NUCLEAR POWER PLANT AKKUYU

Basic report for «Akkuyu» NPPsite

Units 1, 2, 3, 4

AKU.C.010.&.&&&&&.&&&&.002.HC.0004

Revision 1

Moscow,

May 2013

General Director of AKKUYU NPP JSC

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« 17 » 05 2013

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Volume 1

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AKKUYU NPP POWER GENERATION JOINT STOCK COMPANY

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PLANNING AND DESIGN BRANCH JSC "CONCERN ROSENERGOATOM"

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ABBREVIATIONS ACCEPTED

AS	Aerological Station
BOD5	Biological Oxygen Demand
CERC	Coastal Engineering Research Center
CTD	Conductivity, Temperature, Density
DBFL	Design Basis Flood Level
DERINSU	DERINSU Underwater Engineering & Consulting Company
DGPS	Differential Global Positioning System
DL	Design Limit
DO	Dissolved Oxygen
E	East /Easting
ECCS	Emergency Core Cooling System
ECMWF	European Centre for Medium range Weather Forecasts
EF	Efficiency factor
EIA	Environmental Impact Assessment
ENVY	ENVY Energy and Environmental Investments Inc
ESO	Earthquake Source Origin
EUR	The European Utility Requirements For LWR Plants
FA	Fuel Assembly
HAT	Highest Astronomical Tide
HMC	High-Mg calcite
HWL	High water level
IAEA	International Atomic Energy Agency
ISO	International Organization for Standardization
JSC	Joint Stock Company
Akkuyu NPP JSC	Joint Stock Company for power generation of the Akkuyu NPP – the NPP Owner
km	Kilometer
LAT	Lowest Astronomical Tide
LTD	Company with Limited Liability
m	Meter
MB	Multibeam
MDL	Method Detection Limit
MHHW	Mean Higher High Water

mI	iodine molecular form
MLLW	Mean Lower Low Water
MM (MMI)	Modified Mercalli Seismic Intensity Scale
MS	Meteorological Station
MSL	Mean Sea Level
MW	Megawatt
ND	Not Detected
N	North / Northing
NPP	Nuclear Power Plant
OJSC	Open Joint-Stock Company
P-G SC	Pasquill-Gifford Stability Categories
PM	Preventive maintenance
PMT	Probable Maximum Tsunami
PSAR	Preliminary Safety Analysis Report
PWR	Pressurized Water Reactor
RDCP	Recording Doppler Current Profiler
RP	Reactor Plant
RTK	Real Time Kinematic
S	South
SHODB	Navigation, Hydrography, and Oceanography Department of Turkish Navy
SPM	Shore Protection Manual
TAEK	Turkish Atomic Energy Authority(Agency)
TSS	Total Suspended Solids
TWPCR	Turkish Water Pollution and Control Regulation
UPMPZ	Urgent Protection MeasurePlanning Zone
UTC	Universal Time Coordinated
UTM	Universal Transverse Mercator
VVER	Water-to-water Power Reactor
W	West
WD	Water Depth
WGS84	World Geodetic System 84
WLMS	Water Level Measurement Station
WMO	World Meteorological Organization

1. INTRODUCTION

In accordance with the bilateral agreement between the Governments of the Turkish Republic and Russian Federation that was signed on May 12, 2010 [1/1], Project Company "Akkuyu NGS Elektrik Üretim Anonim Şirketi" (the Project Company) was founded to construct, own and operate the proposed Akkuyu NPP. According to the agreement [1/1] the Turkish electricity generation company "Elektrik Üretim Anonim Şirketi" (EÜAŞ) is the owner of the land to be transferred to the Project Company along with the Akkuyu NPP site license issued in 1976.

The Akkuyu site license is a decision issued by the Nuclear Safety Committee of AEK, on 06/30/1976, in response to theapplicationmade by the Turkish Electricity Authority. The license was issued in accordance with the provisions of the Decree "On licensing facilities with nuclear reactor and other nuclear facilities" from 1975.

The technical basis for granting the Akkuyu site license have been included in Site Report № NED-I-16 developed in April 1976 [1/6]. The Site report contains detailed data on the early investigations performed for Akkuyu NPP site.

The Akkuyu NPP Site Report was prepared by the Turkish Electricity Authority. The following organizations, companies and universities had contributed to the preparation of the report:

- Consulting-Engineering Consortium composed by Suiselectra (Switzerland), CAAA (France), Emch and Berger (Switzerland), Basler and Hoffman (Switzerland) for general consultancy.
- Turkish Airforce Headquarters and State Airports Department for investigation on airplane crash hazard.
- Ministry of Tourism, State Planning Organization, Regional Planning Department of Ministry of Reconstruction and Resettlement and iller Bank for population distribution investigations.
- State Institute of Statistics for investigation on land use.
- State Highways Department for investigation on land transportation.
- State Meteorological Department for meteorological investigations.
- State Water Works (DSI) for hydrological investigation.
- Institute for Electrical Surveys (EIEI) for hydrological, geotechnical, geophysical and bathymetric investigations.
- Hydro-biological Research Institute of University of Istanbul for oceanographic investigations.
- Mining Survey and Research Institute (MTA) for geological investigations.

- Middle East Technical University (METU) for geotechnical investigation and seismic risk analysis.

The main reasons for the selection of Akkuyu as the site for the construction of the first nuclear power plant in Turkey as of 1976 were as follows:

- Due to the necessity of considerable amount of service (cooling) water and land transportation problems of heavy components in Turkey, the plant should be located on a sea coast.
- Site selection studies since 1968 showed that the most critical siting factor in Turkey is the earthquake risk. This part of the Mediterranean Sea coast is considered as one of the safest regions in Turkey with respect to earthquake risk.
- The Akkuyu site and its vicinity is one of the most sparsely populated areas in Turkey and in addition the area was not considered suitable for development of touristic, agricultural or industrial activities.
- Due to the favourable meteorological consitions in this coastal region, the site was expected to have favorable atmospheric dispersion characteristics.
- Tsunami or any other flooding was not deemed to constitute a significant hazard to the plant since the maximal flood level was not expected to be more than 6 meters and the topography of the site was considered suitable for construction at various elevations.
- The direction of natural drainage of surface water and ground water in the Akkuyu site is toward the sea and will most likely not affect the off-site wells.

All the above-listed Akkuyu site's characteristics allow siting a nuclear power plant on its territory

The Turkish Atomic Energy Authority (TAEK) has confirmed the validity of this license and issued the License Validity Conditions for Akkuyu NPP Site License dated 13.10.2011 [1/5] that is an obligatory application for the site license within the Akkuyu NPP project. One of the license validity conditions is to update the information for the site and develop an updated site report.

This Updated Site Report for Akkuyu NPP has been developed on the basis of Article 5 of License Validity Conditions for Akkuyu NPP Site License dated 13.10.2011 [1/5] and the Regulation on Nuclear Power Plant Sites published in Official Gazette No. 27176 dated 21.03.2009 [1/3]. This report includes new information on Akkuyu NPP site taking into account additional results of the first priority engineering surveys performed in 2011 [1/7].

Format and content of this report corresponds to the requirements for the updated site report identified in TAEK letter dated 19.01.2012 [1/9], the Article 9 requirements of the Decree on

Licensing of Nuclear Installations published in Official Gazette No. 18256 dated 19.12.1983 [1/2] and the recommendations of the Guide on Format and Content of the Site Report for Nuclear Power Plants No. GK-GR-01 dated 10.12.2009 [1/4].

Furthermore, in order to better clarify the expectations of TAEK with respect to the Updated Site Report, a meeting was organized at TAEK in February 2012. It was emphasized that the focus of the Updated Site Report will be site acceptability issues (such as fault capability in the site vicinity, feasibility of emergency planning with respect to site conditions etc.). Regarding the site related design basis parameters, the expectation is that the database and methodology would be clearly described however the parameters themselves would be provided to TAEK at a later date and not within the scope of the Updated Site Report.

1.1 PURPOSE OF THE PLANT

In accordance with the intergovernmental agreement [1/1] four NPP power units of AES-2006 design with VVER-1200 (V-509) type reactors shall be constructed on Akkuyu site. The Akkuyu NPP is designated for electrical and thermal power generation, and providing energy security of the region.

The Akkuyu NPP site is located at Mediterranean Sea coast in the Gülnar district of Mersin province, approximately 47 km southwest of the town of Silifke and approximately 140 km southwest of the city of Mersin. The site location is shown in Akkuyu NPP project area map (Figure 1/1).

Total area of the Akkuyu site territory (land area within the enclosure) is about 986 hectares. The NPP layout elevation is approximately at altitude of about 9.5 m, and the elevation of open switchgear structures for connection to the grid system is at at altitude of about 19.5 m [1/8].

Commissioning of Akkuyu NPP units plays a significant role in addressing social, economic and environmental tasks of the Republic of Turkey. It provides additional employment, controls the electricity tariffs rates, sustains a low environmental impact by reducing carbon dioxide emissions and harmful substances generated from burning fossil fuels, and restricts the radiation impact below the permissible limits.

The main social and economic benefits will include creating sustainable conditions to meet the electricity demand of the region and ensure reliable power supply to major consumers.

In addition the scientific potential of the region will be significantly increased. Scientific and educational organizations will participate in supporting the NPP operation and perform staff training not only for the NPP, but also for associated industries.

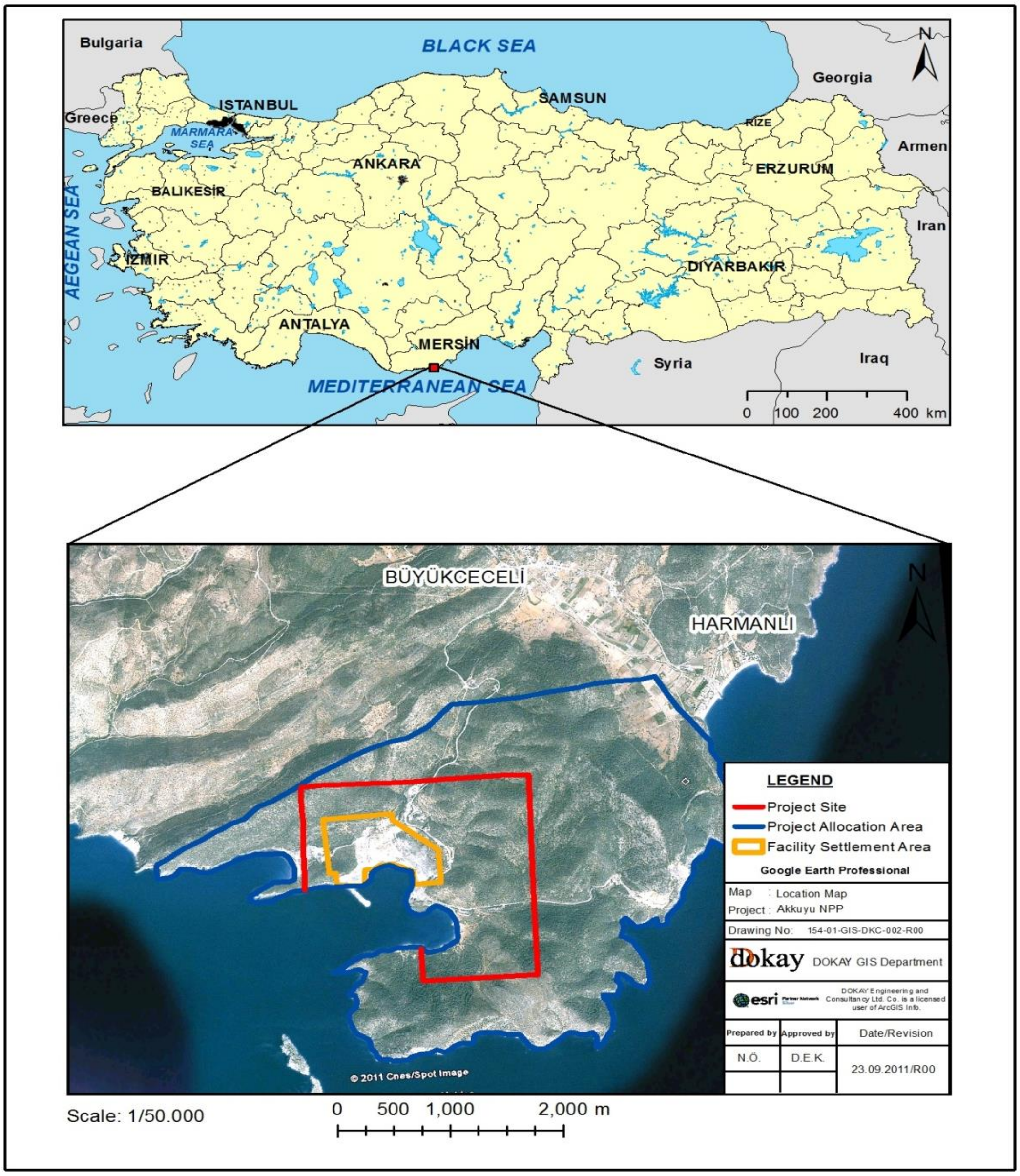


Figure 1/1 – Akkuyu NPP project area map

1.2 APPROXIMATE POWER.

The rated electrical power (base load) of NPP unit is defined as active electrical power that is produced at the generator terminals in nominal conditions.

The expected value of the rated electrical power (gross) for each unit of Akkuyu NPP in nominal conditions (thermal power of the reactor facility 3212 MW and cooling water temperature 20.7 ºC) is approximately 1198 MW. Upon that the electrical power consumed for auxiliaries of each unit of the NPP with account of site needs and service (cooling) water supply consumption is up to 7 % of the generated power [1/8]. Thus, the expected value of the rated electrical power (net) for each unit of Akkuyu NPP in nominal conditions is approximately 1114 MW.

Akkuyu NPP units use direct flow system of service (cooling) water supply with single circulation of Mediterranean Sea water as the ultimate heat sink. At a cooling water temperature of 25 ºC the cooling water flow to the turbine condensators of each unit of the NPP is about 200160 m^3/h. Total flow of cooling water to the turbine condensators with account for auxiliary equipment operation is 216136 m3/h per one unit, and 864544 m3/h per four units of the NPP accordingly [1/8].

At operation of four units of the NPP in base load mode the expected amount of electricity output will be up to 34790 million kW*h per year [1/8].

Total thermal power of the district heating facility of each NPP unit is up to 300 MW [1/8].Turbine steam extraction to the district heating facility in addition to steam extraction for regeneration heat-up it is allowed without maintaining the rated power of the NPP unit [1/8].

1.3 INFORMATION REGARDING THE TECHNICAL CAPABILITY, KNOW-HOW AND EXPERIENCE OF THE APPLICANT AND INSTITUTIONS CARRYING OUT SITE STUDIES ON BEHALF OF THE APPLICANT

1.3.1 OWNER (APPLICANT) AND INVESTOR OF AKKUYU NPP PROJECT

The Owner (Applicant) and Investor of the Akkuyu NPP construction and operation project is the Project Company "Akkuyu NGS Elektrik Üretim Anonim Şirketi" (APC) established in the form of a Joint Stock Company (JSC) in accordance with the inter-governmental agreement [1/1] and under the laws and regulations of the Republic of Turkey. The Project Company has created departments on the territory of Turkey (in Ankara and in Büyükeceli village close to the site for the proposed Akkuyu NPP construction), and also opened the representative office on the territory of the Russian Federation (in Moscow).

The Project Company is the owner of Akkuyu NPP. Initially 100 % of the Project Company shares are owned by the Russian companies authorized by the Russian Party (State Corporation "Rosatom"). After completion of the NPP construction the Project Company will continue operation of the nuclear power plant for 60 years and own the majority stake (51%) while the remaining 49% may be sold to investors. The cumulative shares of the Russian Authorized Organizations in the Project Company shall not be less than 51% at any time. The distribution of the remaining minority shares of the Project Company will at any time be subject to the consent of the Russian and Turkish Parties with the purpose of protecting national interests in issues of national security and the economy. Issues relating to the corporate governance of the Project Company shall be subject to the consent of the Turkish Party (MENR).

The responsibility to insure risks covering investment and operation periods of the Akkuyu NPP project belongs to the Project Company.

The purchase and sale of the electricity generated by Akkuyu NPP will be made in accordance with a separate agreement to be signed between the Turkish Electricity Trade and Contracting Co. Inc. "Türkiye Elektrik Ticaret ve Taahhüt A.Ş." (TETAŞ), and the Project Company. After the Power Purchase Agreement expiry dates for each power unit, but not earlier than 15 years after the commercial operation date of each power unit, the Project Company shall give to the Turkish Party 20% of net profit of the Project Company on a yearly basis throughout the lifetime of the NPP.

At this stage of the Akkuyu NPP project, the Owner (Applicant) provides organization and supervision of the works on development of the pre-project and design documentation, the packages of documents for obtaining necessary licenses and permits, implementation and supervision of survey works at the site, as well as the interface with all state organizations, ministries and regulatory bodies of the Turkish Republic. All works of the Project Company are provided by support of the main Russian companies-stake holders: “Concern Rosenergoatom” JSC, “Atomstroyexport” JSC, “InterRAO UES” JSC, as well as activities of the scientific, research, design and engineering organizations, equipment manufacturers and other companies-subcontractors providing services in licensing, construction, commissioning and operation of the NPP. Nuclear fuel manufacture and supply will be provided by the Russian concern “TVEL” JSC.

In 2011 according to the inter-governmental agreement [1/1] the Project Company applied for obtaining all documents, permits, licenses, consents and approvals necessary to start the construction of the NPP. Particularly, the Project Company organized the works on performing the first priority engineering surveys on Akkuyu NPP site and sent the applications for Environment Impact Assessment, Generation License and prepared materials necessary for development of the updated site report within the valid Site License.

In 2012 the Project Company is completing all engineering surveys and studies needed for determination of final design basis parameters of the site, start to develop the Environment Impact Assessment report and design documentation, including the PSAR for Akkuyu NPP.

1.3.2 TECHNICAL CUSTOMER OF AKKUYU NPP DESIGN

Technical Customer of Akkuyu NPP Design is a Russian company on electrical and thermal power generation at NPPs - “Concern Rosenergoatom” JSC.

“Concern Rosenergoatom” JSC was founded by the decree of the President of Russian Federation on September 7, 1992. According to the by-law of the Russian Government issued on September 8, 2001 “Concern Rosenergoatom” JSC was reformed by a generation company with joining all the Russian NPPs under operation and construction, as well as the organizations providing services on operation, repair, scientific and engineering support.

At present “Concern Rosenergoatom” JSC includes 10 NPPs under operation and 7 NPPs under construction with a branch status, the Department of Rostov NPP Construction, the Directorate of Floating NPP Construction, the Scientific and Engineering Center of NPP Emergency Works, the Project and Design Branch, the Technology Branch and the NPP Engineering Center.

The main activities of “Concern Rosenergoatom” JSC are as follows:

- construction, operation and decommissioning of NPPs;
- economic, financial and commercial support functions of the operating organization;
- centralized sale of the generated electricity;
- investment activity;

– international cooperation in the area of NPP safety improvements;

– personnel training and qualification.

“Concern Rosenergoatom” JSC has significant capabilities and experience of work as an operating organization for all Russian NPPs, and it is the Customer (Applicant) for construction and operation of new NPPs in Russian Federation. “Concern Rosenergoatom” JSC also has experience of performing functions of the Technical Customer of Design in construction and modifications of Russian NPPs.

In general, 33 power units are under operation at 10 operating NPPs in Russia, which include:

– 17 pressurized water reactors: 11 VVER-1000 and 6 VVER-440;

– 15 channel boiling water reactors: 11 RBMK-1000 and 4 EGP-6;

– 1 fast reactor: BN-600.

Since its foundation “Concern Rosenergoatom” JSC has completed the construction of NPPs (initiated earlier) and connected to the grid the following power units: Balakovo NPP unit 4 (1993), Rostov NPP unit 1 (2001), Kalinin NPP unit 3 (2004), Rostov NPP unit 2 (2010) and Kalinin NPP unit 4 (2011).

New NPP units of AES-2006 design with VVER-1200 reactors are under construction at the sites of Novovoronezh NPP-2, Baltic NPP and Leningrad NPP-2. Beloyarsk NPP unit 4 with new BN-800 reactor is being completed for construction.

“Concern Rosenergoatom” JSC will provide support to the Owner (Applicant) in design and operation of Akkuyu NPP.

As the Technical Customer of Akkuyu NPP Design “Concern Rosenergoatom” JSC determines technical requirements to the NPP design, provides verification and performs acceptance of the design, engineering and working documentation on behalf of the Owner (Applicant). The Technical Customer of Akkuyu NPP Design performs its activity in interface with the main scientific, research, design and engineering organizations: “Atomenergoproekt” JSC (General Designer of the NPP), EDO “Gidropress” (Chief Designer of the Reactor Facility) and National Research Centre “Kurchatov Institute” (Scientific Consultant of the NPP design).

1.3.3 GENERAL CONTRACTOR FOR AKKUYU NPP CONSTRUCTION

In accordance with the inter-governmental agreement [1/1] the General Contractor for Akkuyu NPP construction is a Russian engineering company on construction of nuclear power facilities abroad “Atomstroyexport” JSC.

"Atomstroyexport" JSC was founded in 1998 on the basis of two major Russian organizations having 25 year experience in international cooperation on construction of nuclear power facilities: about 30 NPP power units and 10 nuclear scientific and research centers completed in counties of Eastern Europe and other regions.

At present "Atomstroyexport" JSC has the technical capabilities, knowledge and experience for construction of new generation NPPs with VVER type reactors as per "turn-key" contracts, including engineering, procurement of equipment and materials, construction, commissioning and project management. The experience of new NPP construction includes:

- Tianwan NPP units 1,2 construction in China (AES-91 design) – in operation since 2007;
- Busher NPP unit 1 construction in Iran – at commissioning stage (test and power operation);
- Kudankulam NPP units 1,2 construction in India (AES-92 design) – at commissioning stage (physical start-up);
- Belene NPP units 1,2 construction in Bulgaria (AES-92 design) – at design stage (license application);
- Tianwan NPP units 3,4 construction in China (AES-91 design) – at design stage.

In addition, agreements were signed for construction of Khmelnitsky NPP units 3,4 in Ukraine and Ostrovetsk NPP units 1,2 in Belarus (AES-2006).

In 2011 "Atomstroyexport" JSC performed the first priority engineering surveys at Akkuyu NPP site with support of subcontractors: General Designer "Atomenergoproekt" JSC and Turkish company «ENVY Energy and Environmental Investments Inc.». The program of first priority engineering surveys provided for identification of initial data on natural and human-induced hazards of Akkuyu NPP site that are necessary to develop design documentation. The first priority engineering surveys were conducted in accordance with the relevant requirements of Turkish and Russian regulations, as well IAEA safety standards, included in the Unlimited List of Regulations, Standards and Guides for Akkuyu NPP project and agreed with Turkish Atomic Energy Authority (TAEK).

1.3.4 CONSULTANTS

In order to support AKKUYU NPP JSC during project implementation in the areas of licensing, Environment Impact Assessment, engineering surveysand analyses, public and international (IAEA) relations, WorleyParsons Nuclear Services JSC (WPNS) and InterRAO-WorleyParsons LLC were engaged in 2011 as consultats.The companies are with extensive experience in the field of nuclear energy, engineering and project management.

1.3.4.1 WorleyParsons Nuclear Services JSC

WorleyParsons has been actively engaged in the nuclear power industry for over 55 years. In 2003, WorleyParsons established a nuclear hub - WorleyParsons Nuclear Services JSC (WPNS) in Sofia, Bulgaria. Services offered in the field of nuclearenergy include: full program management, design services, licensing support, and construction supervision through all phases of nuclear power projects realization.

WorleyParsons Nuclear Services JSC has a wast experience in providing servises in the areas of site selection and confirmation, technology assessment and analyses, safety assessment and analyses, environmental impact assessments, radioactive waste assessment and management,decommissioning strategy, comprehensive feasibility studies, scheduling, cost estimation, economic analysis and financial structuring, contracting strategy development and risk assessments, bid specification preparation, and complex assessments of offers in accordance with the latest European Utility and IAEA requirements.

1.3.4.2 InterRAO-WorleyParsons LLC

"InterRAO-WorleyParsons" LLC (IRWP) is a Russian company founded in 2010 as a joint venture of the Russian Power Holding "InterRAO UES" JSC and the engineering company "WorleyParsons EA Holdings Pty Limited". IRWP provides engineering, consultancy and management services for construction and upgrading of the nuclear and thermal power plants as well as coal chemistry facilities in Russia and abroad.

For authorization of engineering and management services for construction of nuclear power plants IRWP has the license № ЦО-02-101-6907 issued by the Russian Federal Service for Ecological, Technological and Nuclear Regulation in part of nuclear power plant construction and providing services to the Operators.

The following companies were subcontracted by WPNS to support the services of the Consultants: Paul C. Rizzo Associates Inc, Fugro Oceansismica S.p.A., Anatolian Geophysical Engineering Services Ldd, Middle East Technical University, GEOPET – geological, geotechnical Studies, Dokay-CED Environmental Engineering Ltd. Details for the companies, main participants the engineering studies, are given below.

1.3.5 INSTITUTIONS CARRYING OUT SITE STUDIES ON BEHALF OF THE APPLICANT

In 2011 "Atomenergoproekt" JSC, "ENVY Energy and Environmental Investments Inc." (ENVY), "WorleyParsons Nuclear Services" JSC and its subcontractors: "Paul C. Rizzo Associates" (RIZZO), "Fugro Oceansismica" (FUGRO), "Anatolian Geophysics" and Middle East

Technical University (METU) completed on behalf of the Applicant the first priority engineering surveys at Akkuyu NPP site and site region.

“Atomenergoproekt” JSC participated in engineering survey works, coordinated their performance, and made the technical supervision/analysis of work results prepared by ENVY and other Turkish subcontractors. The General Contractor provided to “Atomenergoproekt” JSC the required authorities for that activity.

ENVY performed the on site and regional engineering survey works and studies of Akkuyu NPP as per the contract for the following scope of work:

- Engineering-Geodetic Surveys;
- Engineering-Geological Surveys (Surface and Borehole Geophysical Surveys);
- Seismological and Seismotectonic Surveys;
- Hydro-Meteorological Surveys;
- Engineering-Environmental and Ecological Surveys (Marine/Surface Hydrology);
- Assessment of Anthropogenic Conditions.

In the conduct of engineering surveys on the site of Akkuyu NPP, ENVY also engaged other Turkish organizations for the following works:

- TOKER/ Middle East Technical University (METU) – Drilling-Digging Works/Engineering Geology;
- BELIRTI/ BAYAR – Surface Geophysical Work/Bore-hole Geophysical Works;
- KANDILLI Earthquake Center – Seismological and Seismotectonic Works;
- DERINSU – Marine Hydrology Works;
- ELLITE/ Hacettepe University – Meteorological and Aerological Works;
- DUZEN/ TAEK Laboratory – Analysis of Soil and Water Samples.

As sub-contractors of WorleyParsons, RIZZO performed on site and regional engineering survey works and evaluations of Akkuyu NPP as per the contract for the following scope of work:

- Re-evaluation of the seismic hazard in compliance with IAEA SSG-09;
- Re-evaluation of other natural external events (flooding except tsunamis and high winds) in compliance with IAEA SSG-18 (2011);
- Re-evaluation of human induced (accidental) external events;
- Evaluation of external zone requirements for the population in relation to site conditions for dispersion of effluents in the atmosphere and hydrosphere including the feasibility of emergency planning (including radiological environmental impact).

FUGRO and Anatolian Geophysics performed the offshore geophysical investigations on a 15 km radius grid from the site in order to confirm site acceptability, in relation to fault capability in the offshore area. Special attention was given to a suspect fault detected in earlier offshore investigations south east of the site.

METU – Civil Engineering Department Coastal and Harbor Engineering Laboratory performed the studies of Akkuyu NPP site for re-evaluation of tsunami hazard in compliance with IAEA SSG-18 (2011).

1.3.5.1 “Atomenergoproekt” JSC

“Atomenergoproekt” JSC is the Russian design, survey, scientific and research institute having experience of complex designing and author’s supervision for construction, commissioning and operation of nuclear power plants in the former Union of Soviet Socialist Republics, the Russian Federation and abroad since 1951.

“Atomenergoproekt” JSC performs functions of the General Designer of the NPP in cooperation with other scientific, research, design and engineering organizations, and develops the technical specifications for power engineering equipment manufacturers. “Atomenergoproekt” JSC also has experience of performing functions of the General Contractor for Novovoronezh NPP-2 construction (AES-2006 design) which is the reference plant for Akkuyu NPP, with conduct of engineering surveys on site and NPP design development, as well as organization of construction and erection works, procurement of equipment and materials, and project management.

For authorization of engineering surveys “Atomenergoproekt” JSC has the following licenses:

- MOG-07045G, issued by the Federal Service of Geodesy and Cartography of Russia in part of geodetic surveying with date of expiry up to August 6, 2014;
- MOG-07046G, issued by the Federal Service of Geodesy and Cartography of Russia in part of cartographic activity with date of expiry up to August 6, 2014.

“Atomenergoproekt” JSC has the certificate of Self-Regulating Organization NP “Soyuzatomgeo” No.SRO-I-002-00022/1-10112010 that is valid with no limitation of date of expiry and territory. This certificate provides the authority for engineering surveys in all type of works on geodesic, geological, hydro-meteorological, ecological, geotechnical engineering surveys and studies of soil for building and structure foundations.

“Atomenergoproekt” JSC completed the certification of Quality Management System in:

- The certification authority of association “TÜV SÜD Management Service GmbH” (Germany) certified that “Atomenergoproekt” JSC has implemented and applied the Quality Management System in engineering surveys, scientific and research, design and engineering, start-up works and procurement of equipment to the nuclear and other power facilities and construction sites. As a result of audit (report No.70004173) confirmation has been received that ISO 9001:2008 requirements was met. The certificate with serial number 1210013667 TMS was issued;

- The Federal Authority of Technical Regulation and Metrology of Russia certified that the Quality Management System of “Atomenergoproekt” JSC applicable to the survey, scientific and research, design and engineering works, engineering services and construction works, including procurement, commissioning works at nuclear energy facilities, electrical and thermal plants, as well as other power facilities, meets the requirements of GOST R ISO 9001-2008 (ISO 9001:2008). The certificate with serial number ROSS RU.FK41.K00029 was issued.

1.3.5.2 ENVY Energy and Environmental Investments Inc.

Turkish company “ENVY, Energy and Environmental Investments Inc.” was founded in Ankara in 1999 to provide engineering, consultancy and supervision services for energy and environment sectors. ENVY, with its experienced personnel, implemented projects with world-wide reputation in a short period by working with many national and international companies.

As one of the leading engineering and consultancy companies of Turkey, ENVY Energy and Environmental Investments Inc. has taken part in a large number of prestigious projects providing services in the following areas:

- Electricity Market Services;
- Natural Gas and Pipeline Engineering;
- Environmental Engineering and Consultancy Services;
- Geographical Information Systems Services;
- Licenses;
- Earth Sciences.

ENVY has the following quality, environment and health and safety system certificates:

- ISO 9001:2000 – Quality Management System;
- ISO 14001 – Environmental Management System;
- OHSAS 18001 – Occupational Health and Safety Management System.

ENVY also has the following certificates:

- "Feasibility-Survey, Project, Consultancy, Inspection and Supervision, Construction, Service, Maintenance and Repair" Certificate granted by Energy Market Regulatory Authority (EMRA);

- BOTAŞ Certificate documenting the qualification to perform engineering and consultancy studies for high pressure natural gas pipelines;
- "EIA Qualification Certificate" granted by the Ministry of Environment and Forestry.

Furthermore, ENVY has the following "Certified Public Consultancy Engineering Bureau, Bureau Registration Certificate" granted by the Engineering Chambers:

- Union of Chambers of Turkish Engineers and Architects (TMMOB) Chamber of Mechanical Engineers;
- TMMOB Chamber of Environmental Engineers;
- TMMOB Chamber of Geological Engineers;
- TMMOB Chamber of Electrical Engineers;
- TMMOB Chamber of Civil Engineers.

1.3.5.3 Paul C. Rizzo Associates

Paul C. Rizzo Associates (RIZZO) is an American company established in 1984 specializing in all aspects of the civil engineering and earth sciences fields for dams and water resources, power generation industry, tunneling, mining and other specialty markets.

For over a quarter century RIZZO has worked around the world on unique, challenging, and technically demanding projects providing services in the following areas:

- Civil Engineering Design;
- Construction Management;
- Nuclear Power Plant Siting Studies;
- Seismic and Specialty Structural;
- Environmental, Geotechnical, Geophysics & Seismology;
- Geology & Hydrogeology;
- Hydrologic and Hydraulic Engineering.

RIZZO is pursuing certification under ISO 9001:2008 and ISO 14001:2004 throughout the company.

For the nuclear industry, RIZZO is an approved supplier to provide nuclear safety-related analysis and design services to AREVA, Westinghouse, MHI, Sargent & Lundy, PBMR, and several utilities, including Ameren Missouri, UniStar Nuclear Energy, and the Emirates Nuclear Energy Corporation (ENEC) in the United Arab Emirates.

1.3.5.4 Fugro Oceansismica S.p.A.

Fugro Oceansismica S.p.A. (FUGRO) is an Italian company supporting offshore oil exploration and field development for more than 30 years in the waters off all continents except Australia and Antartica, with particular expertise in the Mediterranean, Caspian, Red and Black Seas environments.

Fugro’s activities are carried out across the world, onshore, offshore and from the air, and are primarily aimed at the oil and gas industry, construction industry, mining sector and governments providing services in three divisions: Geotechnical, Survey and Geoscience.

FUGRO has developed and implemented an Integrated Management System related to Quality and H&S, compliant to ISO 9001:2008, OHSAS 18001:2007 and ISO 14001.

1.3.5.5 Anatolian Geophysics

Anatolian Geophysics is a Turkish company founded in 2001 providing services for geotechnical site investigations at sites for dam construction, nuclear power plants, and residential and commercial developments. They are also specialists in the interpretation of geophysical data and assessing fault capability in zones where suspect features exist.

1.3.5.6 Middle East Technical University

Coastal and Harbor Engineering Laboratory at Civil Engineering Department of Middle East Technical University in Ankara (METU) provides the experimental facilities both for education and research programs (ocean.ce.metu.edu.tr).

The major research interests of METU Coastal and Harbor Engineering Laboratory includes generation and transformation of wind waves, tidal waves and currents, wave hind casting, wave statistics, wave forces, tsunami, wave structure interaction problems, design of coastal structures, harbor planning and design, coastal pollution, coastal sedimentation, offshore engineering, integrated coastal zone management, seal level rise and marine hazards.

METU Department of Civil Engineering was accredited by ABET (Accreditation Board for Engineering and Technology) in 1994 and renewed every 5 years. The responsible professor for tsunami hazard analysis at the laboratory has provided consultancy and training services to many nuclear power plant projects as an expert to the International Atomic Energy Agency.

1.4 INFORMATION ON SELECTION AMONG WHICH REACTOR TYPES CONSIDERED

The site report developed in 1976 [1/6] considered the possibility of choosing a technology of any manufacturers of pressurized water reactors (PWR), boiling light water reactors (BWR) and pressurized heavy water reactors (PHWR or CANDU) for the Akkuyu NPP site.

In accordance with the bilateral agreement between the governments of Turkey and the Russian Federation dated May 12, 2010 [1/1] for the construction and operation of Akkuyu NPP, the AES-2006 design with third-generation VVER-1200 reactor was chosen. VVER reactors are light water reactors, where light water is used both as neutron moderator and as coolant. VVER reactor is considered one of the safest reactors in the world. More than 50 VVER-type reactors have been built in Russia, Ukraine, Bulgaria, Czech Republic, Slovakia, Hungary, East Germany, Finland, India, Armenia and China over the entire history of the nuclear industry.

The AES-2006 design with VVER-1200 reactor introduces the concept of modern nuclear power plants with up-to-date technology and economic performance and high level of safety.

The AES-2006 design is the result of evolutionary development of NPP safety principle. Akkuyu NPP safety is ensured by applying five levels of the defense-in-depth concept, which includes a multi-barrier system to prevent the propagation of ionizing radiation and radioactive substances into the environment, as well as technical and organizational measures for the serviceability of barriers and for the protection of personnel and local population.

The Novovoronezh NPP-2 design with VVER-1200 reactor was chosen as a reference plant for Akkuyu NPP design.

The Akkuyu NPP design is developed in accordance with the Licensing Basis for Akkuyu NPP Project [1/10] and the requirements for NPP safety established by EUR and IAEA.

VVER-1200 is a four-loop pressurized water reactor with 3200 MW thermal power. The rated electrical power of each unit of the NPP is approximately 1198 MW (gross) [1/8].

Protective safety systems intended for the design-basis and beyond-design-basis accidents include active and passive elements. The safety system design is based on the single failure, multi-channel, physical separation, passivity and diversity principles.

AES-2006 provides for a double containment. The primary (internal) containment is made of pre-stressed reinforced concrete, and the secondary (external) containment is made of cast reinforced concrete. In the bottom of the primary containment there is a core melt catcher designed for severe accident management.

The plant is designed in such a way that radiation impact on the environment during normal operation, anticipated operational occurrences and design-basis accidents remain below regulatory limits and would be as low as reasonably achievable. During normal operation, gas-aerosol emissions through the stack are the source of radionuclide emissions into the environment, and do not exceed permissible limits for any of the operational states.

The design basis of VVER-1200 reactor plant is based on VVER technology with its further improvement.

The basic technical characteristics of AES-2006 unit are presented in Table 1/1[1/8], including:

– 60-year service life of main equipment;
– maximum use of proven technical solutions;
– 2 channels of active safety systems;
– passive safety systems that are operated without the need of power supply and operator action;
– emergency heat removal from reactor core and fuel pool.

Table 1/1 – The basic technical characteristics of AES-2006 unit

№	Parameter	Value
1	Service life of reactor plant, years	60
2	Reactor thermal power, not less than MW	3200
3	Active electrical power, not less than MW	1200
4	Number of reactor circulation loops	4
5	Parameters of primary circuit:	
	– coolant pressure at the core outlet, MPa (abs.)	16.2 ± 0,3
	– coolant temperature at reactor inlet, °C	298.2^{+2}_{-4}
	– coolant temperature at reactor outlet, °C	328.9 ± 5
	– coolant flow in the cold leg of the loop, m^3/h	21500 ± 1000
	– coolant flow through reactor, m^3/h	86000 ± 2900
6	Average fuel enrichment for U-235 isotope, %	3.6
7	Refueling interval, months	12
8	Operation time of fuel in the reactor core, years	4
9	Number of FA in the reactor core	163
10	Containment type: – primary (internal) containment – secondary (external) containment	– pre-stressed reinforced concrete with steel lining – cast reinforced concrete
11	Inner diameter of primary containment, m	44

The main equipment of AES-2006 unit with VVER-1200 reactor plant (Figure 1/) includes the following components [1/8]:

– pressurized water reactor VVER-1200;
– four horizontal steam generators PGV-1000MKR;
– four reactor coolant pump units GTsNA-1391;
– four circulating loops with the Pressurizer and ECCS Hydraulic accumulators;

– steam turbine plant with alternate current generator TA-1200-78.

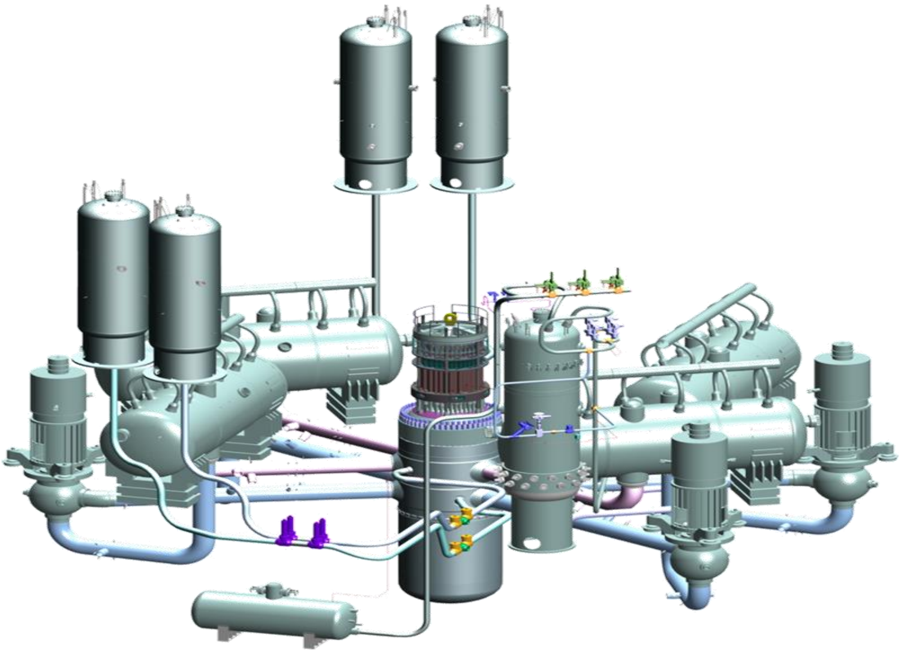


Figure 1/2 – Main equipment of VVER-1200 reactor plant

Reactor, steam generators and other equipment of primary circuit are located in the double reinforced concrete containment. The double containment includes:

– primary containment of pre-stressed reinforced concrete designed to withstand emergency parameters of the medium in accident localizing area;

– secondary containment of cast reinforced concrete designed to provide protection against external natural and human-induced impacts and to isolate annulus space for localization and filtering radioactive leakages through primary containment during accidents.

At present, the AES-2006 design is used as a basis for the construction of new power units at the Novovoronezh NPP-2 Site, Baltic NPP Site and Leningrad NPP-2 Site in Russia. The main difference between these designs is the configuration of safety systems.

1.5 LAYOUT ALTERNATIVES FOR AKKUYU NPP

The layout of Akkuyu NPP was developed for four power units with VVER-1200 reactors. When choosing the place for location of the proposed plant, two alternatives of the NPP location on site were considered [1/8].

The alternative of NPP location in the south-eastern part of the site between two hills was considered in order to optimize the cold water intake and hot water discharge in the service water system. This alternative requires the excavation of large amount of rock/soil. As the existing elevations in the area reach an altitude of 140 meters above sea level, excavation work will be several times greater than the scope of work for ground removal specified for the south-western location of NPP. Moreover, some problems may arise in connection with slopes and storm water discharge, with the arrangement of power transmission line corridors and dispersion of stack emissions. Therefore, the most preferable solution is to locate NPP units in the southwestern part of the site in the bay of Akkuyu.

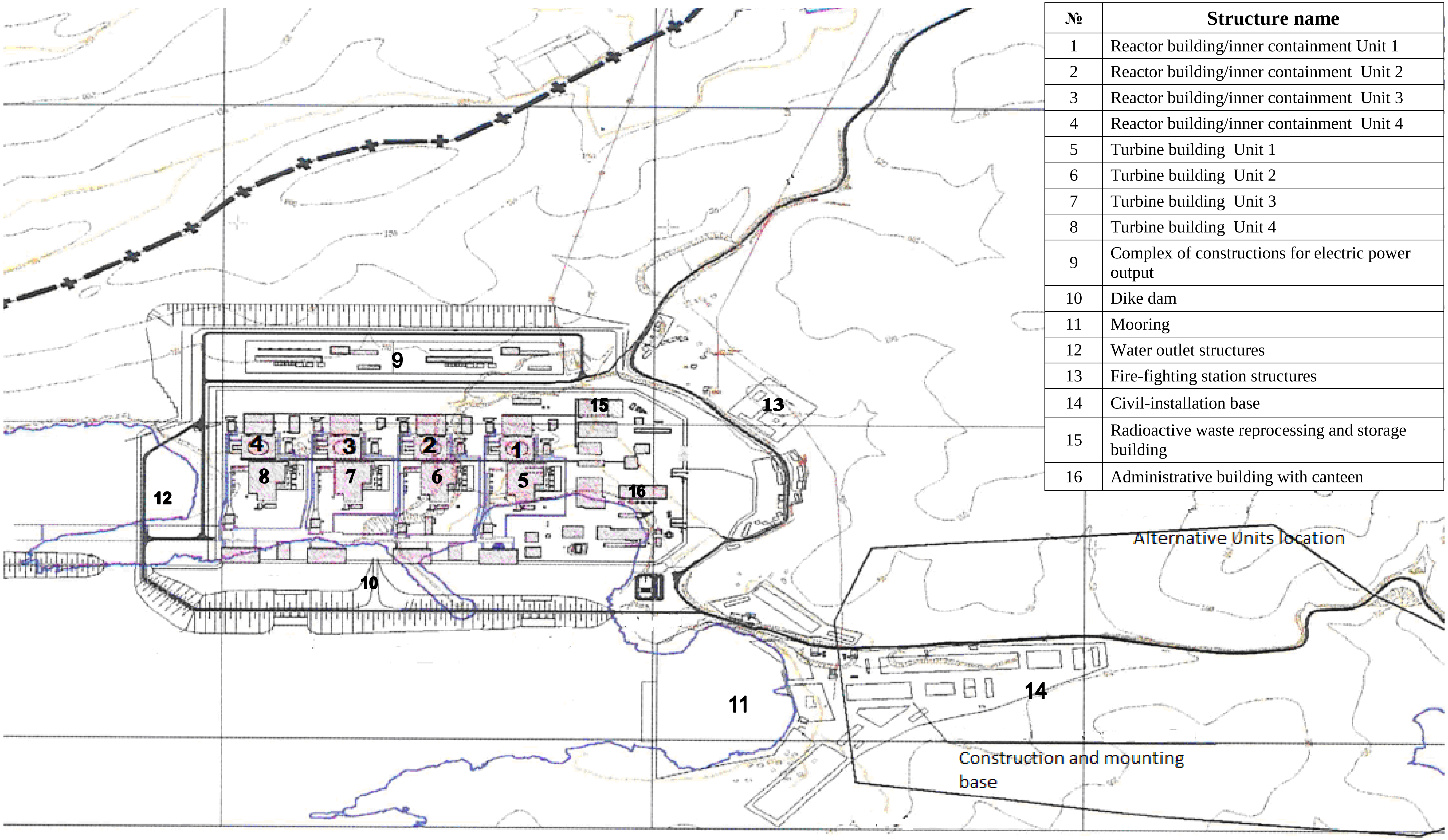
Two schemes of layout for NPP units and auxiliary buildings were considered for the selected variant of NPP location in the southwestern part of the site. The projected basic layout of NPP units and auxiliary buildings implies the arrangement of four power units from east to west, with the main entrance being from the main access road in the eastern part of the plant. With this layout, Units 1 and 2 will be located at currently graded territory, and this can significantly shorten the preparatory period before construction.

The second alternative layout of NPP envisages the arrangement of the four power units from west to east, with common-plant buildings, structures and plant adjacent area being located in the western part of the NPP.

The main deficiency of the second alternative layout is the constrained conditions at the western part of the NPP. There are four service water discharge channels going to the west, which significantly limits the area for the common-plant buildings, structures and communications corridor for them. Moreover, it is not possible to arrange the waste disposal site in this area, which should be included in the start-up complex of Unit 1. The second alternative layout implies that Units 1 and 2 are located on an unprepared territory, which is composed of small hills with a peak elevation of 54 meters.

The second alternative layout of NPP has no reasonable access to the plant adjacent area during the operation of Units 1 and 2. In this case, buses will pass by power output switchgears and transmission lines of Units 3 and 4 being under construction.

For the above reasons, the general layout of Akkuyu NPP with the arrangement of four units from east to west was adopted for further development of the design. The main layout scheme of NPP is shown in Figure 1/3..



№	Structure name
1	Reactor building/inner containment Unit 1
2	Reactor building/inner containment Unit 2
3	Reactor building/inner containment Unit 3
4	Reactor building/inner containment Unit 4
5	Turbine building Unit 1
6	Turbine building Unit 2
7	Turbine building Unit 3
8	Turbine building Unit 4
9	Complex of constructions for electric power output
10	Dike dam
11	Mooring
12	Water outlet structures
13	Fire-fighting station structures
14	Civil-installation base
15	Radioactive waste reprocessing and storage building
16	Administrative building with canteen

Figure 1/3 – Main layout scheme.

REFERENCE LIST

1/1 Agreement between the Government of the Republic of Turkey and the Government of the Russian Federation on Cooperation in Relation to the Construction and Operation of a Nuclear Power Plant at the Akkuyu Site in the Republic of Turkey. 12.05.2010

1/2 Decree on Licensing of Nuclear Installations. Official Gazette № 18256. Date of Issue 19.12.1983. TAEK

1/3 Regulation on Nuclear Power Plant Sites. Official Gazette № 27176. Date of Issue 21.03.2009. TAEK

1/4 Guideline on Format and Content of Site Report for Nuclear Power Plants. GK-GR-01. Revision 1. Date of Issue 10.12.2009. TAEK

1/5 Licensing Conditions for Akkuyu NPP Site License. TAEK letter № B.15.1.TAE.0.10.01.00-120.02[ANS]-2025-14074 dated 13.10.2011

1/6 Nuclear Power Plant Revised Site Report. Turkish Electricity Authority. Nuclear Energy Division. NED-1-16. April 1976

1/7 Akkuyu NPP Units 1, 2, 3 and 4. Pre-project Works. Performance of First Priority Engineering Survey at the Akkuyu NPP Site in Turkey. Stage 4, Development of Engineering Survey Materials in Volume Sufficient for Acquisition of License. 4.1 Development of Engineering Survey Materials Based on Results of First Priority Works. Technical Report, Results of First Priority Engineering Survey. Atomstroyexport JSC, “Atomenergoproekt” JSC January, 2012

1/8 Akkuyu NPP Units 1, 2 3 and 4. Pre-project Documents. Atomenergoproekt, 2011

1/9 Updated Site Report Format. TAEK letter
№ B.15.1.TAE.0.10.01.00-120.02[ANS.31] -105-00780 dated 19.01.2012

1/10 Licensing Basis Regulations, Standards and Guides for Akkuyu NPP. TAEK letter
№ B.15.1.TAE.0.10.00.00-120.02[ANS.17] -11211 dated 08.11.2012

2. GEOGRAPHY AND POPULATION

2.1 GEOGRAPHY

2.1.1 LOCATION

Akkuyu NPP site is accommodated in the southern part of Turkey at the Mediterranean Sea shore, on the territory with a radius not less than 3 km. Geographical coordinates of the site center are 36°08′ n.l. and 33°32′ e.l.

Akkuyu NPP site is located about 250 km west to Syrian border, and 90 km north to Cyprus Island.

The region of works is included in Gülnar municipality (Gülnar is district centre located at a distance of some 25 km to north-north-west, 35 km by highway) Mersin Province (Mersin is administrative centre located approximately 110 km to north-east, 140 km by highway). Mersin Province is located in the southern part of Turkey, at the Mediterranean Sea coast between Antalya and Adana. It is related to the Mediterranean administrative region (Figures 2/1-2/2).

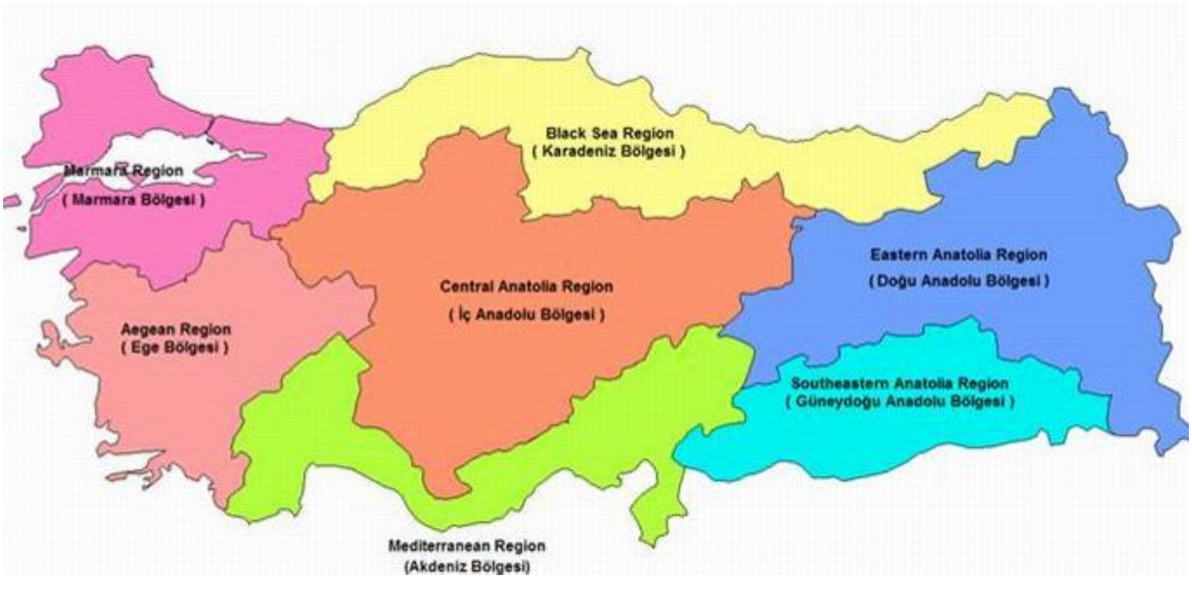


Figure 2/1 – Regional Division of Turkey

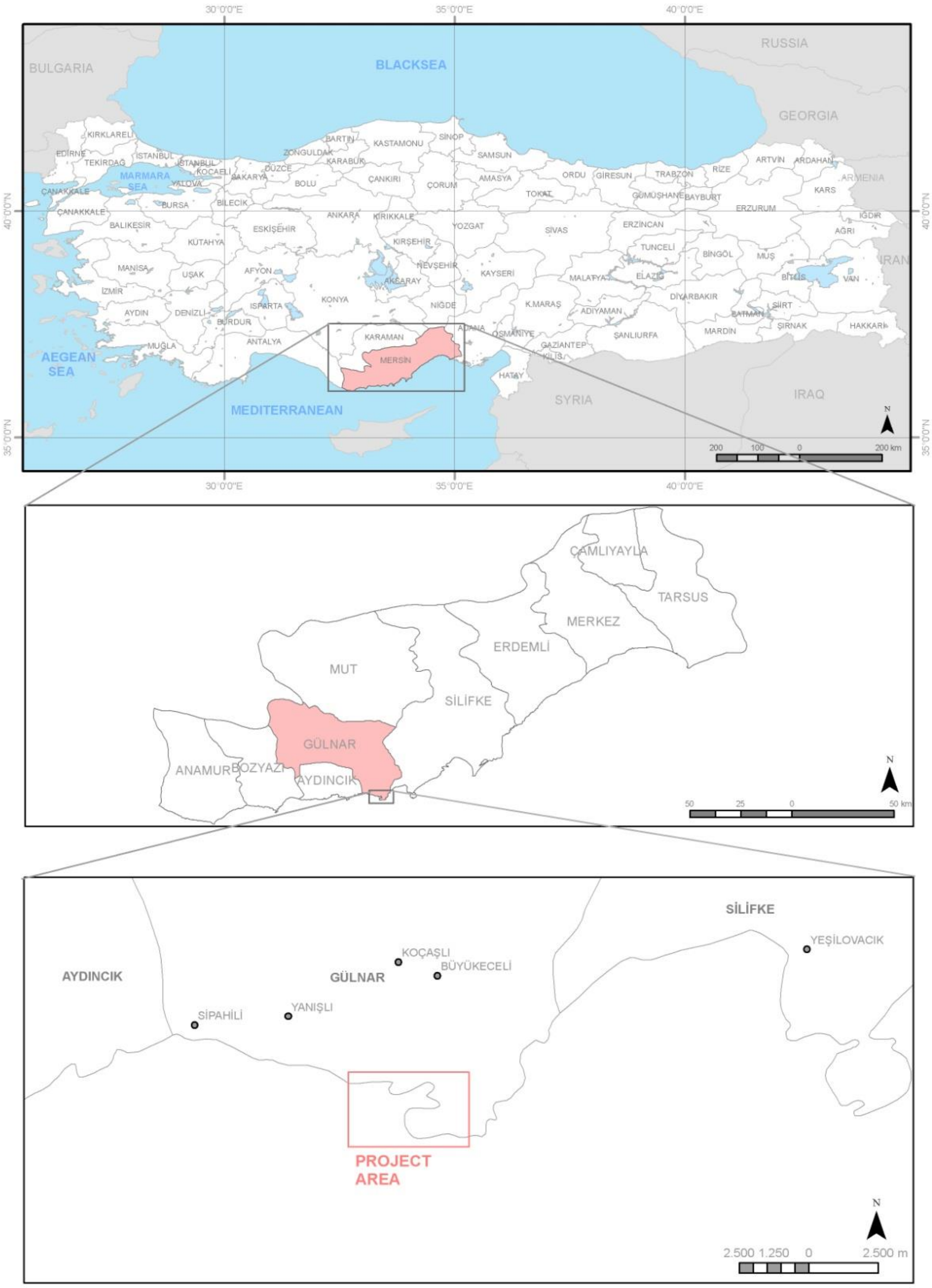


Figure 2/2 – Akkuyu NPP Site Accommodation

2.1.2 REGION AND SITE VICINITY MAPS

The site is surrounded by hills up to 200 m high. These hills form a natural boundary of the NPP accommodation area. The site is overlooking the Aksaz and Akkuyu-Çamalanı Bays in SW direction.

Ground elevation of the site varies between 0 and 50 m above the sea level.

By topographic conditions the Akkuyu NPP site can be divided into two parts as follows:

- coastal part, open territory with gravel soils and rock outcrops; slope of the territory does not exceed 2-3°;
- foothills with rock outcrops onto surface, forest-covered mainly with Mediterranean pines and bushes, with slopes up to 20°.

According to the results of Risk Assessment carried out within frames of the Turkish legislation, it was determined that there are no security zones and controlled areas within 10 km radius area (letter by Akkuyu NGS AŞ No 965 from 22.11.2011).

There are no large industrial, commercial or entertainment facilities in the region of the planned Akkuyu NPP accommodation area. Only stone quarries and water treatment stations in the settlements are located within the Akkuyu NPP 30-km zone. Paper-processing factory (SEKA) is located 35 km north-east from the site in the city of Taşucu. Other industrial enterprises are concentrated between Mersin and Adana, more than 80 km away from the site.

There are no military facilities or constructions that regularly emission fluids or gases within the NPP site vicinity.

Distance to the nearest recreation zone (Hayat Motel) is 3.5 km, distance to recreation zone (Pine Park Hotel) is 8.14 km. There are no reservations or protected territories within the site area.

Large drying watercourse runs through Büyükeceli village at distance of about 3 km northeast to the site. The nearest perennial stream is Sipahili (Babadil). It runs in 7 km ENE. Full-flowing Góksu River is located 30 km northeast to the construction site.

The nearest harbors are in Mersin and Taşucu ports. The nearest to the site large airport is located in the city of Adana approximately 200 km away. The nearest railroad station is located in the city of Mersin.

The most important highway is Adana-Antalya highway. The Akkuyu NPP accommodation site is connected to this highway via a 4.5 km road. The site is also connected with Büyükeceli Village (via asphalted road). Büyükeceli Village is located 3 km northeast of the site.

Map in 1:500 000 scale is given in Appendix A. Map in 1:250 000 scale is given in Appendix B. Map in 1:10 000 scale is given in Appendix C. The general chart of the Akkuyu NPP site accommodation region, large settlements and traffic roads including regular sea transportation routes are shown in Figure 2/3. Distances to settlements (including quarters) in 30-km zone are given in Appendix D. Physical-geographical map of the site vicinity is shown in Figure 2/4. Figure 2/5 shows cadastral map with plotted boundaries of land areas.

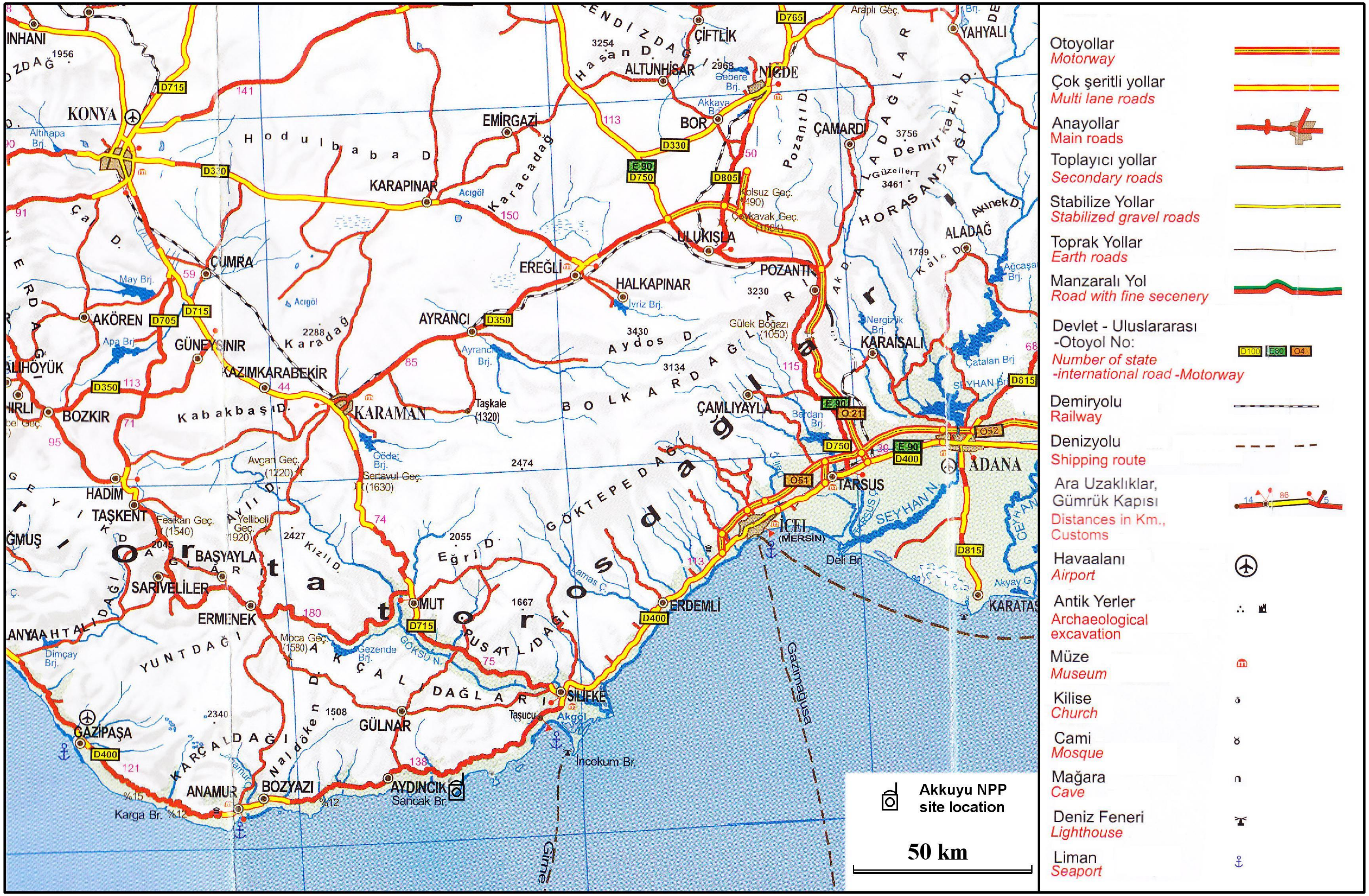


Figure 2/3 – The General Chart of the Akkuyu NPP Site Accommodation Region

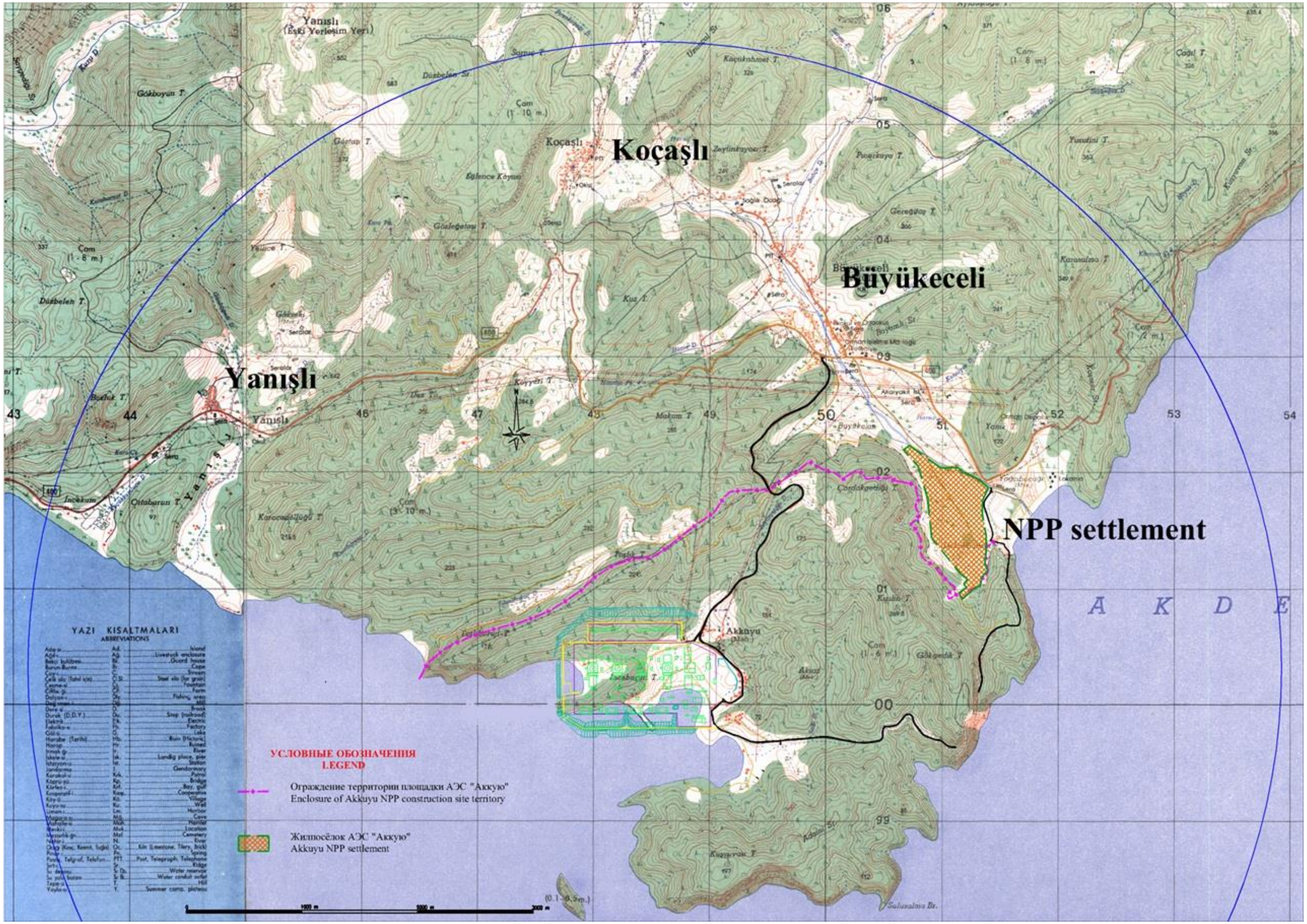


Figure 2/4 – Akkuyu NPP Site Vicinity 5.4 km Area

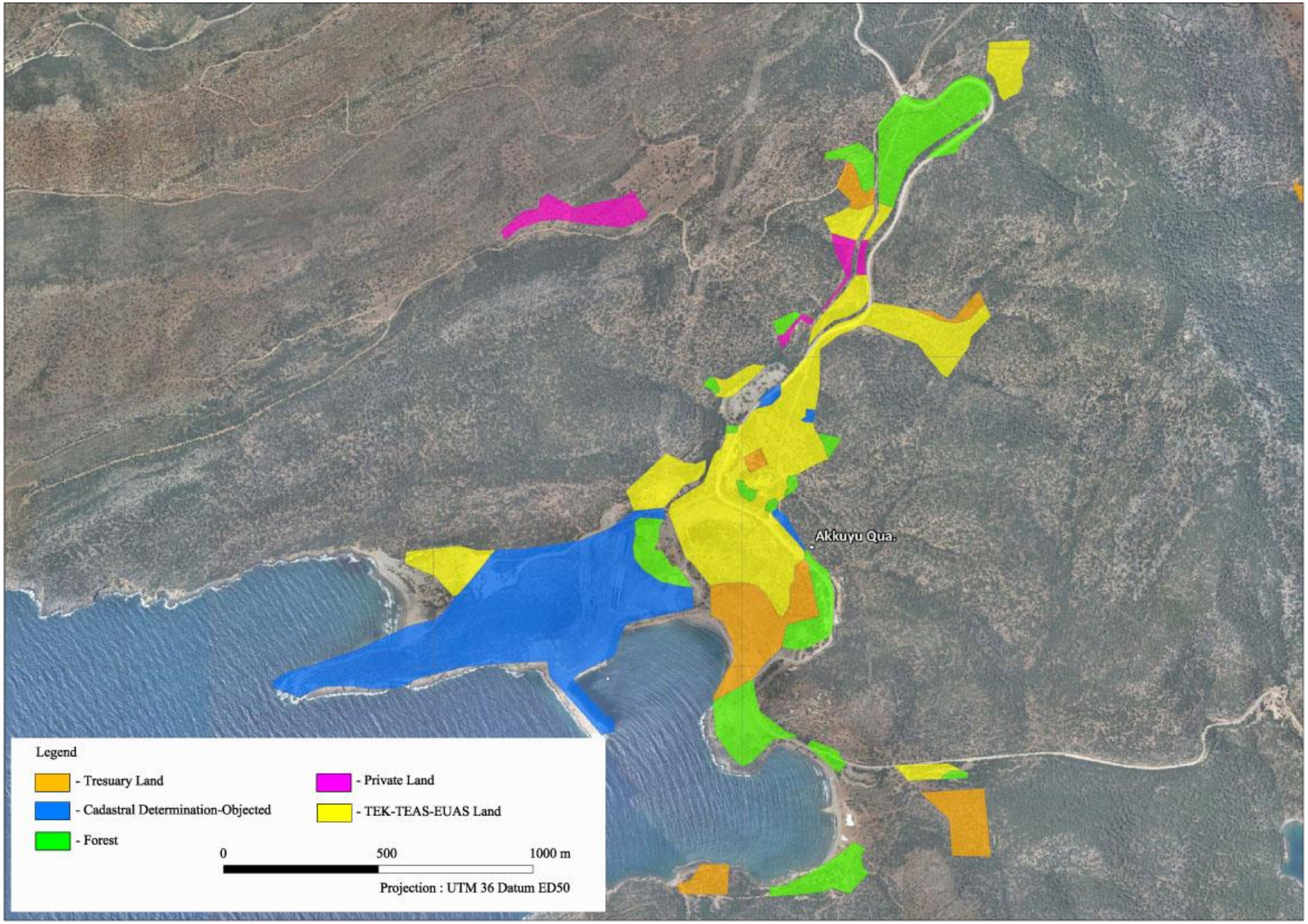


Figure 2/5 – Cadastral Map of Akkuyu NPP Area

The Akkuyu NPP planned accommodation site is an enclosed territory. Area of land plot within the existing fence is 1022 ha. The NPP construction site area is 225 ha. Total area of lands owned by TEK-TEAŞ-EUAŞ is 37 ha. Developed and used territories occupy about 20 ha.

Figure 2/6 presents layout of building and structures of the Akkuyu NPP site.

The NPP site area is located in the south-western part of the site along coastline onto partially developed territory. Two access roads are envisaged to the construction site: one from northern part of the site, the other from eastern part.

The NPP site area in fencing amounts 76 ha with the account for exclusion area perimeter.

Complex of power output structures is envisaged north to the construction site at the terrace within separate fencing. It will be accommodated within 14 ha fenced territory.

It is planned to locate personnel settlement 2.4 km north-east to the site. The Akkuyu NPP Training Center will be situated within the territory of the settlement. Figure 2/6 presents coordinates of the future settlement for the operating personnel.

The basis diagram of the NPP site general layout design is developed for the four power units.

The given version of general layout diagram provides construction of power units from the east to west, with organization of main entrance from the side of access highway in the NPP site eastern part.

Monoblock units are accommodated in the NPP site centre. The power units are oriented by reactor buildings towards the north, turbine buildings are oriented to the south, towards the sea. Spacing between units is accepted equal to 215 m and it ensures accommodation of engineering and transport communication lines between units, and startup of units via starting complexes.

