Effects of geological factors on urban planning: An example from the Termal settlement, Turkey

BAHAR DEREN GOCMEZ[1], NEVIN CEKIRGE[2] & MAHIR VARDAR[3]

[1] *Istanbul Technical University, Faculity of Mines, Department of Applied Geology. (e-mail: baharderen@yahoo.com)*
[2] *Istanbul Technical University, Faculity of Mines, Department of Applied Geology. (e-mail: cekirgen@itu.edu.tr)*
[3] *Istanbul Technical University, Faculity of Mines, Department of Applied Geology. (e-mail: vardar@itu.edu.tr)*

Abstract: The subject of this study is an examination of the geoscience data for the Termal settlement as an input to urban planning decisions. Termal is a district of the Yalova province, which is located at the southeast of the Marmara Region, Turkey. Thermal sources, which have meteoric origin, and the Gökçe dam, with its reservoir area, are the most important elements of the settlement with repsect to urban planning especially when it is considered that the existence of the settlement has been linked to the hot water sources of the area throughout its history.

Since the 1970s, preservation areas have been identified by planning decisions in order to maintain and preserve the Gökçe dam and hot-water sources of the Termal settlement according to sustainable planning principles. Termal settlement sustainability evaluation data, dated 2002, the result of seismic, geological, morphological, hydrogeological and disaster condition researches have been taken into consideration for this study.

As a result of literature searches, for the topics mentioned above, two plans have been created in this study. In the first step, geoscience data have been applied on the present plan of the settlement; subsequently, the study area was classified into four areas: areas which are appropriate for settlement, areas which have specific settlement conditions, areas suggested to have an active green function and areas suggested to have a passive green function.

Additionally, questionnaire research was carried out with visitors to the thermal sources. Results of the questionnaire, which defines inadequate green areas in the settlement, supports the green system of the suggested plan.

This paper demonstrates that considering geoscience data as an input to planning studies is required for both understanding human needs and maintaining sustainable development.

Résumé: Le sujet de cet etude est l'examin des donnees geologiques qui seront la base de la decision sur la planification urbain du bourg Termal situe dans le province de Yalova ville situee au sud est de la region Marmara. Les sources thermales d'origine meteoriqueet le barrage Gökçe avec son reservoir sont Les plus importants elements du bourg du point de vue du plannig urbain particulierement en considerant que l'existence de ce bourg a ete toujours associee aux Eaux chaudes thermales de la region.

Depuis les annees 1970 les regions de presarvation ont ete identifies par les decisions de plannig pour maintenir et preserver le barrage Gökçe et les sources d'eau chaude du Bourg Termal selon lesprincipes de plannig durable. Les donnees datees de 2002 obtenues par des etudes de recherches sismiques, geologiques, morphologiques, hydrogeologiques et conditions de desastre ont ete considere dans cet etude.

Ala suite des recherches mentionnees ci-dessus, deux plans ont ete adoptes : Premierement les donnees geoscientifiques ont ete appliquees sur le plan actuel du bourg Par la suite la region etudiee a ete clasifiee en quatre regions : Regions appropies pour l'etablissement,regions qui ont des conditions speciales pour l'etablissement, regions d'espaces verts actifs, region d'espaces verts passifs.

D'autre part une enquete a ete faite parmi les visiteurs des sources thermales et les resultatsont montre que les espaces verts actuels sont inadequat ce qui soutient le systeme vert du plan suggere par nos recherches.

Cet etude demontre que la consideration des donnees geoscientifiques pour por les etudes du plannig est indispensable la comprehension des besoins humains et pour maintenir un developpement durable.

Keywords: Geodata, Geology of cities, land use, urban geosciences, thermal waters.

INTRODUCTION

In urban development, from land use decisions to planning decisions from the block scale to the plot scale, the geological environmental factors must be analysed, their effects must be evaluated and the required measures must be taken in good time.

Urban planning is the formal or functional arrangement of the physical environment people live in. It is defined as the organization of the design, resourcing, equipping, infrastructure and production work made for this purpose. Within the conception of planning; spatial developments are designed to meet the social and economic requirements of the people.

Since it is oriented by data from various fields, planning is comprised of studies carried out by different disciplines coming together to work in coordination. Especially at the stage where sources are scanned and data is collected to form the basis of planning and also when planning orientation decisions regarding these sources and data are made, a number of experts will be jointly present. For example; geological engineers shall provide the geological data to be used in land evaluation and analysis work.

Urban geology covers all geological knowledge required for urban planning. In this context, geological data is presented to planners in a format that may be utilized in urban planning.

