SUPPORTING REPORT C
HYDRO-GEOLOGY

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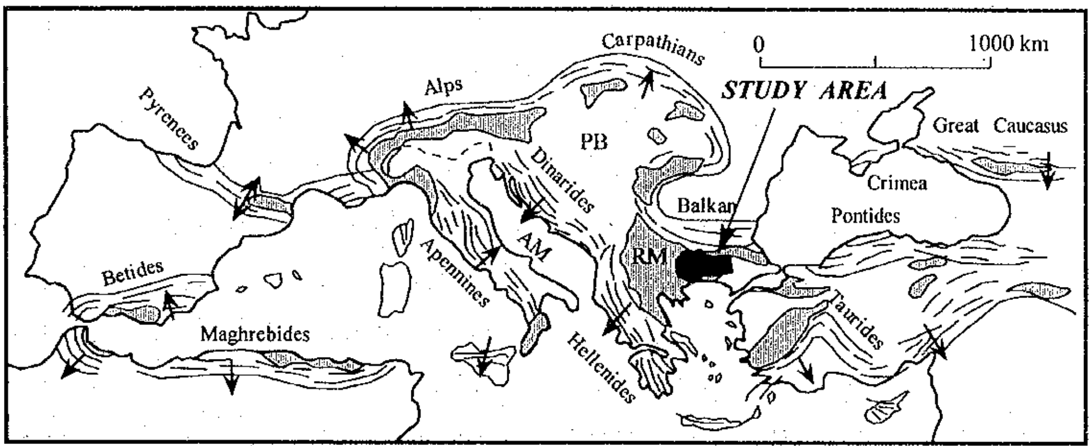
1. Geology

The Maritza River basin is situated at the northern edge of the Alpine orogenic belt, which is the latest major tectonic event (throughout Tertiary) of the geological history.

Distribution of Alpine Orogenic Belt and Related Geologic Units
Alpine orogenic belt: areas with broken lines.
Areas shaded with vertical stripes are pre-Alpine orogenic basements



Arrow marks indicate the direction of tectonic movements (thrust, folding).
AM: Adriatic Massif, PB: Pannonian Block RM: Rhodope Massif.

Fig. C.1.1 shows the geological map of the Maritza River Basin. Precambrian and Paleozoic plutonic and metamorphic rocks outcrop exclusively in the mountainous area. These highly consolidated rocks form a solid basement (hereafter called bedrock) in the study area providing sedimentary basins for overlying younger formations. Mesozoic formations are exposed typically in the northern part, in small areas in the form of narrow strips along major faults. Tertiary sedimentary rocks cover the most part of topographically flat areas. They are considered to fill the depression in the bedrock. Sedimentary formations of the uppermost part of this sequence are unconsolidated. Quaternary deposits are distributed along the river courses, flood plains, and terraces among them. They overlie the tertiary formations as a thin and flat depositional cover.

A complicated set of faults called the Maritza Deep Fault runs through the study area from west to east, which is seismically active nowadays. The study area is divided into two structural zones by the fault zone. The two zones are called Srednogorie Structural Zone (north-western to eastern areas) and the Rhodopes Crystalline Massif (southern area). Since the fault zone is very active, it is considered to affect even the youngest Quaternary deposits in some parts. Table C.1.1 shows the geological units in the Maritza river basin.

(1) Srednogorie Structural Zone

Granites in south Bulgaria (Carboniferous), biotite and two-mica gneisses etc. (Precambrian) accompanied by small portion of lower Paleozoic metamorphic rocks are widely distributed along the northwestern border of the study area. These rocks form the bedrock for overlying Tertiary and Quaternary sequences. A group of faults trending from northwest to southeast with synclinorium are clearly observed in the northwestern plutonic bedrock. They expose formations of cretaceous limestone and volcano-sedimentary rocks called Panagyurishte strip between them. This synclinorium is considered to be the most specific feature of this structural zone. This structure obviously extends to the east and its eastern end is exposed along the north-eastern border of the study area. Another conspicuous structure is observed to its west. Ihtiman-Horst block which is composed of sets of horst and graben filled mainly with Pliocene and Quaternary sediments. In the whole study area, Neogene terrigenous sediments are observed in the depression of the north-west to south-east. They are composed of conglomerate, sand and clay. In the eastern part, coal layers are observed in the Marica Formation (Plaeogene-Neogene) along the Sazliyka River.

(2) Rodopes Crystalline Massif

Rodopes Crystalline Massif is regarded as a part of the larger and older lithosperic block which is known as the Tracian Crystalline Massif. Biotite granite and two mica granites etc. (Precambrian), granite in southern Bulgaria (Carboniferous) and gneiss-schists (Precambrian) are dominant in the most part of the Rodope Mountains. The total thickness of the apparent outcrop is 20km. In its center, acid and intermediate volcanic and volcaniclastic rocks (Oligocene) are observed to fill the structural depression. Marbles and schists of Assenovgrad Group (Precambrian) outcrop in smaller scale in the eastern part of the Rodope Mountains intermediate volcanics (andesites in Eocene) and complex of dominantly intermediate tuffs, tuffaceous sandstones and reef limestone (Oligocene) also outcrop on smaller scale in the east. Neogene terrigenous sediments composed of conglomerate, sand and clay can be observed in the north-eastern part with minor amount of intermediate pyroclastics and limestone (Oligocene).

(3) Quaternary Deposits

Relatively younger and unconsolidated deposits cover most of the topographically even areas. Among them, the distribution of recent river deposits and flood plain deposit are confined to a narrow area along the river course in the east. On the other hand, their distribution is wider in the west.

In addition, quaternary alluvial terrace deposits lie in slightly higher plains between the major tributaries especially in the upper reach of the Sazliyka River and in the middle reach of the Maritza River.

Remarkable development of alluvial fans composed of drift deposits is observed along the northern edge of Rodope Mountains where the mountain slope suddenly levels off into the flood plain.

(4) Others

In relation to the various faults and volcanic activities, there are several mineral resources such as copper, lead, zinc and uranium in the study area. There are also many thermal and mineral water sources in the study area. The distribution of volcanic activities and serpentinized ultrabasic rock bodies appears to be related to the orientation and distribution of faults in the area. It leads to the localization of most of ore minerals- lead-zinc and fluorite deposits are controlled by the northwest-southeast striking fault sets. The localization of the thermal mineral waters is also dependent on the fault orientation.

2. General Hydrogeology

2.1 Hydrogeological Classification

The study area is mainly classified into four units as **bedrocks, Quaternary deposits**, **Neogene deposits**, **carbonate rocks**, and **fractured zones** from the hydrogeological point of view.

(1) Bedrocks

Precambrian rocks, Ordovician, Silurian, Carboniferous, Permian rocks in Paleozoic, Triassic, Jurassic, Cretaceous rocks in Mesozoic, and Tertiary rocks are widely distributed in the study area. Those are practically impermeable with low porosity and considered to be the bedrocks from the hydrogeological point of view.

(2) Quaternary Deposits

Quaternary deposits are distributed in the mountain foot and along Maritza river and its tributaries. The results of previous exploration boreholes show that the depth to the basement rocks ranges from 5 meters at small tributaries to more than 100 meters at the downstream of Maritza river. The thickness of Quaternary deposits tends to increase toward the downstream. It is roughly divided into five different deposits from the topographical point of view as follows.

Flood plain deposit	: recent and modern river bed deposit
Talus deposit	: distributed at the mountain foot
Fan deposit	: distributed at mouths of valleys
Drift deposit	: bad sorted glacial deposit
Terrace deposit	: distributed on the terrace along rivers

These deposits are mainly composed of sand and gravel with clay and considered to be aquifer. Those are most interesting and can be divided into the following three groups from a viewpoint of groundwater development.

Flood plain deposit

Recent flood plain deposit is widely distributed along Maritza river and it's tributaries which have a thickness of over 100 meters in an area. It mainly consist of gravel, sand with clay. Permeability of this deposit may be the highest comparing with another Quaternary deposits.

Talus and Drift deposits

Talus deposit is distributed at the mountain foot and drift deposit is distributed on the hilly region. Those are composed of gravel, sand, and clay and poorly sorted. Clay contents of talus and drift deposit may be the highest comparing with other deposits.

Fan and Terrace deposits

Fan deposit is distributed at valley mouths in the mountain foot and terrace deposit is distributed in the hilly region continuing from mountain foot or flood plain. Those are composed of gravel, sand, and clay. Clay contents may be higher than those of flood plain deposit.

(3) Neogene Deposits

Neogene deposits are mainly composed of sand and gravel with clay. It is reported that maximum thickness is about 150 meters in the northern part of Plovdiv and 250 to 300 meters in Karlovo.

(4) Carbonate Rocks

Basement rocks are basically impervious, but there are some pervious zones due to solution cavities in Mesozoic carbonate rocks.

Carbonate rocks of dolomite, limestone are distributed in the upstream of Topolnitza river, near Brezovo, Stara Zagora, Devin, and Lakki. Those are considered to be aquifers because of many solution cavities and solution openings.

(5) Fractured Zones

Basement rocks are basically impervious, but there are some pervious zones due to fractures in the bedrocks.

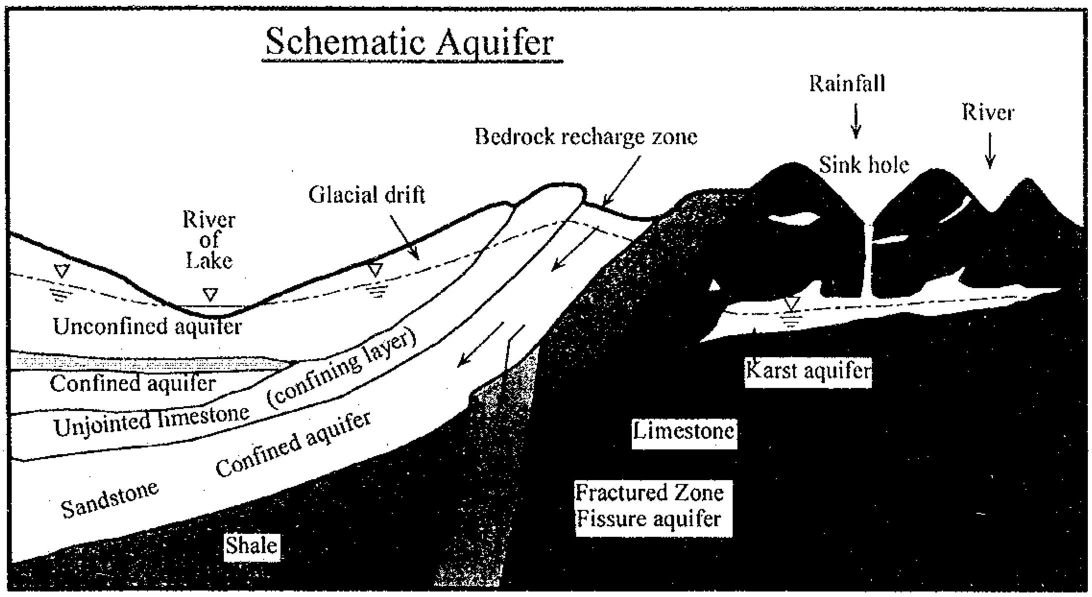
According to the interpretation of topographical and geological maps, some fractured zones are distributed in the study area. Those may form either pervious or impervious zones which control groundwater flow and are expected to be fissure aquifers. Pumping yield of production wells range widely depending on characteristics of faults and fractured zone.

2.2 Aquifer Type

There are mainly three types of water-bearing formations in the study area as follows.

Definition of Aquifer Type

Quaternary aquifer	is defined as an aquifer in sand and gravel layer of Quaternary deposits. Neogene (Pliocene) aquifer is locally included.
Karst aquifer	is defined as water in solution porosity, cavity, and opening in carbonate rocks.
Fissure aquifer	is defined as an aquifer of fractured zone in the bedrocks.



(1) Quaternary aquifer

There are two types of Quaternary aquifers in the study area. Those are the unconfined aquifer and confined aquifer.

Alluvial Unconfined Aquifer

Quaternary deposits distributed along Maritza River and its tributaries are considered to be unconfined aquifers having the water table. The maximum pumping yield of production wells in the study area was 15 liters/second (1,296m^3/day) in the past study. Neogene unconfined aquifer is partly included in this aquifer.

Alluvial Confined Aquifer

Confined aquifer lies under the confining layer that is an impervious clay layer in Alluvial deposit. This aquifer is utilized as the source of artesian well or flowing well.

Neogene Confined Aquifer

Almost Neogene aquifer lies under the Alluvial deposit. Some part of this aquifer is combined with Alluvial confined aquifer. This is not interesting for the groundwater development because of a few potential of groundwater comparing with another Quaternary aquifer.

(2) Karst Aquifer

The acidic rainwater enters joints and beddings in carbonate rocks and it may dissolve small volumes of rocks causing an enlargement of crevices and voids. As a cavern system develops, surface stream flow is diverted to underground flow.

If these voids are close to the land surface, the roofs of resulting caverns may cave in and thus produce sink holes. Lakes in this type of terrain, which is called " karst topography ", are intimately connected to the groundwater system. Water usually moves rapidly in certain directions through aquifers in karstic terrain and extreme measures shall be taken to prevent contamination of the groundwater. Limestone does not initially offer much of a reservoir for storage, but through secondary solution of limestone and dolomite can become large-capacity reservoir for groundwater storage.

Maximum pumping yield was 70 liters/second (6,048 m^3/day in the past data).

(3) Fissure Aquifer

Fractured zones may form either pervious or impervious zones which control groundwater flow. If a fractured zone is large enough without clay fill, water can be stored in the fractured zone. This is called "fissure aquifer".

Pumping yield of production wells ranged widely due to diverse characteristics of faults and fractured zone. Maximum one was 20 liters/second (1,728 m^3/day) near Plovdiv.

2.3 Hydrogeological Characteristics

(1) Hydraulic Properties of the Aquifer

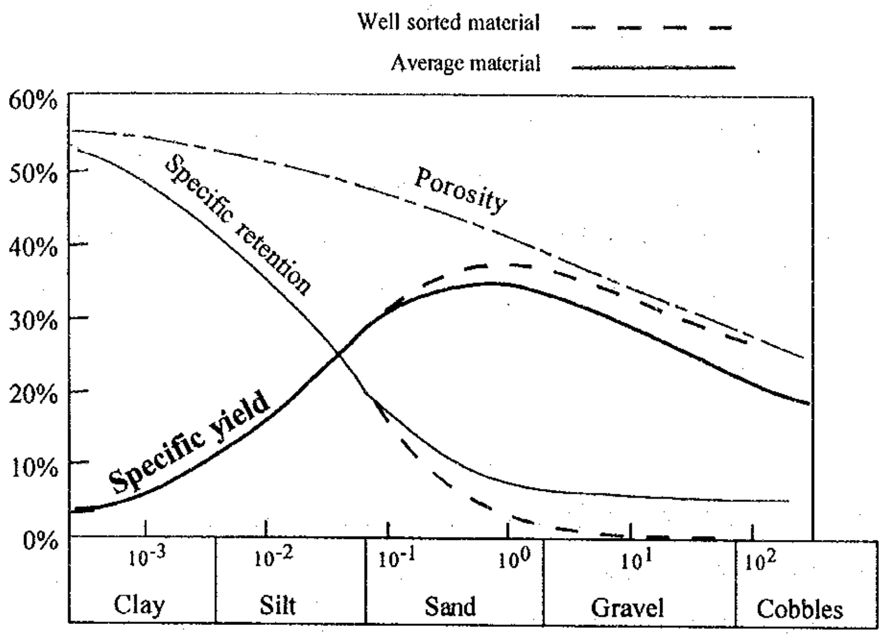
Availability of groundwater depends on two important functions of the aquifer, namely the transmission and the storage of water. These are affected by permeability and porosity of the aquifer. The former is indicated by the permeability coefficient, that is the volume flow rate of water through a unit cross-sectional area of a porous medium under the influence of a hydraulic gradient of unity. The transmissivity or flow in m^3/day through a section of aquifer 1 meter wide under a hydraulic gradient of unity is used as a convenient quantity in the calculation of groundwater flow instead of the permeability coefficient. The transmissivity "T" and permeability coefficient "k" are related to each other as follows:

$$T = kH$$

Where "H" is the saturated thickness of the aquifer. Normally "T" and "k" are determined by aquifer tests. If aquifer tests are not carried out or "T" and "k" are unknown, a **specific capacity** (m^3/day/m), which is the discharge per unit of drawndown, is sometimes used to estimate hydraulic properties of the aquifer empirically.

The porosity is defined as the percentage of pore space within a given volume. However the capacity of an aquifer to yield water is of greater importance than its capacity to hold water as far as supply is concerned. Even the pore space of a rock or soil may be saturated, only a certain proportion of water can be removed by drainage under gravity or pumping. The ratio (usually in %) of volume of water that can be drained by gravity to the total volume of the aquifer is refereed to as a **specific yield** (m^3/m^3). An outline of the specific yield in the study area is compiled in Fig. C.2.1 "Distribution Map of the Specific Yield".

Relationship between the specific yield and particle size distribution



Median grain size (mm)

Ranges of the permeability coefficient for soils and rocks, specific capacity and groundwater supply potential, examples of the specific yield of some common types of soil and rock, and the relationship between the specific yield and particle size distribution are given in Table C.2.1 and the above figure as a reference.

3. Groundwater

3.1 Monitoring System for Groundwater in the Maritza River Basin

The monitoring systems for groundwater are managed by three organizations of National Institute of Meteorology and Hydrology (NIMH), National Center for Environment and Sustainable Development (NCESD), and former Committee of Geology (COG , now the Department of Use and Protection of Groundwaters). NIMH started the measurement of groundwater table and water quality from December 1959 for a few wells. NCESD and COG started also the measurement from 1980 and 1992, respectively. It is reported that National Center of Hygiene and Epidemics in Ministry of Health has the monitoring system for the groundwater quality.