The auxiliary buildings and structures are common for the four units and are accommodated from the Unit 1 side, in the eastern part of the NPP site.

Controlled access buildings and structures are accommodated in the north-eastern part of the site on Reactor Compartment 1 side.

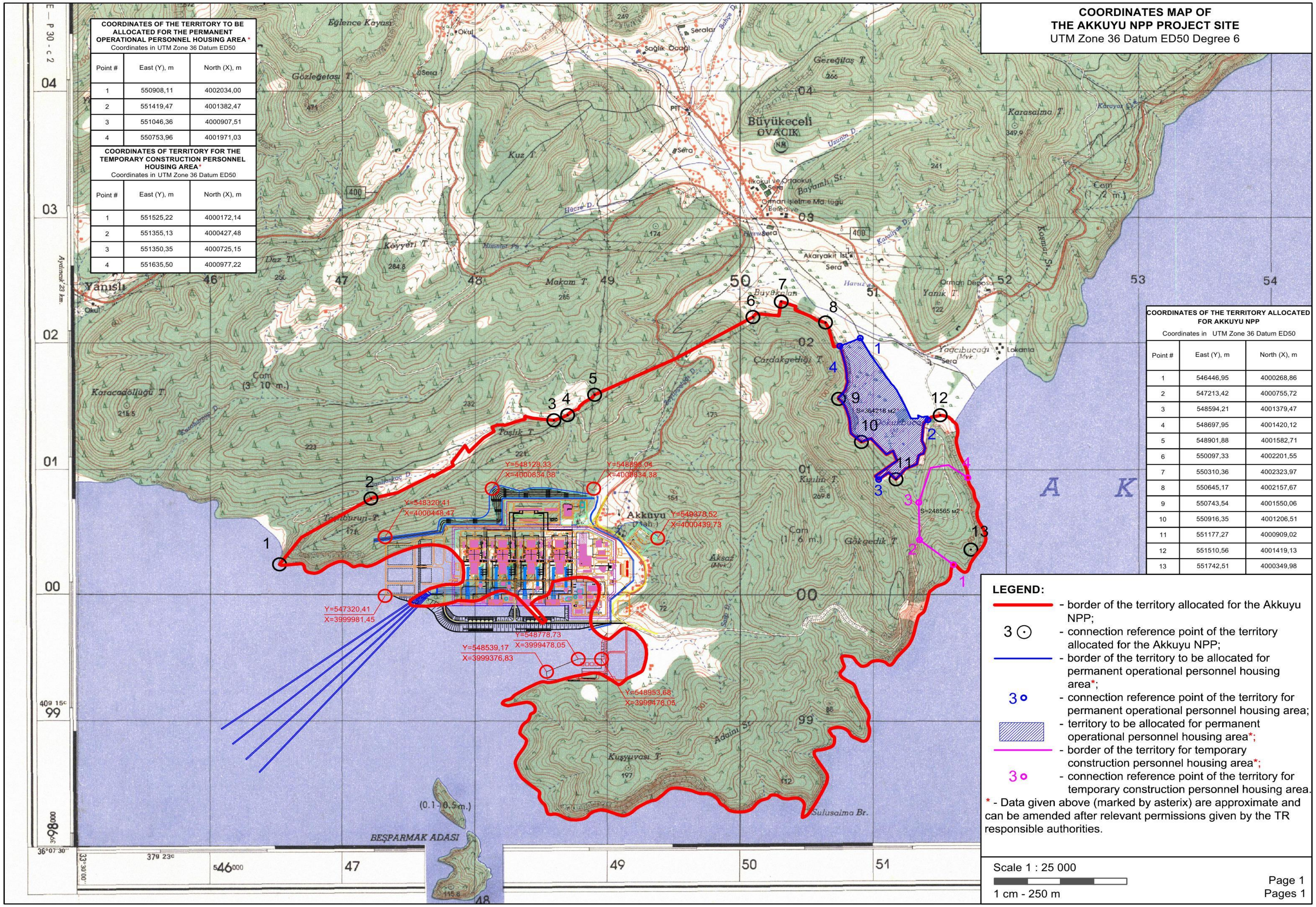
Non-controlled access area buildings and structures are accommodated in the south-eastern part of the NPP site, from a turbine building side.

Fire fighting water tanks with pump station are provided west to power output structures in front of initial water arrival to the site. Akkuyu NPP Training Center is located at the territory of the NPP settlement as far as 2.4 km from the site.

Catalogue of coordinates of Reactor centers in UTM Zone 36 Datum ED50 is presented in Table 2/1.

Table 2/1 – Catalogue of Coordinates of Reactor Centers

Reactor No.	X	Y
10UJA	548638.8	4000315.2
20UJA	548423.9	4000313.8
30UJA	548208.9	4000312.4
40UJA	547993.9	4000311.0



COORDINATES OF THE TERRITORY TO BE ALLOCATED FOR THE PERMANENT OPERATIONAL PERSONNEL HOUSING AREA *

Coordinates in UTM Zone 36 Datum ED50

Point #	East (Y), m	North (X), m
1	550908,11	4002034,00
2	551419,47	4001382,47
3	551046,36	4000907,51
4	550753,96	4001971,03

COORDINATES OF TERRITORY FOR THE TEMPORARY CONSTRUCTION PERSONNEL HOUSING AREA *

Coordinates in UTM Zone 36 Datum ED50

Point #	East (Y), m	North (X), m
1	551525,22	4000172,14
2	551355,13	4000427,48
3	551350,35	4000725,15
4	551635,50	4000977,22

COORDINATES OF THE TERRITORY ALLOCATED FOR AKKUYU NPP

Coordinates in UTM Zone 36 Datum ED50

Point #	East (Y), m	North (X), m
1	546446,95	4000268,86
2	547213,42	4000755,72
3	548594,21	4001379,47
4	548697,95	4001420,12
5	548901,88	4001582,71
6	550097,33	4002201,55
7	550310,36	4002323,97
8	550645,17	4002157,67
9	550743,54	4001550,06
10	550916,35	4001206,51
11	551177,27	4000909,02
12	551510,56	4001419,13
13	551742,51	4000349,98

Figure 2/6 – Layout of Akkuyu NPP Site

2.1.3 AUTHORIZATION ON SITE

According to the letter from the Regional Directorate of Environment and Forestry of Mersin Governorship No B.18.4.İÇO.4.33.00.06-445.01.02/1219-8774 from 28.10.2011 the site is located at the territory that has protected natural territory status.

According to the letter from the Cultural Funds Protection Council for the Adana region General Directorate of Cultural Targets and museums of the Ministry of Culture and Tourism No B.16.0.KVM.4.01.00.03/33.03.107-1791 from 29.05.2012 «protected archeological territory of the 1st category» was registered within Akkuyu NPP site boundaries.

According to the decision No № 4607 from 27.01.2009 made by the Regional Council on Protection of Adana Cultural and Natural Funds the Beşparmak Island is considered as «protective zone of the 1st category in order to protect the habitation and reproduction territory of Mediterranean monk seals that are endangered species».

The land on the site is owned EUAŞ, Ministry of Finance and Ministry of Environment and Urbanization.

EUAŞ

The Board of Directors EUAŞ No 23-134 of 22.04.2011 and No 36-247 of 22.07.2011 Akkuyu NPP JSC passed 109 sites. Ownership of these sites by Akkuyu NPP JSC registered in the register of real estate Gülnar province. The right to use these sites for construction purposes should be provided under the Agreement on the right to build on. At the present time a draft of this agreement is being preparing.

The Ministry of Finance

Agreement was signed between the Ministry of Finance prior authorization and Akkuyu NPP JSC on 06.07.2011 for a period of one year of granting the right to conduct exploration work (with right of renewal for up to 4 years). The right of the construction work may be granted on the basis of final settlement, which will be issued by the Ministry of Finance in the performance of Akkuyu NPP JSC conditions of the Agreement on prior authorization.

The Ministry of Environment and Urbanization

Agreement was signed between the Ministry of Forestry prior authorization (the predecessor of the Ministry of Environment and urbanization) and Akkuyu NPP JSC on 04.07.2011 for a period of 24 months of granting the right to conduct exploration work. The right of the construction work may be granted on the basis of final settlement, which will be issued by the Ministry of Environment and urbanization in the performance of Akkuyu NPP JSC conditions of the Agreement on prior authorization.

Sea Area

Sea area adjacent to the site is not transferred to Akkuyu NPP JSC. The right to provide it belongs to the Ministry of Finance. Akkuyu NPP JSC appeal to the MENR/Ministry of Finance to request the transfer upon approval of the project area of coastal and hydraulic structures and determine their angular coordinates in the sea.

2.1.4 LAND USE

Out of all agricultural lands available in the area, unwatered arable farming takes 512.84 km^2, watered arable farming – 6.39 km^2. Except for a small amount of vegetables and fruits, they are grown for consumption by local farmers. The most widespread culture grown in the area is wheat. People engaged in crop husbandry cultivate various cultures for their own consumption and for the needs of local population. According to the data for the year 1999, wheat grown on 18 km^2 is mainly wheat of local varieties, and it is cultivated on non-productive lands. Besides, barley is cultivated where wheat cannot grow or where the yield is low or on highlands. Among the cultures cultivated for fodder, barley is the second after wheat. If we speak about other cultures, for corn, unlike wheat and barley, wet and marshy areas are preferable. Corn is grown for domestic market; in addition, each family involved in plants cultivation grows corn for domestic consumption. Besides wheat, which is the main culture, chickpea and corn are cultivated. Pulses include chickpea, beans, lentils, vetch and esparcet. Special place among these cultures is occupied by beans. It is cultivated for sale on domestic market in dry or fresh form. In terms of price and method of cultivation it is comparable with chickpea. It is cultivated, as a rule, in vegetable gardens and wet cultivated lands. Other bean cultures (alfalfa, vetch and esparcet) are cultivated in this area relatively recently, mainly as fodder cultures.

Near the Büyükeceli, Babadıl, Yanışlı villages fruits and vegetables are cultivated in green houses. Citrus fruit (oranges, tangerines, etc.) are grown. If we look at the fruit cultivation in the area, we may notice that tomatoes are here the major culture. In gardens, using poly-cultivation method, (better known as avar), tomatoes, pepper, aubergines, onion, zucchini, okra and garlic are grown in spring. Winter vegetables like carrot, cabbage, spinach, lettuce, turnip are cultivated in autumn. Areas allotted for orchards and other gardens may be regular and dispersed. The most grown fruit in the gardens are apples; they are followed by grapes, apricots, almonds, plums, lemons, oranges, pistachios, olives, cherry, figs, walnut, pears, peaches, etc. In the areas around regional center, growing of apples and almond is well-developed. The major part of the Akova, Demirözü environs is taken by apple trees. Due to high ground water, apple trees can grow without watering. In addition to apples, grapes cultivation is also important. Grapes cultivation is the only means of living for some families. The harvest of each product on arable lands is 1/15 and 1/10. Apricots are cultivated in Zeyne and its environs and their cultivation is increased towards the Göksü valley. The most part of the harvest is exported. Wild olive trees and wild carcass tree are grafted, which cause a growth in olive oil in pistachio production during the last years. In particular, noticeable increase in pistachio production is demonstrated in Kuskan, Arıkuyusu and their environs. On the coastal territory, cotton and algarroba are among important agricultural products.

Talking about land using, an important agricultural activity in the Gülnar region is animal husbandry, which mainly takes place on pastures, meadows and flat highlands. Each part of the region is occupied with animal husbandry. Goats are dominating among the leading livestock of small cattle. Climate and geographical structure are very convenient for goats breeding. In the last years however, cattle breeding is declining and sheep breeding took its place within it. Compared with goats, sheep are pastured on lowland and similar lands. In general sheep and goats are mainly pastured in the mountain and highland areas. These animals are mainly pastured in the villages of Köseçobanlı, Kayrak, İsaklar, Kuskan, Örtülü, Arıkuyusu. The largest portion of domestic cattle is cows. Domestic cattle breeding, in this region is mainly taking part on highlands. Areas, which are used as pastures, considerably declines compared with previous years.

Increase of agricultural areas takes place continuously, trees planting by the state and increase of living standards changed the nomad traditions as well as life style of the Yoruk people living in Sarıkeçili, Karatekeli, Karakoyunlu, Gebzeli. Within the region boundaries 200 households of the Sarıkeçili tribe continue their nomadic lifestyle. Living in tents all year round and breeding goats and sheep, the members of the Sarıkeçilis tribe migrate from the coast to the highland as soon as the weather becomes warmer. In general they spend winter in the coastal areas of Gülnar and in the environs of Anamur, Silifke. In summer time they live on highlands of Konya, Seydişehir, Beyşehir. Places where they spend winter months and where they migrate in spring depends on where there is better condition for the animals. Sarıkeçili get permission from the village. If permit is not granted, they pass by without stopping for temporary living. Their migration from the coast to the highland begins in April and takes 3-5 months. Hot summer days they spend on the Seydişehir, Beyşehir, Ermenek plateaus. Return from the plateaus takes place in October and November. And they again return to the coast. The Göksü valley is used as winter housing and road across the plateau. The route from Gülnar, Bozkır goes through Çukurasma, Arıkuyusu, Zeyne (Sütlüce), Mut, Karaman, Bozkır. Cattle drive from winter to summer pastures is concentrated in the environs of Köseçobanlı, Kuskan, İsaklar, Kayrak. Cattle breeding is accompanied with milk and dairy production. Milk farm is available in Zeyne (Sütlüce). Milk collected from nearby villages is delivered to milk farms located here and in Mut.

Thereby conclusion can be made that domestic area of nomadic population is beyond the 5.4 km emergency planning zone. Nomadic population flow through the emergency planning zone can be regulated by administrative measures.

Produced by primitive methods, butter, cheese and pressed curd are produced for domestic market. The area in the region is suitable for agriculture. Due to high elevation, variety of plants and different natural features of the surrounding area, in the region there are 1650 standard and 400 primitive (simple) beehives. The annual honey production is about 9 tons, part of which is used by beehives owners, and the other is solved in local markets such as Gülnar, Bardat. Even when using primitive means in domestic poultry farming, it also increases. Chicken and turkey hens prevail in domestic poultry farming. Every family is engage in domestic poultry breeding in order to meet its own demands in eggs and meat and remains are sold at the market.

The types of agricultural products grown in the agricultural lands around the project site within 5-8 km area is presented in the map given in Figure 2/7. The major agricultural production at this area is based on orchards and vegetable gardens and greenhouses for growing vegetables. Many types of vegetables are especially grown along the river sides because the topography is sloppy and suitable for especially forests. The major part of the area has already been covered by forests and only the areas that are rather flat and suitable for irrigation (proximity to the river) is covered with vegetable gardens and orchards. Dominantly tomatoes, melon, citrus trees such as lemon and mandarin, eggplant, trefoil, vegetable marrow, pepper, pistachios, olives, walnuts, almonds, apples, etc. are the main products grown at this region. There is no wheat, barley and oaf production.

Detailed data on areas of different agricultural types, animal production and fisheries, on dairy and meat farms, forecasts of possible changes in land use, and also routes of possible radiation exposure including food chain talking into account various population groups within 10 km area will be presented after performance of special investigations.

Seafood production area No.2 is located in 10 km zone, but beyond the boundaries of urgent protective action planning zone of 5.4 km established for all units of the NPP.

There are no milk households within the 10 km area.

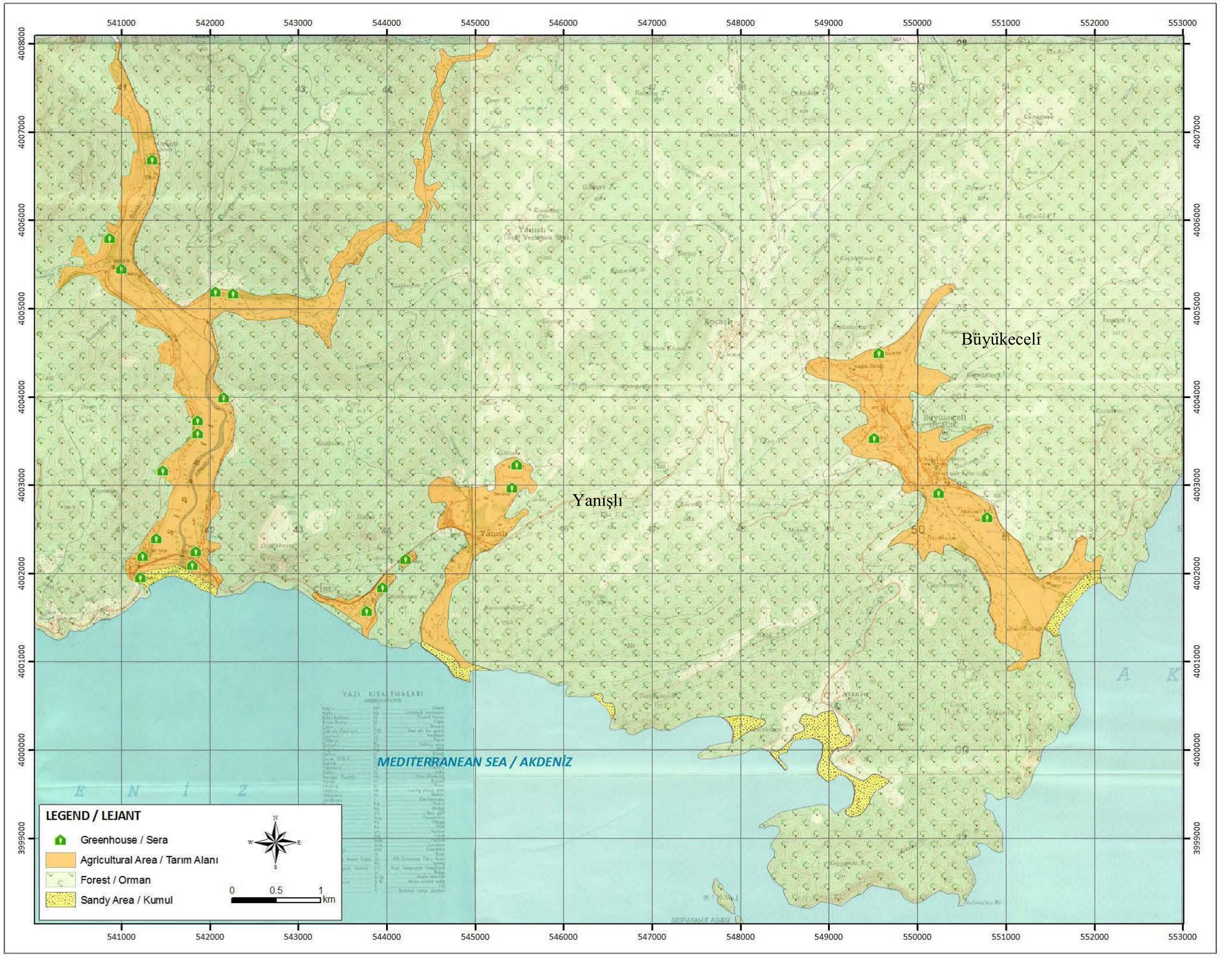


Figure 2/7 – Map Showing Agricultural Production in the Vicinity of Project Site

2.2 POPULATION

It is planned to construct the NPP in Akkuyu – area near the Büyükeceli village in the Mersin Province (vilayet). Büyükeceli village is located 3 km away from the Mediterranean coast and is a part of the Gülnar district, which is included in Mersin Province. The site is located near the Mersin-Antalya highway. The distance via the highway to Gülnar is 35 km, to Mersin – 140 km. The town of Gülnar is located 32 km inland, at a plain high in the Taurus Mountains. The road from central Anatolia to Anamur on the Mediterranean coast passes through this area. Mersin Province is located in the southern Turkey, on the Mediterranean coast between Antalya and Adana.

The administrative center of vilayet is the city of Mersin. The vilayet area is 15853 km^2. Earlier, vilayet was called İçel. In 2002 the vilayet was renamed as Mersin, after the name of administrative center. Mersin is surrounded by Karaman, Nigde, Konya, Antalya, and Adana vilayets. Today the city of Mersin is a large megapolis, and the vilayet itself, which includes 13 districts, 55 municipalities and 510 settlements, takes the 9 place in terms of population in the country. According to the census done in 2010, the population in the Mersin vilayet was 1647899 persons. 78 % of population (1281048 persons) are urban population, 22 % (366851 persons) – rural population.

Bozyazı and Aydıncık became districts in 1987, Çamlıyayla – in 1990, and Akdeniz, Mezitli, Toroslar and Yenişehir within the boundaries of Mersin metropolitan area became districts in 2008. Table 2/2 shows the districts, sub-districts, municipalities and settlements within the Mersin vilayet boundaries.

Table 2/2 – Regions Districts, Sub-districts, Municipalities and Settlements

District	Settlements	Sub- districts	Municipalities	Name of municipality
Akdeniz	8	-	1	Akdeniz
Mezitli	15	2	3	Mezitli, Fındıkpınarı, Tepeköy
Toroslar	32	5	6	Toroslar, Arslanköy, Ayvagediği, Güzelyayla, Gözne, Soğucak
Yenişehir	8	1	2	Yenişehir, Değirmençay
Anamur	37	2	3	Anamur, Çarıklar, Ören
Aydıncık	10	-	1	Aydıncık
Bozyazı	14	2	3	Bozyazı, Tekmen, Tekeli
Çamlıyayla	10	1	2	Çamlıyayla, Sebil
Erdemli	50	10	11	Erdemli, Arpaçbahşiş, Ayaş, Çeşmeli, Esenpınar, Kargıpınarı, Kızkalesi, Kocahasanlı, Kumkyu, Limonlu, Tömük
Gülnar	41	4	5	Gülnar, Büyükeceli, Köseçobanlı, Kuskan, Zeyne
Mut	90	1	2	Mut, Kuskan

District	Settlements	Sub- districts	Municipalities	Name of municipality
Silifke	66	8	9	Silifke, Akdere, Atakent, Arkum, Atayurt, Narlıkuyu, Taşucu, Uzuncaburç, Yeşilovacık
Tarsus	129	5	6	Tarsus, Atalar, Bahşiş, Gülek, Yenice, Yeşiltepe
Total	510	41	54	

Average age of people living in the Mersin vilayet is 29.9 years, density of population is 106 pers./km^2 (Table 2/3).

Table 2/3 – Average Age of Men and Women, Population Density

Vilayet	Average age	Men	Women	Population density, pers./km^2
Mersin	29.9	29.5	30.4	106

Data on population and demographical characteristics is based on data analysis of secondary sources given in [2/1], [2/2]. Secondary sources used in this survey include census data, geographical data (maps inclusive), state and local official statistics, documents of non-governmental and local organizations, and newspaper reports.

A significant part of the data given in this report is provided by the Turkish Institute of Statistics (TÜİK). The data on Turkish population are periodically updated, since new data are coming. Though the data provided by TÜİK, are the latest, they have a number of drawbacks. The data obtained from TÜİK, are mainly based on the information from the vilayet of Mersin on the whole. However, additional data were requested from TÜİK regarding the districts and settlements located in the direct vicinity to the plant site.

The population of vilayets, districts, municipalities and quarters is determined with consideration of the modification of administrative identity, legal entities and names registered by the General Directorate for Population and Citizenship Affairs (GDPCA) in the National Address Database (NAD) according to the applicable regulations and administrative registrars.

2.2.1 EMERGENCY PLANNING ZONE

Emergency Planning Zone (the urgent protective action planning zone)is defined as a circle of 5.4 km radiusaround Akkuyu NPP. Büyükeceli, Koçaşlı, Yanışlı settlements and the planned NPP residential settlement is located within this zone.

Emergency Planning Zone is shown in Figure 2/4. Sector map of Emergency Planning Zone, settlements and also topographic features of the region are given in Figure 2/8.

Total population within the Emergency Planning Zone is 1882 persons as per TÜİK data in 2010 year (Table 2/4).

Table 2/4 – Population within the Emergency Planning Zone (TÜİK, 2010) [2/4]

District	Sub-district	Village	Total number	Male	Female
Gülnar	Ovacık	Koçaşlı	72	32	40
		Yanışlı	133	71	62
		Büyükeceli	1677	859	818
Total			1882	962	920

When the NPP residential community (4500 people) is be set into operation total population will increase to 5950-6000 by 2017-2018.

Near Büyükeceli village there are several apartment complexes that are used for summer vacation such as Mavi Çini, Konyalılar, Tanya, Baha, etc. The project site is well-known for beautiful sea scenery and is opened for tourism. Due to this reason people from Ankara, Koni, Mersin, Camaran have built summer residential housing around this area and visit them in summer to spend vacations.

Büyükeceli and Yanışlı beaches are suitable for rest and touristic usage and are located within the Emergency Planning Zone. They are shown in Figure 2/7.

The major evacuation route is the D400 Adana-Antalya highway which is stretching along the Mediterranean Sea coast. Local roads that go far inland Antalya and also sea routes can be used for evacuation purpose

Such structures and organizations as schools, hospitals, prisons located in the Emergency Planning Zone, as well as assumed distribution of the population for future 50 year with an interval of 5 years, forecasts of changes in the population number in the structures and organizations located in the region will be submitted after the corresponding investigations are finalized.

2.2.2 POPULATION WITHIN 20-KM AREA

The population within 20-km areas from the project site is given in Tables 2/5-2/9, as per TUIK data in 2010 year.

Table 2/5 – Population within 0-10 km Area (TÜİK, 2010) [2/4]

District	Sub-district	Village	Total number	Male	Female
Gülnar	Ovacık	Koçaşlı	72	32	40
		Sipahili	400	200	200
		Yanışlı	133	71	62
		Büyükeceli	1677	859	818
	Merkez	Tepe	118	58	60
Total			2400	1220	1180

There is no population within the sector 5-7 km from the NPP.

Table 2/6 – Population in the sector of 7-9 km radius (TÜİK, 2010) [2/4]

District	Village	Distance from the site center, km	Population number
Gűlnar	Sipahili	7.68	400
	Tepe	8.27	118
Total			518

There is no population within the sector 9-11 km from the NPP.

Table 2/7 – Population in the sector of 11-13 km (TÜİK, 2010) [2/4]

District	Village	Distance from the site center, km	Population number
Gűlnar	Beydili	11.12	86
Silifke	Hirmanli	12.07	245
	Ovacik	12.54	979
	Keslitűrkmenli	12.66	251
Total			1561

There is no population within the sector 13-15 km from the NPP.

Table 2/8 – Population in the sector of 15-17 km radius (TÜİK, 2010) [2/4]

District	Village	Distance from the site center, km	Population number
Gűlnar	Dedeler	15.08	423
	Cavuslar	16.02	345
Silifke	Isikli	16.68	927
Total			1695

Table 2/9 – Population in the sector of 17-20 km radius (TÜİK, 2010) [2/4]

District	Village	Distance from the site center, km	Population number
Gűlnar	Emirhacı	17,03	63
	Tirnak	18.52	108
Silifke	Usakpinari	19.67	247
Aydincik	Eskiyűrűk	17.26	416
	Hacibahattin	17.80	121
	Yeniyűrűk	19.81	113
Total			1068

20-km radius zone also covers Aydıncık urban agglomeration with population of 9050 people, as per TÜİK data in 2010 year. There by, not taking into account the future NPP residential settlement about 15774 people lived within the 20-km radius zone in 2010. There are many small settlements in the mountain gorges. We suppose to use 10 % allowance to record this population.

There is data on population distribution for some settlements. The age distribution of the population within the 30 km area is shown in Table 2/10. The table shows the age indicating the adult population in percentage (65 years and older).

Table 2/10 – Population Distribution by Age in 30-km Area (TÜİK, 2010)

Sub-district	Village	Age group (%)													
		0 - 4	5 - 9	10 - 14	15 - 19	20 - 24	25 - 29	30 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	65+
Gülnar	Çavuşlar	*	19	24	32	*	*	*	17	23	30	18	30	25	87
	Çukurasma	27	38	66	77	38	37	33	47	41	54	50	44	37	106
	Dedeler	25	27	38	30	18	26	32	33	21	23	20	23	21	86
	Kayrak	46	60	62	70	43	47	48	47	38	52	34	38	42	116
	Şeyhömer	46	59	53	56	22	33	25	54	34	42	22	25	23	100
	Ulupınar	17	25	42	34	*	23	20	24	16	23	*	18	*	54
Silifke	İmambekirli	23	27	37	35	*	15	23	28	25	32	*	20	24	44
	Kargıcak	29	31	27	22	27	18	34	30	34	26	28	26	36	90
	Pelitpınarı	22	17	17	24	*	17	18	22	18	18	16	16	*	27
Aydıncık	Duruhan	21	15	26	31	18	30	*	24	*	20	17	18	32	90
	Eskiyürük	19	28	26	33	16	18	20	36	22	24	24	25	29	96
	Karadere	15	19	22	31	21	18	*	22	18	26	*	*	*	25
	Yenikaş	40	48	59	64	68	48	60	64	48	75	47	60	44	112

Population density depending on distance and direction from the site in 20-km zone is given in Table 2/11

Table 2/11 – Density of Population by Ring Sectors

Distance, km	W	WNW	NW	NNW	N	NNE	NE	ENE
0 - 10	-	27.1	-	-	9.7	85.4	-	-
10 - 15	-	-	-	3.5	-	-	10.0	39.9
15 - 20	3.5	4.6	12.1	11.4	18.4	12.3	27.0	-

The settlement’s distribution for areas within the sectors of 0-5, 5-7, 7-9, 9-11, 11-13, 13-15, 15-17 km and 17-20 km radius around the project site are shown in Figure 2/9.

Building and organizations that should be considered when planning emergency measures, supposed distribution of population for future 50 years via 5 year interval will be presented after performance of special investigations.

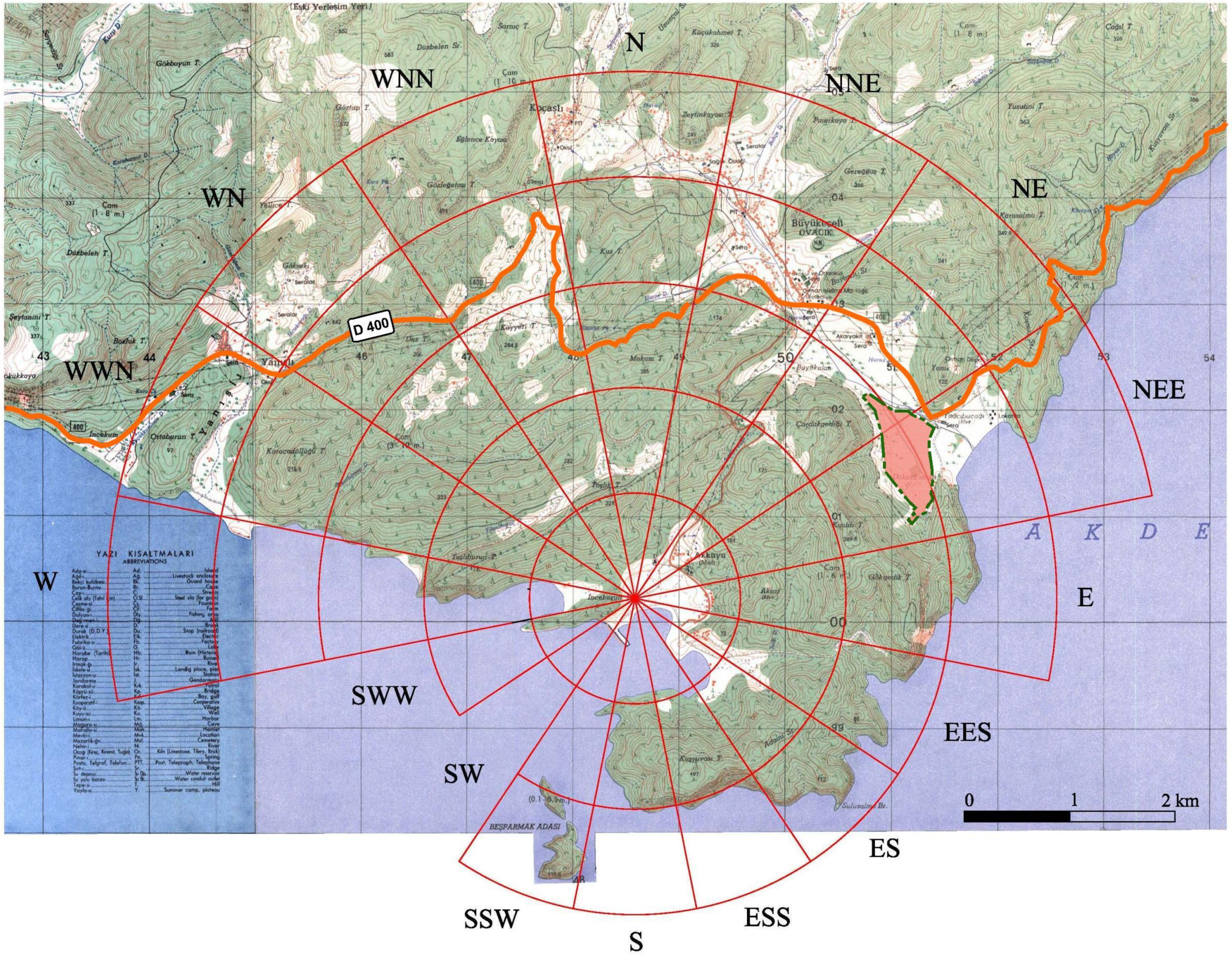


Figure 2/8 – Sector Map of Emergency Planning Zone

Figure 2/9 – Sector Map of 20-km Zone

2.2.3 POPULATION CENTER

Part of Aydıncık, Gülnar and Silifke districts of Mersin Province are located within the NPP 20-km area. The data regarding population in these district centers are provided in Table 2/12.

Table 2/12 – Population of District Centers (TÜİK, 2010) [2/4]

District Center	Male	Female	Total
Gülnar	4043	4035	8078
Silifke	26492	26659	53151
Aydıncık	4610	4440	9050

Relation between population in towns and villages to population of district centers is shown in Table 2/13.

Table 2/13 – Urban and Rural Population, persons (TÜİK, 2010) [2/4]

District	District center	Towns and villages	Total
Aydıncık	9050	2835	11885
Gülnar	8078	20473	28551
Silifke	53151	60951	114102

Relation of male and female population in the districts is given in Table 2/14.

Table 2/14 – Population in Districts, persons (TÜİK, 2010)[2/4]

District	Male	Female	Total
Aydıncık	6031	5854	11885
Gülnar	14221	14330	28551
Silifke	57208	56894	114102

The closest to the NPP site population center (with population more than 25000 people) is Silifke located 42 km north-east to the site.

Tables 2/15, 2/16, 2/17 show distribution of the population age groups in the Aydıncık, Gülnar, Silifke district centers.

Table 2/15 – Age Groups – Aydıncık, 2010

Age group	Population
0 - 4	844
5 - 9	914
10 - 14	1067
15 - 19	942
20 - 24	746
25 - 29	832
30 - 34	949
35 - 39	1051
40 - 44	817
45 - 49	914
50 - 54	580
55 - 59	530
60 - 64	487
65 - 69	359
70 - 74	336
75 - 79	289
80 - 84	168
85 - 89	45
90+	15
Total	11885

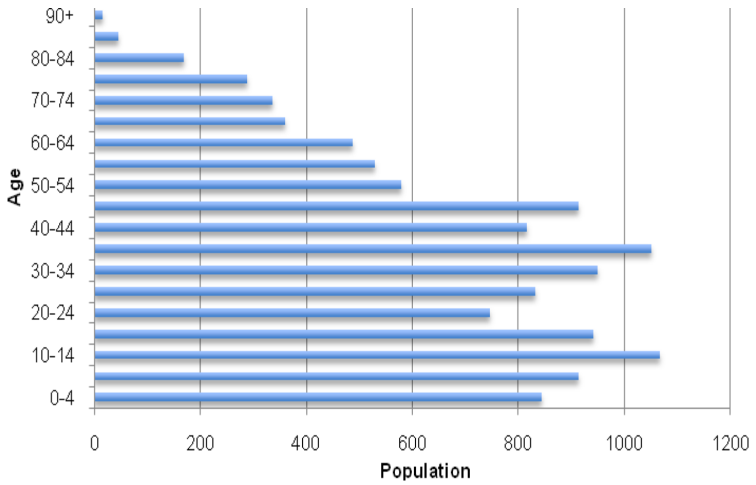


Table 2/16 – Age Groups – Gülnar, 2010

Age group	Population
0 - 4	1923
5 - 9	2126
10 - 14	2559
15 - 19	2352
20 - 24	1977
25 - 29	1897
30 - 34	1892
35 - 39	2058
40 - 44	1717
45 - 49	1945
50 - 54	1368
55 - 59	1450
60 - 64	1283
65 - 69	1254
70 - 74	1084
75 - 79	872
80 - 84	537
85 - 89	193
90+	64
Total	28551

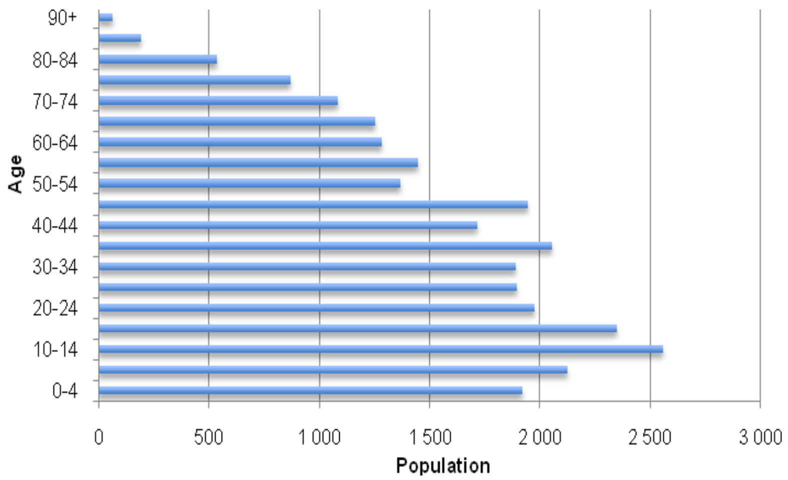
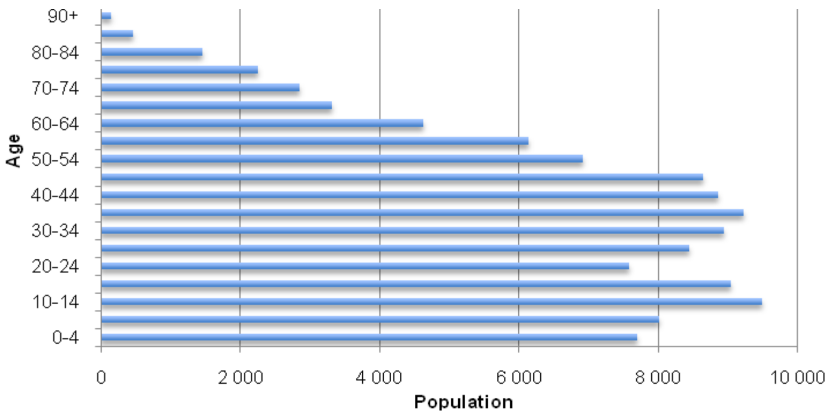


Table 2/17 – Age Groups – Silifke, 2010

Age group	Population
0 - 4	7697
5 - 9	8018
10 - 14	9499
15 - 19	9041
20 - 24	7588
25 - 29	8444
30 - 34	8944
35 - 39	9220
40 - 44	8859
45 - 49	8642
50 - 54	6925
55 - 59	6141
60 - 64	4622
65 - 69	3317
70 - 74	2846
75 - 79	2245
80 - 84	1461
85 - 89	456
90+	137
Total	114102



Annual population growth (‰) for villages is negative, but it is positive for province and district centers such as Silifke, Aydıncık (Table 2/18).

Table 2/18 – Annual Population Growth

Province and district	Population			Annual population growth (‰)		
	Total	Province centers and districts	Towns and villages	Total	Province centers and districts	Towns and villages
Aydıncık	11885	9050	2835	19.9	122.8	- 251.9
Gülnar	28551	8078	20473	- 64.1	- 34.0	- 75.7
Silifke	114102	53151	60951	6.1	28.0	- 12.5

2.2.4 POPULATION WITHIN THE 100 KM AREA

The population of the Mersin Province districts within 100 km area from the project site is represented in Table 2/19. The residential areas having a population more than 100 thousand within the 100 km radius are Silifke and Erdemli districts, Mersin Province. It is important to note that most of Erdemli is located within the 100 km radius. The major populated residential areas are within the borders of the three provinces (Mersin, Antalya and Karaman). Mersin has seven districts having a total population of 434477, Antalya has one district with a total population of 48525 and Karaman Province has three districts with a total population of 48536 as tabulated in Table 2/19.

Table 2/19 – Population of the Districts Within 100 km Area (TÜİK, 2010)[2/4]

Province	District	Total number	Male	Female
Mersin	Anamur	63062	31750	31312
	Erdemli	126538	63233	63305
	Gülnar	28551	14221	14330
	Mut	63607	31683	31924
	Silifke	114102	57208	56894
	Aydıncık	11885	6031	5854
	Bozyazı	26732	13429	13303
Karaman	Başyayla	4665	2361	2304
	Ermenek	30585	15434	15151
	Sarıevliler	13286	6759	6527
Antalya	Gazipaşa	48525	24484	24041
Total		531538	266593	264945

Some part of the Turkish Republic of the Northern Cyprus Island is within the 100 km area. Its territory includes north-eastern part of Cyprus Island with Girne, Gazimağusa settlements (Table 2/20).

Table 2/20 – Population of the Turkish Republic of Northern Cyprus Island within 100 km Area[2/3]

Settlement	Total number	Male	Female
Gazimagusa	63603	33781	29822
Girne	57902	32433	25469
Total	121505	66214	55291

The impact zone of 100 km including the Turkish Republic of Northern Cyprus Island is shown in Figure 2/10.

Figure 2/10 – Buffer Covering 100 km Radius

2.2.5 MIGRATION

There is no data for population movement on village level. The province has received heavy migration from every region of the country and especially from East and Southeast Anatolia. This situation has not only increased the population density of Mersin but has negatively affected urban development and increased the need for local services and requirements.

Among the most significant factors of internal migration in Turkey, one can point out factors such as a high population growth rate, industrialization, mechanization of agricultural production, shifts in land ownership, inadequate educational and health services, desire to break away from traditional social pressures and feuds in rural areas, as well as increased transportation and communication facilities. With the start of 1990s, mainly due to increased instability in Eastern and Southeastern Anatolian regions, compromised security and forced migration, population in villages started migrating first into nearby urban centers in the regions, then to larger urban centers to the west such as Adana, Mersin, Istanbul, İzmir and Bursa. Although Mersin appears to be an in-migration province throughout, the amount of in-migrating population has significantly dropped according to the last census of population. Effectively, migration out of Eastern and Southeastern Anatolian regions display a step-wise character: for example, Adana appears to be an in-migration province up to the 1995-2000 period, while during this last period it proves to be an out-migration province. Table 2/21 below shows in- and out-migration rate for Mersin 2010-2011.

Table 2/21 – Parameters of Migration in Mersin Province in 2010-2011, pers. [2/4]

Province	Population	Internal migration	Out migration	Net migration	Net migration rate
Mersin	1667939	51328	54630	-3302	-0.98 (%)

The cities, districts' and town's population and population movement are presented above. There is expected to be no increase in province's and district's population except general population trends. But it is obvious that there will be increase in the project region's population. It is considered that construction or operation of the project might affect the demographic structure of local communities. The results of the development activities, population growth and activities might be affected. This increase will vary according to the construction and operation processes. Approximately 10000 human power would be needed during project's construction period. It is thought that a workers village will be built in the project area and village's population will be approximately 3400 during project's operation process. In addition to this, it is possible to say that some new workplaces will be opened in order to meet the needs of people living in the area and population will increase.

It is predicted that the following demographic processes will take place:

– In-migration: People from other areas will move to the area to search new opportunities;

– Presence of temporary workers: There will be a short term influx of construction workers during the construction phase of the project. Another important factor to consider is that in Turkey, with its high levels of unemployment, any new project will lead to an influx of people to the area. It is therefore most likely that the area will experience an influx of people looking for jobs and new opportunities.

Capacity of recreation and tourism zones within 5 and 10 - km radius zones and related seasonal migration will be estimated at the next stages.

2.2.6 DISABLED POPULATION

Very scanty data is available about the disabled persons. In 2002 their portion was 12.16 % of the total number of the population in the Mediterranean area. In this area the portion of persons that are incapacitated due to disorders of supporting-motor apparatus, sight-, hearing-, speech-impaired, as well as mentally disabled persons is 2.60 %, and the portion of population disabled due to chronic diseases is 9.56 % (TÜİK, 2010)[2/4]. Table 2/22 gives the data about the number of disabled persons living in the NPP site area. The number of physically disabled population is higher than the number of other disabled population.

Table 2/22 – Disabled Population in the NPP Site Area

Settlement	Disabled population															
	Sight-impaired		Hearing-impaired		Non-speaking		Physically disabled		Mentally disabled		Other		With number of problems		Unknown	
	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.
Duruhan	5	1	5	1		1	8	2	1	1	1	3				1
Eskiyürük	8	2	1				4	6	1	3	7	6	5	8		
Hacibahattin	1						2	1								
Karadere					1		2	1		3						
Teknecik			1													
Yenikaş	6	3	2	1			8	4	2	3	1	1	3		1	1
Yeniyörük							3		1				2			1
Beydili							2								1	
Bozağaç	2							3	2	2	1		1			
Çavuşlar	3	1	1				4	4		5	2		1	1		
Çukurasma	2	3	2	1	1		6	1	3						1	1
Dedeler	3	3	4				8	7	2		1		2	1	1	
Delikkaya	4	1		1				3	1		2					1
Emirhaci	1	1					2	2					1	1		
Kavakoluğu					1											
Kayrak	4	2	2				7	4	1	3	1		1	1		
Korucuk	2	1					1		3	2	3	4				
Mollaömerli								1	1	1						
Şeyhömer	3	1			2		3	1	2			1				
Tepe	3	1					5	1	1				1			
Tirnak	4			1												
Ulupinar	1	2					2	1	1	2	2				2	

Settlement	Disabled population															
	Sight-impaired		Hearing-impaired		Non-speaking		Physically disabled		Mentally disabled		Other		With number of problems		Unknown	
	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.
Yassibağ	1						2	1	1		2	1		2		
Yenice													1	1		
Koçaşli	1						2	4		2						
Sipahili	1	1					1	3					1	2		
Yanişli		1			1		2									
Büyükeceli	5	2	2		1		15	9	3	2	2	3	1	3		2
Gökbelen							5	1	1			1		2		2
Imambekirli	1	2				1	1				2	1				
Kargicak	2		2				3	2	1		2		1			
Pelitpinari		1					2	1							1	

2.2.7 NUMBER OF PERSONS IN JAILS

According to TUİK data, the number of jailed persons is very insignificant (Table 2/23). Formal data, which can be obtained, are very limited.

Table 2/23 – Number of Persons in Jails

Year	Total	Closed-type jails	Open-type jails	Correctional facility for minors
2001	7	7	-	-
2002	7	7	-	-
2003	7	7	-	-
2004	7	7	-	-
2005	6	6	-	-
2006	6	6	-	-
2007	6	6	-	-
2008	6	6	-	-

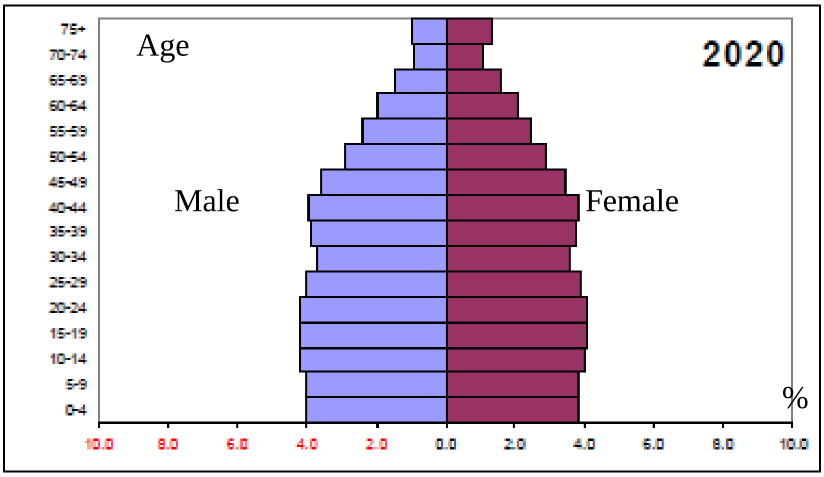
Source: TÜİK, Bölgesel Göstergeler 2010, TR62 Adana, Mersin

2.2.8 FORECAST OF DEMOGRAPHIC SITUATION

Turkish Institute of Statistics (Turkstat TÜİK) does not envisage prospective estimation of the population at the village level. Prospective estimations at this level in the area of the projected NPP require the performance of a detail analysis provided that the data collected during field studies are available. Prospective estimations of the Turkish Institute give a general idea about future population. The calculations are based on the assumption that the modern demographical trends will continue. It is anticipated that together with the modification of the age structure, the senior population with also acquired significance in Turkey in terms of social, demographic and economic indices. Senior population, calculated as 3.9 million persons, according to the year 2000 census, will comprise according to forecasts 19 % of total population by 2050. Figure 2/11 shows percent distribution of age groups by years of census and prospective estimation of the Turkish Institute of Statistics. Percentage variation of the age groups within the population during the period between 2000 and 2050 shows that we will have a considerable increase of senior population compared with other age groups. In 2050, the senior population of Turkey will be approximately 16 million persons [2/5].

The increase of resident population in the nearest region with account to NPP construction is expected. This increase is caused by size of the NPP staff (about 4500 persons) and initiation of accompanying social maintenance sphere (up to 15000 persons).

Perspective development of tourism in 20-km zone will be assessed at the next stages.



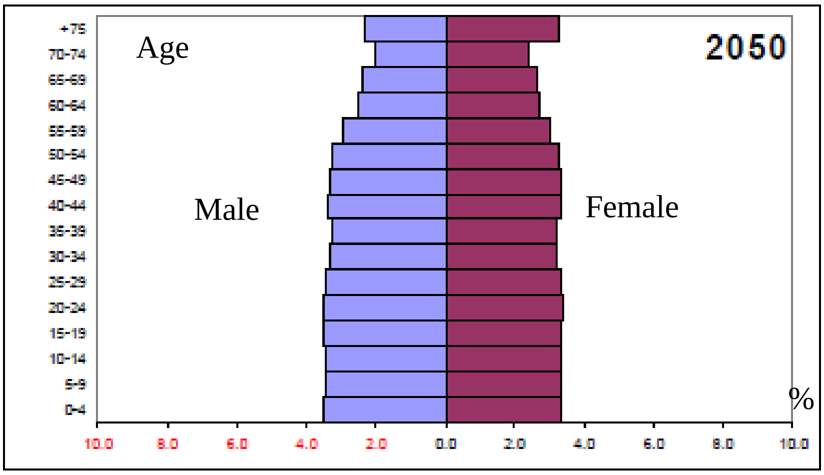


Figure 2/11 – Age Pyramid of Turkey for the Years 2020, 2050

2.3 CONCLUSION

The factors preventing the NPP placing have not been revealed.

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2/4 http://tuik.gov.tr

2/5 The Situation of Elderly People in Turkey and National Plan of Action on Ageing. State Planning Organization, Ankara. 2007

3. NEARBY INDUSTRIAL INSTALLATIONS AND ACTIVITIES

This chapter has been developed in accordance with Turkish Nuclear Regulations "Regulations on NPP sites" [3/1] and "Regulations on the format and content of the NPP site report" GK-GR-01 [3/2]. The purpose of this chapter is to identify potentially hazardous external sources on the Akkuyu NPP caused by human activity.

Technical report "Results of first priority engineering surveys. Volume 6 Anthropogenic Conditions of NPP Region and Site" [3/3] has been used as a main source of input data for this Chapter.

In order to obtain actual information about the facilities considered, letters with requests of necessary information have been sent to Turkish authorities, trade and industrial companies, and public organizations and their answers have been reflected in the Chapter 3.

Chapter 3 presents preliminary data on the natural and anthropogenic conditions of the Akkuyu NPP site, necessary for development of design documentation, and in amount sufficient for license application.

3.1 LOCATIONS AND ROUTES

3.1.1 SITE

The Akkuyu NPP site is located on seashore, inside a natural 2-3 km wide round valley, and is separated from the surrounding areas by a hilly terrain with elevations rising as height from 150 m (at passes) to 200 - 250 m and more.

This relief is a natural protection of NPP against external impacts, which source is located outside the valley (Figure 3/1), as well as provides for easy control of the access route to the site. This naturalvalley 2 - 3 kmwide is located withinthelimitsof site boundaries.

Within the valley there are neither warehouses of solid, liquid, gaseous highly inflammable, explosive, toxic or corrosive substances, oil-, gas- and products pipe lines, railways nor transit land roads, by which combustible or explosive materials, toxic or corrosive liquids might be transported.

Geological and natural-climatic conditions of the valley exclude an availability of coal and peat deposits.

There are no military objects, airports, industrial enterprises, residential areas, where inner explosions or fires are probable, or hazardous technologies are applied, where leaks of toxic or corrosive liquids are possible.

In the valley there are no buildings, structures, and storages with high pressure vessels or installations with gases or overheated liquids.

At the considered area there are neither gas pipelines, gas storages, or warehouses for chemically active substances, which may form gases or aerosols.

There are no enterprises using gases or gas-forming chemically active substances in their process, nor routes for transportation of gases or gas-forming chemically active substances.

The state road D400 is laid approximately 2.5 - 3.0 km away from the NPP. It is isolated from the site by a chain of hills.The site is connected with this transit highway by asphalt road approximately 4.5 km long.

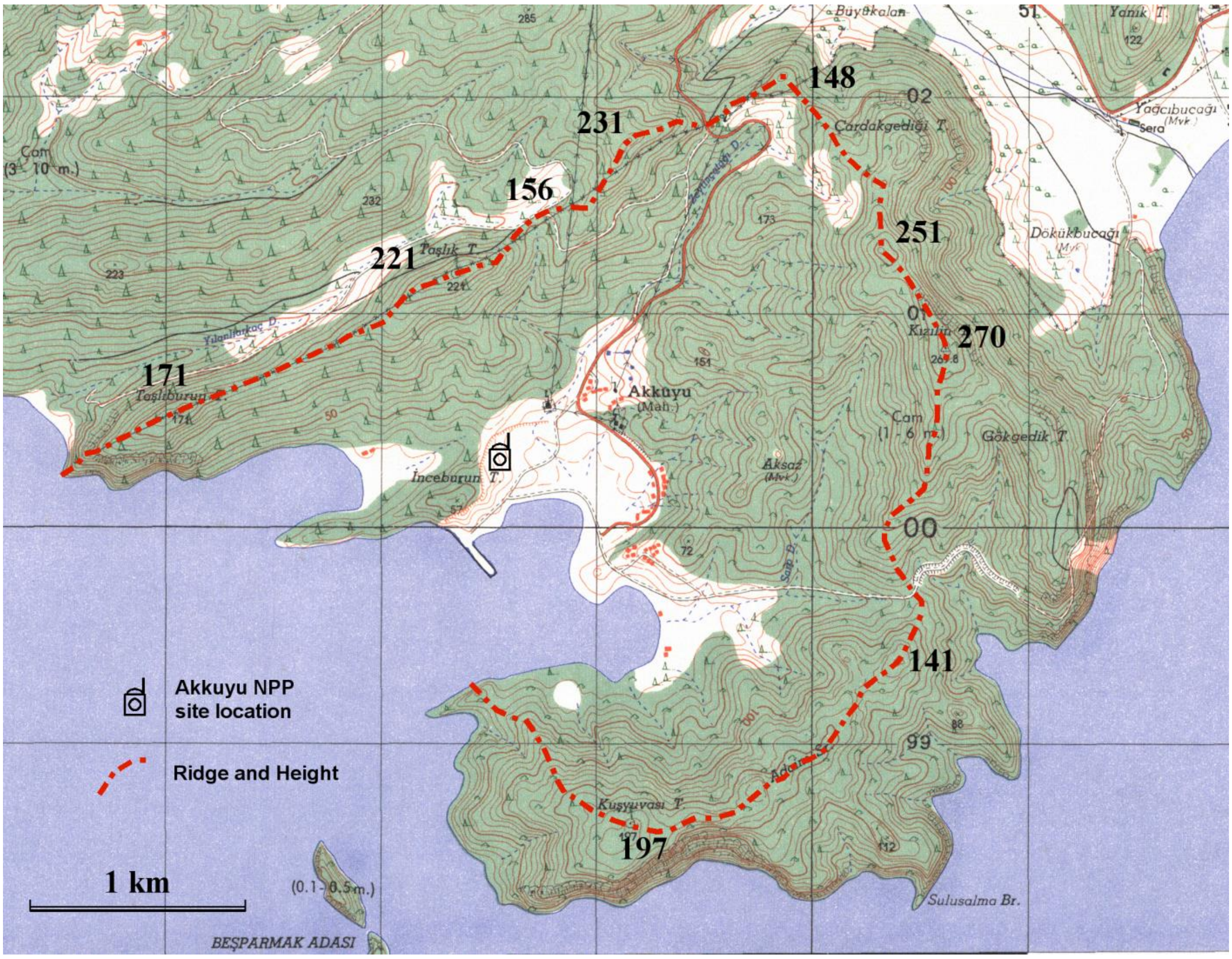

Figure 3/1 – Relief of site vicinity

3.1.2 SITE VICINITY

Beyond the described valley, in radius of approximately 10 km, there are no industrial facilities [3/3]. No sources of electromagnetic fields, generators of electromagnetic pulses or vortex currents are presented within the site vicinity.

The region of 10 km from the site is crossed by the state road Mersin-13 Bl Hd (D400 highway), span Hacıishaklı (km 120+000) – Yanışlı (km 139+000) [3/14]. This state road connecting Adana with Antalya via Silifke and Anamur. Traffic intensity as of 2010 is 2000 vehicles per day, number of motor cars is about 1200 [3/15]. Figure [3/2] provides the localities and routes in the vicinity of Akkuyu NPP site.

There are no railways and associated stations, storages, traffic interchanges within the 10 km zone [3/16]. There are no sea port and within the 10 km zone [3/22].

There are no military facilities within 10 km distance to the NPP.

Figure 3/2 – Locations and routes around Akkuyu NPP site

3.1.3 SITE REGION

Mersin, (province center) is located at a distance of some 140 km eastward from the site and the township of Gülnar is located approximately 37 km northward of the site.

The closest river, Göksu, is located 30 km northeast to the construction site. The closest harbors are situated in Mersin and Taşucu. The closest commercial airport to the site is located in the city of Adana approximately 200 km away.

3.2 FACILITIES

3.2.1 SITE VICINITY

According to the information, submitted by the authorities of Turkey in January 2012 [3/4-3/32], there are no industrial facilities within the NPP site vicinity (radius approximately 10 km).

Within the limits of 10-km zone there is Koçaşlı stone quarry. Totally within the limits of 10-km zone there are 13 sites, licensed for mining operations, among them one site is in exploitation, and works are planned at the other three sites. 64 sites more are at the different stages of minerals exploration [3/6].

In the radius of 10 km from the site there are noindustrial plants andstructures for gas and liquid fuel storage, and also no works are performed for the activity extension by means of such plants, or erection of new facilities [3/107, 3/118, 3/9].

In the region of 10 km from the site there are no potentially hazardous drilling objects, oil wells or similar structures [3/10]. However one permit for oil prospecting No AR/ATL/4874 has been released and the works are in progress [3/11]. Location of prospecting area with permit No AR/ATL/4874 according to 10-km zone is shown in Figure 3/3[3/12]. License was suspended within the territory where NPP site is allocated (within the fence) [3/13].

Near NPP site there are three base stations of Spectral observations Department [3/19]. They are under charge of Ministry of Transportation, Navigation and Communication [3/20]. However there are no sources of electromagnetic fields, electromagnetic pulsers, and eddy currents in the vicinity of the site [3/28, 3/29, 3/30, 3/31, 3/32].

There are springs, watercourses of temporary channels and a number of rivers within the 10 km area from the site, among these Babadıl or Sipahili River is prominent. A land reclamation and water control plan has been developed for the area between Gülnar and Sipahili [3/5].

The valleys of Babadıl River and temporary watercourse at the Büyükeceli village are separated from the site by a chain of hills and do not affect it. The same is true for the Sipahili dam.

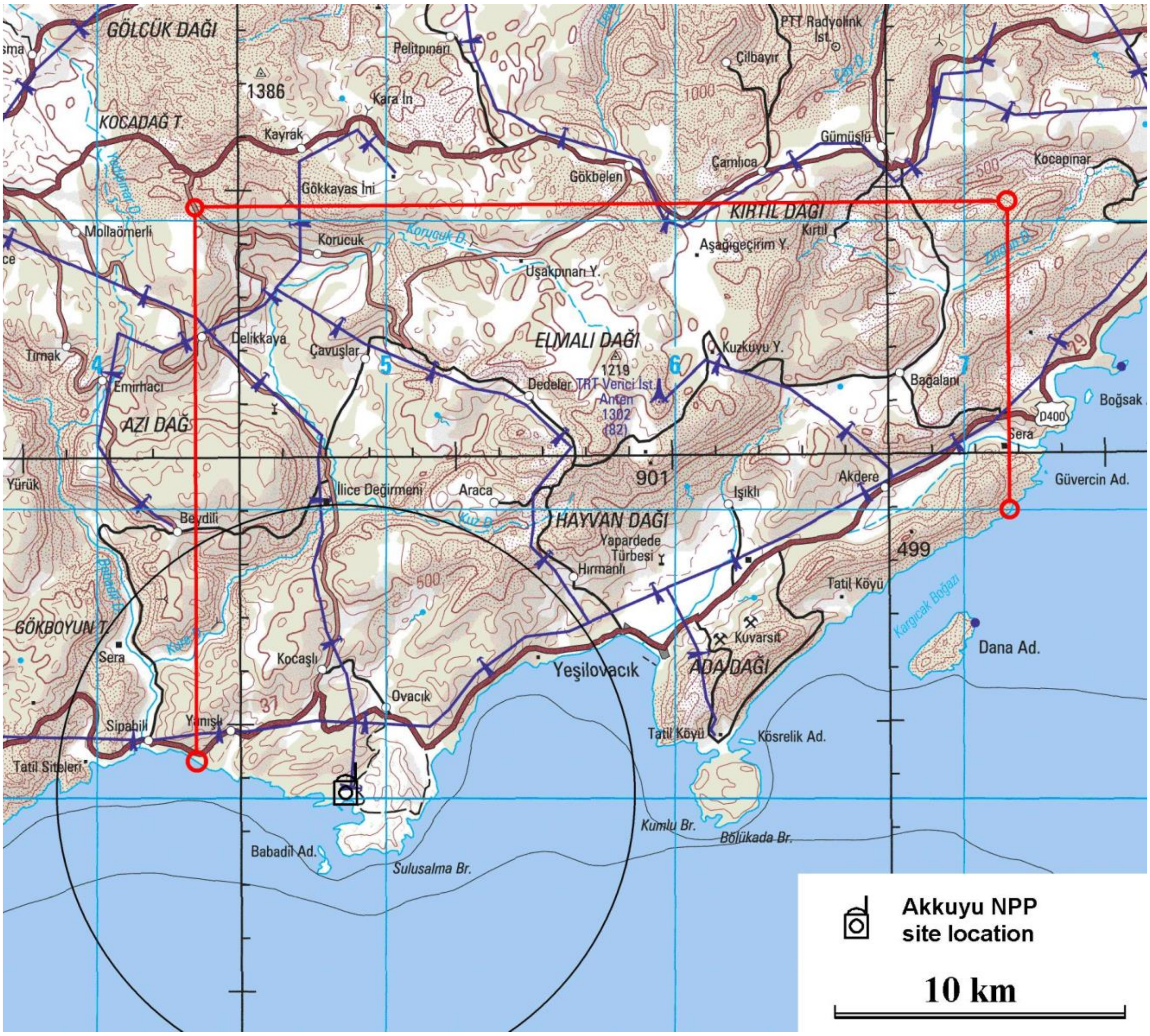

Figure 3/3 – 10-km Zone and Petroleum Exploration License Area

3.2.2 SITE REGION

Data on present industrial activity were requested from Mersin Province Directorate of Environment and Forestry. During 2006-2011 a number of industrial facilities were established in this region. Facilities mostly observed among these facilities are stone, marble and quartzite quarries. In addition to these, wastewater treatment plants (one in Atakent and one in Atık Quarter in Silifke), one cottonseed oil production facility and one ready-mixed concrete facility have been built. However, none of these facilities is within 10 km distance to the NPP. Akkuyu NPP site vicinity area is shown in Figure [3/4].

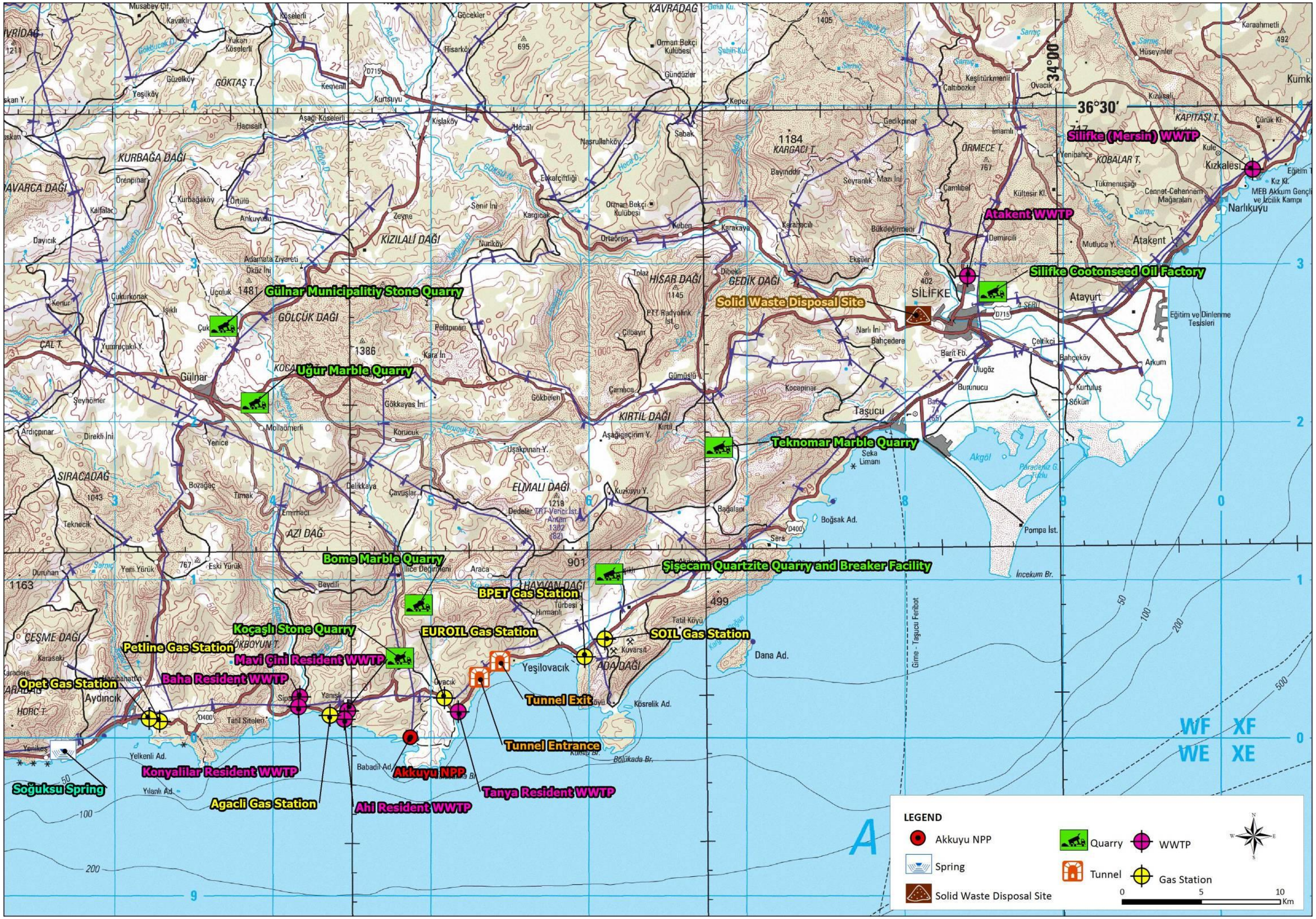

Figure 3/4 – Installations in the NPP construction site vicinity

Stone quarries and water-treatment stations in settlements are the only industrial installations within 30-km area from the site.The nearest important industrial facility is the pulp and paper factory (SEKA) which is located 35 km northward from the site in the town of Taşucu. Most of the industrial installations are concentrated between the cities of Mersin and Adana, more than 90 km away from the site.

There are no manufactured, stored and transported hazardous substances, and no equipment with rotating components capable of reaching the plant site in case of failure. Thus, there are no sources of human induced hazards that can impact the Akkuyu NPP site related to these facilities.

A list of facilities located in Silifke, Gülnar and Aydıncık, which have obtained a permit for effluents and releases during last five years has been requested within the context of Engineering Ecology Studies in The Directorate for Environment and Forestry of Mersin province. According to the response, received from an official body, such facilities are as follows:

- Şişecam Madencilik Sanayi ve Ticaret A.Ş;
- Uğur Soğutma Mak. Teks. Serigrafi Baskı Maden ve Mermer San. Ve Tic. A.Ş;
- Silifke Yağ Küspe Gıda Tarım Petrol Ürünleri İnş. San. E Tic. Ltd;
- Teknomar Mermer Madencilik San. ve Tic. Ltd. Şti. (IR: 7718);
- Teknomar Mermer Madencilik San. ve Tic. Ltd. Şti. (IR: 62462);
- Çimsa Çimento Sanayi ve Tic. A.Ş. Silifke Hazır Beton Tesisi;
- Teknomar Mermer Mad. San. ve Tic. Ltd. şirketine ait 62462 numaralı Ruhsat Sahası;
- Gülnar Belediye (Kalker Ocağı).

The closest railroad station is located in Mersin. Railroad via Yenice connects Mersin with Adana, further with Iskenderun, western provinces of Turkey, Syria, and Iraq. Another railway branch via Yenice connects Mersin with Central Anatolia and inner provinces of Turkey. Information on railway transportation at Mersin-Yenice segment is given in Table 3/1.

Table 3/1 – Train-kilometers by line sections

	Length of line, km	Suburban	Total of passengers	Mainline passengesr	Mixed trains	Freight	Service trains	Total
Yenice-Mersin	43,2	0	837,888	837,888	0	106,239	129	944,256

Source: Turkish State Railway, Annual Statistics (2006-2010), Ankara

Presence of railway allows carrying out goods transportation to Mersin port. Mersin Port is one of the biggest ports in the Mediterranean and Turkey where passenger and cargo transportation activities are conducted to all big ports in the world. Additionally, there are private harbors operated by Ataş Petroleum Refinery, Free Trade Zone, Petroleum Corporation and North Atlantic Treaty Organization (NATO). Passenger and cargo transport is conducted at Taşucu Port to Turkish Republic of Northern Cyprus Island.

The port has bulk cargo, container, Ro-Ro and oil terminals. Total 21 031 100 ton goods were loaded and unloaded in 2011 (see Table 3/2).

Table 3/2 – Loading - Unloading amounts in Mersin Port (Ton)

Year	Loading	Unloading	Total
2003	5 689 433	9 539 723	15 229 156
2004	5 335 867	11 186 599	16 522 466
2005	5 445 221	10 281 852	15 727 073
2006	6 676 683	9 406 697	16 083 380
2007	7 400 012	10 490 090	17 890 102
2008	7 668 196	7 057 519	14 725 715
2009	7 381 461	7 462 683	15 294 144
2010	9 454 114	8 956 183	18 410 296
2011	8 996 348	12 034 752	21 031 100

Source: http://www.mesbas.com.tr/Economical-Structure&59.html

The proximate military base is situated nearby Adana, approximately 150 km away. Reservoir oil tank TF-33 run by Ministry of Defense is located in Mersin about 80 km to north-east [3/9]. Pier for NATO military ships is located 30 km northeast to the site

3.3 PIPELINES

There are no oil-, gas-lines or pipelines of highly inflammable or explosive substances [3/107, 3/118, 3/9, 3/17].