In this study the relations between urban geology and urban planning are taken into account from the perspective of settlements. In this context, the effects of geological (and hydrogeological) factors on planning are explored and the results are discussed based on the example of the Yalova Termal settlement.

THE RELATIONSHIP BETWEEN URBAN PLANNING AND URBAN GEOLOGY

The main aim of each scale of planning is to relate the problem of shelter, which stems from the increase in population, which in turn follows from socio-demographical growth, to necessary areas of equipment so that the community may continue to exist in a healthy environment. Within the scope of this aim, the problem of shelter in urban planning is solved by the use of land.

In the planning of land; the following parameters are the planning criteria: the present use of land, forest areas, agricultural areas, marshland, and landslide areas. To make decisions regarding the potential uses of land in the future, the present condition of the land and the limiting-potential qualities in terms of planning must be carefully scrutinized.

For planning on the national, regional or urban scale, the decision regarding the choice of location and settlement should be made by taking into view research made on the physical and socio-economical environment. Under the natural environment data heading, the geological data scrutinized at the analysis stage of planning researches the physical characteristics of the land that will be planned as an urban area. Geological research not only influences cities spatially but also economically.

From land use decisions in urban development, to decisions regarding the choice of location at the block or plot scales, the geological environmental factors must be researched, their effects must be evaluated and the necessary measures must be taken. Yet in today's urbanisation process, although events like landslides, floods, earthquakes, collapses of building stress the importance of geology, they only attract attention once they have occurred. The most significant reason for this is the fact that the restricting and delimiting effects of the geological environment in urban planning have not been researched, assessed and reflected in plans. We come across these events in all our larger cities including stanbul, a metropolitan city.

Both regional and local, development is a dynamic and active concept. Natural sources are required to provide for regional or local development. To sustain the dynamic of development and for sustainable development, the use of natural resources (both subterranean and aboveground), of which reserves can be calculated, must be balanced. In planning work, the potential and restrictive criteria of land must be researched and assessed geologically by relevant disciplines. For example, both subterranean and aboveground resources (mines and ores, streams, ground waters) carry potential for regional development. For the optimum use of natural resources in regional planning all subterranean and aboveground characteristics must be examined. At this stage, in the research and assessment of geological data, the science of geology and planning work jointly.

Urban planning requires many disciplines to work together. Professionals such as architects, landscape designers, geologists, geographers, civil servants, sociologists, lawyers etc. work together with urban planners. At every stage of planning the urban planners receive support and views from expert staff in other disciplines. Urban planning is team work. At the decision making stage of planning, when necessary data is accumulated and interpreted, experts are included into this study group. Urban planners play an effective role in the use and interpretation of the accumulated data for planning. They execute the planning work in view of the received data.

THE LOCATION OF THE YALOVA TERMAL SETTLEMENT

Termal district, the area of research, is in the northwest of Turkey, and administratively tied to Yalova province, in the southeast of the Marmara region. The Yalova province is placed on the northern shore of the Armutlu peninsula and on the northern skirts of the Samanlı mountains. Termal district is one of the 5 districts tied to Yalova province. Termal province is in the southwest of the Yalova provincial area (Figure 1).

Figure 1. The geographical location of the research area (MTA).

The Yalova thermal springs is the closest thermal cure settlement to stanbul. The springs are also located in the vicinity of cities such as zmit, Adapazarı and Bursa, all subject to extremely rapid urbanisation, industrialisation and trade development. The springs are in a position to supply for the thermalism and other tourism needs of this region's population (Çekirge, 2004). Besides the natural and cultural resources the Yalova thermal springs possess, they are one of the few settlements that, through air and sea transport over stanbul, have the chance to expand into international tourism. The Yalova thermal springs and their close vicinity are also important from the point of touristical variety. In this region, thermalism (health tourism), Third Age tourism, nature tourism (such as trekking), eco-tourism, hunting tourism (in areas to be defined), cultural tourism, religious tourism, congress tourism and daily recreations that support tourism may be developed (Çekirge, 2004). The physical and chemical attributes of the Yalova thermal springs and the suitable climate of the region create an important natural potential in terms of health tourism. Besides, the area's proximity to the Marmara Sea shall make it possible to practice thermal cure and sea cure simultaneously and give the region advantage over the competition.

Table 1. Professional relations on the planning process (Turner and Coffman, 1973).