Monitoring stations of each organization are shown in Fig. C.3.1 and Fig. C.3.2. Monitoring system is composed of 327 stations in total. 161 stations of them are managed by NIMH, 67 of them are managed by NCESD, and 99 of them are managed by COG. No organization has been established to synthesize the data of each organization at present.

161 monitoring stations of NIMH consists of spring, artesian well, and well. The Study team could recognize only 135 stations on the map. 67 stations of NCESD also could not be clarified the geological formation and aquifer type. 99 stations of COG could be realized the geological and hydrogeological conditions, and aquifer types such as unconfined aquifer, confined aquifer, and fissure aquifer in each station. The monitoring system of COG is well examined on its purpose, location and depth from the view points of topography, hydrology, geology, and hydrogeology.

There is no integrated database for groundwater monitoring. Consequently, all data could not be analyzed, JICA study team selected carefully the data, and has investigated to realize the general characteristics of groundwater in Maritza river basin.

3.2 Hydrogeological Condition

Unconfined aquifer and locally confined aquifer are distributed in the plain and hilly region. Its aquifer basin has a thickness of over 100 meters in the maximum and mainly consist of gravel, sand with clay.

Karst water is also distributed near Pazardjik, Stamboliyski, Devin, upstream part of Assenovgrad in Rhodopes Massif, and Brezovo to Stara Zagora in the Srednogorie Structural Zone where Precambrian and Cretaceous carbonates rock are distributed respectively. Those are considered to be aquifer because of many solution cavities and solution openings.

It is expected the distribution of fissure water because of the distribution of many faults. Fractured zones may form either pervious or impervious which control groundwater flow. If the fractured zone has a large scale without clay, water can be stored in the fractured zone. Some of them are the thermal groundwater. But, fissure water is not thoroughly investigated in the whole Basin.

According to the study report of COG, average transmissivity of unconfined aquifer is about 1500 m^3/day/m in the left bank and about 3000 m^3/day/m in the right bank side of Pazardjik and Plovdiv. This study suggested also the distribution of thermomineral water in the bed rocks of Proterozoic marbles laid under the basin of unconfined aquifer.

The result is shown in Fig. C.3.3 "Hydrogeological Map" as one of the typical hydrogeological characteristics. This is compiled from hydrogeological map issued by former Bulgarian Academy of Science in 1967. High productivity of groundwater is expected in the surroundings of from Septemvri to Sadovo along Maritza river, from Harmanli to Lyubimetz along Maritza river, and along Stryama river. Its transmissivity ranges from 500 to 2000, locally to 4000 m^3/day/m and these areas are suitable for big-scaled development. Other plain and hilly regions are expected to develop for local consumption. Groundwater is used as spring for local consumption in mountainous area.

Hydrogeological conditions of each area are described below on the basis of COG data.

3.2.1 Karlovo Area

Summary of aquifer is shown in Table C.3.1.

(1) Unconfined Aquifer

General characteristics

The unconfined aquifer is related to the distribution of Quaternary and Upper Pliocene deposits. It is widely distributed in Karlovo valley. The Quaternary deposit is composed of Alluvial and drift deposits overlaying on the Pliocene deposits. Alluvial deposits of Stryama and Byala rivers are present by pebble. In some places pebble are interbedded by clayey lens. The thickness of the alluvial deposits is increased from west to east direction in parallel with their hydrogeological parameters and it is about 50 m. Drift deposits (old and recent) are bad-sorted deposits located at the foot of Balkan mountain ridge. Their hydrogeological parameters are extremely lower than Alluvial sediments. The underlying bed of the horizon, at the deepest part in the Karlovo graben, is made up of Pliocene diatomite clays which are regional aquiclude in the area of confine aquifer spreading.

The direction of water flow is generally from north to south in the northwest and central part of the valley. In the eastern part of the valley, water flow direction is from northeast to southwest.

Water is porous type. Groundwater table is relatively shallow that is recharged mainly by streams from Balkan mountain and particularly from Sredna gora mountain. A few portion of water is recharged by the infiltration of rainfalls. The main drainage is Stryama river.

Hydrochemical Classification

According to chemical composition, waters are mostly bicarbonate type, low hardness, with low salinity varied from 0.1g/l to 0.5 g/l and pH - 6.7 - 7.4.

Hydrogeological Constant

According to classification in terms of transmissivity values, Karlovo area can be divided into three as follows :

① Alluvial deposits have relatively higher transmissivity values in some cases they are reaches up to 609 m^3/day/m.

② an area with transmissivity of less than 30 m^3/day/m which is located in the northern part of Quaternary-Pliocene aquifer, and

③ an area with transmissivity of 30 m^3/day/m to 300 m^3/day/m which is located in the central southern part of the Karlovo graben.

Predominate transmissivity values in Karlovo graben range from 30 m^3/day/m to 200 m^3/day/m. Average transmissivity values are 75 m^3/day/m for the central and west part of the valley and 175 m^3/day/m for its east part.

Drift deposits have lower transmissivity value comparing with another Alluvial deposits.

Diversity of the transmissivity values depends on the differentiation of sedimentation.

(2) Pliocene Confined Aquifer

General Characteristics

The Pliocene confined aquifer is locally distributed in Karlovo graben which is confined by diatomite clays from the unconfined aquifer with quite difference thickness. This aquifer is formed in sand and pebble deposits. The thickness of its is less than 10 meters. But Pliocene layer has the thickness of about 250 – 300 meters.

The waters connected to that aquifer are porous with piezometric level under the surface in a larger part of its spreading. The piezometric level is above the surface in those areas in which Pliocene aquifer is under the influence of bedrock waters and Pliocene waters are actually secondary accumulated into Pliocene deposits bedrock waters. Drilling hydrogeological works has revealed the waters.

This aquifer is recharged from north drift deposits in the zone of Balkan mountain and from bedrock through fractures.

Water flows generally from north to south to Stryama river which is appear to be a drainage area by means of complicated vertical hydraulic relation in the zone of Stryama fault.

Hydrogeological Constant

The transmissivity is 5 m^3/day/m to 30 m^3/day/m in the north-eastern part and 30 m^3/day/m to 90 m^3/day/m in the south-western part of aquifer. It tends to be increasing from northeast to south-west (from the recharge area to the discharge area).

The Pliocene aquifer is relatively well prevented for surface contamination because of presents of clays in its upper part. In these parts where clays become wedge-shaped and in alimentation area there are potential possibilities for its contamination.

Hydrochemical Classification

Water is classified into HCO_3-Ca-Na-Mg type with the salinity of 0.16 g/l to 0.27 g/l, low hardness, and relatively high alkalinity. There is no contamination. These water samples may be connected to the granite.

(3) Fissure Aquifer in the Karlovo Graben

General Characteristics

This fissure water is classified into sub-thermal and thermomineral water with low salinity. This is caused by the Stryama dislocation. The aquifer is discharged by the system of fractures located along the southwest boundary of the graben such as the Stryama fault. There are several artesian wells that the piezometric water level is above the surface.

Temperature of water ranges from 19°C (Rozino) to 54°C (Banya).

Hydrochemical Types

Water is characterized as soft, alkaline with a salinity of 0.23 g/l to 0.46 g/l, high contents of F and Si. Ge and W are also contained that are characteristics of deep water circulation. Waters are not contaminated.

3.2.2 Northern Part of Plovdiv - Pazardjik Region

(1) Quaternary Aquifer

General Characteristics

Pliocene sediments is distributed at a shallow depth and Quaternary sediments covered them are with a small thickness. Maximum thickness of Quaternary sediments is about 100 meters at Momino in the central and about 69 meters at Manole in the southwest parts of the area. The thickness of aquifer is relatively small raged from 0.3 to 11 meters in the northern part of the area and ranged from 6 to 12 meters in the eastern and southeast parts of the area.

Hydrogeological Constant

The investigated area can be divided roughly into four on the basis of the transmissivity as follows.

① with transmissivity more than 2000 m^3/day/m.

These areas are located in the Stryama river terrace (southeast from Radjevo konare) and a small part of Maritza river terrace (the place around Avramitza river flows). It is reported that maximum transmissivity is 4888 m^3/day/m in these area.

② with transmissivity ranged from 500 m^3/day/m to 2000 m^3/day/m.

These areas are located in the whole Stryama river terrace and a part of Maritza river terrace (south of Skutare, Rogosch, Manole, and south of Bratya Cholakovi). It is reported that the transmissivity is ranged from 567 m^3/day/m to 1921 m^3/day/m where sand and pebble with thin clayey layers are distributed.

③ with transmissivity ranged from 30 m^3/day/m to 500 m^3/day/m.

This area takes the largest part of investigated area in the central, west, and east part where alluvial drift deposits are distributed. It is reported that the transmissivity varies between 36 m^3/day/m and 492 m^3/day/m.

④ with transmissivity less than 30 m^3/day/m.

This area takes the northern part of the territory where the drift fans are distributed in the south slopes of Sredna gora. The drift deposits are mainly composed of sandy clays and clayey sands with the thickness of a few meters. Its transmissivity varies from 1.8 m^3/day/m to 6.4 m^3/day/m.

Hydrochemical Classification

Water type is HCO_3-SO_4-Ca and HCO_3-SO_4-Ca-Mg in the west part of the area. It can be classified into HCO_3-SO_4-Ca, HCO_3-SO_4-Ca-Mg, SO_4-HCO_3-Ca-Mg, and HCO_3-Ca in the central part of the area. In the northeast part of the area sulfate contents is low and water is classified into HCO_3-Ca-Na and HCO_3Ca-Mg type. It is HCO_3Ca-Mg type in Maritza river terrace.

Groundwater mechanism

It is supposed that groundwater may flow from north to south in this area.

The Quaternary aquifer is recharged by the infiltration of rain water and it is also recharged by the lateral inflow from north (crystalline massif of Sredna gora) and from Stryama river between Dalgo pole and Trilistnik.

Groundwater is discharged mainly into Maritza river and its tributaries.

(2) Pliocene Aquifer

General Characteristics

The Pliocene aquifer is distributed in the whole Study area with an area of about 876 km^2. In the north and east parts of the area, the Pliocene aquifer occurs at a shallow depth that is covered by thin Quaternary layers. Thick alluvial-drift deposits cover the aquifer in the rest parts.

Pliocene sediments are composed mostly of clayey-siltstone (drift sediments) in Popovishko-Stryama horst. The thickness of sediments is about 50 m.

The Pliocene aquifer is yielded in the Pliocene sediments, and Alluvial sediments that are composed mostly of sandy-pebble deposits of the Paleo-Mominska and Paleo-Maritza rivers and their tributaries. They had flown in the region between the two paleogeographic structures : Momino fault in north, and Maritza fault in south which are divided by the Popovischko-Stryama horst.

The thickness of Pliocene aquifer is about 150 m in the northern part (Momino) and it is relatively large in the region of Marishki trench.

A few production wells have been utilized for this aquifer because of the following reason.

- The Pliocene aquifer is covered almost everywhere by Quaternary sediments with a big thickness.
- The transmissivity of this aquifer is relatively low.

- No requirement of this aquifer is expected because of sufficient Quaternary aquifer.
- Water may be contaminated by the rare metal's processing.
- Presence of natural radioactive background.

Groundwater Flow

The regional direction of groundwater flow is from north to south. The recharge area for the Pliocene aquifer is situated in the northern part of the Study area where water infiltrate through the Quaternary drift funs. The Pliocene aquifer may be recharged from the crystalline complex in Sredna gora. Its drainage area is in the region of Maritza river through its paleochannel.

Hydrogeological Constant

The Pliocene aquifer is characterized by the low transmissivity in its central parts : 5-30 $m^2/24h$. The transmissivity is the highest at near Maritza river : 400-500 $m^2/24h$. In the rest parts of the area, the transmissivity varies between 31 $m^2/24h$ and 252 $m^2/24h$.

Hydrochemical Classification

Water can be divided into several groups on the basis of their chemical composition. Groundwater of this aquifer can be divided into HCO_3-Ca-Na type, and it is characterized that chloride content is relatively higher than the sulfate content in the northern.

The groundwater is divided into four groups from the viewpoint of solidity as follows :

① soft,

② half-soft,

③ hard, and

④ very hard.

Soft water is distributed in the area of Stryama terrace.

Hard water is distributed in the eastern part (southwest of Choba, Bolyarino, Belozem, Chalakovo villages), in the central part (in the vicinity of Boretz, Momino, Rakovski villages), in the south part (around Skutare and Rogosh villages), and in the western part (Kalekovetz, Voivodino, Dalgo pole) of the area.

3.2.3 Plovdiv - Pazardjik Region

There are thee type of aquifer in this region as unconfined aquifer and confined aquifer of porous type, and fissure type.

The porous type of water is yielded mainly in Quaternary and Pliocene sediment. They are intensively exploited for a domestic, industrial, irrigation, and agricultural water.

The fissure type of water is yielded in the bedrock distributed in the post-orogenic Upper Thracian depression and its surrounding mountain massifs. This water is utilized rarely.

(1) Quaternary Aquifer

General Characteristics

Quaternary aquifer is widely distributed in both sides of Maritza river with an area of about 317 km^2 in the north and about 717 km^2 in the south where the Upper Thracian depression is distributed.

Water yield in the following alluvial sediments :

① flood plain and higher terraces of Maritza river and its tributaries composed of sand, and pebble,

② alluvial drift sediments in the northern and southern part of Maritza river composed of boulders, pebbles, granule, and sand, and

③ drift fans in the mountain foot of surrounding Rhodopian and Sredna gora slopes composed of boulders, pebbles, granule, and sand. Its yield locally in talus sediments coarse composed of unsorted gravel with sand.

Clay contents of the drift and talus deposits may be the highest in comparison with other deposits.

The maximum thickness of aquifer is in the drift fans distributed in the mountain foot of

Rhodopian massif near villages Parvenetz, Kuklen, and Assenovgrad. The thickness varies from 89 m in the drift fan near Assenovgrad and 85 m in the drift fan near Parvenetz.

In the northeast of Assenovgrad, groundwater table is shapely lowered in local. It is caused by the exploitation for the domestic and industrial water. Non-ferrous metals and industrial enterprise "Agria" has withdrawn the groundwater of about 400 l/s. The groundwater table is also lowered locally around the water supply system of "Plovdiv-east". Groundwater is recharged by Chepinska river in the upstream and discharged into the same river.

Hydrochemical Classification

In the region northern of Maritza river, water is characterized as HCO_3-Ca-Na and HCO_3-SO_4-Ca-Na type with a salinity of 0.46 g/l to 0.86 g/l, with a total hardness of 2.6 mg.eqw/l to 6.5 mg.eqw/l.

In the south of Pliocene sediments exposure, water is classified into hard and very hard and HCO_3-SO_4-Na type, as sulfate contents increase from north to south direction. Salinity of water varies from 0.89 g/l to 0.45 g/l decreasing to the south direction. In the west of village Trud, salinity is 0.3 g/l increasing to the southwest direction as 0.63 g/l. The total hardness is the highest in the western and southern area of village Kaloyanovo in where it ranges from 9.5 mg.eqw/l to 12.5 mg.eqw/l. The hardness gradually decreases from 1.8 to 2.9 mg.eqw/l.as and it is the lowest in the Trud vicinity located in the southward of Maritza river.

Different water type is distributed in the south of Maritza river. It is classified into HCO_3-Ca-Mg type with a salinity of about 0.68 g/l to 0.91 g/l (Plovdiv-west).

In the area east of Plovdiv to Katunitza, water is classified into HCO_3-SO_4-Na-Mg, HCO_3-SO_4-Cl-Ca-Mg type, and HCO_3-Na-Ca-Mg type in local. The salinity is usually 0.5 - 0.6 g/l, but it is 1.03 g/l and 1.74 g/l at some places in Plovdiv.

In the region south of Yagodovo, salinity decrease to 0.32 g/l. But in east from Yagodovo water is classified into HCO_3-Ca type with a salinity of 0.5 g/l to 0.8 g/l. The hardness of water in the both region ranges from 2.8 mg.eqw/l to 10.9 mg.eqw/l (Plovdiv-east).

In the northern part of Kuklen, the hardness of water is about 10 mg.eqw/l and it can be defined that water is recharged by carbonaceous collectors distributed in the south of Kuklen.

In the region of villages Cherven and Topolovo, waters is classified into HCO_3-Ca and HCO_3-Ca-Mg type with a salinity of 0.56 g/l to 0.68 g/l and hardness of 6.2 mg.eqw/l to 8 mg.eqw/l.

In the area between Popovitza and Filevo villages located on the Maritza river terraces, waters are classified into HCO_3-Ca and HCO_3-SO_4-Ca-Mg type with a salinity of about 0.7-0.8 g/l.

In the vicinity of Debar, water is classified into HCO_3-SO_4-Ca and HCO_3-SO_4-Ca-Na types. This chemical diversity can be supposed that Quaternary aquifer is recharged through fractures by the underlying Neogene and Paleogene aquifers. It is also some possibility of the contamination by "Debar" mine : a part of ore deposit "Pravoslaven". Water is hard and very hard with a hardness of 6.5 mg.eqw/l (Popovitza) and 11.9 mg.eqw/l (Parvomay) in the western part of this area.

(2) Pliocene Aquifer

General Characteristics

The Pliocene aquifer has the largest distribution in the area. It is yielded in the deposit mainly composed of sand, granule, and pebble with clay, sandy clay. It is classified into a porous semi-confined aquifer.

