and modelling approaches. We expect that we can define a set of criteria by comparing trend analysis approaches and results from the various hydrogeological situations and monitoring types considered within TREND 2.

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Annex I

General remarks

Essential data are available in different formats, projections. Data integration within one ad hoc GIS require huge work.

Part of data (including maps) is available in form of .pdf or raster files. Raster data require registration and vectorisation. Some of .pdf maps is available as vector drawings that after conversion into .dxf files require transformation from picture coordinates into geographic ones. Joining of attributes spread in text files is also a time consuming work. Table below presents some information about the scope of necessary actions connected with data collection and integration.

Layer name	type	Resolution/accuracy	Source	Coordinate system	Required action	Remarks
Administrative boundaries	Vector – line, polygon		ESRI – countries.sdc – ARC GIS9	GCS-WGS84	Selection, integration in ELBE-GIS	
Landuse	Grid	100mx100m	EEA	Projected CS-Lambert Azimuthal Equal Area - sphere	Transformation into GCS-WGS84, selection of Elbe part	For regional analysis (error ~+-100m)
Soil	Vector (.shp)	1:5 000 000	EEA	Projected CS-Lambert Azimuthal Equal Area - sphere	Transformation into GCS-WGS84, selection of Elbe part	Regional purposes only
Location of monitoring point in Czech Republic	Point – HTML tables		ChMU	Projected CS- S-JTSK	Transformation into information layer, Transformation into GCS-WGS84, selection of Elbe	
Location of monitoring point in Germany	Table-pdf		LAWA	GCS-WGS84	Transformation into information layer, comparison with other data sources	
Location of monitoring point in Schleswig Holstein	Point – xls, pdf, HTML	+-10m	Ministry of Environment - Dezernat 44 - Grundwasserhydrologie, Grundwasserschutz, Landesamt für Natur und Umwelt Schleswig-Holstein	Projected CS – Gauss-Kruger 3and 4 Bessel41	Transformation into GCS-WGS84	
River network-Czech Republic	Vector-Line		Hydroecological information system VÚV T.G.M. (HEIS VÚV) for Czech Republic http://heis.vuv.cz/	Projected CS- S-JTSK	Transformation into GCS-WGS84	
River network-Germany	Vector-line	1:1000000	ESRI – water.sdc ARC INFO 9	GCS-WGS84	Cliping	Regional course
River network - Schleswig-Holstein	Vector-line	1:1000000	ESRI – water.sdc ARC INFO 9	GCS-WGS84	Cliping	Provisionally replaced with data from ESRI Digital Chart of the World
Morphology	DEM	1kmx1km	USGS-GTOPO30		Conversion into information layer, clipping, transformation	Only for regional analysis
Geology – Germany, Czech Republic	Description					Lack of information layers

Hydrogeological region	Line, polygons atributes		Hydroecological information system VÚV T.G.M. (HEIS VÚV) for Czech Republic http://heis.vuv.cz/	Projected CS-S-JTSK	Transformation into GCS-WGS84	
Boundaries of Groundwater bodies - Schleswig-Holstein	Line - .pdf, tables - .pdf		SH - Ministry of Environment		Conversion into information layer, transformation	
Time series GW quality – Schleswig-Holstein	.xls		SH - Ministry of Environment - Dezernat 44		Integration in MS Access	
Time series GW quality – Czech RepublicRepublic	Table, HTML		ChMU	Projected CS-S-JTSK	Transformation into GCS-WGS84	
Time series – water level Schleswig-Holstein	.txt		SH - Ministry of Environment - Dezernat 44		Integration in MS Access	
Time series- water level – Czech Republic						Lack
Deposition of nitrogen – Czech, Germany						Lack of information layer
History of nitrogen fertilizer application Czech , Germany						Lack of information layer

Data handling for Trend2 needs

Czech data

The coordinates of the monitoring points as well as other environmental data are available as projected coordinates. The Czech Republic Datum is based on Bessel ellipsoid and so called S-JTSK projection. Parameters of S-JTSK projection as well as other coordinate datum applied in Czech Republic are described on several internet web pages. The transformations rules from one datum into other is provided by ESRI within ARC-GIS 9 software package.

All presented within report data were transformed into WGS84 geographic coordinates.

German data

Generally, the German data are available in coordinates of so called Gauss-Kruger projection that is used in western part of Germany. The projection is a version of Transvers Mercator projection developed on Bessel 1941 ellipsoid. Based on information provided on internet web pages as well as algorithm applied by ESRI within ARCGIS 9 it was possible to transform projected coordinates (GK3 and GK4) into WGS84 geographic coordinates.

EEA data

Data on land use (CORINE LAND COVER – CLC) and soil have been obtained from European Environmental Agency http://terrestrial.eionet.eu.int .

Data are available only for noncommercial purposes on permission of EEA (CLC90) and on permission of local government (CLC2000). At present the CLC2000 data for Germany are unavailable. The permission has been granted for use of CLC90 in AQUATERRA project n.

Available, at the EEA internet web pages, data on land use and digital map of European soils are in Lambert Azimutal Equal Area projection that is based on

sphere with radius 6378388 equal to longer radius of International 1924 (1909) ellipsoid.
The straight transformation from this projection into WGS84 is not available. The data were transformed in three following steps. From the projected coordinate system into geographic coordinate system (Sphere). From sphere data were transformed into GCS based on International 1924 ellipsoid. The last step include transformation from GCS International 1924 into WGS84. Estimated error within the boundaries of Central and East Europe is 100m.