3.4 ACTIVITIES

There are no industrial plants and structures for gas and liquid fuel storage within 10 km from the site, and also no expansion activities are performed by means of such plants, or erection of new facilities.There are no industrial facilities where internal explosions or fires are possible or dangerous technologies are applied, or flammable or toxic gas cloud can be initiated.

Two nearest to the site gasoline filling stations are located in Büyükeceli and Yanışlı [3/18]. They are located behind chain of hills and therefore can’t affect the site.

3.5 WATER LINES

10 km zone water area is actively used by fishing boats, tourist cutters, commercial yachts and high-speed motor-boats.

An overwhelming part of the shipping through the channel between Turkey and Cyprus Islandis executed by oil tankers from the Middle East region or belonged to the Iskenderun oil refinery.According to the Letter of Maritime Traffic Chief Management of Council for Marine Affairs under the Prime Minister of Turkish Republic [3/21]at present time shipping and transportation of hazardous materials has currently ceased and there are no coastal installations within 10 km area from the Akkuyu NPP site.

There is a fishing harbor "Yeşilovacık" located in the eastern part at a distance of 11.8 km, which is actively used by local people engaged in fishing [3/25]. The fishing harbor includes a conveyor belt and a place to moor the ships (for loading / unloading), as well as materials handling areas. The occupied area is 2125 m^2[3/22].

There is a fishing harbor "Aydıncık" located in the western part at a distance of 19.5 km, which is actively used by fishing, high-speed vessels and tourist boats [3/22].

There are no potentially hazardous objects, such as a mooring place, place of training and firing ranges, underwater pipelines and cables, and similar objects both within the offshore and coastal 10 km zone [3/4].

3.6 AIR CORRIDORS

There are no civil or military airports near the NPP site.

Within the 10-km area from the Akkuyu NPP site there are neither airfields, nor stations for air corridors support [3/23]. The proximate commercial civil airport is situated in Adana at a distance of approximately 180 km east to the NPP. There is also airfield in Gazıpaşa 110 km western of the site.

Air corridors W84/UW84, N135/UN135, UT38 (Figure 3/5) cross 10-km area [3/2824].

Air corridors are mainly used by wide-body civil aircrafts of Airbus and Boeing types in instrument flights within 24 hours.

Data on coordinates of these corridors (in WGS84 format) that cover 10-km radius zone of the Akkuyu NPP and also minimum flight altitudes are given below[3/25]:

a) for W84/UW84 corridors:

TARSU point 36° 37' 32" North - 34° 31' 14" East

MERAM point 36°02' 11" North - 33° 17' 13" East

Minimum flight altitude is FL100 (with variation with regard to local pressure value – in average approximately 10000 feet (3048 m) above sea level).

b) for N135/UN135 corridors:

NEKES point 36° 09' 13" North - 33° 17' 05" East

VESAR point 35° 54' 56" North - 34° 00' 58" East

Minimum flight altitude is FL130 (with variation with regard to local pressure value – in average approximately 13000 feet (3962.4 m) above sea level).

c) for UT38 corridor:

KETEK point 36° 53' 16" North - 32° 28' 42" East

VESAR point 35° 54' 56" North - 34° 00' 58" East

Minimum flight altitude is FL290 (with variation with regard to local pressure value – in average approximately 29000 feet (8839.2 m) above sea level).

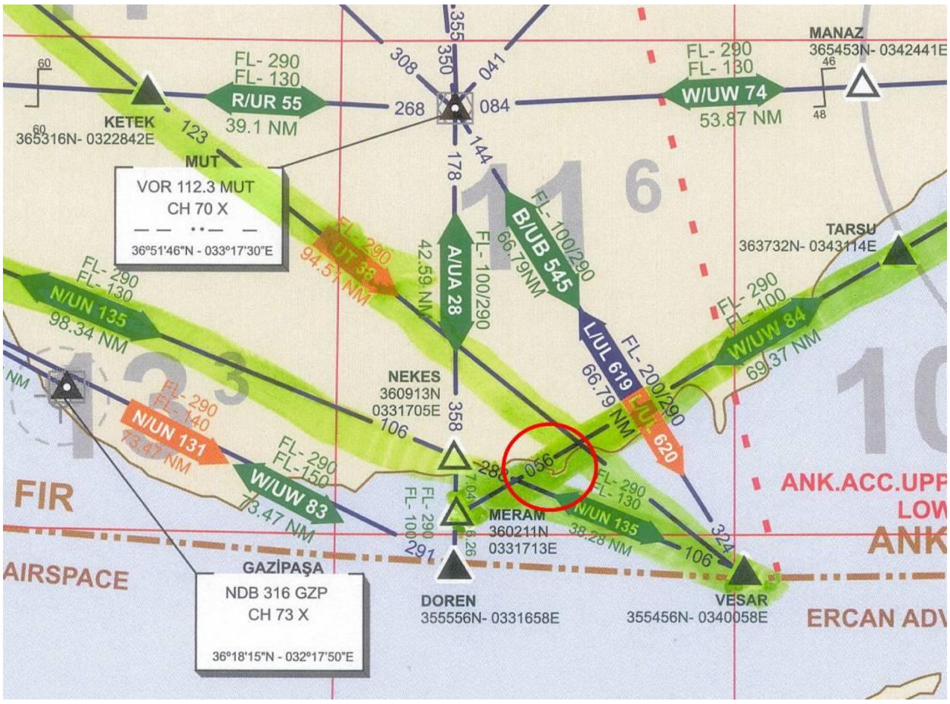

Figure 3/5 – Air Corridors of Civil Aircrafts

According to the information received from the General Staff of the Republic of Turkeythere is data about military aviation air corridors cross the 30-km zone 3/26.

3.7 INDUSTRIAL GROWTH PROJECTION

Request for construction of 510m pier to the outer side from the main part of breakwater in Yeşilovacık fishing shelter is approved [3/22].

State highway D400 is being reconstructed, number of lanes is increased, and some areas are straightened, including tunneling through mountains. However, since parts of two-lane mountain road will remain in the next years, the usage of D400 highway during the NPP construction will be minimal.

The General Directorate of Railways, Harbors and Airports Construction (DLH) is currently implementing the project of building railway Ankara-Konya-Silifke-Mersin. In 80-s of XX century the possibility of railroad Ankara-Konja-Silifke-Mersin construction was considered, but at the present time doesn’t carry out any works in order to implement this project [3/27].

No additional aviation routes and AST corridors are planned to open in the 10-km area form the Akkuyu NPP site [3/23].

3.8 CONCLUSION

Summing up the review of facilities and activities that may be considered as potential sources of hazardous external impacts on Akkuyu NPP site, it can be stated that from the perspective of human-induced hazards due to industrial facilities and transport the Akkuyu site conditions are favorable for construction of a NPP.

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3/13 Letter No B.15.1.PİG.0.10.04.00/99 330 from General Directorate of Petroleum Affairs, Ministry of Energy and Natural Resources, dated 19.01.2012

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3/15 Motorways and State roads traffic flow map, 2010 // General Directorate of highways. Department of strategy development, 2011 *http://www.kgm.gov.tr*

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3/30 Letter No.B.11.0.KUG.0.13.00.02-719/574. On engineering and risk assessment, from the Main Department for Road Transport dated.09.01.2012

3/31 Letter No.B.02.1.DNM.0.65.04.619/930. On engineering and risk assessment, from the Shipping Board of the Ministry of Transportation Maritime Affairs and Communication, dated.12.01.2012

3/32 Letter No.B.11.1.TCK.077.03.00-710.05-0023. On engineering and risk assessment, from the Main Department for motor roads of the Ministry of Transportation Maritime Affairs and Communication, dated.06.01.2012

4. METEOROLOGY

4.1 REGIONAL CLIMATE

The Akkuyu Nuclear Power Plant (ANPP) site is located in the south-eastern section of Turkey’s coasts along the Mediterranean Sea. The site is situated in the borders of Mersin Province. It is approximately 45 km west of Silifke and 66 km east of Anamur. The Akkuyu NPP site is a descending to the sea valley which is surrounded by small hills. The range includes the Bolkar Mountains, Aladağ Mountains, and Tahtalı Mountains from west to east. The site is at latitude 36° 08’ N and longitude 33° 32' E. A map showing the site with the neighboring area is provided in Figure 4/1.1.

Figure 4/1.1 – Akkuyu NPP Site Region

The general weather characteristics in the Mediterranean region are windy, mild and wet winters and relatively calm, hot and dry summers. The seasonal features are associated directly with the motion and development of the great pressure systems of the Atlantic, Eurasia and Africa[4/15].

In the cool season (from October to May) the main air stream bring arctic and polar air masses from the Atlantic or the continents of Europe and Asia. Arctic and polar air masses are rapidly modified by the warm sea surface. The most important property of Mediterranean air is that it is convectively instable. Heavy orographic rain may be generated from these air masses at the southern coasts of Turkey.

During the warm season (from June to September) the modifications which take place in the invading air masses producing Mediterranean air are rather different from those of the cool season. The air which flows into the Mediterranean area is mainly polar air from the northwest or north which has been warmed and dried in its passage over the European continent. As it moves it is cooled from the relatively cool sea. A low level inversion forms which induces some stability but above this inversion the air is convectively instable and in areas of active convergence showers and thunderstorms may develop.

The seasonal cycle in the site is well defined. July, August and September (JAS) are characterized by warm and dry weather in a large part of the basin as a consequence of a strong high pressure ridge extending from the subtropical high Azores. During JAS, the eastern Mediterranean is affected by an extension of the Indian Ocean summer monsoon depression.

In October the rainy season begins. The winter is characterized by cyclonic disturbances and low pressure in the Mediterranean with higher pressure to the east associated with the Siberian high [4/12].

During the spring, the rainy season continues. By May, the polar front and associated strong jet stream is sufficiently far to the north that its influence is diminished, and the subtropical highs and associated ridges once more exert their influence [4/2-4/4].

4.2 LOCAL METEOROLOGY

4.2.1 METEOROLOGICAL STUDY

Reference meteorological stations that are the basis for the characteristics of the climatic conditions of Akkuyu NPP site region are Silifke MS and Anamur MS. The distance to the NPP site, elevation, climatology, duration of observations, content of measured parameters, and sufficiency of available fund data were taken into account in the analysis. These stationary meteorological stations perform continuous observations; Silifke MS is located 46 km ENE and Anamur MS 66 km WSW from the site. Detailed characteristics of both meteorological stations are given in Table 4/2.1.

Table 4/2.1 – Characteristics of Reference MS

Station	Location	Distance from the site, km	Elevation, m	Observation period, years	Frequency of observations
Anamur	36°05'N 32°52'E	66	5	1981-2010	Hourly, Daily
Silifke	36°23'N 33°56'E	46	15	1981-2010	Hourly, Daily

Both meteorological stations were used to provide the database of input meteorological data for calculation of characteristics of meteorological regime of the region.

The nearest to the Akkuyu NPP site meteorological and radiosonding station is located in Adana. Air soundings are performed twice per day (00 and 12 UTC).

When evaluating the representativeness of the above mentioned stations to the NPP site the main information sources were the hourly surface meteorological measurements performed at the Anamur MS and Silifke MS within 2009-2010 years and the Akkuyu temporary MS – from June 2009 to the present time [4/1].

4.2.2 SOLAR RADIATION

The average solar radiation intensity for Anamur and Silifke stations are 368 and 389 cal/cm^2·day and the average sunshine duration is 7:55 and 8:06 h/d (Table 4/2.2).

Table 4/2.2 – Average Daily and Monthly Sunshine Duration, Average Solar Intensity and Maximum Daily Solar Intensity at Anamur (1970-2010) and Silifke (1985-2010) Stations

Month	Average Daily Total Duration of Sunshine, hour-min		Average Monthly Total Duration of Sunshine, hr		Average Solar Intensity, cal/cm²·day		Max. Daily Total Solar Intensity, cal/cm²·min	
	Anamur	Silifke	Anamur	Silifke	Anamur	Silifke	Anamur	Silifke
Jan	4:39	5:03	145.4	156.4	184.30	209.60	1.13	1.18

Month	Average Daily Total Duration of Sunshine, hour-min		Average Monthly Total Duration of Sunshine, hr		Average Solar Intensity, cal/cm²·day		Max. Daily Total Solar Intensity, cal/cm²·min	
	Anamur	Silifke	Anamur	Silifke	Anamur	Silifke	Anamur	Silifke
Feb	5:31	5:48	155.4	163.4	256.80	279.10	1.28	1.32
Mar	6:50	7:10	213.2	222.2	354.90	377.50	1.39	1.55
Apr	8:06	8:09	246.5	244.6	441.30	455.50	1.77	1.59
May	9:22	9:30	305.2	294.6	513.00	525.20	1.44	1.67
Jun	10:22	10:46	327.6	323.0	546.70	566.00	1.90	1.49
Jul	10:29	11:09	343.0	345.5	528.50	552.80	1.46	1.46
Aug	10:27	10:44	336.6	332.9	479.90	503.80	1.25	1.38
Sep	9:53	9:52	305.4	299.8	417.90	437.60	1.30	1.39
Oct	8:58	8:03	252.5	248.4	315.00	337.30	1.17	1.28
Nov	6:00	6:09	190.4	185.8	215.20	238.50	1.02	1.19
Dec	4:27	4:45	143.9	145.6	164.50	187.40	0.96	1.06
Annual	7:55	8:06	247.1	246.8	368.17	389.19	1.34	1.38

4.2.3 WIND

The average monthly variation in wind speed was determined using the data set from Anamur and Silifke Stations. Monthly averaged wind speeds are presented in Table 4/2.3. As it can be seen the lowest wind speed is observed during the summer months, and the highest wind speed observed at the winter.

Table 4/2.3 – Average Monthly Wind Speeds at Anamur and Silifke MS

Period, years	Wind speed, m/s			
	Anamur	Silifke	Anamur	Silifke
	1981-2010		1975-2009	
January	2.4	2.8	2.7	3.0
February	2.5	2.8	2.8	3.0
March	2.3	2.4	2.5	2.5
April	2.0	1.8	2.2	2.0
May	1.8	1.6	1.9	1.7
June	1.9	1.5	2.0	1.7
July	1.9	1.7	2.1	1.8
August	1.9	1.7	2.2	1.9
September	2.1	1.9	2.3	2.1
October	2.1	2.2	2.3	2.4
November	2.2	2.4	2.5	2.6
December	2.4	2.5	2.6	2.7

Period, years	Wind speed, m/s			
	Anamur	Silifke	Anamur	Silifke
	1981-2010		1975-2009	
Winter	2.4	2.7	2.7	2.9
Spring	2.0	1.9	2.2	2.1
Summer	1.9	1.6	2.1	1.8
Autumn	2.1	2.2	2.4	2.4
Year	2.1	2.1	2.3	2.3

The wind roses given in Figure 4/2.1 indicate that the majority of the winds at Anamur station are from the NNW - NNE, with somewhat lesser winds from the SSW. Winds from the other directions are the least frequent. For Silifke station, there is a difference. The dominant wind pattern is from WNW-NNW direction. The differences of the dominant wind patterns are mainly due to the local topography.

The directional mean wind speed variations could be seen in Figure 4/2.2. At Anamur station, when the wind is blowing from ENE-W sections, the wind speed is above 2 m/s, from the rest of the sections, it is below 1.5 m/s. The highest wind speed is observed from SW winds.

The wind speed is relatively lower at Silifke station. The long term annual mean wind speed is around 2.1 m/s and it is almost constant all over the wind sectors.

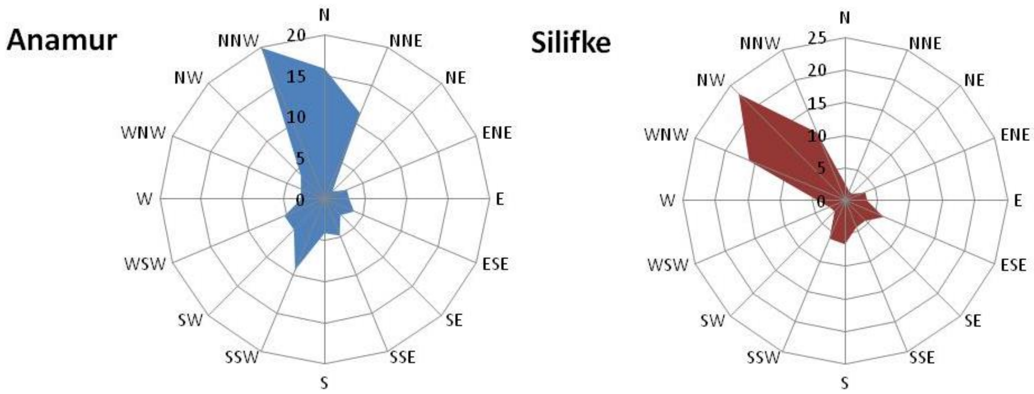


Figure 4/2.1 – Wind Roses for Long-Term Period at Anamur and Silifke.

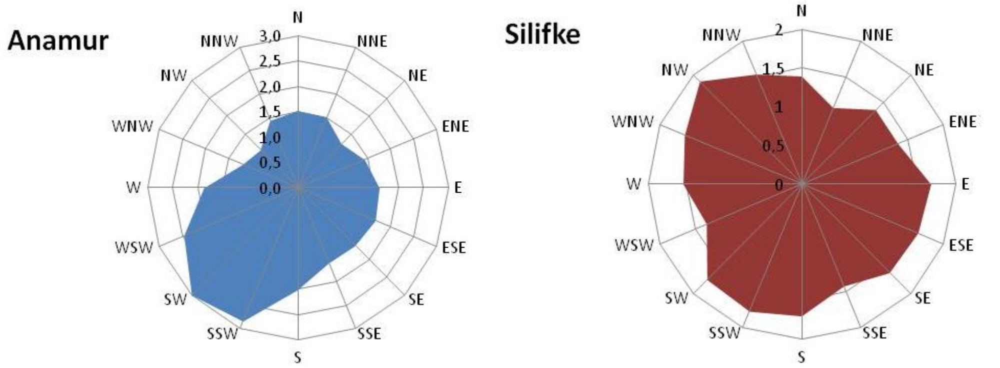


Figure 4/2.2 –Long-Term Average Wind Speeds in Rhumbs for Anamur and Silifke.

Wind roses during dry and wet seasons are shown in Figure 4/2.3.

During the dry season 36.1 % of all winds were from NNW through NE and 28.4 % were from SSW through WSW at Anamur station, and 36.5 % from WNW through NNW and 34.3 % were from SSW through SE at Silifke stations during 1970-2010 period.

During the wet season predominant winds are from northerly directions. Approximately, 60 % of the winds are from WNW through NNW sections at Silifke and from NNW through NNE sections at Anamur stations.

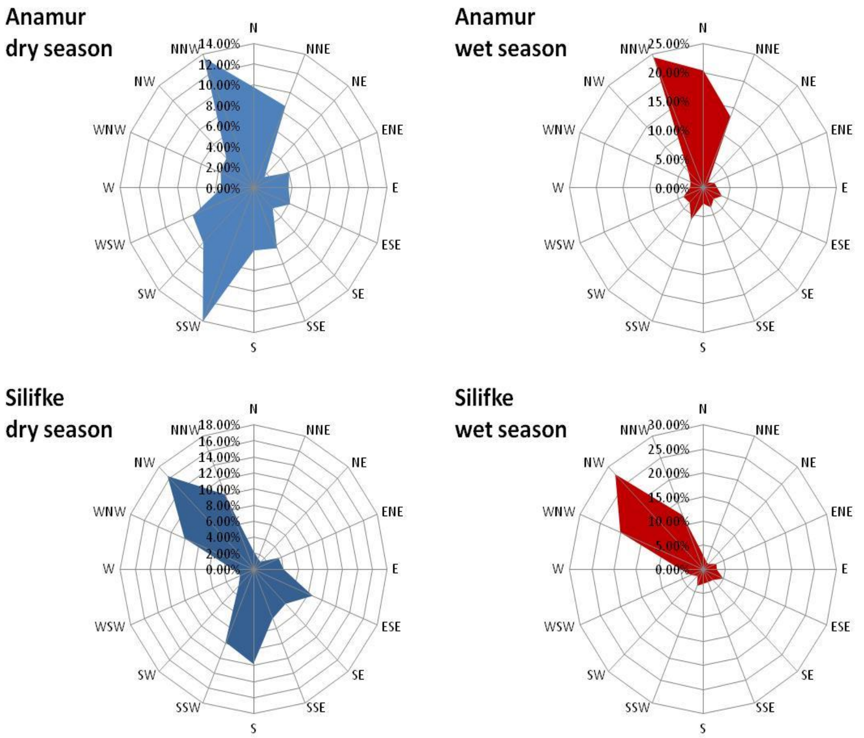


Figure 4/2.3 – Wind Roses for Dry and Wet Seasonsat Anamur and Silifke.

Figure 4/2.4 illustrates variation of wind velocity in time during 1975-2009 at both stations. Wind velocity at both stations changes during each year synchronously: during the winter it increases, in summer – decreases.

The last-30-year observations demonstrated that the wind speed decrease by 5-50% in the northern middle latitude resulted from alterations of the average circulation indicators and decrease of the synoptic systems power. Growth of the underlying terrain roughness in weather station locations has also contributed to the air flow velocity decrease [4/22].

Y.Ünal, S.Incecik (2012) have studied the surface winds and the upper winds during the last 30 years in ten Turkish cities and concluded that also there is a wind velocity decrease [4/23].

The wind velocity reduction trend during the period considered is due explained by increase of construction around meteorological stations. It can be clearly seen that starting from about 1995 when the construction process was completed the wind velocity at the meteorological stations has not been decreasing and is constant.

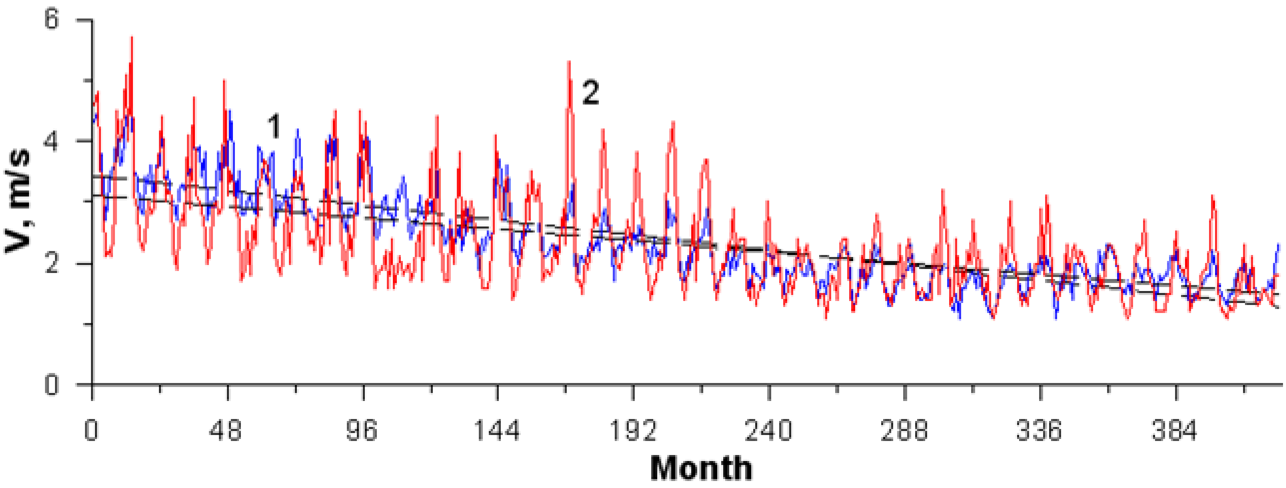


Figure 4/2.4 – The Temporal Variation of Average Monthly Wind Speeds at Anamur (blue line - 1) and Silifke (red line - 2) for 1975-2009

Values of annual maximums of wind velocity and respective wind directions per daily data are given in Table 4/2.4.

Table 4/2.4 – The Annual Maximums of Wind Speeds (m/s) and Corresponding Wind Directions (Degree) for 1975-2009at Silifke and Anamur.

Year	Silifke MS		Anamur MS	
	V_{max}	*D*	V_{max}	*D*
1975	26.3	315.0	29.5	225.0
1976	30.2	337.5	27.4	360.0
1977	26.4	292.5	25.6	337.5
1978	23.9	292.5	32.6	225.0
1979	28.0	292.5	30.0	292.5
1980	24.0	315.0	34.9	202.5
1981	21.0	315.0	25.0	360.0
1982	27.4	315.0	23.2	292.5
1983	24.1	337.5	25.8	22.5
1984	25.8	67.5	24.3	247.5
1985	27.9	337.5	22.8	270.0
1986	24.2	337.5	23.7	270.0
1987	27.0	337.5	17.7	112.5
1988	28.6	337.5	18.8	225.0
1989	28.6	360.0	18.4	337.5

Year	Silifke MS		Anamur MS	
	V_{max}	D	V_{max}	D
1990	30.3	292.5	24.0	337.5
1991	27.6	315.0	14.7	360.0
1992	22.2	315.0	18.9	360.0
1993	26.2	315.0	18.4	360.0
1994	24.5	315.0	15.6	270.0
1995	20.8	315.0	14.2	247.5
1996	18.8	270.0	14.5	90.0
1997	19.2	292.5	16.6	90.0
1998	21.1	292.5	18.4	337.5
1999	20.0	315.0	17.8	225.0
2000	21.7	315.0	17.1	315.0
2001	20.3	315.0	16.7	157.5
2002	21.5	315.0	15.6	202.5
2003	26.8	270.0	22.8	360.0
2004	24.2	315.0	18.0	202.5
2005	15.2	315.0	14.4	360.0
2006	17.0	315.0	17.2	202.5
2007	17.9	292.5	20.5	360.0
2008	20.1	292.5	17.2	360.0
2009	15.7	292.5	15.8	360.0

The maximum recorded wind speed is 34.9 m/s from SSW at Anamur station and 30.3 m/s from WNW at Silifke station. Average monthly number of days with wind speed equal or higher than 10.8 m/s and 13.9 m/s [4/1] is given in Table 4/2.5.

Table 4/2.5 – Average Monthly Number of Days with Wind Speed ≥10.8 and ≥13.9 m/s

Period	Average number of days with wind speed ≥10.8 m/s		Average number of days with wind speed ≥13.9 m/s	
	Anamur	Silifke	Anamur	Silifke
Jan	6	11	3	5
Feb	5	11	2	5
Mar	5	11	2	5
Apr	4	8	1	4
May	3	5	1	3
Jun	3	5	1	3
Jul	3	6	1	4
Aug	2	6	0	3
Sep	2	7	0	3
Oct	2	8	1	4
Nov	4	7	2	3
Dec	5	9	2	4
Annual	45	92	15	46

Calm winds (<0.5 m/s) frequency during the years 2009-2010 is 6.8 % at Silifke and 9.7 % at Anamur station.

Average and maximum duration of calms were calculated from the hourly wind data for the years 2009-2010. At Anamur station, 35 % of the calm conditions last 1 hour, 14 % last 2 hours and 5 % last 2 consecutive hours whereas at Silifke station the corresponding values are 32 % (1 hour), 11.7 % (2 hours), 3.6 % (3 hours), 2.4 % (4 hours). Max uninterrupted duration of calms is 7 hours at Anamur and 12 hours at Silifke stations during the years 2009 and 2010. Within 2009 and 2010 years, based on daily average wind speed data upper 5 % of wind speed levels at Anamur and Silifke stations are 1.8 m/s and 1.4 m/s respectively.

Calm conditions (calm or weak winds < 2 m/s) occur at Anamur and Silifke stations around 57-58 percent of the time. The highest percentage of calm and weak winds was observed during the summer season and the lowest at winter season.

4.2.4 AIR HUMIDITY

The average annual relative humidity at Anamur station is 71 %; it is 60 % at Silifke station.

Monthly average relative humidity per observation terms is given in Table 4/2.6.

The relative humidity in the time of the day with highest temperature(14:00) ranges between 60-69 with a mean value of 65 % at Anamur; between 46-57 with a mean value of 51 % at Silifke. During summer months, the mean relative humidity at this time of the day is 67 and 57 % at Anamur and Silifke stations, respectively. During the winter months, the relative humidity levels during the hottest time of the day decreased down to 63 and 49 % at Anamur and Silifke, respectively.

Table 4/2.6 – Relative Air Humidity at 07 a.m., 02 p.m. and 09 p.m, Average and MinimumAir Humidity1975-2009

Parameter	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Relative humidity f, %,Average and Minimum Air HumidityAnamur MS												
07 a.m.	75	74	75	77	77	77	76	76	69	67	70	75
02 p.m.	64	64	65	68	69	70	67	68	63	60	61	64
09 p.m.	77	76	78	79	81	78	76	77	73	71	74	77
$\overline{f}$	72	71	73	75	76	75	73	73	69	66	68	72
f_{min}	7	6	13	9	17	14	7	11	15	6	4	13
Relative humidity f, %, Average and Minimum Air Humidity Silifke MS												
07 a.m.	62	62	65	69	70	67	66	65	59	56	60	62
02 p.m.	50	49	50	53	54	56	57	58	52	47	47	51
09 p.m.	62	63	67	70	72	73	74	74	67	63	62	63
$\overline{f}$	58	58	61	64	65	65	66	66	59	55	56	58
f_{min}	10	5	8	11	13	4	9	12	12	2	7	8

For the period 1975-2010, the average number of days in a month with relative humidity 30 % and lower are shown in Table 4/2.7 for Anamur and Silifke stations. The total number of days with less than 30 % relative humidity levels was 316 and 1210 at Anamur and Silifke stations respectively. Average number of days with less than 30 % for a total of 35 years period is 316 days/35 yr= 9 days/yr at Anamur station and 1210 days/35 yr=35 days/yr at Silifke Station.

Table 4/2.7 – The Monthly Average Relative Humidity Values for less than 30 % and more than 80 % at Anamur and Silifke Stations for the Period 1975-2010 Years.

Month	Number of days with relative humidity			
	Less than 30 %		More than 80 %	
	Silifke	Anamur	Silifke	Anamur
Jan	144	47	104	254
Feb	121	33	71	217
Mar	113	16	51	231
Apr	87	15	46	280
May	59	15	22	340
Jun	31	31	8	351
Jul	30	41	3	304
Aug	29	23	5	267
Sep	94	8	4	153
Oct	186	22	28	125
Nov	189	28	65	146
Dec	127	37	105	246
Total	1210	316	512	2914

Table 4/2.7 also contains information about monthly total number of days with relative humidity higher than 80 % in the hottest daytime for Anamur and Silifke stations. The relative humidity levels were higher at Anamur station. The number of days with 80 % and higher relative humidity levels is significantly higher than Silifke station. Total number of days with 80 % and higher relative humidity levels during the hottest time of the day is 2914 and 512 at Anamur and Silifke stations, respectively. The average number of days with higher than 80 % for a total of 35 years period is 2914 days/35 yr=83 days/yr at Anamur station and 512 days/35 yr=15 days/yr at Silifke Station.

The time dependence of average monthly relative air humidity in 1970-2009 is shown on Figure 4/2.5. It is evident, that humidity at the coastal Anamur MS was in average higher than at Silifke MS located at some distance from the sea. In middle of the nineties humidity at both stations differed insignificantly.

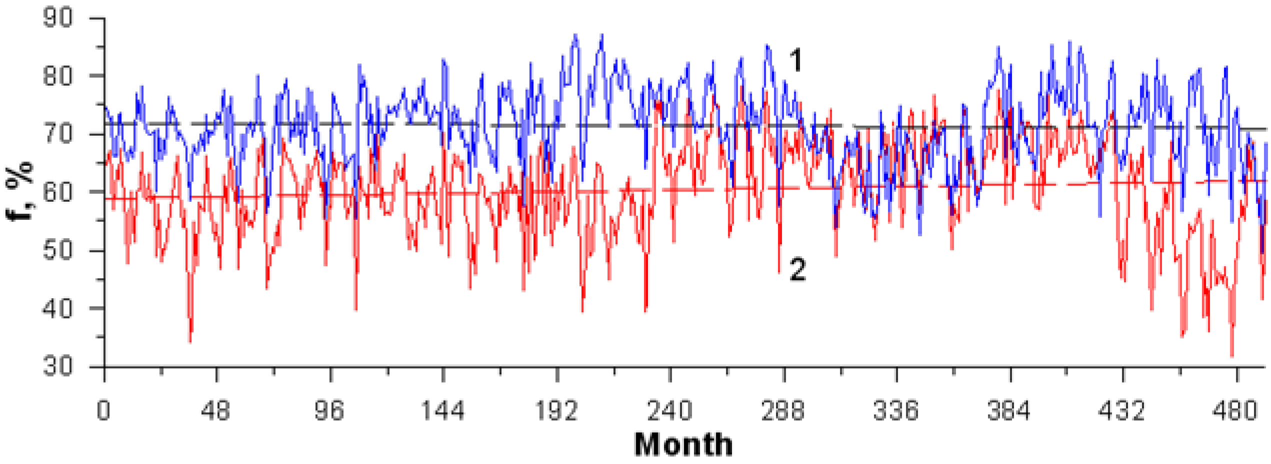


Figure 4/2.5 – Time Dependence of Relative Air Humidity as per Anamur (blue line - 1) and Silifke (red line - 2) Data), 1970-2009

4.2.5 PRECIPITATION AND SNOW COVER

The monthly average and annual total precipitation amounts for the past 40 years are presented in Table 4/2.8.

Table 4/2.8 – Variation of Monthly Average Precipitation for 1970-2010 Period at Reference Stations.

Station	Months												Annual Total
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Anamur	186	141	88	53	23	6	1	4	14	73	138	199	926
Silifke	104	80	54	32	24	10	5	4	10	38	88	125	574

The maximum average monthly precipitation of 199 mm observed at Anamur station is occurring during December within the last 40 year period, at Silifke station – it is 125 mm which was observed again in December. The average number of days with precipitation ≥0.1 mm from

1970 until 2010 is 74.2 at Anamur and 60.8 at Silifke stations. Only 3.5 % of rainy days, the precipitation is above 30 mm at Anamur station, and 2 % of rainy days are above 30 mm at Silifke station. Long term monthly number of days with rain intensity reaching 0.1, 10, 30 and 50 mm is given in Table 4/2.9

Table 4/2.9 – The Monthly Average of RainyDayswith 0.1, 10, 30 and 50 mm and Maximum Precipitations at Anamur and Silifke for 1981-2010 period.

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anamur Station												
Max. precipitation, mm	129.3	91.4	89.7	76.2	94.0	28.9	1.9	13.7	41.6	90.5	150.8	113.4
Mean number of days with precipitation >0.1 mm	12.9	11.2	9.2	7.0	3.5	1.4	0.3	0.3	1.6	5.5	8.9	12.4
Mean number of days with precipitation >10 mm	5.5	4.4	3.0	1.4	0.6	0.2	-	0.1	0.3	1.9	4.3	5.6
Mean number of days with precipitation >30 mm	0.6	0.4	0.2	0.1	0.0	-	-	-	0.0	0.2	0.4	0.7
Mean number of days with precipitation >50 mm	0.5	0.3	0.1	0.1	0.0	-	-	-	-	0.2	0.4	0.7
Silifke Station												
Max. precipitation, mm	139.5	92.6	56.4	42.1	72.5	25.8	27.2	31.9	39.0	50.3	125.4	127.8
Mean number of days with precipitation >0.1 mm	9.8	9.1	7.0	6.2	4.3	1.3	0.5	0.2	1.1	4.7	7.1	9.5
Mean number of days with precipitation >10 mm	3.7	2.6	1.6	0.8	0.7	0.2	0.1	0.0	0.3	1.2	3.0	4.1
Mean number of days with precipitation >30 mm	0.2	0.1	0.1	0.0	0.0	0.0	-	0.0	0.1	0.3	0.3	0.0
Mean number of days with precipitation >50 mm	0.2	0.1	0.0	-	0.0	-	-	-	-	0.0	0.4	0.4

Number of days with precipitation for 24 hours within different range is given in Table 4/2.10.

Table 4/2.10 – Number of Days with Precipitation by Months and Year, Period of 1975-2009

Month	Precipitation h, mm						
	>0.1	>0.5	>1	>5	>10	>20	>30
Silifke MS							
Jan	10.4	9.3	8.5	5.6	4.0	1.7	0.6
Feb	9.3	8.2	7.3	4.4	2.7	1.2	0.5
Mar	7.5	6.4	5.7	3.0	1.7	0.7	0.4

Month	Precipitation h, mm						
	>0.1	>0.5	>1	>5	>10	>20	>30
Apr	6.5	4.7	3.9	1.7	0.9	0.4	0.1
May	4.2	3.0	2.3	1.2	0.6	0.3	0.1
Jun	1.2	0.8	0.6	0.3	0.2	0.1	-
Jul	0.5	0.4	0.3	0.2	0.1	-	-
Aug	0.2	0.1	0.1	-	-	-	-
Sep	1.0	0.7	0.6	0.4	0.2	0.1	-
Oct	4.5	4.0	3.4	2.0	1.3	0.7	0.4
Nov	6.8	5.9	5.3	4.1	2.9	1.6	0.9
Dec	10.1	8.9	8.1	5.5	3.9	2.0	0.9
Year	62.3	52.3	46.1	28.4	18.7	8.8	4.1
Anamur MS							
Jan	13.6	12.1	11.3	7.8	5.9	3.8	2.1
Feb	11.7	10.7	9.7	6.3	4.4	2.6	1.4
Mar	9.6	8.7	7.8	4.7	3.1	1.3	0.7
Apr	7.3	5.9	5.1	2.9	1.6	0.7	0.3
May	3.6	2.7	2.4	1.1	0.6	0.3	0.1
Jun	1.3	0.8	0.7	0.2	0.1	-	-
Jul	0.3	0.1	0.1	-	-	-	-
Aug	0.3	0.2	0.2	0.1	0.1	-	-
Sep	1.5	1.1	0.9	0.5	0.3	0.2	0.1
Oct	5.4	4.6	4.2	2.7	1.9	1.2	0.9
Nov	8.6	7.7	7.2	5.4	4.2	2.3	1.5
Dec	12.9	11.4	10.4	7.6	5.7	3.7	2.4
Year	76.1	65.8	60.0	39.3	27.9	16.1	9.3

The available data on snow cover is given in Table 4/2.11.

Table 4/2.11 – Characteristics of Snow Cover, 1975-2009

Parameter	Month			
	I	II	XI	XII
Anamur MS				
Number of days with snow	0.0	0.3	0.0	0.0
Number of days with snow cover	-	0.0	-	-
Maximum thickness of snow cover, cm	-	3	-	-
Silifke MS				
Number of days with snow	0.1	0.4	0.1	-
Number of days with snow cover	-	0.1	0.0	-
Maximum thickness of snow cover, cm	-	2	3	-

4.2.6 CLOUDINESS

The monthly and annual average cloudiness is given in Table 4/2.12. The mean cloudiness is about2 both at Anamur and Silifke stations, with high values at winter months and lowest at summer months.

Table 4/2.12 – Monthly and Annual Mean Cloudiness at Anamur and Silifke Stations (1975-2010)

Station	Months												Annual
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Anamur	3.6	3.6	2.9	2.2	1.4	0.0	0.0	-	0.3	2.4	2.1	3.4	2.0
Silifke	4.1	4.0	3.5	2.9	1.7	1.1	2.2	0.0	0.6	1.4	2.6	3.7	2.3

Average number of clear, cloudy and overcast days is given in Table 4/2.13.

Table 4/2.13 – Average Number of Clear, Cloudy and Overcast Days, 1975-2009

Days	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Anamur MS												
Clear	7.4	7.4	9.9	9.9	15.1	22.0	25.5	25.3	23.6	17.3	11.0	7.3
Cloudy	18.2	17.1	18.5	18.5	15.5	7.9	5.5	5.7	6.4	13.1	16.8	19.4
Overcast	5.4	3.8	2.6	1.5	0.4	0.1	-	-	0.1	0.6	2.2	4.3
Silifke MS												
Clear	8.3	7.0	9.0	7.3	11.1	18.0	22.2	23.9	21.8	15.7	10.9	7.7
Cloudy	16.5	16.9	18.9	20.9	19.1	11.9	8.8	7.1	8.1	14.7	16.4	17.9
Overcast	6.1	4.3	3.1	1.8	0.8	0.1	0.0	-	0.1	0.7	2.7	5.4

4.2.7 AIR TEMPERATURE

Summarized characteristics of air temperature as per Anamur and Silifke MS data are given in Tables 4/2.14-4/2.16.

Table 4/2.14 – Average Monthly Air Temperature, 1975-2009

Period, hours	Month											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Anamur MS												
07 a.m.	9.1	9.0	10.7	14.4	18.8	23.2	26.0	25.4	22.1	18.3	13.8	10.7
02 p.m.	14.6	14.8	16.9	19.9	23.6	27.6	30.8	31.4	29.6	25.8	20.4	16.1
09 p.m.	10.7	10.8	12.8	16.1	20.1	24.4	27.5	27.5	24.2	20.0	15.4	12.1
Average	11.3	11.4	13.3	16.7	20.7	24.9	27.9	27.9	25.1	21.0	16.2	12.8
Silifke MS												
07 a.m.	8.0	8.3	10.7	14.7	19.2	23.3	25.8	25.4	22.4	18.8	13.5	9.5
02 p.m.	13.7	14.5	17.8	21.6	25.6	29.0	31.6	32.0	30.4	26.7	20.4	15.2
09 p.m.	9.4	10.1	12.8	16.4	20.4	24.5	27.3	27.4	24.5	20.3	14.8	10.8
Average	10.1	10.7	13.5	17.3	21.4	25.3	28.0	28.1	25.4	21.5	15.9	11.6

Table 4/2.15 – Extreme Values of Air Temperature and Observation Dates, 1975-2009

Parameter	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Anamur MS												
T_{max}	20.7	22.8	26.4	31.2	37.0	41.0	42.0	40.0	38.2	34.6	30.3	23.0
Day	8	24	21	24	28	30	29	8	27	6	2	8
Year	1994	1998	2001	1981	1990	1980	2002	1998	1979	1992	1992	2005
T_{min}	0.3	-0.8	-0.7	3.6	8.6	12.2	16.2	15.8	10.8	1.7	2.3	1.2
Day	8	21	1	10	1	7	11	20	27	14	25	24

Parameter	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Year	2004	1983	1976	1997	1982	1977	1979	1978	1986	2009	1992	1992
Silifke MS												
T_{max}	22.2	23.8	30.3	35.0	38.3	41.3	42.2	42.4	40.0	37.0	31.9	24.8
Day	12	8	24	24	23	26	30	7	27	2	1	8
Year	2003	2002	2008	2008	1995	2007	2007	1998	1979	2007	1992	2005
T_{min}	-0.6	-3.2	-0.3	2.8	8.4	13.0	16.9	18.0	12.8	7.8	1.8	0.7
Day	8	9	1	10	3	1	2	31	16	29	25	31
Year	2004	1976	1985	1997	1987	1991	1992	1988	2004	2003	1995	2008

Table 4/2.16 – Maximum Amplitude of Daily Temperature, 1975-2009

	Month											
Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Temperature amplitude, ºC												
Anamur	14.5	14.9	16.7	16.6	18.3	20.3	20.4	20.8	21.3	26.2	14.9	12.9
Silifke	14.7	13.5	16.0	19.0	19.3	17.4	18.5	15.2	19.0	18.8	16.4	14.8

The correlation coefficient of average monthly air temperatures at Silifke and Anamur MS reaches 0.99, i.e. the temperature at both stations is practically the same.

The average annual duration and temperature of heating period according to MS Anamur data is 4 days and 7.0 ^{o}C, and according to Silifke MS data 12 days and 6.5 ^{o}C. Average daily temperature of the coldest month and period at Anamur MS is 8.0 and 6.3 ^{o}C, at Silifke MS – 6.3 and 4.9 ^{o}C.

4.2.8 SOIL TEMPERATURE

The long term mean and minimum soil surface temperature, and the average number of days in each month with minimum soil surface temperature less than minus 0.1, minus 3 and minus 5 °C are given in Table 4/2.17 for Anamur and Silifke stations. Negative values of the soil surface in Anamur station were observed occasionally in January, February, March, November and December. The mean number of days in which soil surface temperature is less than minus 3.0 °C is only 0.5 at Anamur station and 0.1 at Silifke station.

Distribution of average minimum and minimum soil temperatures in depth is given in Table 4/2.18.

Table 4/2.17 – Characteristics of Soil Temperature for Observation Period of 1981-2010

Parameter	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Anamur Station												
Mean Min.Soil Surface temperature, °C	5.7	5.4	6.7	9.9	13.7	17.7	20.9	21.2	17.8	14.1	10.2	7.5
Min.Soil Surface temperature, °C	-3.6	-6.0	-4.2	0.1	5.3	10.0	13.5	12.6	8.1	4.9	-3.3	-4.0
Mean number of days < minus 0.1 °C soil surface temp.	1.4	1.2	0.2	-	-	-	-	-	-	-	0.1	0.2
Mean number of days < minus 3 °C soil surface temp.	0.1	0.3	0.1	-	-	-	-	-	-	-	0.0	0.0
Mean number of days < minus 5 °C soil	-	0.0	-	-	-	-	-	-	-	-	-	-

Parameter	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
surface temp.												
Silifke Station												
Mean Min.Soil Surface temperature, °C	5.1	5.0	6.8	9.9	13.7	17.7	21.0	21.3	18.2	14.9	10.0	6.5
Min. Soil Surface Min. temperature, °C	-1.6	-3.2	-1.6	1.1	6.2	10.0	14.4	2.1	10.4	2.0	-1.0	-1.0
Mean number of days < minus 0.1 °C soil surface temp.	0.5	1.3	0.1	-	-	-	-	-	-	-	0.1	0.1
Mean number of days < minus 3 °C soil surface temp.	-	0.1	-	-	-	-	-	-	-	-	-	-
Mean number of days < minus 5 °C soil surface temp.	-	-	-	-	-	-	-	-	-	-	-	-

Table 4/2.18 – Average and Minimum Soil Temperatures in Depth, m

Depth, m	Soil temperature	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Anamur MS													
0.05	Average	10.6	11.6	15.2	20.5	26.5	31.5	34.6	34.0	29.9	23.4	16.3	12.1
	Minimum	0.5	0.4	1.4	6.8	13.1	18.6	18.6	21.0	17.1	10.7	3.0	1.0
0.1	Average	10.8	11.7	15.2	20.3	26.2	31.1	34.0	33.5	29.7	23.5	16.5	12.3
	Minimum	2.5	1.6	4.0	7.9	14.3	18.5	24.4	23.8	19.0	12.7	5.0	2.2
0.2	Average	11.0	11.8	15.1	20.0	25.6	30.2	32.8	32.5	29.0	23.5	16.7	12.6
	Minimum	4.2	3.8	6.6	11.0	15.2	20.8	25.2	24.4	20.6	14.9	7.4	4.2
0.5	Average	12.5	12.8	15.3	19.4	24.1	28.3	30.7	30.9	28.6	24.3	18.5	14.5
	Minimum	8.5	8.1	10.3	13.8	18.1	17.8	27.8	28.6	24.3	18.4	12.6	9.1
1.0	Average	14.4	14.0	15.5	18.4	21.9	25.3	27.7	28.4	27.2	24.5	20.3	16.6
	Minimum	11.2	11.4	12.1	15.2	17.8	22.1	25.6	26.5	24.7	20.6	15.8	13.2
Silifke MS													
0.05	Average	8.6	10.0	14.2	19.8	25.5	30.6	33.8	33.8	29.9	23.0	15.0	10.0
	Minimum	-0.1	-0.2	-0.2	4.2	11.6	15.8	21.0	20.3	15.2	7.4	0.7	0.8
0.1	Average	8.6	9.8	13.8	19.2	24.6	29.3	32.4	32.6	29.3	23.1	15.3	10.3
	Minimum	1.3	1.0	2.0	6.0	12.8	16.2	21.2	23.3	18.4	10.2	4.5	2.0
0.2	Average	9.0	9.8	13.4	18.6	23.8	28.4	31.4	31.8	28.8	23.3	15.9	10.9
	Minimum	0.8	3.9	4.2	9.6	15.4	18.4	25.0	23.5	22.8	12.1	7.5	4.6
0.5	Average	10.9	10.9	13.4	17.6	22.1	26.5	29.6	30.6	28.7	24.4	18.2	13.3
	Minimum	6.8	7.4	7.6	12.8	12.0	21.5	26.4	28.2	25.3	18.3	12.2	8.4
1.0	Average	13.4	12.6	13.8	16.7	20.2	24.0	27.1	28.6	28.0	25.2	20.7	16.2
	Minimum	10.0	7.4	10.6	12.9	16.8	20.8	24.5	26.5	25.8	21.3	14.9	10.5

4.2.9 ATMOSPHERIC PRESSURE

Representative values of atmospheric pressure normalized to sea level for each reference MS using data from 1970 to 2010 are presented in Table 4/2.19.

Table 4/2.19 – Monthly and Annual Mean, Maximum and Minimum Averaged Atmospheric Pressure (hPa) from 1970-2010 at Anamur and Silifke Stations

Period	Mean Atmospheric Pressure, hPa		Maximum Atmospheric Pressure, hPa		Minimum Atmospheric Pressure, hPa	
	Anamur	Silifke	Anamur	Silifke	Anamur	Silifke
Jan	1017	1017	1026	1026	1006	1004
Feb	1016	1015	1024	1024	1004	1003
Mar	1014	1013	1022	1022	1003	1001
Apr	1012	1011	1020	1019	1003	1002
May	1011	1010	1017	1016	1005	1003
Jun	1008	1007	1013	1012	1003	1001
Jul	1005	1004	1009	1008	1001	1000
Aug	1006	1005	1010	1009	1003	1001
Sep	1010	1009	1015	1014	1006	1004
Oct	1014	1013	1020	1019	1008	1007
Nov	1017	1016	1024	1023	1008	1006
Dec	1018	1017	1026	1025	1006	1005
Annual	1012	1011	1019	1018	1005	1003

4.3 ON-SITE METEOROLOGY

At the Akkuyu NPP site, a 60-meter meteorological mast was placed at a location (Existing Station) shown in Figure 4/3.1. It is located at an elevation of 42.00 MSL and is 474 m inland from the coastal line. The meteorological equipment (wind speed and direction sensors, temperature sensor, radiation shield, rain gauge) were mounted on a 60 m mast at 10, 25 and 60 m levels. The parameters, type of equipment and measurement heights are given in Table 4/3.2. Measurements at all three levels at ANPP site are available since June 2009.

Two meteorological stations were established in August 2011 near the main gate and Aksaz Bay-İnceburun locations (Figure 4/3.1). The data is available from September 19, 2011. Equipment used in the stations, their type and model and their accuracy are listed in Table 4/3.1.

Figure 4/3.1 – The Location Of Meteorological Stations In The Akkuyu NPP Site Vicinity

Table 4/3.1 – Meteorological Parameters Measured at 60-m Mast, the Name of Equipment and Height of Measurements

Parameter	Equipment	Height
Wind Speed	Met One 014A Wind Speed Sensor	10, 25, 60 m
Wind Direction	Met One 020C Wind Direction Sensor	10, 25, 60 m
Temperature	Met One 062 Temperature Sensor	10, 25, 60 m
Temperature-Humidity	Rotronic MP101A Temperature-Humidity Sensor	2 m
Precipitation	Hydrological TB3 Precipitation Sensor	2.5 m
Solar Radiation	Kipp Zonen NR LITE Net Radiation Sensor	2 m
Atmospheric Pressure	Setra CS100 Pressure Sensor	1.5 m

An Aerological Station (AS) with Sodar-Rass system is established near to the existing 60-meter meteorological mast for the remote measurement of wind, air temperature and turbulence in the lower atmosphere. Technical specification of the Sodar-Rass system is summarized in Table 4/3.3.

The data on vertical profiles of wind velocity and direction, air temperature and turbulence in the lower 2000-m atmosphere layer is available from 29 July 2011.

Table 4/3.2 – Meteorological Equipment, Their Type and Model and Specifications Installed at ANPP Site

Meteorological Station	Sensor Model No.	Sensor Type	Sensor Specification	
Meteorological Observation Tower A (60m)	020C	Wind Direction Sensor	Performance Characteristics Azimuth Threshold Linearity Accuracy Damping Ratio Delay Distance Temperature Electrical Characteristics Input Power Output*	Electrical 0 - 356° Mechanical 0 - 360° 0.6 mph ±½% of full scale ±3° 0.4 Less than 3 feet -50 °C to 85 °C 12V DC, 10 mA 0 - 5 volts for 0 - 360° 0 - 2.5 volts for 0 - 360° 0 - 1.0 volts for 0 - 360°
			Output Impedance Maximum Cable Length	100 Ohms maximum 300 feet maximum (consult factory for special cable requirements)
			Physical Characteristics Weight Finish Mounting Fixtures Cabling	1.1 pounds Anodized Aluminum Use with Crossarm Model 191 or equivalent 1957-XX Cable (XX is cable length in feet)
			Optional Accessories: – External heater assembly and power supply for extreme low temperature – Aluminum vane assembly – Model 040 Degree Wheel Calibrator – Model042 Telescopic Orientation Fixture	

Meteorological Station	Sensor Model No.	Sensor Type	Sensor Specification	
Meteorological Observation Tower A (60m)	062	Temperature Sensor	Maximum Range Linearity Accuracy Time Constant Cable Length Connector	-50 °C to 50 °C ±0.15°C ±0.1°C 10 seconds 1 foot none
Meteorological Observation Tower A (60m)	014A	Wind Speed Sensor	Performance Characteristics Maximum Operating Range Starting Speed Calibrated Range Accuracy Temperature Range Distance Constant** Standard (1812 Aluminum Cup Assembly) Optional (1708 Lexan Cup Assembly)	0 - 60 meters/sec or 0 - 125 mph 0.5 meters/sec or 1 mph 0 - 50 meters/sec or 0-100 ±1.5% or 0.25 mph -50 °C to 85 °C Less than 15 feet Less than 5 feet
			Electrical Characteristics Output Signal	Contact closure at frequency V= (f x 1.7892) + 1 mph
			Physical Characteristics Weight Finish Mounting Fixtures Cabling	1.5 Ibs. Anodized. Use with Crossarm Model 191 2-Conductor Cable, XX is cable length in feet
			Optional Accessories 1708 Lexan Cup Assembly, Fast Response Type	

Meteorological Station	Sensor Model No.	Sensor Type	Sensor Specification	
Meteorological Observation Tower A (60m)	076B-4	Aspirated Temperature Shield 12 VDC FAN	Radiation Error Power Requirement Temperature Weight Shield Capacity Power Connection Signal Connection	Less than 0.05 under maximum solar radiation of 1.6 gm-cal/cm2/min 12 VDC at 0.450 amps (Typical) -50 °C to 85 °C 5.5 Lbs Up to each 3/8” Diameter temperature and one ¾” humidity probe. 9 total connections Connector MOI part number 500109 Assembled Cable Part Number 2423 Connector MOI part number 500296 Assembled Cable Part Number 2144
Meteorological Observation Tower B, C (10m)	064-2	Temperature Sensor	Maximum Range Linearity Accuracy Time Constant Cable Length Connector	-50 °C to 50 °C ±0.15°C ±0.1°C 10 seconds 1 foot none
	060A-4		Maximum Range Linearity Accuracy Time Constant Cable Length Connector	0 °C to +100 °C ±0.21°C ±0.15°C 10 seconds 1 foot none
	063-1		Maximum Range Linearity Accuracy Time Constant Cable Length Connector	-50 °C to 50 °C ±0.15°C ±0.1°C 60 seconds 1 foot none
Meteorological Observation Tower B, C (10m)	063-2		Maximum Range Linearity Accuracy Time Constant Cable Length Connector	0 °C to +100 °C ±0.21°C ±0.15°C 60 seconds 1 foot none

Meteorological Station	Sensor Model No.	Sensor Type	Sensor Specification	
	083E 593A	Relative Humidity/ Temperature Sensor	Relative Humidity Model Number RH Sensing Element Range Temperature Operation Range Response Time Accuracy Temperature Coefficient Output AutoMet Auto ID	083E Thin film polymer capacitor 0 to 100 %RH -50 °C to 50 °C (-58°F to 122°F) 10 sec. with 2 m/s aspiration ± 2.0 % from 0 to 100 %RH Compensated internally 0 to 1 VDC standard 0 to 5.0 VDC optional Yes (Model 593A Only)
			Temperature Sensor Temperature Sensor Temperature Range Accuracy Output AutoMet Auto ID	Thermistor -50 °C to 50 °C (-58°F to 122°F) ±0.10°C (0.18 °F) Resistive No
			General Input Power Dimensions	10 to 18 VDC @ < 5 mA Length: 8.5 in (21.59 cm) Diameter: 0.75 in (1.91 cm)
** The distance travelled by the air after a sharp-edged gust has occurred for the anemometer rate to reach 63 % of the new speed.*				

Table 4.3.3 – Specifications of SODAR-XFAS System

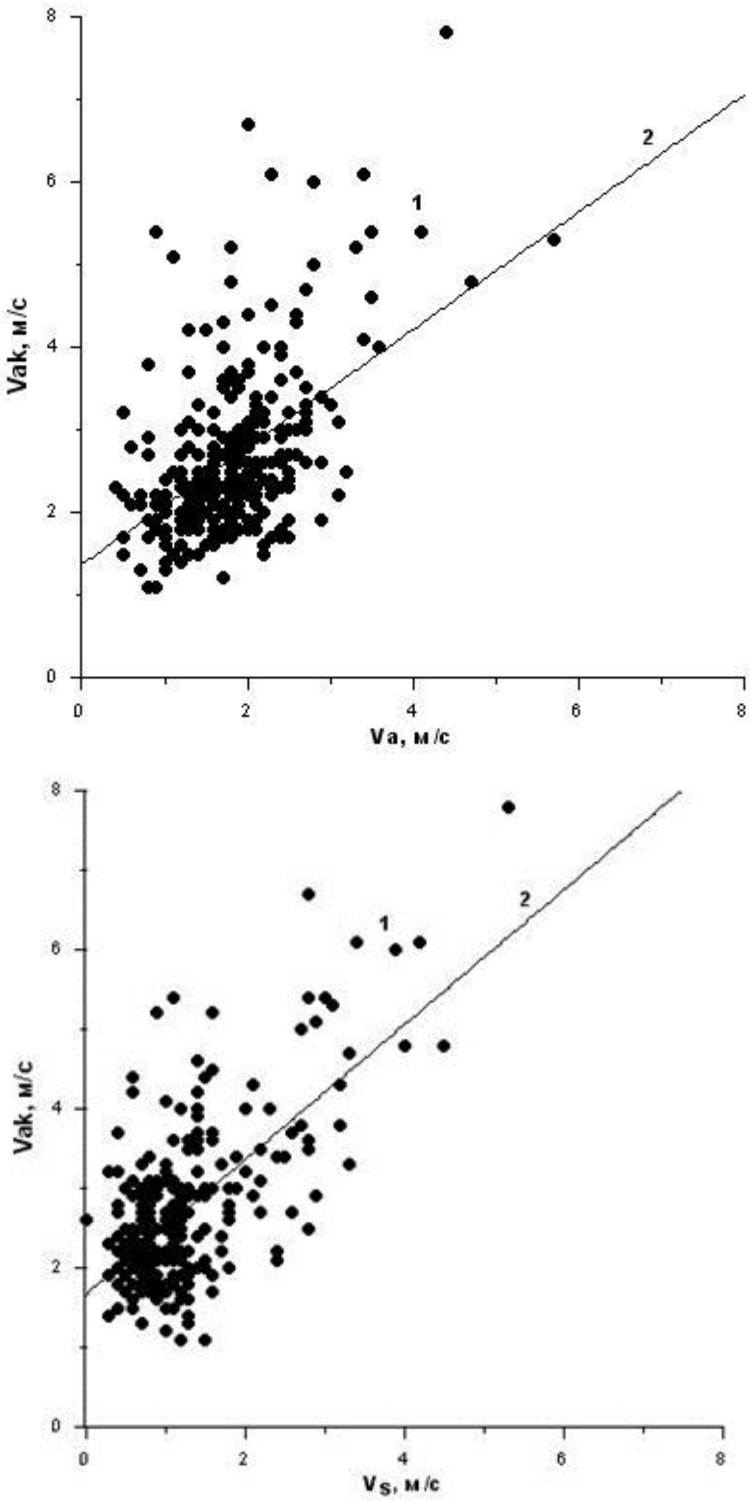
Description	SODAR-RASS XFAS	Remarks
No. of elements	52	Individually driven
Frequency range	825-1375 Hz	All frequencies user selectable
Electric (acustic) output power	500 W (35 W)	Maximum value user selectable
Multi-frequency operation	Ye up to 80 frequencies	Model user selectable
Beam angles	0° , ±22°, ±29°	Independent of frequency
No. of range gates	256	Max. user selectable
Vertical resolution	20 m	Finest selectable
Minimum- max. range	40- >2000 m	Depending on settings and atmosphere
Averaging time	1 - 180 min	
Accuracy of horizontal wind speed	0.1 to 0.3 m/s	Depending on mode

Accuracy of vertical wind speed	0.03 to 0.1 m/s	Depending on mode
Accuracy of wind direction	2 to 3°	At wind speeds > 2 m/s
Measurement range horizontal	0 to 50 m/s	Depending on mode
Measurement range vertical	Minus 10 to 10 m/s	Depending on mode
Operation range temperature	Minus 35 to +50°C (-95 to 122°F)	Antenna, Processing Unit, Power Supply

The correlation connections of average daily values of wind speed, air temperature and humidity in timely parallel measurements at the Akkuyu NPP site, Anamur and Silifke stations are illustrated in Figures 4/3.2 and 4/3.4. Wind speedregressive connection at the Anamur and NPP site are approximated through the ratio $V_{Ak} = 0.71 \cdot V_A + 1.4$with correlation factor 0.26, at the second station and at the site - $V_{Ak} = 0.85 \cdot V_S + 1.7$ with correlation factor 0.43.

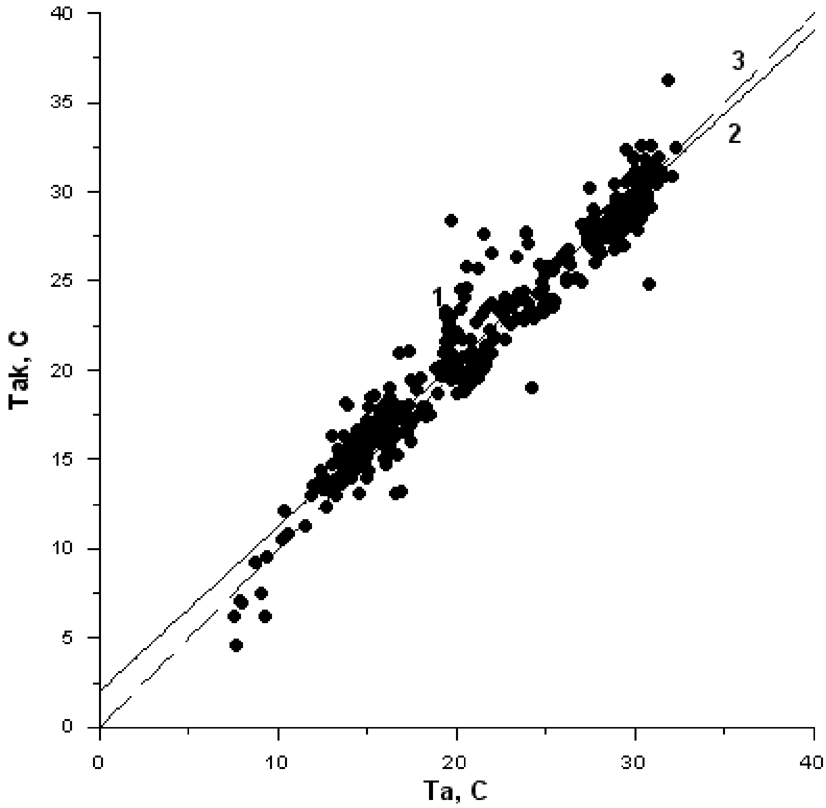
A regression line of the average daily temperature values at the Anamur station and at the site is described through the ratio $T_{Ak} = 0.92 \cdot T_A + 2.0$ with correlation factor 0.93, at the second station and at the site– $T_{Ak} = 0.88 \cdot T_S + 3.2$ with correlation factor 0.95. A sufficiently close relation between the values is observed even in spite of the fact that temperature at the stations was determined at level of 2 m, and at the site – at level of 10 m.

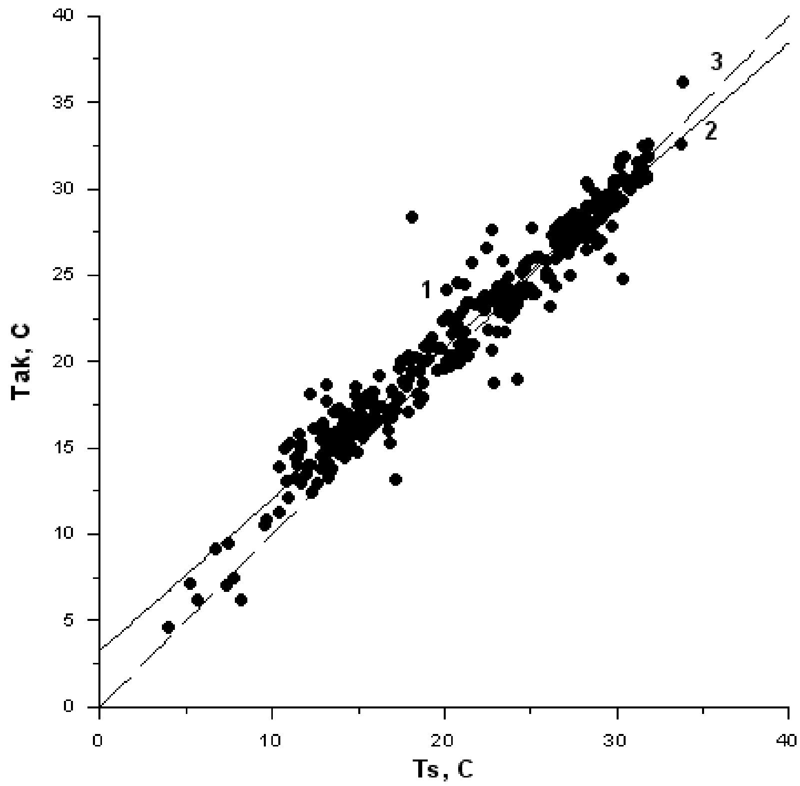
A relation of average daily relative humidity at the Anamur station and at the NPP site is described through the ratio $F_{Ak} = 0.77 \cdot F_A + 12$ with correlation factor 0.43, at the second station and at the site – $F_{Ak} = 0.73 \cdot T_S + 21$ with correlation factor 0.75.



1 –average daily wind velocity values; 2 – regression line

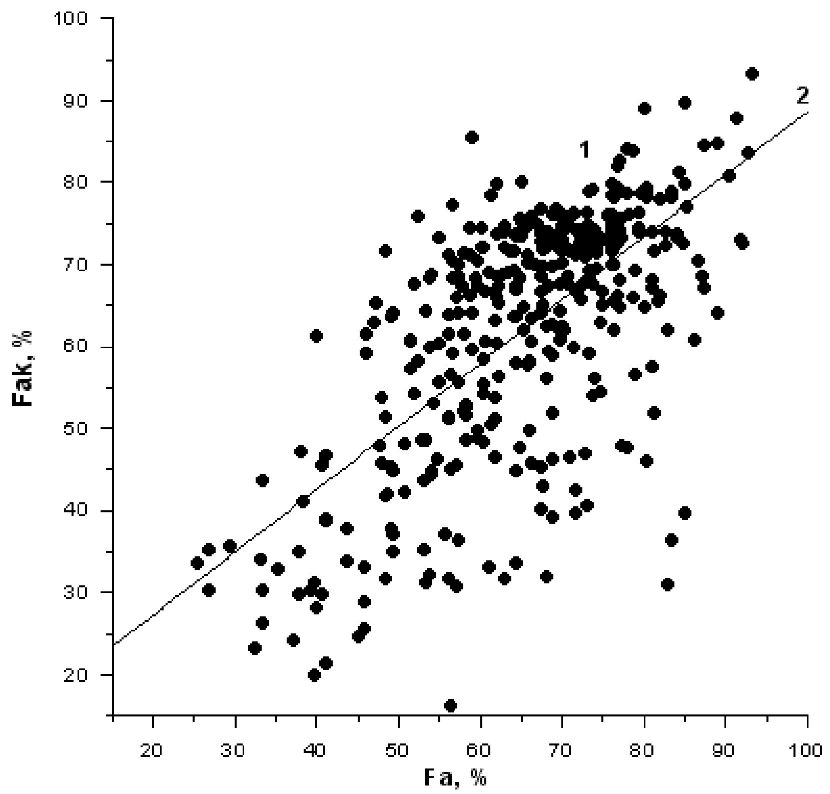
Figure 4/3.2 – Relationshipsof Average Daily Wind Speed (m/s)between NPP Site *(Vak)*, Anamur and Silifke (*Va, Vs)* for2009-2010 Period.

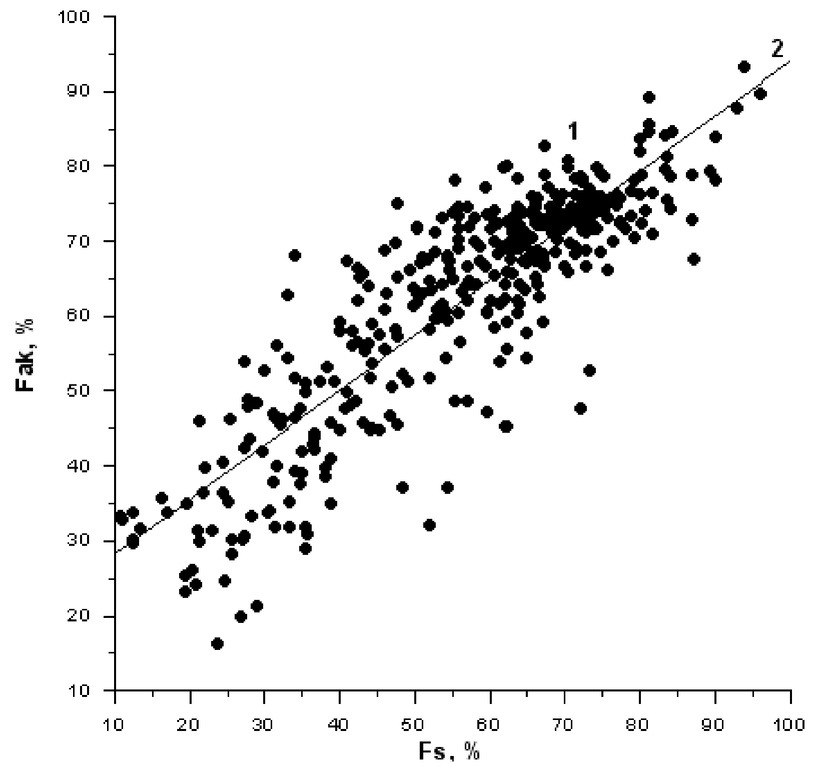




1 – average daily temperature values; 2 – regression line; 3 – line $Y = X$

Figure 4/3.3 – Relationshipsof Average Daily Temperature (°C) between NPP Site (*Tak*), Anamur and Silifke (Ta, Ts) for 2009-2010 Period.





1 – average daily relative humidity values; 2 – regression line

Figure 4/3.4 – Relationships of Average Daily Relative Humidity (%) between NPP Site (*Fak*) and Anamur and Silifke (Fa, Fs) for 2009-2010 period.

The average monthly values of the main meteorological parameters as per the results of surface measurements at the NPP site, Anamur and Silifke MS performed in 2010 are presented in Tables 4/3.4 and 4/3.5. These Tables are obtained only based on the results of timely parallel measurements at the stations.