The deposit is distributed with an area of 47 km^2 in the northern part of this region, 343 km^2 in the central and eastern part.

The thickness of the aquifer also varies from 11 m (north of Parvomay) to 356 m (south of

Kaloyanovo).

Hydrogeological Constant

The transmissivity of Pliocene aquifer ranges from 16 m^3/day/m. (Kaloyanovo) to 76 m^3 /day/m (Staro Jelezare).

It is worse in the northern part of this area covered by Quaternary aquifer.

The Pliocene aquifer is characterized with low transmissivity in the south of Maritza river.

Hydrochemical Classification

Water of this aquifer is classified into HCO_3-Ca-Na and HCO_3-Ca-Na-Mg types. It is classified into HCO_3-SO_4-Ca and HCO_3-Ca-Na-Mg type in the south of uranium deposit near Tzeretelevo village which may be resulted by using H_2SO_4 or the sedimentation of gypsum in Pliocene sediments.

Water is characterized by HCO_3-Ca-Mg in the south of Maritza river and HCO_3-SO_4-Ca-Mg in local. Water is classified into HCO_3-SO_4-Ca and HCO_3-Ca-Na types in the vicinity of Katunitza – Sadovo – Popovitza villages. Sulfate ions may show the distribution of gypsum in Pliocene sediments and sodium ion may show the deep aquifer.

Water is classified into HCO_3-Ca-Mg, HCO_3-Ca and HCO_3-Na type in the south of Sadovo-Assenovgrad where the Pliocene aquifer exposures on the surface.

In the vicinity of villages Lenovo and Topolovo and northern part of Parvomai, water contains nitrate which is caused by the contamination of organic matter.

(3) Fissure Aquifer in the Pre Neogene Basement

It yields cold, subthermal, thermal, fresh, and mineral water. But, fissure aquifer is not investigated well.

There are some investigation at the vicinity of Lenovo, Iskra, and Parvomay. Water can be classified into HCO_3-Na type that is slightly alkaline, soft with low salinity and with contents of F and Si. Its temperature ranges from 19 to 32°C. Water is used as for a curative water by the local people.

There are also some investigation at the vicinity of Hrabrino, Kuklen, Assenovgrad, Dolnoslav, Lenovo, and Bryagovo villages. All available data of wells are shown in a table.

3.3 Groundwater Table

3.3.1 General

The fluctuation of groundwater table in an unconfined aquifer shows the change of water volume stored. There are 327 observation wells in the Maritza river basin. Continuous measurement of groundwater table and water quality analyses by NIMH have been conducted for 16 wells of them, and another 78 wells of them have measured several times in a year.

The data of long-term groundwater table fluctuation show a tendency to lower slightly as the following sites.

618 in MU2: tendency to lower from GWL211m in 1971 to 209.5 m in 1995
631 in MM1: tendency to lower from GWL 178m in 1971 to 176m in 1995
214 in MM2: tendency to lower from GWL 174m in 1971 to 171m in 1995
666 in MM2: tendency to lower from GWL 128.5m in 1971 to 128m in 1995
520b in MM3: tendency to lower from GWL 77.0m in 1971 to 75.5m in 1995
672 in TOP: tendency to lower from GWL 627.0m in 1975 to 625.5m in 1995
536 in LUD: tendency to rise from GWL 335m in 1967 to 338.5 m in 1995
277a in SAZ: tendency to lower from GWL 164.5m in 1971 to 163m in 1995

Groundwater table in the Maritza Basin is shown in Fig. C.3.4.

3.3.2 Northern Part of Plovdiv - Pazardjik Region

Groundwater table fluctuation of Quaternary aquifer has shown lowering about 1 meter during the summer. It is reflected the rain water recharge to the aquifer and the utilization of groundwater for irrigation.

Groundwater table fluctuation is very small with ranging from 0.02 to 0.06 meters in the north part of this area. The significant hydraulic gradient may be supposed from the south slopes of Sredna gora. There is also no significant water table fluctuation in the south part of this area. The maximum fluctuation was recorded from 1995 to 1996 have registered in the central part of this area (around villages Dalgo pole, Choba).

3.4 Groundwater Quality

3.4.1 Data of NIMH

Water quality data from NIMH are collected 13 wells in this Study. These data consist of sufficient items for the characteristics of groundwater quality analysis. The result is shown as trilinear diagram in the Fig. C.3.5 and summarized in the following table. Water quality as groundwater, the greater part of observation wells are classified into " Ca (HCO_3) type" representing river water and or unconfined water. Groundwater quality of 1055 well in Galabovo and 1084a well in Pazardjik have the character of " $CaSO_4$ - $CaCl_2$ type" midway between unconfined water and mineralized or karstic water. Groundwater quality of Galabovo may be contaminated from the high contents of sulphates.

Groundwater Quality - data from NIMH

(average value : mg/l)

No.	Well No.	Basin	pH	HCO_3	SO_4^{2-}	Cl^-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Mg^{2+}	$NH4^+$	Na+ K	Total Fe	Hard-ness
*BSS2823		-		-	250	250	50	no	0.5	150	80	no	-	0.2	12
1	1084a	MU2	7.4	240	201.0	33.9	42.66	0.21	0.06	95.5	32.8	0.29	58.3	0.25	20.7
2	1082g	MM1	7.2	283	84.1	21.6	15.28	0.13	0.05	54.0	17.1	0.13	69.0	0.11	11.5
3	651	MM1	7.9	573	90.4	61.9	9.00	0.05	0.08	136.0	46.4	0.92	46.0	1.88	29.8
4	1052	MM2	7.4	283	93.2	21.9	21.61	0.33	0.11	0.33	16.0	0.33	64.2	0.50	12.9
5	1028	MM2	7.9	482	117.0	22.6	6.91	0.07	0.03	55.5	39.5	0.23	102	0.83	16.8
6	1066	MM3	7.5	328	109.0	35.3	10.98	0.25	0.27	79.7	20.4	0.37	78.3	0.67	15.8
7	1053	MM3	7.5	275	100.0	23.2	6.06	0.15	0.22	74.8	17.3	0.32	50.1	0.47	14.1
8	1059	MD	7.5	244	71.9	31.6	7.72	0.01	0.03	78.3	21.9	0.21	46.7	1.67	16.0
9	1081	LUD	7.2	186	85.4	24.7	10.60	0.58	0.09	52.5	16.0	0.50	41.9	0.36	10.9
10	1068	STR	7.2	135	36.2	15.1	23.41	3.94	0.03	31.3	13.1	1.47	30.0	0.51	7.1
11	1042a	STR	7.3	121	42.8	13.8	8.07	0.06	0.02	21.5	2.0	0.38	50.6	0.25	3.3
12	1061	HAR	7.3	247	124.0	33.3	10.30	0.16	0.31	71.3	20.2	0.83	65.2	0.26	14.3
13	1055	SAZ	7.5	292	299.0	49.2	10.42	0.19	0.05	119.0	42.0	0.37	92.6	1.35	26.4

Data are collected from 1984 to 1996. Data of well 1028,651, 1042a,1059 are collected from 1984 to 1988 or 1989 because of deteriorating equipment.

Type of sources : pipe well, shaft well, spring
* Bulgarian State Standard 2823/83 "Drinking water"

Generally speaking, water quality of raw groundwater is not so good on the basis of NIMH data. Nitrite, ammonia of all samples exceed the Bulgarian State Standard 2823/83 "Drinking water", and many samples exceed the Standard in total Fe and hardness. It is noted that water quality of the station number 1084a near Pazardjik and 1055 near Garabovo are characterized by the high concentration of sulphates comparing with another stations, and 1068 near Karabovo by the high contents of ammonia and nitrite.

3.4.2 Data of Ministry of Health (MOH)

Data of the raw groundwater quality for the domestic water from MOH are summarized in the following table. These data indicate the type of source, pumping rate, and deviating items from the Bulgarian State Standard 2823/83 "Drinking water" by regions and water supply stations. It is reported that manganese contents deviates the Bulgarian drinking water standard in all regions. The groundwater quality in Pazardjik region is characterized by the high contents of bacterial count, and water quality in Haskovo region is worse than another regions in general.

Groundwater Quality for Domestic Water - data from MOH
(average value : mg/l)

Region	Number of source*	NH_4^+	No_2^-	No_3^-	Fe total	Mn^{2+}	Bacterial count (no./liter)
**BSS2823/83	-	Not be counted	Not be counted	50	0.2	0.1	50
Pazardjik	64	-	-	-	-	0.14	50
Plovdiv	60	0.01	1.5	-	-	0.25	-
Stara Zagora	6	-	-	-	-	0.3	-
Haskovo	66	0.005 - 0.19	0.02 - 0.17	62.3	-	0.29 - 1.13	-
Total	196						

* Type of sources : pipe well, shaft well, spring
** Bulgarian State Standard 2823/83 "Drinking water"

3.4.3 Data of COG

COG started the measurement of groundwater table and the analysis of groundwater quality from 1992 and they have managed 99 groundwater monitoring stations in the regions of Pazardjik, Plovdiv, Karlovo, and Haskovo. Results are shown in Table C.3.2 – C.3.6.

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General tendency of groundwater quality in these four regions is recognized as follows.

Unconfined aquifer

① Phosphates (PO_4^{3-}) contamination is found in the tributary area of Topolnitza, Syate, Luda Yana, Potoka, Vacha, Pyassachnik, Guldere, Mechka, and Haskovo river, especially in May and April.

② Nitrate (No_3^-) contamination is distributed in the catchment area of Mechka river.

③ Haskovo region is characterized by the contamination of Sulphate (SO_4^{2-}) in the left tributary of Haskovo river. 13 wells of 17 monitoring wells are recorded the contamination of Phosphates (PO_4^{3-}), or Nitrate (No_3^-), or Sulphates (SO_4^{2-}).

④ Unconfined water of these four region is connected with river water and it may be easy to be polluted by the human activity for production.

Neogene Confined Aquifer

Monitoring wells are divided into two categories of Quaternary aquifer and Neogene aquifer. The deference of water quality between the two is slightly distinguished on their chemical contents and an extent of contamination.

Wells of R8,R12, R14,andR16, located in the north of Plovdiv, indicate the excess contents of radium (Ra226) and total beta activity comparing with the BSS2323/83. Uranium ore deposits are distributed in these areas.

(1) Water Quality of Karlovo Area

Quaternary Aquifer

Water contains high NO_3^- around populated areas without sewerage systems and in which areas a big amount of fertilizers are used. Some water samples indicate a high PO_4^{2+}

content as a result of fertilizer usage.

Water contains high PO_4^{2+} in the area where the coal-bearing deposits are distributed. The surface water of Byala river has the direct relation to the groundwater of which are contaminated by oil products. It content reach 0.35 mg/l. Phenols also is detected in vicinity of this river

Water is contaminated by NO_3^- in the northern part of Karlovo, it reach 73-128 mg/l that exceeds the admissible standards (50 mg/l) of BSS2823, as well as by NH_4^+ and NO_2^- which is contained inconstantly in it. The observation well "K3", located at about 700-800 meters south-west from Ignatovo village, suggested that groundwater is contaminated by the fertilizer of agriculture and sewage from Ignatovo village. NH_4^+ and NO_2^- are detected only during the dry season and the source of contamination may be the coal-bearing deposits. In drainage zone, water is not contaminated and it can be used for all purposes.

Fissure Aquifer

Water temperature ranges from 19 degree (Rozino) to 54 degree (Banya). Water is charctelized as soft and alkaline with a salinity of 0.23 g/l to 0.46 g/l, high contents of *F*, and *Si* and some times of *Ge* and *W*. These elements indicate that water of fissure aquifer is resulted the deep circulation. Water is not contaminated.

(2) Northern Part of Plovdiv - Pazardjik Region

Quaternary Aquifer

Water contamination has a tendency to increase year by year because of human activities. The main sources of contamination are sewerage and fertilizer of agriculture in this area. The intensive farm activity caused the fertilizer accumulation into a soil. In this area, there is no significant industrial enterprises without the metallurgical plant in the vicinity of Shishmantzi village. That plant has never affected on the water quality.

One of the most danger to the water quality of Quaternary aquifer is the rare metal factory of "Momino-Rakovski", "Trilistnik", and "Belozem". The greater part of water samples contain NH_4, NO_2 and many of them contain NO_3 and PO_4 in high concentrations in the vicinity of these factories. These items are the indicator of organic pollution. It is also reported that some water samples contain high concentrations of calcium and sulfate at the vicinity of Belozem, Manolsko, Konare, Yasno pole, Bolyarovo, and Kaloyanovo-Chernozem villages. This anomaly may be caused by the land reclamation for salty soils. It is reported that there were some anomalies of Ra-226 is detected in the vicinity of rare metal mine.

Groundwater is classified into three categories from the viewpoint of total dissolved solid (TDS) as follows :

- TDS ; less than 1 g/l. This type of water is distributed in the greater part of the northern part of Plovdiv-Pazardjik.
- high concentration of TDS ; more than 1 g/l in the vicinity of Bolyarino, Shishmantzi, Belozem, Rogosh -- Momino and western part of Rajevo konare.
- very low concentration of TDS ; less than 0.2 g/l. It is distributed from the northern part of this area to the vicinity of Krislovo village. This type of water is distributed to the Alluvial terrace deposits of Stryama river.

Pliocene Aquifer

The Pliocene aquifer is relatively well protected against the contamination from surface. It is due to the distribution of aquiclude between Pliocene sediments and overlying Quaternary deposits and it is distributed in the deeper place.

The aquifer is contaminated directly by the suspended uranium mines located in "Momino-Rakovski", "Trilistnik", and "Belozem". These mines are suspended and its waste has been left without neutralization. There are high concentrations of SO4 and Ra-226 in some water samples taken from old boreholes in the vicinity of uranium mines.

(3) Plovdiv – Pazardjik Region

Quaternary Aquifer

The contamination sources for groundwater in this Plovdiv – Pazardjik region are listed below :

① combine enterprise of Plovdiv and "Agriya" for non-ferrous metals,

② industrial zone of Plovdiv,

③ uranium mines of "Tzeretelevo" and "Pravoslaven" (already closed),

④ all populated areas without sewerage system, and

⑤ over consumption of fertilizers (nitrogen and phosphate) in the past.

The contamination elements are nitrate (NO_3), nitrite (NO_2), ammonium (NH_4), and orthophosphate (PO_4). Groundwater is heavily contaminated by NO_3 and PO_4 among of them.

Concentrations of nitrate in water varies from 64 mg/l to 343 mg/l (Trud) in the north of Maritza river. The highest nitrate content is 126 mg/l at Kuklen in the south of Maritza river, and it gradually decrease to 60 mg/l toward for Maritza river (Plovdiv-east).

The content of orthophosphate varies from 2.2 mg/l (at Trud and Ignatievo) to 3 mg/l (at Kaloyanovo) in the northern part of Maritza river.

In the southern part of Maritza river, the highest orthophosphate content is above 1.1 mg/l at the south of Plovdiv. But there is some problem for the accuracy of water quality test for orthophosphate.

Pliocene Aquifer

The salinity of Pliocene aquifer varies from 0.2 g/l to 0.7 g/l in the northern part and from 0.3 g/l to 0.71 g/l in the southern part of this area.

In northern part of this area, the mineralization decrease into the direction to Momino-Orizovsko because of the distribution of uranium mine.

In the southern part of this area where Pliocene aquifer is covered by Quaternary sediments, the mineralization decrease from southeast to northwest. It may be affected by the recharge from Pre- Pliocene basement.

The mineralization of waters ranges from 0.3 g/l to1.71 g/l with an average of about 0.4-0.5 g/l in the vicinity of Parvomay to Vagbitza village. Higher values of mineralization may be resulted by the processing of uranium at the uranium mine "Pravoslaven".

The hardness of water varies from 0.34 mg.eqw/l to more than 21.4 mg.eqw/l.
In the northern part of Maritza river, the hardness ranges from 2.8 mg.eqw/l to 4.7 mg.eqw/l which characterize water as soft to moderately soft.
In the southern part of Maritza river, where Pliocene aquifer is covered by Quaternary sediments, water is very soft and moderately soft, with the hardness of 3 mg.eqw/l to 5.8 mg.eqw/l.

In the eastern border of this area, the hardness of water ranges from 0.34 mg.eqw/l to 10.34 mg.eqw/l.

The contamination sources for Pliocene aquifer are listed bellow.

① All agricultural sites with old cesspools and dunghills.
② Industrial enterprises located on the Pliocene aquifer exposures.
   It is industrial zone of Parvomay and industrial zones in the vicinity of Plovdiv.
③ Previous uranium mines of "Tzeretelevo" and "Pravoslaven".
   They had used sulfuric acid through boreholls for an ore leaching.
④ Sewerage from all populated sites (villages) located on the Pliocene aquifer exposure.

3.5 Groundwater Resources

Most interesting groundwater resource is the Quaternary unconfined aquifer in the study area. It is distributed mainly in Quaternary deposit along the Maritza river and its tributary in where flood plane is widely distributed.

Karst water distributed in the carbonates rocks and fissure aquifer in the fractured zone are not suitable for the large scale development of urban water supply, industrial and irrigation supply. A possible development volume of them is small and located in remote area from the big town and beneficiaries.

3.5.1 Karlovo Area

Quaternary-Pliocene Unconfined Aquifer

The Quaternary-Pliocene unconfined aquifer is important for the regional economy and it is exploited well. It is reported that the groundwater resource was assessed 1273 l/s. About 1028 l/s of its is utilized during the dry season. Available utilization volume is about 245 l/s or 7.73 x 10^6 m^3 / year.