PROFESSIONAL INTERRELATIONSHIP DURING THE PLANNING

Primary Interrelationship
Secondary Interrelationship
No Interrelationship

Major Study Groups	Typical Study Topics	Geologists	Geographers	Civil Engineers	Sanitary Engineers	Architects	Landscape Architects	Planners	Recreation Planners	Conservationists	Lawyers	Public Administrators	Sociologists
Regional Economy	Economic Base		S					P	S		S	P	
	Resource Potential	P	S	S		S	S	S	S	S	S	S	S
Regional Population	Population Studies				S			P	S				S
	Socio-economic Studies							S	P	S	S	S	P
Transportation	Transport Facilities	P	S	P		S	S	P		P		S	
	Public Transport	S		P		S		P			S	S	
	Parking Facilities	S		P		S	S	P		S		S	
Natural Environment and Public Utilities	Natural Resources	P	P	P	S		S	P	S	P			
	Hazard Protection	P		P	S			S		S		S	
	Land Reclamation	P	S	P	P			S		P	S	S	
	Public Utilies	P		P	P			P			S	P	
Community Facilities	Schools, Libraries	S		S		P	S	P				P	P
	Police and Fire			S				P		S	P	P	S
	Parks, Recreation	S	S	S		S	P	P	P	P		P	S
Land Use	General Plans	S	S	P	S		P	P	S	P			S
	Neighborhood Plans	S	S	P	S	S	P	P	S	S			P
	Commercial Developments	S	S	S	S	P	S	S		S	S		
	Industrial Developments	S	S	S	S	P	S	S		S	S		
Housing and Public Buildings	Private Dwellings	S			S	P	S	S				S	S
	Public Buildings	S		S		P	P	S	S			P	
Aesthetics	History, Cultural Values	S	S			P	P	P	P	P			P
	Community Improvement	S		P	S	P	P	P	S	P		P	S
	Legislative Controls				S	S	S	S				P	P
Administration and Legislation	Legislation		S					S		S	P	P	P
	Adminisration							P	S		P	P	S
Finance	Capital Improvements			S				P	S		P	P	
	Federal-aid Programs			P	S	S		P		S	P	P	
Other Planning Studies	Defining Goals	S		P		P	P	P	P	P	S	S	P
	Urban Renewal Programs	S		P	S	P	P	P	P	P	P	P	P
	Waste Disposal	P		P	P			S	S	P		S	
	Public Health	S		S	P			S	S			P	S
	Civil Defence	S		S				S				P	

THE HISTORICAL DEVELOPMENT OF YALOVA THERMAL SPRINGS

In 2000 B.C., in the area where the Yalova thermal springs are situated, there lived an Asian tribe that worshipped stones and the earth. The hot water and steam gushing from a crack in the geological faultline drew the attention of this community (Akan, 2003). In order to benefit from the invigorating and health-giving properties of the hot water, the Greeks, the Phoenicians and the Romans built the systems that are still in use today to protect, preserve and use the thermal water (Özer et al, 1981).

After Helena, the Byzantine King Constantine's mother, who had contracted leprosy was cured at the Yalova thermal springs, the Byzantines opened this thermal spring to public use with its palaces and baths. The building of the baths and mineral-water springs have been traced back to the reigns of Justinian I and Justinian II. The region was left in ruins due to wars that lasted from the 9th to the 13th century.

The Yalova thermal springs regained their importance in the Ottoman era and new buildings were added during the reign of Sultan Abdülmecid. In the Republic era, Atatürk visited the Yalova thermal springs in 1929 and ordered Yalova to be redeveloped as an exemplary European Thermal Water Town. For this aim, urban planning experts who had worked on the urban planning of Paris were invited to Yalova and the first Thermal Settlement projects of Turkey were designed by them (Göçmez 2005).