Table 4/3.4 – Average Air Temperature and Its Deviation from the Data at the NPP Site, 2009-2010 Years

Year	Time, h UTC	Month												During year
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Air temperature, °C (Anamur MS)														
2010	00	12.1	11.6	13.7	16.8	20.2	23.7	27.6	28.2	26.0	21.2	17.9	14.1	20.5
2010	03	11.9	11.2	12.8	16.2	19.6	22.9	27.0	27.8	25.4	20.6	17.5	14.1	19.9
2010	06	11.5	10.6	13.2	16.9	20.3	24.0	26.9	28.1	25.1	20.2	16.8	13.3	20.0
2010	09	13.4	13.6	16.9	21.9	23.5	27.3	30.4	31.3	29.9	24.6	22.7	15.1	23.7
2010	12	15.1	14.5	18.5	22.6	24.6	28.5	31.5	32.6	31.9	26.1	24.5	16.4	25.1
2010	15	14.8	14.0	18.1	22.4	24.8	28.8	32.1	33.3	31.9	25.6	23.7	16.5	25.1
2010	18	13.2	12.6	15.9	20.2	23.1	27.1	31.1	31.5	29.3	23.3	19.4	14.8	23.0
2010	21	12.4	12.0	14.6	17.9	21.2	24.9	28.6	29.1	27.0	21.5	18.1	14.3	21.3
2010	Average	13.0	12.4	15.5	19.3	22.2	25.9	29.4	30.2	28.3	22.9	20.1	14.8	22.3
Air temperature, °C (Silifke MS)														
2010	00	10.7	11.0	13.7	17.2	18.9	22.5	25.6	28.0	24.5	20.3	18.5	12.2	19.6
2010	03	10.4	10.5	12.9	16.5	18.2	21.4	24.6	27.0	23.6	19.4	17.9	12.1	18.8
2010	06	9.8	9.8	13.3	17.4	19.5	23.4	26.0	27.5	23.9	19.1	17.7	11.9	19.3
2010	09	12.5	13.4	18.6	23.0	24.6	28.1	31.2	33.5	31.6	24.8	23.2	13.8	24.5
2010	12	14.6	15.5	20.4	24.1	26.1	29.4	32.0	34.7	32.4	27.2	27.9	17.9	26.3
2010	15	14.7	15.0	20.0	23.7	25.9	29.9	32.2	34.6	32.0	25.9	25.8	16.6	25.9
2010	18	11.9	12.5	16.7	20.7	23.3	27.1	29.2	31.4	28.4	22.2	19.9	13.8	22.6
2010	21	11.0	11.9	14.8	18.3	20.6	24.2	27.0	29.1	26.0	20.5	19.2	12.5	20.7
2010	Average	11.9	12.3	16.3	20.0	22.1	25.7	28.5	30.7	27.8	22.4	21.2	13.8	22.2
Air temperature, °C (NPP site)														
2010	00	13.4	12.5	15.7	18.6	20.2	23.7	26.6	29.4	26.3	22.4	22.2	14.5	21.4
2010	03	13.2	12.4	15.3	18.0	20.0	23.1	26.2	28.7	25.8	21.8	21.8	14.7	20.9
2010	06	13.2	12.1	15.2	18.7	20.9	24.6	27.4	29.4	26.5	21.7	21.5	14.4	21.4
2010	09	14.2	14.2	17.9	22.0	23.0	26.4	29.2	32.4	30.5	25.6	25.9	16.6	24.2
2010	12	15.0	14.7	18.7	21.7	23.5	26.6	29.9	32.8	31.0	26.3	26.3	17.9	24.7
2010	15	15.1	13.9	18.1	21.9	23.6	27.0	29.9	33.0	30.3	25.5	24.9	17.3	24.5
2010	18	13.9	13.1	16.7	19.8	21.7	25.2	28.1	30.7	28.1	23.2	21.6	15.0	22.5
2010	21	13.5	12.9	16.4	19.2	21.1	24.5	27.3	29.8	27.2	22.5	22.4	14.4	21.9
2010	Average	13.9	13.2	16.7	19.9	21.7	25.1	28.1	30.8	28.2	23.6	23.3	15.5	22.7
Temperature difference, °C at Anamur MS and at the NPP site														
2010	00	-1.4	-1.0	-2.0	-1.7	-0.1	0.1	1.0	-1.2	-0.2	-1.1	-4.3	-0.3	-0.9
2010	03	-1.3	-1.3	-2.5	-1.8	-0.4	-0.2	0.8	-0.9	-0.4	-1.1	-4.4	-0.5	-1.0
2010	06	-1.7	-1.5	-2.0	-1.8	-0.7	-0.6	-0.5	-1.3	-1.4	-1.5	-4.7	-1.1	-1.5
2010	09	-0.8	-0.6	-1.0	-0.1	0.5	0.9	1.2	-1.1	-0.6	-1.0	-3.2	-1.5	-0.5
2010	12	0.1	-0.3	-0.1	0.9	1.0	1.9	1.6	-0.1	0.9	-0.2	-1.8	-1.5	0.4
2010	15	-0.3	0.1	0.0	0.5	1.2	1.9	2.2	0.3	1.6	0.1	-1.3	-0.8	0.6

Year	Time, h UTC	Month												During year
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2010	18	-0.7	-0.4	-0.8	0.5	1.4	1.9	3.0	0.8	1.2	0.1	-2.1	-0.2	0.6
2010	21	-1.1	-0.9	-1.7	-1.3	0.2	0.4	1.4	-0.7	-0.2	-1.0	-4.2	-0.1	-0.6
2010	Average	-0.9	-0.8	-1.3	-0.6	0.4	0.8	1.3	-0.5	0.1	-0.7	-3.3	-0.8	-0.4
Temperature difference, °C at Silifke MS and at the NPP site														
2010	00	-2.7	-1.6	-2.0	-1.4	-1.3	-1.2	-1.0	-1.4	-1.7	-2.1	-3.7	-2.3	-1.8
2010	03	-2.9	-1.9	-2.4	-1.6	-1.8	-1.7	-1.6	-1.7	-2.2	-2.3	-4.0	-2.5	-2.2
2010	06	-3.4	-2.3	-2.0	-1.2	-1.5	-1.3	-1.4	-1.8	-2.6	-2.6	-3.8	-2.5	-2.2
2010	09	-1.7	-0.8	0.6	1.0	1.6	1.8	2.0	1.1	1.1	-0.9	-2.7	-2.9	0.3
2010	12	-0.4	0.8	1.7	2.4	2.5	2.8	2.2	1.9	1.5	0.9	1.6	0.0	1.6
2010	15	-0.4	1.1	1.9	1.7	2.3	2.9	2.3	1.6	1.8	0.4	0.9	-0.7	1.5
2010	18	-2.0	-0.6	0.0	0.9	1.6	1.9	1.2	0.7	0.4	-1.1	-1.7	-1.2	0.1
2010	21	-2.5	-1.0	-1.5	-0.9	-0.4	-0.4	-0.2	-0.7	-1.2	-1.9	-3.2	-2.0	-1.2
2010	Average	-2.0	-0.9	-0.5	0.1	0.4	0.6	0.4	0.0	-0.4	-1.2	-2.1	-1.8	-0.5
Number of time parallel periods														
2010	00	31	16	27	14	31	30	31	31	30	31	19	9	300
2010	03	31	16	28	14	31	30	31	31	30	31	19	9	301
2010	06	31	16	27	14	31	30	31	31	30	31	19	9	300
2010	09	31	15	24	13	31	30	31	31	30	31	19	8	294
2010	12	31	14	27	13	31	30	31	31	30	31	19	8	296
2010	15	31	13	28	13	31	30	31	31	30	31	19	8	296
2010	18	31	14	30	13	31	30	31	31	30	31	19	8	299
2010	21	31	15	25	13	31	30	31	31	30	31	19	9	296
2010	Total	248	119	216	107	248	240	248	248	240	248	152	68	2382

Table 4/3.5 – Average Air Relative Humidity and Its Deviation from the Data at the NPP Site, 2009-2010 Years

Year	Time, h UTC	Month												During year
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Air relative humidity, % (Anamur MS)														
2010	7	70.0	66.5	59.9	64.8	69.9	67.9	69.1	61.9	56.2	58.1	37.7	73.5	62.9
2010	14	64.5	62.3	53.6	60.8	65.3	60.7	62.8	60.2	51.2	55.2	43.6	62.3	58.5
2010	21	71.3	67.6	68.1	71.3	75.3	73.3	72.5	68.9	61.1	65.3	45.2	74.7	68.1
2010	Average	68.6	65.6	60.1	65.6	70.1	67.3	68.1	63.7	56.1	59.5	42.1	70.3	63.2
Air relative humidity, % (Silifke MS)														
2010	7	56.3	68.7	58.1	65.3	76.5	68.2	72.7	65.8	57.7	58.4	31.5	78.4	62.9
2010	14	43.8	46.5	45.1	53.2	55.0	51.1	56.5	52.5	51.0	45.9	23.3	50.1	48.4
2010	21	57.5	65.1	63.9	69.5	75.0	66.7	77.0	72.0	64.0	57.5	33.3	73.9	64.9
2010	Average	52.5	60.7	55.2	62.7	68.8	62.0	68.7	63.4	57.6	54.0	29.4	67.7	58.7
Air relative humidity, % (NPP site)														
2010	07	60.9	65.2	58.1	64.4	68.6	66.2	70.9	63.2	56.2	51.6	25.2	73.7	60.2
2010	14	61.3	58.5	55.7	57.6	63.3	60.4	62.6	60.1	58.7	54.6	37.3	59.9	58.0
2010	21	65.2	66.4	70.8	73.0	80.4	76.6	83.7	74.9	71.9	60.1	32.4	75.4	70.1
2010	Average	62.5	63.6	61.1	65.0	70.8	67.7	72.4	66.1	62.3	55.4	31.7	69.9	62.8
Relative humidity difference at Anamur MS and at the NPP site														
2010	7	9.1	1.3	1.8	0.3	1.3	1.7	-1.8	-1.2	0.0	6.5	12.4	-0.2	2.7

Year	Time, h UTC	Month												During year
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2010	14	3.2	3.8	-2.1	3.3	2.0	0.3	0.2	0.1	-7.5	0.7	6.3	2.4	0.5
2010	21	6.0	1.2	-2.8	-1.7	-5.1	-3.3	-11.2	-5.9	-10.8	5.3	12.7	-0.7	-2.0
2010	Average	6.1	2.0	-1.0	0.6	-0.6	-0.4	-4.2	-2.4	-6.1	4.1	10.5	0.5	0.4
Relative humidity difference at Silifke MS and at the NPP site														
2010	07	-4.5	3.4	0.1	0.8	7.9	2.1	1.8	2.6	1.5	6.8	6.3	4.7	2.6
2010	14	-17.5	-12.0	-10.6	-4.4	-8.3	-9.3	-6.1	-7.7	-7.6	-8.7	-14.0	-9.7	-9.6
2010	21	-7.8	-1.4	-7.0	-3.6	-5.4	-9.9	-6.7	-2.9	-8.0	-2.5	0.8	-1.5	-5.3
2010	Average	-9.9	-2.9	-5.9	-2.3	-1.9	-5.7	-3.7	-2.7	-4.7	-1.4	-2.3	-2.1	-4.1
Number of time parallelperiods														
2010	7	31	15	28	14	31	30	31	31	30	31	19	8	299
2010	14	31	13	30	13	31	30	31	31	30	31	19	8	298
2010	21	31	15	25	13	31	30	31	31	30	31	19	9	296
2010	Total	93	43	83	40	93	90	93	93	90	93	57	25	893

According to the data acquired at the Anamur and Akkuyu stations, in 2010 a difference higher than 1 °C was observed approximately in 50 % of the cases, while at the Silifke MS this parameter reached 77 %. A convergence of the average daily temperature values was considerably better – at the Anamur MS a difference higher than 1 °C was observed for 1/6 of the time, and at the Silifke MS - 1/3 of the time. A better agreement of the data could be expected, if temperature at the NPP site was taken at a standard for the surface measurements level of 2 m.

Taking into account this circumstance and temperature comparison results, both stations in the first approximation may be considered as the representative for the NPP site.

According to the the time paralleldata of the Anamur and Akkuyu MS, Silifke and Akkuyu MS for 2010, a criterion of the stations' representativeness for relative humidity (difference not higher than 10 %) is fulfilled in four cases from 36, i.e. by relative humidity both stations in the first approximation may be considered as representative. Apparently, in 2009 measuring system adjustment was performed on the meteorological mast, and therefore matching of the average monthly data was essentially worse.

Average daily wind speedat the Anamur and Silifke MS, and also their deviation from the data at the site within 2010 are given in Tables 4/3.6 and 4/3.7.

Table 4/3.6 – Average Daily Wind Speed at the Stations and its Difference from the Data at the Site, 2010 Year

Parameter	Month												Year
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Wind Speed, m/s (Anamur MS)													
$\bar{V}$	2.0	2.2	1.9	1.6	1.8	1.8	1.6	1.4	1.8	2.1	2.0	2.3	1.8
ΔV	-1.6	-1.0	-1.0	-0.5	-0.5	-0.5	-0.6	-0.9	-0.7	-0.7	-0.8	-1.2	-0.8

Parameter	Month												Year
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Wind Speed, m/s (Silifke MS)													
$\bar{V}$	1.4	1.7	1.5	1.1	1.0	1.0	0.9	1.1	1.0	1.3	1.4	1.2	1.2
ΔV	-2.2	-1.6	-1.4	-0.9	-1.4	-1.3	-1.3	-1.2	-1.5	-1.5	-1.4	-2.3	-1.5
Wind Speed, m/s (Akkuyu MS, mast at elevation 10 m)													
$\bar{V}$	3.6	3.3	2.9	2.1	2.4	2.3	2.2	2.3	2.5	2.8	2.8	3.5	2.7
Number of time parallelperiods													
N	31	15	27	13	30	29	30	31	29	30	19	9	293

Table 4/3.7 – Average Wind Speedat the Silifke MS, at the Site and their, 2009-2010 Years

Year	Time, h UTC	Month												During year
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Wind Speed, m/s (Silifke MS)														
2010	00	1.4	2.1	1.4	0.6	0.3	0.5	0.1	0.5	0.4	1.6	2.0	0.5	0.9
2010	06	1.3	1.8	1.1	1.0	0.9	0.8	0.3	0.8	1.0	1.5	2.1	1.2	1.1
2010	12	1.5	2.7	1.8	1.5	1.8	2.0	1.8	1.9	2.2	1.8	1.5	1.5	1.9
2010	18	1.2	1.5	0.3	0.8	0.4	0.5	0.6	0.6	0.5	0.8	1.2	0.9	0.7
2010	Average	1.3	2.0	1.1	1.0	0.9	1.0	0.9	1.0	1.1	1.4	1.6	1.1	1.2
Wind Speed, m/s (NPP site)														
2010	00	4.4	3.1	2.9	1.0	1.9	2.0	1.8	1.5	1.8	2.9	3.1	3.0	2.5
2010	06	3.8	3.8	2.8	1.7	1.9	1.6	1.4	2.0	2.3	3.3	3.2	2.8	2.5
2010	12	3.6	3.3	3.3	3.3	3.4	3.3	3.0	3.3	3.3	3.1	2.9	3.7	3.3
2010	18	3.5	3.5	2.7	2.3	2.5	2.9	2.9	2.6	3.1	2.3	1.8	2.9	2.7
2010	Average	3.7	3.4	2.9	2.2	2.5	2.5	2.4	2.5	2.7	2.9	2.7	3.1	2.8
Wind Speeddifference at Silifke MS and at NPP site														
2010	00	-3.0	-1.0	-1.5	-0.5	-1.6	-1.5	-1.7	-1.0	-1.4	-1.3	-1.1	-2.5	-1.5
2010	06	-2.6	-2.0	-1.6	-0.7	-1.0	-0.7	-1.1	-1.2	-1.3	-1.8	-1.1	-1.6	-1.4
2010	12	-2.1	-0.5	-1.5	-1.7	-1.5	-1.3	-1.2	-1.3	-1.1	-1.3	-1.4	-2.2	-1.4
2010	18	-2.2	-2.0	-2.3	-1.5	-2.1	-2.4	-2.2	-2.0	-2.6	-1.5	-0.7	-2.1	-2.0
2010	Average	-2.4	-1.4	-1.8	-1.2	-1.5	-1.5	-1.5	-1.5	-1.6	-1.5	-1.1	-2.0	-1.6
Number of time parallelperiods														
2010	00	15	11	12	7	20	17	7	13	14	16	7	2	141
2010	06	31	16	25	14	30	30	31	30	30	31	18	9	295
2010	12	31	14	26	13	31	30	31	31	30	31	19	8	295
2010	18	31	13	30	13	31	29	31	31	28	31	19	8	295
2010	Average	108	54	93	47	112	106	100	105	102	109	63	27	1026

It can be seen from the tables that as per the Silifke MS and NPP site data, daily wind speedaverage monthly values at anemometer elevation (10 m)differ approximately by 2 times, i.e. this MS is not representative for the NPP site.

The reason for such deviations in velocities may be due to the progressively increasing in time horizon shadiness at the Silifke MS. A confirmation to that maybe a wind speedmonotonous decrease within the entire 36-years period of measurements, apparently, because of the rising vegetation, as well as growth of density and height of developments in the NPP vicinity.

The convergence between the data acquired at the Anamur MS and NPP site was significantly better: difference of wind speedvalues exceeded 1 m/s (a representativeness criterion) just within three months from 12, and an average yearly difference amounted only 0.8 m/s.

In Table 4/3.7 an average speedaccording to the Silifke MS data is compared with the results of measurements run at the NPP site mast anemometer elevation during the basic synoptic dates.

4.3.1 SOLAR RADIATION

The solar radiation has been measured at ANPP site at a height of 2 m during November 2009-October 2010. Monthly total solar radiation intensity at ANPP site during November 2009-October 2010 period is given in Table 4/3.8.

Table 4/3.8 – Parameters of Monthly Total Solar Radiation Measured at ANPP Site

Month	Number of measurements	Total solar radiation		
		Average W/(m^2 hour)	Maximum W/(m^2 hour)	Total W/(m^2 month)
Jan	744	3.0	309.6	2212.7
Feb	354	23.7	443.2	8375.7
Mar	661	56.1	529.2	37114.0
Apr	322	97.4	595.3	31359.8
May	744	114.9	569.7	85502.5
Jun	720	127.3	584.5	91690.9
Jul	744	122.4	538.6	91095.4
Aug	744	102.2	527.1	76033.7
Sep	720	79.1	472.7	56971.3
Oct	744	40.7	450.7	30279.4
Nov	720	19.3	386.7	13873.9
Dec	581	2.8	287.5	1634.4
Annual	7798	67.5	595.3	526144.0

During the year the maximum total radiation is observed in June and July (256 - 274 W/m^2). The lowest flux of total radiation is observed in December and January (163 - 208 W/m^2). The annual global radiation on a horizontal surface under average cloudiness conditions is 178 - 189 W/m^2 and annual total radiation is 65160 - 68875W/m^2.

4.3.2 WIND

Average speed and recurrence of wind directions in 16 rhumbs, obtained at the Akkuyu NPP site for the three levels are presented in Tables 4/3.9 – 4/3.10.

Table 4/3.9 – The Frequency of Wind Directions by Seasons, and by Year. The NPP Site, Heights 10, 25 and 60 m, November 2009 - October 2010

Height Z, m	Season	Recurrence, %																
		Wind direction, rhumb																Calms
		N	NNE	NE	ENE	E	ESE	SE	SES	S	SSW	SW	WSW	W	WNW	NW	NNW	
10	Winter	12.5	16.0	41.9	3.6	1.6	0.9	1.4	0.6	0.9	1.9	7.6	3.2	1.4	1.3	1.8	3.5	2.4
25		7.6	19.1	41.7	2.3	1.5	1.0	1.1	0.6	1.1	2.3	8.0	3.0	1.5	2.0	2.7	4.5	1.1
60		10.2	10.7	29.0	5.9	5.3	7.6	1.6	1.1	1.0	1.8	4.7	3.1	3.3	5.2	3.2	6.4	1.3
10	Spring	9.7	13.6	19.1	2.8	2.2	1.8	3.9	2.8	2.1	7.3	16.0	11.6	2.2	1.1	1.3	2.4	6.1
25		9.5	20.1	7.6	2.5	2.2	2.8	4.0	1.7	2.0	9.7	19.5	7.7	1.4	1.6	2.1	5.7	5.3
60		1.9	2.0	6.7	8.8	13.0	7.8	3.7	2.9	4.4	2.5	1.2	2.4	8.9	21.3	10.4	2.1	5.3
10	Summer	7.9	12.0	10.8	1.7	1.0	1.5	5.0	3.0	2.7	12.5	24.5	12.7	2.5	0.4	0.6	1.2	5.9
25		6.6	15.9	3.4	1.6	1.5	3.5	4.1	2.1	2.8	18.8	25.2	7.7	1.3	0.7	0.9	3.8	5.4
60		2.9	1.8	2.6	3.6	8.0	6.0	2.8	2.4	5.2	3.3	2.9	4.3	14.8	27.1	9.0	3.1	6.4
10	Autumn	13.1	17.5	25.0	2.9	2.1	2.4	3.3	2.2	2.0	5.0	11.8	6.6	1.9	0.9	0.9	2.3	2.7
25		13.4	25.6	12.9	2.6	2.9	2.2	3.2	1.6	1.8	6.4	13.7	4.4	1.6	1.6	2.3	3.8	2.8
60		8.3	7.1	6.2	14.3	9.5	7.0	2.6	2.9	3.4	1.8	2.2	1.9	5.9	14.2	6.9	5.9	3.3
10	Year	10.8	14.8	23.2	2.7	1.7	1.7	3.5	2.2	2.0	6.9	15.3	8.8	2.0	0.9	1.1	2.3	4.3
25		9.5	20.4	15.0	2.3	2.1	2.4	3.2	1.6	2.0	9.7	17.0	5.8	1.5	1.4	1.9	4.4	3.7
60		5.7	5.2	10.0	8.4	9.1	7.1	2.7	2.4	3.6	2.4	2.7	2.9	8.4	17.5	7.6	4.3	4.2

Table 4/3.10 – Average Wind Speed by Seasons, and By Year, Regardless of the Period of Measurement. The NPP Site, Heights 10, 25 and 60 m. November 2009 - October 2010

Height Z, m	Season	Average wind speed, m/s																
		Wind direction, rhumb																$\bar{V}$
		N	NNE	NE	ENE	E	ESE	SE	SES	S	SSW	SW	WSW	W	WNW	NW	NNW	
10	Winter	4.2	2.6	3.7	3.4	2.1	2.4	2.2	1.9	2.5	2.4	4.8	3.7	2.6	2.1	2.4	3.2	3.5
25		4.9	3.8	4.7	3.3	3.0	2.5	2.8	2.3	2.9	4.3	7.6	5.1	3.0	2.7	3.0	3.9	4.5
60		6.1	3.7	6.4	4.8	4.1	6.1	3.6	3.3	3.6	3.3	11.4	6.2	5.1	5.6	3.6	6.5	5.8
10	Spring	3.8	1.8	2.6	3.0	2.6	2.6	2.8	2.3	1.6	2.1	2.9	2.9	2.4	1.5	2.7	3.0	2.6
25		3.5	2.5	3.6	2.8	3.3	3.5	2.8	2.2	2.2	2.9	4.4	4.3	2.2	1.8	3.3	4.9	3.4
60		2.6	3.7	6.9	4.9	3.1	3.6	3.0	3.4	3.6	2.8	2.5	2.3	3.4	5.1	5.0	2.7	4.2
10	Summer	3.5	1.8	1.9	1.2	1.6	2.3	2.9	2.2	1.8	2.4	2.6	2.6	2.8	1.8	1.3	2.2	2.4
25		4.0	2.2	1.7	1.5	2.1	3.5	3.1	2.0	2.3	3.2	3.9	3.8	2.0	1.5	1.4	4.2	3.2
60		6.9	2.5	4.4	4.0	2.1	2.4	2.1	2.4	3.6	2.8	2.8	4.1	3.2	4.4	4.5	6.1	3.7
10	Autumn	3.9	2.4	3.0	2.9	2.5	3.0	2.8	2.4	2.2	2.6	3.0	2.9	1.8	1.4	1.7	2.5	2.9
25		4.5	3.3	3.5	2.9	3.8	3.2	3.2	2.7	3.0	3.6	4.5	3.7	2.1	2.0	2.1	3.6	3.6
60		5.9	3.1	4.6	5.5	2.8	3.8	3.2	4.2	3.7	3.9	4.1	3.3	3.5	5.3	4.2	5.8	4.5
10	Year	3.9	2.1	3.0	2.8	2.3	2.6	2.8	2.3	1.9	2.4	3.0	2.9	2.4	1.6	2.2	2.8	2.8
25		4.2	3.0	4.0	2.7	3.2	3.4	3.0	2.3	2.6	3.3	4.5	4.1	2.3	2.1	2.6	4.2	3.6
60		5.8	3.3	6.0	5.1	2.9	3.9	2.9	3.4	3.7	3.1	6.1	4.0	3.5	4.9	4.5	5.6	4.5

The wind rose diagram based on ANPP site wind speed and direction data during November 2009-October 2010 at 10, 25 and 60 m heights is given in Figure 4/3.5. As the dominant wind direction is from NNE, NE and SW directions at 10 and 25 m height, wind pattern changes at 60 m height, the dominant pattern is from WNW and NE and E directions at 60 m.

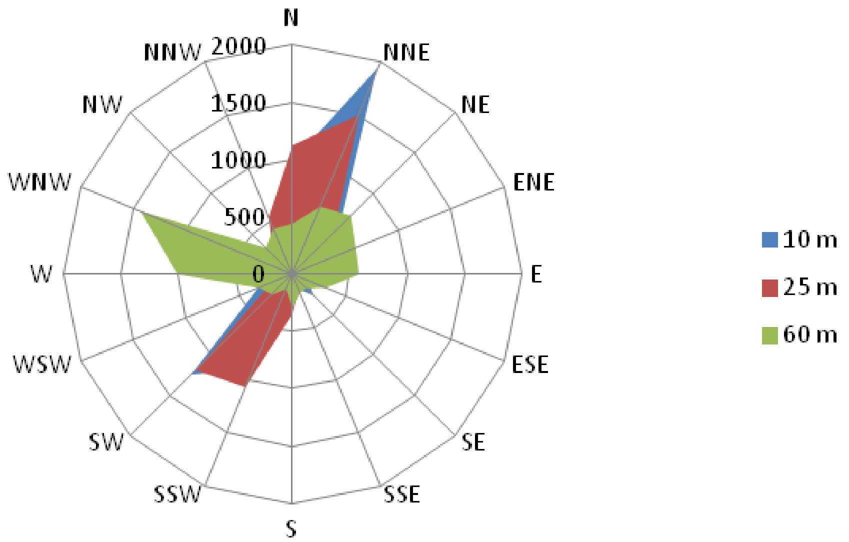


Figure 4/3.5 – Wind Rose Diagram Of 10, 25 And 60 M Wind Direction Data Measured At ANPP Site In 2009- 2010

The directional mean wind speed variations at 10, 25 and 60 m height at ANPP site during November 2009-October 2010 can be seen in Figure 4/3.6. At ANPP site, at 10 m height, when the wind is blowing from N, NE and SW sectors, the wind speed is above 3 m/s. At 25 m height, wind speeds from N, NE and SW sectors are above 4 m/s. At 60 m height, the highest wind speed is observed with 6.55 m/s value when the wind is blowing from the SW sector.

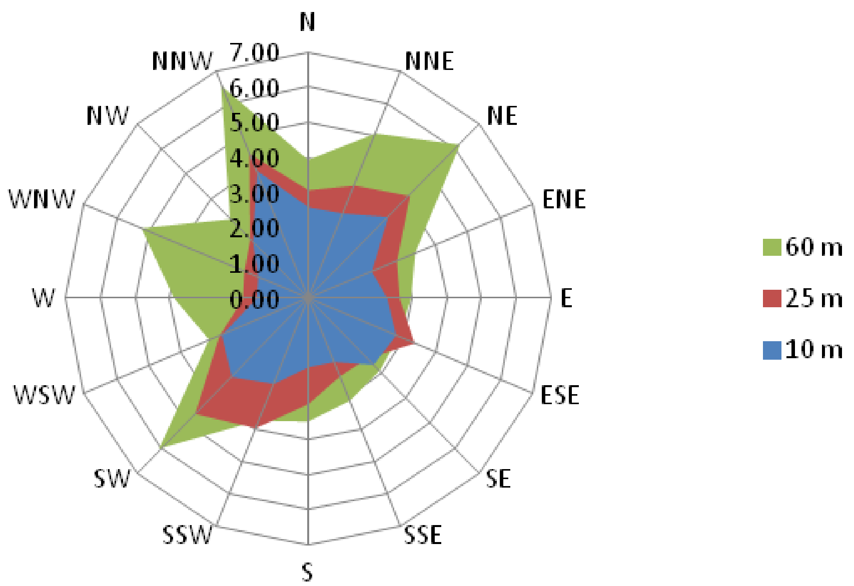


Figure 4/3.6 – Directional Wind Speed Variations At 10, 25 And 60 M Heights At ANPP Site

4.3.3 MAIN PARAMETERS OF LOCAL METEOROLOGICAL CONDITIONS OF THE AKKUYU NPP SITE

Table 4/3.11 presents average monthly values of wind velocity, air temperature at heights of 10, 25 and 60 m, atmospheric pressure, relative air humidity, radiation balance and temperature gradients in layers of 10 - 60 and 25 - 60 m.

Table 4/3.11 – Monthly Average Meteorological Variables taken at 60-m Meteorological Mast in Akkuyu NPP Site for June 2009 – April 2011 period.

Height, m	Month												Year
	1	2	3	4	5	6	7	8	9	10	11	12	
Velocity, m/s													
10	3.6	3.3	2.9	2.6	2.4	2.4	2.4	2.4	2.5	2.8	3.2	3.4	2.8
25	4.6	4.1	3.7	3.4	3.1	3.3	3.2	3.0	3.3	3.6	3.9	4.6	3.6
60	5.9	5.4	4.6	4.2	3.6	4.0	3.7	3.5	3.8	4.5	4.8	5.7	4.5
Air temperature, ^oC													
10	13.9	13.2	16.6	18.9	21.7	25.5	28.6	30.8	28.3	23.3	20.3	15.6	21.8
25	13.8	13.0	16.4	18.4	21.1	24.9	27.7	30.1	27.8	23.1	20.2	15.4	21.4
60	13.9	13.0	16.3	18.3	21.7	25.5	28.6	30.6	27.8	23.1	20.3	15.5	21.6
Pressure, hPa													
2	1011.1	1006.5	1011.2	1007.2	1006.1	1003.2	1001.1	1001.0	1004.9	1008.2	1012.1	1010.5	1007.1
Relative humidity, %													
2	62.6	64.8	60.7	63.8	73.1	67.8	70.1	67.3	64.9	57.6	46.4	63.5	62.8
Radiation balance, W/m^2													
2	3.0	23.7	61.4	92.8	114.9	128.0	121.5	102.2	79.1	40.9	17.9	4.8	66.8
Temperature gradients, ^oC													
60 - 10	-0.135	-0.346	-0.717	-1.308	-0.117	-0.043	-0.074	-0.411	-1.005	-0.326	0.116	-0.075	-0.343
60 - 25	0.077	-0.090	-0.317	-0.309	1.537	1.860	2.530	1.414	-0.013	0.110	0.289	0.250	0.663

In Figure 4/3.7 average monthly local temperature and relative humidity values, obtained for different short observation periods at the Akkuyu NPP site and their regional values calculated from long-term meteorological observations at the Anamur MS are given for comparison.

It can be seen from the figure that local and regional air temperature values correlate more than the relative humidity. It should be also mentioned, that average monthly values of relative humidity at the Akkuyu NPP site are less than those at Anamur MS.

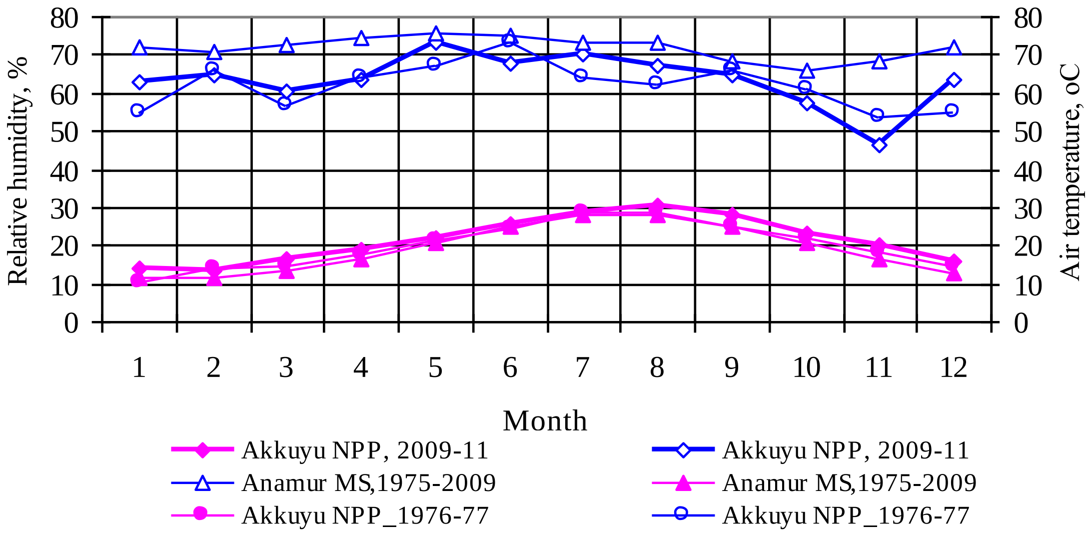


Figure 4/3.7 – Annual Variation of Average Monthly Values of Air Temperature and Relative Humidity at the Akkuyu NPP Site and Anamur MS

Monthly average relative humidity levels at Anamur and Silifke stations and Akkuyu NPP site are given in Figure 4/3.8.

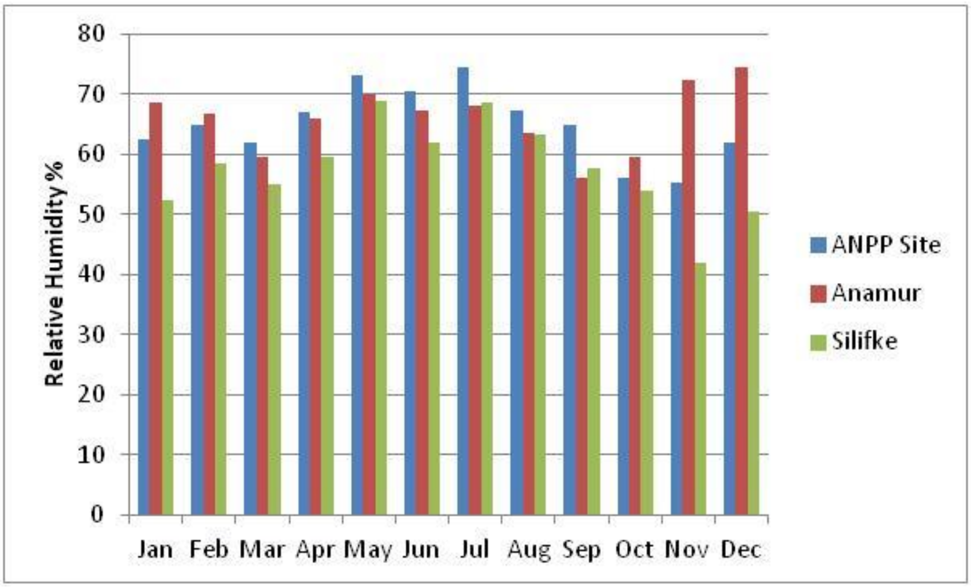


Figure 4/3.8 – Monthly Variation of Relative Humidity During November 2009-October 2010 at Akkuyu NPP Site, Anamur and Silifke Stations

4.3.4 ATMOSPHERE STABILITY CHARACTERISTICS

The Pasquill – Gifford (P-G) stability categories were calculated using computer code PCRAMMET [4/5] based on the data acquired at the Anamur and Silifke stations within 2009 & 2010 years, dependent on hourly insolation, cloudiness and wind velocity. PCRAMMET distinguishes seven stability categories. The first six from them (A-F) correspond to the classification [4/6] (Pasquill's, 1974). The seventh category (G) corresponds to the “problems” in the Pasquill's initial classification (Pasquill's,1974) during strong temperature surface inversion at night with uncertain wind velocity.

Average annual and seasonal recurrence distributions of stability categories are given in Table 4/3.12 and average yearly in Figure 4/3.9.

Approximately 19 % of the time stability category B is observed in the region while stability category G represents 28 - 29 %.

Table 4/3.12 – Recurrence of P-G Stability Categories at the Anamur and Silifke Meteorological Stations in 2009 & 2010 Years

Station	Period	Recurrence, %						
		Stability categories						
		A	B	C	D	E	F	G
Anamur	Year	4.33	18.90	14.15	9.40	9.99	13.81	29.42
	Winter	0.19	11.87	15.31	11.35	12.29	18.66	30.34
	Spring	5.64	21.08	14.47	9.15	9.28	12.88	27.49
	Summer	10.44	22.35	13.04	8.42	8.76	9.85	27.13
	Autumn	0.89	20.08	13.80	8.72	9.68	14.01	32.81
Silifke	Year	5.29	18.92	13.17	9.62	10.62	14.31	28.05
	Winter	0.09	11.46	15.97	12.07	13.45	17.97	28.99
	Spring	6.34	21.65	13.72	9.38	9.56	14.45	24.91
	Summer	14.27	21.01	10.24	8.33	8.74	9.42	27.99
	Autumn	0.64	21.93	12.64	8.61	10.62	15.25	30.31

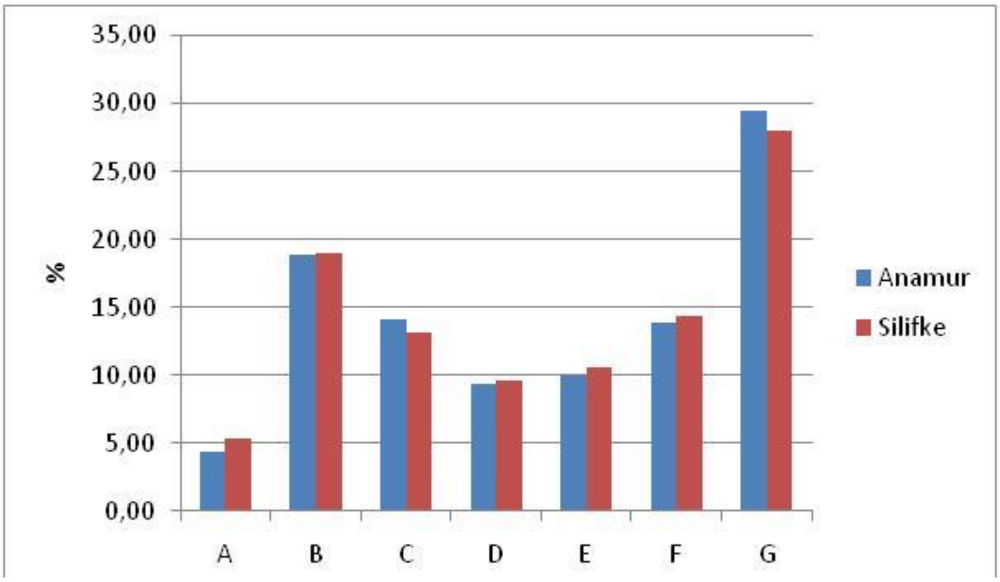


Figure 4/3.9 – Recurrence of P-G Stability Categories at the Anamur and Silifke Meteorological Stations in 2009 & 2010 Years

In order to assess the atmosphere conditions a classification based on the temperature gradients (differentials) in the 20 - 120 m layer and the wind velocity at anemometer level (10 m) [4/7] was also utilized. This classification distinguishes six atmosphere stability categories (SC):

extremely unstable (A), moderately and slightly unstable (B, C), neutral (D), weak (E), moderately and strongly stable (F).

Table 4/3.13 demonstrates recurrence of stability categories based on the results of measurements carried out at the Adana station and ANPP site. The calculated SC distributions significantly differ from those acquired based on the fund materials of the Anamur and Silifke stations, and presented in Table and in Figure 4/3.9.

Table 4/3.13 – Stability Categories and Monthly Recurrences (%) for Adana(2009 – 2010) and ANPP Site (2009 – 2011).

SC	Recurrence, %												
	Month												Year
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Adana station, 2009-2010 years													
A	3.3	0.9	11.3	6.7	9.8	12.3	21.0	16.9	13.3	8.9	5.0	7.3	9.7
B	17.2	22.1	25.0	27.5	23.0	23.7	28.2	26.6	12.2	25.0	20.8	10.5	22.0
C	3.3	8.0	4.8	5.8	10.7	10.5	5.6	4.0	8.9	1.6	3.3	2.4	5.6
D	36.1	40.7	21.0	27.5	26.2	24.6	25.8	31.5	41.1	11.3	12.5	34.7	27.4
E	18.0	16.8	9.7	10.0	14.8	15.8	17.7	15.3	8.9	10.5	25.8	22.6	15.6
F	22.1	11.5	28.2	22.5	15.6	13.2	1.6	5.6	15.6	42.7	32.5	22.6	19.6
ANPP site, 2009-2011 years													
A	0.4	2.5	10.3	14.5	1.6	3.5	1.4	19.1	18.1	12.6	8.8	0.8	7.9
B	3.0	5.4	13.3	16.0	6.7	7.4	6.5	18.1	21.7	15.3	9.9	4.7	10.8
C	0.9	4.2	3.5	5.2	2.4	2.0	3.5	1.9	1.8	2.7	2.0	2.3	2.6
D	67.8	57.6	41.7	26.8	28.2	29.6	23.7	9.8	14.7	27.9	43.8	66.4	35.8
E	14.2	12.4	10.3	12.6	16.9	16.5	16.5	7.4	9.7	16.3	21.2	16.5	14.7
F	13.7	17.8	20.9	24.9	44.1	41.0	48.5	43.7	34.0	25.1	14.2	9.3	28.3

It can be seen from the Table, that in average for a year and during some months, SC D (neutral stratification) is observed more often. During the summer recurrence of neutral stratification (D) and moderate instability (B) is approximately the same. In October and November moderate and very stable stratification prevails (F). In all seasons of the year recurrence of weak instability (C) is little and, apparently, it could be explained only by the peculiarities of the atmosphere conditions based classification.

The joint recurrences of stability gradations, wind velocity and direction for each season and for a year, normalized to the common number of measurement cases at elevation 10 and 100 m are produced in Table 4/3.14. In order to enhance the statistic confidence of the assessments, joint distributions are calculated at wind velocity enlarged gradations and in 8 rhumbs.

Table 4/3.14 – Stability Categories for Wind Speed Gradationsand Wind Sectors at Heights at Adana Station for 2009-2010 Years.

Height, m	SC	Speed gradations, m/s	Recurrence, %							
			Rhumb							
			N	NE	E	SE	S	SW	W	NW
10	A	0.6 - 1.5	0.94	0.24	0.24	0.94	2.36	1.30	0.59	0.35
		1.6 - 3.5	0.07	0.14	0.07	0.00	1.06	1.34	0.07	0.00
	B	0.6 - 1.5	1.28	0.94	0.68	0.85	2.65	1.97	0.43	0.77
		1.6 - 3.5	1.13	0.56	0.91	1.06	2.46	2.89	0.28	0.21
		3.6 - 5.5	0.14	0.49	0.00	0.28	0.77	1.06	0.21	0.00
	C	1.6 - 3.5	0.49	0.07	0.00	0.28	0.99	0.63	0.28	0.07
		3.6 - 5.5	0.00	0.49	0.00	0.07	0.28	0.77	0.07	0.07
		5.6 - 10.5	0.07	0.00	0.07	0.07	0.14	0.63	0.00	0.07
	D	0.6 - 1.5	3.79	1.52	0.89	1.01	0.76	0.38	0.51	1.14
		1.6 - 3.5	3.38	2.39	0.56	0.35	1.06	0.56	0.35	0.49
		3.6 - 5.5	1.48	1.76	0.14	0.21	0.49	0.42	0.00	0.07
		5.6 - 10.5	0.42	0.99	0.14	0.14	0.35	0.91	0.35	0.14
		10.6 - 15.5	0.00	0.07	0.00	0.00	0.00	0.07	0.00	0.07
	E	0.6 - 1.5	0.87	0.54	0.44	1.09	1.53	1.20	0.65	0.44
		1.6 - 3.5	2.67	1.41	0.28	0.28	0.49	0.49	0.28	0.28
		3.6 - 5.5	1.13	0.63	0.14	0.00	0.00	0.00	0.00	0.14
	F	0.6 - 1.5	7.26	3.07	0.41	0.72	0.41	0.72	0.20	1.23
		1.6 - 3.5	3.66	1.27	0.07	0.14	0.00	0.07	0.07	0.35
100	A	0.6 - 1.5	0.26	0.43	0.60	0.60	0.60	0.51	0.09	0.09
		1.6 - 3.5	0.14	0.00	0.07	0.56	1.48	1.06	0.21	0.07
		3.6 - 5.5	0.00	0.07	0.00	0.00	0.91	1.06	0.07	0.00
		5.6 - 10.5	0.00	0.14	0.00	0.00	0.35	0.28	0.00	0.00
	B	0.6 - 1.5	0.09	0.43	0.43	0.43	1.02	0.94	0.51	0.17
		1.6 - 3.5	0.14	1.20	0.91	1.41	2.89	2.67	0.77	0.21
		3.6 - 5.5	0.21	0.70	0.21	0.42	1.41	1.27	0.28	0.00
		5.6 - 10.5	0.14	0.28	0.07	0.07	0.63	1.90	0.14	0.07
	C	0.6 - 1.5	0.00	0.00	0.00	0.07	0.07	0.07	0.00	0.00
		1.6 - 3.5	0.07	0.00	0.07	0.21	0.56	0.56	0.14	0.00
		3.6 - 5.5	0.21	0.21	0.07	0.14	0.42	0.42	0.14	0.00
		5.6 - 10.5	0.14	0.28	0.07	0.00	0.56	0.84	0.07	0.00
	D	0.6 - 1.5	1.12	0.72	0.56	0.64	0.64	0.88	0.56	0.72
		1.6 - 3.5	1.34	1.62	1.27	1.20	0.77	0.63	0.42	0.77
		3.6 - 5.5	1.06	1.55	0.49	0.07	0.49	0.49	0.07	0.21
		5.6 - 10.5	1.27	3.03	0.42	0.21	0.70	1.48	0.14	0.14
		10.6 - 15.5	0.28	1.13	0.00	0.00	0.00	0.21	0.00	0.00
	E	0.6 - 1.5	0.44	0.27	0.36	0.80	0.89	0.44	0.44	0.09
		1.6 - 3.5	0.63	1.62	0.35	0.56	1.55	0.99	0.28	0.14
		3.6 - 5.5	0.84	2.32	0.21	0.00	0.21	0.28	0.14	0.14
		5.6 - 10.5	0.56	0.99	0.07	0.00	0.00	0.00	0.00	0.00
	F	0.6 - 1.5	1.04	0.67	0.97	0.59	0.82	0.52	0.22	0.45
		1.6 - 3.5	1.97	3.38	0.84	0.35	0.07	0.42	0.21	0.56
		3.6 - 5.5	1.13	3.17	0.07	0.00	0.07	0.14	0.00	0.35
		5.6 - 10.5	0.35	0.91	0.07	0.07	0.07	0.07	0.00	0.00

4.3.5 WIND VELOCITY AND TEMPERATURE VERTICAL PROFILES BY RADIOACOUSTIC SOUNDING DATA

Table 4/3.15 and Figure 4/3.10 present data on wind velocity values obtained from radioacoustic sounding data of the lower 2000-m atmosphere layer during period of August, 05-October, 11 2011 at the Akkuyu NPP site.

Table4/3.15 – The Monthly Average Wind Speed at Heights in Akkuyu NPP Site in the period of 05th August–11th October2011

Height, m	Wind velocity, m/s		
	Month		
	VIII	IX	X
10	1.7	1.3	1.2
50	2.8	2.2	2.0
100	3.5	2.8	2.7
150	3.8	3.2	3.1
200	4.1	3.4	3.6
250	4.3	3.5	3.8
300	4.4	3.6	4.2
400	4.4	3.8	4.9
500	4.4	4.0	5.4
600	4.2	3.8	5.1
700	4.6	4.2	5.4
800	4.9	4.4	5.6
1000	6.0	5.3	6.1
1200	7.0	6.2	6.4
1500	8.7	8.3	7.4

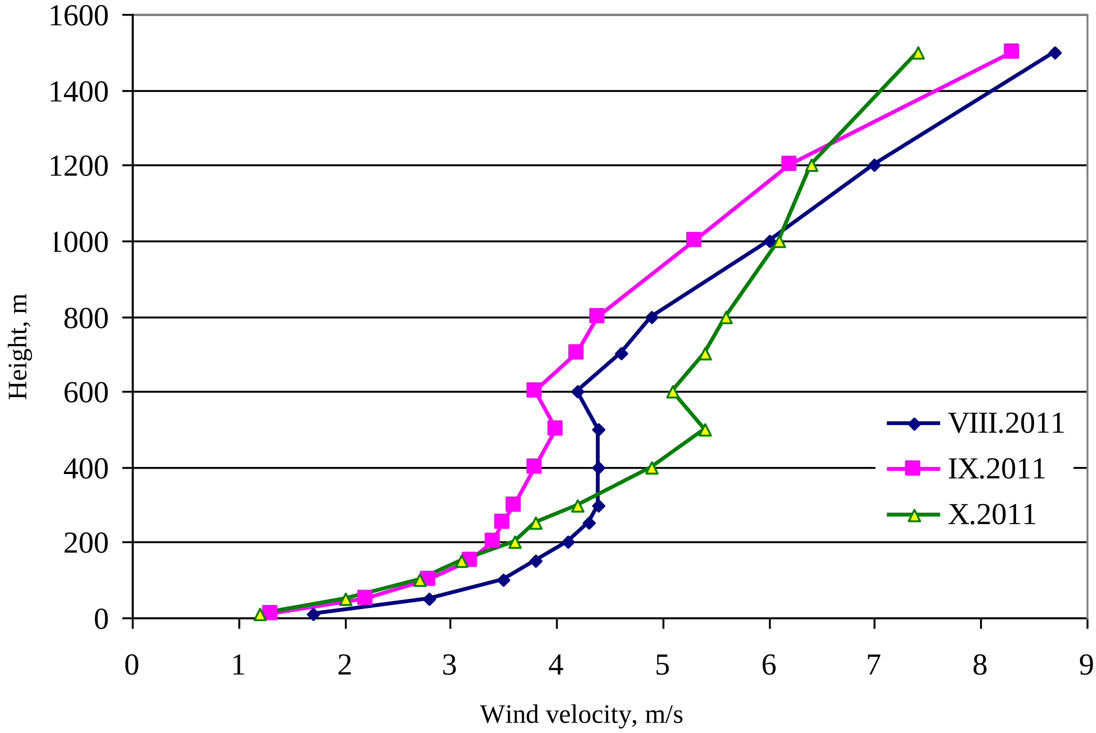


Figure 4/3.10 – Vertical Profiles of Average Wind Velocities from Radioacoustic Sounding Data of the Lower 2000-m Atmosphere Layer During Period of August, 05-October, 11 2011Akkuyu NPP Site

Recurrence of wind directions in 8 rhumbs at different elevations are produced in Table 4/3.16 and shown in Figure 4/3.11 calculated for a measurement period of August, 05-October, 11 2011.

Table 4/3.16 – Recurrence of Wind Directions in 8 Rhumbs at Different Heights, August-October, 2011.

Height, m	Recurrence, %							
	Rhumb							
	N	NE	E	SE	S	SW	W	NW
10	12.9	16.2	9.5	8.4	11.7	30.8	9.8	0.8
50	22.6	14.3	3.8	8.9	12.3	30.4	4.6	3.3
100	17.9	12.1	7.0	8.6	11.4	36.4	5.0	1.5
150	21.2	10.9	5.7	9.5	14.6	32.5	5.0	0.8
200	22.2	8.6	5.7	9.0	15.9	30.6	6.1	1.8
250	23.2	8.1	5.5	8.6	17.5	26.7	8.2	2.3
300	23.5	7.5	6.6	9.1	15.9	24.4	10.0	2.9
400	23.1	6.0	11.3	8.0	11.8	22.8	12.2	4.8
500	22.1	7.0	12.6	6.7	9.1	19.9	15.9	6.7
600	24.3	10.3	12.3	4.3	6.3	13.6	19.9	8.9
700	28.1	11.4	9.1	3.3	4.5	11.9	17.1	14.6
800	31.3	13.8	6.7	2.8	2.0	8.9	16.4	18.1
1000	44.9	13.8	4.1	1.5	1.2	6.1	8.4	20.0
1200	48.9	18.2	2.7	2.4	1.2	4.0	4.0	18.5
1500	30.9	38.2	0.0	10.9	3.6	7.3	3.6	5.5

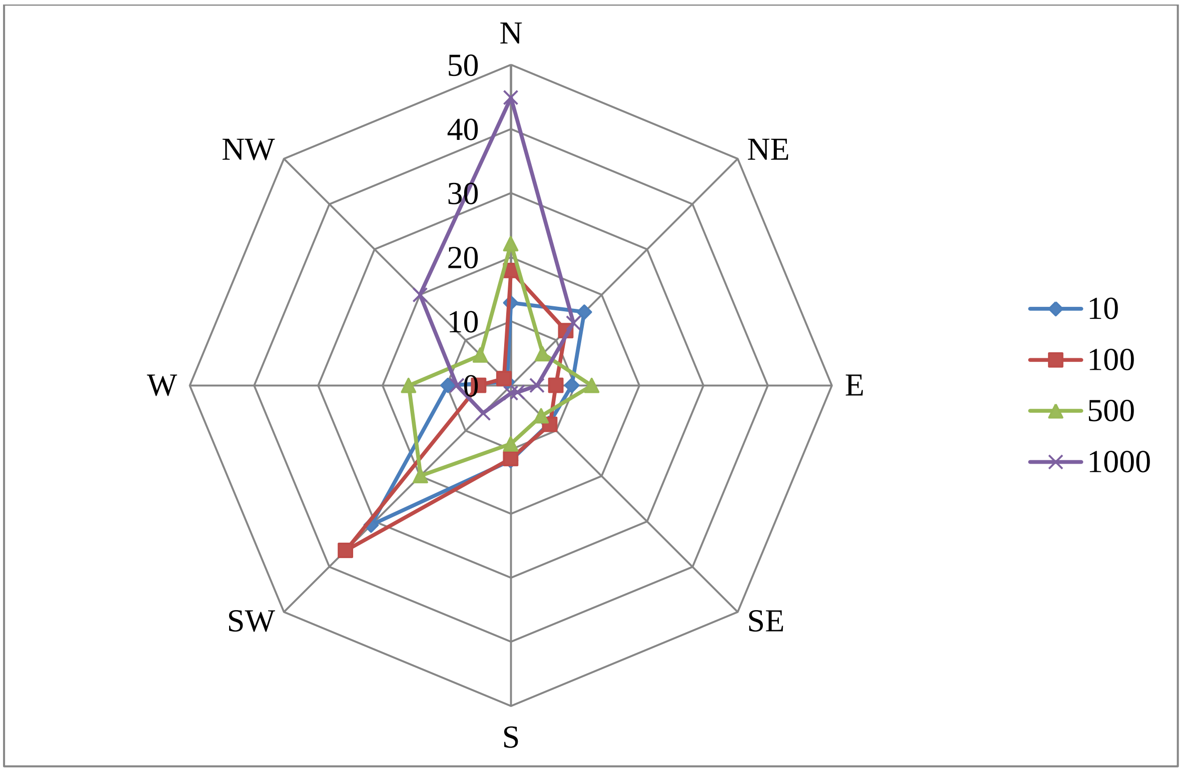


Figure 4/3.11 – Wind Roses for Hourly Radioacoustic Data in the Period of 05thAugust-11thOctober2011 in Akkuyu NPP Site.

As it could be seen from this figure, during the measurement period, redistribution of the predominant wind direction with increasing altitude is from SW to N, what is typical for the local circulations due to the orographic situation.

Table 4/3.17 and Figure 4/3.12 present data on air temperature values obtained from hourly radioacoustic sounding data of the lower 2000-m atmosphere layer during the period of August, 05-October, 11 2011 at the Akkuyu NPP site.

Table 4/3.17 – Average Air Temperature at Heights from SODAR XFAS with RASS Attachment Data, Akkuyu NPP Site

Height, m	Air temperature, ^{o}C		
	Month		
	VIII	IX	X
10	29.4	28.5	25.0
50	29.7	28.4	25.0
100	29.8	28.3	25.0
150	29.8	28.3	25.1
200	29.6	28.0	24.8
250	29.2	27.7	24.4
300	28.8	27.2	23.9
400	27.9	26.4	23.0
500	27.2	25.6	22.0
600	26.4	24.8	21.0
700	25.8	24.1	20.2
800	24.7	23.4	19.3

Height, m	Air temperature, °C		
	Month		
	VIII	IX	X
1000	21.9	21.0	19.0

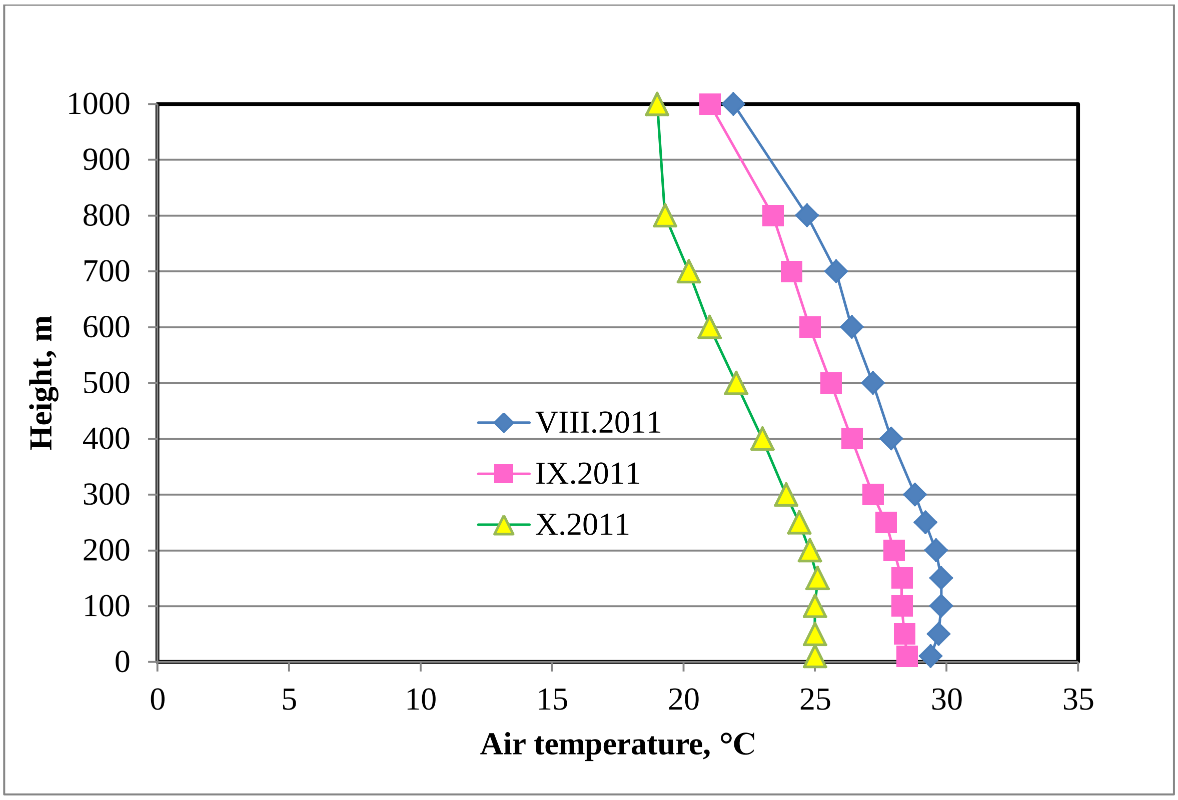


Figure 4/3.12 – Vertical Profiles of Air Average Air Temperature from Hourly SODAR XFAS With RASS Attachment Data During Period of August, 05 – October, 11 2011, Akkuyu NPP Site

4.4 SHORT AND LONG TERM ATMOSPHERIC DISPERSION ANALYSIS

The hourly measurements at 60-m mast located at the Akkuyu NPP site were used as input data for short and long term atmospheric dispersion analysis. Meteorological parameters were collected in the period 2009-2010, in particular, hourly measurements of wind velocity and direction and the air temperature were made at the three levels (10, 25 and 60 m).

The assessment of the atmospheric dispersion properties within short time intervals are acquired according to the recommendations of Regulatory Guide 1.145 “Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants” [4/8], in compliance with which are considered gas-aerosol admixture short-term releases through air vents and other openings of the reactor building. Under conditions of atmosphere neutral (category D of the Pasquill-Gifford (P-G) stability classification) or stable stratification (stability category E and F), when wind velocity is lower than 6 m/s, a flame meandering is taken into account.

The values χ/Q are determined via the method of selective choice of calculation results for relative land concentration on a flame central line using the following set of equations:

$$\chi/Q = \frac{1}{U_{10}(\pi\sigma_y\sigma_z + A/2)}, \tag{4-1}$$

$$\chi/Q = \frac{1}{U_{10}(3\pi\sigma_y\sigma_z)}, \tag{4-2}$$

$$\chi/Q = \frac{1}{U_{10}(3\pi\Sigma_y\sigma_z)}, \tag{4-3}$$

where χ/Q - relative land concentration oratmospheric dispersion factor, s/m^3;

U_{10} - wind mean velocity at elevation 10 m, m/s;

σ_y, σ_z - standard cross and vertical deviations of coordinates of admixture particles in a jet (flame), m;

A - the minimum reactor building area (in vertical plan), perpendicular to the wind direction, m^2;

Σ_y - the standard cross deviation, accounting meandering effects and turbulent trace from the reactor building, wind velocity function, atmosphere stability categories and distances.

The values χ/Q acquired as per (4-1) and (4-2) were compared, and the maximal value was selected. Under neutral and stable stratification, it was compared to the value, obtained from the equation (4-3), and the minimal from these two values was selected as an appropriate χ/Q

value. Under the other meteorological conditions (categories A and B corresponding to unstable stratification), a flame meandering is not postulated. For these conditions the maximal value obtained from equations (4-1) and (4-2) is accepted as the appropriate χ/Q value.

Calculations of χ/Q are carried out for the minimal distances from the reactor building to the boundary of the territory allocated for the Akkuyu NPP construction, which are changing dependent on the wind direction (Figure 4/4.1). These distances change from one rhumb to another.

The values σ_y and σ_z dependent on a distance and P-G stability categories were determined by the Hosker-Smith formulas given in [4/9]. For distances less than 800 m $\Sigma_y = M\,\sigma_y$, where M value was determined from Figure 3 of [4/8]. For long distances, in accordance with [4/8], the following interpolation $\Sigma_y = (M-1)\sigma_{800} + \sigma_y$ was applied. The value A is taken to be 3000 m^2.

The algorithm of calculations is described in details in [4/8] and it could be briefly summarized as per the following:

- using the data of hourly meteorological measurements of selected period, by-earth concentrations are calculated at the boundaries of territory allocated for the Akkuyu NPP construction (hourly mean values of χ/Q for the stationary land source as per equations (4/4.1) – (4/4.2);
- for each hour and also time intervals 8, 16, 72 and 624 h of the yearly cycle data, recurrences of χ/Q gradations are calculated in 16 compass points at the outer boundaries of the territory allocated for NPP construction. Renormalization by 100 % for each compass point gives the accumulated recurrences of gradations, required for calculation of χ/Q with the assigned probability of 0.5, 5 and 50 %;
- for hourly mean and other time intervals, the maximal concentrations χ/Q_{max} are obtained at the outer boundaries of territory allocated for NPP construction, and also appropriate wind velocities and stability categories are obtained by the hourly means.

Atmosphere stability was evaluated as per the Pasquill-Gifford classification, in which prediction variables are the temperature gradients in a stratum of 20 - 120 m, and wind velocity at level of 10 m [4/9, 4/10]. The results of the analysis of aerological measurements data were used as substantiation for utilization of such method for determining stability. The calculations have demonstrated, that as per the data of elevation measurements performed at the Adana aerological station in layers of 20 - 120 m and 25 - 60 m, mean seasonal (and mean monthly) temperature gradients differ insignificantly (Table 4/4.1).

Table 4/4.1 – Temperature Gradients as per the Results of Atmosphere Sounding at the Adana Station, 2009-2010 Years

Layer, m	Time, h UTC	Temperature gradient, ^{o}C/100 m				
		Season				Year
		Winter	Spring	Summer	Autumn	
25 - 60	00	-0.721	-0.405	0.183	-0.932	-0.457
	12	0.491	0.736	0.900	0.594	0.683
20 - 120	00	-0.762	-0.373	0.262	-0.991	-0.453
	12	0.608	0.801	0.846	0.620	0.722

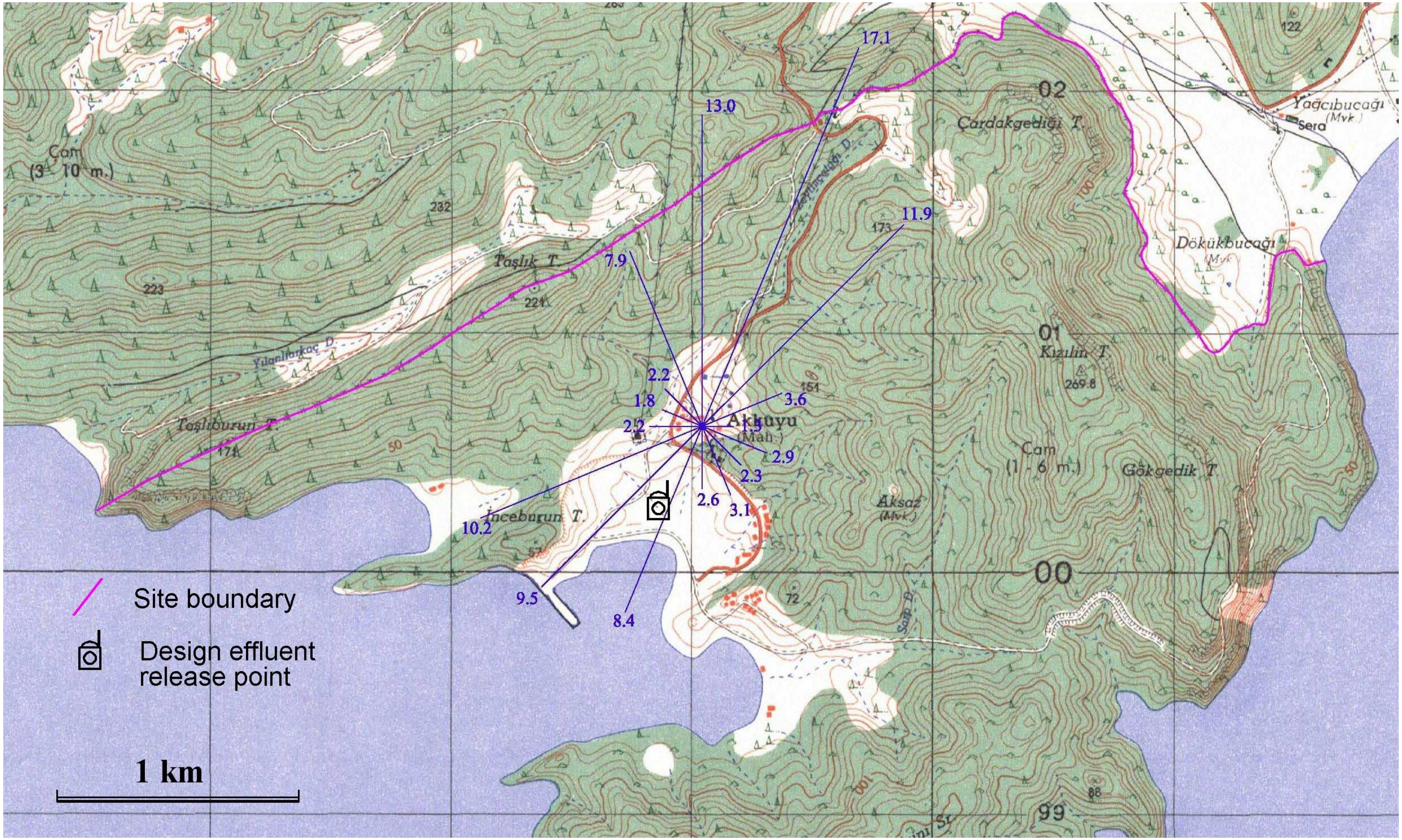


Figure 4/4.1 – Recurrence of Wind Directions at the Akkuyu NPP Site at Anemometer Level (10 m)

It is clear, that the obtained temperature gradients reduced to 100-m layer, differ insignificantly, and this means that gradients in the layer of 25 - 60 m obtained at the meteorological mast, at first approximation might be also used for determining an atmosphere stability state of the Akkuyu NPP region.

Figure 4/4.2 shows recurrence of stability categories as per the results of measurements performed at the Adana aerological station and the Akkuyu NPP site (ANPP).

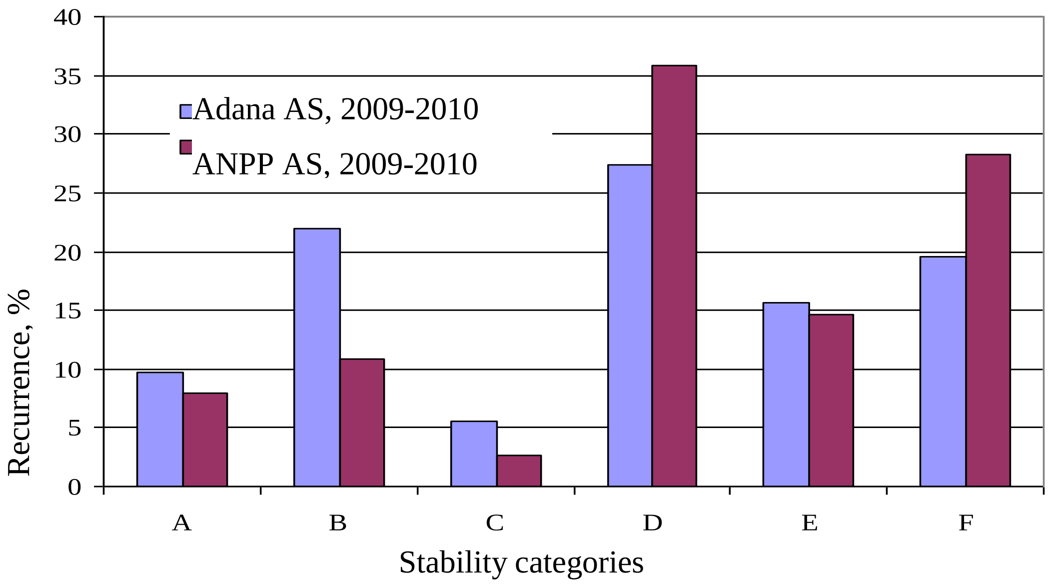


Figure 4/4.2 – Recurrence of Atmosphere Stability Categories

The results of χ/Q calculations including their recurrence by gradations, maximal values at the outer boundaries of territory allocated for the Akkuyu NPP construction by 16 rhumbs, as well as the corresponding values of wind velocity and Pasquill-Gifford stability categories (P-G SC), are presented in Table 4/4.2. The second line of the table gives distances by wind of corresponding rhumb from release source to the outer boundaries of the territory. These distances change from 0.29 km in the S and SSW directions to 5.96 km in the E direction.

In dispersion calculations of σ_z^2 and σ_y^2 by the Hosker-Smith formulas [4/9], roughness parameter was taken to be 0.5 m, which value is typical for heterogeneous underlying surface with alternating areas of bush, forest and open surface. A relief affect to χ/Q distribution was not considered.

The fact that the maximums of χ/Q at the boundary territory allocated for the Akkuyu NPP construction were observed during strongly stable stratification and weak wind is explained by a flame weak smearing at these conditions.

Conservative assessments of the relative average yearly (within a long period) concentration values in rhumbs are obtained by the formula from [4/10, 4/7].

$$\chi_j / Q = \frac{16}{\sqrt{2\pi^3} RN} \sum_{i=1}^{N_j} \frac{1}{\sigma_{zi} U_{Hi}} \exp[-0.5(H/\sigma_{zi})^2], \qquad (4\text{-}4)$$

where:

- R - distance from reactor building to design point along rhumb axis, m;
- N - number of hour dates per year cycle;
- $i = 1...N_j$ number of date in selection of year cycle data in $j-$th rhumb;
- σ_{zi} - standard vertical deviation for $i-$th member of data selection row, m;
- H - ventilation stack elevation (release elevation without account for initial flame rise), m;
- U_{Hi} - wind velocity extrapolated for elevation H for each data hour date, m/s.