Pliocene Confined Aquifer

The groundwater resource of the Pliocene confine aquifer is divided into two parts and it is estimated on the basis of transmissivity as follows.

Area	Transmissivity	Potential	Potential
Northern part (recharge area)	30 m^3/day/m.	60.4 l/s	1.90 x 10^6 m^3 / year
Southern part (drainage area)	60 m^3/day/m.	25.3 l/s	0.80 x 10^6 m^3 / year
Total	-	85.7 l/s	2.70 x 10^6 m^3 / year

3.5.2 Northern Part of Plovdiv – Pazardjik Region

Quaternary Aquifer

Quaternary aquifer of this region is well investigated and it is reported that available utilization volume is estimated about 21.9x10^6 m^3 / year.

Water resource of Quaternary aquifer is determined by the following factor.

Natural factors : recharge from precipitation and others, base flow.

Artificial factors : water utilization for water supply, industry, and irrigation.

The balance equation for the estimate of water resource is

$$P1 = P2 + P3 + P4 - (P5+P6) = 21.9x10^6 \ m^3 / year$$

P1 = $21.9x10^6$ m^3 : available utilization volume of groundwater

P2 = $16.7x10^6$ m^3/year : recharged amount of lateral water inflow from north

P3 = $52.3x10^6$ m^3/year : infiltration and recharge from precipitation

P4 = $26.2x10^6$ m^3/year : recharge from Stryama river

P5 = $19.9x10^6$ m^3/year : groundwater runoff (base flow) to Maritza river

P6 = $53.4x10^6$ m^3/year : water utilization

water supply ($17.3x10^6$ m^3/year), irrigation ($6.2x10^6$ m^3/year), transpiration and evaporation ($29.9x10^6$ m^3/year).

In the calculation, it is not taken into account all recently constructed installations which are still not in operation.

Pliocene Aquifer

Static reserves of Pliocene aquifer are estimated to $9.2x10^9$ m^3.

3.5.3 Plovdiv – Pazardjik Region

Quaternary Aquifer

Groundwater resource potential of Quaternary aquifer is estimated to 5,355 l/s or 168.88 x 10^6 m^3 / year on the basis of the following transmissivity.

- North of Maritza river : 756 m^3/day/m
- South of Maritza river : 1100 m^3/day/m

Pliocene Aquifer

Groundwater resource potential of Pliocene aquifer is estimated to 459 l/s or 14.48 x 10^6 m^3 / year. The area of north of Maritza river is estimated to 68 l/s or 2.14 x 10^6 m^3 / year and the south of its is 391 l/s or 12.33 x 10^6 m^3 / year.

The transmissivity values used for these calculations are 197 m^3/day/m and 225 m^3 /day/m respectively.

3.5.4 Geothermal Resources

Data of thermomineral water are collected. It was clarified that flow rate of its was small and temperature of its was insufficient for a large development. It is suitable for the development of local use on the basis of collected data.

It shall be investigated in another project. But, the geothermal resources may affect on the environment in the large development. EIA shall be conducted, if the large geothermal resources are found and developed.

3.6 Groundwater Utilization

3.6.1 The Whole Study Area

There are five Water Supply and Sewerage Companies in Maritza river basin and they have utilized the waters of surface water of rivers and groundwater, and supply them for domestic, public, commercial, industrial, agricultural, and other usage. The pumping rate in each region is summarized in the following table.

Groundwater Utilization of Water Supply & Sewerage Company in 1996

Region	Number of sources	Pumping rate	Pumping rate	Unit rate/well	Served population
(unit)		(m^3/year)	(liter/sec)	(liter/sec)	(person)
Part of Sofia	?	?	?	?	69,317
Pazardzhik	97 wells	59,674,000	1,919	19.78	236,749
	43 springs	5,658,000	182	-	
Plovdiv	293 wells	272,270,000	8,634	29.47	733,025
Stara Zagora	213 wells 100 springs 12 cappings	62,587,100	1,985	9.32	270,269
Haskovo	207 wells 11 springs	41,913,170	1,329	6.42	195,988
Others	?	?	?	?	?
Total in basin	> 976	> 442,102,270	>14,049	-	> 1,505,348

Groundwater utilized for the domestic water is more than 442,102,270 m^3/year excluding a part of Sofia. The population of unknown regions is smaller than Haskovo, and the total pumping rate shall be increased another a few percentage. The total groundwater utilization of water supply & sewerage company in Maritza river basin can be roughly projected more than 450,000,000 m^3/year or 15,000 liter/second.

3.6.2 Regional Groundwater Utilization

(1) Karlovo Area

Groundwater utilization of this area is estimated 950 l/s for the whole valley, 620 l/s in the central and west part of the valley, and 330 l/s in the east part for a domestic, industrial, and agricultural water. Average transmissivity values are 75 m^2/24h for the central and west part of the valley and 175 m^2/24h for its east part.

(2) Northern Part of Plovdiv – Pazardjik

According to the information of "Plovdiv Water Supply and Sewerage Company", the total amount groundwater utilized for a domestic water is 1073 l/s. But actual water supply is less than its. Pumping station "Plovdiv-east" takes occasionally the waters of the Maritza river. The groundwater utilization for the domestic water supply is less than 550 l/s and for the irrigation water is about 480 l/s.

Groundwater Utilization in Northern part of Plovdiv – Pazardjik Region

No	Basin	Water supply facilities	Yield (l/s)	Supplied areas	Geological index
1	STR	2 shaft water wells	40	Paisievo, Suhozem, Sarnegor	Q
2	STR	2 shaft water wells	40	Pesnopoy, Ivan Vazov	Q
3	STR	1 shaft water well 1 tube well	20	Gorna mahal	Q
4	STR	1 shaft water well 2 tube well	25	Dolna mahala, Begovo	Q
5	STR	2 shaft water wells	30	Chernozem, Rajevo	Q
6	STR	1 shaft water well	10	Padrsko	Q
7	STR	3 tube wells	45	Rajevo Konare, Kaloyanovo, Duvanli, Jitnitza	Q
8	STR	2 tube well	6	Glavatar	Q
9	STR	2 shaft water wells	8	Dalgo pole	Q
10	STR	2 shaft water wells	35	Stryama	Q
11	STR	2 tube wells	14	Boretz	Q
12	STR	2 tube wells	18	Momino	Q

		Sub total	**291**		
13	MM1	3 tube wells	36	Kalekovetz, Krislovo	Q
14	MM1	3 tube wells	30	Voivodinovo, Jelyazno	Q
15	MM1	2 tube wells	50	Rogosh, Skutare, Trilistnik	Q
		Sub total	**116**		
16	MM2	2 tube wells	32	Kirilovo, Drangovo, Zlatosel, Varben	Q
17	MM2	4 tube wells	54	Rakovski	Q
18	MM2	4 tube wells	48	Manole, Yasno, Monolsko konare	Q
19	MM2	3 tube wells	26	Belozem, Chalakovi	Q
20	MM2	12 tube wells	450	Plovdiv	Q
21	MM2	6 tube wells	20	Choba, Brezovo, Zelenikovo	N_2
22	MM2	5 tube wells	25	Shishmantzi	Q-N_2
23	MM2	3 tube wells	11	Bolyarino	N_2-Pg
		Sub total	**666**		
Grand total			**1073**		

Remark: The location of water supply facilities is shown in Figure

(3) Provdiv – Pazrdjik Region

Quaternary Aquifer

The groundwater utilization of Quaternary aquifer is about 4940 l/s as follows:

- for a domestic water supply - about 1540 l/s;
- for a irrigation - about 2900 l/s;
- for a agricultural water supply - about 500 l/s.

Total amount - about 4940 l/s

Pliocene Aquifer

The groundwater utilization of Pliocene aquifer is approximately 309 l/s.

The intake facilities for Pliocene aquifer are scattered in this region. Their pumping yields are relatively low with 3 to 67 l/s. They are utilized to be complementary to Quaternary aquifer. The biggest facilities are located near Plovdiv (PS "South", PS "North", PS "East").

3.7 Water Balance

The groundwater potential is not investigated well in the whole study area. It is investigated only for the vicinity of Karlovo, Plovdiv, and Pazardjik. But the further investigation is required to establish the groundwater preservation program.

Groundwater Balance

Investigated by COG (Unit : liter / second)

Region	Aquifer type*	Potential	Utilization	Available volume
Karlovo	Q	1,273	950-1,028	323-245
	P	85	-	-
Sub total	-	1,358	-	-
Northern part of Plovdiv -Pazardjik	Q	2,387	1,030-1,693	694-1,357
	P	-	-	-
Sub total	-	-	-	-
Plovdiv - Pazardjik	Q	5,355	4,900	455
	P	459	309	150
Sub total	-	5,814	5,209	605

* : Q ; Quaternary unconfined , P ; Pliocene confined

4. Groundwater Preservation and Management Plan

Groundwater shall be utilized sustainably for the public and the economic activity because of its advantage such as the distribution near the consumer, a good water quality, and an easiness of intake comparing with surface water. The overall restriction of groundwater utilization is not appropriate without the scientific investigation.

According to the existing data, groundwater quantity may be sufficient for the water demand in Maritza river basin. But, shallow groundwater is easy to be polluted by surface water. For the time being, it shall be focused on the preservation for water quality.

The following steps shall be taken to establish the program for groundwater management and groundwater preservation.

(1) Institutional Strengthening

According to the Decree of the CM No. 278 issued in 1997, administrative restructuring of the water management is established. But, the problem is that no organization has the responsibility of synthesizing the existing data of NIMH, NCESD, COG, and others.

The scientific organization for research and development shall be established to synthesize and analyze the existing dispersed data from the geological and hydrogeological points of view. "Department of Use and Protection of Groundwaters (former COG)" may be the most suitable for it.

(2) Investigation

It shall be clarified the present condition of groundwater basin structure, aquifer structure, recharge volume, groundwater quality, and groundwater utilization. It shall be also continued the hydrogeological investigation at where existing data did not cover.

- The volume of groundwater basin. This means the storage capacity of groundwater.
- The essential element of hydrogeological parameters of permeability, transmissivity, storativity, specific storage, specific yield, and so on.
- The external element of precipitation, river discharge, and so on. Those are utilized to estimate the recharge volume to groundwater.
- Groundwater quality. This is important to estimate an available volume of groundwater and the cost of purification for groundwater.

(3) Making Inventory and Database

All existing data shall be investigated, and established the inventory and the database. Inventory of production well and monitoring observation well has to be described coordinates of location, screen position, the result of pumping test (pumping rate, permeability, specific capacity) and water quality, geological condition and the constructed year.

(4) Preliminary Examination

Temporary estimation of the groundwater potential shall be conducted, and the temporary utilization plan shall be established on the basis of groundwater potential, national development plan, and regional development plan.

(5) Monitoring

Monitoring shall be continued on the existing station, and new station shall be distributed at the sites that are determined on the result of preliminary examination.

Groundwater table

The actual storage volume of unconfined groundwater is effected by the groundwater table that can be used for the estimation of stored or remaining volume of groundwater and to judge the safety pumping yield. If the groundwater table is a tendency to lower, its cause shall be clarified. It is considered many causes such as the seasonal fluctuation or long-term fluctuation, reduction of precipitation and river discharge (decrease of recharge volume), excess utilization of groundwater, and deterioration of pumping equipment.

Hydrological and meteorological data

These data will effect the fluctuation of recharge volume. Groundwater balance shall be considered on the balance of utilizing volume of groundwater and recharging volume from precipitation, and surface water. The fluctuation of groundwater table shall be considered in connection with hydrological and meteorological data.

Groundwater quality

The change of groundwater quality is important to estimate the available volume of groundwater and to find the source or site of pollution.

Regarding the karst water, measures shall be taken to prevent a polluted water inflow from the sink hole to aquifer. Water moves rapidly through cavity and opening in karst terrain. It is easy to be polluted.

Groundwater utilization

Groundwater utilization was not clear in the study area. It is one of the important element to assess the groundwater balance and remaining volume for the development.

(6) Establishment of the Groundwater Management and Preservation Plan

- The water balance including surface water shall be simulated from the monitoring data of at least five (5) years.
- The groundwater potential and recharge volume shall be projected.
- The groundwater utilization plan shall be established on the basis of estimated hydrogeological condition, national development plan, and regional development plan.

(7) Opening Information

- All database and information shall be opened to the public and other user to improve the awareness for saving water, preservation of the environment, and sustainable development that groundwater is limited natural resources.
- Consequently, groundwater shall be managed and preserved by not only the government but also the public and user. Otherwise, it cannot be controlled the irregular development of groundwater.

5. Recommendation

Master plan study shall be conducted to formulate the water resources development and the preservation program for the groundwater basin.

The Study area is divided into 16 drainage area. The groundwater basin is spread on some drainage areas. The groundwater basin, which is located in and around Pazardjik and Plovdiv, shall be given priority to formulate the master plan. This groundwater basin is the most important for the human activity from the environmental and economic points of view in the study area and includes of the MU1, TOP, LUD, CPI, STA,VAC, PYA, and MM1 drainage basin.

The following item should be clarified and conducted mainly in the master plan study :

① geologic structure of the groundwater basin

② essential element of hydrogeology ; permeability and etc.

③ external element of hydrology and meteorology

④ groundwater potential and utilization

⑤ groundwater quality

⑥ making inventory and database

⑦ monitoring of groundwater table, hydrology and meteorology, and water quality

⑧ water balance

⑨ groundwater simulation

⑩ formulation of the water resources development

⑪ establishment of the preservation program

TABLE C.1.1 MAJOR GEOLOGICAL UNITS AND THEIR COMPONENTS IN THE STUDY AREA

Geological Age		Major unit	Lithology
Quaternary	Holocene		Recent flood plain and lower terrace deposit (sand and gravel
			talus and fan deposits, drift sediment (clay, send, gravel)
	Pleistocene		Terrace deposit (sand and gravel with clay)
Tertiary	Neogene	Bursarci Formation	Sands, pebbles
		Valchepole Formation	Sand, conglomerate, clay, coal layers
		Others	Conglomerate, sand, clay, coal layers
	Paleogene	Marica Formation	Clay, sands, coal
		Draginovo Formation	Sandstone, clays
		Others	Marine limestone, granite, acid-intermediate volcanics and volcanoclastics
			Breccia-conglomerate, coal bearing sandstone, tuffaceous sandstone
Mesozoic	Cretaceous	Emine Formation	Sandstone and mudstone alternation
		Panagjurishte Strip	Volcanoclastic sedimentary rocks
		Paradzhik Formation	Clayey limestone and silty marl
		Brugas Group	Trachy basalt and trachy andesite
		Stara Zagora Strip	Marl, flysh and marl limestone
		Kaliaka Foramtion	Limestone
		Others	Calcareous sandstone, sandy limestone, limestones
			Coal-bearing sandstone, conglomerate, sandstone, shale
			Granite, granodiorite, dioriteporphyry
	Jurassic		Marine and terrigenous carbonate rocks
	Triassic	Toporovgrad Grooup	Metasandstone, schists, dolomite marbles, calsite
		Petrohan Group	Conglomerate, sandstone, siltstone, shale
		Iskar Formation	Limestone, dolomite
Paleozoic	Permian		Volcanic and hypabyssal rock bodies, quartzporphylites
		Yambol Group	Metabreccia-Conglomerate
	Carboni-ferous		
		Stara Planina Complex	Grandiorite-granite
		Granitoide in south Bulgar	Granite, granodiorite
		Others	Coal-bearing terestrial rocks, metabreccia-conglomerate
	Silurian		Sandstone, lidite
	Ordovician	Stublica, Zoravcenica, Slivaska and Javorov Formations	Metamorphosed shales,
		Grohoten and Cerecel Formations	Siltstone, quartzite and shales
		Berkovica Group	Metamorphosed shales, sitestone and sandstone
		Others	Gneiss-granite, migmatite
Precambrian		Arda Group	Granitized two-maica gneiss, migmatite, amphybolite, schist
		Asenovgrad Group	Marble, dolomitic marble, schist
		Others	Metamorphosed basic and ultrabasic rocks

TABLE C.2.1 HYDROGEOLOGICAL CONSTANT

(1) Ranges of permeability coefficient for soil and rock in general

k (cm/s)	Description	Soil	Rock
10^{2}			
10^{1}	very high	clean gravel	porous lava, limestone with solution cavity and solution opening
1			
10^{-1}	high	clean sand and gravel	
10^{-2}			fault, fractured zone in the bedrocks
10^{-3}			
10^{-4}	moderate		
10^{-5}		fine sand – silt	
10^{-6}	low		laminated rocks
10^{-7}			
10^{-8}	very low	compact clay	massive rocks
10^{-9}			

(2) Specific capacity and groundwater potential in general

Sc:* (l/s/m)	Sc* (m^3/d/m)	description	groundwater supply potential
>10	>864	very high	
10	864		withdrawals of great regional importance
1	8.6	high	withdrawals of lesser regional importance
10^{-1}	8.6	intermediate	withdrawals for local water supply
10^{-2}	0.86	low	withdrawals for local water supply with limited consumption
10^{-3}	0.086	very low	sources for local water supply are difficult (if possible) to ensure
10^{-3}<	-	imperceptible	- ditto -

* Sc: Specific capacity

(3) Specific yield of common type of soil and rock

Lighology	Specific yield (m^3/m^3)
Gravel	15 – 30%
Sand	10 – 30%
Dune sand	25 – 35%
Sand and gravel	15 – 25%
Silt	5 – 10%
Clay	1 – 5%
Sandstone	5 – 25%
Limestone	0.5 – 10%
Shale	0.5 – 5%