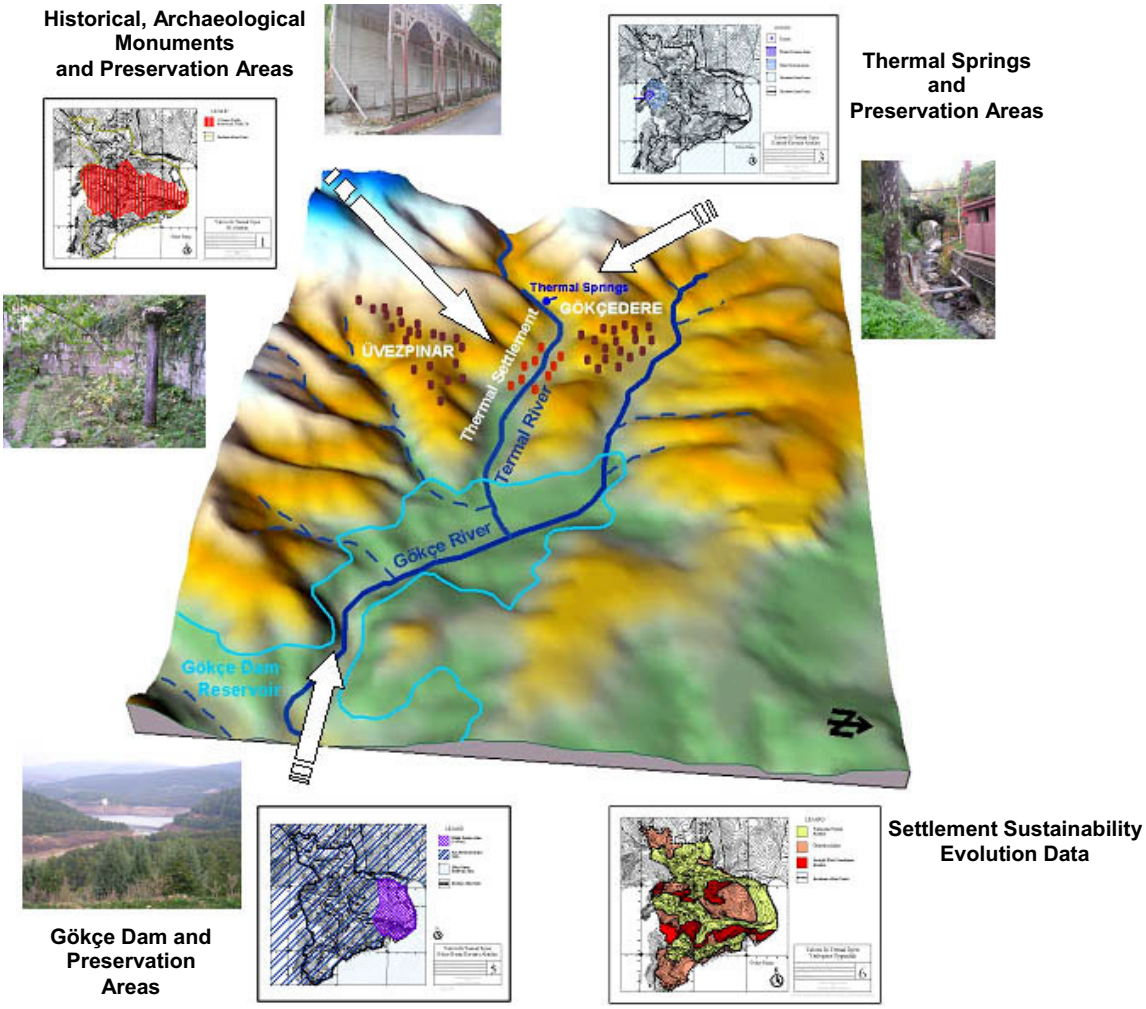

Figure 2. Urban geological data and preservation areas of Yalova Termal settlement.

Both for its value as a natural resource and also for the archeological and historical value it carries due to the presence of different civilizations throughout history, the Yalova thermal springs were granted the status of first degree preservation area in 1996 by the Culture Ministry of the Turkish Republic. For all building and infrastructure to be carried out within the preservation area the Ministry must be consulted (Figure 2).

GEOLOGICAL FACTORS

The investigation area and its vicinity can be divided three basic stratigraphical groups. The fisrt group is represented by Paleozoic schists, phyllites, greywacke and schists at the base level. These units are overlapped by the Carboniferous- Permian marbles.

The second group is comprised of dark green, yellow, brown andesitic lava, tuff with small rough grains, agglomerates, medium thick layered volcanic sandstone and tuff, lava and gravel lithologies as interbeded levels. The conglomerate is composed of angular quartz gravel, the percentage of cement is low and it has a grainy structure. The claystone contains sand and gravel, quartz grains, limestone concretion and clay. The limestone contains nummulites, quartz grains and is of the composed stone variety. The plastic conglomerates are comprised of andesitic tuff and conglomerate pieces within fine or rough grains of tuff and lapilli. At some levels there are large andesitic blocks, conglomerate and material akin to beach gravel. Lava effluence with a thickness of 5 cm followed by pyroclastic conglomerates is placed in composures. The lava effluence is comprised of plagioclase, pyroxene and andesitic volcanic conglomerates containing hornblend phenocrystalls. The tuff is placed within a glasslike paste and contains volcanic glass and volcanic conglomerate pieces with a fluid texture. Normal or symmetrically graded lahar sediments formed by watery plastic fluxes scrape the pyroclastic sediment surfaces and form heavily irregular incontinuity planes. The basalt dikes observed at the upper levels interrupt this group. The age of this group is Eocene (Lutetian).

The first detailed study in the area was made by Akartuna (1968) and tuff, lava and agglomerates are placed on the lower flysch layer from the Paleocene-Eocene epoch.