Extrapolation of wind velocity measured at elevation 10 m for release level H was realized using power law

$$U_H = U_{10}(H/10)^{\varepsilon}, \qquad (4\text{-}5)$$

where index ε was taken equal to 0.08, 0.09, 0.11, 0.16, 0.32, 0.54 and 0.54 for P-G SC from 1 to 6, accordingly. Standard vertical deviations σ_{zi} were calculated by the Hosker-Smith formulas [4/9].

Average yearly (within a long period) χ/Q values calculated based on the meteorological measurements run within the period from 2009 to 2010 for releases from NPP ventilation stack 100 m high at different distances from the reactor building are given in Table 4/4.3. Distributions of χ/Q values by rhumbs dependent on the distance by wind from source to design point are presented here.

It is seen, that the maximums of χ/Q in rhumbs are observed at distances approximately 400 - 1000 m from the source. The maximal value of χ/Q should be expected at a distance some 400 m at the north-east wind. Following the maximum, χ/Q changes inversely to a distance from the reactor building (see formula (4-4)).

Figure 4/4.3 demonstrates distribution of design χ/Q values around NPP ventilation stack.

It is clear, that geometry of the field of average yearly surface χ/Q values is mostly governed by the recurrence of the wind directions (Figure 4/4.1). The values of atmospheric dispersion factor on the surface $\chi/Q > 0.5$ are mainly formed in the south-west quarter, at the most often recurred wind directions, in particular, at north-north-east, north and north-east wind directions.

Table 4/4.4 presents the maximal values and also relative concentration values with different probability according to the results of direct calculations by hour dates of measurements (without utilization of joint recurrences of P-G stability categories, velocity gradations and wind direction).

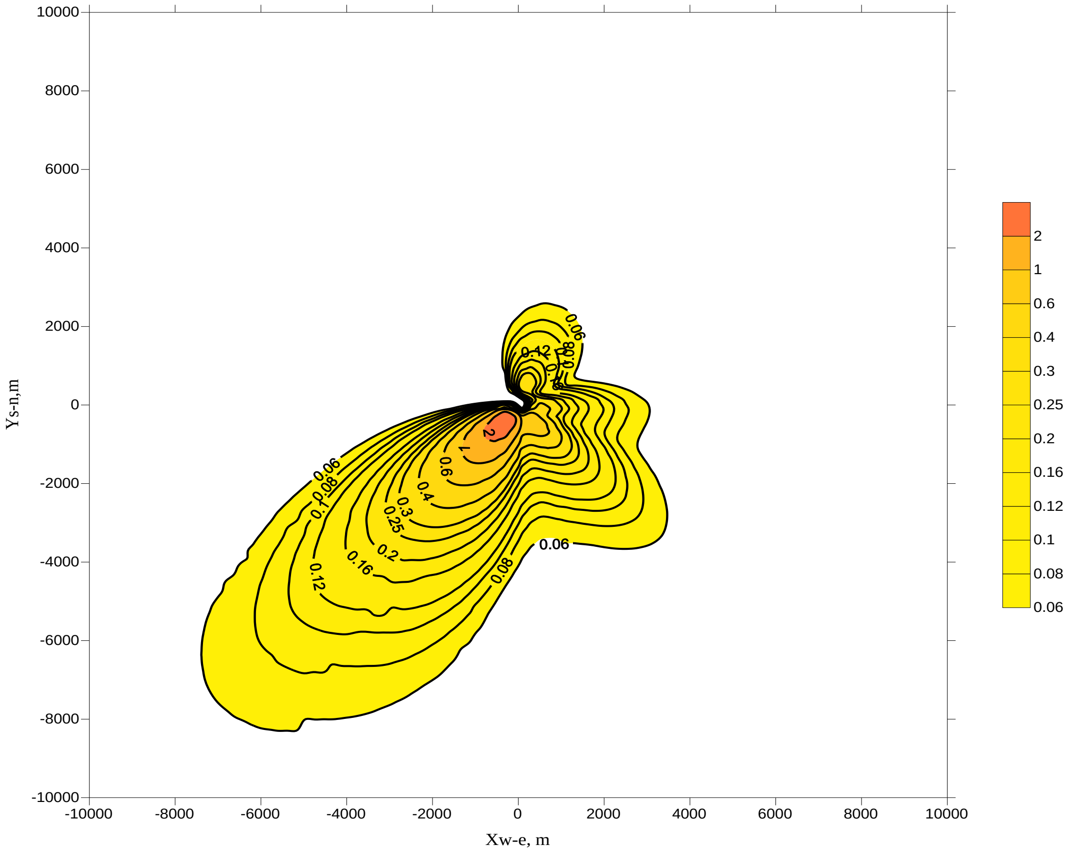


Figure 4/4.3 – Distribution of Design Values $\chi / Q(x, y)$ around NPP Ventilation stack

Point with coordinates (0, 0) – ventilation stack layout. Distance from ventilation stack (m) northward and eastward is positive, and southward and westward – negative

In case of accident, when releases are effected through the ventilation stack, near-surface concentrations are calculated by the formula (4-4) at H =100 m.

The results of the calculations are produced in Table 4/4.5. From this Table it is clear that at this scenario of accident, pollution levels in the near-surface atmosphere layer are several degrees lower.

Table 4/4.2 – Characteristics of χ / Q at Boundaries of the Territory Allocated for the Akkuyu NPP Construction, Averaging Time 1 H

Rhumb		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
Distance to boundary, km		0.29	0.29	0.81	1.47	4.56	2.57	1.99	1.99	2.28	3.75	5.22	5.00	5.96	4.34	5.15	3.75	
Gradations $\chi / Q * 10^6$, s/m^3		Accumulated recurrence of concentration values χ / Q by gradations, %																
2000.00	3000.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0,0
1000.00	2000.00	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0,5
900.00	1000.00	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0,6
800.00	900.00	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0,7
700.00	800.00	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0,8
600.00	700.00	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,0
500.00	600.00	0.6	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,3
400.00	500.00	0.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,5
300.00	400.00	0.7	1.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,8
200.00	300.00	0.7	1.1	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,3
100.00	200.00	1.2	3.4	1.1	0.5	0.0	0.2	0.3	0.6	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,9
90.00	100.00	1.2	3.6	1.6	0.6	0.0	0.2	0.3	0.7	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10,0
80.00	90.00	1.2	3.8	2.3	0.7	0.0	0.2	0.4	0.7	2.1	1.0	0.0	0.0	0.0	0.0	0.0	0.1	12,6
70.00	80.00	1.3	4.0	3.0	0.9	0.2	0.3	0.4	0.8	2.3	1.4	0.0	0.0	0.0	0.2	0.0	0.2	14,9
60.00	70.00	1.4	4.2	3.0	1.2	0.3	0.3	0.5	0.9	2.8	1.9	0.5	0.2	0.0	0.2	0.1	0.2	17,5
50.00	60.00	1.5	4.9	3.0	1.7	0.3	0.4	0.5	1.1	3.3	2.6	0.6	0.2	0.1	0.2	0.1	0.2	20,7
40.00	50.00	1.7	5.8	3.1	2.6	0.4	0.5	0.7	1.3	3.8	3.7	0.8	0.3	0.1	0.3	0.1	0.2	25,4
30.00	40.00	2.0	7.2	4.2	2.7	0.5	0.6	0.7	1.4	4.1	5.8	1.2	0.4	0.1	0.3	0.2	0.3	31,7
20.00	30.00	2.1	7.9	6.4	2.7	0.9	0.6	0.7	1.4	4.2	8.8	2.5	0.6	0.2	0.4	0.2	0.3	40,0
10.00	20.00	2.1	7.9	12.4	4.7	1.0	0.7	1.0	1.7	4.5	9.8	6.5	0.7	0.3	0.4	0.3	0.4	54,5
9.00	10.00	2.1	7.9	13.2	4.9	1.1	0.8	1.0	1.7	4.6	9.8	6.5	0.8	0.3	0.4	0.4	0.4	56,0
8.00	9.00	2.1	7.9	14.0	5.8	1.1	0.9	1.0	1.7	4.7	9.9	6.5	0.8	0.3	0.5	0.4	0.4	57,8
7.00	8.00	2.1	7.9	14.7	7.8	1.1	0.9	1.0	1.7	4.7	9.9	6.5	0.8	0.4	0.5	0.4	0.5	60,8
6.00	7.00	2.1	7.9	15.4	7.9	1.1	0.9	1.1	1.7	4.7	10.5	6.6	0.8	0.4	0.5	0.4	0.5	62,6
5.00	6.00	2.1	7.9	16.1	8.0	1.1	1.0	1.2	1.9	4.8	11.8	6.6	0.8	0.4	0.5	0.4	0.6	65,3
4.00	5.00	2.1	7.9	17.3	8.2	1.2	1.0	1.3	2.2	5.4	12.3	7.8	0.9	0.4	0.6	0.5	0.6	69,8
3.00	4.00	2.1	7.9	17.3	8.8	1.3	1.0	1.3	2.3	8.5	12.4	10.9	1.0	0.6	0.7	0.7	0.7	77,5
2.00	3.00	2.1	7.9	17.3	9.4	1.6	1.1	1.3	2.3	9.1	13.8	12.0	1.1	0.7	0.8	0.8	1.1	82,4
1.00	2.00	2.1	7.9	17.3	9.8	1.9	1.1	1.3	2.3	9.4	14.7	19.6	2.1	0.9	1.1	1.8	1.3	94,7
0.90	1.00	2.1	7.9	17.3	9.8	1.9	1.1	1.3	2.3	9.4	14.7	19.7	2.1	1.0	1.1	1.8	1.4	95,0
0.80	0.90	2.1	7.9	17.3	9.8	1.9	1.1	1.3	2.3	9.4	14.7	19.7	2.1	1.0	1.1	1.9	1.5	95,2
0.70	0.80	2.1	7.9	17.3	9.8	1.9	1.1	1.3	2.3	9.4	14.8	19.7	2.1	1.0	1.2	1.9	1.6	95,7
0.60	0.70	2.1	7.9	17.3	9.8	1.9	1.1	1.3	2.3	9.4	14.9	19.8	2.2	1.1	1.2	2.0	1.8	96,2
0.50	0.60	2.1	7.9	17.3	9.8	1.9	1.1	1.3	2.3	9.4	15.0	19.8	2.2	1.2	1.4	2.0	1.9	96,7
0.40	0.50	2.1	7.9	17.3	9.8	1.9	1.1	1.3	2.3	9.4	15.0	19.9	2.2	1.2	1.7	2.6	1.9	97,7
0.30	0.40	2.1	7.9	17.3	9.8	1.9	1.1	1.3	2.3	9.4	15.1	19.9	2.3	1.4	1.7	3.2	2.2	99,0
0.20	0.30	2.1	7.9	17.3	9.8	1.9	1.1	1.3	2.3	9.4	15.1	20.0	2.3	1.6	1.8	3.5	2.3	99,7
0.10	0.20	2.1	7.9	17.3	9.8	1.9	1.1	1.3	2.3	9.4	15.1	20.0	2.3	1.6	1.8	3.6	2.3	100,0
Maximum $\chi / Q * 10^6$		1925	1925	354	213	74	128	162	162	143	89	65	67	57	77	66	89	1925
Wind velocity, m/s		0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	-
P-G SC		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	-
$\chi / Q * 10^6$ of 0.5% probability		1887	1671	327	209	74	127	161	161	142	89	64	67	56	77	64	88	-

Table 4/4.3 – Average Annual atmospheric dispersion factors $\chi / Q * 10^7$ at Different Distances From Ventilation Stack 100 m Height, Z0=0.5 m

Distance, m	Average annual atmospheric dispersion factors $\chi / Q * 10^7$, s/m^3															
	Rhumb															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
200	0.264	0.946	0.902	0.182	0.020	0.000	0.009	0.000	0.084	0.096	0.084	0.052	0.129	0.086	0.155	0.201
400	1.066	3.645	3.845	0.936	0.082	0.001	0.033	0.029	0.322	0.408	0.324	0.197	0.531	0.399	0.821	0.834
600	0.963	3.189	3.680	1.028	0.077	0.004	0.027	0.049	0.291	0.393	0.291	0.176	0.500	0.417	0.903	0.778
800	0.743	2.433	2.952	0.885	0.061	0.005	0.019	0.048	0.233	0.319	0.229	0.138	0.401	0.355	0.771	0.615
1000	0.568	1.851	2.314	0.722	0.047	0.006	0.014	0.042	0.184	0.252	0.179	0.107	0.315	0.289	0.623	0.477
1200	0.442	1.438	1.832	0.586	0.037	0.005	0.011	0.035	0.147	0.201	0.141	0.085	0.250	0.235	0.502	0.375
1400	0.352	1.144	1.477	0.480	0.030	0.005	0.008	0.029	0.120	0.163	0.114	0.068	0.202	0.193	0.410	0.301
1600	0.286	0.931	1.213	0.399	0.025	0.004	0.007	0.025	0.099	0.135	0.094	0.056	0.167	0.160	0.339	0.247
1800	0.237	0.772	1.013	0.336	0.020	0.004	0.006	0.021	0.083	0.113	0.078	0.047	0.139	0.135	0.285	0.206
2000	0.200	0.651	0.859	0.287	0.017	0.003	0.005	0.018	0.071	0.096	0.067	0.040	0.118	0.116	0.243	0.174
2200	0.171	0.557	0.739	0.248	0.015	0.003	0.004	0.016	0.061	0.083	0.057	0.034	0.102	0.100	0.210	0.149
2400	0.148	0.483	0.642	0.217	0.013	0.003	0.003	0.014	0.053	0.072	0.050	0.030	0.089	0.087	0.183	0.130
2600	0.130	0.422	0.564	0.191	0.011	0.002	0.003	0.012	0.047	0.063	0.044	0.026	0.078	0.077	0.161	0.114
2800	0.115	0.373	0.499	0.170	0.010	0.002	0.003	0.011	0.042	0.056	0.039	0.023	0.069	0.069	0.143	0.101
3000	0.102	0.333	0.446	0.152	0.009	0.002	0.002	0.010	0.037	0.050	0.035	0.021	0.062	0.061	0.128	0.090
3200	0.092	0.299	0.401	0.137	0.008	0.002	0.002	0.009	0.034	0.045	0.031	0.019	0.055	0.055	0.115	0.081
3400	0.083	0.270	0.363	0.124	0.007	0.002	0.002	0.008	0.030	0.041	0.028	0.017	0.050	0.050	0.104	0.073
3600	0.075	0.245	0.330	0.113	0.007	0.002	0.002	0.007	0.028	0.037	0.026	0.015	0.046	0.046	0.095	0.066
3800	0.069	0.224	0.302	0.104	0.006	0.001	0.002	0.007	0.025	0.034	0.024	0.014	0.042	0.042	0.087	0.061
4000	0.063	0.205	0.277	0.095	0.006	0.001	0.001	0.006	0.023	0.031	0.022	0.013	0.038	0.039	0.080	0.056
4200	0.058	0.189	0.256	0.088	0.005	0.001	0.001	0.006	0.022	0.029	0.020	0.012	0.035	0.036	0.074	0.051
4400	0.054	0.175	0.237	0.082	0.005	0.001	0.001	0.005	0.020	0.027	0.018	0.011	0.033	0.033	0.068	0.047
4600	0.050	0.162	0.220	0.076	0.004	0.001	0.001	0.005	0.019	0.025	0.017	0.010	0.030	0.031	0.063	0.044
4800	0.046	0.151	0.205	0.071	0.004	0.001	0.001	0.005	0.017	0.023	0.016	0.010	0.028	0.029	0.059	0.041
5000	0.043	0.141	0.191	0.066	0.004	0.001	0.001	0.004	0.016	0.022	0.015	0.009	0.027	0.027	0.055	0.038
5200	0.041	0.132	0.179	0.062	0.004	0.001	0.001	0.004	0.015	0.020	0.014	0.008	0.025	0.025	0.052	0.036
5400	0.038	0.124	0.169	0.058	0.003	0.001	0.001	0.004	0.014	0.019	0.013	0.008	0.023	0.024	0.049	0.034
5600	0.036	0.117	0.159	0.055	0.003	0.001	0.001	0.004	0.013	0.018	0.012	0.007	0.022	0.022	0.046	0.032
5800	0.034	0.110	0.150	0.052	0.003	0.001	0.001	0.003	0.013	0.017	0.012	0.007	0.021	0.021	0.043	0.030
6000	0.032	0.104	0.142	0.049	0.003	0.001	0.001	0.003	0.012	0.016	0.011	0.007	0.020	0.020	0.041	0.028
6200	0.030	0.099	0.134	0.047	0.003	0.001	0.001	0.003	0.011	0.015	0.011	0.006	0.019	0.019	0.039	0.027
6400	0.029	0.094	0.128	0.044	0.003	0.001	0.001	0.003	0.011	0.014	0.010	0.006	0.018	0.018	0.037	0.026
6600	0.027	0.089	0.121	0.042	0.002	0.001	0.001	0.003	0.010	0.014	0.009	0.006	0.017	0.017	0.035	0.024
6800	0.026	0.085	0.115	0.040	0.002	0.001	0.001	0.003	0.010	0.013	0.009	0.005	0.016	0.016	0.033	0.023
7000	0.025	0.081	0.110	0.038	0.002	0.001	0.001	0.003	0.009	0.013	0.009	0.005	0.015	0.016	0.032	0.022
7200	0.024	0.077	0.105	0.037	0.002	0.001	0.001	0.002	0.009	0.012	0.008	0.005	0.015	0.015	0.030	0.021
7400	0.023	0.074	0.101	0.035	0.002	0.001	0.001	0.002	0.009	0.011	0.008	0.005	0.014	0.014	0.029	0.020
7600	0.022	0.071	0.096	0.033	0.002	0.000	0.000	0.002	0.008	0.011	0.008	0.004	0.013	0.014	0.028	0.019
7800	0.021	0.068	0.092	0.032	0.002	0.000	0.000	0.002	0.008	0.010	0.007	0.004	0.013	0.013	0.027	0.018
8000	0.020	0.065	0.089	0.031	0.002	0.000	0.000	0.002	0.008	0.010	0.007	0.004	0.012	0.013	0.026	0.018
8200	0.019	0.062	0.085	0.030	0.002	0.000	0.000	0.002	0.007	0.010	0.007	0.004	0.012	0.012	0.025	0.017
8400	0.018	0.060	0.082	0.028	0.002	0.000	0.000	0.002	0.007	0.009	0.006	0.004	0.011	0.012	0.024	0.016
8600	0.018	0.058	0.079	0.027	0.002	0.000	0.000	0.002	0.007	0.009	0.006	0.004	0.011	0.011	0.023	0.016
8800	0.017	0.056	0.076	0.026	0.002	0.000	0.000	0.002	0.006	0.009	0.006	0.004	0.011	0.011	0.022	0.015

Distance, m	Average annual atmospheric dispersion factors χ / Q *10^7, s/m^3															
	Rhumb															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
9000	0.016	0.054	0.073	0.026	0.001	0.000	0.000	0.002	0.006	0.008	0.006	0.003	0.010	0.010	0.021	0.015
9200	0.016	0.052	0.071	0.025	0.001	0.000	0.000	0.002	0.006	0.008	0.006	0.003	0.010	0.010	0.021	0.014
9400	0.015	0.050	0.068	0.024	0.001	0.000	0.000	0.002	0.006	0.008	0.005	0.003	0.010	0.010	0.020	0.014
9600	0.015	0.048	0.066	0.023	0.001	0.000	0.000	0.002	0.006	0.008	0.005	0.003	0.009	0.009	0.019	0.013
9800	0.014	0.047	0.064	0.022	0.001	0.000	0.000	0.001	0.005	0.007	0.005	0.003	0.009	0.009	0.019	0.013
10000	0.014	0.045	0.062	0.022	0.001	0.000	0.000	0.001	0.005	0.007	0.005	0.003	0.009	0.009	0.018	0.012

Table 4/4.4 – Maximum, 0.5, 5 and 50 % Probability Values χ / Q at Distance from Release Source to Boundary of the Territory Allocated for the Akkuyu NPP Construction for Different Time Intervals After Accident. Accidental Release from Reactor Compartment

Interval, h		Values χ / Q *10^6, s/m^3															
		Rhumb															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	Max.	1925	1925	354	213	74	128	162	162	143	89	65	67	57	77	66	89
	0.5 % probability	1887	1671	327	209	74	127	161	161	142	89	64	67	56	77	64	88
	5 % probability	1576	670	126	103	72	118	147	148	128	82	34	62	51	74	32	77
	50 % probability	115	75	15	9	15	34	42	46	7	24	3	2	1	2	1	2
8	Max.	1925	1925	354	213	74	128	162	162	143	89	65	67	57	77	66	89
	0.5 % probability	1884	1739	325	208	74	127	161	161	142	88	64	67	56	77	65	88
	5 % probability	1545	810	140	100	72	119	150	151	132	74	41	63	52	74	45	75
	50 % probability	123	85	18	13	21	37	47	59	50	25	7	3	2	3	1	2
16	Max.	1925	1925	354	213	74	128	162	162	143	89	65	67	57	77	66	89
	0.5 % probability	1875	1713	280	206	74	127	161	161	142	88	64	67	56	77	65	88
	5 % probability	1474	695	109	90	72	120	151	152	134	70	47	63	52	74	53	75
	50 % probability	126	85	19	15	22	42	53	68	58	26	10	7	2	3	1	2
72	Max.	1925	1097	354	213	74	128	162	162	143	89	65	67	57	77	66	89
	0.5 % probability	1801	692	184	136	74	127	161	161	142	79	57	67	56	77	63	87
	5 % probability	997	478	72	70	72	121	152	153	133	57	35	63	52	73	41	52
	50 % probability	156	99	22	20	21	54	59	80	69	29	11	11	3	4	1	2
624	Max.	1925	316	59	47	64	128	155	162	143	63	32	67	57	77	16	57
	0.5 % probability	1639	311	59	46	64	127	153	161	139	61	31	66	39	76	15	56
	5 % probability	741	282	55	40	58	117	141	150	105	47	26	58	27	54	12	50
	50 % probability	423	118	18	19	19	41	68	77	53	30	10	16	3	14	3	4

Table 4/4.5 – Maximum, 0.5, 5 and 50 % Probability Values χ / Q at Distance from Release Source to Boundary of the Territory Allocated for the Akkuyu NPP Construction for Different Time Intervals After Accident. Accidental Release from Ventilation Stack

Interval, h		Values χ / Q $*10^7$, s/m^3															
		Rhumb															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	Max.	62.5	62.5	35.6	13.4	3.8	10.3	12.4	12.1	11.4	6.9	4.5	4.8	3.8	5.8	4.6	5.8
	0.5 % probability	62.1	61.1	24.1	11.5	3.2	10.2	11.8	10.3	7.8	5.9	2.4	4.6	3.5	5.3	4.2	5.5
	5 % probability	48.4	25.6	9.4	4.4	1.8	4.1	4.2	2.2	1.9	1.7	0.9	1.8	1.4	1.8	1.4	2.6
	50 % probability	10.5	11.2	1.7	2.0	0.4	0.0	0.0	0.0	0.7	0.1	0.5	0.5	0.5	0.5	0.5	0.8
8	Max.	62.5	62.5	35.6	13.4	3.8	10.3	12.4	12.1	11.4	6.9	3.9	4.8	3.8	5.8	4.6	5.8
	0.5 % probability	62.2	61.4	27.9	12.0	3.3	10.1	12.0	10.7	9.3	5.9	2.1	4.6	3.6	5.4	4.4	5.6
	5 % probability	48.4	24.9	9.9	5.3	1.8	4.3	3.7	2.2	2.2	1.7	0.9	1.9	1.6	2.3	1.5	2.8
	50 % probability	7.9	8.9	2.7	1.8	0.3	0.0	0.0	0.0	0.0	0.2	0.5	0.5	0.5	0.5	0.5	0.8
16	Max.	62.5	62.5	35.6	13.4	3.8	5.7	12.4	12.1	11.4	6.9	4.5	4.8	3.8	5.8	4.6	5.8
	0.5 % probability	62.2	60.3	28.9	11.6	3.4	5.5	12.0	10.5	9.5	6.2	1.9	4.7	3.6	5.5	4.4	5.5
	5 % probability	46.7	21.7	10.2	5.2	1.8	3.8	3.6	1.9	2.7	1.6	0.9	2.5	1.8	3.0	1.5	3.1
	50 % probability	7.6	8.5	3.3	1.8	0.3	0.0	0.0	0.0	0.0	0.2	0.4	0.5	0.6	0.6	0.5	0.8
72	Max.	62.5	62.5	35.6	7.5	3.8	5.7	12.4	12.1	9.3	2.5	1.8	4.8	3.8	5.8	4.6	5.8
	0.5 % probability	62.0	37.1	19.3	6.7	3.5	4.9	11.6	3.0	9.1	2.1	1.3	4.6	3.6	4.8	4.5	5.3
	5 % probability	34.9	19.6	9.7	5.0	1.8	3.3	3.6	1.7	2.0	1.3	0.8	1.9	1.7	3.2	2.0	2.5
	50 % probability	6.6	8.0	3.8	1.6	0.4	0.0	0.0	0.0	0.0	0.3	0.4	0.5	0.6	0.6	0.5	0.8
624	Max.	60.1	33.7	15.2	5.6	3.8	3.0	4.9	2.2	7.5	1.1	0.7	1.6	3.8	1.9	1.8	2.5
	0.5 % probability	60.0	32.7	14.3	5.4	3.4	2.9	3.9	2.0	3.2	1.1	0.7	1.4	3.5	1.9	1.8	2.4
	5 % probability	27.4	22.9	9.5	3.7	1.7	2.8	3.4	1.7	1.5	1.0	0.7	0.9	1.8	1.6	1.5	2.1
	50 % probability	7.3	8.2	3.4	2.0	0.6	0.6	0.4	0.2	0.7	0.4	0.5	0.6	0.5	0.6	0.6	0.9

4.5 METEOROLOGICAL EVENTS

4.5.1 FOG, HAIL AND GLAZE-ICE PHENOMENA

Fog, hail and frost rarely happen at both Anamur and Silifke (Table 4/5.1). Within the last 41 years (1970 - 2010), hail was observed in 117 days at Anamur and 50 days at Silifke. The number of days with fog within the last 40 years is 19 for Anamur and 5 for Silifke. The average number of days with hail was 2.3 at Anamur MS and 1.2 at Silifke MS.

Table 4/5.1– Average Number of Days with Fogs, Hail and Frosts at Anamur and Silifke MS

Month	Average number of days with fogs	Average number of days with hail	Average number of days with frosts
Anamur MS			
I	-	0.5	-
II	-	0.5	0.1
III	-	0.3	-
IV	-	0.2	-
V	0.3	0.1	0.0
VI	-	0.0	-
VII	-	-	-
VIII	-	-	-
IX	-	0.0	-
X	-	0.0	-
XI	-	0.2	-
XII	-	0.5	-
Year	0.3	2.3	0.1
Silifke MS			
I	0.1	0.1	-
II	-	0.1	-
III	-	0.2	-
IV	0.0	0.1	-
V	-	0.2	-
VI	-	0.1	-
VII	-	-	-
VIII	-	-	-
IX	-	-	-
X	-	0.1	-
XI	-	0.1	-
XII	0.1	0.2	-
Year	0.2	1.2	-

There is no information on glaze-ice phenomena.

4.5.2 THUNDERSTORM

Average number of days with thunderstorm is 7.7 at Anamur station and 8.8 at Silifke station (for details see Table 4/5.2). Most of the thunderstorms were observed in January, February, March, October, November and December at both stations.

Table 4/5.2 – Average Number of Days with Thunderstorm at Reference Meteorological Stations for 1981-2010 Period

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Anamur MS	1.0	0.8	0.9	0.6	0.4	0.3	0.1	0.0	0.3	1.1	1.1	1.1	7.7
Silifke MS	0.8	0.8	0.8	0.8	1.0	0.5	0.2	0.1	0.4	1.2	1.1	1.1	8.8

4.5.3 DUST STORM

Eastern Mediterranean region is under the influence of frequent dust storms. Desert dust reaches the east Mediterranean from the North African and Arabian deserts [4/16] and [4/17]. Every year one hundred and fifty million tons out of the one billion tons of dust originating from North Africa are transported to the Mediterranean basin [4/18] and [4/19]. An example for such a dust storm can be seen over the eastern Mediterranean on the high-resolution image (Figure 4/5.1).

Dust storms, moving from the Sahara Desert to the eastern Mediterranean, occur between October and May, but mostly from December to April. More than 89 % of the total annual dust is accumulated between December and May, considered as the ‘high dust season’. The annual totals vary as much as an order of magnitude from year to year. The previous studies both at the eastern and the western part of the basin indicate that the number of days per year affected by particulate matter input from the Sahara ranges from 40 to 60 days.

Based on the results of a study conducted at Erdemli which is 75 km northwest of Akkuyu site, concentrations indicated orders of magnitude day to day variation (PM_{10} =2 - 326 μg m^{-3}; $PM_{2,5}$ = 0.5 - 28 μg m^{-3}) [4/20]. Recent studies have shown that there is an increasing trend in the total number of dust days with an average rate of 2.7 days per decade. This increasing trend in dust storm occurrence fits with previous results for the eastern Mediterranean and south Europe [4/21].

Figure 4/5.1 – Dust Storm at April 04, 2003 Over the Eastern Part of the Mediterranean

4.5.4 TORNADO

Tornadoes occur infrequently in Turkey, however small scale weaker tornados are common in the region. There appears to be no institutionalized process of gathering and archiving reports of severe tornado events in Turkey, perhaps owing to the perception that such storms are too rare to merit such a commitment.

The tornado analysis is based on a region within a radius of 150 km of Akkuyu NPP. The European Severe Weather Database identifies 48 tornados in this region for the 30 year period 1981 to 2010[4/11] which corresponds to 1.6 tornadoes per year. Six of the tornados were reported to have started over water, seven started over land, and the start locations of the remaining 35 tornados were not reported. Two tornado events occurred in the city of Larnaca and in the province of Antalya with path lengths of 12 km and 5 km, respectively.

Table 4/5.3 shows the tornado observations within 150 km of the Akkuyu NPP site from 1981 to 2010. Tornadoes were observed during every month of the year; however, approximately 60 percent of the annual total occurred in fall and winter (September to February). The nearest tornado occurred over water and was approximately 33 km NNE of the Akkuyu NPP site in November 2008. Forty six of the 48 observed tornados were more than 80 km from Akkuyu NPP.

Table 4/5.3 – Tornado Events within 150 km of Akkuyu NPP (1981-2006)[4/13]

Date	Location	Start	Latitude (ºN)	Longitude (ºE)	Distance to Akkuyu NPP (km)

Date	Location	Start	Latitude (ºN)	Longitude (ºE)	Distance to Akkuyu NPP (km)
22-Nov-08	SE Kargicak	Water	36.42	33.67	33
12-Dec-10	Tasucu	Water	36.3	33.88	35
8-Sep-09	Karakesli	Land	36.68	34.15	81
16-Feb-01	Istiklal, Aydin, Esentepe	Land	36.61	32.69	92
6-Dec-09	Kumyali	Land	35.43	34.13	95
26-Dec-03	Larnaka		35.31	33.14	99
18-Sep-09	Nicosia	Land	35.17	33.37	109
17-May-05	Nicosia		35.17	33.37	109
24-Aug-99	Kokkini Trimithia		35.15	33.2	114
23-Feb-09	SSW Gazipasa	Water	36.22	32.27	115
27-Nov-00	Yeri		35.1	33.42	116
8-Dec-02	Akaki		35.13	33.13	118
14-Jun-91	Akaki		35.13	33.13	118
18-Feb-90	Athienou		35.07	33.54	119
21-May-86	Famagusta		35.12	33.95	119
18-Aug-01	Ghaziveran	Land	35.17	32.92	122
18-Aug-01	Troulli		35.03	33.62	124
30-Mar-86	Troulli		35.03	33.62	124
7-Feb-06	Pyla	Land	35.03	33.69	124
20-Sep-99	Dhali		35.02	33.42	125
24-Aug-99	Dhali		35.02	33.42	125
1-Mar-82	Avgorou		35.04	33.83	125
8-Jan-97	Xylotymbou		35.02	33.75	126
1-Jun-95	Pera		35.03	33.25	126
26-Mar-09	Athienou, Leivadia, Oroklini, Pyla, Dasaki	Land	35.01	33.69	126
1-Jun-95	Politiko		35.03	33.24	127
19-Feb-00	Ormidhia		35	33.78	129
29-Oct-04	Sotira		35.03	33.95	129
22-Oct-96	Sotira		35.03	33.95	129
8-Jan-97	Dhekelia Cantonment		34.98	33.73	130
21-May-86	Aradhippou		34.95	33.59	132
28-Mar-06	Mosphiloti		34.95	33.43	133
6-Oct-96	Mosphiloti		34.95	33.43	133
18-Sep-08	Mahmutlar	Water	36.46	32.1	134
21-May-86	Lythrodhondas		34.95	33.3	134
19-Feb-00	Larnaca		34.92	33.63	136
20-Dec-86	Larnaca		34.92	33.63	136
1-Nov-84	Larnaca		34.92	33.63	136
7-Feb-99	Kornos		34.92	33.39	136
29-May-85	Kornos		34.92	33.39	136
14-Apr-01	Alethriko		34.86	33.5	142
27-Jan-03	Kiti		34.85	33.58	144
19-Oct-06	Alanya	Water	36.55	32	145
6-Mar-95	Perivolia		34.83	33.58	146
28-Jan-94	Kophinou		34.83	33.39	146

Date	Location	Start	Latitude (ºN)	Longitude (ºE)	Distance to Akkuyu NPP (km)
5-Oct-09	S Alanya	Water	36.47	31.95	147
19-Feb-00	Alaminos		34.81	33.43	148
31-Oct-06	Ayios Theodhoros		34.8	33.39	150

Only one tornado was reported with an enhanced Fujita classification of F1 [4/11]. The F1 class tornado occurred in the village of Pyla in Cyprus Island on 7 February 2006, approximately 124 km from Akkuyu NPP. Fujita classes for the remaining 47 tornado events were not reported.

The enhanced Fujita scale is based on the average amount of tornado damage due to a nominally averaged 3-second (gust) wind speed as shown in Table 4/5.4. The enhanced scale wind speeds are greater than speeds of the original Fujita Scale, which were based on winds occurring over a 400 m interval. The F1 enhanced classification corresponds to maximum wind speeds of 39 m/s to 49 m/s (3 second gust); F0 tornados have maximum wind speeds of 29 m/s to 38 m/s.

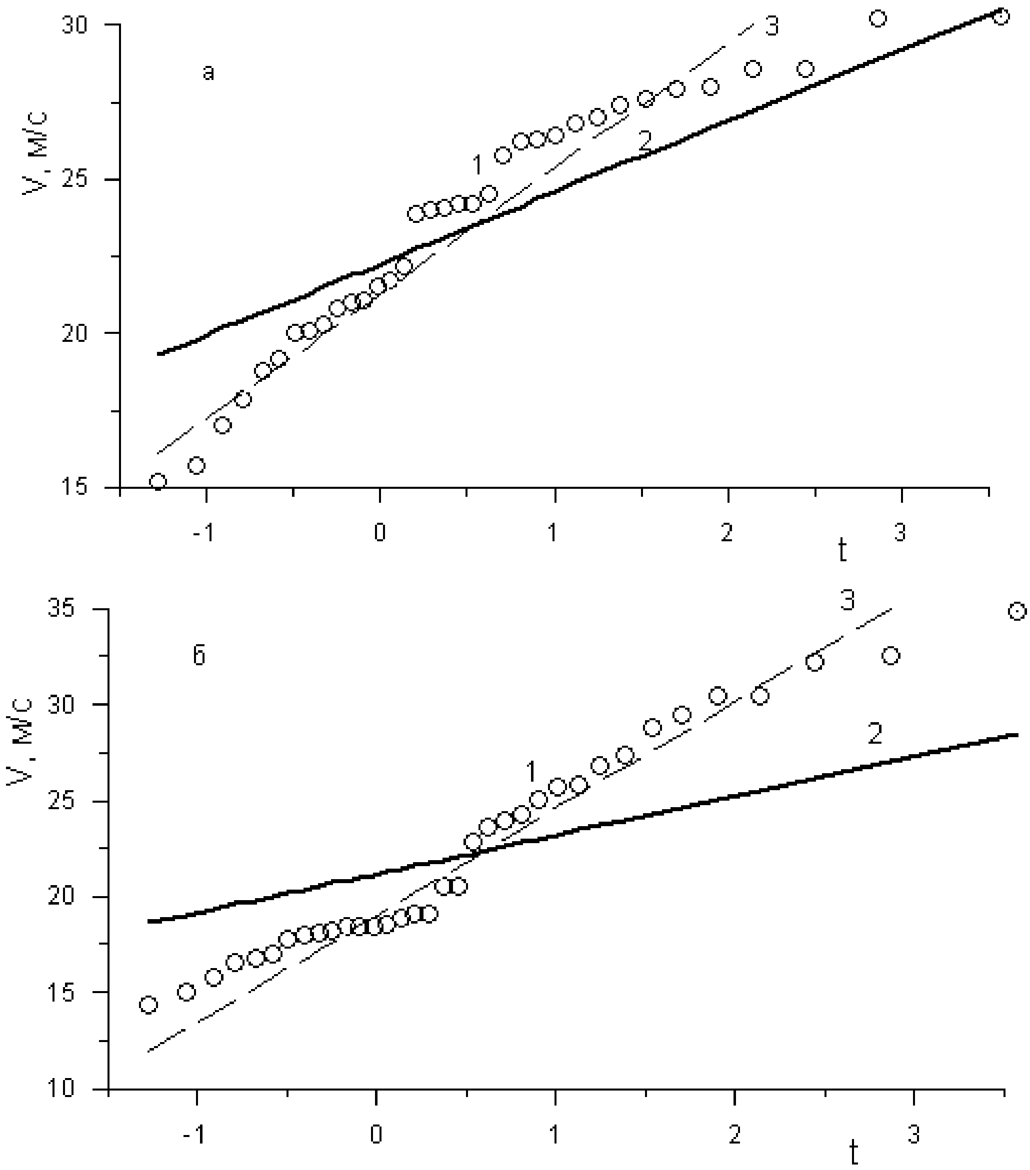
Table 4/5.4 – Enhanced Fujita Tornado Intensity Classification ([4/13] and [4/14])

Class	Typical Damage	EF Scale 3 Second Gust(m/s)
F0	Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.	29 - 38
F1	Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.	39 - 49
F2	Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.	50 - 60
F3	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.	61 - 74
F4	Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.	75 - 89
F5	Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters; trees debarked; incredible phenomena will occur.	>89

4.6 EXTREME VALUES OF METEOROLOGICAL VALUES

4.6.1 WIND VELOCITY

The input data for obtaining design maximums for wind velocities with different probabilities are daily (absolute) maximums of wind velocities presented in Table 4/2.4. For their equalization Gumbell distribution and linear approximation are used (Figure 4/6.1).



1 – velocity maximums, 2 – Gumbel distribution, 3 – linear approximation

Figure 4/6.1 – Approximation of Absolute Maximums of Wind Velocity at Silifke (A) and Anamur (Б) MS With Different Dependences, 1975-2009

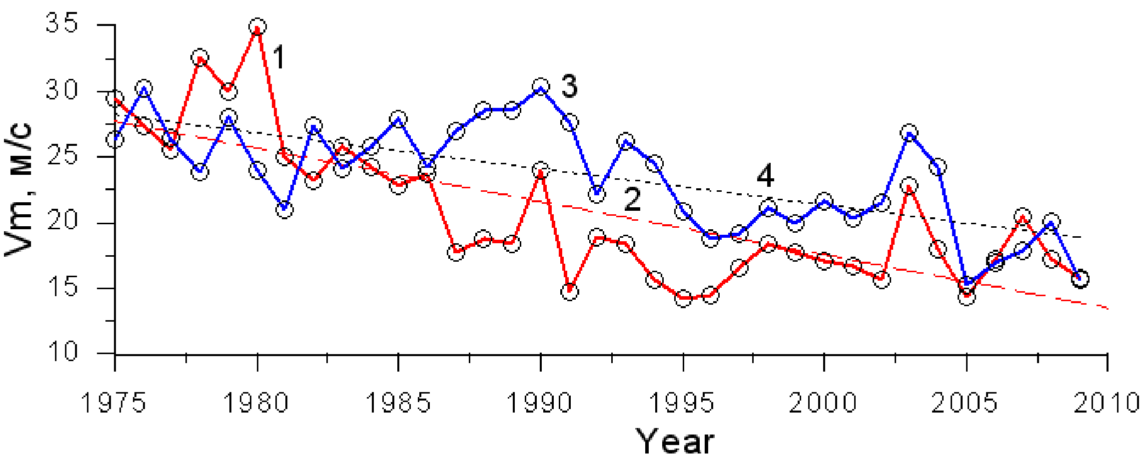
It can be seen from the figure that according to Silifke MS data, Gumbell distribution better approximates maximum velocities of high-range wind, and linear approximation is more suited for description of low-range maximums (low values of maximums). For Anamur MS linear approximation gives the best results within the full range of determination of maximums.

Taking into account the quality of equalizing of experimental data the design maximums of different probability are defined using Gumbel distribution for Silifke MS and linear approximation for Anamur MS (Table 4/6.1).

The time variation of absolute maximums of wind speed by years is shown in Figure 4/6.2. The figure shows that over the years, the absolute maximum of wind speed at both meteorological stations is gradually reduced, and at the Anamur station it fells down quite rapidly first and then more slowly. In recent years, they are almost equal by value. Reduction of absolute maximums of wind speed over the years may be due to shading by trees of wind vane and multi-storey buildings.

Table 4/6.1 – Design Maximums of Wind Velocity per Silifke and Anamur MS Data, 1975-2009

Probability of exceedance	Anamur MS	Silifke MS
	Vмax, m/s	Vмax, m/s
0.5	23.1	21.1
0.2	25.7	27.4
0.1	27.5	31.6
0.08	28.0	32.9
0.05	29.2	35.6
0.02	31.3	40.8
0.01	32.9	44.7
0.004	35.1	49.9
0.001	38.3	57.6
0.0001	43.6	70.5



(red line – 1), (red dash line – 2) – maximums of speed and time trend at Anamur; (blue line – 3), (black dotted line – 4) – the same at Silifke

Figure 4/6.2 – The Time Variation of Absolute Maximums of Wind Speed and Time Trend at Anamur and Silifke, 1975-2009

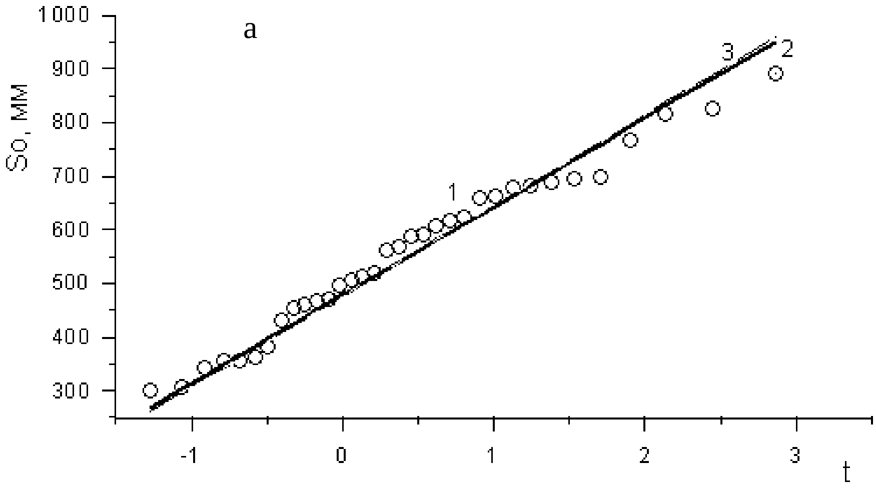
It is recommended to use values of maximum wind speed at Silifke MS for design calculations.

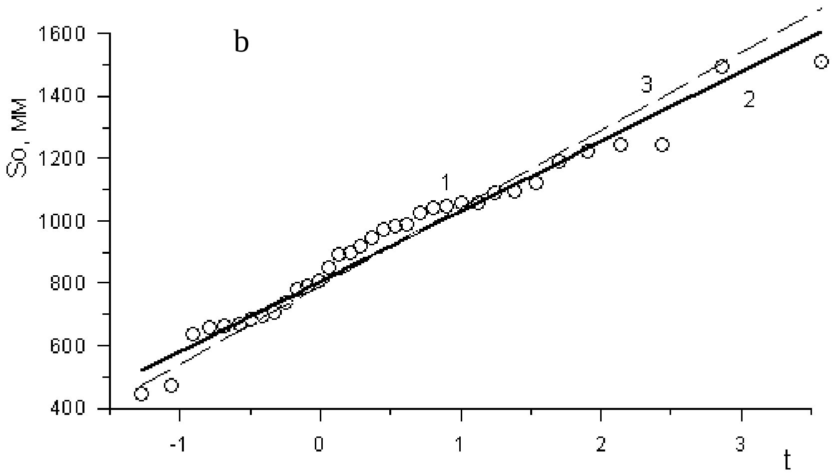
4.6.2 PRECIPITATION

Design precipitation values with given probability are given in Table 4/6.2, equalization was performed using double exponential Gumbell distribution (Figure 4/6.3).

Table 4/6.2 – Design Annual Precipitation of the Given Probability, 1975-2009 Period

Probability of exceedance	Annual precipitation h, mm			
	Silifke MS		Anamur MS	
	So	σ_{So}	*So*	σ_{So}
0.97	271.1	38.8	524.6	52.8
0.95	297.1	36.3	560.0	49.4
0.90	340.5	32.9	619.0	44.7
0.80	399.6	29.9	699.4	40.7
0.50	538.6	32.9	888.5	44.7
0.20	725.6	52.1	1142.9	70.9
0.10	849.5	68.4	1311.3	93.1
0.05	968.2	85.0	1472.9	115.6
0.03	1054.2	97.2	1589.9	132.3
0.01	1237.2	123.9	1838.7	168.5





a, b – Silifke and Anamur MS data for 1975-2009 period

Figure 4/6.3 – Approximation of Annual Precipitation (1) by Gumbell Distribution (2) and Linear Dependence (3)

For mid-season months, the design total precipitation of different probability is listed in Table 4/6.3.

Table 4/6.3 – Design Total Precipitation for Mid-Season Months

Exceedance probability	Monthly total precipitation h, mm			
	January	April	July	October
Silifke				
0.50	98	27	2	33
0.20	156	48	4	66
0.10	195	62	6	88
0.08	207	66	7	95
0.05	232	75	8	109
0.01	316	105	12	157
0.001	436	147	17	225
0.0001	554	189	22	292

Exceedance probability	Monthly total precipitation h, mm			
	January	April	July	October
Anamur				
0.50	180	45	0	59
0.20	269	79	0	113
0.10	328	102	1	149
0.08	346	109	1	160
0.05	384	124	1	183
0.01	512	173	1	261
0.001	693	243	2	372
0.0001	874	313	2	482

Design maximum of total daily precipitation were extracted from the 1965-2005 data sets using Gumbel distribution (see Table 4/6.4).

Table 4/6.4 – Extreme Design Daily Precipitation of Given Probability at the Reference MS

Return Period (yrs)	Anamur Station			Silifke Station		
	Max. daily precipitations, mm	Confidence Limits 95 %		Max. daily precipitations, mm	Confidence Limits 95 %	
		Lower	Upper		Lower	Upper
10000	314	307	321	267	255	278
1000	255	250	260	214	205	222
100	195	192	199	161	155	166
50	177	175	180	145	140	149
20	153	151	156	123	120	127
5	116	114	117	89	87	91

4.6.3 AIR TEMPERATURE

Absolute extremes of air temperature are given in Table 4/6.5. Calculations of extreme temperature values of given probabilities are based on this information.

Table 4/6.5 – Measured Extremums of Air Temperature at Anamur and Silifke MS, 1975-2009

Year	Anamur MS		Silifke MS	
	T_{min}	T_{max}	T_{min}	T_{max}
1975	0.8	36.1	1.6	37.0
1976	-3.2	35.3	-0.7	36.8
1977	2.3	39.6	1.5	38.4
1978	4.0	40.8	5.0	40.0
1979	2.6	40.0	1.2	41.1
1980	0.0	39.6	1.0	41.0
1981	4.4	38.8	4.2	39.5
1982	1.8	38.7	2.2	38.0

Year	Anamur MS		Silifke MS	
	$T_{\min}$	$T_{\max}$	$T_{\min}$	$T_{\max}$
1983	0.2	37.1	-0.8	39.8
1984	4.6	36.1	3.5	39.0
1985	-2.5	39.8	0.6	38.4
1986	3.7	36.4	2.2	37.4
1987	0.5	38.5	3.0	38.4
1988	2.5	40.1	2.9	39.2
1989	-0.1	37.5	2.0	37.3
1990	0.5	36.5	1.9	37.0
1991	-2.6	39.0	0.9	36.2
1992	0.0	38.6	0.9	39.4
1993	-0.6	39.6	1.4	37.5
1994	1.8	39.2	2.9	38.7
1995	1.8	38.3	4.7	36.9
1996	2.6	38.0	3.3	36.4
1997	-1.8	39.4	0.2	37.8
1998	3.8	42.4	4.0	40.0
1999	2.0	38.4	2.8	36.8
2000	0.1	38.6	2.3	37.4
2001	3.0	39.0	1.4	36.7
2002	-0.2	39.1	3.6	42.0
2003	0.7	40.2	2.4	36.6
2004	-1.8	38.0	-0.5	38.8
2005	0.7	36.2	1.0	37.5
2006	0.1	38.5	2.6	38.6
2007	0.4	42.2	4.1	39.6
2008	-0.4	40.0	2.6	36.7
2009	-0.3	38.3	1.7	37.5

In 1975-2009 at Anamur MS the absolute extremes of air temperature were recorded – minus 0.8 and 42 °C and at Silifke MS – minus 3.2 and 42.4 °C.

Results of the calculations obtained using Gumbel distribution are given in Table 4/6.6.

Table 4/6.6 – Design Extreme Values of Air Temperature of Different Probability by Gumbell Distribution (T_{ext}^{Gum}) and Linear Approximation (T_{ext}^{Lin})

Probability of exceedance	Anamur MS			Silifke MS		
	T_{ext}^{Gum}	σ_T^{Gum}	T_{ext}^{Lin}	T_{ext}^{Gum}	σ_T^{Gum}	T_{ext}^{Lin}
Minimum air temperature, °C						
0.5000	2.3	0.21	2.3	1.2	0.13	1.2
0.2000	0.9	0.08	0.9	-0.7	0.08	-0.8
0.1000	0.0	0.00	-0.1	-2.0	0.23	-2.1
0.0800	-0.3	0.03	-0.4	-2.4	0.27	-2.5
0.0500	-0.9	0.08	-1.0	-3.2	0.36	-3.4
0.0200	-2.1	0.19	-2.2	-4.8	0.54	-5.0

0.0100	-3.0	0.26	-3.1	-6.0	0.67	-6.2
0.0010	-5.9	0.52	-6.0	-10.0	1.11	-10.3
0.0001	-8.8	0.78	-9.0	-13.9	1.55	-14.3
Maximum air temperature, °C						
0.5000	38.0	0.42	38.1	38.4	0.68	38.4
0.2000	39.5	0.43	39.5	40.0	0.71	40.1
0.1000	40.5	0.44	40.5	41.0	0.72	41.1
0.0800	40.8	0.45	40.8	41.3	0.73	41.4
0.0500	41.4	0.45	41.4	42.0	0.74	42.1
0.0200	42.6	0.47	42.6	43.3	0.76	43.5
0.0100	43.5	0.48	43.5	44.3	0.78	44.5
0.0010	46.4	0.51	46.5	47.4	0.84	47.7
0.0001	49.4	0.54	49.4	50.6	0.89	51.0

It is recommended to use values of extreme air temperatures at Silifke MS for design calculations.

Table 4/6.7 presents design extremes of daily air temperature at Anamur and Silifke MS.

Table 4/6.7 – Design Extremes of Daily Air Temperature of Different Probability and RMS Deviation Σ_τ for 1975-2009

Probability of exceedance	Minimum		Maximum	
	T_{min}, °C	σ_T	T_{max}, °C	σ_T
Anamur MS				
0.5000	5.8	0.44	31.4	0.36
0.2000	4.0	0.31	32.8	0.37
0.1000	2.9	0.22	33.8	0.38
0.0800	2.5	0.19	34.1	0.39
0.0500	1.8	0.13	34.7	0.39
0.0200	0.3	0.02	35.8	0.41
0.0100	-0.8	0.06	36.7	0.42
0.0010	-4.3	0.33	39.5	0.45
0.0001	-7.9	0.60	42.4	0.48
Silifke MS				
0.5000	4.1	0.81	32.4	0.43
0.2000	2.2	0.43	33.9	0.45
0.1000	0.9	0.18	35.0	0.46
0.0800	0.5	0.10	35.3	0.47
0.0500	-0.3	0.06	35.9	0.48
0.0200	-1.9	0.37	37.2	0.49
0.0100	-3.1	0.61	38.1	0.51
0.0010	-6.9	1.38	41.2	0.55
0.0001	-10.8	2.16	44.4	0.59

Table 4/6.8 presents characteristics of the hotter five days (pentades), including extreme values and relative humidity for this period and also year/month/date of pentades.The characterization of such pentades of high temperatures and air humidities is done for designing the ventilation and air conditions systems.

Table 4/6.8 – Extreme Temperatures of Pentades (T, ºc) and Corresponding Relative Humidity F, Observation Date, 1975-2009

Year	Minimum				Maximum			
	T_{min}, ºC	f_{min}, %	Month	Pentade	T_{max}, ºC	f_{max}, %	Month	Pentade
Anamur MS								
1975	7.2	59.8	2	11	28.6	64.4	7	14
1976	5.7	53.8	2	10	27.7	67.1	8	15
1977	7.2	33.2	1	6	30.7	57.2	7	29
1978	10.3	74.5	2	9	28.7	70.1	7	18
1979	7.7	69.1	12	28	29.2	46.0	7	13
1980	8.3	63.0	1	31	29.6	54.4	8	3
1981	9.5	71.1	2	18	29.4	59.5	8	5
1982	6.9	46.1	2	5	28.6	65.2	9	3
1983	5.2	66.4	2	20	29.2	44.8	7	27
1984	9.7	73.4	12	13	28.3	77.5	7	26
1985	5.2	60.7	2	24	29.5	69.6	8	13
1986	9.3	60.6	1	21	28.9	77.9	8	14
1987	6.9	80.7	3	8	30.2	83.7	7	25
1988	9.0	70.9	3	3	32.1	61.9	7	8
1989	7.7	56.9	2	13	30.2	57.3	7	22
1990	7.7	54.2	1	7	29.3	61.4	7	30
1991	6.6	60.8	2	3	28.5	78.3	7	24
1992	5.4	65.7	2	23	29.8	63.3	8	8
1993	6.5	52.9	2	1	28.9	69.8	8	16
1994	7.9	64.9	12	19	29.2	67.2	7	24
1995	9.0	65.4	1	18	29.5	49.0	7	29
1996	7.6	72.3	1	18	29.0	47.1	7	27
1997	6.0	48.1	2	4	30.9	43.9	7	5
1998	8.7	73.9	3	19	32.0	41.8	8	7
1999	9.3	59.4	1	20	30.3	78.7	8	18
2000	7.4	47.1	1	28	29.8	63.7	7	6
2001	8.2	71.5	2	21	29.4	87.1	8	5
2002	7.0	45.6	1	8	31.4	50.1	7	30
2003	6.8	63.1	2	23	30.8	60.0	7	22
2004	6.7	81.1	2	16	29.1	79.6	7	28
2005	6.5	24.8	2	10	30.2	85.2	8	2
2006	8.5	58.9	2	16	30.9	80.7	8	20
2007	10.1	84.9	2	5	31.9	78.7	7	31
2008	8.4	49.7	1	31	30.9	81.2	8	22
2009	8.4	52.6	1	1	30.3	77.7	7	23
Silifke MS								
1975	5.7	43.7	2	10	29.2	42.7	8	14
1976	2.9	44.4	2	10	28.7	52.6	8	12
1977	5.4	36.7	1	6	30.5	54.5	7	17
1978	9.5	62.5	1	4	30.4	53.1	7	15

Year	Minimum				Maximum			
	T_{min}, °C	f_{min}, %	Month	Pentade	T_{max}, °C	f_{max}, %	Month	Pentade
1979	6.8	55.0	1	7	31.5	32.3	9	28
1980	5.4	41.6	1	15	30.5	41.9	8	3
1981	9.4	55.8	2	18	31.8	41.9	6	29
1982	5.5	36.8	2	5	30.1	47.3	9	4
1983	4.2	43.2	1	4	29.2	45.5	7	25
1984	7.3	59.1	12	14	28.6	43.7	7	12
1985	2.8	33.1	2	23	30.4	62.0	8	15
1986	8.4	43.1	1	21	28.4	63.1	7	17
1987	5.3	43.3	3	14	30.5	50.2	7	25
1988	8.2	41.6	2	24	31.2	39.7	7	8
1989	5.1	34.7	1	28	30.4	50.5	7	23
1990	4.5	35.8	1	8	29.9	46.3	7	31
1991	3.5	50.9	2	3	28.6	64.3	8	23
1992	3.1	49.2	2	2	30.6	49.0	8	10
1993	4.4	57.8	1	7	31.0	53.0	8	1
1994	5.8	53.0	12	19	30.4	61.7	8	15
1995	7.3	51.1	1	20	29.3	62.8	8	12
1996	7.6	58.3	1	22	29.7	42.7	7	26
1997	4.5	37.1	2	5	30.4	49.3	7	5
1998	9.0	44.9	1	11	33.9	35.3	8	7
1999	9.2	61.4	1	20	30.1	53.1	7	21
2000	6.5	43.6	1	28	31.4	48.3	7	7
2001	7.4	65.3	12	21	30.2	77.0	8	10
2002	3.8	45.9	1	9	29.7	61.1	7	25
2003	4.9	52.5	2	22	31.9	57.2	8	21
2004	5.1	71.6	2	16	29.6	69.6	7	8
2005	4.8	47.1	2	10	29.5	67.7	8	4
2006	6.7	36.5	12	28	30.2	59.4	8	20
2007	5.2	58.7	2	5	31.8	42.0	6	26
2008	4.8	23.8	12	31	31.5	40.0	8	1
2009	5.3	20.4	1	1	31.2	37.2	7	23
Note – Date of pentade corresponds to date of its middle								

Design minimum and maximum temperatures of pentades of selected probability are given in Table 4/6.9.

Table 4/6.9 – Design Extreme Values of Pentade Temperature of Different Probability, 1975-2009

Probability of exceedance	Minimum		Maximum	
	T_{min}	σ_T	T_{max}	σ_T
Anamur MS				
0.5000	7.9	0.28	29.6	0.35
0.2000	6.5	0.23	30.7	0.36
0.1000	5.6	0.20	31.4	0.37
0.0800	5.4	0.19	31.6	0.37
0.0500	4.8	0.17	32.1	0.38
0.0200	3.7	0.13	33.0	0.39

Probability of exceedance	Minimum		Maximum	
	T_{min}	σ_T	T_{max}	σ_T
0.0100	2.8	0.10	33.6	0.40
0.0010	0.1	0.00	35.8	0.42
0.0001	-2.7	0.09	38.0	0.45
Silifke MS				
0.5000	6.1	0.52	30.2	0.43
0.2000	4.4	0.37	31.3	0.45
0.1000	3.2	0.27	32.0	0.46
0.0800	2.9	0.24	32.2	0.46
0.0500	2.1	0.18	32.7	0.47
0.0200	0.7	0.06	33.6	0.48
0.0100	-0.4	0.04	34.3	0.49
0.0010	-4.0	0.34	36.6	0.53
0.0001	-7.6	0.64	38.8	0.56

It is recommended to use values of extreme air temperatures at Silifke MS for design calculations.

Temperature of the hottest decades per years, month and decade are given in Table 4/6.10.

Table 4/6.10– Temperature of the Hottest Decades and Observation Date in 1975-2009

Year	Anamur MS			Silifke MS		
	Month	Decade	T_{max}, °C	Month	Decade	T_{max}, °C
1975	7	2	28.1	7	2	28.2
1976	8	2	27.1	8	2	27.5
1977	7	3	29.2	7	2	29.2
1978	7	2	28.1	7	2	29.9
1979	8	1	27.8	7	3	28.3
1980	8	1	28.8	8	1	29.4
1981	8	1	28.8	8	1	30.1
1982	8	1	28.0	6	3	28.1
1983	7	3	28.2	7	3	28.1
1984	7	2	27.7	7	2	27.9
1985	8	2	28.8	8	2	29.2
1986	7	3	28.2	7	3	27.8
1987	7	3	29.3	7	3	29.7
1988	7	1	30.4	7	1	29.6
1989	7	3	28.7	7	3	28.9
1990	7	3	28.7	7	3	28.8
1991	7	3	27.8	8	2	27.8
1992	8	1	28.4	8	2	29.1
1993	8	2	28.0	8	1	28.9
1994	7	3	28.4	8	2	29.2
1995	7	3	29.1	7	3	28.9
1996	7	2	28.6	7	3	29.0
1997	7	1	29.1	7	1	29.1
1998	8	1	30.8	8	1	31.9

Year	Anamur MS			Silifke MS		
	Month	Decade	T_{max}, °C	Month	Decade	T_{max}, °C
1999	8	2	29.9	8	2	29.5
2000	7	1	29.0	7	1	30.0
2001	8	1	29.1	8	1	29.6
2002	7	3	30.1	7	3	29.5
2003	7	3	30.0	8	2	29.7
2004	7	1	28.4	7	1	29.0
2005	7	3	29.6	8	1	28.9
2006	7	3	30.1	7	3	28.9
2007	8	3	31.1	6	3	30.2
2008	8	1	30.4	8	1	30.3
2009	7	3	29.6	7	3	30.4

The hottest decade was registered at Anamur MS in August, 2007 and at Silifke MS – in August, 1998 (31.1 and 31.9 °C, correspondingly). Design maximums of decade temperature with different probabilities are given in Table 4/6.11.

Table 4/6.11 – Design Values of Temperatures of the Hottest Decades with Different Probability, 1975-2009

Probability of exceedance	Anamur MS		Silifke MS	
	T_{ext}, °C	σ_T	T_{ext}, °C	σ_T
0.5000	28.8	0.30	29.0	0.40
0.2000	29.8	0.31	29.9	0.41
0.1000	30.4	0.32	30.5	0.42
0.0800	30.6	0.32	30.6	0.42
0.0500	31.0	0.33	31.0	0.43
0.0200	31.8	0.33	31.7	0.44
0.0100	32.3	0.34	32.3	0.45
0.0010	34.3	0.36	34.0	0.47
0.0001	36.2	0.38	35.8	0.49

It is recommended to use values of extreme air temperatures at Silifke MS for design calculations.

Design temperature of the hottest decades of 5 and 10 % probability is 31.0 and 30.4 °C as per Anamur MS data. Values close to these were observed in 2007 (31.1 °C) and 2008 (30.4 °C).

As per Silifke MS data, design maximums are 31.0 and 30.5 °C, correspondingly. By observation close value of the hottest decades of 10 % probability was registered in 2009 (30.4 °C), and absolute maximum (31.9 °C) in 1998 (exceeds 2 % probability).

Table 4/6.12 presents duration of periods during which air temperature didn’t exceed or was not lower than design temperature extremes of 50, 10 and 5 % probability.

Table 4/6.12 – Number of Days with Daily Extremes of Air Temperature for Given Probabilities Using Gumbel Distribution

Probability, %	Temperature in conformance with probability, °C			
	Minimum		Maximum	
	Temperature	Number of days with $T \le T_{min}$	Temperature	Number of days with $T \ge T_{max}$
Silifke MS, 1975-2009				
50%	1.2	2.171	40.0	0.23
10%	-2.1	0.086	41.4	0.06
5%	-3.4	0.000	42.1	0.06
Anamur MS, 1975-2009				
	Temperature	Number of days with $T \le T_{min}$	Temperature	Number of days with $T \ge T_{max}$
50%	2.3	1.543	38.0	1.20
10%	-0.09	0.143	40.5	0.09
5%	-1.01	0.000	41.4	0.03

Tables 4/6.13 and 4/6.14 present duration of air temperature extremes in given gradations using Silifke and Anamur MS data for 1975-2009.

Table 4/6.13 – Number of Days with Daily Air Temperature Extremes in Given Intervals, Silifke MS, 1975-2009

Temperature, °C	Month												Year
Interval: from - to	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Temperature minimums													
-4.9 - 0.0	0.2	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
0.1 - 5.0	7.1	4.9	1.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5	3.4	17.5
5.1 - 10.0	20.9	18.7	16.6	4.5	0.1	0.0	0.0	0.0	0.0	0.1	5.2	18.8	84.9
10.1 - 15.0	2.9	4.1	11.8	20.2	10.6	0.4	0.0	0.0	0.1	4.8	18.9	8.7	82.5
15.1 - 20.0	0.0	0.0	0.8	4.9	17.6	13.7	1.8	1.2	11.1	21.8	5.4	0.1	78.4
20.1 - 25.0	0.0	0.0	0.0	0.4	2.6	15.3	24.1	24.3	18.1	4.3	0.0	0.0	89.1
25.1 - 30.0	0.0	0.0	0.0	0.0	0.1	0.6	5.0	5.5	0.8	0.0	0.0	0.0	11.9
30.1 - 35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Temperature maximums													
0.1 - 5.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
5.1 - 10.0	3.2	2.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.4	7.5
10.1 - 15.0	12.5	8.9	3.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	2.4	10.1	37.5
15.1 - 20.0	14.6	14.3	15.3	5.2	0.4	0.0	0.0	0.0	0.0	0.9	7.5	15.6	73.8
20.1 - 25.0	0.7	2.6	10.6	17.9	9.4	0.3	0.0	0.0	0.1	4.8	13.9	3.9	64.2
25.1 - 30.0	0.0	0.0	0.9	5.5	16.1	14.3	1.1	0.3	6.1	17.1	5.8	0.0	67.2
30.1 - 35.0	0.0	0.0	0.0	1.2	4.6	13.9	25.6	26.2	22.1	7.9	0.2	0.0	101.8
35.1 - 40.0	0.0	0.0	0.0	0.0	0.5	1.5	4.1	4.4	1.8	0.3	0.0	0.0	12.6
40.1 - 45.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.2
45.1 - 50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4/6.14 – Number of Days with Daily Air Temperature Extremes in Given Intervals, Anamur MS, 1975-2009

Temperature, °C	Month												Year
Interval: from - to	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Temperature minimums													
-4.9 - 0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
0.1 - 5.0	3.5	3.8	1.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.1	10.0
5.1 - 10.0	21.7	18.7	17.9	5.1	0.3	0.0	0.0	0.0	0.0	0.2	4.2	16.6	84.7
10.1 - 15.0	5.8	5.6	11.5	21.0	11.9	0.5	0.0	0.0	0.5	6.5	20.0	13.1	96.3
15.1 - 20.0	0.1	0.0	0.3	3.7	17.6	16.0	2.9	2.9	14.7	21.4	5.7	0.2	85.3
20.1 - 25.0	0.0	0.0	0.0	0.1	1.3	13.0	22.5	22.3	14.3	2.9	0.0	0.0	76.4
25.1 - 30.0	0.0	0.0	0.0	0.0	0.0	0.5	5.6	5.7	0.5	0.0	0.0	0.0	12.3
30.1 - 35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Temperature maximums													
5.1 - 10.0	0.7	1.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.1
10.1 - 15.0	10.6	8.3	3.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.6	29.6
15.1 - 20.0	19.5	17.9	19.7	9.6	0.7	0.0	0.0	0.0	0.0	0.5	7.6	21.2	96.7
20.1 - 25.0	0.3	1.1	7.2	17.5	14.5	0.8	0.0	0.0	0.1	6.1	17.8	3.9	69.1
25.1 - 30.0	0.0	0.0	0.1	2.5	14.0	17.4	3.2	1.3	10.4	21.3	3.6	0.0	73.7
30.1 - 35.0	0.0	0.0	0.0	0.1	1.7	10.8	23.1	26.2	19.1	3.1	0.0	0.0	84.1
35.1 - 40.0	0.0	0.0	0.0	0.0	0.1	1.0	4.7	3.6	0.5	0.0	0.0	0.0	9.8
40.1 - 45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1

Table 4/6.15 presents number of hours of hourlyair temperature from data obtained in 2010 at 10-m level of 60-m meteorological mast located at the Akkuyu NPP site.

Table 4/6.15 – Number of Hours with Period (Hourly) Air Temperature of Given Intervals. Akkuyu NPP Site, meteorological mast, 2010

Temperature, °C	Month												Year
Interval: from - to	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
0.1 - 5.0	25	4	0	0	0	0	0	0	0	0	0	0	29
5.1 - 10.0	97	60	0	0	0	0	0	0	0	0	0	0	157
10.1 - 15.0	301	166	149	4	0	0	0	0	0	0	0	92	712
15.1 - 20.0	318	124	464	166	200	1	0	0	0	96	70	105	1544
20.1 - 25.0	4	0	48	147	484	374	30	0	36	386	249	5	1763
25.1 - 30.0	0	0	0	5	53	313	591	330	468	254	137	0	2151
30.1 - 35.0	0	0	0	0	7	27	123	379	216	8	1	0	761
35.1 - 40.0	0	0	0	0	0	5	0	35	0	0	0	0	40

4.6.4 CONCLUSION

The Report provides the preliminary climatic characteristics of the region calculated on the basis of data from meteorological observations for the last 30 years at Anamur and Silifke meteorological stations nearest to the Akkuyu NPP site. A comparison with the observations performed at the site has been performed in order to justify the selected dataset for analysis.

Detailed information on the meteorological equipment installed at the NPP site and the meteorological measurements and studies performed for atmospheric dispersion conditions and local circulations at the site are provided in the report.

The report also includes description of the models, which were used for calculation of the short term dispersions in the atmosphere of the site and assessment of the input parameters obtained at the preliminary investigation stage.

Data on potentiallyadverse and hazardous meteorological phenomena observed at Akkuyu NPP as available at the current investigation stage is presented.

The report provides the extreme values of meteorological parameters (wind speed, precipitation, air temperature etc.).

Comprehensive data on climatic parameters and atmosphere dispersion conditions of the Akkuyu NPP site will be obtained after performance of annual cycle of meteorological survey at the site and reassessment of the representativeness of the near-by meteorological and aerological stations.

It can concluded that there are no adverse meteorological conditions that may in any way jeopardize the safety of Akkuyu NPP or provide a basis for significant radiological impact of the plant to the environment.

Evaluation of the lay of land influence on atmospheric dispersion will be included in the Site Parameters Report.

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5. HYDROLOGY

5.1 GENERAL HYDROLOGICAL STRUCTURE OF THE REGION

5.1.1 HYDROLOGICAL CHARACTERISTICS OF THE AKKUYU NPP SITE ACCOMMODATION REGION

Akkuyu NPP site is located on the Mediterranean Seashore in the Akkuyu Bay at the territory with about 3 km radius. Geographical coordinates of the site center are 36°08′ N and 33°32′E. The region of interest is related to Mediterranean region.

Marine Survey works covered a coastal zone westward at a distance of 2.5 km and eastward embracing water area around the cape Sulusalma as shown in Figure 5/1.1.

The site is located in surrounding of hills of height up to 200 m, which are a natural boundary of the NPP accommodation area. A ground elevation varies from 0 to 50 m above the sea level. Akkuyu NPP site is flat coastal plain. Approximately within 1.5 km from the coastal line the elevation of the site increases reaching about 270 m at its outer boundary. There is a valley located between the hills which is opened to the sea in SW direction. Akkuyu NPP site is covered with dense and low trees. Relief of the region plays an important role in determination of weather and microclimate of the Akkuyu NPP site.

There are no swamp lands at the Akkuyu NPP site. There are no reservoirs that can affect the Akkuyu NPP site.