TABLE C.3.1 SUMMARY OF AQUIFER IN KARLOVO AREA

No	Aquifer	Stratigraphy	Lithology	Aquifer type	Recharge area	Drainage area	Hydrochemical type
1	Quaternary and Upper Pliocene unconfined aquifer	Quaternary Upper Pliocene	pebble, sand clay, siltstone, small size pebble	Unconfined (porous)	northern part - from streams flowing from Balkan Mountain and by infiltration particularly from Sredna gora Mountain	Stryama river terrace and particularly Byala river	low salinity, bicarbonate type
2	Lower Pliocene confined aquifer	Lower Pliocene	clayey siltstone and sand alteration pebble-sandy sediments	Confined (porous)	northern part - from streams flowing from Balkan Mountain	Stryama river terrace	low salinity, HCO_3-Ca type
3	Fissure aquifer in the bedrock in Karlovo graben	Paleozoic Precambrian	granite gneiss and schist	Confined (fissure)	granite massif of Sredna gora Mountain	along the Stryama fault secondary in Pliocene or Quaternary deposits	HCO_3-SO_4-Na type nitrogenous mineral waters with low salinity

TABLE C.3.2 GROUNDWATER QUALITY – UNCONFINED WATER-DATA FROM COG

(unit: mg/l)

Basin	pH	HCO_3	SO_4^{2-}	Cl^-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Mg^{2+}	$NH4^+$	Na+ K	Total Fe	Hard-ness
* BSS2823/83			250	250	50	no	0.5	150	80	no		0.2	12
MU1	7.0-7.9	51-201	6-49	15-21	1-10	0-0.1	0.1-0.6	7-73	6-16	0-0.27	11-14	<0.1	0.9-4.7
MU2	6.8-8.3	67-387	5-189	4-47	0-90	0-0.07	0.2-1.6	7-154	2-31	0-0.03	13-54	<0.1-0.9	0.8-10.2
MM1	7-8.3		9-273	7-104	1-266	0-2.23	<0.2-2.4	7-206	3-48	0-0.04	9-116	<0.1-2.5	2.4-13.6
MM2	7.2-8.2	188-375	27-346	10-73	5-189	0-0.2	0-1.7	68-184	8-58	0 (0.05)	10-120	<0.1-0.2	4.1-12.8
MM3	7.3-8	338-448	17-276	20-217	5-72	0-0.02	<0.2-1.4	100-182	6-63	0-0.008	29-104	<0.1	6.6-11.8
TOP	7.0-7.8	199-449	6-810	18-71	1-136	0-0.36	0.2-2.4	75-320	16-84	0-0.03	16-77	<0.1-(1.8)	5.0-7.8
LUD	7.0-7.8	239-407	9-111	12-19	13-20	0-0.18	0.4-1.6	80-92	17-26	0-0.03	21-35	<0.1-(0.2)	5.5-6.5
PYA	7.4-8.7	62-206	11-19	9-13	8-20	0-0.07	0.1-1.4	15-48	5-11	0 (0.1)	20-24	<0.1	1.2-3.3
STR	6.4-8.8	33-237	12-62	4-31	0-128	0-0.8	<0.05-1.4	6-60	0-38	0 (0.01)	7-61	<0.1	0.3-4.8
VAC	7.2-7.8	156-436	11-41	5-30	10-105	0-1.03	0.05-1.2	56-114	4-43	0	8-33	<0.1 (0.4)	3.2-9.2
CPE	7.8-7.9	145-171	32-37	5-9	2-3	0	<0.2	48-57	6	0	10-13	<0.1	2.9-3.3
HAR	7.5-8.3	66-485	27-506	5-68	1-59	0-1.36	<0.2-1.8	25-160	4-47	0-0.01	13-220	<0.1 (0.2)	1.6-11.8

Data are collected from 1995 to 1997. Total monitoring well are 99. No numerical analysis

* Standard : Bulgarian State Standard 2823/83 "Drinking water"

TABLE C.3.3 SEASONAL FLUCTUATION OF GROUNDWATER QUALITY – UNCONFINED WATER

(average value : mg/l)

Basin	Season	No*	HCO_3	SO_4^{2-}	Cl^-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Mg^{2+}	Na+K
**BSS2823/83				250	250	50	no	0.5	150	80	
MU2	May	6	226	129.3	22.7	16.1	2.7	1.10	89.9	19.5	31.3
	October		207	51.8	16.3	15.1	0.015	0.45	64.8	13.6	22.1
MM1	May	13		94.3	27.4	24.9	0.13	0.71	98.3	24.5	35.0
	October		303	70.0	24.0	18.0	0.09	0.30	84.0	22.4	35.0
MM2	May	9	271	165.4	45.1	84.2	0.03	0.45	125.5	29.8	49.7
	October		265	132.0	36.0	64.0	0.04	0.44	108.0	24.0	46.0
MM3	May	4	405	135.0	67.8	30.1	0	0.88	134.0	31.0	64.2
***	October		390	142.5	51.3	34.4	0.004	0.60	127.9	31.5	60.7
STR	May	11	123	43.0	16.3	14.1	0	0.40	36.6	12.2	17.2
	October		134	40.8	18.4	25.6	0.04	0.37	43.2	13.3	18.2
HAR	May	17	294	112.5	36.3	25.6	0.006	0.95	91.3	20.5	60.8
	October	13	304	119.0	38.0	27.5	0.057	0.55	93.0	20.9	66.4

Data are collected from 1995 to 1997. * : sample number, No numerical analysis

** Bulgarian State Standard 2823/83 "Drinking water"

*** MM3 : Only Haskovo area

TABLE C.3.4 SEASONAL FLUCTUATION OF GROUNDWATER QUALITY – PLIOCENE CONFINED WATER

(average value : mg/l)

Basin	Season	No*	HCO_3	SO_4^{2-}	Cl^-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Mg^{2+}	Na+K
**BSS2823/83				250	250	50	no	0.5	150	80	
MM1	May	4	187	31.8	16.6	11.8	0.06	0.37	46.8	13.0	20.6
	October		182	40.2	17.5	2.9	0	0.27	40.8	14.0	28.5
MM2	May	9	326	80.7	29.4	31.4	0.08	0.80	101.1	25.9	42.3
	October		345	53.7	21.7	27.1	0	0.20	87.8	23.3	43.4
STR	May	6	154	37.0	17.3	25.4	0.02	0.35	37.9	10.3	32.9
	October	7	156	27.1	14.0	1.7	0.02	0.40	32.8	8.3	31.4

Data are collected from 1995 to 1997. * : sample number, No numerical analysis

** Bulgarian State Standard 2823/83 "Drinking water"

TABLE C.3.5 WATER QUALITY IN PLOVDIV – PAZARDJIK REGION

No	Basin	Location	Altitude	Depth	Year	Geological index	Lithology	TDS	T	pH	Hardness
			m	m				mg/l	°C		mg.eqw/l
1	MM2	Iskra	298.99	1244	1986	Pg	conglomerate	491.3	21	8.4	0.5
2	MM2	Bryagovo	222.46	300	1984	Pg	tuff	492	$31_{300\,m}$	8.7	0.3
3	MM1	Hrabrino	320.22	1196	1978	Pg	sandstone	743.6	16	9.2	0.4
4	MM2	Topolovo	412.00	983	1980	Pz	granite	998	61	8.3	4.2
5	MM1	Hrabrino	333.00	1085	1976	Pt	gneiss	1399	17	8.8	0.4
6	MM2	Dolnoslav	357.41	810	1985	Pt	Schist, granite	367	16	8	1
7	MM2	Lenovo	295.62	1312	1980	Pt	gneiss	420	47	9.4	0.2
8	MM2	Bryagovo	214.00	1545	1986	Pt	gneiss	2832	$79.2_{1530\,m}$	8.3	0.2
9	MM1	Dolni Voden	226.72	1413	1981	Pt	gneiss	403	$52_{1390\,m}$	8.4	1.2
10	MM1	Kuklen	191.64	390	1972	Pt	Marble	430	23	6.9	4.4
11	MM1	Kuklen	244.18	560	1978	Pt	Limestone	430	23	7.3	4.8
12	CPE	Assenovgrad	226.95	666	1969	Pt	Marble	382	$26.5_{500\,m}$	7.6	4.2
13	CPE	Assenovgrad	214.85	1205	1984	Pt	Marble	1344	25	7.6	4.3

No	Basin	HCO_3	CO_3	SO_4	Cl	Ca	Mg	Na	NO_3	NO_2	PO_4	NO_4	Fe	Mn	H_2SiO_4	F
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	MM2	135	6	127	21	6	3	130.1	0	0.04	2.4	0.013	0.014	0.002	59	1.5
2	MM2	252	10	8	10	5	0.6	107	0	0	0.4	0	0.004	0	98	0.6
3	MM1	212	32	212	6	6	2	228.7	0	0	5.6	0	1.7	0.007	28	10
4	MM2	30	2	551	21	85	0	204.5	0	0	2.2	0	0.01	0.003	96	0.6
5	MM1	407	51	458	18	5	1	424.2	0	0	0	0		0.12	21	12.5
6	MM2	168	0	46	20	18	2	73.9	0	0	1.2	0	0.006	0.002	36	0.9
7	MM2	35	30	132	18	3	0	118.9	0	0	1.2	0	0.009	0.001	74	0.7
8	MM2	1501	43	103	274	4	0.24	834.5	0	1.17	1.8	0	0.04	0.007	50	10
9	MM1	153	12	22	87	10	8	102.6	0	0	0.8	0	0.01	0.003	7.3	0.1
10	MM1	287	0	16	4	51	22	18.4	0	0	0	0	2.67	0.08	31	0.2
11	MM1	285	0	17	6	61	22	9.1	0	0	1	0	0.009	0.15	29	0.2
12	CPE	283	0	24	5	69	9	13	1	0	0.6	0	0.08	0.003	13	0.2
13	CPE	240	0	603	40	57	18	330	0	0	1.6	0	0.012	0.004		5.6

TABLE C.3.6 WATER QUALITY IN HASKOVO (H), KARLOVO (K), NORTHERN PART OF PLOVDIV-PAZARDJIK (Pz), AND PLOVDIV-PAZARDJIK (P) REGION (1/4)

No.	Data	*Well No.	Location	Geological index	Basin	pH	HCO_3^-	SO_4^{2-}	Cl^-	NO_2^-	NO_3^-	PO_4^{3-}	NH_4^+	Mg^{2+}	Ca^{2+}	Na+k	Total Fe	Mn^{2+}	Zn^{2+}	TDS	Temp.	Hadrness	Dry residual
							(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(oC)	(mgeq/l)	
BSS2826/83						-	-	250	250	-	50	0.5	-	80	150	-	0.2	0.1	5	-	-	12	-
	V. 1995					7.9	406	271	60	0	56	0.6	0	56	140	97.4	< 0.1	< 0.05	< 0.05	1110		11.5	910
	V. 1996		spring			7.9	402	261	57	0	72	0.6	0	51	136	94.3	< 0.1	< 0.05	< 0.05	1094		11	912
1	IV. 1997	H1	"Ters dere"	T_{1-2}	HAR	7.7	406	271	64	0	52	0.2	0	49	136	89.4	< 0.1	< 0.05	< 0.05	1090		10.8	
	X. 1995					7.8	383	276	64	0	60	0.4	0	52	130	93.5	< 0.1	< 0.05	< 0.05	1083		10.8	910
	X. 1997					7.6	403	254	62	0	54	< 0.2	0	52	139	90.2	< 0.1	< 0.05	< 0.05	1079		11.2	
					Av	7.8	400	267	61	0	58.8		0	52	136.2	92.96				1091		11.1	911
	V. 1995		WSS"Haskovo-1"			7.8	217	46	19	0	14	1.2	0.005	12	67	29.5	< 0.1	0.15	0.05	452		4.3	360
	V. 1996		observation well			7.9	223	45	19	0	25	1.4	0.002	13	69	29.4	< 0.1	< 0.05	< 0.05	466		4.5	370
2	IV. 1997	H6	is 46 m far from	Q_{al} +Pl	HAR	7.6	239	52	20	0	21	0.4	0	14	72	31	< 0.1	< 0.05	< 0.05	449		4.8	
	X. 1995		production well			7.7	210	45	21	0	18	0.5	0	13	64	23.8	< 0.1	0.2	< 0.05	439		4.3	350
	X. 1997					7.6	228	77	34	0	16	0.2	0	16	87	34	< 0.1	< 0.05	< 0.05	532		5.7	
					Av	7.7	223	53	22.6	0	18.8	0.74	0.0014	13.6	71.8	29.54				468		4.7	360
	V. 1995		WSS"Uzundjovo-1"			8.3	276	62	50	0.02	36	1.2	0.01	36	66	55.5	< 0.1	< 0.05	0.1	627		6.2	500
	V. 1996		observation well			8.3	243	54	56	0	16	0.6	0.002	30	45	63	< 0.1	< 0.05	< 0.05	555		4.8	446
4	IV. 1997	H9	is 10 m far from	Q_{al} +Pl	HAR	8.3	291	64	53	0	40	0.4	0	33	62	57	< 0.1	< 0.05	< 0.05	639		5.8	
	X. 1995		production well			7.9	297	50	52	0.03	40	0.8	0.005	31	68	59.6	< 0.1	< 0.05	0.2	640		5.9	500
	X. 1997					7.9	305	56	54	0	24	< 0.2	0	32	54	59	< 0.1	< 0.05	< 0.05	622		5.3	
					Av	8.1	282	57	53	0.01	31.2		0.0034	32.4	59	58.82				617		5.6	482
	V. 1995		WSS"Uzundjovo-II"			7.8	410	56	39	0.01	29	1.2	0.008	36	109	32.6	0.1	< 0.05	< 0.05	756		8.4	570
	IV. 1996		observation well			7.8	381	37	37	0	22	0.6	0	27	77	53	< 0.1	< 0.05	0.05	683		6	522
5	IV. 1997	H10	is 12 m far from	Q_{al} +Pl	HAR	7.7	454	80	48	0	30	0.4	0	35	125	34	< 0.1	< 0.05	< 0.05	843		9.2	
	X. 1995		production well			7.6	364	66	42	0	35	0.8	0.004	34	100	31.1	0.2	< 0.05	< 0.05	714		7.8	550
	X. 1997					7.5	413	42	35	0	22	< 0.2	0	32	97	34	< 0.1	< 0.05	< 0.05	710		7.5	
					Av	7.7	404	56	40	0.002	27.6		0.0024	32.8	101.6	36.94				741		7.8	547
	V. 1995		WSS"Eastern zone"			7.6	298	27	27	0.02	29	1.4	0.01	18	88	29.2	< 0.1	< 0.05	< 0.05	560		5.9	430
	V. 1996		observation well			7.9	293	29	26	0	30	1.4	0.002	14	87	29	< 0.1	< 0.05	< 0.05	551		5.5	420
6	IV. 1997	H12	is 115 m far from	Q_{al} +Pl	HAR	7.7	302	37	28	0	28	0.4	0	16	90	29	< 0.1	< 0.05	< 0.05	568		5.8	
	X. 1995		production well			7.9	297	33	27	0.01	32	0.8	0.005	18	90	28.1	< 0.1	< 0.05	< 0.05	570		6	430
	X. 1997					7.5	300	34	28	0	28	0.6	0	21	88	30	< 0.1	< 0.05	< 0.05	568		6.1	
					Av	7.8	298	32	27	0.0075	29.75	1	0.0043	16.5	88.75	28.83				562		5.8	427
	V. 1995		WSS"Knijovnik"			7.9	318	98	39	0.02	23	0.4	0	19	112	41.2	< 0.1	< 0.05	0.1	679		7.2	535
	IV. 1996		observation well			7.9	249	81	37	0	25	0.6	0	18	110	49	< 0.1	< 0.05	< 0.05	703		7	562
7	IV. 1997	H15	is 15 m far from	Q_{al} +Pl	HAR	7.6	329	104	36	0	36	0.4	0	24	125	29	< 0.1	< 0.05	< 0.05	708		8.2	

TABLE C.3.6 WATER QUALITY IN HASKOVO (H), KARLOVO (K), NORTHERN PART OF PLOVDIV-PAZARDJIK (Pz), AND PLOVDIV-PAZARDJIK (P) REGION (2/4)