Bargu and Sakınç (1987) who conducted geological studies in the area defined the sedimentation environment of the volcano–sedimentary composure as a shallow sea that deepens only very slightly. They also indicate that the area became land in the Oligocene epoch following the Late Eocene. High degrees of alterations have incurred on the pyroclastic rocks, of these composed volcano-sedimentary structures that thicken in some areas. Alteration may be

observed in the tuffs with andesitic, dasitic, and partly rhyodasitic compositions. The lava is basaltic but generally of the andesite variety. Spherical disintegration is also observed in the breccia and the agglomerates.

The last group is reperesented by Neogene conglomerates, marl and limestones. Also, Quaternary alluvium are observed as a actual deposites in the studied area (Figure 3).

The main fault directions are NE to SW and NW to SE. Thermal water circulated along the discontinuities of the andesitic rocks and Paleozoic marbles.

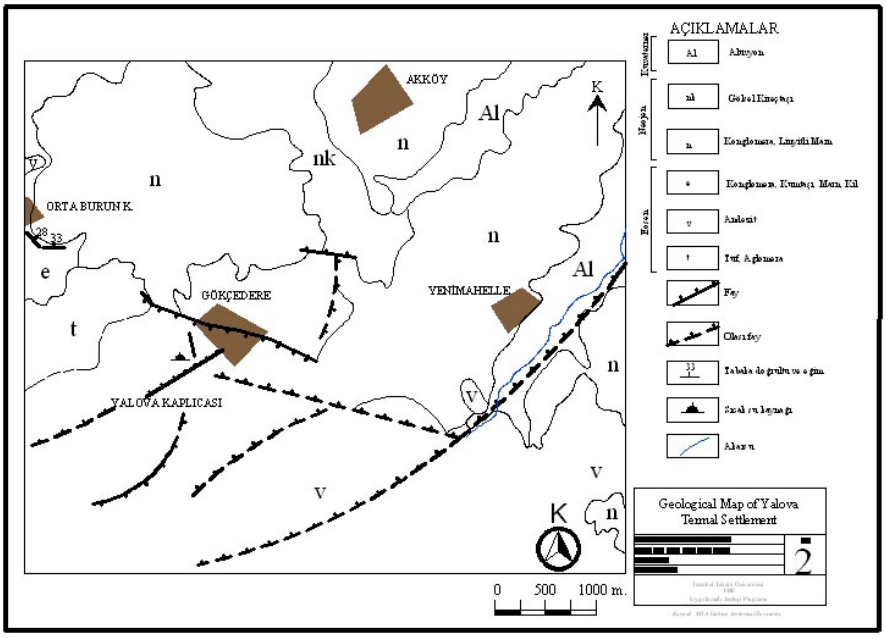

Figure 3. Geological map of Yalova Termal Settlement (Erişen et al,1996).

HYDROLOGICAL AND HYDROGEOLOGICAL FACTORS

Rivers

Within the area of study there is also the İsmail (Termal) river which flows in a southwesternly direction. There are also dry brooks that gain flow seasonally depending on the topography and morphology of the region.

The Condition of Ground Waters

The dominant units surfacing in the study area are andesites of the Eocene period. The andesite is generally impermeable. Influenced by the tectonic activity in the area, the unit has taken on incontinuous structural characteristics and has secondary permeability. In addition to this, the Neocene Quarternary aged conglomerates and lacustral limestone compose the permeable units which are seen at the surface of the study area.

When these two states are taken into account, the area is comprised of volcanic units with low permeability and weak aquifer characteristics and sediments of the Neocene Quarternary period with abundant aquifer characteristics. The direction of the subterranean waterflow is from southwest to northeast.

Springs

Many hot water springs reach the surface on the thermal river. Of these sources, the one with the higher output flow has been captaged. The spring that has been captaged is redirected to baths, hotels and motels for use.

2 weeks before the earthquake on 17 August 1999, from a fracture in the faultline zone where the thermal sources are, a new spring of the same heat and with an output flow of 1lt/sn appeared. The water discharge from this spring continues.

The origin of the thermal springs

The Yalova Termal spring water has vadose water characteristics. During filtering and storage the water heats up with the geothermal gradient effect and rises to the surface with the help of the incontinuous planes of the land. The springs are surfaced with the faultlines and fractures within the volcanic conglomerates (Ünalp, 1994).

The Yalova Termal hot water springs are of meteoric origin and they reach the surface with the help of deep faultlines. The mineral content of the hot water springs varies depending on the chemical characteristics of the conglomerates through which precipitation is filtered.