Two bays are located at the coastal section of the site: Aksaz Bay at the western and Akkuyu-Çamalanı Bay at eastern section as shown in Figure 5/1.1. The western part of the Akkuyu Bay is partially protected by a breakwater while the western part of the eastern bay and the western bay itself are not protected from any direct wave action and related effects.

At the NPP site there are entitled and untitled temporary streams in which the flow occurs only during the cold period from November to February, when the main amount of precipitation falls. A total of five dry rivers are present at the site location where hydrological observations for water flow and levels haven't been performed. So because of this to determine maximum flow rate in design water flows Mockus synthetic method and rational synthetic method are used within the study area. Basins of these streams are shown in Figure 5/1.2, and numbered, and morphometric characteristics of streams are given in Table 5/1.1.

Hydrologic surveys of these temporary streams by gauging are intended at the predesign activities stage. Performance of these activities will start at the subsequent stages: site parameters report or design stage.

ABCD - boundary of survey performed in June - October, 2011
Figure 5/1.1 – Map-Scheme of Hydrological Survey Area

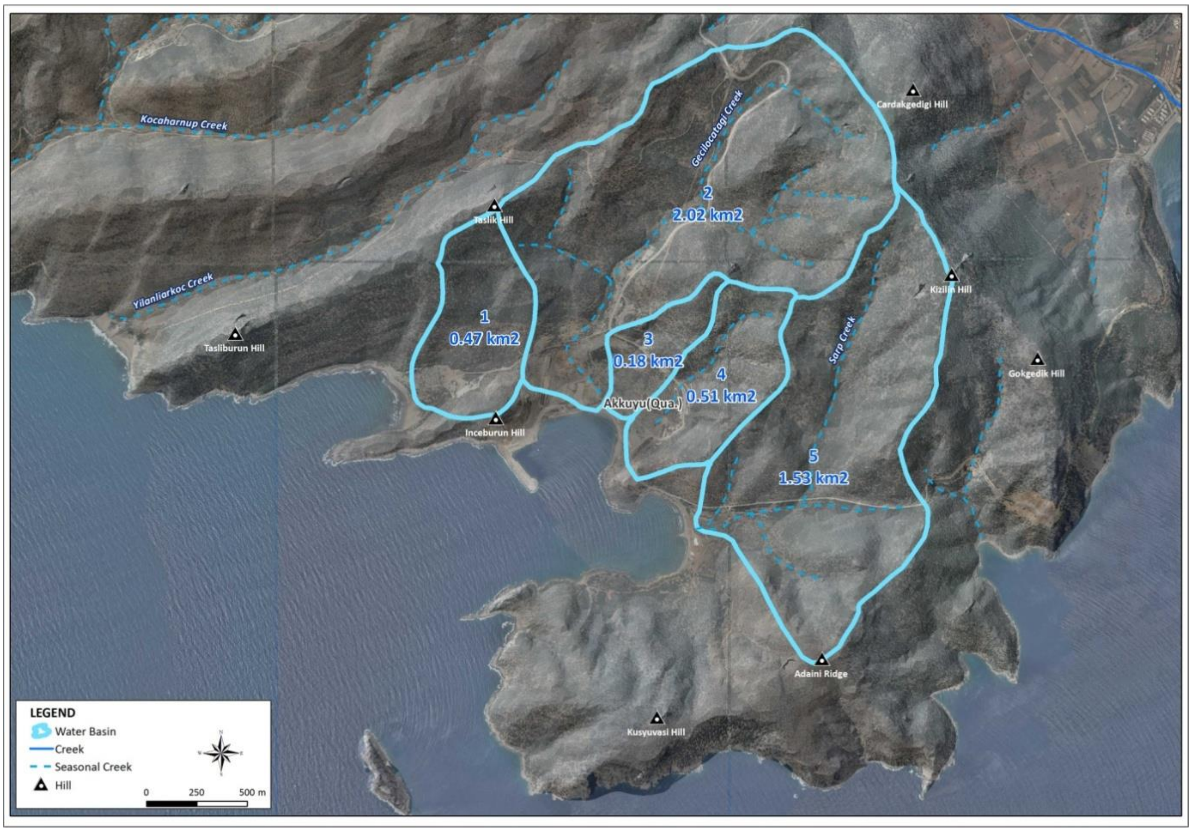


Figure 5/1.2 – River Basins at the Project Area

Table 5/1.1 – Morphometric Characteristics of Temporary Waterflows at the Akkuyu NPP Site

Name and number of waterflow	Length L, m	Catchment area, A, km^2	Absolute elevation of source H s.	Absolute elevation of mouth H m.
Noname (No 1)	1150	0.47	221	0
Zeytincatagi (No 2)	2825	2.02	-	0
Noname (No 3)	850	0.18	151	0
Noname (No 4)	1200	0.51	-	0
Sarp (No 5)	2100	1.53	-	0

The Sipahili River, 7 km to the west from the NPP, is the most important surface water source in the area. It has a constant watercourse made up due to surface runoffs from the mountains located on the north. In Sipahili place the river connects with the Kurudere River and goes along its wide bed around 3 km and then flows into the Mediterranean Sea. The previous name of this river was Babadil.

The head of the Sipahili River dries up during the summer season. The river however, fed by alluvium aquifer, continues as underflow in the alluvium section. A small round-the-year flow one can be observed at the firth into the Mediterranean even if there is no surface flow in the upper reach of the river. The basin of the Sipahili River has a relatively vast watershed area, around 574 km^2. The basin mainly consists of the karst carbonate rock, and many specificities of the karst rock morphology can be found in the basin. Due to the physical and hydrological separation of the Sipahili River from the Akkuyu NPP site the runoff of the Sipahili River can by no means impact the region of Akkuyu NPP or cause impounding of the NPP construction site.

Since the constant surface runoff does not exist in the area of Akkuyu NPP, hydrological measurements and characteristic investigations in order to assess the aerial hydrological behavior have been done at the Sipahili river. However, the use of the Sipahili river runoff for needs of Akkuyu NPP is so far not supposed due to the long distance from the Akkuyu NPP construction site.

Two meteorological stations (MS) are found in the close proximity of the project site. These stations are Aydincik (data of observation period 1957-1992, elevation 5 m above MSL) and Ovacik (data of observation period 1969-1992, elevation 30 m above MSL) meteorological stations.

Maximum precipitation and corresponding distribution functions for these two stations are given in Table 5/1.2.

As it can be seen from Table 5/1.2, maximum precipitation in the site area is observed in November, December and January.

Table 5/1.2 – Maximum daily precipitation at MS and possible distribution function

Operator	*DMI (Department of Meteorological Investigations)*			
Name of Station	*AYDINCIK*		*OVACIK*	
Elevation	5 m		30 m	
Year	Precipitation, mm	Month	Precipitation, mm	Month
1958	55.60	12		
1959	95.20	12		
1960	48.60	11		
1961	106.70	2		
1962	120.30	10		
1963	47.20	10		
1964	81.70	11		
1965	56.20	12		
1966	67.20	1		
1967	79.20	1		
1968	82.20	1		
1969	94.20	10	58.10	10
1970	37.80	1	35.10	3
1971	66.50	3	92.30	3
1972	60.00	10	40.50	11
1973	64.10	11	55.00	2
1974	75.50	12	58.70	12
1975	63.70	4	93.60	1
1976	71.20	12	62.90	10
1977	49.40	12	52.20	12
1978	98.80	1	79.90	11
1979	63.10	12	72.60	2
1980	37.30	10	40.20	11
1981	67.10	12	48.00	12
1982	52.20	10	75.50	12
1983	60.00	11	55.50	3
1984	50.50	1	76.90	11
1985	55.60	11	80.80	11
1986	60.30	12	71.20	12

Operator	*DMI (Department of Meteorological Investigations)*			
Name of Station	*AYDINCIK*		*OVACIK*	
Elevation	5 m		30 m	
1987	98.10	11	63.90	11
1988	78.60	3	65.80	3
1989	109.80	3	83.40	1
1990	30.00	12	35.20	12
1991	71.40	12	41.50	12
1992	63.20	11	-	-
Design daily maximum precipitation, mm				
Recurrence Period, years	UDF, Distribution Function			
	Gumbel		Pearson Type 3	
	Observation Period			
	35		23	
2	65.80		62.40	
5	87.34		77.38	
10	101.61		85.31	
25	119.64		93.82	
50	133.01		99.35	
100	146.29		104.35	

Probability values of maximum precipitation height for different dispersion options were calculated on the basis of precipitation measurement data at these MS. These values are given in Tables 5/1.3 and 5/1.4.

Table 5/1.3 – Maximum design precipitation height calculated based on different probability functions according to Aydincik MS data

Type of distribution	Maximum precipitation height, mm							
	Average recurrence interval, years							
	2	5	10	25	50	100	200	500
Normal	69	87	97	107	113	119	124	131
Log-Normal (2 Parameters)	66	85	97	112	123	134	144	158
Log-Normal (3 Parameters)	67	86	97	110	119	127	135	145

Type of distribution	Maximum precipitation height, mm							
	Average recurrence interval, years							
	2	5	10	25	50	100	200	500
Pearson Type-3	67	86	98	110	119	128	135	143
Log-Pearson Type-3	67	86	98	112	121	130	138	147
Gumbel	66	87	102	120	133	146	160	177

Statistical distribution parameters, Aydincik MS	
Number of years	35
Distortion factor	0.55199
Logarithmic distortion factor	-0.25192
Linear mean	69.10000
Linear standard deviation	21.45574
Logarithmic mean	1.81886
Logarithmic standard deviation	0.13755

Table 5/1.4 – Maximum design precipitation height calculated based on different probability functions according to Ovacik MS data

Type of distribution	Maximum precipitation height, mm							
	Average recurrence interval, years							
	2	5	10	25	50	100	200	500
Normal	63	77	85	94	99	104	108	113
Log-Normal (2 Parameters)	60	76	86	98	106	115	123	134
Log-Normal (3 Parameters)	62	77	85	94	99	104	109	114
Pearson Type-3	62	77	85	94	99	104	109	114
Log-Pearson Type-3	61	78	87	97	104	110	116	123
Gumbel	60	78	91	106	118	129	140	155

Statistical distribution parameters, Ovacik MS	
Number of years	23
Distortion factor	0,05280
Logarithmic distortion factor	-0,38540
Linear mean	62,55652
Linear standard deviation	17,67180
Logarithmic mean	1,77849
Logarithmic standard deviation	0,12976

The areal distribution coefficient of precipitation (*YADK*) has been taken equal to 1 (homogeneous distribution), because precipitation areas are less than 25 km^2.

Pluviograph rates are taken from Silifke meteorological station rectified values. The rectified pluviograph rates (DPLV) are presented in Table 5/1.5.

Table 5/1.5 – Corrected Pluviograph (DPLV) Rates of Silifke Meteorology Station

SILIFKE	
T (min)	DPLV (rates)
5	0.16
10	0.24
15	0.30
30	0.41
60	0.48
120	0.55
180	0.60
240	0.65
300	0.68
360	0.72
480	0.77
720	0.85
1080	0.93
1440	1.00

For the calculations applying the Mockus method [5/23] related with Zeytincatagi and Sarp streams and no name streams No 1, 3, 4, probabilistic values of sediment layer with Pearson distribution of Type 3 for Ovacik MS were used. The rational method can be used safely for the areas up to 0.5 km². It is not suggested for areas larger than 0.5 km² since the values obtained are rather high. It is not appropriate to use this method when the volume of the hydrograph is significant given that it is arranged as per precipitation of one hour.

The general formula for runoff calculation in rational method is as follows

$$Q = \frac{C \times A \times I}{3.6},$$

where:

Q – Flow rate of project cross-section (m³/s);

C – Flow coefficient without unit; is relationship between runoff layer and precipitation layer. C value depends on precipitation intensity. Catchment area and type of underlying surface for the catchment area.

A – Drainage area (km²);

I – Intensity of precipitation per time interval as per H, L and Tc values;

H – Difference between the highest elevation and elevation of the project cross-section for the longest tributary at the drainage area (m);

L – Length of longest tributary at the drainage area (km);

Tc – Time of concentration of water as per H and L (hour).

The parameters Tc and I are determined from Figure 5/1.3.

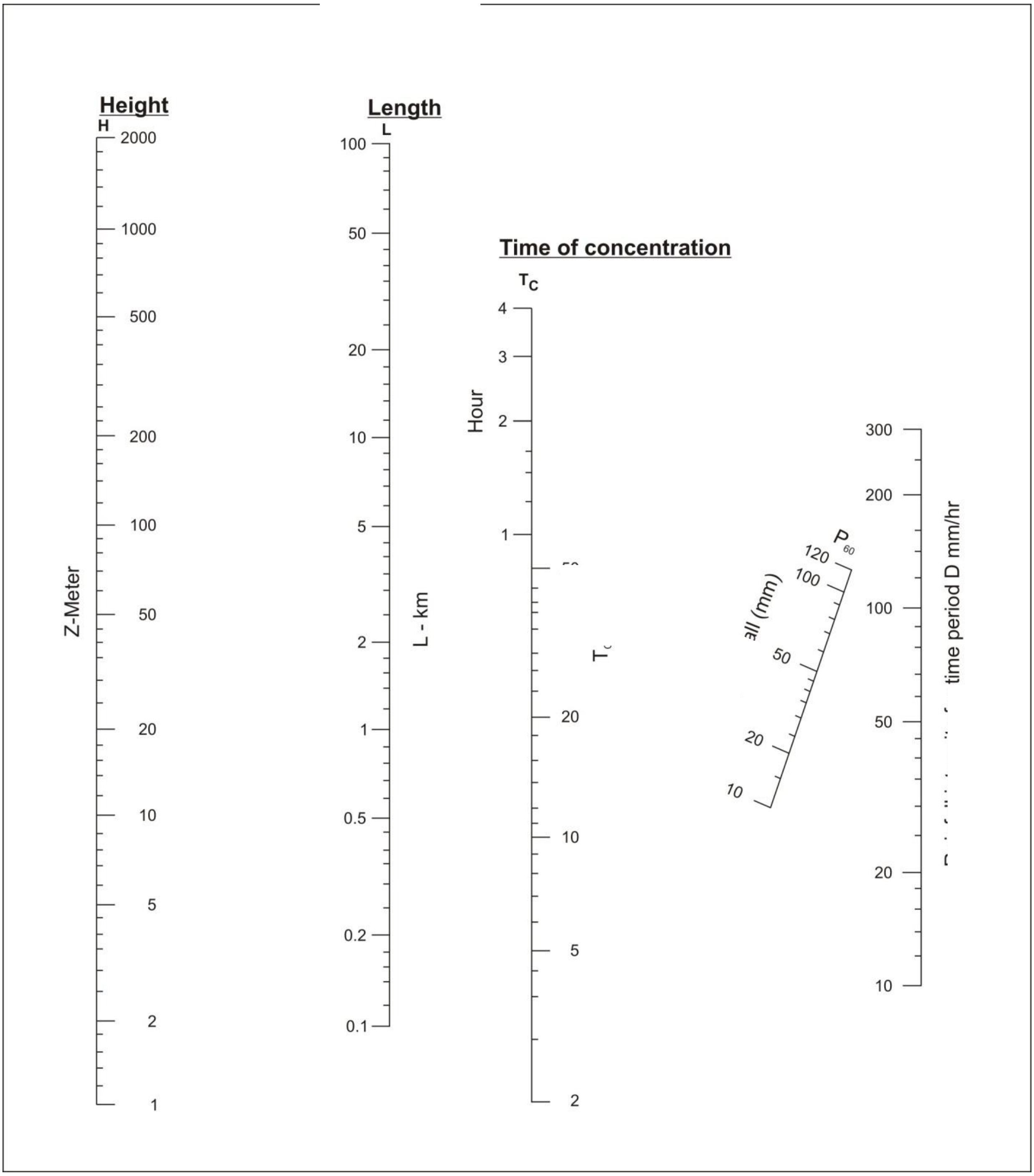


Figure 5/1.3 – Scale for Accumulation Period of Water in Rational Method and Precipitation Intensity Corresponding to this Period [5/29]

Mockus Method

The Mockus method [5/29] is applied to the drainage areas with (Tc) up to 30 hours. For the larger areas, the runoff measurements are made by dividing into sections. The selection of unit downpour period (ΔD) is significant for the runoffs to be calculated via Mockus method. The criteria in the selection of unit downpour period (ΔD) is generally ΔD ≤ (Tc/5). For the first 6 hours of project downpour period, ΔD is generally 1 hour. As for the situation when the accumulation period (Tc) is shorter than 3 hours, ΔD is taken as ½ hour. In case when the accumulation period is between 10 to 15 hours, ΔD is 2 hours, while for 15 to 30 hours ΔD=3 hours.

It is observed for the Mockus method that more reliable results could be obtained if the method is used without superposing.

Therefore, the runoff calculation performed by Mockus method for the Akkuyu NPP site was carried out without superposing.

The physical values of Mockus method without superposing are presented below.

H=H10-H0 = (elevation difference)		m
Tc=0.00032*L^0.77/S^0.385) = (Time of concentration of water)		hour
K =(0.201+0.01183*L/$A^{0,5}$-02646*H/1000/$A^{0,5}$) (coefficient) =	0.163 or 0.208	
ha (flow height) =		mm
WITHOUT SUPERPOSING		
D=2*(Tc)^.5 = (project precipitation period)		hour
Tp=.5*D+.6*Tc = (duration for flow to reach peak)		hour
Qp=K*A*ha/Tp = (flow rate when peak is reached)		m^3/s/mm
Tr=1.67*Tp = (time between peak and disappearance)		hour
T=Tp+Tr = (Total period of runoff)		hour

The coefficient of C is determined from the tables arranged for this method [5/23] based on the land use map (see figure 2/8) and the soil composition in the area. The catchments are covered by forests and the soil type is mainly composed of low to moderately permeable material. Based on this fact the coefficient of C is taken as 0.3 for the whole area. The results of runoff calculations for each watershed is tabulated in table 5/1.6

Table 5/1.6 – Water flow Discharge of Design Probabilities at the Site

Name and number of water flow	Discharge, m^3/s							
	Interval of average recurrence, years							
	5	10	25	50	100	500	1000	10000
Noname (No 1)	2.0	2.5	3.1	3.7	4.5	5.9	6.5	8.5
Zeytincatagi (No 2)	5.4	6.7	8.1	9.0	9.9	12.1	13.1	16.3
Noname (No 3)	0.8	1.0	1.3	1.6	1.9	2.4	2.7	3.7
Noname (No 4)	2.1	2.5	3.2	3.8	4.6	6.1	6.7	8.8
Sarp (No 5)	5.2	6.4	7.8	8.7	9.6	11.8	12.8	16.0

A detailed analysis of the on-site precipitation situation will be performed based on on-site measurements of roughly two years within the site-parameter report.

The closest to the NPP site continuously flowing river is Sipahili. There are no hydrological stations at Sipahili River. It is the most important surface water source in the neighborhood and is located at about 7 km distance to the west of the NPP site. During dry season Sipahili River has non-continuous surface flow. The river however, fed by alluvium aquifer, continues underground. At the Sipahili settlement, it is combined with Kurudere and flows a distance of approximately 3 km through a wide riverbed and finally it is discharged into the Mediterranean Sea. The previous name of the river is Babadıl River and some views from the river before it is discharged to the sea are provided in Figures 5/1.6 and 5/1.7.

Figure 5/1.6 – Sipahili River from the highway bridge before its discharge into the Mediterranean Sea

Figure 5/1.7 – Sipahili River under the highway

There is no operating Stream Gauging Station (SGS) over Sipahili River by any organizations. The only SGS established around the project site is the one that belongs to State Hydraulic Works (DSI) on the Kurucak River, which is a branch of Sipahili, and the number of the station is 17-24. This station is in operation since 1977. Daily water level observations and discharge measurements are performed at this station.

For determining hydraulic potential and quality characteristics of Sipahili River, observations on several locations in Sipahili River have been performed by ENVY [5/24].

Using hydrological data on its left tributary – Kurucak River, approximate values of average monthly and annual flows for Sipahili River in range with catchment area of 574 km^2 for period of 1977-2009, are given in Table 5/1.7.

Table 5/1.7 (values of Sipahili River monthly flows at the distance of 3 km from the estuary for period of 1977-2009) were deducted (recalculated) from the observed monthly flows for Kurucak River at station No. 17-24. The monthly flows of Sipahili River are calculated using the measured flows of Kurucak by flow area ratio method. The ratio of the areas of Sipahili (574 km^2) and Kurucak (194 km^2) basins is equal to 2.96. The flows of Kurucak River were then multiplied by this ratio to find the Sipahili flows (Table 5/1.8).

Table 5/1.7 – Calculated Monthly Flows of Sipahili River, m^3/s [5/24]

Year	Month												Average
	10	11	12	1	2	3	4	5	6	7	8	9	
1977	0.60	0.86	2.76	14.26	8.61	2.13	2.63	2.12	0.85	0.43	0.10	0.78	3.01
1978	0.61	0.98	3.63	9.73	62.65	7.51	4.41	2.27	1.10	0.69	0.41	0.53	7.87
1979	2.76	1.53	6.72	22.44	11.78	3.90	1.34	1.12	0.71	0.34	0.34	0.34	4.44
1980	0.93	1.93	4.86	11.05	6.56	12.05	8.85	2.96	1.05	0.59	0.29	0.27	4.28
1981	0.56	1.56	1.81	27.41	27.41	10.41	4.90	1.35	1.00	0.20	0.20	0.21	6.42
1982	0.66	1.62	21.44	12.82	7.31	3.86	2.23	1.76	1.13	0.35	0.46	0.71	4.53
1983	0.95	1.35	1.98	9.55	10.66	17.46	6.28	3.87	1.68	0.74	0.60	0.30	4.62
1984	0.63	3.30	6.83	17.35	18.78	5.76	6.16	1.87	1.03	0.63	0.31	0.31	5.25
1985	0.49	4.51	3.23	12.27	11.21	5.97	3.12	1.15	1.03	0.40	0.13	1.06	3.71
1986	0.97	6.51	3.81	12.49	11.60	3.99	2.71	1.16	0.47	0.41	0.08	0.08	3.69
1987	0.31	0.97	4.08	15.36	7.31	18.13	4.58	4.12	2.20	0.62	0.41	0.39	4.87
1988	0.53	1.26	3.54	1.88	9.00	21.48	7.18	2.13	1.04	0.17	0.54	0.24	4.08
1989	1.44	4.96	8.70	16.58	4.61	2.66	0.91	0.39	0.17	0.11	0.17	0.17	3.40
1990	1.10	1.98	4.56	1.86	11.70	5.22	1.35	0.79	0.65	0.44	0.16	0.16	2.50
1991	0.42	0.93	3.38	1.88	1.68	1.40	0.62	0.19	0.13	0.05	0.00	0.00	0.89
1992	0.21	0.50	10.83	5.59	3.80	3.80	1.38	1.81	0.70	0.10	0.05	0.10	2.41
1993	0.05	0.52	7.44	4.16	5.38	10.22	1.92	1.11	0.20	0.06	0.00	0.00	2.59
1994	0.05	1.93	0.78	2.17	5.75	1.76	0.69	0.39	0.07	0.00	0.00	0.00	1.13
1995	0.40	4.70	3.66	12.27	6.79	4.70	1.77	0.66	0.60	0.33	0.08	0.26	3.02
1996	0.27	1.94	1.27	9.93	4.37	6.18	2.38	0.77	0.51	0.36	0.06	0.14	2.35
1997	0.87	1.09	2.55	2.58	5.57	3.70	9.18	1.40	0.56	0.32	0.11	0.05	2.33
1998	0.92	2.00	4.05	5.29	2.88	2.33	1.87	0.82	0.58	0.06	0.05	0.05	1.74
1999	0.13	2.48	10.38	4.87	21.78	3.81	1.92	0.55	0.40	0.09	0.07	0.20	3.89
2000	0.23	0.49	0.94	3.27	10.36	5.45	4.25	2.46	0.65	0.27	0.11	0.14	2.39
2001	0.47	1.21	1.33	1.88	8.69	3.01	1.01	0.62	0.26	0.06	0.03	0.03	1.55
2002	0.11	6.00	52.28	24.43	16.64	7.58	7.41	2.02	0.62	0.45	0.29	0.34	9.85
2003	0.58	0.85	1.06	2.23	12.60	4.07	4.80	0.65	0.63	0.23	0.11	0.15	2.33
2004	0.46	0.56	3.27	22.44	21.26	4.26	2.76	1.20	0.52	0.20	0.15	0.30	4.78
2005	0.56	1.74	1.25	4.65	7.64	1.09	0.71	0.73	0.37	0.06	0.03	0.07	1.57
2006	0.34	0.68	1.51	3.78	13.09	3.67	1.09	0.68	0.35	0.22	0.07	0.28	2.15
2007	0.69	4.91	1.06	0.80	2.56	1.17	0.50	0.28	0.05	0.00	0.00	0.00	1.00
2008	0.09	0.55	5.29	0.97	4.28	0.94	0.42	0.32	0.15	0.83	0.19	0.26	1.19
2009	0.21	3.20	2.04	7.80	14.32	13.26	7.15	5.33	1.28	1.04	0.42	0.39	4.70

Year	Month												Average
	10	11	12	1	2	3	4	5	6	7	8	9	
Average	0.59	2.11	5.83	9.27	11.47	6.15	3.29	1.49	0.69	0.33	0.18	0.25	3.47
min	0.05	0.49	0.78	0.8	1.68	0.94	0.42	0.19	0.05	0	0	0	0.89
max	2.76	6.51	52.28	27.41	62.65	21.48	9.18	5.33	2.2	1.04	0.6	1.06	9.85

Table 5/1.8 – Calculated Monthly Flows of Kurucak River, m^3/s [5/24]

Year	Month												Average
	10	11	12	1	2	3	4	5	6	7	8	9	
1977	0,20	0,29	0,93	4,82	2,91	0,72	0,89	0,72	0,29	0,15	0,03	0,26	1,02
1978	0,21	0,33	1,22	3,29	21,17	2,54	1,49	0,77	0,37	0,23	0,14	0,18	2,66
1979	0,93	0,52	2,27	7,58	3,98	1,32	0,45	0,38	0,24	0,12	0,12	0,12	1,50
1980	0,31	0,65	1,64	3,73	2,21	4,07	2,99	1,00	0,35	0,20	0,10	0,09	1,45
1981	0,19	0,53	0,61	9,26	9,26	3,52	1,66	0,46	0,34	0,07	0,07	0,07	2,17
1982	0,22	0,55	7,24	4,33	2,47	1,30	0,75	0,59	0,38	0,12	0,16	0,24	1,53
1983	0,32	0,46	0,67	3,23	3,60	5,90	2,12	1,31	0,57	0,25	0,20	0,10	1,56
1984	0,21	1,11	2,31	5,86	6,34	1,95	2,08	0,63	0,35	0,21	0,10	0,10	1,77
1985	0,16	1,52	1,09	4,14	3,79	2,02	1,05	0,39	0,35	0,13	0,04	0,36	1,25
1986	0,33	2,20	1,29	4,22	3,92	1,35	0,91	0,39	0,16	0,14	0,03	0,03	1,25
1987	0,10	0,33	1,38	5,19	2,47	6,12	1,55	1,39	0,74	0,21	0,14	0,13	1,65
1988	0,18	0,43	1,20	0,63	3,04	7,26	2,43	0,72	0,35	0,06	0,18	0,08	1,38
1989	0,49	1,67	2,94	5,60	1,56	0,90	0,31	0,13	0,06	0,04	0,06	0,06	1,15
1990	0,37	0,67	1,54	0,63	3,95	1,76	0,46	0,27	0,22	0,15	0,06	0,05	0,84
1991	0,14	0,31	1,14	0,63	0,57	0,47	0,21	0,06	0,04	0,02	0,00	0,00	0,30
1992	0,07	0,17	3,66	1,89	1,28	1,28	0,47	0,61	0,24	0,03	0,02	0,03	0,81
1993	0,02	0,18	2,51	1,40	1,82	3,45	0,65	0,37	0,07	0,02	0,00	0,00	0,87
1994	0,02	0,65	0,26	0,73	1,94	0,59	0,23	0,13	0,02	0,00	0,00	0,00	0,38
1995	0,14	1,59	1,24	4,14	2,29	1,59	0,60	0,22	0,20	0,11	0,03	0,09	1,02
1996	0,09	0,66	0,43	3,35	1,48	2,09	0,80	0,26	0,17	0,12	0,02	0,05	0,79
1997	0,29	0,37	0,86	0,87	1,88	1,25	3,10	0,47	0,19	0,11	0,04	0,02	0,79
1998	0,31	0,68	1,37	1,79	0,97	0,79	0,63	0,28	0,20	0,02	0,02	0,02	0,59
1999	0,04	0,84	3,51	1,65	7,36	1,29	0,65	0,19	0,13	0,03	0,02	0,07	1,31
2000	0,08	0,17	0,32	1,11	3,50	1,84	1,44	0,83	0,22	0,09	0,04	0,05	0,81
2001	0,16	0,41	0,45	0,63	2,94	1,02	0,34	0,21	0,09	0,02	0,01	0,01	0,52
2002	0,04	2,03	17,66	8,25	5,62	2,56	2,50	0,68	0,21	0,15	0,10	0,11	3,33
2003	0,20	0,29	0,36	0,75	4,26	1,37	1,62	0,22	0,21	0,08	0,04	0,05	0,79
2004	0,16	0,19	1,11	7,58	7,18	1,44	0,93	0,41	0,18	0,07	0,05	0,10	1,62
2005	0,19	0,59	0,42	1,57	2,58	0,37	0,24	0,25	0,13	0,02	0,01	0,02	0,53
2006	0,12	0,23	0,51	1,28	4,42	1,24	0,37	0,23	0,12	0,07	0,02	0,09	0,73
2007	0,23	1,66	0,36	0,27	0,86	0,40	0,17	0,09	0,02	0,00	0,00	0,00	0,34
2008	0,03	0,19	1,79	0,33	1,44	0,32	0,14	0,11	0,05	0,28	0,06	0,09	0,40
2009	0,07	1,08	0,69	2,64	4,84	4,48	2,42	1,80	0,43	0,35	0,14	0,13	1,59
Average	0,20	0,71	1,97	3,13	3,88	2,08	1,11	0,50	0,23	0,11	0,06	0,08	1,17

Information on species of commercial fish in the region is included in Chapter 7 Ecological Effects of the present Report.

Information on sport or other type of activity using water sources in the region is given in section 3.5 of Chapter 3.

Water from Sipahili and Büyükeceli Rivers is used for agriculture. There is no information on other water consumers of water sources or constructions at the seashore in the site vicinity.

Description of groundwater is presented in Chapter 6 Geology, Geophysics and Seismology. Soil parameters are given in Chapter 6 Geology, Geophysics and Seismology.

Radius of coverage for description of structure of hydrosphere of the region including marine coastal zone ranges between several dozens of km from the NPP (characteristics of surface waters) to several hundreds of km (hydrological characteristics of marine water area, including tsunami).

Information on available water resources flow-rate control facilities or water consumption control facilities, distance from the NPP, volume of water consumption, etc. will be presented at the next stages of designing.

Characteristics of service water supply are given in section 5.3 of the present Report.

5.1.2 NEAREST RUNNING FRESH SPRINGS FOR DRINKING AND UTILITY WATER SUPPLY

During project implementation a decision was taken to build at the Akkuyu NPP site a desalination plant which will cover the need for drinking and utility water supply. Therefore the availability of water for these purposes is not an issue anymore. However, the previous works related to the groundwater potential at and around the site are summarized in the following paragraphs to demonstrate the groundwater availability in the region.

At the areas adjacent to the Akkuyu NPP site, the principal groundwater collectors are alluvial deposits of small rivers and temporary watercourses.

In the immediate proximity from NPP, the Büyükeceli River flows (eastern side), which water-catchment area amounts 384 m2 and which dries up in a summer period, and Sipahili River (western side) with water-catchment area 574 km2, which in summer time on the surface at some places also sometimes dries up due to performance of irrigation works and water evaporation.

There are three currently non-operational water supply wells at Babadil River about 8 km west to the Akkuyu NPP site in Sipahili river valley. Total capacity is 50 l/s. According to results of the studies, this fresh water spring satisfies drinking and utility water supply demands for hydrochemical purposes.

On the basis of the declared demand of 100-115 l/s, this value of flow rate can be reached if two additional water intake wells are drilled in Sipahili River valley and three wells – in Büyükeceli River valley.

Feeding of groundwater aquifers is realized by atmospheric precipitation infiltration (up to 40 % of the total quantity of precipitation in the Büyükeceli River valley and 60 % in the Sipahili River valley), and also water infiltration from surface watercourses.

The groundwater total storage is estimated as follows: in the Büyükeceli River valley – $0.8x10^6$ m^3 per year, and in the Sipahili River valley – $2.6x10^6$ m^3 per year [5/24].

Thereby total ground water storage in both river valleys is estimated to equivalent capacity of 107 l/s.

These aquifers are utilized by the local population for drinking and utility water supply and for irrigation of agricultural holdings. As per the general appraisals, water flow rate for these purposes amounts for the Büyükeceli River valley – $0.5x10^6$ m^3/year and $0.48x10^6$ m^3/year for the Sipahili River valley. Thereby, unreduced storage of groundwater is equal to 77 l/s.

Another potential water supply source are the fresh water springs within the NPP accommodation region:

- the Aksaz spring located at a distance of 1.5 km westward from the Akkuyu and having flow rate 1.2 l/s;
- the Kochashly spring located eastward from the Kochashly settlement (4 km west to the site) and having flow rate from 5 l/s (minimally) to 400 l/s (maximally);
- underwater springs (sea coast) near the Hadji Iskhakly settlement;
- the Soguksu springs located westward from the Filindire (20 - 25 km west to the site), which have a total flow rate of 1120 l/s as the minimum(per data of 1978).

5.1.3 WATER CHEMICAL COMPOSITION OF AVAILABLE SOURCES

From a chemical composition standpoint, the groundwater is fresh (except for strand 300 - 500 m wide, where the groundwater is salty because of seawater intrusion), calcic, magnesium, chloride-sulfate with mineralization from 0.4 to 1.0 g/l.

In July 2011 water samples were taken from three sampling locations (WS4, WS5, WS6) from Sipahili River. Location of sampling points is given in Figure 5/1.8.

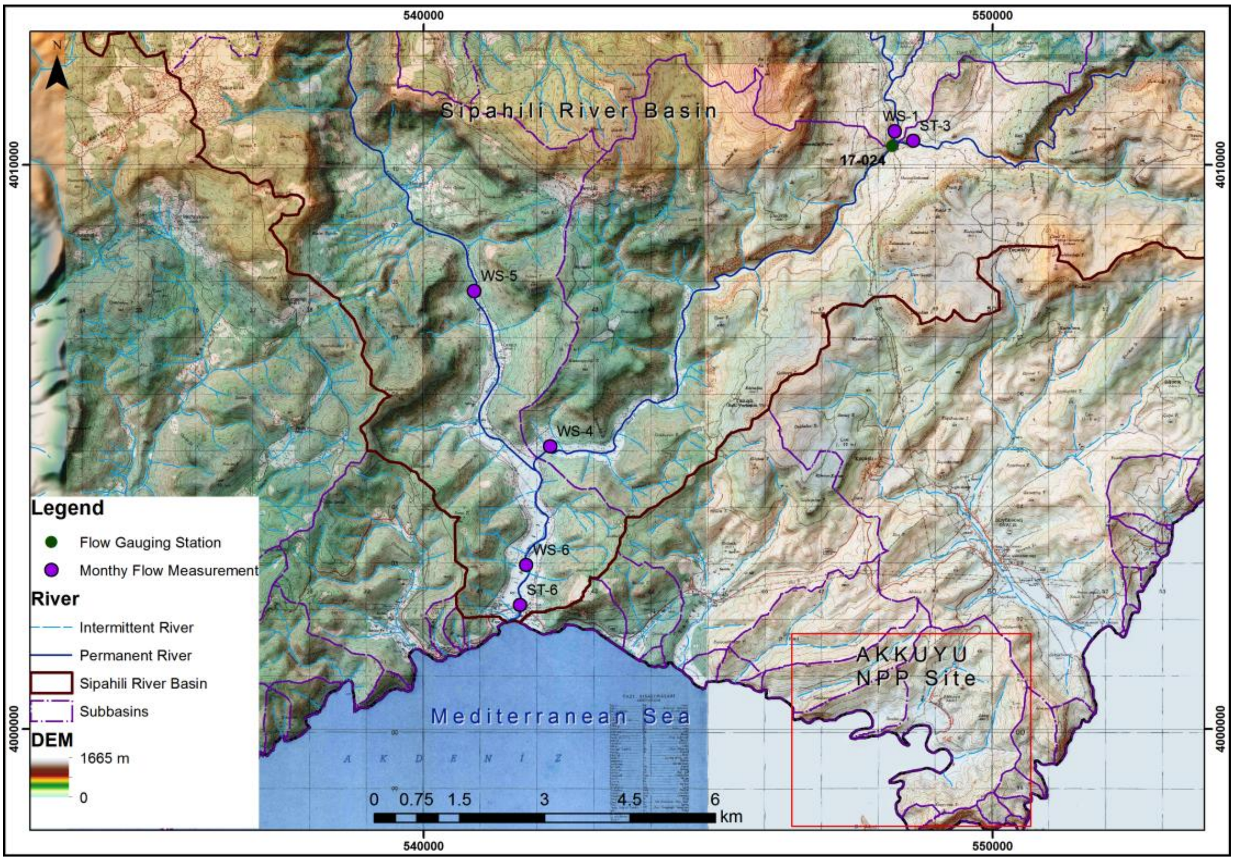


Figure 5/1.8 – Scheme of Water Sampling of Surface Fresh Water in the Akkuyu NPP Site Accommodation Region

Results of chemical analysis of water samples from Sipahili River are presented in Table 5/1.9.

Table 5/1.9 – Results of Chemical Analysis of Water Samples from Sipahili River

Parameters	Sampling stations		
	WS4	WS5	WS6
Temperature, ^{o}C	26.5	28.6	29.1
pH	7.46	7.64	7.54
Dissolved Oxygen, mg O_2/L	7.3	7.8	4.7
Chlorides, mg Cl^-/L	9.5	9.7	10.9
Sulphates, mg $SO_4^=$/L	32.3	11.4	26.4
Ammonium Nitrogen, mg NH_4^+-N/L	0.07	0.05	0.02
Nitrite-N, mg NO_2^--N/L	0.002	0.005	0.002
Nitrate-N, mg NO_3^--N/L	0.07	0.3	0.2
Total Phosphorus, mg P/L	0.01	0.01	< 0.009 (1)
Total Dissolved Solids, mg/l	260	506	308
Colour, Pt-Co unit	0,1	0,2	< 0,09 (1)
Turbidity, NTU	1,9	40	1,6
Sodium, mg Na^+/L	10,4	12,7	10,6
COD, mg/L	12,4	13,5	13,2
BOD, mg/L	< 2 (1)	< 2 (1)	< 2 (1)
Total Organic Carbon, mg/L	4	< 0,33	1,7

Parameters	Sampling stations		
	WS4	WS5	WS6
Total Kjedahl Nitrogen, mg/L	< 0,1 [1]	< 0,1 [1]	< 0,1 [1]
Oil and Grease, mg/L	< 2 [1]	< 2 [1]	< 2 [1]
Surfactants reacting with MBAS, mg/L	0,16	0,11	0,09
Volatile phenols, mg/L	0,004	0,005	0,006
Mineral Oils, mg/L	< 0,05	< 0,05	< 0,05 [1]
Total Pesticides, mg/L	0,06	< 0,04	< 0,04 [1]
Mercury, µg Hg/L	< 0,07	< 0,07	< 0,07 [1]
Cadmium, µg Cd/L	< 2 [1]	< 2 [1]	< 2 (1)
Lead, µg Pb/L	< 4 [1]	< 4 [1]	< 4 (1)
Arsenic, µg As/L	< 5 [1]	< 5 [1]	< 5 [1]
Copper, µg Cu/L	18	16,7	19,1
Total Chromium, µg Cr/L	< 1 [1]	< 1 [1]	< 1 [1]
Chromium, µg Cr^{+6}/L	< 10 [1]	13	< 10 [1]
Cobalt, µg Co/L	2,6	2,4	2,6
Nickel, µg Ni/L	< 6 [1]	< 6 [1]	< 6 [1]
Zinc, µg Zn/L	< 5 [1]	< 5 [1]	< 5 [1]
Total Cyanide, µg CN/L	< 10 [1]	< 10 [1]	< 10 (1)
Fluoride, µg F^-/L	94,8	161,4	99,1
Free Chlorine, µg Cl_2/L	< 10 [1]	< 10 [1]	< 10 [1]
Sulphur, µg $S^=$/L	< 2 [1]	< 2 [1]	< 2 [1]
Iron, µg Fe/L	36	90	29,6
Manganese, µg Mn/L	< 1 [1]	3,1	< 1 [1]
Boron, µg B/L	< 200 [1]	< 200 [1]	< 200 [1]
Selenium, µg Se/L	< 1 [1]	< 1 [1]	< 1 [1]
Barium, µg Ba/L	27,1	24	41
Aluminium, mg Al/L	0,01	0,1	< 0,003 [1]
Calcium, mg/L	47,6	48,4	63,3
Magnesium, mg/L	19,8	12,8	17,5
Fecal Coliforms, EMS/100 mL	93	240	93
Total Coliforms, EMS/100 mL	460	> 1100	1100
1) – MDL, Method Detection Limit			

As mentioned above, a decision was taken to build at the Akkuyu NPP site a desalination plant which will cover the need for drinking and utility water supply. The quality of the water will be controlled through this desalination plant.

5.2 DISPERSION OF RADIOACTIVE MATERIALS

5.2.1 TRANSPORTATION OF RADIONUCLIDES IN GROUNDWATER

Inflow, transportation and lifetime of radionuclide in groundwater will be considered within the frames of the hydrogeological model (see Chapter 6).

5.2.2 TRANSPORTATION OF RADIONUCLIDES IN SURFACE WATERS

In general terms the surface and sea water transport of radionuclides at the NPP location area can be described by the following three-dimensional equation, taking into account advection and turbulent diffusion [5/1, 5/2, 5/3]:

$$\frac{\partial C_{w,tot}}{\partial t} + U\frac{\partial C_{w,tot}}{\partial x} + V\frac{\partial C_{w,tot}}{\partial y} + W\frac{\partial C_{w,tot}}{\partial z} = \varepsilon_x \frac{\partial^2 C_{w,tot}}{\partial x^2} + \varepsilon_y \frac{\partial^2 C_{w,tot}}{\partial y^2} + \varepsilon_z \frac{\partial^2 C_{w,tot}}{\partial z^2} - \lambda_i C_{w,tot} + S \quad (5\text{-}1)$$

where:

$C_{w\,tot}$ – radionuclides in water taking into account the suspension, (Bq/m^3);

U, V, W - water velocity in directions of x, y and z axes, accordingly, (m/s);

S – source of radionuclides input or output from water mass including relating to secondary radionuclides formation, Bq·m^{-3}·s^{-1};

t – time, s;

x, y, z – Cartesian coordinates, m;

ε_x, ε_y, ε_z – dispersion coefficients in direction of x, y and z axes, accordingly, m^2/s;

λ_I – the radioactive decay factor, s^{-1}; λ_I = ln(2)/$t_{1/2}$, where $t_{1/2}$ – is the half-life of a radionuclide.

In general the equation (5-1) is rarely applied because of its complexity and lack of effective measurements on the parameters in the equation variables. To solve the specific targets for determination of radionuclide content levels in water and sea-floor sediments from NPP disposal and discharge at different operation modes (normal operation, emergency conditions) a simplification of equation (5-1) is used.

5.2.2.1 Model of radionuclides dispersion in coastal waters of the sea from NPP's liquid discharge

The mathematical model, for calculation of radionuclides content in coastal waters of the seas and the big lakes from quasi permanent waste disposal of the NPP containing radionuclides, is mentioned in [5/1, 5/4]. The model is based on two-dimensional simplification of the advective-diffusion equation (5-1). On the assumption that incoming to sea water radionuclides are instantly and evenly distributed at depth, and also neglecting a longitudinal dispersion in comparison with advective transfer, the differential equation describing the steady state spatial pollution of water mass is

$$U\frac{\partial C_{w,tot}}{\partial x} = \varepsilon_y \frac{\partial^2 C_{w,tot}}{\partial y^2} - \lambda_i C_{w,tot} \qquad (5\text{-}2)$$

where:

U – water flow velocity along the coast, m/s; other parameters are given in explanation to (5-1);

λ_I – the radioactive decay factor, s^{-1}; $\lambda_I=\ln(2)/t_{1/2}$, where $t_{1/2}$ – is the half-life of a radionuclide.

The steady state solution is chosen as a worst case solution. In practice releases under normal operation are punctual (small releases over a given time).

Proposed model assumes conservatively also that:

- water front is linear and matches with axis x;
- depth of the sea - D in the coastal zone is constant;
- water flow velocity U is constant and parallel to water front.

Equation (5-2) describes the plume contaminated by water radionuclides along the coastline (Figure 5/2.1). Solution of equation (5-2) for steady state continuous release, from a discharge point located at (x = 0, y = y_0) is [5/6]:

$$C_{w,tot} = \frac{Q}{D\sqrt{\pi U \varepsilon_y x}}\left[\exp\left(-\frac{U(y-y_0)^2}{4\varepsilon_y x} - \frac{\lambda_i x}{U}\right)\right] \qquad (5\text{-}3)$$

The location of y_0 (the distance of the discharge point from the shore-line) is a function of the thermal release from the Akkuyu NPP and will be defined during the design phase.

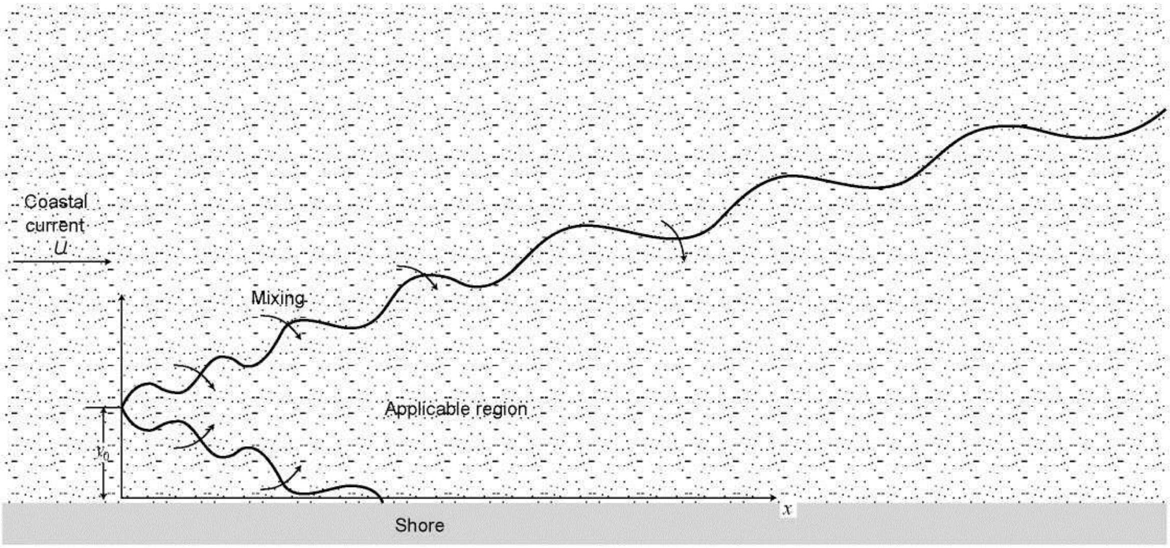


Figure 5/2.1 – Diagram of Waste Discharge, Containing Radionuclides, at which the Considered Methodology is Applicable [5/1]

Application of equation (5-3) in the calculation is reasonable in cases that the parameter ε_y (depending on values *x* and *U*) is measured with sufficient accuracy along sea coast.

In practice the design dependences for determination of the ε_y value are often applied by researches such as Okubo [5/5] where for calculation of ε_y value is suggested the equation:

$$\varepsilon_y = \left(3,44 \cdot 10^{-7}\right)\left(\frac{x}{U}\right)^{1,34}$$

Taking into account [5/5], expression (5-3) becomes suitable for calculations.

It is assumed that the discharge is realized at a discrete point (x=0, y=y0) satisfying the following conditions [5/5]:

$$7D < x < 8 \cdot 10^7$$

$$\left|\frac{y - y_0}{x}\right| << 3,7$$

Volume radionuclide activity in water $C_{w,tot}$ (Bq/m^3) can be calculated by means of the following equation [5/1]:

$$C_{w,tot} = \frac{962 U^{0,17} Q_i}{D x^{1,17}} \exp\left(-\frac{\lambda_i x}{U}\right), \qquad (5\text{-}4)$$

where Q_i – discharge capacity of radionuclide i, Bq/s; other parameters are given in explanation to (5-1).

Volume radionuclide activity, calculated according to (5-4), in accordance with [5/1], can be applied for further radio-ecological assessment related to nuclide buildup in fish and population radiation dose from fishing and eating polluted fishes. If a particular fishing location cannot be defined precisely, the distance equaled to x = 50D [5/1] conservatively is accepted.

The radionuclide content in the water along the coastline, for pollution assessment of sea front and beaches is determined as follows [5/1]:

$$C_{w,tot} = \frac{962U^{0,17}Q_i}{Dx^{1,17}}\left[\frac{\left(-7,28\cdot 10^5\right)U^{2,34}y_0^2}{x^{2,34}}\right]\exp\left(-\frac{\lambda_i x}{U}\right), \qquad (5\text{-}5)$$

All parameters in the equation are determined above.

In accordance with the mentioned scheme of calculations for determination of $C_{w,tot}$ it is required to measure or determine the following parameters:

- mean water flow velocity along bank U. Preliminary measurements of the water flow velocity were performed around the Akkuyu bay (see later in this chapter 5.4.12.4). It is necessary to notice that current measurements would be inadequate because the thermal release of the NPP can considerably change local flow velocities. According to [5/1], if it is impossible to get reliable U estimates, it is conservatively assumed that U = 0,1 m/s;
- mean depth of coastal waters considered at the NPP site area, m. For not stratified parts of the sea as D average depth for distance of discharge point to design area is accepted. In that case if there is water stratification for value D the depth of the top layer (epilimnion) is assigned [5/1];
- to specify the nearest from the NPP site (in direction of flow velocity) locations of fishing and beaches;
- for clarification of calculations the dispersion coefficient ε_y,(m2/s) needs to be measured.

Figure 5/2.2 includes the logic scheme for engineering calculations of volume radionuclides activity in sea water from a stationary source of liquid discharge during NPP normal operation.

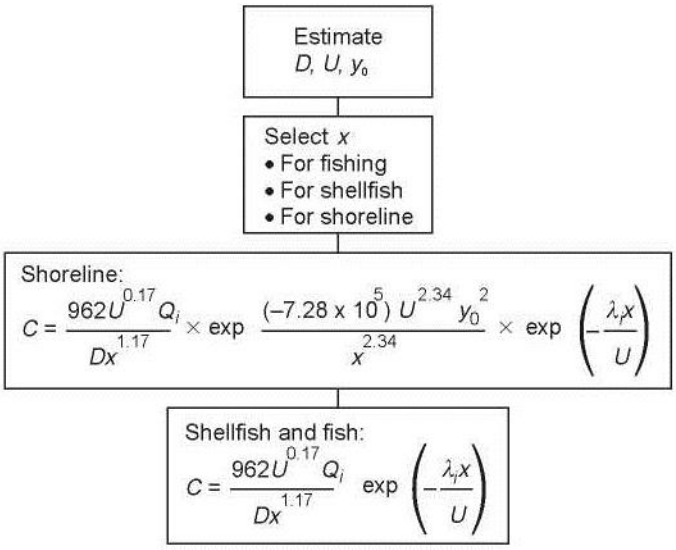


Figure 5/2.2 – Logic Procedure of Calculation of Volume Radionuclides Activity in Water

It is necessary to note that emergency discharge of liquid radionuclides in sea and rivers is excluded by technical decisions of the NPP design, therefore the models describing dispersion in sea and rivers connected with emergency discharge of radionuclides with sewage is not considered in this section.

5.2.2.2 Pollution of sea areas from gas-aerosol NPP discharge

Annual intake of radionuclides from the NPP in the sea with atmospheric fallout at the water and coast surface is defined from the correlation:

$$Q_r = \int_A \sigma_r(\theta)d\theta + \mu\int_S \chi_r(\theta)d\theta \qquad (5\text{-}6)$$

where:

Q_r – annual radionuclides intake to the sea, as a result of gas-aerosol emission, Bq/year;

A – water-surface area on which radionuclides fallout from the NPP gas-aerosol emission;

S – drainage area of sea coast on which radionuclides fallout;

σ_r – fallout density from gas-aerosol emission on water surface, Bq/(m^2·year);

χ_r – radioactive contamination of terrain on which radionuclides fallout, Bq/m^2;

Θ – surface element;

μ – average annual radioactivity washout factor, year^{-1}. The factor describes the process of washout of radionuclides from the terrain to the sea.

In the engineering calculations related to the ecological safety of the NPP in order to estimate radionuclides intake from gas-aerosol emissions under the formula (5-6), there is no need to consider the greatest possible radionuclides intake in water object. Further even under the most adverse conditions and the maximum fallouts from gas-aerosol emission of the NPP there is no radio-ecological threat to the population and the environment. For more details related to maximum gas aerosol emissions during operational conditions see chapter 9.2.

5.2.2.3 NPP normal operation

For assessing the impact of the Akkuyu NPP on the water objects to the greatest extent experiencing the effects of radiation from gas-aerosol emissions from the nuclear power plant it is advisable to consider close to the Akkuyu NPP site an area of the Mediterranean sea with 3 km radius (Figure 5/2.3). The selection of the considered zone size is due to the fact that in that zone are observed the maximum aerosol deposition in normal NPP operation.

Figure 5/2.3 – Scheme of Mediterranean Sea Area in 3-km Zone of the Akkuyu NPP

For maximum impact assessment of gas-aerosol emissions in the coastal zone of the sea during NPP normal operation it can be assumed that all radionuclides present in the gas-aerosol emissions from all of the designed (four) power units, except for the EWG, are falling on the water surface of the selected conditional part of the sea. Assuming that fallouts occur evenly over the area of the sea and are quickly mixed in depth one can use the model describing a pond ideal mixing.

For calculating the radionuclides content in pond water with ideal mixing the following simplified differential equation is applied, see [5/1]:

$$\frac{dC_{w,tot}}{dt} = \frac{(q_r + \lambda_i V)C_{w,tot}}{V} + \frac{Q}{V}, \qquad (5\text{-}7)$$

where:

V – water mass volume of conditional water object, m^3;

q_r – rate of water exchange of pond, m^3/s;

Q – maximum density of radionuclides intake with fallouts from gas-aerosol discharge of all NPP power units, Bq/s;

other parameters are described above.

Assuming that under time t = 0, $C_{w,tot}$ = 0, the solution of equation (5-7) will be the following formula:

$$C_{w,tot} = \frac{Q}{q_r + \lambda_i V}\left\{1 - \exp\left[-\left(\frac{q_r}{V} + \lambda_i\right)t\right]\right\}. \qquad (5\text{-}8)$$

If the exponent condition [5/1] is performed

$$\left(\frac{q_r}{V} + \lambda_i\right) > 10^{-8} c^{-1}$$

in formula (5-8) and is significantly less than one

$$\exp\left[-\left(\frac{q_r}{V} + \lambda_i\right)t\right] << 1$$

and formula (5-8) is given to simple term, not depending on time t

$$C_{w,tot} = \frac{Q}{q_r + \lambda_i V} \qquad (5\text{-}9)$$

Formulas (5-8) and (5-9) can be applied for assessing the maximum volume water activity of coastal parts of sea from gas-aerosol emissions at mode of NPP normal operation.

Emergency conditions

In the general case for the calculation of pollution of the sea water in radiation accidents, related to atmospheric transfer and fallout of radionuclides on the surface of the water requires the application of complex models of migration and transfer of radionuclides in the sea, based on equation (5-1). The generally accepted model of calculations of emergency pollution of the sea does not exist. There are a large number of complex computer models, developed by the authors and used in different countries [5/3, 5/7, 5/8].

The same way as during the NPP normal operation for engineering calculations and consideration of the effects of radiation accidents at sea and surface water simple models can be proposed, based on conservative simplifying assumptions to assess the maximum levels of water pollution, and bottom sediments of the coastal zone. One such simplification can be considered as a conservative assumption of instantaneous and a uniform mixing of emergency deposition of radionuclides at depth of the contaminated area of the sea (in the absence of stratification) or to the depth of the upper layer (epilimnion) in the presence of stratification. In this case, the maximum volumetric activity of radionuclides in contaminated area of the sea can be estimated from the simple equation:

$$C_{w,tot,i}^{\max} = \frac{\sigma_i^{\max}}{D}, \qquad (5\text{-}10)$$

where:

σ_i^{max} – maximum density of fallouts of i radionuclide at considered section of sea surface at accident discharge, Bq/m^2;

D – mean depth in the absence of stratification (epilimnion depth at the presence of stratification), m.

The accident negative consequences of maximum volumetric activity of radionuclide i in the water - $C_{w,tot,i}^{\max}$ can be used for assessment of the maximum levels of radionuclide contamination of fish and bottom sediments of the coastal zone (beaches). The estimates can be used to assess the maximum doses of exposure of the population of the waterway and absorbed dose of hydrobionts.

5.2.3 CALCULATION OF THE RADIONUCLIDES CONTENT IN THE FILTERED WATER (SALINE), AT THE SUSPENDED PARTICLES, IN THE SEA-FLOOR SEDIMENTS AND SOILS OF COASTAL ZONE

Filtered water

Volumetric radionuclides activity in the filtered water can be estimated as per the following formula [5/1]

$$C_{w,s} = \frac{C_{w,tot}}{1 + 0{,}001 K_d S_s}, \qquad (5\text{-}11)$$

where:

$C_{w\ tot}$ - total volumetric activity of radionuclides in water considering the activity, sorbed by suspension, (Bq/m^3);

$C_{w,s}$ – volumetric activity of radionuclides in dissolved phase (filtered water), Bq/m^3;

K_d – radionuclides distribution coefficient between water and suspension, l/kg;

S_s – particle concentration in water, kg/m^3.

Value K_d depends on some parameters and can be assessed be means of sorption experiments [5/9]. At the absence of experimental data it’s allowed to use the literature data.

Values K_d for radionuclides, presented in the NPP discharge and emission for salt and fresh water in accordance with [5/1], is mentioned in Table 5/2.1, which is list of potential radioactive matter that can emit into the environment under any circumstances of NPP operation and corresponding recommended values of distribution coefficients K_d.

The suspended sediment concentration in water shall be measured. At the absence of measurements it's conservatively accepted for the coastal sea water Ss = 1x10-2 kg/m^3, for the river and freshwater lakes Ss = 5x10-2 kg/m^3.

Table 5/2.1 – Recommended Value Distribution Coefficient of Kd [5/1]

Nuclide	Value K_d, l/kg	
	Fresh waters	Salt waters
^{3}H	0.0	0.0
^{51}Cr	$1.0 \cdot 10^{4}$	$5.0 \cdot 10^{4}$
^{54}Mn	$1.0 \cdot 10^{3}$	$2.0 \cdot 10^{5}$
^{59}Fe	$5.0 \cdot 10^{3}$	$5.0 \cdot 10^{4}$
^{58}Co	$5.0 \cdot 10^{3}$	$2.0 \cdot 10^{5}$
^{60}Co	$5.0 \cdot 10^{3}$	$2.0 \cdot 10^{5}$
^{65}Zn	$5.0 \cdot 10^{2}$	$2.0 \cdot 10^{4}$
^{89}Sr	$1.0 \cdot 10^{3}$	$1.0 \cdot 10^{3}$
^{90}Sr	$1.0 \cdot 10^{3}$	$1.0 \cdot 10^{3}$
^{95}Zr	$1.0 \cdot 10^{3}$	$1.0 \cdot 10^{6}$
^{103}Ru	$5.0 \cdot 10^{2}$	$3.0 \cdot 10^{2}$
^{106}Ru	$5.0 \cdot 10^{2}$	$3.0 \cdot 10^{2}$
^{131}I	$1.0 \cdot 10^{1}$	$2.0 \cdot 10^{1}$
^{134}Cs	$1.0 \cdot 10^{3}$	$3.0 \cdot 10^{3}$
^{137}Cs	$1.0 \cdot 10^{3}$	$3.0 \cdot 10^{3}$
^{141}Ce	$1.0 \cdot 10^{4}$	$2.0 \cdot 10^{6}$
^{144}Ce	$1.0 \cdot 10^{4}$	$2.0 \cdot 10^{6}$

Radionuclides content in suspended particles

Specific radionuclides activity, sorbed in suspended particles $C_{s,w}$ (Bq/kg) is determined as per formula [5/1]

$$C_{s,w} = \frac{0{,}001 K_d C_{w,tot}}{1 + 0{,}001 K_d S_s}, \qquad (5\text{-}12)$$

where all formula parameters are determined above in the explanation to (5-11).

Radionuclides content in sea-floor sediments

According to [5/1], the specific radionuclides activity in sea-floor sediments, related to the processes of sorption and deposition of contaminated suspension to the bottom $C_{s,b}$ (Bq/kg) is determined according to the following formula:

$$C_{s,b} = \frac{(0,1)\cdot 0,001K_d \cdot C_{w,tot}}{1+0,001K_d \cdot S_s} \times \frac{1-e^{-\lambda_i T_e}}{\lambda_i T_e} = 0,1C_{s,w} \times \frac{1-e^{-\lambda_i T_e}}{\lambda_i T_e}, \qquad (5\text{-}13)$$

where T_t – effective time of sediments accumulation, (s).

For conservative assessment for T_t the period of one year is applied that is 3.15×10^7s.

Radionuclides content in soils of coastline zone and beaches

Surface activity of radionuclides in soils of coastline zone and beaches $C_{s,s}$ (Bq/m^2) according to [5/1], can be determines as per formula:

$$C_{s,b} = \frac{(0,1)\cdot 0,001K_d \cdot 60 \cdot C_{w,tot}}{1+0,001K_d \cdot S_s} \times \frac{1-e^{-\lambda_i T_e}}{\lambda_i T_e} = 60 \cdot C_{s,b} \qquad (5\text{-}14)$$

Here, as in the expression (5-13), as a conservative assessment for T_t, the period of 1 year is applied, i.e. 3.15x10^7 s.

The mentioned models allow to calculate the concentration of radionuclides in water, sea-floor sediments, soils of the coastal zone and the beach of the liquid discharges of nuclear power plant under normal operation and assess the maximum level of the radionuclides in the components of the marine environment from gas-aerosol emissions, as at the NPP normal operation, as well as for emergency conditions. For the calculations $C_{w,tot}$ in the marine environment it is necessary to obtain the measured values of the following parameters:

- mean water flow velocity along the bank U, (m/s). If for some reason it is impossible to receive reliable estimates of U it is conservatively assumed that U = 0.1 m/s;
- distribution of depths in considered part of sea in the NPP location area, m. For the stratified parts of the sea the value of mean depth of top layer (epilimnion).
- content of suspended particles in water S_s, (kg/m3).
- also for calculations it is desirable to have experimental data on:
- values of distribution coefficients Kd for dose-forming radionuclides between sea water and seafloor sediments;
- values of dispersion coefficients e_x, e_y in the considered sea area, (m^2/s).

5.3 ADEQUACY OF WATER SOURCES

5.3.1 AKKUYU NPP SERVICE WATER SUPPLY SYSTEM

The service water supply system serves to provide cooling water to normal operation consumers and consumers of safety systems located on the site of Akkuyu NPP, Units 1, 2, 3, 4.

The service water supply system is of once-through design with single circulation of cooling seawater through the heat-exchanging equipment.

The source of the service water supply system of Akkuyu NPP is seawater of the Mediterranean Sea.

The ultimate heat sink is the basin of the Mediterranean Sea.

Total cooling water flow rate per one Power Unit is 216136 m^3/hr (in round figures: 220000 m^3/hr), for four Power Units is correspondingly 864544 m^3/hr (in round figures: 880000 m^3/hr).

Preliminary design of service water supply for the Akkuyu NPP includes four surface water intake structures in the Mediterranean Sea, that provide design water intake of 240 m^3/s for four Units.

Proposed once-through scheme of water discharge uses submerged water-discharge channels discharging warm water back to the Sea in order to reduce/minimize recirculation effect. Sea water intake completely provides service water supply requirements for Akkuyu NPP.

Water intake and water discharge hydraulic works, their layouts and protection measures against biological fouling discussed herein are preliminary; they will be finalized at the design stage.

5.3.2 DRINKING AND UTILITY WATER SUPPLY

Maximum daily fresh water requirements during the construction period are:

- drinking and utility water: 660 m3/day (7.6 l/s);
- service water: 2280 m^3/day (26.4 l/s).

Maximum total fresh water requirement for operating four Units is 415 m^3/h (115 l/s) for utility and 450 m^3/h (125 l/s) of drinking quality water. The total daily consumption is estimated to be about 2.210 m^3/day.

5.3.3 SUFFICIENCY OF WATER SUPPLY FOR THE AKKUYU NPP

Water supply for service water supply system for Akkuyu NPP (once-through scheme form the Mediterranean Sea) is sufficient. Water resources of the region allow guaranteeing service water supply for safety related consumers form sea water-intake. Design parameters of water-intake allow performing reliable service water supply of safety related consumers within the full range of Mediterranean Sea level variations in the area of Akkuyu NPP hydraulic structures.

Suitability of sea water for firefighting will be assessed at the next design stages. Characteristics of drinking and utility water sources of fresh water are given in section 5.1 of the present report. Available in the region fresh water recourses for drinking and utility water supply are considered sufficient for development of relevant engineering solutions for water withdrawal extension. However, a decision was taken to build at the Akkuyu NPP site a desalination plant which will cover the need for drinking and utility water supply.

Probable changes in water consumption in the Akkuyu NPP region are defined by perspective demands of the Turkish side, first of all by labor migration due to NPP construction and also by development of tourism. Forecast of drinking and utility water consumption will be performed at the next design stages.

5.3.4 DESIGN SEA LEVELS WITH EXCEEDANCE PROBABILITY OF 0.01, 0.1, 1, 95, 97, 99.9 %

For the purpose of determination of design sea levels, tidal and seasonal fluctuations, the sea level measurements by Erdemli - II Mareograph Station (General Command of Mapping - Turkey) between the dates 30.05.2003-16.09.2011 is used. Sampling rate of the sea level measurements is 15 minutes. The datum of the given measurements is converted to TUDKA-99 datum adding minus 0.96698 m to the measurement values.

Tides are mainly semidiurnal with a 0.165 m tidal variation (varying between 0.035 - 0.25 m) within an average period of 12.39 hours (varying between 12.0 - 12.8 hours). Moreover, using the method given by Pawlowicz, the main tidal constituents shown in Figure 5/3.1 are given in Table 5/3.1. Taking the monthly average values of the data, the seasonal variation is observed to occur as 0.29 m on average (varying between 0.19 - 0.37 m) taking a maximum value on July and August and a minimum value between December and April in general according to the measurements between the dates 30.05.2003-16.09.2011 (Figure 5/3.2). The sea level rise observed from the measurements is approximately + 7.2 mm per year (Figure 5/3.3). Effects of crustal movements are not included.

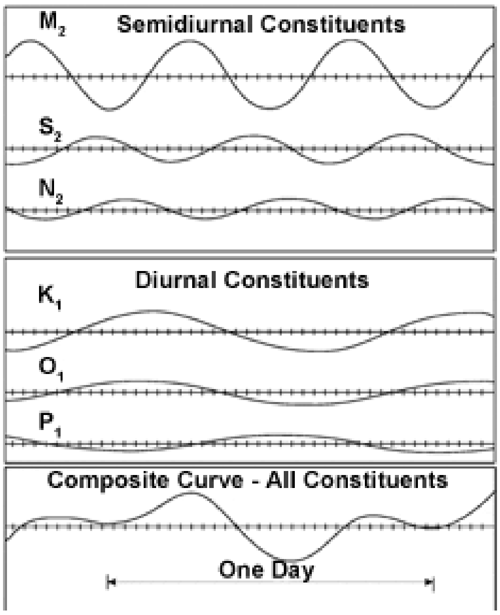


Figure 5/3.1 - Main Tidal Constituents

Table 5/3.1 – Main Tidal Constituents Obtained from Erdemli - II Sea Level Measurement Data (30.05.2003 - 16.09.2011)

Tidal Constituent	Amplitude (m)	Period (hr)
O1 (Principal lunar diurnal)	0.020	25.82
P1 (Principal solar diurnal)	0.010	24.07
K1 (Lunisolar diurnal)	0.027	23.93
N2 (Lunar elliptic semidiurnal)	0.017	12.66
M2 (Principal lunar semidiurnal)	0.106	12.42
S2 (Principal solar semidiurnal)	0.061	12.00

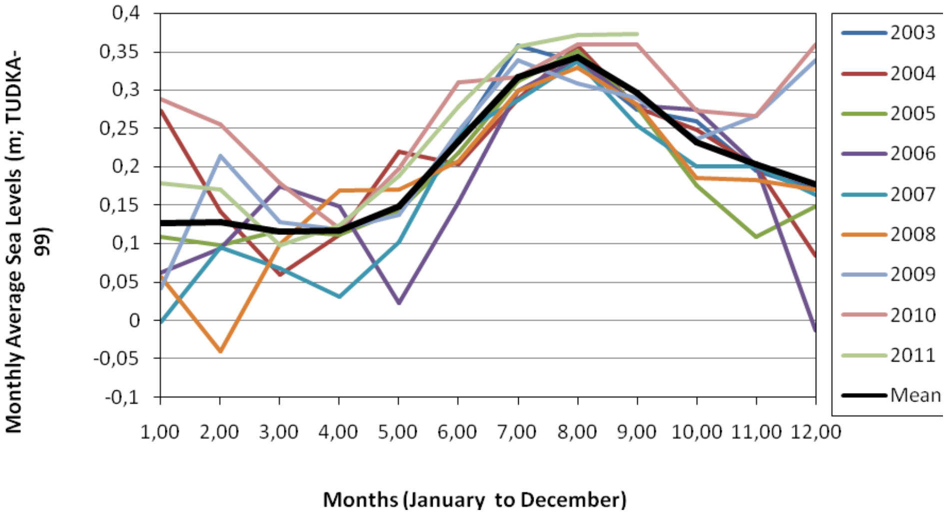


Figure 5/3.2 – Variation of Monthly Average Sea Levels With Respect to Months (Erdemli-II Sea Level Measurement Data Between 30.05.2003 - 16.09.2011, TUDKA-99 Datum)

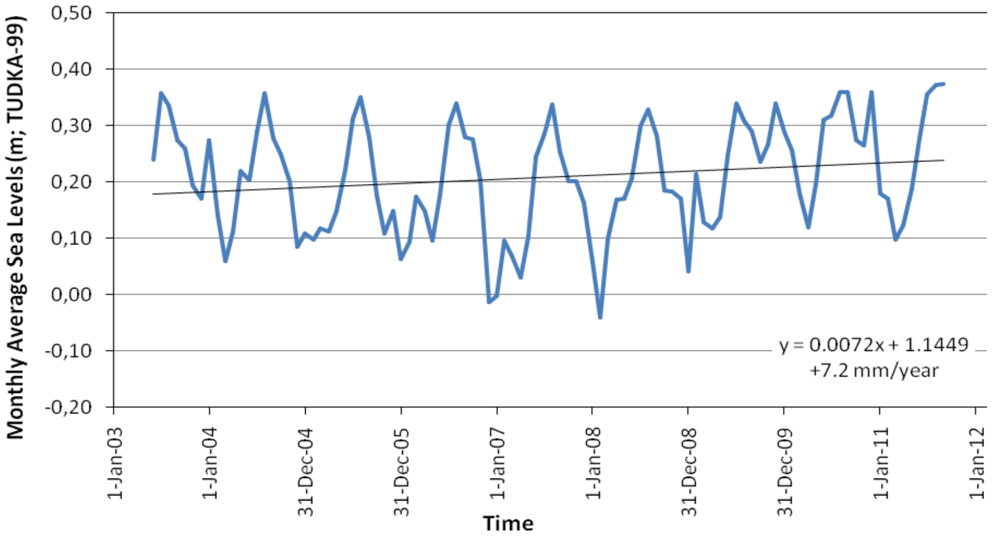


Figure 5/3.3 - Variation of Monthly Average Sea Levels With Respect to Years (Erdemli-II Sea Level Measurement Data Between 30.05.2003 - 16.09.2011, TUDKA-99 Datum)

Monthly average sea levels are given in Table 5/3.2. Monthly maximum and minimum sea levels are given in Table 5/3.3 and Table 5/3.4 respectively.