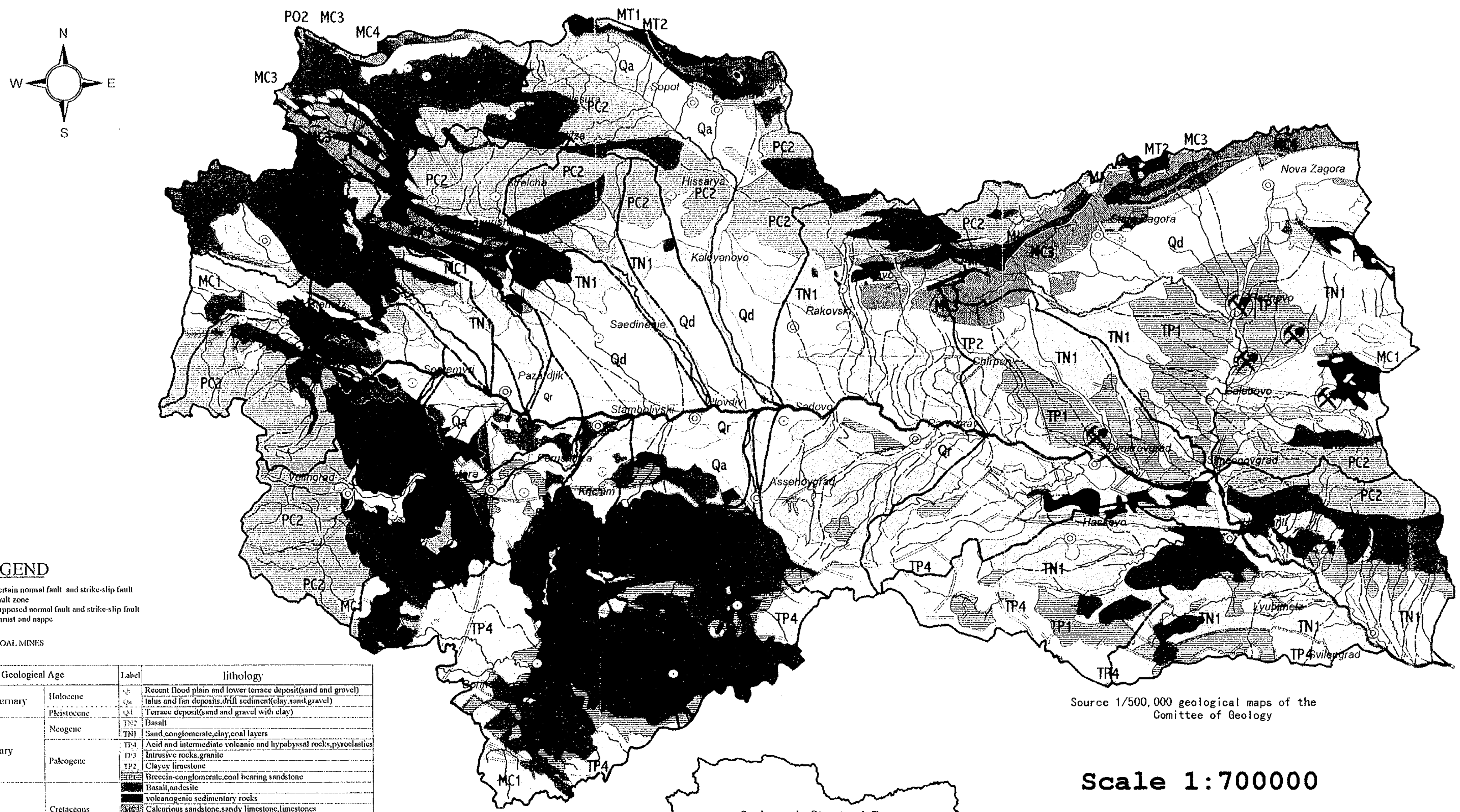
	X. 1995		production well			7.8	297	102	41	0.01	25	0.4	0	12	120	44.3	0.1	< 0.05	< 0.05	671		7	540
	X. 1997					7.5	338	98	32	0	27	0.2	0	23	114	33	< 0.1	< 0.05	< 0.05	691		7.6	
					Av	7.7	306	97	37	0.006	27.2	0.4	0	19.2	116.2	39.3				690		7.4	546
	V. 1995		WSS"Dinevo"			8.3	264	35	19	0	10	1.4	0.008	16	70	35.2	< 0.1	< 0.05	< 0.05	509		4.7	386
	V. 1996		observation well			8.3	348	45	21	0	18	1.4	0	21	80	46	< 0.1	< 0.05	< 0.05	637		5.8	476
8	IV. 1997	H16	is 57 m far from	Q_{al} +Pl	HAR	7.8	380	80	23	0	55	1.2	0	25	107	20	< 0.1	< 0.05	< 0.05	764		7.4	
	X. 1995		production well			8	359	45	18	0	12	0.6	0	19	76	44.3	< 0.1	< 0.05	< 0.05	619		5.4	450
						7.6	378	42	26	0	30	0.6	0	20	93	46	< 0.1	< 0.05	< 0.05	684		6.3	
					Av	8	346	49	21	0	25	1.04	0.0016	20.2	85.2	38.3				643		5.9	437
	V. 1995		WSS"Bryagovo"			7.8	302	76	50	0	4	0.8	0.004	19	74	71.6	< 0.1	0.4	0.05	639		5.2	506
	V. 1996		observation well			8.3	305	66	52	0	0	1.4	0.002	16	72	83	< 0.1	0.37	< 0.05	648		4.9	460
9	IV. 1997	H17	is 100 m far from	Q_{al} +Pl	HAR	7.7	318	80	52	0	5	0.4	0	25	76	69	< 0.1	0.64	< 0.05	764		5.8	
	X. 1995		production well			7.7	306	82	52	0.02	4	0.4	0	19	80	61.2	< 0.1	0.4	< 0.05	647		5.6	510
	X. 1997					7.4	310	82	52	0	4	0.6	0.04	20	76	72	< 0.1	0.89	< 0.05	656		5.4	
					Av	7.8	308	77	52	0.004	3.4	0.72	0.0092	19.8	75.6	71.36				671		5.4	492
					Total Av	7.8	310	60	36	0.0042	23.279		0.0032	22.071	85.45	43.3				627		6.1	470
	IV. 1996		WSS"Slatina"			7.7	209	24	11	0	18		0	21	55	7.4	< 0.1	< 0.05	< 0.05	368		4.5	280
	IV. 1997		production well			7.4	215	28	10	0	18	< 0.2	0	22	56	7.9	< 0.1	< 0.05	< 0.05	378		4.6	284
10	IX. 1995	K1		Q_{al}	STR	8.3	223	26	11	0	17	0.4	0	20	57	7.9	< 0.1	< 0.05	0.05	392		4.4	295
	X. 1996					7.8	224	27	11	0	28	< 0.05	0	21	59	7.6	< 0.1	< 0.05	< 0.05	401		4.7	312
	IX. 1997					7.2	237	27	12	0	20	< 0.2	0	22	60	7.9	< 0.1	< 0.05	< 0.05	410	15.2	4.8	308
					Av	7.7	222	26	11	0	20.2		0	21.2	57.4	7.74				390	15.2	4.6	296
	VI. 1995		WSS"Bogdan-2"			7.8	113	38	12	0	4	0.4	0	10	10	15.2	< 0.1	< 0.05	< 0.05	260	12.8	2.6	216
	IV. 1996		observation well			7.1	98	37	14	0	17	0.6	0	11	11	12.9	< 0.1	< 0.05	< 0.05	252		2.7	220
11	IV. 1997	K2	is situated in a sanitary	Q_{al}	STR	7	98	32	9	0	12	0.2	0	10	10	10.8	< 0.1	< 0.05	< 0.05	228		2.4	194
	X. 1996		protected area			7.7	117	46	16	0	24	0.1	0	13	13	14.9	< 0.1	< 0.05	< 0.05	303		3.2	260
	IX. 1997					6.8	120	40	14	0	19	0.4	0	38	38	14	< 0.1	< 0.05	< 0.05	287	15.2	2.8	240
					Av	7.3	109	39	13	0	15.2	0.34	0	16.4	16.4	13.56				266	14	2.7	226
	VI. 1995		WSS"Dabene-1"			7.8	91	33	13	0	22		0	11	33	12.8	< 0.1	< 0.05	< 0.05	242	13.2	2.6	206
	IV. 1996		observation well			7.2	89	32	11	0	21	0.2	0	10	32	12.8	< 0.1	< 0.05	< 0.05	235		2.4	214
12	IV. 1997	K11	is situated in a sanitary	Q_{al}	STR	6.9	85	37	12	0	18	0.2	0	11	32	12.7	< 0.1	< 0.05	< 0.05	230		2.5	204
	X. 1996		protected area			6.8	90	37	11	0	28	< 0.05	0	10	34	13.7	< 0.1	< 0.05	< 0.05	252		2.6	222
	IX. 1997					6.8	94	38	10	0	25	0.2	0	10	32	12.8	< 0.1	< 0.05	< 0.05	248	15.2	2.4	214
					Av	7.1	90	35	11	0	22.8		0	10.4	32.6	12.96				241	14.2	2.5	212
	III. 1995		WSS"Hisar"			7.8	99	21	15	0	20	0.2	0	10	31	13	0.2	< 0.05	< 0.05	242	13.4	2.4	206
	III. 1996		observation well			7.1	98	25	13	0	16	0.2	0	9	33	12.9	< 0.1	< 0.05	< 0.05	237		2.4	206
13	IV. 1997	K14	is situated in a	Q_{al}	STR	6.8	67	46	13	0	24	0.2	0	13	26	12.9	< 0.1	< 0.05	< 0.05	230		2.4	210

TABLE C.3.6 WATER QUALITY IN HASKOVO (H), KARLOVO (K), NORTHERN PART OF PLOVDIV-PAZARDJIK (Pz), AND PLOVDIV-PAZARDJIK (P) REGION (3/4)

			sanitary																				
	X. 1996		protected area			7.7	124	29	27	0	19	< 0.05	0	14	43	15.2	< 0.1	< 0.05	< 0.05	300		3.3	258
	IX. 1997					7	80	42	13	0.09	25	0.2	0	15	24	12.1	< 0.1	< 0.05	< 0.05	236		2.4	214
					Av	7.3	96	31	16	0	20.36		0	11.28	33.12	13.39				250	13.8	2.6	218
					Total Av	7.2	133	33	13	0	19.59		0	15.02	35.53	11.95				292	14.3	3.2	241
	V. 1996		WSS"Panagurische"			7.8	189	32	19	0	21	1.2	0	11	64	14	< 0.1	< 0.05	< 0.05	306	14.2	4.1	384
	V. 1997		observation well			8.2	190	39	16	0.01	14	0.4	0	13	62	13	< 0.1	< 0.05	< 0.05	299		4.2	380
14	IX.1995	Pz26	is 6 m far from	Q_{al}	MU1	7.3	196	34	13	0.01	13	0	0	13	61	12	< 0.1	< 0.05	< 0.05	292		4.1	376
	IX. 1996		production well			6.9	199	35	16	0	14	0.1	0	12	63	12	< 0.1	< 0.05	< 0.05	308		4.2	382
	VIII. 1997					7.7	220	47	15	0	0	0.6	0	12	73	13	< 0.1	< 0.05	< 0.05	342		4.6	433
					Av	7.6	199	37	16	0.004	12.4	0.46	0	12.2	64.6	12.8				309	14.2	4.2	391
	V. 1996		WSS"Pazardjik"			7.3	199	35	15	0	21	1.2	0	8	66	21	< 0.1	< 0.05	< 0.05	320		4	404
	V. 1997		observation well			7.8	208	41	13	0	17	0.6	0	10	64	19	< 0.1	< 0.05	< 0.05	320		4.1	410
15	IX.1995	Pz27	is 80 m far from	Q_{al}	MU2	8.6	177	45	13	0	10	0	0	11	64	19	0.2	< 0.05	< 0.05	316		4.1	385
	IX. 1996		production well			7.3	199	38	13	0	12	0.15	0	10	62	19	< 0.1	0.05	< 0.05	314		4	392
	VIII. 1997					7.6	197	54	15	0	21	1.2	0	11	66	21	< 0.1	< 0.05	< 0.05	344		4.2	423
					Av	7.7	196	43	14	0	16.2	0.63	0	10	64.4	19.8				323		4.1	403
	V. 1996		WSS"Ognyanovo"			7.5	186	30	13	0.12	10	1.2	0.002	11	53	16	< 0.1	< 0.05	< 0.05	262		3.6	358
	V. 1997		observation well			8	186	40	10	0	9	0.6	0	17	52	15	< 0.1	< 0.05	< 0.05	286		4	365
16	IX.1995	Pz30	is 20 m far from	Q_{al}	MU2	7.5	177	37	7	0	7	0.4	0	10	51	14	< 0.1	< 0.05	< 0.05	264		3.4	340
	IX. 1996		production well			7.6	184	25	11	0	6	< 0.05	0	6	52	15	< 0.1	< 0.05	< 0.05	266		3.1	336
	VIII. 1997					7.7	178	41	10	0	8	1.2	0	12	52	15	< 0.1	< 0.05	< 0.05	288		3.6	354
					Av	7.7	182	35	10	0.024	8		0.0004	11.2	52	15				273.2		3.5	351
	V. 1996		WSS"Bratanitza"			7	263	29	17	29.6	2	1.4	0.032	13	86	16	< 0.1	< 0.05	< 0.05	400	13.7	5.5	508
	V. 1997		observation well			7.9	259	30	16	0.01	38	0.6	0	14	82	16	< 0.1	< 0.05	< 0.05	378		5.3	492
17	IX. 1995	Pz5	is 20 m far from	Q_{al}	MU2	7.2	259	29	13	0.07	38	0.2	0	15	81	16	0.1	< 0.05	0.05	372		5.2	487
	IX. 1996		production well			7.4	254	36	14	0	39	0.2	0	17	81	16	< 0.1	< 0.05	< 0.05	384	13.5	5.4	494
	IX. 1997					8.1	249	33	15	0	44	0.8	0	15	83	15	< 0.1	< 0.05	< 0.05	400		5.4	500
					Av	7.52	257	31	15	5.936	32.2	0.64	0.0064	14.8	82.6	15.8				387	13.6	5.4	496
					Total Av	7.6	212	36	13	1.9867	18.8		0.0023	12	66.33	16.87				328	13.6	4.3	417
	V. 1996		WSS"Unatzite"			8	201	129	26	0	6	0.6	0	26	89	22	< 0.1	< 0.05	< 0.05	440	15.1	6.6	522
	V. 1997		observation well			7.9	186	131	24	0	11	0.6	0	19	84	21	< 0.1	< 0.05	< 0.05	420		5.8	498
18	IX.1995	Pz28	is 60 m far from	Q_{al}	TOP	7.3	199	134	24	0	4	0.2	0	19	86	22	0.1	< 0.05	< 0.05	426		5.8	511
	IX. 1996		production well			7.2	187	121	21	0	4	0.1	0.002	19	80	21	< 0.1	< 0.05	< 0.05	404		5.6	476
	VIII. 1997					7.5	192	135	25	0	0	0.6	0	18	84	21	< 0.1	< 0.05	< 0.05	428		5.7	503
					Av	7.6	193	130	24	0	5	0.42	0.0004	20.2	84.6	21.4				424	15.1	5.9	502
	V. 1996		WSS"Brestovitza"			7.5	261	30	53	0	23	1	0.002	17	101	15	< 0.1	< 0.05	< 0.05	392	15.4	6.4	501
	V. 1997		observation well			7.7	309	29	16	0	14	0.6	0	14	95	15	< 0.1	< 0.05	< 0.05	388		5.6	523
19	IX.1995	Pz31	is 8 m far from	Q_{al}	VAC	7.5	311	32	14	0	13	0	0	16	93	14	< 0.1	< 0.05	< 0.05	378		6	521

TABLE C.3.6 WATER QUALITY IN HASKOVO (H), KARLOVO (K), NORTHERN PART OF PLOVDIV-PAZARDJIK (Pz), AND PLOVDIV-PAZARDJIK (P) REGION (4/4)

	IX. 1996		production well			7.4	323	33	16	0	13	0.05	0	15	96	14	< 0.1	< 0.05	< 0.05	400		6.1	540
	VIII. 1997					8.2	311	30	14	0.04	16	0.4	0	15	91	15	< 0.1	< 0.05	< 0.05	386		5.8	524
					Av	7.7	303	31	23	0.008	15.8	0.41	0.0004	15.4	95.2	14.6				389	15.4	6.0	522
	V.1996		WSS"K.Konare"			7.2	156	11	10	0	10	0.6	0	4	57	8	< 0.1	< 0.05	< 0.05	216	12.8	3.2	279
	V. 1997		observation well			7.6	241	37	14	0.05	16	0.4	0	11	93	11	< 0.1	< 0.05	< 0.05	388		5.1	439
20	IX. 1995	Pz20	is 110 m far from	Q_{al}	VAC	7.7	168	23	5	0	10	0.4	0	6	56	8	< 0.1	< 0.05	< 0.05	221		3.2	294
	IX. 1996		production well (out of			7.5	177	28	8	0	13	0.1	0	5	60	8	< 0.1	< 0.05	< 0.05	244	12.5	3.4	317
	VIII. 1997		sanitary protected area)			7.7	262	38	15	0.07	11	0.6	0	11	88	12	< 0.1	< 0.05	< 0.05	348		5.3	462
					Av	7.5	201	27	10	0.024	12	0.42	0	7.4	70.8	9.4				283	12.65	4.0	358
					Total Av	7.6	252	29	17	0.016	13.9	0.415	0.0002	11.4	83	12				336	14.03	5.0	440
21	V. 1997	P9	WSS"Non-ferrous metals	Q_{al}	MM1	7.9	369	206	27	2.23	48	0.4	0	28	188	18	< 0.1	< 0.05	< 0.05	915		11.7	
	X. 1997		Plovdiv"production well			8	270	49	15	0	19	< 0.2	0	12	98	9	< 0.1	< 0.05	< 0.05	494		5.9	
					Av	8.0	320	128	21	1.115	33.5		0	20	143	13.5				705		8.8	
22	V. 1997	P12	WSS"Katunitza"	Q_{al}	MM2	7.9	188	41	14	0	8	0.2	0	8	69	11	< 0.1	< 0.05	< 0.05	355		4.1	
	X. 1997		production well			7.8	223	33	12	0	23	< 0.2	0	11	84	10	< 0.1	< 0.05	< 0.05	414		5.1	
					Av	7.9	206	37	13	0	15.5		0	9.5	76.5	10.5				385		4.6	
24	V. 1997	P26	WSS"Parvomay-east"	Pl	MM2	7.9	344	119	19	0.04	30	1.2	0	18	100	61	< 0.1	< 0.05	< 0.05	735		6.5	
	X. 1997		production well			7.8	331	107	20	0	25	0.2	0	18	96	61	< 0.1	< 0.05	< 0.05	699		6.2	
					Av	7.9	338	113	20	0.02	27.5	0.7	0	18	98	61				717		6.4	
25	V. 1997	P25	WSS"Pravoslaven"	Pl	MM2	7.1	136	45	23	0.4	16	1.2	0	8	54	25	< 0.1	< 0.05	< 0.05	352		3.4	
	X. 1997		production well			7.1	131	48	17	0	18	0.4	0	10	49	24	< 0.1	< 0.05	< 0.05	330		3.3	
					Av	7.1	133.5	46.5	20	0.2	17	0.8	0	9	51.5	24.5				341		3.4	
					Total Av	7.5	236	80	20	0.11	22.25	0.75	0	13.5	74.75	42.75				529		4.9	
26	V. 1997	P4	WSS"Plovdiv-north"	Pl	MM1	7.9	284	66	19	0.04	8	0.4	0	15	80	35	< 0.1	< 0.05	< 0.05	542		5.2	
	X. 1997		observation well			8	284	70	18	0	10	< 0.2	0	15	82	36	< 0.1	< 0.05	< 0.05	553		5.3	
			is 9 m far from																				
			production well																				
					Av	8.0	284	68	18.5	0.02	9		0	15	81	35.5				548		5.3	
27	V. 1997	P3	WSS"Plovdiv-south"	Pl	MM1	7.8	203	29	10	0.01	5	0.6	0	14	52	11	< 0.1	< 0.05	< 0.05	359		3.8	
28	V. 1997	P8	WSS"Plovdiv-east"	Pl	MM1	7.9	232	34	16	0.04	9	1	0	16	56	25	< 0.1	< 0.05	< 0.05	435		4.1	
			observation well																				
			is 15 m far from																				
			production well																				
					Total Av	7.88	240	44	15	0.0233	7.6667		0	15	63	23.83				447		4.4	