Physical and chemical characteristics

The total output flow of the thermal springs that rise through the faultlines and fractures that run along the thermal river is approximately 20 lt/sec and their temperature is between 49° C and 66° C. The chemical characteristics of the springs resemble each other yet there are differences in terms of their radioactive properties. Their common characteristics are the presence of sulphates, sodium, calcium and floride and they are all hyperthermal and hypotonic. Their total mineralization is approximately 1400 mg/lt .

PRESERVATION AREAS

Water sources are a component of the natural environment which must be preserved with a sense of planning and development that aims for harmony between human beings and nature and then handed down to future generations. Sustainability must be accounted for in the planning stage of the water resources and the planning criteria, limits, potential, purpose and targets must be assembled within this approach.

Within the research area, Yalova Termal spring settlement, there are the hot water springs, mineral water springs and the dam that has been built to supply water. Within the frame of sustainability, the preservation areas of these two natural sources have been defined and the boundaries have been drawn. In the decision making for the planning of the settlement, the preservation areas must be protected and the regulations regarding construction for the preservation areas must be respected.

Hot Water Springs Preservation Areas

The physical and chemical characteristics, the water quality and the natural output flow of the sources which create a great potential for the settlements must be maintained and preserved. For this reason, in planning work water sources must be assessed as part of the preservation approach. By an examination of the source and its close environment the 1st, 2nd and 3rd degree preservation areas are determined. Yalova Thermal Springs are located to the west of the thermal spring settlement and along the thermal river. The preservation areas are shown on the map with elliptic curves. Within the 1st degree preservation area the spring and its environment is protected against all manners of pollution and construction and roadwork are not permitted. Within the 2nd degree preservation area environmental planning is allowed and present buildings are protected insofar as necessary measures are taken against the pollution of the environment. The 3rd preservation area is outside the settlement area (Figure 2).

Dam Preservation Areas

The Yalova Gökçe Dam was built in order to provide drinking and potable water for the Yalova Çınarcık – Karamürsel strip (DSİ, www.dsi.gov.tr). The dam preservation areas to protect the water accumulating in the Gökçe Dam and its reservoir and the subterranean and terrestrial water sources against pollution have been determined. The preservation areas are divided into four categories, the peremptory preservation area, the short distance preservation area, the middle distance preservation area and the long distance preservation area. The Yalova thermal settlement area is within the peremptory and short distance preservation areas. There is a construction restriction for the area within this preservation area and no activity that might pollute the dam water is allowed (Figure 2).

SEISMICITY

Orogenic effects, that have been active since the beginning of the Tertiary period are dense in the Yalova Thermal site. The faults that bring the hot waters of the region to the surface are related to the tectonism of the Miocene and later.

There have been 34 destructive earthquakes in the Marmara Sea area and its vicinity. The earthquakes that caused great damage to Istanbul and within the area of impact are the 557, 989 and 1509 earthquakes (Yaltırak et al, 2003). The most effective fault in view of the seismicity of the study area is the North Anatolian Fault. Following the 1939 Erzincan earthquake, the earthquakes which took place on the North Anatolian Fault, which has a high potential for generating earthquakes, occurred on segments that followed each other toward the west. This situation indicates that, following the earthquakes of Gölcük and Düzce in 1999, the risk for earthquakes in the Marmara Sea and its vicinity has increased.

The Yalova Thermal water springs that have been used since historical times and that were put under preservation by Atatürk's orders were affected by the recent earthquakes. The earthquake risk map of Turkey shows the Yalova Thermal settlement to be in a 1st degree earthquake zone. Therefore the selection for location and the construction process must be carried out in accordance with the Regulations Concerning Construction in Disaster Zones.

THE SETTLEMENT SUSTAINABILITY EVALUATION DATA

The settlement sustainability evaluation data is obligatory for all settlements with building schemes. The necessary procedures regarding planning and building have been defined by the Ministry of Development and Housing following the 17 August Marmara Earthquake (Ministry of Development and Housing, The General Directorate for Disaster Management, 1999).

The settlement sustainability evaluation data carried out for the Yalova Termal settlement covers seismicity, geological, morphological and hydrogeological state and disaster state studies carried out by geological engineers.

With the help of parameters determined according to land and office work the suitability for housing assessment has been made (Termal Municipality-Zetaş AŞ, 2002).

There are appropriate for settlement, restricted areas and areas that require detailed geological research within the research area selected from within the Yalova Termal settlement. The areas not suitable for housing are outside the boundaries of the research area (Figure4).

The assessments show that the areas appropriate for settlement are those with a slope gradient of less than 20 %. In accordance with the calculated surface safety stress, construction up to three floors may be permitted. The restricted areas are those with slope gradients of 20-40 %. The fracture and rift systems on the study area carry a risk for ground water and disintegration zone foundation excavations. The buildings must be 2 or 3 floors high and must be arranged in detached organizations. The areas where the study area is steeper than 40 % are the areas that require detailed geological study. In these areas there are mass movements of creep form and a potential risk of landslide. Therefore these areas must be designed as recreation areas in planning. Housing may only be permitted following detailed geological studies.