Table 5/3.2 – Monthly Average Sea Levels (m) (TUDKA-99 Datum)

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
2003	-	-	-	-	-	0.24	0.36	0.34	0.27	0.26	0.19	0.17
2004	0.27	0.14	0.06	0.11	0.22	0.20	0.29	0.36	0.28	0.25	0.20	0.08
2005	0.11	0.10	0.12	0.11	0.14	0.22	0.31	0.35	0.28	0.18	0.11	0.15
2006	0.06	0.09	0.17	0.15	0.02	0.15	0.30	0.34	0.28	0.27	0.20	-0.01
2007	0.00	0.09	0.07	0.03	0.10	0.24	0.29	0.34	0.25	0.20	0.20	0.16
2008	0.06	-0.04	0.10	0.17	0.17	0.21	0.30	0.33	0.28	0.19	0.18	0.17
2009	0.04	0.21	0.13	0.12	0.14	0.25	0.34	0.31	0.29	0.24	0.27	0.34
2010	0.29	0.25	0.18	0.12	0.20	0.31	0.32	0.36	0.36	0.27	0.27	0.36
2011	0.18	0.17	0.10	0.12	0.19	0.28	0.36	0.37	0.37	-	-	-

Table 5/3.3 - Monthly Maximum Sea Levels (m) (TUDKA-99 Datum)

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
2003	-	-	-	-	-	0.52	0.60	0.57	0.57	0.57	0.62	0.48
2004	0.73	0.46	0.50	0.43	0.52	0.47	0.57	0.61	0.52	0.51	0.52	0.34
2005	0.56	0.44	0.53	0.39	0.42	0.50	0.55	0.60	0.54	0.45	0.47	0.47
2006	0.32	0.44	0.46	0.45	0.36	0.49	0.52	0.59	0.50	0.56	0.63	0.29
2007	0.41	0.39	0.34	0.35	0.43	0.53	0.54	0.57	0.50	0.51	0.49	0.60
2008	0.34	0.26	0.46	0.48	0.41	0.44	0.55	0.58	0.53	0.41	0.46	0.45
2009	0.49	0.71	0.50	0.38	0.41	0.53	0.57	0.54	0.57	0.50	0.58	0.74
2010	0.79	0.64	0.61	0.40	0.54	0.60	0.58	0.63	0.63	0.51	0.53	0.75
2011	0.53	0.63	0.47	0.42	0.55	0.56	0.64	0.63	0.55	-	-	-

Table 5/3.4 - Monthly Minimum Sea Levels (m) (TUDKA-99 Datum)

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
2003	-	-	-	-	-	0.01	0.16	0.10	-0.04	0.00	-0.22	-0.15
2004	-0.09	-0.19	-0.32	-0.19	-0.09	-0.06	0.08	0.09	-0.01	0.00	-0.14	-0.23
2005	-0.28	-0.30	-0.20	-0.21	-0.53	-0.41	0.09	0.10	0.03	-0.08	-0.20	-0.15
2006	-0.28	-0.30	-0.11	-0.17	-0.73	-0.63	-0.04	0.11	0.01	0.02	-0.07	-0.29
2007	-0.39	-0.21	-0.31	-0.23	-0.23	-0.03	0.06	0.05	-0.05	-0.10	-0.03	-0.17
2008	-0.18	-0.37	-0.24	-0.19	-0.06	0.00	0.06	0.06	0.06	-0.14	-0.09	-0.16
2009	-0.40	-0.10	-0.15	-0.16	-0.09	0.01	0.11	0.06	0.05	-0.02	-0.06	-0.10
2010	-0.23	-0.03	-0.16	-0.13	-0.03	0.08	0.05	0.10	0.09	0.00	-0.08	0.07
2011	-0.17	-0.14	-0.18	-0.14	-0.05	-0.01	0.10	0.11	0.13	-	-	-

The maximum and minimum sea levels are measured as 0.79 m and minus 0.73 m, between and the minimum sea level respectively, between 30.05.2003-16.09.2011, with respect to TUDKA-99 datum. An extreme analysis has been carried out to find the design sea levels using annual maxima method for the 15 minute interval measurements. The annual maximum and minimum sea levels given in Table 5/3.5 with respect to TUDKA-99 datum are analyzed using the best fitting distributions among FT-1 (Gumbel), FT-2, FT-3 (Weibull) and Log-Normal with different distribution coefficients. To determine the extreme minimum sea levels, the data given in Table 5/3.5 is multiplied with minus 1 and analyzed similar to the annual maximum sea level data.

Table 5/3.5 - Annual Maximum and Minimum Sea Levels Observed Between 30.05.2003 - 16.09.2011 (m) (TUDKA-99 Datum)

Year	Annual Maximum Sea Level (m)	Annual Minimum Sea Level (m)
2003	0.62	-0.22
2004	0.73	-0.32
2005	0.60	-0.53
2006	0.63	-0.73
2007	0.60	-0.39
2008	0.58	-0.37
2009	0.74	-0.40
2010	0.79	-0.23
2011	0.64	-0.18

FT-1a distribution which gave the best fitting results is used to show the relation between the extreme sea levels and the cumulative non-exceedance probability of these extreme sea levels.

Pm = 1-(m)/(N+1) for descending ordered data,

P(<WLmax) = exp[-exp(-(WLmax -B)/A)],

where:

- m is the order of data;
- N is the total number of data;
- WLmax is the extreme sea level within the reference time length;
- P(<WLmax) is the cumulative probability that WLmax value is not exceeded within the reference duration;
- A and B are the distribution parameters.

Above given equation indicates that a plot of WLmax as ordinate versus -ln[-ln(1/(P(<WLmax))] should give a straight line with +A as its slope and +B as the intercept (Figure 5/3.4). The upper horizontal axis of Figure 5/3.4 and Figure 5/3.5 shows the return period Rp which is related to non-exceedance probability value by the following relationship [5/2]:

Rp = 1/(1-P(<WLmax))

The extreme sea levels for selected return periods (Rp in years) are given in Table 5/3.6. The design sea levels with 0.01 %, 0.1 %, 1 %, 95 %, 97 %, 99.9 % exceedance probabilities is given in Table 5/3.7.

Table 5/3.6 - Extreme Sea Levels for the Respective Return Periods

Return Period (years)	Exceedance Probability, Q	Maximum Water Level (m) for 15 Min	Minimum Water Level (m) for 15 Minutes
5	0.2	0.73	-0.55
10	0.1	0.79	-0.68
20	0.05	0.84	-0.80
50	0.02	0.91	-0.96
100	0.01	0.97	-1.08

Table 5/3.7 - Design Sea Levels for the Exceedance Probabilities

Exceedance Probability, Q (%)	Maximum Water Level (m) for 15 Minutes	Minimum Water Level (m) for 15 Minutes
1	0.967	-1.08
0.1	1.140	-1.47
0.01	1.313	-1.86
95	0.540	-0.10
97	0.528	-0.08
99.9	0.477	0.04

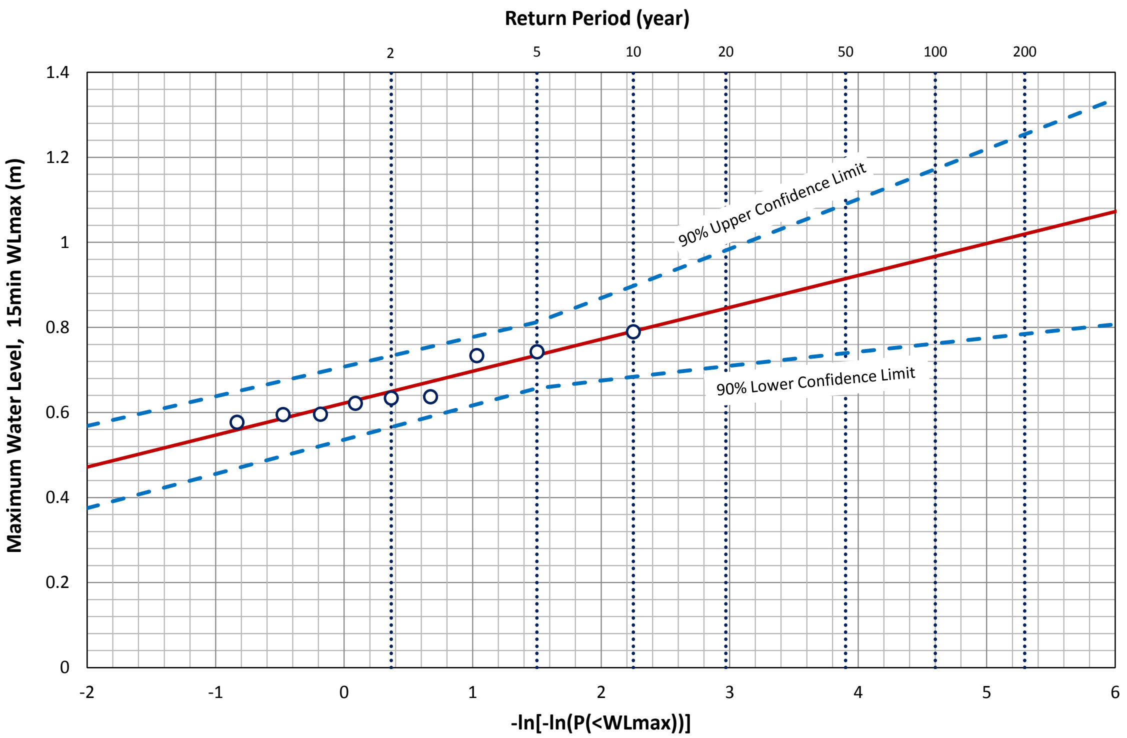


Figure 5/3.4 - Extreme Value Statistics for the Annual Maximum Sea Level Data between 30.05.2003 - 16.09.2011 (TUDKA-99 Datum)

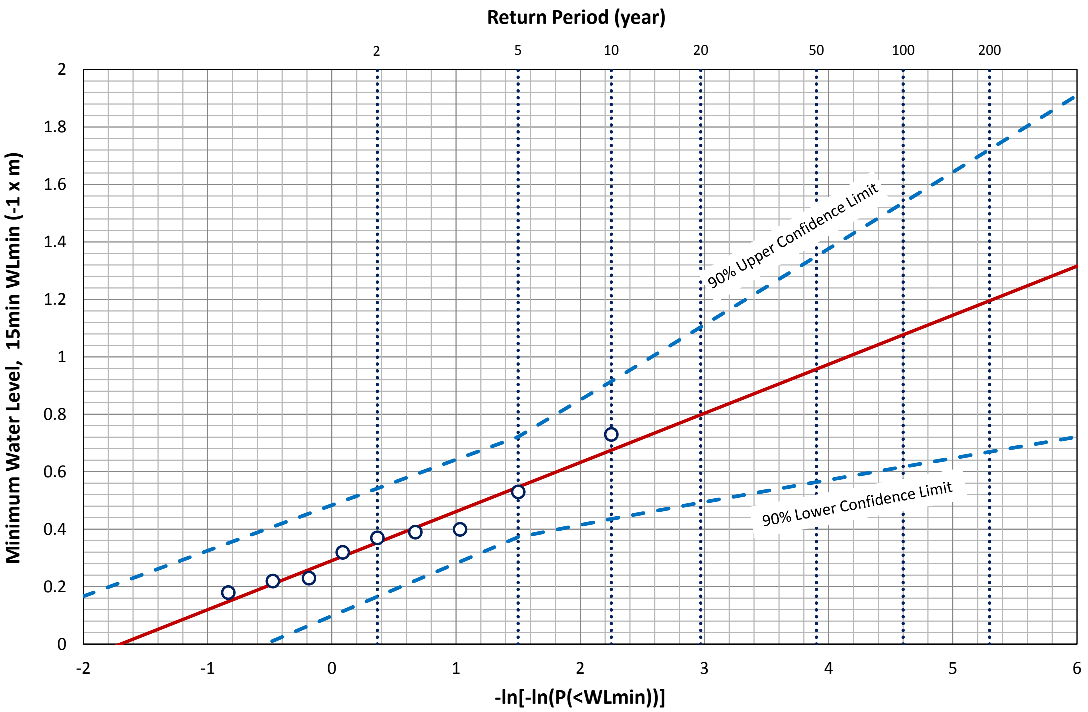


Figure 5/3.5 - Extreme Value Statistics for the Annual Minimum Sea Level Data between 30.05.2003 - 16.09.2011 (TUDKA-99 Datum)

As it is given in Table 5/3.7, the extreme positive water levels with exceedance probabilities of 1 %, 0.1 % and 0.01 % are found to be 0.97, 1.14 and 1.31 m respectively with respect to TUDKA-99 Datum. Similarly, the extreme negative water levels with exceedance probabilities of 1 %, 0.1 % and 0.01 % are found to be minus 1.08, minus 1.47 and minus 1.86 m respectively with respect to TUDKA-99 Datum.

5.3.5 TEMPERATURE CHARACTERISTIC OF FINAL HEAT ABSORBER

Discharge of warm service water will be performed to one of the Mediterranean bays nearest to the NPP. Mediterranean Sea is the ultimate heat sink. Hydrological characteristics of the Mediterranean Sea in the Akkuyu NPP site vicinity is given in Section 5-4. Data on temperature characteristics of the Mediterranean Sea in the Akkuyu NPP site region is given in this Section.

5.3.5.1 Thermal Mode of Mediterranean Sea Coastal Zone

The warming trend begins in early April with highest temperatures occurring in August and the cooling trend beginning in early September. The warming is most rapid between April and June. The sharpest drop in temperature occurs in October. The lowest water temperatures occur in March. The air temperature cycle exhibits similar features. The maximum sea water temperature observed was 29.84°C on 23 August 1977 while the minimum was 15.57°C on 31 March 1978.

From late summer to winter the sea water temperature decreases in a succession of stepwise drops which coincide with strong atmospheric events. These wind events, marked by very large north-westerly wind stresses reflect the local Poyraz wind system, almost every time a Poyraz event occurs, the sea water temperature indicates a net drop of 0.5 - 1.5°C from the previously existing temperatures. Part of this difference may be recovered immediately after the wind event, but in general the net drop even after recovery is large; the temperature remains constant in the long term until the next wind event. Since there is no decreasing trend between such events, it may be concluded that the succession of Poyraz mixing event is largely responsible for the cooling of the water masses in autumn and winter seasons. Such rapid cooling is a combination of wind-mixing and latent heat losses during Poyraz.

After December, the net temperature drops due to Poyraz are insignificant since the mixed-layer is already deep enough and has lost all of its excessive temperature as compared to deep waters. However, in the spring months Poyraz winds are related to long-term fluctuations in temperature and in June, when the maximum rate of warning occurs in surface waters. Poyraz events also induce effective mixing, simultaneously disrupting the developing temperature stratification.

Temperature stratification in the bay begins with the beginning of the warming trend in air temperature in April. With the heating of the surface layers, a continuously stratified water column develops. As the air temperature increase, a surface mixed layer of approximately uniform temperature (and salinity) is formed under the action of summer time wind-mixing. With the fall in air temperatures beginning in September, and with increasing vertical mixing due to winter storms, the surface layer both cools and becomes deeper. During these months, September through March, the depth of the mixed layer is in the order of 50 - 100 m. Consequently, the variation in temperature in Akkuyu bay both vertically and horizontally is less than 1°C during these months.

Continued stratification is observed at all stations during May and June. The isotherms for 20°C and 21°C in May slope lightly upwards into the bay indicating the presence of relatively warmer water in the offshore region of the bay. A thin surface layer of warm and relatively lower salinity water is situated at the mouth of the bay. June transect show the continuation of the vertical stratification while the horizontal temperature distribution has become more uniform relative to the distribution in May.

In August most of the water mass in the bay is seen to have reached a well-mixed state where to a depth of about 25 meters the temperature is varying from about 29°C at the surface to 28°C at 25 m.

Temperature fluctuations with periods of a few hours to about two days were observed superimposed over the general temperature trend in records obtained from the moored current meters. The magnitude of some of the larger fluctuations was between 3 - 4°C. The fluctuations were observed at both the 5 in and the 15 m depths at which the current meters were located.

The temperature fluctuations are largest during the months of May, June, and July, when the temperature in the upper layer has a continuous variation. Most dominant form of the short-term fluctuations are the near-diurnal periods, that are part of the motions forced by the diurnal sea breeze system of winds.

In contrast to the situation in May and June the fluctuations are smaller when a mixed layer has been formed.

In order to assess the thermal mode of the Akkuyu Bay during present 2011 studies, CTD profiling survey (conductivity, temperature, density of water) was performed at 30 locations (Figure 5/3.6) at every 10 day period.

CTD measurements at each temporary station were performed via 1 m along vertical profile.

In order to prepare the thermal cross sectional profile of the Akkuyu Bay; 3 sections were selected as defined above:

- Western thermal profile – stations CTD6, CTD12, CTD14, CTD22, CTD23 and CTD30 respectively;
- Middle thermal profile – stations CTD3, CTD11, CTD15, CTD21 and CTD29;

– Eastern thermal profile – stations CTD17, CTD20, CTD27 and CTD28.

CTD data collected from 30 stations were used to analyze the sea water temperature trends during survey period. Surface water temperature distribution maps, bottom water temperature distribution maps, cross sectional thermal profiles are prepared and supplied accordingly.

Data sets and temperature for period of 21.06.2011-29.10.2011 is enclosed in [5/13].

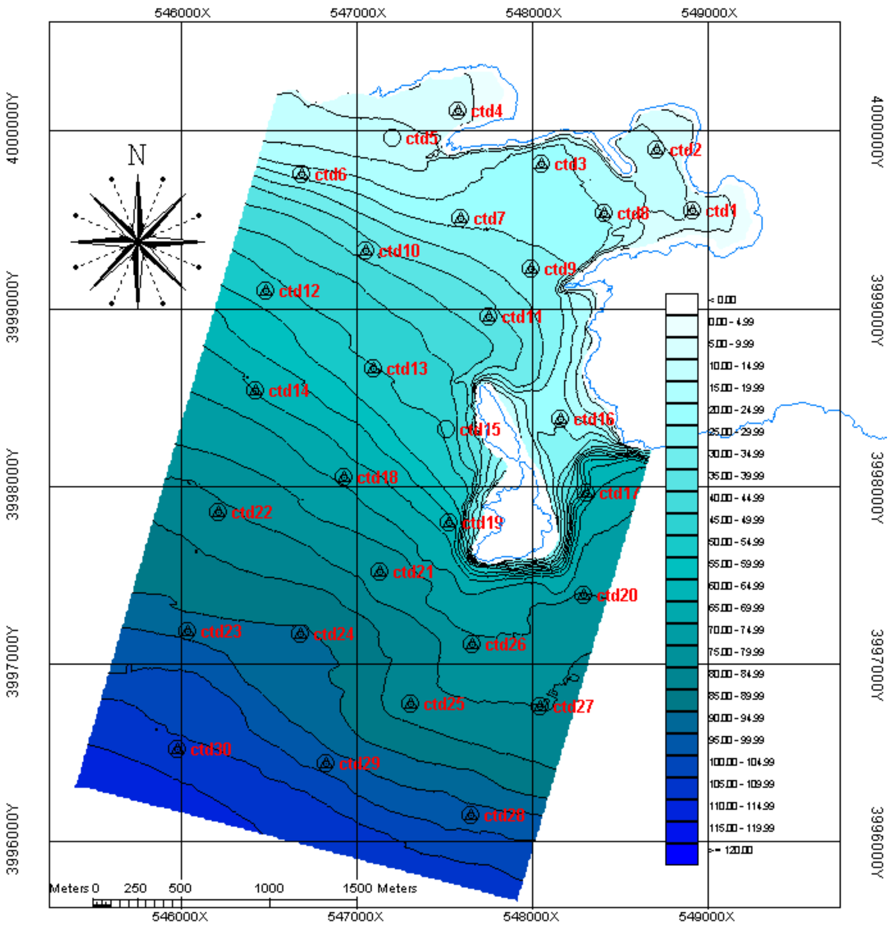


Figure 5/3.6 – CTD Locations

It is seen from RDCP records that temperature fluctuations with period from several hours to two days are relevant to the general temperature trend. The magnitude of some of the larger fluctuations was between 3 - 4°C. The fluctuations were observed at both the 5 in and the 15 m depths at which the current meters were located.

The temperature fluctuations are largest during the months of May, June, and July, when the temperature in the upper layer has a continuous variation. Most dominant form of the short-term fluctuations are the near-diurnal periods, that are part of the motions forced by the diurnal sea breeze system of winds.

In contrast to the situation in May and June the fluctuations are smaller when a mixed - layer has been formed.

The cooling effect of the north easterly Poyraz winds is clearly seen in the temperature record following August 28 2011. The cooling penetrates down to at least the 15 m level, and the temperature of the entire water column in decreased by 1.5°C.

In February both the fluctuations and the Poyraz cooling effect are minimal, since the mixed layer has deepened and a well-mixed water mass of 16 - 17°C reaches the surface.

5.3.5.2 Continuous Monitoring of Water Temperature at Stationary Stations and Main Design Temperature Parameters

Daily recording of temperatures were performed at six locations

- WLMS located at nearshore by CTD sensor 3231, to measure the surface temperature at every 10 minute interval;
- WAVE1 and WAVE2 by temperature sensor integrated in pressure sensor 4648 to monitor the bottom temperatures. at every 1 hour interval;
- DCP1, RDCP2, RDCP3 by temperature sensor installed on equipment at every 1 hour interval.

Locations of stations are given in Figure 5/3.7.

Temperature data sets for 6 measurement stations are enclosed in [5/14] separately for each station.

In order to define the hottest 10 day for each location separately average of daily maximum values for investigated and below periods were selected for each location;

For the WLMS location the hottest 10 day period was observed in between 03.08.2011 and 12.08.2011 whereas the average of daily maximum is 29.50 °C. It is also worth to mention that the hottest water temperature value was observed on 21.07.2011 at 15:59 (30.10 °C) but this trend was only limited for 5 days until 25.07.2011 and neglected for the selection of 10 day period.

For the RDCP1 location the hottest 10 day period was observed in between 21.08.2011 and 30.08.2011 whereas the average of daily maximum is 29.32 °C. The hottest water temperature of 29.59 °C was measured on 28.08.2011 (inside the hottest 10 day period) at 22:01.

For the RDCP2 location the hottest 10 day period was observed between 07.09.2011 and 16.09.2011 whereas the average of daily maximum is 29.26 °C. The hottest water temperature of 29.58 °C was measured at 10.08.2011 at 19:01 which out of the hottest 10 day period.

For the RDCP3 location the hottest 10 day period was observed between 21.08.2011 and 30.08.2011 (likewise RDCP1 location) whereas the average of daily maximum is 29.19 °C. The hottest water temperature of 29.44°C was measured outside the selected period on 12.09.2011 at 21:01.

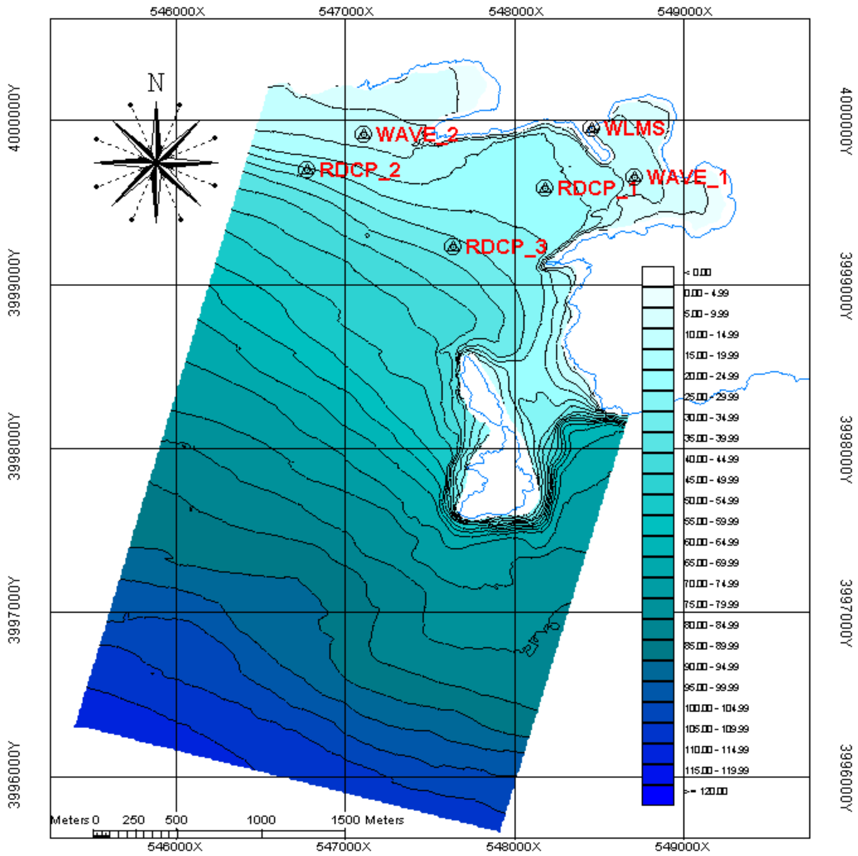


Figure 5/3.7 – Locations of Daily Temperature Measurement Stations WAVE, WLMS, RDCP

For the WAVE1 location the hottest 10 day period(s) were observed between 22.08.2011and 31.08.2011, 09.09.2011 and 18.09.2011 and 10.09.2011 and 19.09.2011 with the daily maximum average of 29.42 °C. The average of daily mean temperature of the 22.08.2011-31.08.2011 period is 29.17 °C whereas the average of the daily mean temperature is 29.25 °C both for the 09.10.2011-18.09.2011 and 10.09.2011-19.09.2011 periods. The hottest water temperature of 29.89 °C was measured outside the selected period on 11.08.2011 at 23:00. It has been decided to select the 22.08.2011 to 31.08.2011 for the discussion of hottest 10 day period of WAVE1 Location.

For the WAVE2 location the hottest 10 day period was observed between 07.08.2011 and 16.08.2011 whereas the average of daily maximum is 29.58 °C. The hottest water temperature of 29.83 °C was measured inside the selected period on 11.08.2011 in-between 18:00-21:00.

From the above datasets it is observed that for the surface water temperature the hottest period is observed at the beginning of July (03.08.2011-12.08.2011) and for RDCP1 (depth 21.6 m), RDCP2 (depth 26.0m) and RDCP3 (depth 31.8 m) the hottest period was observed during the period 14.08.2001-23.08.2011. For WAVE1 and WAVE2 the hottest period was observed between 06.08.2011 and 15.08.2011 and between 07.08.2011 and 16.08.2011, respectively.

The hottest period for bottom water temperature was observed from late August to mid September.

Table 5/3.8 shows water temperature for the hottest 10 days at selected stations. No evidence of thermal pollution is encountered during the 2011 survey in the Akkuyu Region.

Table 5/3.8 – Daily Behavior of Water Temperature for the Hottest 10 Day for Selected Stations

Station	Depth, m	Hottest 10 Day Period		Temperature, °C		
				Max	Min.	Average
WLMS	Surface	03.08.2011	12.08.2011	29.74	28.36	28.99
RDCP1	21.6	21.08.2011	30.08.2011	29.59	28.38	29.01
RDCP2	26.0	07.09.2011	16.09.2011	29.44	27.41	28.95
RDCP3	31.8	21.08.2011	30.08.2011	29.41	27.17	28.77
WAVE1	13.7	22.08.2011	31.08.2011	29.71	26.78	29.17
WAVE2	12.4	07.08.2011	16.08.2011	29.83	26.72	28.97

5.3.5.3 Design Maximum, Average Monthly and Daily Water Temperatures with Probability up to 0.01 %

In order to obtain the design maximum values, statistical calculations are carried out according to the long term dataset which is obtained from the Turkish State Meteorological Service. The dataset is recorded at Anamur station which records the daily water temperature. The daily water temperatures between 1970 and 2011 are analyzed to obtain the maximum water temperatures for each year. Based on the extreme values of each year, extreme value statistics are carried out to find the best fitting distribution representing the dataset. 9 distributions are analyzed and by the least squares method, the best fitting distribution for each case is determined. These distributions are FT-I, FT-II (k = 2.50, 3.33, 5.00, 10.00) and Weibull (k= 0.75, 1.00, 1.40, 2.00).

The best fitting distribution for average monthly water temperature with probability up to 0.01% is Weibull Distribution with shape parameter k=2.00. The design maximum average monthly temperature of probability up to 0.01% is 31.95°C.

The best fitting distribution for daily water temperatures up to 0.01% is Weibull Distribution with shape parameter k = 2.00.

The design water temperatures of the hottest ten days are listed in Table 5/3.9.

Table 5/3.9 – Design Water Temperatures for Hottest 10 Day Period

Probability, %	Max. Water Temperature, °C
50	28.056
10	29.313
1	30.466
0.1	31.351
0.01	32.097

The best fitting distribution for the hottest 5 days is Weibull Distribution with shape parameter k = 2.00.

The design water temperatures of the hottest five days are listed in Table 5/3.10.

Table 5/3.10 – Design Water Temperatures for Hottest 5 Day Period

Probability, %	Max. Water Temperature, °C
50	28.243
10	29.408
1	30.476
0.1	31.297
0.01	31.988

5.3.5.4 Chemical and Physical Properties of Sea Water and Bottom Sediments

In order to evaluate the water impurities and the pollution levels of the Akkuyu Bay, sea water and sediment chemical analysis survey was performed in Akkuyu Bay.

Parameters analyzed on Sea Water Samples are given below:

- pH, Color, Turbidity, Floating Solids, Total Suspended Solids, Dissolved Oxygen (mg/L), Dissolved Organic Pollutants (BOD5), Total Petroleum Hydrocarbons, Productivity (Chlorophyll-a), Toxicity (Fish Bio-Experiment), Phenols, Cu, Cd, Cr, Pb, Ni, Zn, Hg, As and NH3;
- Radioactive parameters alpha, beta, gamma radiation, tritium, total indicative dose, 238U, 90Sr and 137Cs.

Sediment analyzed from the uppermost layer (20 cm depth) for ^{90}Sr, ^{137}Cs, ^{232}Th, ^{40}K elements.

In order to collect required samples from sea YSI 556 MPS, Hydrobios Niskin Sampler and Hydrobios Van Veen Grab Sampler were used.

Seawater and sediment sampling was conducted at 10 stations, spatially distributed in the Akkuyu Bay. Sediment samples were taken from the uppermost sediment layer up to 20cm depth from the seafloor. Water sampling was performed for bottom and surface layers. Locations of the sampling points are given in Figure 5/3.8.

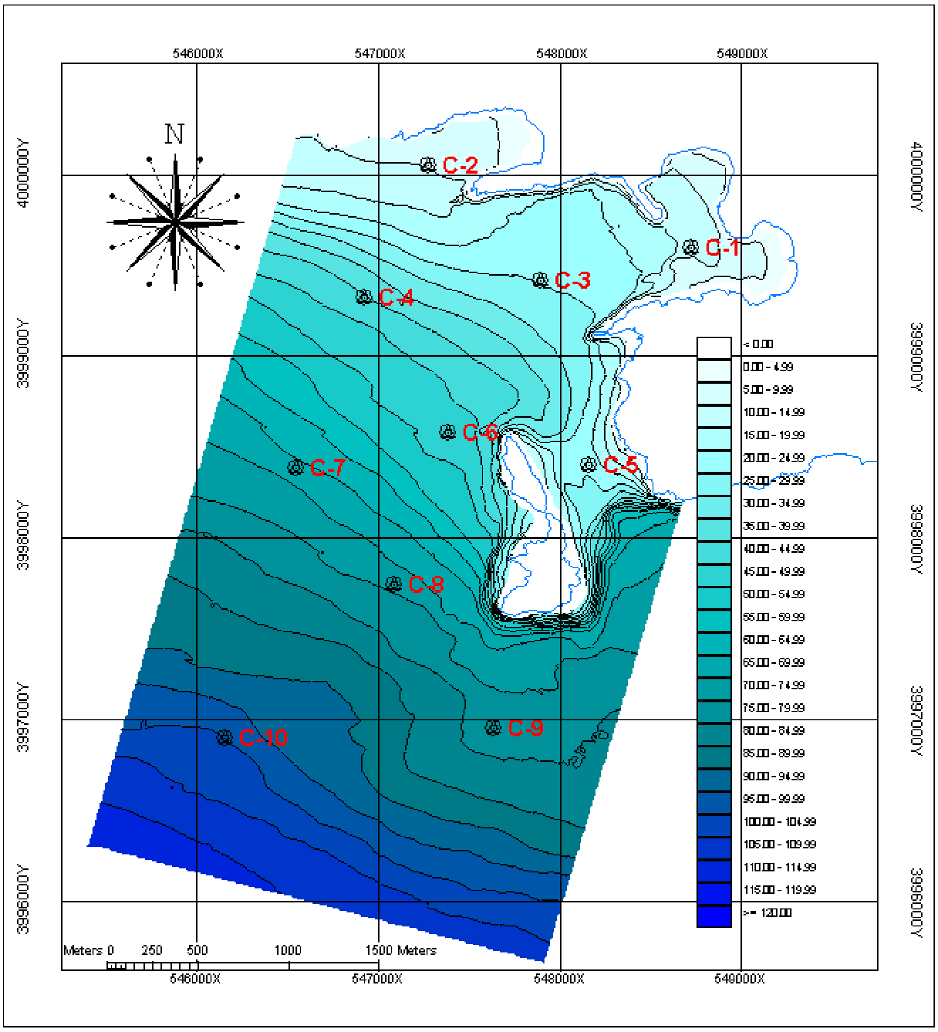


Figure 5/3.8 – Locations of Seawater & Sediment Sampling Points

The measured values with method detection limits and requirements of TWPCR are given in Table 5/3.11. The measured concentrations for all studied parameters are below the criteria set by TWPCR (where applicable) for all stations and all depths.

Table 5/3.11 - PH, Color, Turbidity, Floating Solids, Total Suspended Solids, DO in Akkuyu Seawater

Station	Depth	PARAMETER					
		pH	Color & Turbidity	Floating Material	TSS (mg/L)	DO (mg/l)	DO (%sat)
1	S	8.09	Natural	ND	5.4	6.46	99.7
	B	8.20	Natural	ND	2.2	6.91	106.9
2	S	8.16	Natural	ND	3.0	6.32	96.8
	B	8.20	Natural	ND	4.2	6.43	99.4
3	S	8.11	Natural	ND	2.0	6.50	99.2
	B	8.25	Natural	ND	2.2	6.64	101.5
4	S	8.01	Natural	ND	2.2	7.50	113.2
	B	8.02	Natural	ND	2.8	6.92	106.0
5	S	8.20	Natural	ND	5.4	7.63	116.5
	B	8.17	Natural	ND	3.2	6.99	105.7
6	S	8.04	Natural	ND	3.8	7.45	112.8
	B	7.97	Natural	ND	4.0	7.62	110.2
7	S	8,08	Natural	ND	3.4	7.92	105.1
	B	8.13	Natural	ND	2.6	7.57	105.4
8	S	8.21	Natural	ND	3.8	6.75	103.7
	B	8.09	Natural	ND	3.0	7.60	104.4
9	S	8.23	Natural	ND	2.8	5.89	90.5
	B	8.18	Natural	ND	3.0	7.58	103.7
10	S	8.11	Natural	ND	2.8	6.41	97.4
	B	8.07	Natural	ND	4.0	7.85	106.8
TWPCR	-	6 - 9	Natural	ND	30	-	90

The measured concentrations for BOD5, chlorophyll-a, total petroleum hydrocarbons and toxicity given in Table 5/3.12 are below the criteria set by TWPCR, for all stations and all depths. Phenol concentrations are incompliant with the given criterion for surface waters of Stations 1, 2, 3, 6, 7, 9 and 10, and bottom waters of Stations 1, 2, 3, 5, 7, 8 and 9. Ammonium concentrations are incompliant with the given criterion in TWPCR for surface waters of Stations 3 and 9, and bottom waters of Station 8.

The metal concentrations are given in Table 5/3.13 with method detection limits and minimum concentration required by TWPCR. The measured radioactivity values with method detection limits and requirements of TWPCR are given in Table 5/3.14.

The measured radioactivity values in sediments with method detection limits and requirements of TWPCR are given in Table 5/3.15.

Table 5/3.12 – BOD_5, Chlorophyll-A, Total Petroleum Hydrocarbons, Toxicity, Phenol and Ammonium Concentrations in Akkuyu Seawater

Station	Depth	Parameter					
		BOD_5 mg/l	Chl-a ug/l	TPHC mg/l	Toxicity	Phenol mg/l	NH_4 mg/l
1	S	3.2	0.27	<MDL	<MDL	0.002	<MDL
	B	3.5	0.52	<MDL	<MDL	<MDL	0.010
2	S	3.8	0.40	<MDL	<MDL	0.001	<MDL
	B	3.6	0.55	<MDL	<MDL	0.005	<MDL
3	S	3.2	0.22	<MDL	<MDL	0.002	0.040
	B	3.3	0.77	<MDL	<MDL	0.003	<MDL
4	S	3.2	0.82	<MDL	<MDL	<MDL	<MDL
	B	3.4	0.52	<MDL	<MDL	<MDL	0.010
5	S	3.3	<MDL	<MDL	<MDL	<MDL	<MDL
	B	4.4	0.34	<MDL	<MDL	0.002	<MDL
6	S	5.3	0.52	<MDL	<MDL	0.005	<MDL
	B	4.3	0.31	<MDL	<MDL	<MDL	<MDL
7	S	3.3	0.40	<MDL	<MDL	0.002	<MDL
	B	4.5	0.40	<MDL	<MDL	0.002	0.010
8	S	3.2	0.32	<MDL	<MDL	<MDL	<MDL
	B	3.3	0.73	<MDL	<MDL	0.009	0.050
9	S	3.2	0.52	<MDL	<MDL	0.002	0.020
	B	3.4	0.88	<MDL	<MDL	0.004	<MDL
10	S	3.5	0.70	<MDL	<MDL	0.001	<MDL
	B	3.8	0.47	<MDL	<MDL	<MDL	<MDL
TWPCR	-	-	-	0.003	ND	0.001	0.02
MDL	-	-	0.20	0.003	1	0.0001	0.01

Table 5/3.13 - Metal Concentrations in Akkuyu Seawater

Station	Depth	Parameter							
		Cu (mg/L)	Cd (mg/L)	Cr (mg/L)	Pb (mg/L)	Ni (mg/L)	Zn (mg/L)	Hg (mg/L)	As (mg/L)
1	S	0.005	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
	B	0.007	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
2	S	0.005	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
	B	0.006	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
3	S	0.005	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
	B	0.007	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
4	S	0.007	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
	B	0.005	<MDL	<MDL	<MDL	0.03	<MDL	<MDL	<MDL
5	S	0.006	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
	B	0.005	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
6	S	0.006	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
	B	0.009	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL

Station	Depth	Parameter							
		Cu (mg/L)	Cd (mg/L)	Cr (mg/L)	Pb (mg/L)	Ni (mg/L)	Zn (mg/L)	Hg (mg/L)	As (mg/L)
7	S	0.007	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
	B	0.006	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
8	S	0.008	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
	B	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
9	S	0.009	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
	B	0.006	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
10	S	0.008	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
	B	0.005	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
TWPCR	-	0.010	0.010	0.100	0.100	0.100	0.100	0.004	0.020
MDL	-	0.005	0.002	0.020	0.020	0.020	0.050	0.002	0.030

Table 5/3.14 - Measured Radioactivity in Seawater of the Study Region (Bq/L)

Station	Parameter							
	Depth	Total Alfa Radioactivity, Bq/L	Total Beta Radioactivity, Bq/L	Tritium, Bq/L	Beta Radioactivity, Bq/L	Gamma Radioactivity, Bq/L		
					^{90}Sr	^{137}Cs	^{134}Cs	^{238}U
1	S	<MDL	14.849	<MDL	0.032 ± 0.003	<MDL	<MDL	<MDL
	B	2.798	16.544	<MDL	0.052 ± 0.005	<MDL	<MDL	<MDL
2	S	2.349	12.926	<MDL	<MDL	<MDL	<MDL	<MDL
	B	<MDL	13.275	<MDL	2.358 ± 0.144	<MDL	<MDL	<MDL
3	S	<MDL	13.929	<MDL	<MDL	<MDL	<MDL	<MDL
	B	11.026	18.813	<MDL	<MDL	<MDL	<MDL	<MDL
4	S	13.864	19.248	<MDL	<MDL	<MDL	<MDL	<MDL
	B	<MDL	11.339	<MDL	<MDL	<MDL	<MDL	<MDL
5	S	5.081	17.800	<MDL	<MDL	<MDL	<MDL	<MDL
	B	<MDL	11.997	<MDL	<MDL	<MDL	<MDL	<MDL
6	S	<MDL	15.497	<MDL	<MDL	<MDL	<MDL	<MDL
	B	<MDL	15.389	<MDL	<MDL	<MDL	<MDL	<MDL
7	S	16.551	26.129	<MDL	<MDL	<MDL	<MDL	<MDL
	B	<MDL	15.334	<MDL	<MDL	<MDL	<MDL	<MDL
8	S	<MDL	14.296	<MDL	<MDL	<MDL	<MDL	<MDL
	B	<MDL	13.499	<MDL	<MDL	<MDL	<MDL	<MDL
9	S	<MDL	13.306	<MDL	<MDL	<MDL	<MDL	<MDL
	B	<MDL	12.819	<MDL	<MDL	<MDL	<MDL	<MDL
10	S	<MDL	12.622	<MDL	<MDL	<MDL	<MDL	<MDL
	B	5.214	14.246	<MDL	<MDL	<MDL	<MDL	<MDL

Table 5/3.15 - Measured Radioactivity in Marine Sediments of the Study Region

Station	Sediment					
	Beta Radioactivity, Bq/kg	Radioactivity Measured by Gamma Spectrometric Method, Bq/kg				
	^{90}Sr	^{226}Ra	^{232}Th	^{40}K	^{137}Cs	^{134}Cs
1	0.450±0.044	<MDL	<MDL	<MDL	<MDL	<MDL
2	0.410±0.040	16.7±3.9	14.5±1.8	100±12	<MDL	<MDL
3	<MDL	17.6±3.1	17.9±1.8	178±14	<MDL	<MDL
4	<MDL	42.9±14.6	18.6±1.8	217±15	2.9±1.0	<MDL
5	<MDL	33.4±17.2	23.7±2.0	177±14	<MDL	<MDL
6	0.507±0.052	38.2±20.6	19.3±2.2	194±17	4.2±1.2	<MDL
7	0.541±0.057	35.7±22.5	18.5±4.0	206±11	7.2±1.5	<MDL
8	<MDL	42.0±2.4	<MDL	222±19	5.4±1.4	<MDL
9	<MDL	14.8±4.5	9.5±3.2	168±76	3.4±2.5	<MDL
10	<MDL	26.8±7.0	<MDL	313±107	<MDL	<MDL

The color and turbidity of the seawater in the studied region comply with the criteria given in TWPCR for sea water.

In the study region, TSS varied spatially between 2 and 5.4 mg/L at the surface with an average concentration (with standard deviation) of (3.5±1.2) mg/l. The highest values belonged to Station 1 and Station 5, the two near-shore stations. Above the seabed, the TSS concentrations ranged between 2.2 and 4.2 mg/L with an average concentration of (3.1±0.7) mg/l.

TSS concentrations are compliant with the quality criteria given in TWPCR (30 mg/l).

In the study area, the dissolved oxygen concentrations ranged between 6.32 and 7.92 mg/l in surface waters, with average concentration (with standard deviation) of (6.88 ± 0.68) mg/l. Above the seabed, the DO concentrations ranged between 6.43 and 7.85 mg/l, with an average of (7.21 ± 0.48) mg/l. DO concentrations were close to or above saturation values, being in the range of 90.5 - 116.5 % for surface and 99.3 - 110.2 % for bottom waters and all are compliant with the TWPCR criteria. The DO concentrations presented little spatial variation and were comparable with the previous studies (Table 5/3.16).

For this study, BOD_5 levels ranged between 3.2 and 3.8 mg/l in the surface waters, with an average value (with standard deviation) of (3.3 ± 0.2) mg/l (5.3 mg/l BOD_5 measured for Station 6 was excluded). Above the seabed, the values were in the range of 3.3 and 4.5 mg/l, leading to an average of (3.7 ± 0.4) mg/l. Chlorophyll-a concentrations were measured as an indicator of phytoplankton productivity. Chlorophyll-a can be an effective measure of trophic status of a marine environment.

Table 5/3.16 – Dissolved Oxygen (DO) Concentration Ranges in the Mediterranean Sea

DO, mg/L	Region	Season	Reference
6.32 - 7.92	AKKUYU, surface	May, 2011	THIS STUDY
6.43 - 7.85	AKKUYU, bottom	May, 2011	THIS STUDY
6.01 - 7.65	Gulluk	2007	MEDPOL 2007
5.02 - 7.3	Gulluk	2008	MEDPOL 2008
6.15 - 7.98	Gulluk	2009	MEDPOL 2009
7.31 - 8.64	Saros	June-2009	MEDPOL 2009
6.8 - 7.8	Mersin	January, 2009	MEDPOL 2009
7.38 - 9.04	Mersin	February, 2009	MEDPOL 2009
7.48 - 8.98	Mersin	April, 2009	MEDPOL 2009
6.08 - 7.31	Mersin	October, 2009	MEDPOL 2009

For surface waters of Station 7, chlorophyll-a (chl-a) concentrations were below the method detection limit (0.2 μg/l). For the other stations, chl-a concentrations ranged between 0.22 and 0.82 (average of 0.46 ± 0.19 μg/l) for the surface waters and between 0.31 and 0.88 μg/l (average of 0.55 ± 0.18 μg/l) for the bottom waters. The concentrations were comparable with the eastern Mediterranean values. In the surface waters, near-shore stations had lower chlorophyll-a content than the deeper stations.

The major sources of petroleum hydrocarbons are oil spills, municipal and industrial wastewater discharges, deposition of airborne particles, runoff from streets, commercial and recreational boating activities. Petroleum hydrocarbons are not evenly distributed among sediments, biota, and waters coastal ocean. These compounds accumulate near point sources and their concentrations drop logarithmically with increasing distance from the sources. Seawater unaffected by industrialization or other anthropogenic activity usually contains <0.1 μg/l total polyaromatic hydrocarbons (PAHs) [5/25].

In this study the total petroleum hydrocarbons were below the analytical detection limit (<0.003 mg/l) for all sampling points. Earlier measurements performed along the Turkish coast of the Mediterranean Sea water column give a wide range of concentrations of petroleum hydrocarbons (0.02 - 40 μg/l). More recent measurements conducted in the study site reported comparable values, though concentrations as high as 25.38 μg/l has been reported for polluted regions (İskenderun Bay) in the Turkish coast of the eastern Mediterranean [5/26].

As the TPH concentrations in the study region were below the method detection limit of 0.003 mg/l, which is also the limit set by TWPCR, it can be concluded that the water column of the study region was compliant with the TWPCR criteria (<0.003 mg/l) in terms of total petroleum hydrocarbons.

The toxicity tests conducted according to TWPCR guideline have shown that no dilution was required and the sea water in the study site does not have any toxic effect, therefore, it is compliant with TWPCR criteria.

Phenol concentrations in surface water were lower than bottom water, probably as a result of volatilization. In the surface water, Stations 4, 5, and 8 had phenol concentrations below the minimum detection limit of the method (0.0001 mg/l). The surface phenol concentrations for the other stations were in the range of (0.001 - 0.005) mg/l, with an average (with standard deviation) of 0.002 ± 0.001 mg/l. Above the seabed, samples from stations 1, 4, 6, and 10 had phenol concentrations below the analytical detection limit. The phenol concentrations of bottom water ranged from 0.002 to 0.009 mg/l, with an average concentration of 0.004 ± 0.002 mg/l. Though the concentrations were low in general, they exceeded the limit set by TWPCR, which is 0.001 mg/L.

The source of phenols detected in seawater may be derived from a paper industry operating nearby the study area as the effluent water of such industries contain phenolic compounds and has high flow [5/27]. Road construction and asphalting activity close to the coastline, carried out during the study may be another source of phenol in seawater. Other anthropogenic sources of phenolic compounds may include atmospheric inputs and road runoff and pesticides, though phenolic compounds may also be derived autocotonously.

Ammonium concentrations in the study region were mostly below the detection limit of the method (0.01 mg/l) and are compliant with TWPCR criterion (0.02 mg/l). The concentrations were higher and above the limit set by TWPCR at the surface waters of Station 3 (0.02 mg/l; 2.85 µM)) and Station 9 (0.04 mg/l; 1.42 µM), and bottom waters of Station 8 (0.05 mg/l; 3.57 µM). These concentrations are also above the natural background concentrations reported for the eastern Mediterranean, excluding eutrophic Mersin Bay.

In this study, the metal concentrations were below the analytical method detection limits except for copper. Copper concentrations were below required limit, and are compliant with TWPCR criterion (0.01 mg/l) for all stations and depths.

The highest copper concentration was observed at Station 9, although the concentrations showed little spatial variation. Above the seabed, Cu concentration was below the method detection limit (<0.005 mg/l) for Station 8. Excluding Station 8, bottom water Cu concentrations ranged between 0.005 and 0.009 mg/l, again presenting small spatial variation. The average Cu concentrations with standard deviations were 0.007 ± 0.001 mg/l and 0.006 ± 0.001 mg/l for surface and bottom waters, respectively.

The considerable amount of heavy metal input to the marine environment ultimately accumulates in the bottom sediments.

Arsenic, Cadmium, Chromium, Lead, Zinc and Mercury concentrations were below detection limits of analyses methods for all stations and depths. Ni concentration (0.03 mg/l) was above, but close to the minimum detection limit (0.02 mg/l) only for bottom water of Station 4. Therefore, all concentrations for these parameters were below the criteria set by TWPCR.

5.3.5.5 Characteristics of the Temperature Mode Depending on the Water Mass Stratification

In order to understand the relation between temperature regime and water mass stratification CTD (Conductivity, Temperature and Density) surveys, performed at 30 CTD stations in between 21.06.2011 and 29.10.2011, were analyzed and discussed in this chapter for each sampling period.

The locations of the 30 CTD sampling stations are shown in Figure 5/3.6.

During this period it is observed that water temperatures are more than 25 ºC down to 10m WD (Water Depth) and temperature values decreases as the depth increases. Starting from approximately 70m WD temperature values are observed to be less than 19 ºC.

For the measurements performed on 04.07.2011, the hottest section of the temperature layer varies between 0-20m WD with more than 25 ºC, whereas temperature values increase along the water column and the coldest layer was observed approximately at 80m depth with temperature values less than 19 ºC. Temperature values decrease relatively slowly down to 50-55 m WD and then the temperature decrement increases between 60 - 65m of WD. During this period, two layers of well mixed layers were observed in between surface to approximately 45-55m of WD and from approximately 60m to the sea bottom a bottom stratified layer is observed as it can be seen on sample stations CTD7, CTD14, CTD18 and CTD30.

For the measurements dated 04.08.2011 the hottest temperature layer with temperature of more than 28 ºC was observed approximately up to 15m of WD. Minimum bottom water temperatures less than 19 ºC were observed at the eastern profile at WD less than 95m WD approximately; whereas the most rapid temperature change is observed between 35-50m approximate WD from 26 ºC to 23 ºC. Uniform layer is observed between surface (29.5-30 ºC) to approximately 30m (28 ºC) of WD and from this depth to the bottom continuous temperature decrement layers are observed.

According to the measurements performed on 08.09.2011, the hottest temperature layer with temperatures greater than 29 ºC is about 10-20m WD up to a certain distance from the shore and then this layer increase to 30m of WD. During this period it is also observed that the layer with temperatures of more than 28 ºC reaches 40-50m of WD, whereas the biggest temperature drop is observed between 55-65m.

According to the measurements performed on 06.10.2011, the hottest surface temperature layer decreases to 27 ºC with the water depths up to 40-50m except for the northwest section of the Akkuyu Bay, whereas the thickness of the top layer is between 0-20m WD top layer. Biggest temperature drop is observed between 55-65m WD approximately. Based on the depth, minimum water temperature is measured at southwest section of the survey area. Stratification of the surface from 50-55m WD is observed, whereas cooling trend (approximately 27.0ºC) for this stratified layer continues.

According to the measurements performed on 29.10.2011, the hottest surface temperature layer is above 23 ºC with the water depths up to 65-70m then decreases rapidly to 20-20.5 ºC in next 5-10m water depth. Minimum water temperatures above 18 ºC were absorbed at depths greater than approximately 75m at the southern offshore section of the survey area. Stratification on surface is narrowed to 65-70m WD. With respect to previous measurement trend cooling of water continues (above 23.0ºC). In fact during the measurements between 14.10.2011-29.10.2011 maximum cooling is observed.

5.4 FLOOD

5.4.1 POSSIBLE FACTORS OF FLOODING

The design basis flood elevation for the Akkuyu NPP site is determined by considering a number of different flooding scenario combinations. The flooding scenarios investigated include:

– effects of local Probable Maximum Precipitation (PMP);

– PMF on streams and rivers;

– potential dam failures;

– probable maximum surge and seiche flooding;

– probable maximum tsunami;

– channel diversion flooding.

Each of these flooding scenarios is investigated in conjunction with other flooding and meteorological events, such as wind generated waves.

Akkuyu NPP site is conceptually graded from 9.5 m MSL at the north end to 7.5 m MSL at the south end, giving a slope of approximately 0.3 percent. Akkuyu NPP is flat in the east-west direction so that all runoff passes through the Akkuyu NPP site and around the buildings. Therefore, the Akkuyu NPP project was analyzed as an open channel with obstructions. The 24-hour PMP was calculated using 44 years of daily rainfall data from the Silifke Meteorological Station available from NOAA (2011) [5/21] Data from the Silifke Station, along with a meteorological station historically operated by the Turkish Electricity Authority (TEA) (historically called ANES), Ovacik and Anamur, was used in the previous Zeytincatagi watershed PMF analysis by Elektrik isleri Etut (EIE, 1978) [5/21]. The Silifke Station was determined to be the most relevant with respect to the Akkuyu NPP site because it is located on the same precipitation isoline for the mean annual rainfall as the Akkuyu NPP site. Using the Hershfield Method (WMO, 2009) [5/21], the calculated 24-hour PMP is 688.5 mm.

The depth-duration curve was developed based on regional depth-duration curves for the local region of Turkey. Three sources of depth-duration curves were examined: EIE (1978); Kizilkaya (1988); and WMO (2009) [5/21]. The depth-duration curve at the Silifke site from EIE (1978) [5/21] was more conservative than either the Kizilkaya (1988) [5/21] curve or the WMO (2009) curve. The design precipitation depth-duration curve was generated by using ratio analysis of the incremental rainfall depths to the total 24-hour depth to obtain the 5-minute, 15-minute, 1-hour, 2-hour, 3-hour, 6-hour, 12-hour, and 24-hour PMP depths. The resulting depth-duration curve is presented on Figure 5/4.1 below.

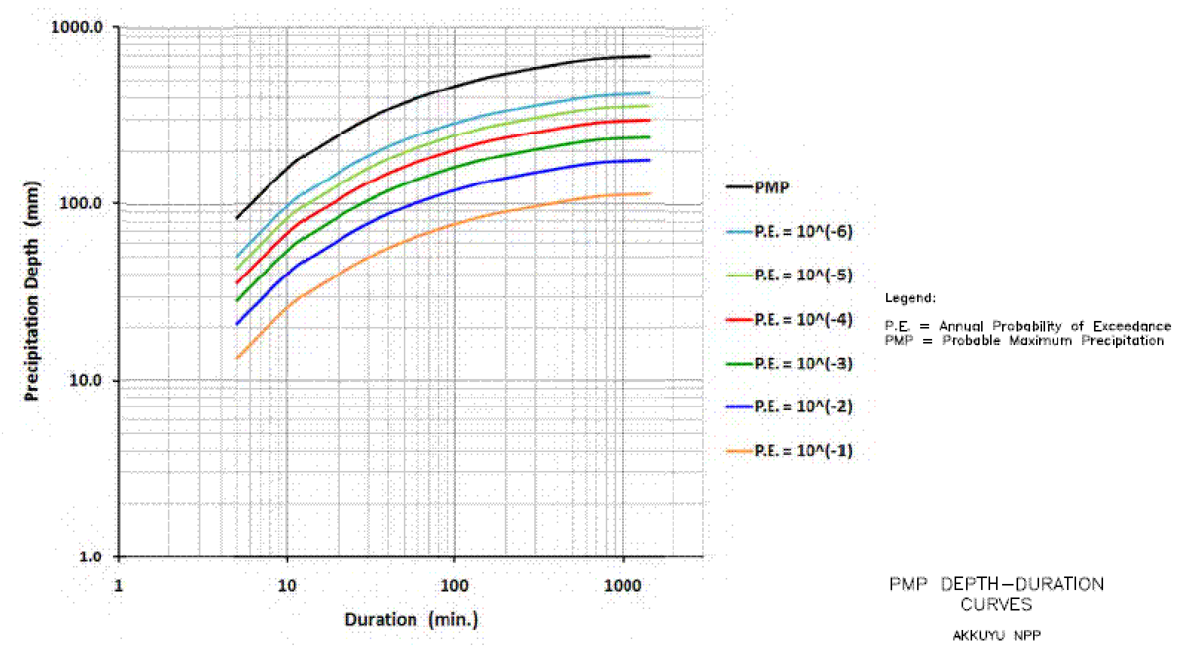


Figure 5/4.1 – Resulting Depth-Duration Curve

The depth-duration curve was later transformed to a rainfall hyetograph using the Alternating Block Method (USACE, 2000) [5/21] and the resultant precipitation hyetograph was generated. The hyetograph was used to compute the rainfall runoff flow values for local PMP analysis for the Akkuyu NPP site, which includes both rainfall directly on the Akkuyu NPP site and runoff from the hills surrounding the Akkuyu NPP site. HEC-HMS 3.5 and USACE, 2010a [5/21] was used to evaluate the all-season PMP to develop the runoff hydrographs and peak flows.

Water profile through the Akkuyu NPP site was calculated, shown on Figure 5/4.2. Based on his profile, all safety-related facility entrances should be located at least 0.5 m above the plant grade elevation in order to protect the safety-related facilities from the effects of local intense precipitation at the Akkuyu NPP site. In the report it is proposed that the drainage ditches should be designed such that they can handle storms of smaller magnitude and can prevent Akkuyu NPP from flooding.

Design value of the daily maximum precipitation of recurrence once in 10000 years is equal to 314.22 mm (Anamur MS) and 266.8 mm (Silifke MS) [5/10]. The maximum probable precipitation (MPP) is more than two times higher than the design daily maximum precipitation. It is obvious that the value of 688.5 mm MPP is conservative and as such value it is possible to use in determination of design parameters for the Akkuyu NPP design basis.

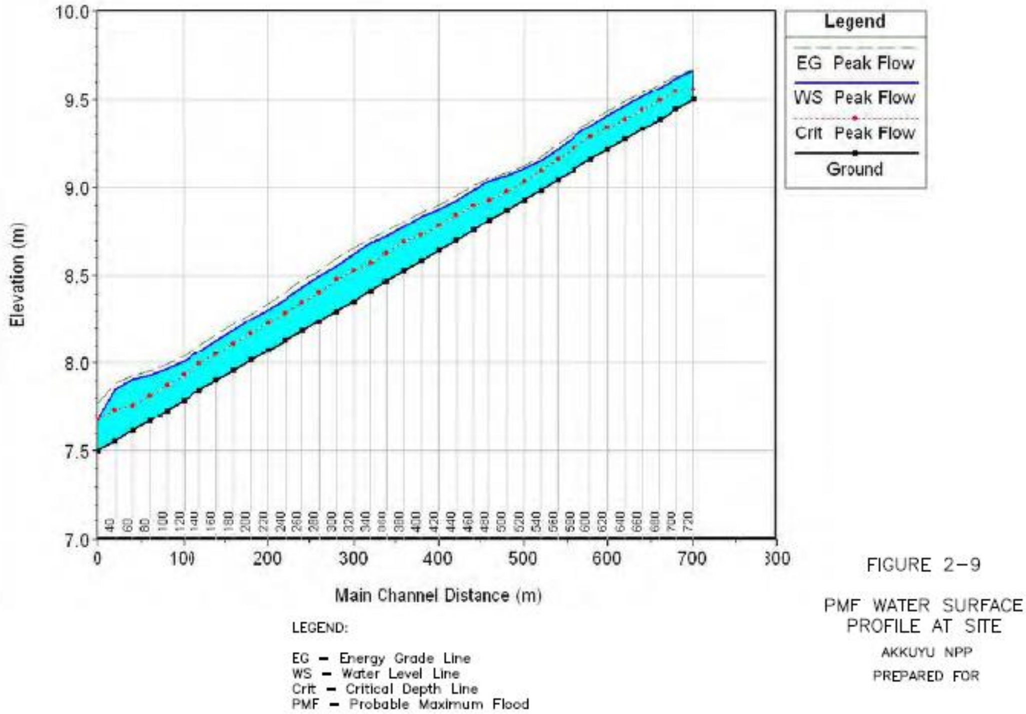


Figure 5/4.2 – PMF Water Surface Profile for the Akkuyu NPP Site

5.4.2 PROBABLE MAXIMUM FLOOD (PMF) ON STREAMS AND RIVERS

Site-specific information to describe the PMF effects of precipitation runoff from areas upgradient of the Akkuyu NPP site and near-site regions is to be discussed.

Because the Akkuyu NPP site is located on the Mediterranean Sea coastline, PMF water levels are potentially influenced by tide levels, storm surges, and wind-generated waves. Storm surges and precipitation runoff events are interdependent and, thus, could occur at the same time (ANSI/ANS, 1992 [5/21]). Therefore, for the determination of the PMF water level, the influences of the tide, storm surge, and coincident wind-generated waves were considered at the downstream boundary of the hydraulic stream model. Water level changes associated with tsunamis and runoff events are considered to be independent events, and it is considered to be probabilistically unlikely that tsunami and PMF would occur at the same time (IAEA, 2003 [5/38]). The PMF analysis is based on a deterministic modeling approach. There is no associated probability of exceedance associated with the PMF. International Atomic Energy Agency guidance recommends comparative PMF estimations for both deterministic (i.e. hydrologic modeling) and probabilistic methods. However, there are no recorded flow data for the local streams, Zeytinçatağі Creek and Çamalani-Sarp Creek; therefore, only the deterministic approach was performed.

Hydrologic surveys of these temporary streams by gauging are intended at the predesign activities stage. Performance of these activities will start at the subsequent stages: site parameters report or design stage.

The local streams, Zeytinçataği Creek and Çamalani-Sarp Creek, convey precipitation runoff from the local drainage basins to the Mediterranean Sea. The overall drainage basin (or watershed) is delineated from topographic contours and the effects of precipitation runoff are determined using a hydrologic runoff model. A 1D hydraulic stream flow model was created to calculate water levels in Zeytinçataği Creek, Çamalani-Sarp Creek, and Akkuyu Bay to determine if Akkuyu NPP could be affected by runoff flooding.

The contributing peak flow from Sub basin SB4 of 332.4 m^3/s is entered as the flow in the upper reach of Zeytinçataği Creek, and when combined with the runoff from Sub basin SB5, the peak discharge is 405.8 m^3/s through the lower reach of Zeytinçataği Creek. These two flows were input in the hydraulic model: 332.4 m^3/s enters at the upstream cross section and the flow remains constant through the upper reach of the model, and then at cross section 918.2 a flow change to 405.8 m^3/s is input, and this flow is constant through the remainder of the cross sections of the lower stream reach. A flow value of 367.8 m^3/s enters at the upstream cross section of Çamalani-Sarp Creek and the flow remains constant through the creek. The two creek flows combine as 773.6 m^3/s at the head of Akkuyu Bay. Flow accumulates from other contributing drainage areas to the bay; thus, flows of 1060 m^3/s and 1123.5 m^3/s are entered at intermediate sections along the bay flow line.

The water surface profile is below the assumed Akkuyu NPP site grade at all cross sections. The resultant water surface elevations along the flood flow profile are below the corresponding Akkuyu NPP site grade elevation for each of the cross sections. The maximum water surface elevation at the downstream boundary is 6.01 m MSL and the corresponding Akkuyu NPP site elevation is approximately 7.50 m MSL. The maximum water surface elevation at the upstream boundary is 7.52 m MSL and the corresponding Akkuyu NPP site elevation is approximately 9.50 m MSL.

The PMF runoff from the Zeytinçataği Creek and Çamalani-Sarp Creek, as well as direct runoff to Akkuyu Bay do not create an appreciable rise in water level in Akkuyu Bay, thus the peak water level in Akkuyu Bay does not rise above PMSS still water level of 2.3 m MSL. This is because the relatively broad and deep cross sections of the bay and the open boundary to Mediterranean Sea are capable of conveying the surface water runoff without appreciable rise in water level. The runoff from the creeks quickly spreads out across the broad section of Akkuyu Bay. Also, water levels in Çamalani-Sarp Creek do not affect Akkuyu NPP.

5.4.3 POTENTIAL DAM FAILURE

Analyses of potential hazards to safety-related facilities due to seismically induced failure of upstream and downstream water control structures have been done [5/21].

As mentioned, the Akkuyu NPP site is located within two small, coastal watersheds (or drainage basins) of the Zeytinçatağі Creek and Çamalanı-Sarp Creek. These watersheds are surrounded by a mountain range, essentially isolating it from the basins where dams are located. Any dams in the region are separated from the Akkuyu NPP site by the mountain range divide.

Factors such as distance from the adjacent dams, watershed boundaries, and a mountain range encompassing the Akkuyu NPP site give the facility vital protection from the potential effects of dam failures, due to seismic events. Therefore, there are no dams that could fail and flood the Akkuyu NPP site. Gezende Dam, the closest dam to the Akkuyu NPP site, is approximately 53.3 km away. Additional dams in distance from the Akkuyu NPP site are approximately 110.5 km to 161.7 km away. All of these dams are located beyond the drainage divide of the Akkuyu NPP watershed area. Other dams were not considered in the analysis because they were either a great distance from the Akkuyu NPP site or divided by a diversion feature (e.g. mountain range).

5.4.4 PROBABLE MAXIMUM STORM SURGE (PMSS) AND SEICHE FLOODING

Two types of storms were evaluated to estimate the PMSS at Akkuyu NPP. These storms are not based on the “frequent phenomena” concept but on the “rare phenomena” concept as described by IAEA [5/22]:

- regional Cyclonic Wind Storm that moves toward the East Mediterranean Sea. Cyclonic activities are rare in Turkey; however, cyclones do occur (Karaka et al., 2000 [5/21]). Hurricane-like storms are also possible;
- local Uniform and Steady Wind Storm using maximum wind speeds of 30 m/s and 70 (up to 73) m/s based on the estimate of the probabilistic maximum wind storm.

Based on the list of historic wind storms that affected the southern coastline of Turkey the maximum wind gust observed at the Silifke Meteorological Station between 1968 and 2000 was 52.4 m/s [5/15].

Forty storm tracks were analyzed and the highest surge level in Akkuyu Bay was considered the critical track. For the critical storm track, the maximum 10-minute wind speed of the storm along the storm track is approximately 57.40 m/s. Near the Akkuyu NPP site (at the location of landfall), the maximum 10-minute overwater wind speed of the storm is 56.50 m/s. These estimates are within the range of the probabilistic estimate of the maximum wind storm (a maximum of 65.96 m/s) as discussed below.

The storm surge is essentially a stochastic element, its contribution to the PMSS level is derived by three different approaches:

A probabilistic approach extrapolating the water level exceedance frequency for once in 10,000 and 1,000,000 years from the available historic records of about 25 years;

Simplified deterministic-empirical approach using the storm's pressure depth, radius of maximum wind and direction to derive a surge level in the deep water and ultimately at the coastline after accounting for shoaling and storm direction effects;

A deterministic-numerical approach that involves computing the maximum water level due to the critical storm track at the mouth of Akkuyu Bay using the Delft3D software (Deltares, 2008 [5/21]) and evaluating the near-shore responses to the critical track using both empirical equations and numerical modeling.

5.4.5 ICE EFFECT ON INTAKE SYSTEM

The proposed conceptual intake system for Akkuyu NPP consists of four intake structures which are drawing water from Akkuyu Bay to the power plants, located on the Mediterranean Sea. Taking into account the location of the Akkuyu NPP site and facilities plan including the location of the intake structures, the water temperature in the Mediterranean Sea is not expected to fall to the freezing point and therefore the potential for frazil ice and ice jams affecting Akkuyu NPP are negligible.

5.4.6 COOLING WATER CHANNEL AND RESERVOIRS

Proposed intake system for the Akkuyu NPP consists of four intake structures which are drawing water from the Akkuyu Bay to the power plants, located on the Mediterranean Sea. The Akkuyu NPP cooling water design consists of four surface intake structures placed in the Akkuyu Bay to draw the design intake flow of 240 m^3/s for four units (60 m^3/s for one unit). The proposed water discharge system utilizes outlet tunnels in the Akkuyu Bay.

As discussed previously, ice effects (i.e. ice thickness, frazil ice) will not block the cooling water intake or interrupt the water supply to Akkuyu NPP. The maximum water level in the intake structure is controlled by the PMSS and PMT. The minimum water level in the intake structure resulting from the PMSS was evaluated approximately minus 2.30 m MSL.

5.4.7 CHANNEL DIVERSIONS

Topographic characteristics, geological features, and the seismic activity of the drainage basin indicate there is no possibility for the occurrence of a landslide blocking or limiting flow to Akkuyu NPP.

Akkuyu NPP should be set above the DBFL in order channel diversions, if they occur, not to pose any flooding hazards to the power block structures, systems, and components at Akkuyu NPP. In addition, the safety-related water supply of Akkuyu NPP does not rely on the continuous availability of water from any local streams and rivers. Therefore, any potential diversions or localized rerouting of local streams and rivers near the Akkuyu NPP would not affect the safety functions of Akkuyu NPP.

There are no reliable long-term sea level measurements in the eastern and southern Mediterranean, which makes it difficult to identify reliable trends in sea level. Given the seismic, topographical, and geologic setting, it is highly unlikely that any shoreline changes of the Mediterranean Sea (due to shoreline migration, shoreline cutoffs, ice jams, or subsidence) will adversely affect safety-related facilities or water supplies at Akkuyu NPP. In addition there are no historical records of channel diversions in the Akkuyu NPP site watershed.

The PMSS level was derived using probabilistic approach, simplified deterministic-empirical approach, and a deterministic-numerical approach. Surge level at the Turkish coastline was calculated 2.30 m after accounting for shoaling. The 10,000-year offshore significant wave height is 8.02 m based on the historic wind data at Silifke. The 10,000-year significant wave height at the Turkish coastline is 7.52 m after accounting for shoaling. The wave run-up at the Turkish coastline including wave setup is 4.54 m. The potential maximum water level due to the PMSS, including wave effects, is calculated to be 6.84 m MSL based on a wave run-up of 4.54 m at Akkuyu NPP.

5.4.8 CHANNEL DIVERSIONS CAUSED BY ICE

There is no historical evidence of an ice jam event in the Mediterranean Sea in the vicinity of the Akkuyu NPP site, as discussed previously. Consequently, ice jams that could cause an interruption in the supply of cooling water to Akkuyu NPP are considered unlikely.

5.4.9 SITE FLOODING DUE TO CHANNEL DIVERSION AND SHORELINE MIGRATION

Diversion or rerouting of the cooling water supply from the Mediterranean Sea (due to shoreline migration, shoreline cutoffs, ice jams, or subsidence) is not considered to be credible.

Therefore, diversion or rerouting would not adversely affect safety-related facilities or water supplies.

Furthermore, based on the preliminary power block grading, all safety-related facility entrances are located above DBFL and flooding due to channel diversion is prevented from reaching safety-related entrances.

5.4.10 ALTERNATE WATER SOURCES

An alternate water supply is not required for the Akkuyu NPP design. By using air as an ultimate heat sink, the passive heat removal system can perform its function for an unlimited period of time under a design basis accident [5/15]. Operation of the passive heat removal system alone will be sufficient to cool the reactor in the event of an active system failure [5/15].