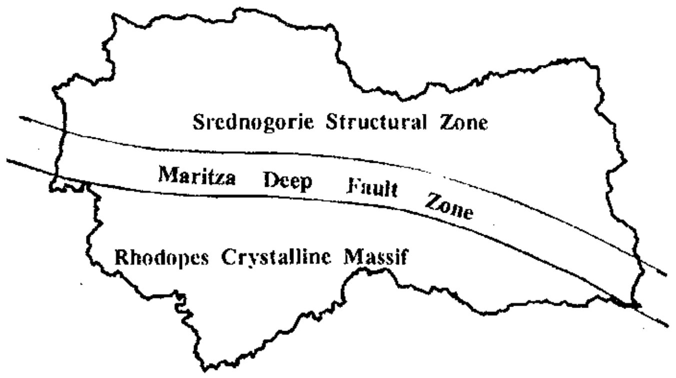


LEGEND

Certain normal fault and strike-slip fault
Fault zone
Supposed normal fault and strike-slip fault
Thrust and nappe

COAL MINES

Geological Age		Label	lithology
Quaternary	Holocene	Qr	Recent flood plain and lower terrace deposit(sand and gravel)
		Qa	talus and fan deposits,drift sediment(clay,sand,gravel)
	Pleistocene	Qd	Terrace deposit(sand and gravel with clay)
Tertiary	Neogene	TN2	Basalt
		TN1	Sand,conglomerate,clay,coal layers
	Paleogene	TP4	Acid and intermediate volcanic and hypabyssal rocks,pyroclastics
		TP3	Intrusive rocks,granite
		TP2	Clayey limestone
		TP1	Breccia-conglomerate,coal bearing sandstone
Mesozoic	Cretaceous		Basalt,andesite
			volcanogenic sedimentary rocks
		MC3	Calcarious sandstone,sandy limestone,limestones
		MC2	Coal-bearing sandstone,conglomerate,sandstone,shale
		MC1	Granite,granodiorite,dioriteporphyry
	Jurassic		Terrigenous carbonate rocks
	Triassic		Metasandstone,schists,dolomite marbles
			Conglomenate,sandstone,siltstone,shale
		MT1	Limestone,dolomite
Paleozoic	Permian		Volcanic and hypabyssal rock bodies,quartzporphylites
	Carboniferous	PC2	Granite,granodiorite
			Coal-bearing terrestrial rocks,metabreccia-conglomerate
	Silurian	[illegible]	Sandstone,lidite
	Ordovician	PO2	Metashale,metsandstone,quartzite
			Gneiss-granite,migmatite
Precambrian			Gnesiss,migmatite,amphybolite,schist
		[illegible]	Marble,dolomitic marble,schist
			Metamorphosed basic and ulrtabasic rocks



Source 1/500,000 geological maps of the Comittee of Geology

Scale 1:700000

SCALE

10 0 10 20 km

FIG.C.1.1 GEOLOGICAL MAP FOR THE MARITZA RIVER BASIN

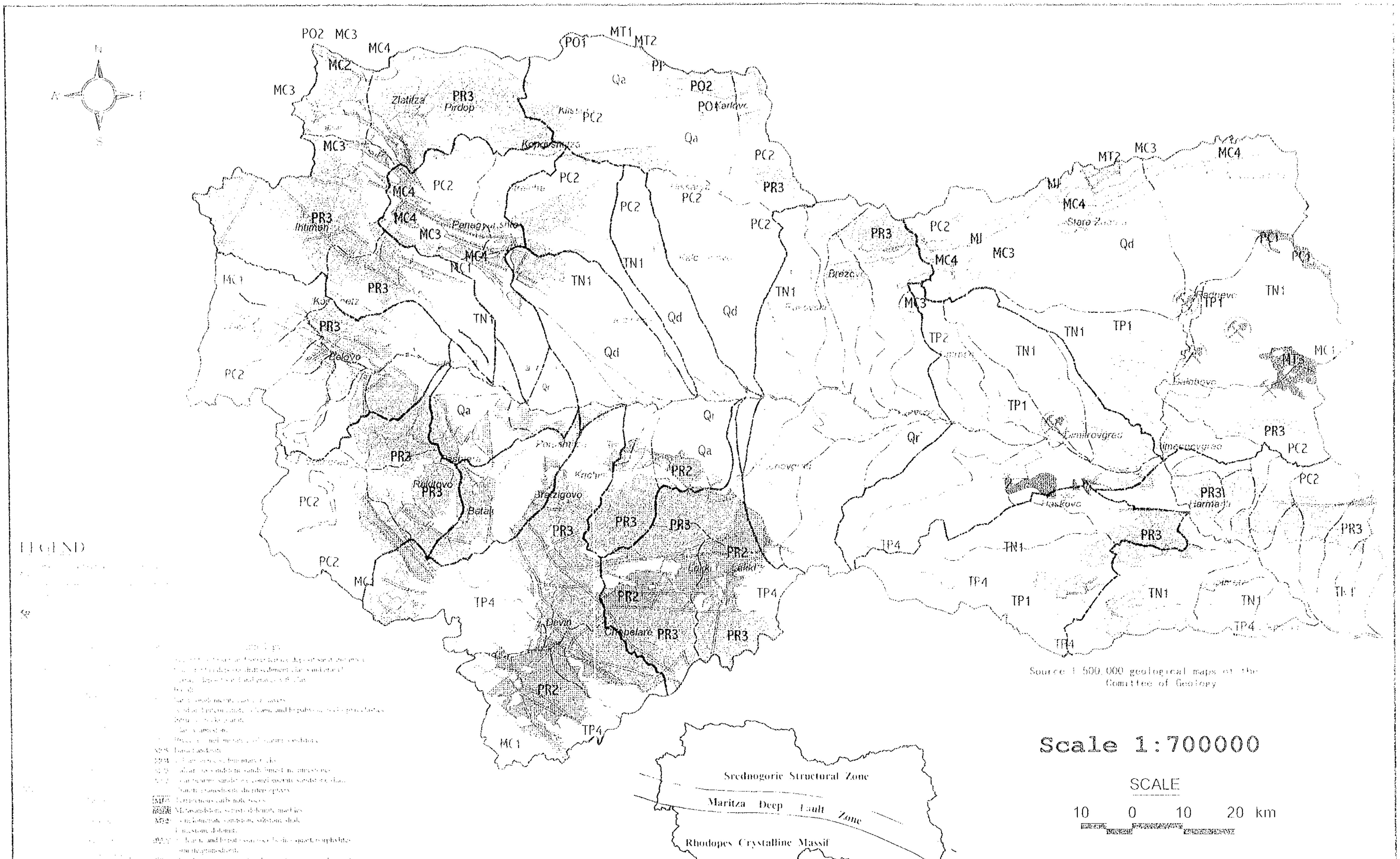
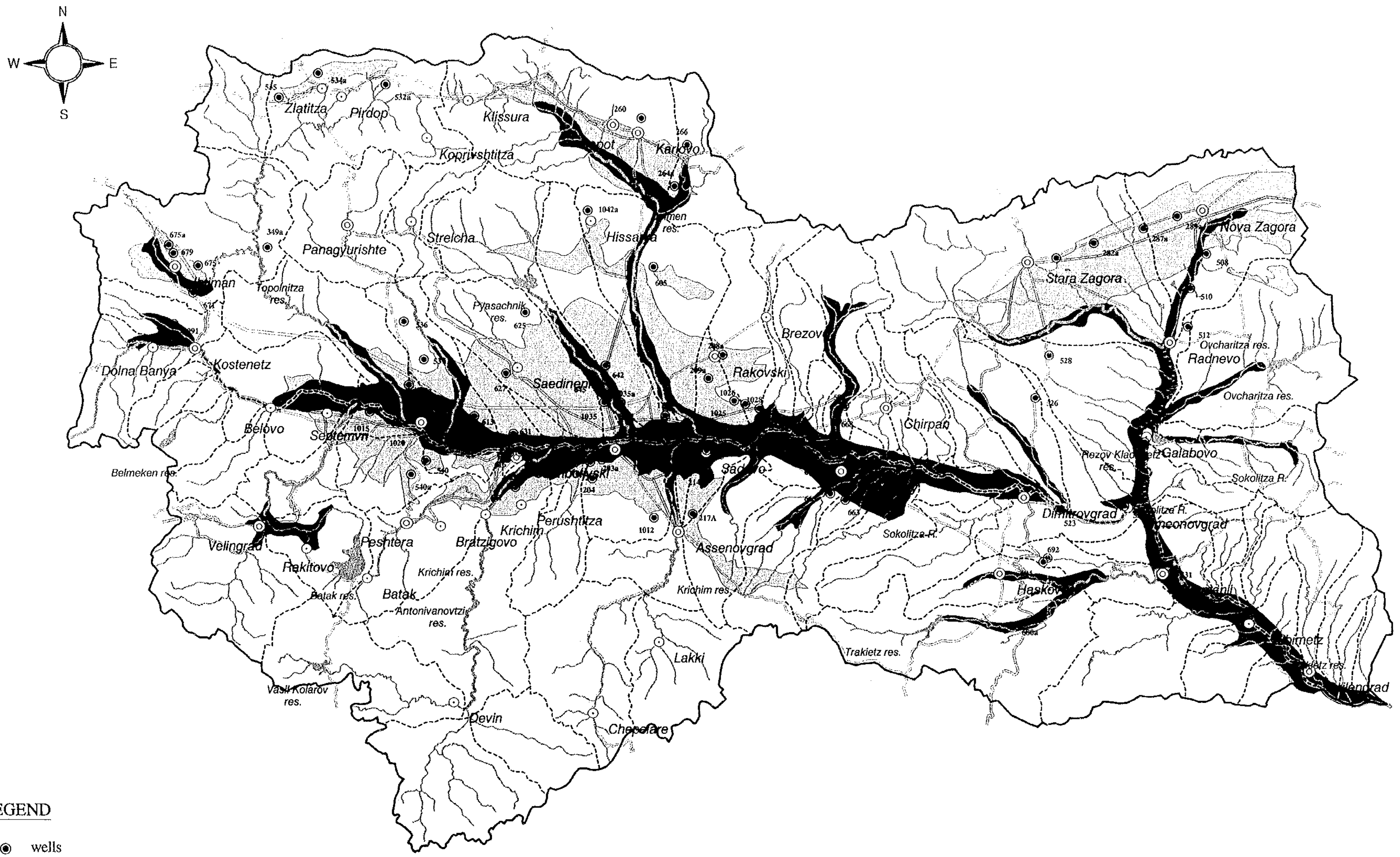


FIG.C.1.1 GEOLOGICAL MAP FOR THE MARITZA RIVER BASIN



LEGEND

◉ wells

Classification	Specific yield (m³/m)
Flood plain / terrace deposit	10-30 %
Talus / drift deposits	5-10 %
Tertiary / Bedrock	0- 5 %