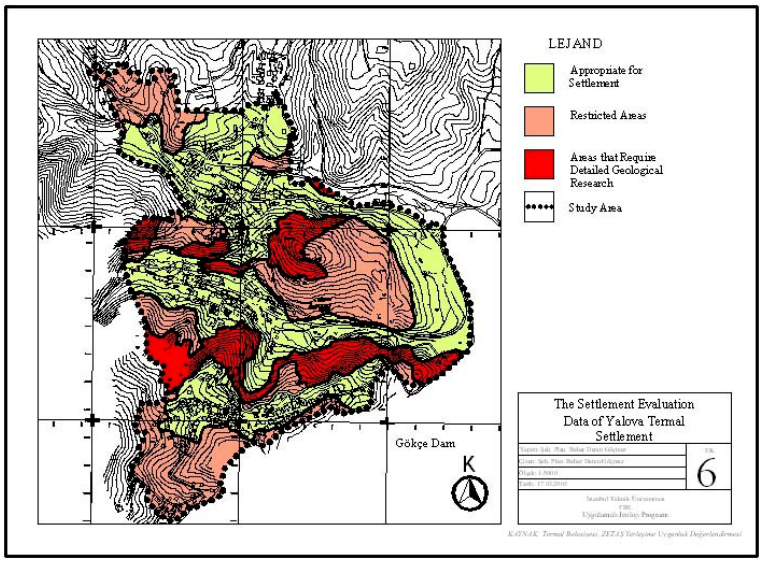

Figure 4. The settlement sustainability evaluation data

CONCLUSIONS AND PROPOSALS

A questionnaire was carried out to help the orientation of and to build a database for the planning activities in the Termal district of the Yalova province (Göçmez and Cekirge, 2005). The socio-economical characteristics of the users, the aim of use of the springs and the frequency of use and also the level of satisfaction of the springs was researched. According to the results of the questionnaire, the visitors to Yalova Termal settlement and springs come from Yalova and surrounding provinces, mainly from Istanbul, seeking cures and recreation. It has been clearly proven that the accomodation facilities and the green areas the region presently has do not meet the requirements of the visitors. In the proposals study, the results of the , and the present criteria, were taken into account. The planning of green areas has been given priority and the areas that are not inconvenient for the building of accommodation units have been defined. The proposed

The proposals synthesis map to be used in the Yalova Termal Settlement's planning work has been shaped by taking into account the geological and hydrogeological factors that affect urban planning (Göçmez, 2005). In this map, the development areas of the Yalova Termal settlement have been shown as the areas that are geologically convenient for the planning of urban functions and as areas appropriate for settlement. In accomodation areas the spring and settlement requirements must be planned appropriately for settlement. The accomodation facilities must be placed in those areas deemed to be appropriate for settlement following the required feasibility studies, preferably in the vicinity of the springs and the city center. Another area indicated in the proposals map is the area in which there are specific settlement conditions. These areas have been defined as geologically restricted areas. The restricted areas are areas where construction is limited, there is a limit to the floors to be built and detached planning is obligatory.

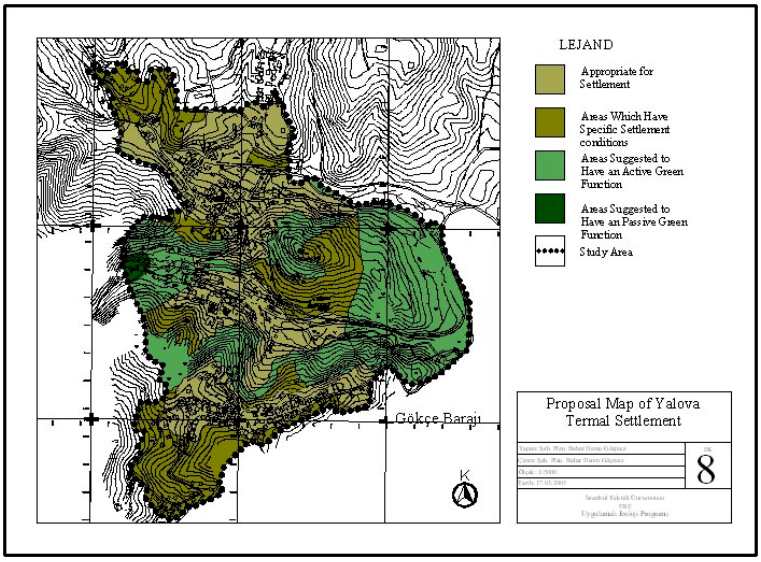

Figure 5. Proposal map of Yalova Termal Settlement (Göçmez, 2005).