FIG.C.2.1 DISTRIBUTION OF SPECIFIC YIELD

Scale 1:700000

10 0 10 20 km

C - 53

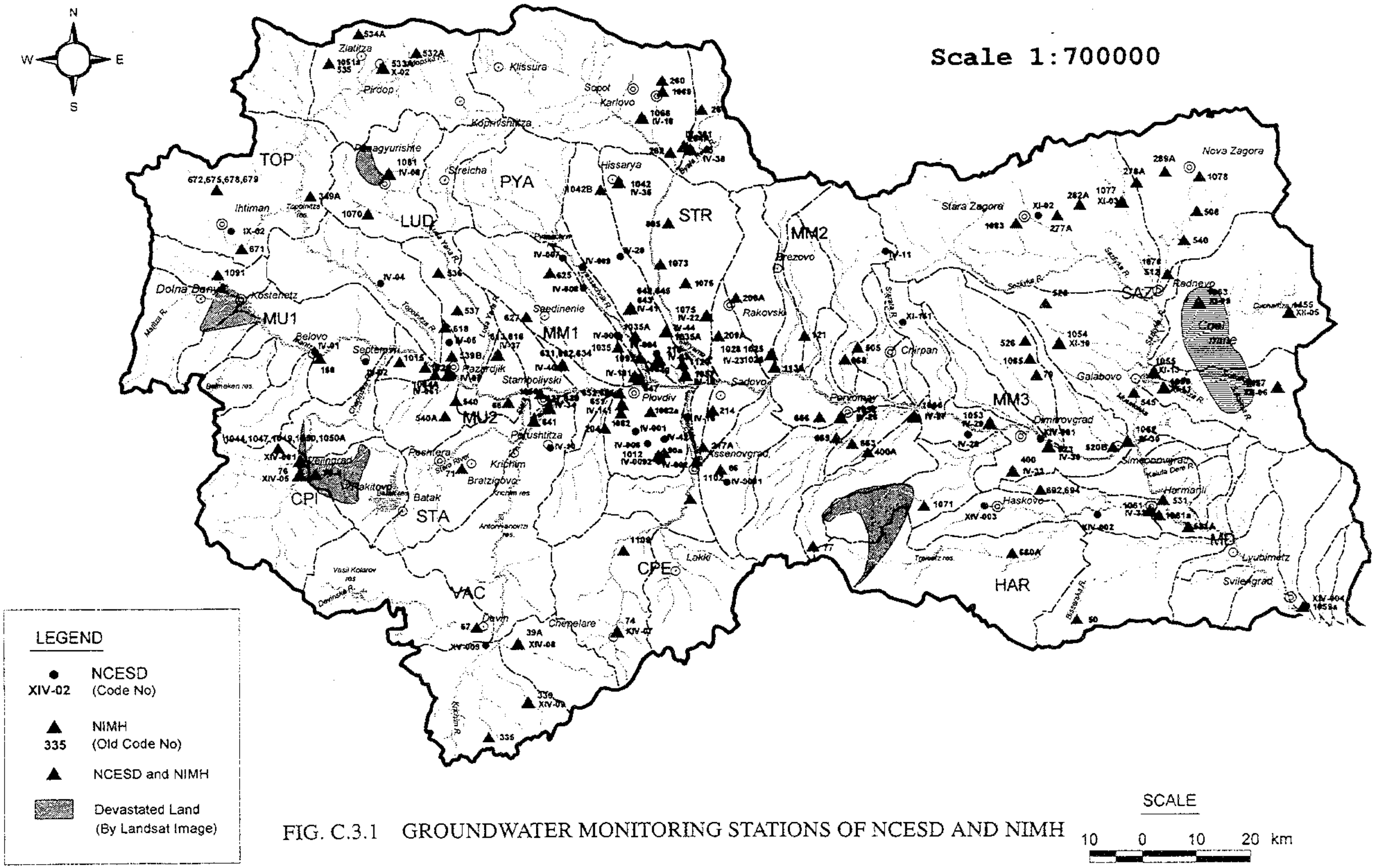


FIG. C.3.1 GROUNDWATER MONITORING STATIONS OF NCESD AND NIMH

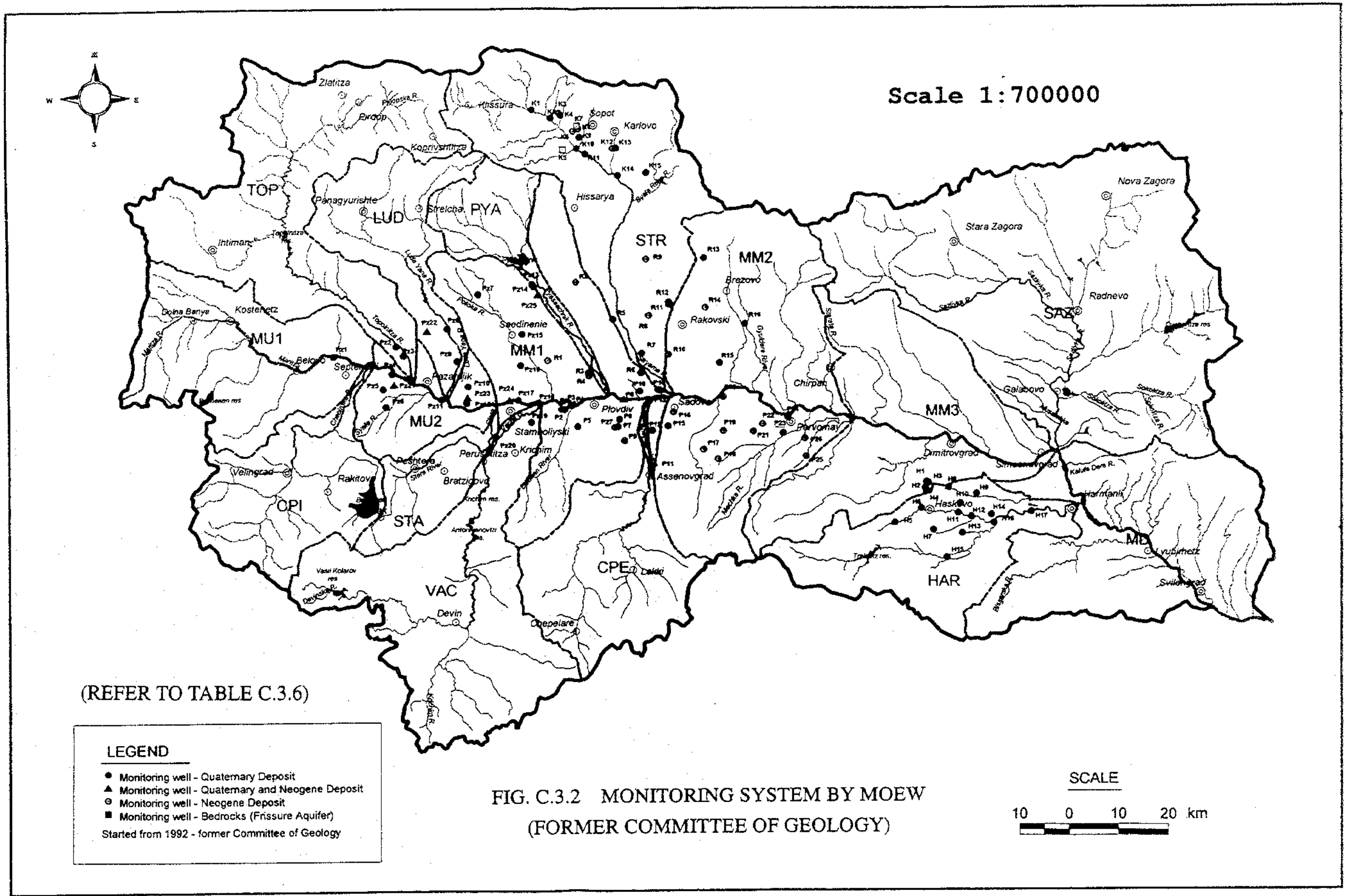
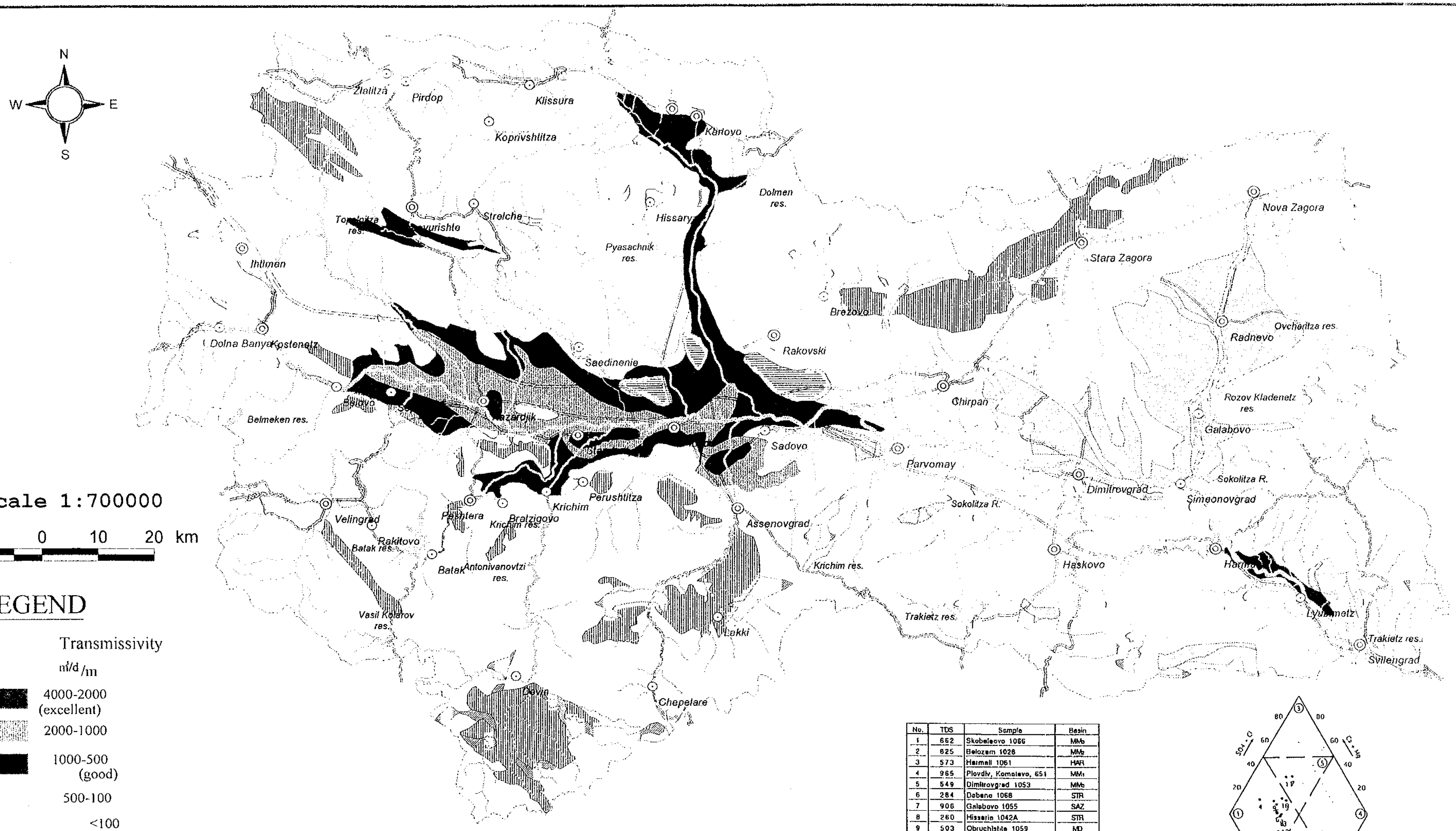


FIG. C.3.2 MONITORING SYSTEM BY MOEW
(FORMER COMMITTEE OF GEOLOGY)



Scale 1:700000

10 0 10 20 km

LEGEND

Transmissivity

m³/d/m

- 4000-2000 (excellent)
- 2000-1000
- 1000-500 (good)
- 500-100
- <100 (bad)
- High Mineralized Water
- Groundwater is used as spring water
- Exposure of coal bearing sandstone (possibility of bad water quality)
- Exposure of carbonate rocks (possibility of hard water)

FIG.C.3.3 DISTRIBUTION OF TRANSMISSIVITY

No.	TDS	Sample	Basin
1	662	Skobeleovo 1066	MM_5
2	625	Belozem 1028	MM_2
3	573	Harmali 1061	HAR
4	965	Plovdiv, Komatevo, 651	MM_1
5	549	Dimitrovgrad 1053	MM_5
6	284	Dabene 1068	STR
7	906	Galabovo 1055	SAZ
8	260	Hissaria 1042A	STR
9	503	Obruchishte 1059	MD
10	417	Panegyurishte 1081	LUD
11	705	Pazardjik 1084a	MU_2
12	544	Plovdiv, East, 1082g	MM_1
13	569	Parvomai 1052	MM_2

Data from NIMH

Groundwater Qunlity Type

1. Unconfined aquifer
2. Confined aquifer
3. Mineralized water
   Volcanic water
   Karst aquifer
4. Sea water, Fossile water
5. Intermediate water

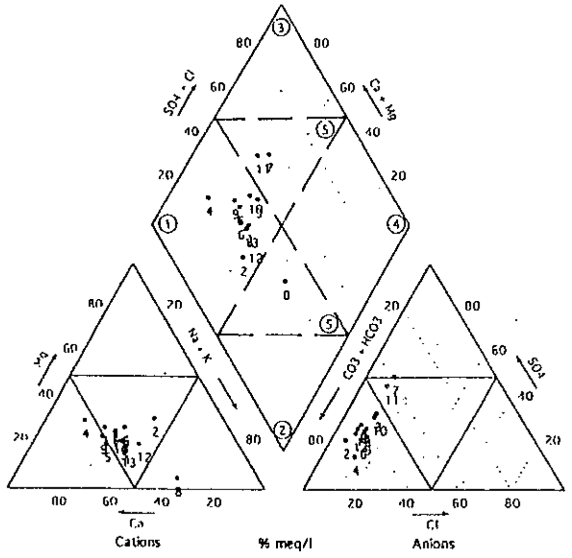


FIG.C.3.3 DISTRIBUTION OF TRANSMISSIVITY

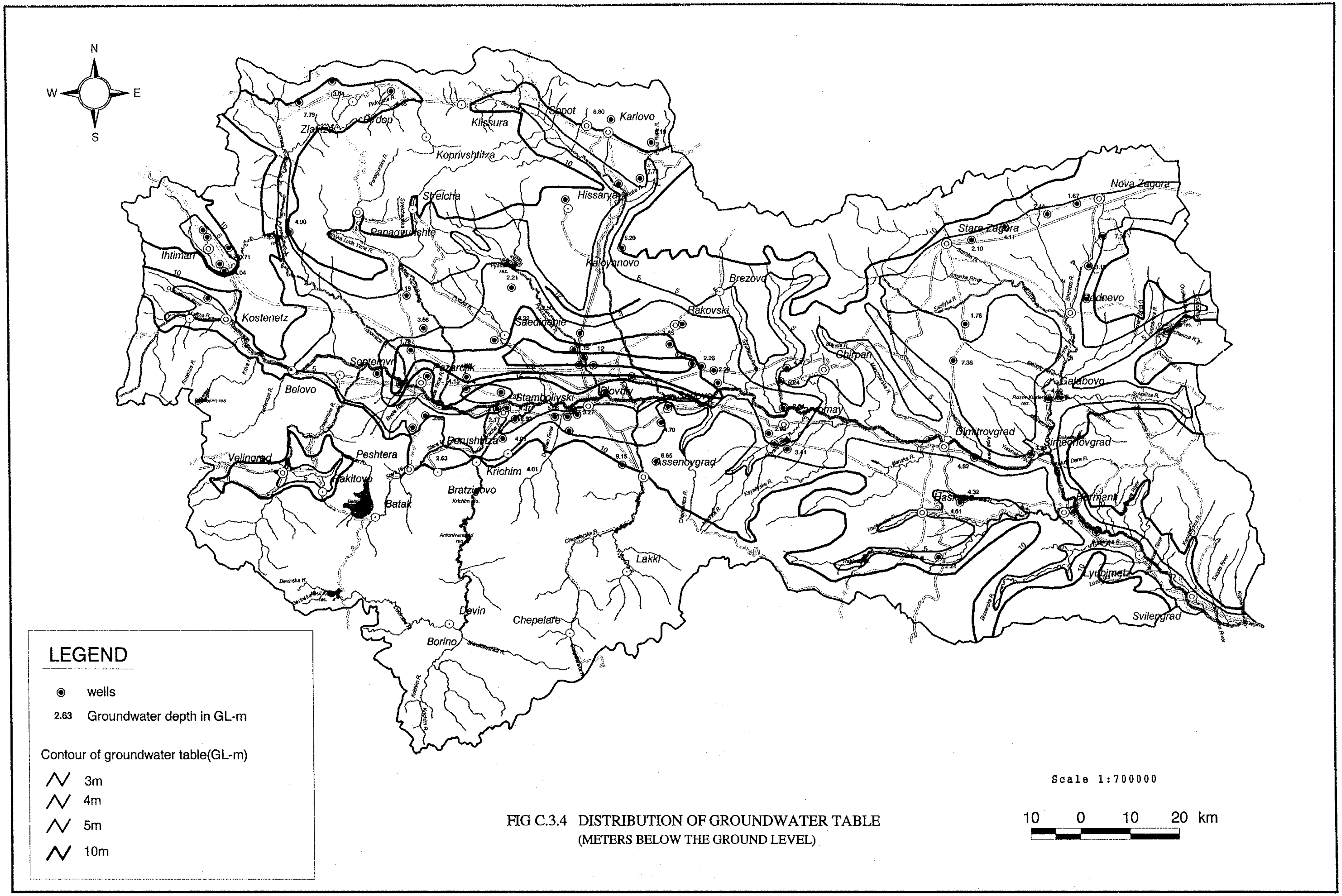
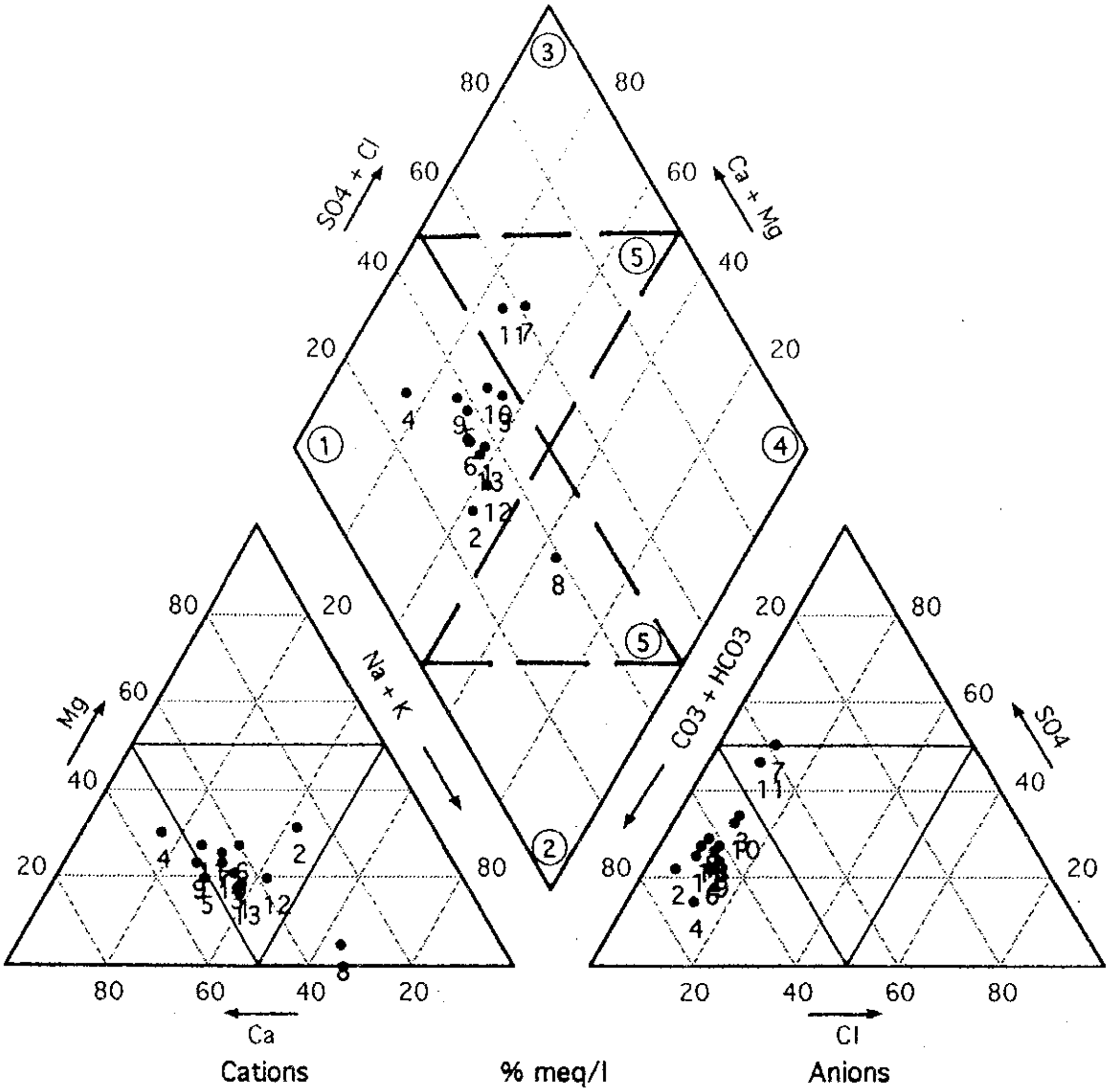


FIG C.3.4 DISTRIBUTION OF GROUNDWATER TABLE
(METERS BELOW THE GROUND LEVEL)



No.	TDS	Sample	Basin
1	662	Skobeleovo 1066	MM3
2	825	Belozem 1028	MM2
3	573	Harmali 1061	HAR
4	965	Plovdiv, Komatevo, 651	MM1
5	549	Dimitrovgrad 1053	MM3
6	284	Dabene 1068	STR
7	906	Galabovo 1055	SAZ
8	260	Hissaria 1042A	STR
9	503	Obruchishte 1059	MD
10	417	Panagyurishte 1081	LUD
11	705	Pazardjik 1084a	MU2
12	544	Plovdiv, East, 1082g	MM1
13	569	Parvomai 1052	MM2

Groundwater Quality Type

1. Unconfined aquifer
2. Confined aquifer
3. Mineralized water
   Volcanic water
   Karst aquifer
4. Sea water, Fossile water
5. Internediate water

FIG.C.3.5 TRILINAR DIAGRAM (NIMH)