The areas which are to be planned as passive green areas, in concordance with the structuring conditions determined for thermal spring preservation sites, have been shown in the proposal map. The first source preservation site will be arranged as a passive green area, in view of the restrictions that have been brought. No construction, vehicle passageway nor pedestrian route shall be allowed in this area. The land in these areas shall be planted with trees with roots that shall not harm the spring or its source and that shall not require manuring.

Another application shown in the proposal map is the area that shall be arranged as active green area. This area is formed by the spring and dam preservation sites' preservation strips and the creation of recreation areas without structuring is permitted. The vehicle areas should be isolated, and all pedestrian area planning and all units that are used in active green areas may be situated in these areas. The results derived from the questionnaire presented to the visitors of the springs indicates the need for the planning of green areas in the Yalova Termal settlement. The landscape planning must be carried out keeping in view the user profile and the use interval of these green areas which are used perennially.

Acknowledgements: The writers would like to acknowledge the contribution of Gokhan Sans, who created the 3D model of urban geological datas and preservation areas and helped to prepare geological data.

Corresponding author: Miss Bahar Deren Gocmez, Istanbul Technical University, Faculty of Mines, Department of Applied Geology, Ayazaga Kampusu, Istanbul, 34, Turkey. Tel: +90 212 245 99 00. Email: baharderen@yahoo.com.

REFERENCES

AKAN, A., 2003, Her yönüyle Termal ilçesi, *Emek Ofset Matbaa, Yalova,* 6-22 (In Turkish).

AKARTUNA, M., 1968, Armutlu yarımadasının jeolojisi, İstanbul Üniv. *Fen Fakültesi Monografileri,* 20, 42-58 (In Turkish).

BARGU, S., SAKINÇ M., 1987, Armutlu yarımadasında Kretase Paleosen ilişki, *Türkiye Jeoloji Bülteni,* 30, 41,48 (In Turkish).

ÇEKİRGE, N.,2004a, Yalova Termal Su Şehri, Yalova Kent Planlaması Ön Değerlendirme Raporu, *Yalova Belediyesi,* 52-61 (In Turkish).

ÇEKİRGE, N., 2004b, Şehir ve Çevre Jeolojisi Dersi Notları, İ.T.Ü. Maden Fak., *İstanbul* (In Turkish).

ERİŞEN B. et al, 1996, Türkiye Jeotermal Envanteri, *MTA Genel Müdürlüğü, Ankara* (In Turkish).

GÖÇMEZ, B. D., ÇEKİRGE N., 2005, Kentsel jeoloji kentsel planlama ilişkileri: Yalova Termal yerleşmesi örneği, *Dünya Şehircilik Günü 29. Kolokyumu, İstanbul* (In Turkish).

GÖÇMEZ, B. D, 2005. Jeolojik faktörlerin kentsel planlamaya etkisi : Yalova Termal yerleşmesi örneği, *Yüksek Lisans Tezi, İ.T.Ü. Fen Bilimleri Enstitüsü, İstanbul* (In Turkish).

ÖZER, N. et al, 1981. Yalova kaplıcalarının tarihsel gelişimi, doğal özellikleri, tıbbi değerlendirilmesi, *İstanbul Üniversitesi İstanbul Tıp Fakültesi Tıbbi Ekoloji ve Hidroklimatoloji Bölümü, İstanbul* (In Turkish).

TERMAL BELEDİYESİ, ZETAŞ AŞ., 2002. İmar planına esas jeolojik ve jeoteknik etüd raporu, *İstanbul, Türkiye.*

TURNER and COFFMAN, 1973. Geology for planning: A review of envirenmental geology, *Quarterly of the Colorado School of Mines,* 68(3).

ÜNALP D. 1994, Yalova ve Armutlu kaplıcaları dolayının hidrojeolojisi ve sıcak su kaynaklarının kökenlerinin araştırılması, *Yüksek Lisans Tezi, İ.T.Ü. Fen Bilimleri Enstitüsü, İstanbul* (In Turkish).

YALTIRAK, C., ERTURAÇ, M. K., TÜYSÜZ, O., YALTIRAK, S. K., 2003. Marmara Denizi'nde tarihsel depremler: yerleri, büyüklükleri, etki alanları ve güncel kırılma olasılıkları, *Kuvaterner Çalıştayı IV, İstanbul*, 174-180 (In Turkish).

DSI (1999). www.dsi.gov.tr

Ministry of Davelopment and Housing (1999). www.mta.gov.tr