5.4.11 WAVE REGIME IN THE AKKUYU BAY

Here, the probable conditions for the occurrence of floods are further characterized based on the report from 2011.11 [5/11].

In this part, the long term and extreme wind statistics for ECMWF (European Centre for Medium range Weather Forecasts) (35.90^{0}N-33.50^{0}E) wind data between years 1983-2010 are presented together with wind rose and wind velocity frequency histogram.

The annual wind rose and wind velocity class frequency histogram considering all directions are presented in Figure 5/4.3 and 5/4.4. In the histogram, hourly average wind velocities (Uave) are classified in 1.5 m/sec intervals and presented in the graphs with their respective frequencies (%).

The long term wind statistics analysis has been carried out by classifying the ECMWF wind data (1983-2010) in 1.5 m/s ranges and plotting the cumulative number of occurrences of each wind class for each direction on to a semi-log graphical paper. The cumulative exceedance probability of wind speeds, Uave,10, is given as:

$Q(> U_{ave,10}) = \exp[(U_{ave,10}-B)/A]$,

where:

- Q(>Uave,10) is the cumulative exceedance probability of a hourly average wind speed at 10 meter above still water level (Uave,10).

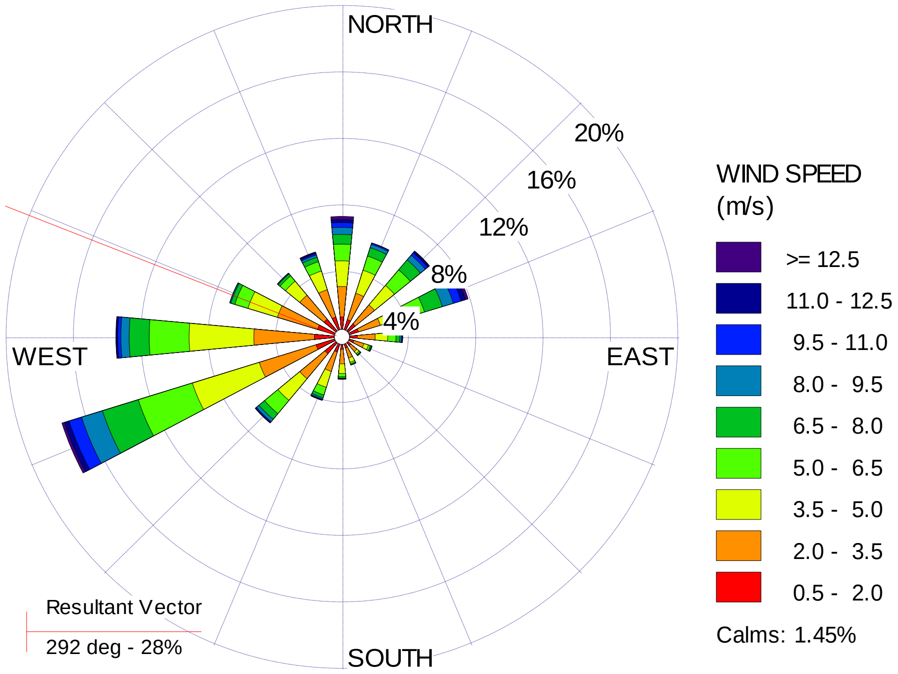


Figure 5/4.3 - Annual Wind Rose, ECMWF (1983-2010)

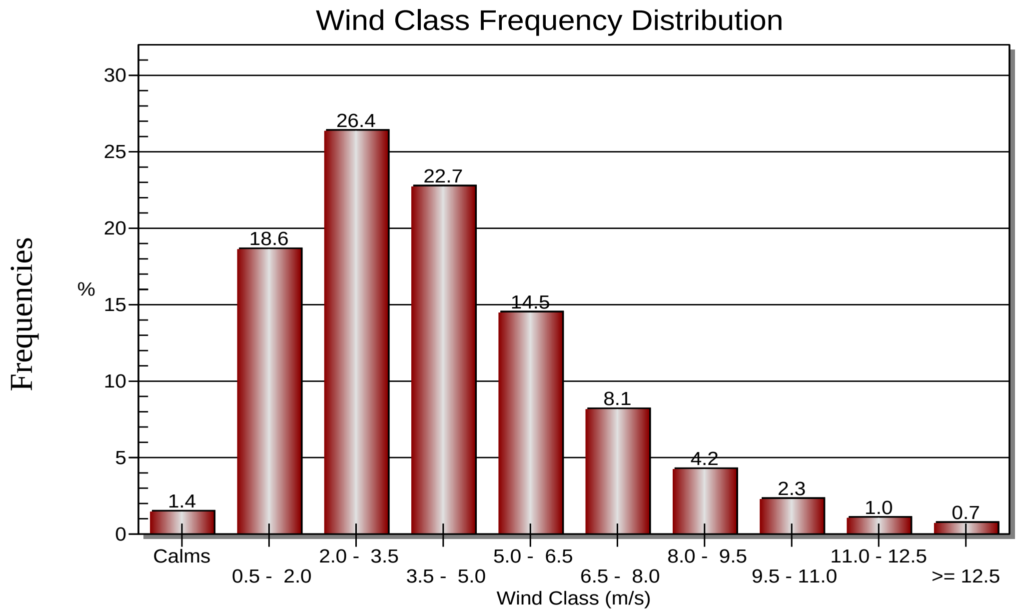


Figure 5/4.4 - Wind Velocity Class Frequency Histogram (All Directions; ECMWF, 1983-2010)

The prevailing wind directions from land are N, ENE and NE, and the average wind speeds with 10 hours/year exceedance probability from these directions are 12.71, 11.97 and 10.28 m/s, respectively. Moreover, the prevailing wind directions from sea are WSW, W and SW and the average wind speeds with 10 hours/year exceedance probability from these directions are 12.64 m/s, 10.29 m/s and 8.85 m/s, respectively.

The prevailing extreme wind directions from land are N, NNW and ENE, and the hourly average wind speeds with 100 years return period from these directions are 26.2 m/s, 24.4 m/s and 21.2 m/s, respectively. Moreover, the prevailing wind directions from sea are WSW, SSW and S and the hourly average wind speeds with 100 years return period from these directions are 22.3 m/s, 21.1 m/s and 20.0 m/s, respectively [5/11].

The effective fetch lengths for the wave hindcasting are determined from the navigation maps of SHODB (Navigation, Hydrography, and Oceanography Department of Turkish Navy). Effective fetch studies are carried out between ENE and W directions. In the computation of fetch lengths, for each direction, the effective area is considered as a sector from minus 22.5^0 to $+22.5^0$ totally covering an area of 45^0 with 7.5^0 intervals. The fetch lengths are taken from offshore of the project site as shown in Figure 5/4.5. The effective fetch lengths for corresponding directions are given in Table 5/4.1.

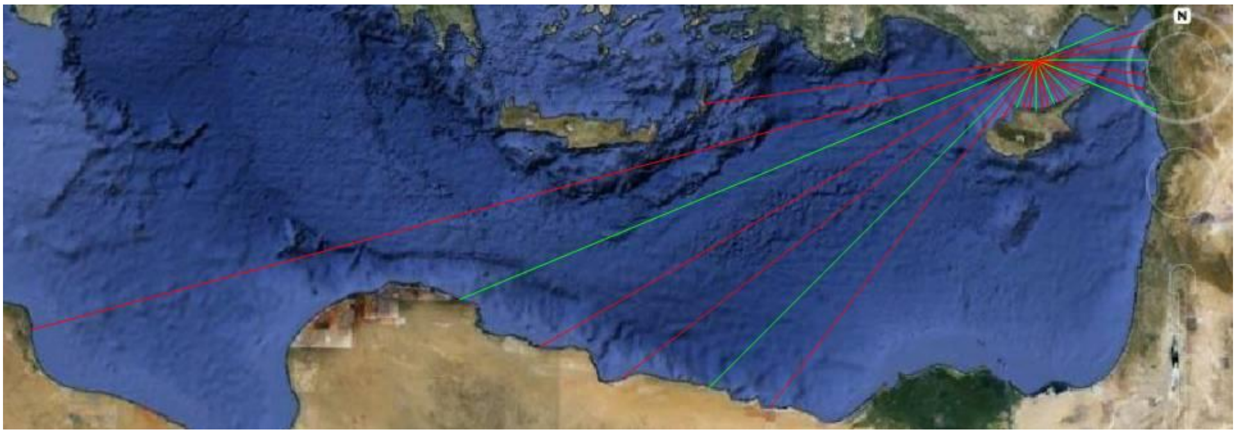


Figure 5/4.5 - Fetch Directions from the Project Site

Table 5/4.1 - Effective Fetch Length (km)

Direction	Effective Fetch Length (km)
W	443.65
WSW	818.95
SW	617.50
SSW	253.76
S	78.70
SSE	77.29
SE	93.67
ESE	137.61
E	170.18
ENE	92.38

The wave steepness value for the project site is obtained from plotting deep water significant wave heights (H_{s0}) versus deep water wave lengths (L_0) computed from corresponding significant wave periods (T_s) of each individual storm. The wave steepness value obtained using individual storm wave characteristics is around 0.0391.

The long term wave statistics analysis has been carried out classifying deep water significant wave heights in 0.40m ranges hindcasted using the numerical model W61 (METU, Ocean Engineering Research Center) using effective fetch lengths and wind speeds taken from ECMWF (1983-2010) and by plotting the cumulative number of occurrences on to a semi-log graphical paper obtained from W61. The cumulative exceedance probability of deep wave height, H_{s0}, is given as

$Q(> U_{ave,10}) = \exp[(H_{s0}-B)/A]$,

where:

- $Q(>H_{s0})$ is the cumulative exceedance probability of deep water wave height (H_{s0}).

This equation indicates that if data points corresponding to H_{s0} and $Q(> H_{s0})$ are plotted on a semi-log graphical paper (H_{s0}on normal, and $Q(> H_{s0})$ on logarithmic scales), they should lie on a straight line with a slope of A and intercept of B when $Q(> H_{s0})$ is the horizontal axis. The long term wave statistics results are plotted in Figure 5/4.6 for all effective fetch directions. In Figure 5/4.6, the vertical axis is the deep water significant wave heights (H_{s0}) and the horizontal axis is the cumulative exceedance probability ($Q(>H_{s0})$) of these significant wave heights. Table 5/4.2 presents deep water significant wave heights that are observed at the region for certain periods (1, 5, 10, 20, 50 and 100 hours per year) and for each effective direction using Figure 5/4.6.

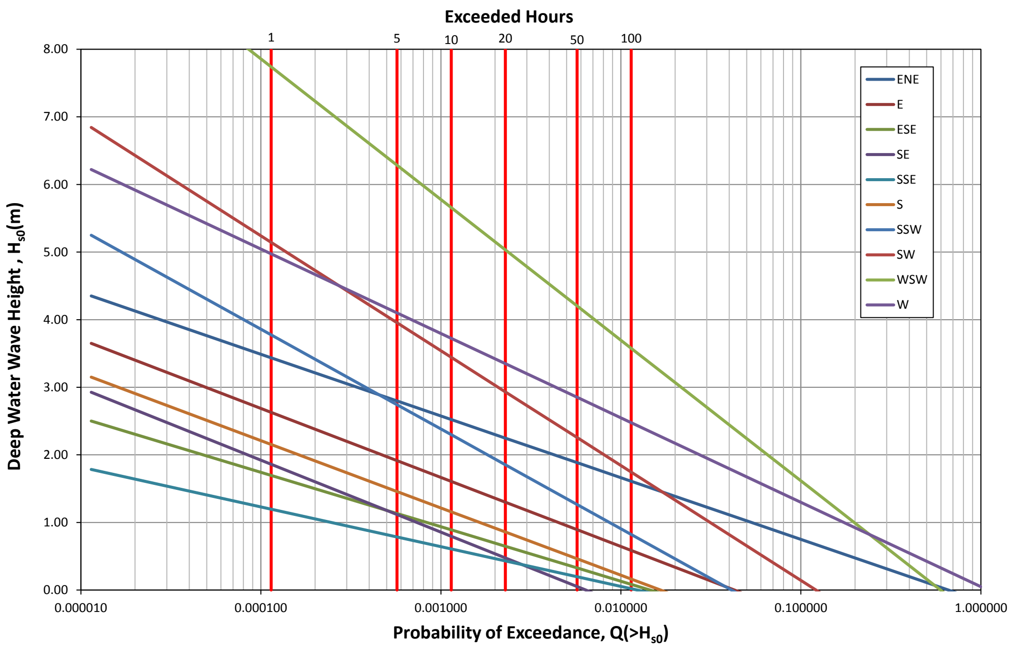


Figure 5/4.6 - Long Term Wave Statistics

Table 5/4.2 - Wave Statistics Results (Deep Water)

Exceedance probability h/yrs	Wave para-meters	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W
1	H_{s0},m	3.44	2.63	1.70	1.86	1.20	2.15	3.77	5.14	7.74	4.97
	T_s, s	7.52	6.57	5.28	5.53	4.44	5.95	7.88	9.20	11.28	9.04
5	H_{s0}, m	2.80	1.92	1.13	1.12	0.79	1.46	2.74	3.96	6.28	4.10
	T_s, s	6.78	5.61	4.32	4.28	3.59	4.90	6.71	8.06	10.16	8.21
10	H_{s0},m	2.52	1.61	0.89	0.80	0.61	1.16	2.30	3.44	5.66	3.72
	T_s, s	6.44	5.14	3.83	3.62	3.16	4.36	6.15	7.52	9.64	7.82
20	H_{s0},m	2.25	1.30	0.65	0.48	0.43	0.86	1.85	2.93	5.03	3.35
	T_s, s	6.08	4.62	3.26	2.80	2.67	3.76	5.52	6.94	9.09	7.42
50	H_{s0},m	1.88	0.89	0.33	0.05	0.20	0.46	1.27	2.26	4.20	2.85
	T_s, s	5.57	3.83	2.32	0.93	1.81	2.76	4.56	6.09	8.31	6.85
100	H_{s0},m	1.61	0.59	0.08	-	0.02	0.16	0.82	1.74	3.58	2.48
	T_s, s	5.14	3.11	1.18	-	0.59	1.64	3.68	5.35	7.67	6.38

As it is seen from Table 5/4.2, the dominant wave directions are WSW, W and SW, and the wave heights of those with a 10 hour annual exceedance probability are 5.66, 3.72 and 3.44 meters, respectively.

Extreme wave height probability distribution is valuable for aiding the decision on the design wave height to be used for a coastal activity or structure which is susceptible for destruction during one storm event. In order to obtain the extreme wave statistics of the region, extreme wave data for the project areas is analyzed using different extreme wave height probability distributions (FT-1, FT-2, Weibull, Log Normal) with different distribution coefficients. Gumbel distribution which gave the best fitting results is used to show the relation between the extreme wave heights and the cumulative non-exceedance probability of these extreme wave heights.

$$P(< H_{s0}) = \exp[-\exp(-(H_{s0}-B)/A)],$$

where:

- H_{s0} is the extreme significant wave height (deep water) within the reference time length;
- P(<Hs0) is the cumulative probability that Hs0 value is not exceeded within the reference duration;
- A and B are the distribution parameters.

The equation above indicates that a plot of H_{s0} as ordinate versus $-\ln[-\ln(1/(P(<H_{s0}))]$ should give a straight line with +A as its slope and +B as the intercept.

Wave heights and corresponding non-exceedance probability of waves are given in Figure 5/4.7. In Figure 5/4.7 the vertical axis, upper horizontal axis and lower horizontal axis represent deep water significant wave heights (Hs0) (in meters), return periods (RP) (in years) and occurrence probabilities for deep water significant wave heights P(< Hs0) (in %), respectively. The results of extreme wave statistics for eight different return periods within 90 % confidence interval limits and for different wave steepness values are given in Table 5/4.3.

The upper horizontal axis of Figure 5/4.7 shows the return period R_P (defined as the average period of occurrence of a certain event) which is related to non-exceedance probability value by the following relationship:

$R_p = 1/(1-P(<H_{s0}))$

Table 5/4.3 - Extreme Wave Statistics Results (Deep Water)

Return Period (years)	Hs, m (90 % Confidence Upper Limit)	Hs, m	Hs, m (90 % Confidence Lower Limit)	Ts, s (90 % Confidence Upper Limit)	Ts, s	Ts, s (90 % Confidence Lower Limit)
5	6.19	5.57	4.95	10.07	9.55	9.00
10	7.20	6.38	5.55	10.87	10.22	9.54
20	8.19	7.15	6.11	11.59	10.83	10.01
50	9.48	8.15	6.82	12.47	11.56	10.58
100	10.45	8.90	7.35	13.09	12.08	10.98
200	11.42	9.65	7.88	13.68	12.58	11.37
500	12.70	10.64	8.58	14.43	13.21	11.86
1000	13.67	11.39	9.10	14.97	13.66	12.21
5000	15.92	13.12	10.31	16.16	14.66	13.00
10000	16.89	13.86	10.83	16.64	15.08	13.33

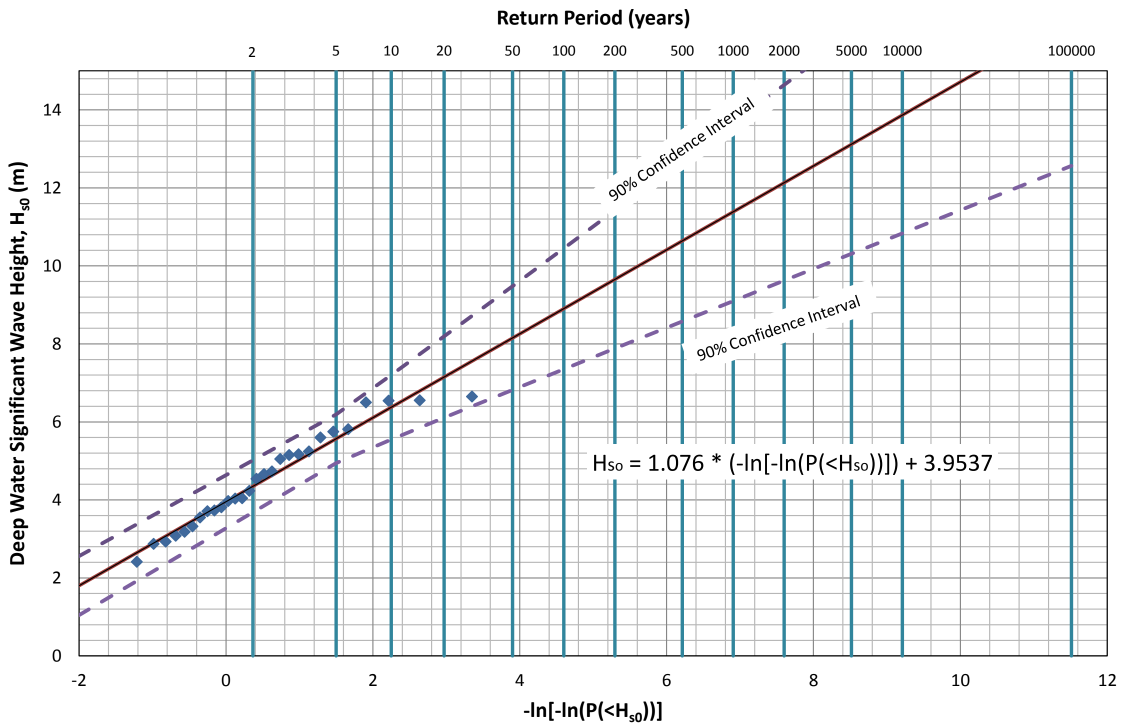


Figure 5/4.7 – Extreme Wave Statistics (Deep Water)

As it is seen from Table 5/4.2, the highest annual deep water significant wave heights are mainly from WSW, W and SW directions. Using the data given in Table 5/4.3, the deep water significant wave heights (H_{s0}) with return periods of 100, 1000 and 10000 years are found to be 8.90 ± 1.55, 11.39 ± 2.29 and 13.86 ± 3.03 meters respectively within 90 % confidence limits.

In wave transformation studies, the sea level rise possible to occur in the coming century due to global warming is 1.0 m. The tidal variation is assumed as 0.30 m and the seasonal variation is assumed as 0.30 m Water level variations due to atmospheric pressure changes and Coriolis effects taken as 1/10 of the total sea level rise resulting from the wind setup, tidal and seasonal variations and sea level rise due to global warming [5/28].

Within the scope of wave transformation, refraction and shoaling analyses were conducted. If the water depth (d) is less than half of the deep water wave length (L_0), this depth is defined as intermediate depth ($d/L_0 < 0.5$). The refraction and shoaling of waves start when they reach this intermediate depth [5/29].

$$H_{s0} = 0.35586[-\ln(-\ln(P(< H_{s0})))] + 1.59621$$

For wave transformation studies, near shore seabed topography (bathymetry) of the project area is obtained from the navigation maps of (SHODB) Navigation, Hydrography, and Oceanography Department of Turkish Naval Forces and the nearshore bathymetric measurements held around project area (Figure 5/4.8).

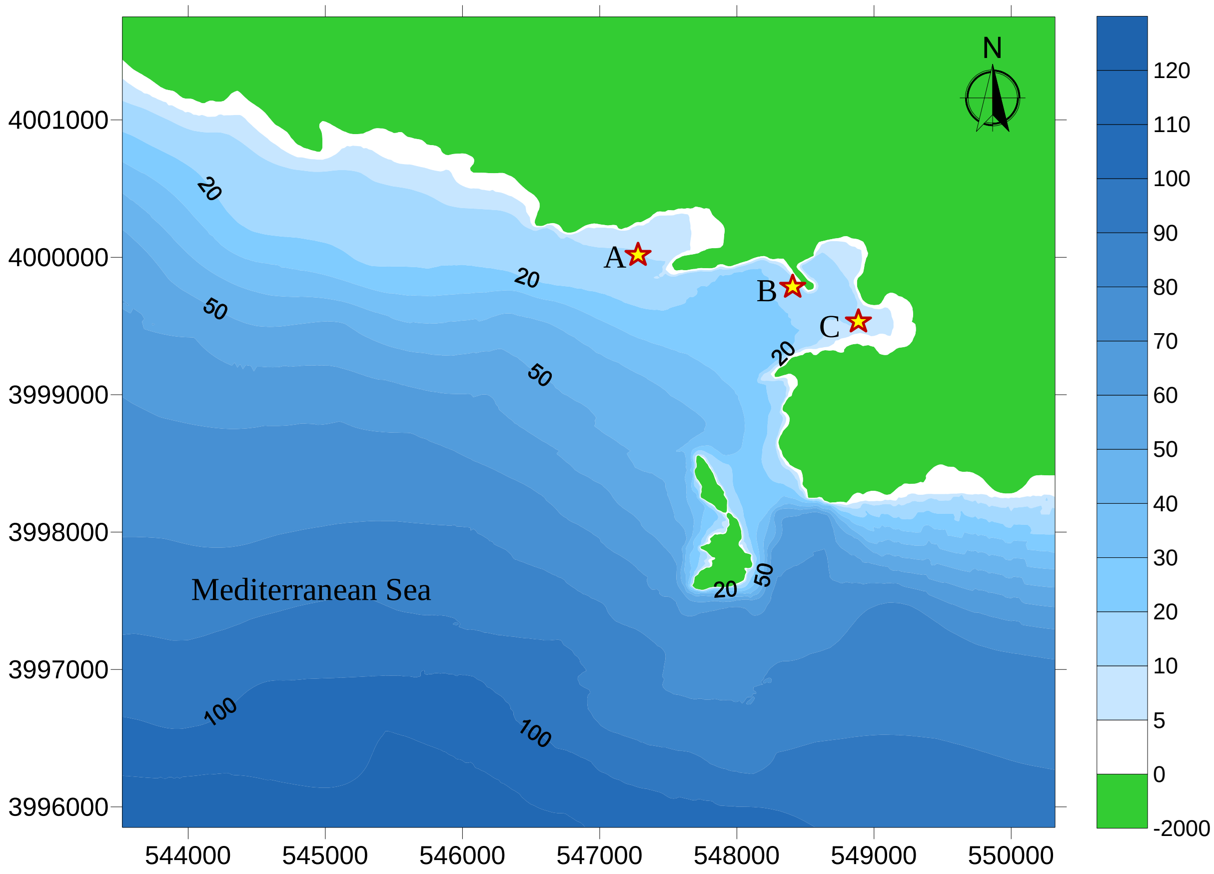


Figure 5/4.8 - Nearshore Bathymetry of the Project Area

Depths are in meters. The coordinate system is given in ED50, UTM-DOM33. Determination of possible extreme water levels at shoreline and run-up heights for the selected locations at the project area (Location A, B and C in Figure 5/4.8) in case of extreme storm events is carried out by scenarios of extreme storm events with different return periods (100, 1000 and 10000 years) and long term storm events with the deep water wave characteristics exceeded 10 hours in a year from dominant wave directions; WSW, W and SW. From the extreme and long term wave analyses, it is seen that the dominant wave directions are WSW, W and SW. In all scenarios, selected extreme wave conditions are assumed to approach from WSW direction, representative for dominant wave directional sector. Also, all storm events are taken as to occur in the respective high water levels (HWL) which are defined as the sum of astronomical tidal and seasonal variation amplitudes, accelerated sea level rise, respective wind set-up and the sea level rise due to atmospheric pressure changes and possible Coriolis effects.

In the computations of wind set-up for each case of extreme wave conditions, the average wind speeds ($U_{ave,10}$) that may generate the deep water wave conditions from the respective effective fetch areas found using the S-M-B [5/30] method. The wind setup (η_0) along an effective fetch distance (F) from a specific direction formed by the average wind speed ($U_{ave,10}$) and the average water depth (h_{mean}) in the same direction was calculated using the equation below (OCDI, 2002) [5/31]:

$$\eta_0 = 4.8 \cdot 10^{-2} \frac{F}{h_{mean}} U^2_{ave,10.}$$

The above given equation is an approximate solution of the wind set-up and set-down that may occur at downwind and upwind boundaries of an enclosed basin with a constant water depth and length, respectively, due to a constant wind speed, $U_{ave,10}$ (m/s), blowing over the enclosed basin (Rock Manual, 2007) [5/11].

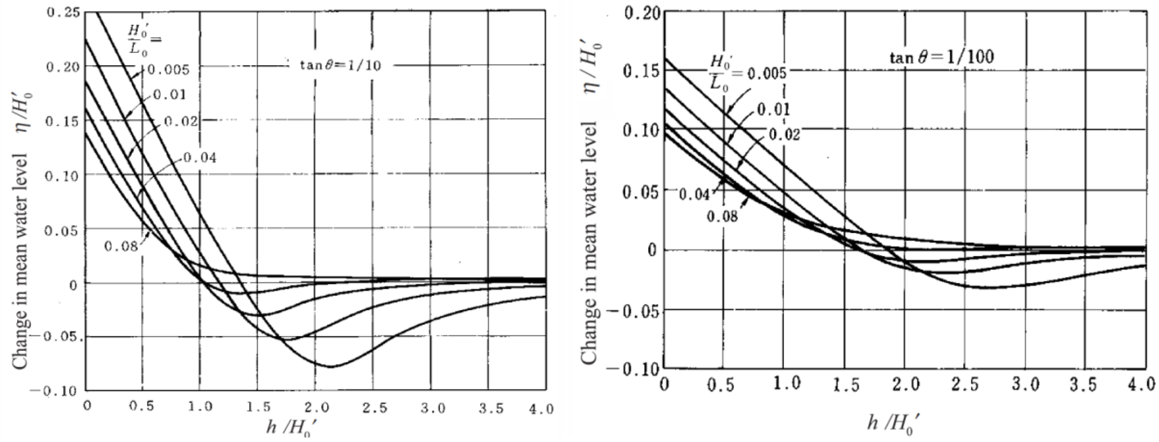
Therefore, the wind set-downs at the shoreline due to extreme winds blowing from land with the exceedance probabilities of 1, 0.1 and 0.01 % are approximated using the same equation given above, and the average water depths and fetch distances in the opposite direction of the winds blowing from land. As an example, to compute the probable wind set-down from North direction, the maximum hourly average wind speed from North direction with the required exceedance probability, average water depth and fetch distance along South direction from project site are used in above. For the Akkuyu NPP, as it seen from the extreme wind statistics study, the maximum wind speeds with the 100, 1000 and 10000 year return periods are observed from N, NNW and ENE directions. Using the hourly average wind speeds from these directions with the above given return periods, probable wind set-downs at the shoreline are approximated. The details of the computations are given in Table 5/4.4.

Table 5/4.4 - Wind Set-Down Computations

Direction	N			NNW			ENE		
Return Period, years	100	1000	10000	100	1000	10000	100	1000	10000
Fetch Length in Opposite Direction, km	78.7	78.70	78.70	77.29	77.29	77.29	818.95	818.95	818.95
Wind Speed, $U_{ave,10}$, m/s	26.3	34.3	42.4	24.4	32.0	39.6	21.2	26.3	31.3
Average Water Depth in Opposite Direction, km	707	707	707	673	673	673	1462	1462	1462
Wind Set-down at Shoreline, m	-0.04	-0.06	-0.10	-0.03	-0.06	-0.09	-0.12	-0.19	-0.26

As it is seen from Table 5/4.4, the set-down in mean sea level due to extreme winds blowing from land directions (N, NNW and ENE) with exceedance probabilities of 1 %, 0.1 % and 0.01 % are between 0.03-0.26 meters.

The total rise in the mean water level at the shoreline due to random wave breaking (total wave set - up) is the sum of static (mean wave set-up, η), and dynamic (surf beat, ζ_{rms}) components of wave set - up. The static component of wave set-up values (η) at relative water depths (h/H_0') for different sea bottom slopes (tanθ) are obtained from Figure 5/4.9 [5/36].



a) - Bottom Slope 1/100 b) - Bottom Slope 1/10

Figure 5/4.9 - Change in Mean Water Level (OCDI, 2002)

The dynamic (oscillating) component of wave set-up, surf beat amplitudes (ζ_{rms}) at shorelines are computed from equation below [5/36]

$$\zeta_{rms} = \frac{0.01H_0^{'}}{\sqrt{\frac{H_0^{'}}{L_0}(1+\frac{h}{H_0^{'}})}} \quad , \qquad H_0^{'} = H_0 K_r$$

where:

- h is the intermediate water depth;
- Kr is the refraction coefficient at respective depth;
- L0 is the deep water wave length.

Similar to wave set-up at the shoreline due to breaking waves, a set - down in the mean sea level occurs where the wave breaking takes place; at a water depth called as “breaking depth, d_b”. To compute the wave set-down values, breaking wave height (H_b) is obtained using below equation given by Gourlay [5/11], the breaker index is (γ_b) obtained using second below equation given by Janssen and Battjes [5/11].

$$H_b = 0.478H_0^{'}\left(\frac{H_0^{'}}{L_0}\right)^{-0.28} \qquad \text{for } m < 0.07$$

$$\gamma_b = \frac{H_b}{d_b} = 0.39 + 0.56\tanh(33H_0{'}/L_0).$$

After computing the wave breaking parameters using the above given equations, wave set-down, η_b, is computed using the equation given below.

$$\eta_b = -\frac{\gamma_b H_b}{16(1+\gamma_b^2/16)}$$

For the computation of run-up heights ($R_{2\%}$), the methodology given in [5/32] is followed (see equation below). The bottom slopes at the selected locations which are at approximately 10 m water depths (from still water level, SWL) close to project area are obtained from the available bathymetrical data.

$$\frac{R_{2\%}}{H_{m0}} = 1.75 \cdot \gamma_b \cdot \gamma_f \cdot \gamma_\beta \cdot \xi_{m-1.0}, \qquad \xi_{m-1.0} = \frac{\tan\alpha}{\sqrt{H_{m0}} / L_{m-1.0}}.$$

where:

- H_{m0} is the significant wave height in front of the composite profile (or at the toe of a structure);
- ξm-1.0 is the spectral surf similarity parameter;
- tanα is the average slope along the composite profile obtained from the point of wave breaking (defined as the depth equal to 1.5 Hm0) to the wave run-up height (R2%), the spectral deep water wavelength (Lm-1,0) is obtained from spectral wave period, Tm-1.0;
- γb, γf and γβ are the reduction coefficients for berm, roughness and oblique wave attack respectively.

These coefficients are taken as to be equal to 1.0. In the computation of run-up heights at selected locations, the nearshore wave heights and average bottom slopes at 10 m water depth are used and the slope is assumed to be constant up to computed run-up height on land. Therefore, the computed run-up heights are approximate and theoretical and should be re-evaluated considering land topography and the structural features at the nearshore project area.

The distance from shoreline (at SWL) to the run-up height exceeded by 2 % of the incoming waves is assumed as the inundation distance of the storm surge. The inundation distances of storm surge on land from the shoreline (at SWL) for the selected scenarios of extreme storm events are computed assuming the average sea bottom slope at 10 m water depth constant on land also.

The selected storm events, deep water characteristics and computed high water levels are given in Table 5/4.5. Nearshore wave parameters and extreme water levels at the shoreline together with the run-up heights and wave set-ups are given in Table 5/4.6.

Extreme water levels at the shoreline with respect to SWL are assumed as the sum of static and dynamic components wave set-up and respective high water levels. As it is seen from Tables 5/4.5 and 5/4.6, expected extreme water levels at shoreline from SWL close to locations A, B, and

C are 2.79, 2.59 and 2.64 m respectively in case of an extreme storm event with a return period of 100 years (probability of exceedance of 1%).

Computed values of run-up heights, wave set-ups and set-downs, extreme water levels at shoreline and inundation distance from shoreline are approximate and theoretical values and should be re-evaluated in detail considering types and layout of coastal structures at the NPP site.

Table 5/4.5 - Deep Water Wave Characteristics and High Water Level Computations for the Selected Scenarios of Storm Events for the Project Area

Deep Water Wave Characteristics	Scenarios					
	SC1	SC2	SC3	SC4	SC5	SC6
Direction	WSW	WSW	WSW	W	WSW	SW
Return Period, Year /Exceeded Duration, hours	100 years	1000 years	10000 years	10 hours	10 hours	10 hours
Deep Water Significant Wave Steepness, Hs0/L0	0.0391	0.0391	0.0391	0.0391	0.0391	0.0391
Deep water wave Height, Hs0, m	8.90	11.39	13.86	3.72	5.66	3.44
Significant Wave Period, Ts, s	12.08	13.66	15.08	7.81	9.63	7.51
High Water Level Computations						
P Effective Fetch Distance, F, km	819.0	819.0	819.0	443.7	819.0	617.5
Wind Speed, U, m/s	23.2	28.4	33.6	14.2	17.0	12.9
Average Depth, hmean, m	1462.7	1462.7	1462.7	679.2	1462.7	1690.7
Wind Setup, η0, m	0.14	0.22	0.30	0.06	0.08	0.03
Tidal Variations, tv, m	0.15	0.15	0.15	0.15	0.15	0.15
Seasonal Variations, sv, m	0.15	0.15	0.15	0.15	0.15	0.15
Sea Level Rise, slr, m)	1.00	1.00	1.00	1.00	1.00	1.00
Barometric and Coriolis Effects, m [1)]	0.14	0.15	0.16	0.14	0.14	0.13
High Water Level, Δh (+m from SWL)	1.59	1.67	1.76	1.50	1.52	1.46

[1)] *The sea level variations due to atmospheric pressure changes and possible Coriolis effects are assumed as 10 percent of the sum of wind set-up (of extreme wave events), tidal and seasonal variations and the expected sea level rise.*

Table 5/4.6 - Nearshore Wave Characteristics and Wave Set-up and Run-up Computations for the Selected Scenarios of Storm Events at Location-B

Nearshore Wave Characteristics and Wave Set - up and Run - up Computations - Location B	Scenarios					
	SC1	SC2	SC3	SC4	SC5	SC6
Significant Wave Height, Hs,d = 10m, m	5.95	7.42	8.29	2.36	3.89	2.24
Average Approach Angle, [1)] αmean,d = 10m, °	229.8	228.6	227.7	243.2	233.3	230.1
Equivalent Deep Water Wave Height, H0’,d = 10m, m	6.37	8.15	9.92	2.43	4.05	2.50
Significant Breaking Wave Height, Hsb, m	8.29	10.60	12.91	3.24	5.27	3.24
Breaker Index, γb, m	0.71	0.71	0.71	0.69	0.71	0.72
Breaking Depth, db, m	11.65	14.90	18.15	4.70	7.41	4.53
Wave set-down at breaking depth, [2)]ηb, m	-0.36	-0.46	-0.56	-0.14	-0.23	-0.14
Wave set-up at shoreline, η, m[5/2]	1.00	1.27	1.55	0.39	0.63	0.39

Surf beat, [2]ζrms, m	0.38	0.49	0.59	0.15	0.24	0.15
Average Slope, tanα	0.060					
Spectral Surf Similarity Parameter, ξm - 1,0	0.396	0.401	0.419	0.406	0.391	0.402
2% Run-up Height, [2]R2%, m	4.12	5.21	6.08	1.68	2.66	1.57
2% Run-up Height, [3]R2%, m	5.71	6.88	7.84	3.18	4.17	3.03
Extreme Water Level at Shoreline from SWL [4], m	2.97	3.43	3.91	2.04	2.39	2.00
Inundation Distance from Shoreline at SWL, m	94.5	113.7	129.6	52.6	69.0	50.2

[1] The approach angles are in clockwise direction from the North.
[2] The wave set-ups and the run-up heights are given from HWL.
[3] The run-up heights are given from SWL.
[4] Extreme water level at the shoreline is assumed as the sum of static and dynamic components wave set-up and respective high water levels.

5.4.11.1 Types of High Tides. Maximum Amplitude of Tide Level Fluctuations, Storm Positive and Negative Setups at Maximum Wind Speed of Various Probabilities

Water level measurement system (WLMS), was installed in Akkuyu Bay to measure the water level every 10 minute interval.

Two SEAGUARD WTR (Wave and Tide Recorder) were installed at two stations in order to measure the tide level. Equipment is set to record the tide value for every 1 hour interval with a tidal average period of 40 seconds.

Reference long-term tide level data is gathered from the water level station in Erdemli (closest to Akkuyu) which is operated by Turkish Command of Mapping. Location of the station and Akkuyu Bay is shown in Figure 5/4.10. Levels for highest astronomical Tide (HAT), lowest astronomical tide (LAT), mean sea level (MSL), mean, mean lower low water (MLLW) and mean higher high water (MHHW) are given in Table 5/4.7.

Table 5/4.7 – Reference Tide Levels for Project Area (Erdemli)

Datum Level	Value, m
HAT	0.56
LAT	-0.12
MSL	0.20
MLLW	0.07
MHHW	0.34

Figure 5/4.10 – Location of Akkuyu Bay and Erdemli

In METU (1985) [5/33], based on the measurements performed in 1984-1985, it is shown that the observed maximum and minimum tidal range was about 88.5 cm (21 Nov 1984, 22:00) and 0.0 cm (10 Mar 1985, 05:00) with an average amplitude of 27.6 cm. The results of monthly tide measurements at Akkuyu bay is given in Table 5/4.8.

Table 5/4.8 – Monthly Tide at Akkuyu NPP Site

TABLE:1 Monthly Tide at Akkuyu NPP Site												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Maximum	82.1	82.2	70.0	69.8	67.9	69.0	83.2	77.0	80.5	75.0	88.5	60.0
Minimum	22.1	9.8	0.0	15.1	19.8	28.1	35.0	32.7	32.4	15.9	22.8	15.2
Daily Mean Maximum	62.7	73.0	54.0	57.9	60.1	52.0	62.6	62.4	60.8	59.2	68.7	42.2
Daily Mean Minimum	36.5	16.3	12.6	30.5	38.0	39.4	47.4	51.5	50.7	31.9	37.5	27.7
Monthly Average	48.2	42.2	29.2	39.2	48.4	46.5	54.5	56.1	55.1	44.8	51.2	34.8

Another report prepared by Report Turkish Electricity Authority Nuclear Power Plant Division (TEA-NPPD July, 1985) [5/11], suggest that the maximum and minimum tidal range observed was about 88.5 cm and 0.0 cm with amplitude of 27.6 cm. Monthly maximum amplitude is 78.4 cm and daily maximum and minimum amplitude are 50.2 cm and 8.5 cm.

During the measurement period, maximum water level was observed at 29.07.2011 at 10:10 (0.58 m) and minimum water level was measured at 17.06.2011 03:58-04:28 (minus 0.05). Difference between maximum and minimum level is measured as 0.63 m. Daily average water level is observed as 0.29 m with average amplitude of 0.28 m. Maximum daily amplitude is measured as 0.47 m and minimum daily amplitude is measured as 0.09 m during study.

The maximum positive wave setup will occur at WSW wind direction at 23.2 m/s of wind speed direction with 1000 year of return period which will produce a 0.30m of wind setup.

As it is seen from Table 5/4.4 the set-down in mean sea level due to extreme winds blowing from land directions (N, NNW and ENE) with exceedance probabilities of 1 %, 0.1 % and 0.01 % are between 0.03-0.26 meters.

5.4.12 TSUNAMI AND SEICHE HAZARD ANALYSIS

5.4.12.1 Tsunami Hazard Analyses

5.4.12.1.1 General Description of the Region

The Mediterranean and connected seas are characterized by high seismicity with the basin of East Mediterranean Sea being the most active. Hence the tsunami activity gradually increases from west to east within the basin with Greece and the surrounding regions related with the occurrence of large historical and instrumental earthquakes which are sometimes triggering tsunamis.

Going towards East, the southern continental margin of Anatolia is undergoing a complex pattern of deformation along a broad zone of collision between the African and the Anatolian plates. Therefore, the seafloor morphology of the Northeastern Mediterranean is largely controlled by tectonic features and high sediment input from large rivers, [5/38]).

The Cilician Basin is bordered by Turkey to the north (where Akkuyu NPP site is located), the Iskenderun Basin to the east, the Antalya Basin to the west and Kyrenia Mountains in Cyprus to the south (Figure 5/4.11).

Figure 5/4.11 North-Eastern Mediterranean and Akkuyu NPP site, [5/11]

5.4.12.1.2 Tsunami Hazard Studies of Akkuyu NPP site

Several site specific studies were performed for Akkuyu NPP site in the past 35 years. The studies were performed by different authors under different technical and regulatory requirements. They are presented shortly below with the idea to provide the input database and the methodologies applied for tsunami hazard assessment. Although the results of the studies are also provided they have only indicative character and do not relate with the actual design basis flooding characteristics which will be presented in the Site Parameters Report.

5.4.12.1.2.1 METU 1979 Study

The tsunami investigations in the Eastern Mediterranean based on numerical modeling were initiated by METU, [5/19]. These studies are directly related to Akkuyu NPP site. METU developed a numerical model solving the long wave equations for the tsunami propagation in Eastern Mediterranean.

Historical Tsunami and Seismicity Catalogues

METU, made a remarkable compilation of 141 tsunamigenic events in the Eastern Mediterranean (31^o-44^oN, 18^o-36^oE) using Ambraseys [5/39] by covering the period II millennium B.C. to 1961. The tsunami catalogue is available in the original report [5/19].

The statistical information concerning earthquakes in the southern Aegean plate used by METU is mainly based on Karnik [5/35 and 5/41]. Other sources of seismological information (such as International Seismological Center and Kandilli Observatory) were also evaluated by METU but it was concluded that the temporal and spatial distribution of earthquakes in these sources does not imply different frequency magnitude relations, return period computations etc. Thus the information provided by Karnik [5/35 and 5/41] forms the primary seismological basis in the study.

Description of the Tsunamigenic Sources

The report has indicated two regions PR1 and PR2 (Figure 5/4.12) where sufficiently large tsunamis have been observed in the past.

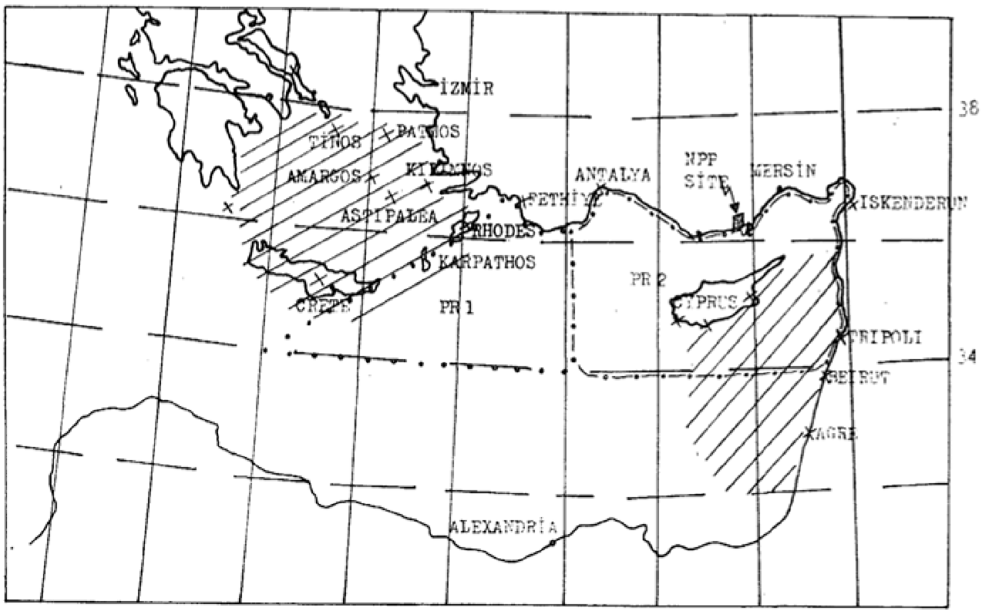


Figure 5/4.12 – Eastern Mediterranean and Model Domains for Tsunami Study, [5/19]

The region PR1 is bounded by 30° longitude to the east and 34° latitude to the south and by the Cretan Arc (formed by Rhodes, Karpathos and Crete) to the NW (Figure 5/4.12). The region PR2 lies to the east of 30° longitude and between the south coast of Turkey and 34° longitude.

In addition the authors made correlation of the two regions with the seismological regionalization suggested by Karnik [5/41] (Figure 5/4.13).

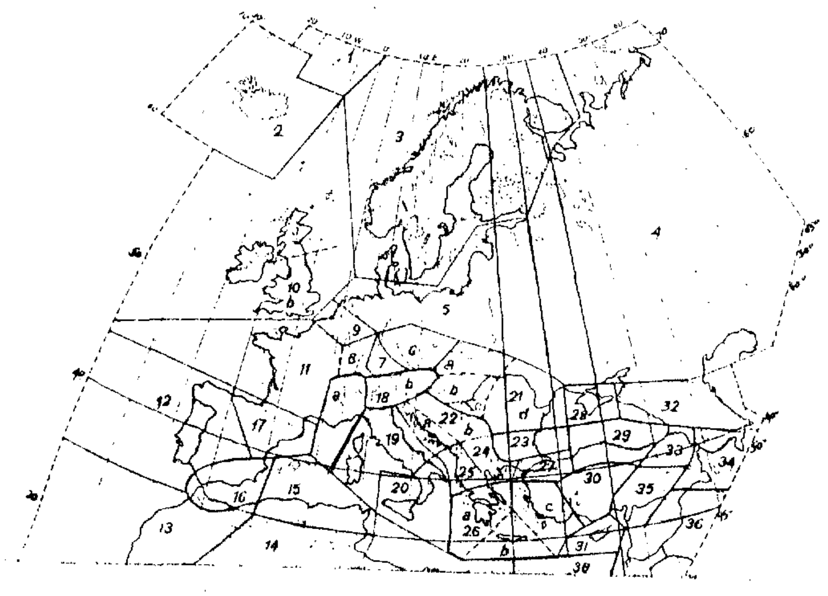


Figure 5/4.13 – Specifications of the Region Considered by Karnik [5/41]

As a result of the evaluation of historical tsunami and seismological data and pertinent regionalization studies, METU has identified a set of 10 tsunamigenic sources presented in Figure 5/4.14.

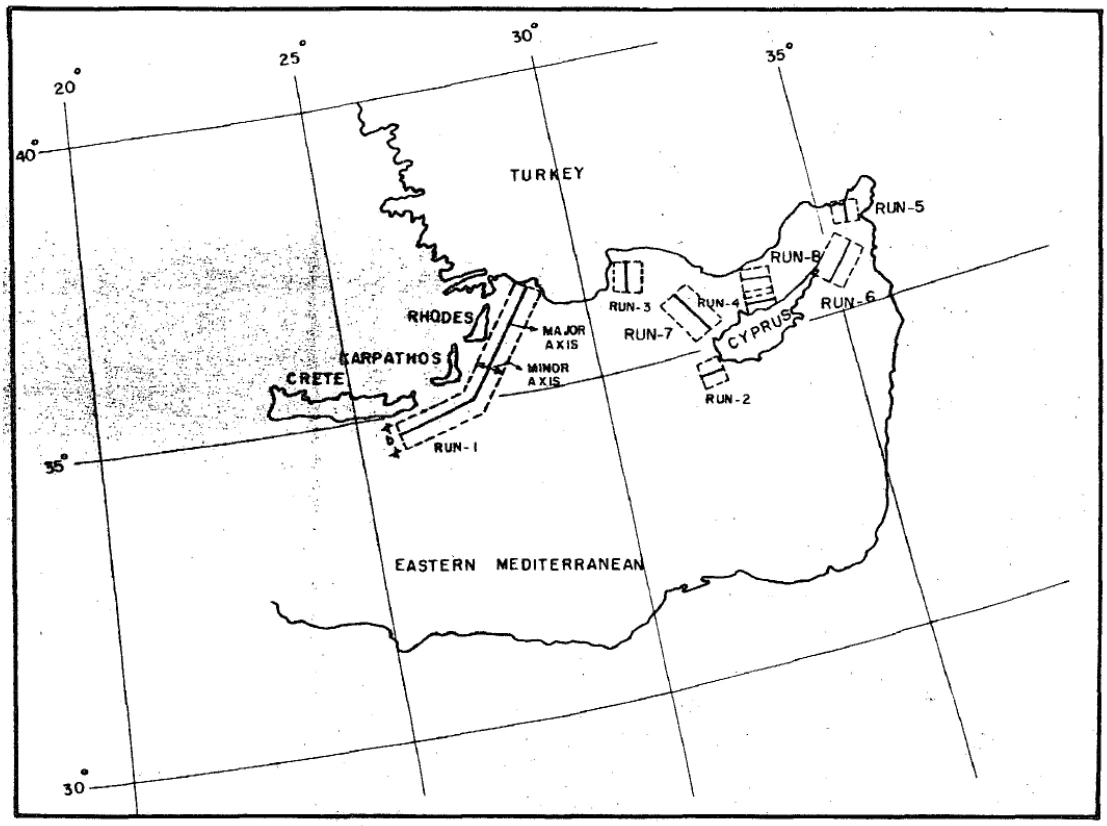


Figure 5/4.14 – Locations of Selected Tsunami Sources in Eastern Mediterranean Region for Akkuyu NPP Site, [5/19]

The identification numbers of the sources are numbered after the computation runs performed for each of these i.e. R1, R2, R3 etc. Table 5/4.9 provides the source kinematic parameters.

Table 5/4.9 Tsunamigenic source parameters of the METU 1979 study [5/19]

RUN		R.1	R.2	R.3	R.4	R.5	R.6	R.7	R.8	R.9	R.10
Magnitude		8.0	6.75	7.0	7.0	7.0	7.5	7.5	7.0	7.0	7.0
Fault Length, L (km)		350.0	40	55.0	55.0	55.0	120.0	120.0	55.0	55.0	55.0
Max. Ground Disp. (m)		8.0	1.2	2.0	2.0	2.0	4.0	4.0	2.0	2.0	2.0
Duration (sec)		10.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Equv. Diam. D (km)		229.0	47.3	63.1	63.1	63.1	105.0	105.0	63.1		63.1
Source Area (km²)		41218.4	1758.3	3126.7	3126.7	3126.7	8812.4	8812.4	3126.7	4690.0	3126.7
Equv. Width, b (km)		117.8	44.0	55.0	55.0	55.0	73.43	73.43	55.0	85.3	55.0
Exp. Const., B		0.102	0.272	0.217	0.217	0.217	0.163	0.163	0.217	0.141	0.217
1/2 Time Step, Δt (sec)		100.0	100.0	100.0	100.0	100.0	200.0	200.0	200.0	100.0	200.0
Coordinates of Main Fault.	Start	36°15′ N 29°05′E	34°25′ N 32°15′E	36°35′ N 31°05′E	35°30′ N 33°45′E	36°00′ N 35°25′E	35°05′ N 34°25′E	35°15′ N 31°50′E	35°47′ N 33°45′E	36°35′ N 31°05′E	35°47′ N 33°45′E
	Corner	34°30′ N 26°55′E									
	End	34°30′ N 25°55′E	34°25′ N 31°55′E	36°30′ N 31°05′E	35°30′ N 33°10′E	36°32′ N 35°25′E	35°40′ N 35°25′E	36°15′ N 31°14′E	35°47′ N 33°10′E	36°30′ N 31°05′E	35°37′ N 33°10′E
Description		Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Area Run	Fric.Run

Source R1 located to the East-North-East from Crete has the highest maximal magnitude potential with M=8.0. It was very conservatively assumed that it will trigger a 350km long fault rupture over two segments.

Sources R2 and R6 are in the southern PR2 area. The source R6 has a magnitude M = 7.5 and source R2 has a magnitude of M = 6.75. Cyprus should provide protection against tsunamis emanating from this part of PR2. However, it was felt that the tsunami originating from this source may suffer multiple reflections from the Syrian and the Turkish coastline and consequently amplify of the partial blockage of Cyprus.

Sources R3 and R7 are in the western PR2 area. An earthquake of a magnitude M = 7.5 (called source R7) originating in the NNW of the western end of Cyprus seemed to be a conservative estimate. In view of the existence of observed earthquakes with 6.0 < M < 7.0 in Antalya bay and to its south, another source called R3 with magnitude 7.0 is simulated.

Sources R4, R5 and R8 are in the Northern PR2 area. The area shows very little seismic activity, though the Bay of Iskenderun and its vicinity have experienced tsunamis of unknown origin in the past. In any case, the critical importance of a tsunami occurring in the northern PR2 to the NPP site was assumed to be clear. R4 is located on the northern coast of Cyprus across the NPP site. The source R8 is located midway between R4 and the NPP site. R5 is situated in Iskenderun Bay. All three sources have estimated maximal magnitudes of M= 7.0. The source R9 is located near the source R7 with the magnitude of M=7.0. The source R10 is located near the source R4 at north of Cyprus. The effects of these sources are already enveloped by others.

Bathymetric and Topographic Data

Finite difference grid size (11 x11 km^2) and (5.5 x 5.5 km^2) were used in the modeling. The depths and the coastal configuration were taken from the Admiralty maps of scale 1:1100000. These maps have been updated by the Hydrographic Office of the Turkish Navy, with corrections up to 1976. Additional bathymetric data giving the details of the region between Turkey and Cyprus was obtained from a 1:300000 map prepared by MTA Institute. Obviously, the bathymetric grid was too coarse for precise simulation of the near shore tsunami behavior.

Numerical Modeling

Nonlinear form of shallow water equations (momentum equations on horizontal plane in x and y directions, and continuity equation) are solved using Finite Difference Method (FDM) Method. Bottom friction and Earth rotation with Coriolis parameter are also included in the equations. The solution technique is summarized in [5/19]. The grid size is selected as 11km x 11km. Some of the simulations are performed with the grid size of 5.5km x 5.5km. The computations in FDM are carried out in two cycles. In advancing from time t to the next half step time more, in the first cycle, v (velocity in vertical South-North direction) is computed explicitly while u (velocity in East-West direction) and η (water surface elevation) are computed implicitly. In the second cycle, u and η are computed explicitly and v implicitly. Model was tested and a Finite Element Model (FEM) is developed partially to check the results of FEM and also for assessment of the dispersion.

Discussion on the Results

It was concluded that source R1 generates the largest tsunami wave heights at the target area. The original report includes the tsunami wave time histories from the source to the site. Figure 5/4.15 provides an example tsunami wave time history from source R1.

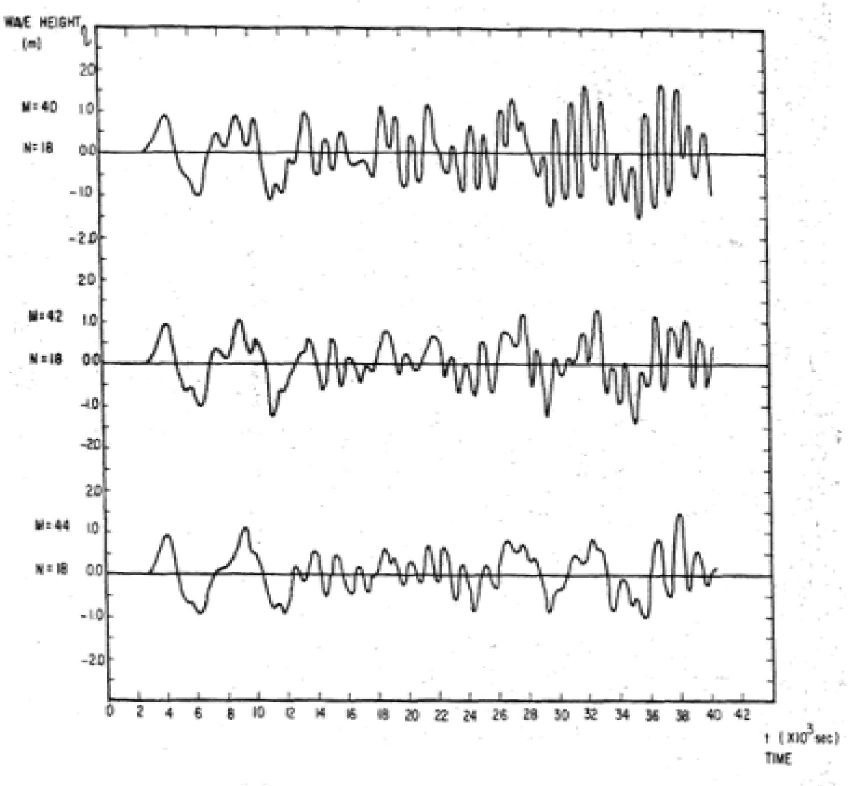


Figure 5/4.15 – Tsunami wave time history of RUN-I, South East of Aegean Archipelago, [5/19]

For R1, the amplitude of the initial motion at the target is 2 m almost evenly distributed between 1m above and 1m below the still water level.

A coarse bathymetric finite grid size was utilized in the numerical modeling therefore the near shore modification of the tsunami waves immediately of the coast had not easily been resolved by the model simulations. This area actually extends to a considerable offshore distance on the shelf. For example, in the critical run of R1 the grid size is 11 km and the grid depth at which the calculations were carried out near Akkuyu was taken as 200 m. This depth corresponded to an offshore distance of about 10 km. An attempt was made to account for the modification in this narrow region of the shelf by conservatively assigning the calculated wave heights at the shelf break. Following this approach the maximum tsunami wave height of 1.5 m found by the numerical modeling was increased because of the shallow water amplification to 3.2 m which was considered to be the result.

As the near shore bathymetry in tsunami wave propagation simulations is very critical for the resulting wave heights at the site such simplification is obviously introducing considerable uncertainty in the obtained result.

Sea Level Changes due to Additional Effects

The sea level changes due to tides and storm surges and their expected maximum levels were also analyzed in METU [5/19].

The storm surge and storm wave heights have been calculated for statistically representative storm magnitudes following standard procedures outlined in the Shore Protection Manual [5/40], prepared by the U.S Army Corps of Engineers. The wind statistics and design storm parameters as available in the time of the study were evaluated and their extremes calculated.

Sea level rise due to combined events are of interest in evaluating the design alternatives. For this purpose two possible statistically independent events were considered:

- the combined occurrence of storm surge, storm wave setup and tides;
- the combined occurrence of tsunami and tide.

The maximum measured tidal amplitude at Akkuyu based upon the statistical tide data at the time of the study was found to be 0.7 m above mean sea level. The maximum tsunami wave run-up is found to be about 3.2 m by the METU study, and roughly corresponds to a 10^{-4} probability of occurrence. The summary of combined events can be found in Table 5/4.10. The combined occurrence of the two independent events of the previous paragraph has also been included as an event of 10^{-8} probability.

Table 5/4.10 – Combined Events [5/19]

Probability of occurrence	Storm surge+ Wave setup+ Tide, m	Tsunami+ Tide, m	Tsunami +Tide+ Storm Surge+ Storm Wave Setup, m
10^{-2}	1.9	-	-
10^{-4}	3.1	3.9	-
10^{-8}	-	-	7.0

5.4.12.1.2.2 MorTransProject 2011 Study

The study was performed by Marine Transport Projects Company LTD under a contract from JSC “Atomenergoproject”. The report [5/18] was prepared by a team of Russian scientists with purpose to study the storm wave conditions in the area of the site. The study included as well investigation of specific features of the Mediterranean seashore catastrophic tsunami waves behavior by mathematical simulation methods and evaluation of the tsunami waves impact at Akkuyu NPP site.

Historical Tsunami and Seismicity Catalogues

The study utilized a tsunami catalogue including the time span 2000 BC to 2000 AD [5/32]. However, the terms of reference for the study required statistical analysis of tsunamigenic earthquakes in the last 200 years. It is recognized in the Report that 200 years is too short a period and the authors considered 1000 years during which period seven tsunamigenic earthquakes have occurred. These seven events were used in the analysis.

Description of the Tsunamigenic Sources

7 sources corresponding to the historical events from the tsunami catalogue occurred in the last 1000 years were identified. No information is provided on the maximal magnitude of these sources/events and no fault kinematic parameters associated with the sources are available. No geological and tectonic description of the sources is available.

Bathymetric and Topographic Data

Information on the bathymetric and topographic data used in the analysis is not available in the report.

Numerical Modeling

The numerical solution of long wave equations (shallow water equations) are used in [5/18]. The computational field is represented by a rectangle, 721x421 nodes. The horizontal computational grid step equals 1 minute (1852m). The time step is used as 8 seconds.

Hydrodynamic modelling for long wave porpagation in homogeneous fluid [5/18] has been performed taking into account non-linear wave behaviour. The bottom friction was determined to be proportional to the average squared flow velocity. Wind stress and Coriolis effects were considered within the hydrodynamic calculations.

A finite difference approximation of the solitary wave runup problem is used to compute the runup at Akkuyu.

Discussion on the Results

The presented results have probabilistic nature based upon Gumbel based statistical distribution of the 7 events. The resulting maximum tsunami wave height at the site has been calculated separately for the eastern (presumably Çamalanı Bay) and western (presumably Akkuyu Bay) parts of the bay. The maximum tsunami wave height with 10 000 year return period is 2.42m for the western part of the bay and 2.62m for the eastern part with the relevant wave run-ups of 3.55m and 3.41 respectively.

There are several deficiencies in the study. The time constrain in the tsunami catalogue is too short given the target return period of 10 000 year considered in the analysis. By considering only sources at which historical events have already occurred, the site specific geotectonic regime in the region has been totally neglected. In other words, there might be tsunamigenic sources in the Mediterranean where there is a potential for a tsunami important for Akkuyu but with no recorded historical event. This is contrary to IAEA SSG-18 [5/42], which recommends the use of the potential of tsunamigenic sources and not only historical data in tsunami hazard assessment. This is also a clear lesson learned from the Fukushima accident. Finally, it is difficult to estimate how the near shore modification of the tsunami wave has been taken into account because no discussion on the bathymetry and site topography has been made.

Sea Level Changes due to Additional Effects

The report includes extensive analysis of other contributing effects such as tides and maximum storm related wave and wind setups. The maximum water level at the site with 10 000 year return period including the combined effects of these phenomena is estimated to be 5.61m for the western part of the bay (presumably Akkuyu Bay) and 4.28m for the eastern part of the bay (presumably Çamalanı Bay).

5.4.12.1.2.3 METU 2011 Study for Envy

The study of METU for tsunami hazard assessment of Akkuyu NPP site is part of a comprehensive Engineering Hydro-Meteorological Survey [5/11]. As stated in [5/11] the study was a preliminary tsunami investigation which in 22 pages includes very detailed description of the original METU study and some preliminary results for the Akkuyu site mainly based on the source model of a regional tsunami investigation for the Mediterranean Sea [5/37]. In fact, by the time of the report finalization [5/11] the same METU investigation team led by Prof. Ahmet Yalciner, has been assigned with the performance of a comprehensive tsunami and seiche hazard assessment of Akkuyu NPP site [5/17] which will be described in the next subsection. Both studies [5/11] and [5/17] were based on the same historical tsunami catalogue, utilized the same software code and the same initial list of tsunamigenic sources. However the tsunamigenic modeling has been significantly updated and improved in [5/17] where the bathymetric data has been more accurately defined and on-site topographic measurements made.

Hence, the study [5/11] is considered as a preliminary version of the study of WorleyParsons [5/17]. This could be easily recognized if the two reports are compared. For that reason in order to avoid repetition the study [5/11] is not summarized here as a distinct investigation.

5.4.12.1.2.4 METU 2011-2012 Study for WorleyParsons

The study of METU [5/17] performed for WorleyParsons has been developed under very extensive and detailed technical requirements closely following IAEA SSG-18 [5/42]. It includes seismically and non-seismically induced tsunami hazard assessment and seiche hazard analysis.

Historical Tsunamis

Tsunami assessment studies initiate with understanding and evaluation of historical tsunamis in the region. There are numerous tsunami cataloging efforts for Eastern Mediterranean. The recent one (Altınok et al. [5/37]) compiles all available data under the framework of TRANSFER Project supported by European Commission. Altınok et al. [5/37] contains the data of 134 tsunamigenic events that have occurred on and near the Turkish coasts from 17th century BC to the recent 1999 event in the Sea of Marmara. Appendix 1 here to provides the full list of historical events used in the study including their coordinates, magnitude and intensity estimates and the references in peer sources. Location map of the historical tsunamigenic earthquakes (as per Appendix 1) is provided on Figure 5/4.16.

The investigation of historical tsunami events are necessary and effective tools for appropriate tsunami numerical modeling. Historical documents and geological investigations in the Eastern Mediterranean basin reveal that earthquakes, submarine landslides and tsunamis have occurred because of the high seismicity, volcanic eruptions and steep sea bottom slopes in Mediterranean region over 3000 years.

The compilation of reliable tsunami database especially for the Eastern Mediterranean region is essential in tsunami-related studies of wave numerical simulation, inundation mapping and risk assessment. Tsunamis in the Eastern Mediterranean were investigated by numerous researchers. The historical documents in the Eastern Mediterranean are compiled in [5/37]. The list includes date, region, cause, relevancy, approximate epicenter and magnitude of tsunamigenic earthquakes and other triggering mechanisms together with the information on observation and estimated epicenter coordinates of the earthquakes of the historical tsunamis (Appendix 1). This appendix provides also a list of tsunamis in Eastern Mediterranean.

Since the available data of past tsunamis is usually insufficient, often the only way to determine the potential run-ups and inundation at selected study areas (such as Akkuyu region) from a local or distant tsunami is to use tsunami simulations. It is one of the efficient procedures for tsunami assessment. In tsunami simulations, the generation, propagation, coastal amplification and inundation of tsunamis can be modeled and the simulation results can also be visualized. Accurate and reliable applications in tsunami simulation need valid and verified tsunami model together with high resolution and reliable tsunamigenic data (tsunami source parameters) and accurate bathymetric and topographic data. The numerical model NAMI DANCE used in this study is described briefly in the respective section below.

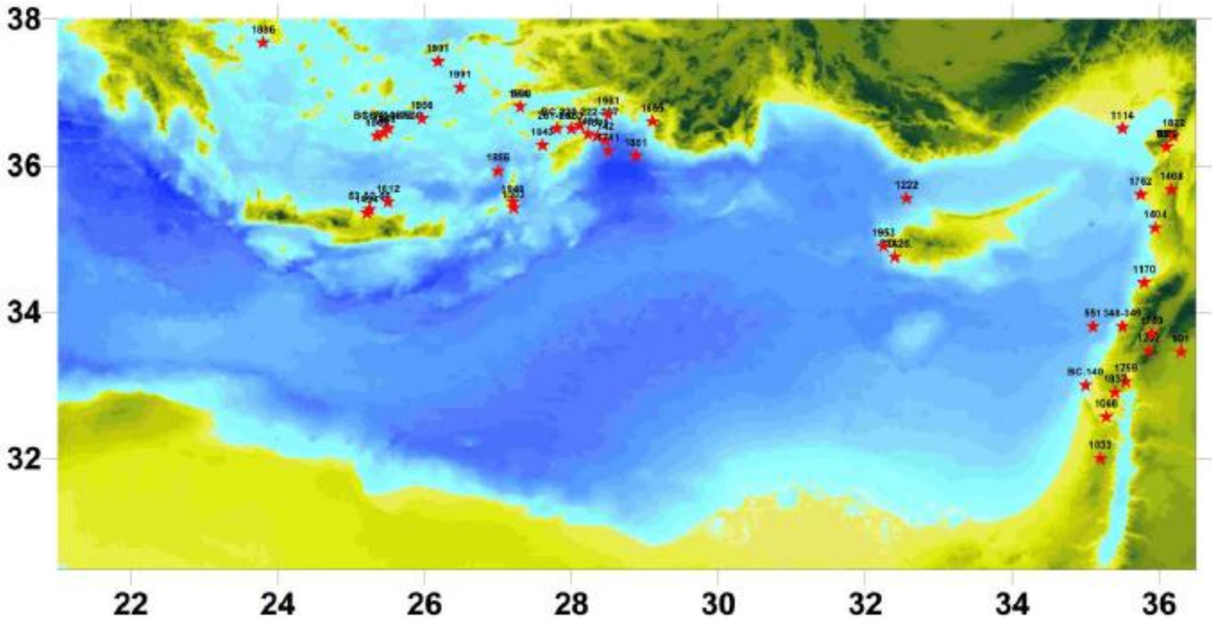


Figure 5/4.16 – Historical tsunamigenic earthquakes, source [5/17]

Description of the Tsunamigenic Sources

The historical tsunami catalogue [5/37], the data on the geological constraints and the fault kinematics of the offshore seismic zones in Eastern Mediterranean provided by Worley Parsons and Paul C. Rizzo Associated, the previous tsunami analysis for Akkuyu NPP site [5/19], previous studies about Turkey [5/16] and other historical data for earthquakes and tsunamis were considered in the tsunami source modeling. Several possible tsunami scenarios that may be occurring in Eastern Mediterranean Basin in the future have been evaluated in the study. The maximum vertical ground displacement, the length and width of the causative fault, location of the epicenter and the orientation and the shape of the source are determined based on available information and provided for each selected source separately [5/17].

The initial source list includes all critical sources of the original METU study [5/19] described above.

The source fault kinematic parameters were checked against several empirical magnitude-fault rupture relationship widely used in the engineering practice [5/43], [5/44] and [5/45].

After the source list compilation a screening has been performed in order to screen out sources that will not contribute (either because they are distant; with low triggering potential or both) to the resulting high water levels at the site.

Bathymetric and Topographic Data

For accurate modeling of tsunami inundation and run-up, a detailed model of near shore bathymetry and coastal topography is required. Therefore the data were valuated, compared with aerial photography and manually adjusted as needed to reflect more accurately the coastal topography of the Akkuyu site. METU collected and purchased available bathymetric and topographic data from several sources:

- Collection of bathymetry/topography data with 30 sec (900m grid size) resolution from GEBCO (General Bathymetric Chart of the Oceans) of the British Oceanographic Data Centre (See Figure 5/4.17) for domains B and C. For smaller domain, (i.e. domain D), the data are gathered from on-site measurements. Field surveys were conducted to assess the vertical accuracy of the datasets. The grid size and lower left/upper right coordinates of Domain B are 405m, 21° E 30.50°N and 36.50°E, 38°N respectively. The grid size and lower left/upper right coordinates of Domain C are 135m, 32.9625°E 35.3208°N and 34.0208°E, 36.3292°N respectively. The grid size and lower left/upper right coordinates of Domain D are 45m, 33.50957°E 36.11412°N and 33.57°E, 36.15546°N respectively.
- Purchase of WORLDVIEW2 4 band pan sharpened satellite of study area, with a radiometric resolution of 16 bit in 2 different pieces image covering 25 km^2 of the region from NIK Systems. These three are combined by using ArcGIS 10.

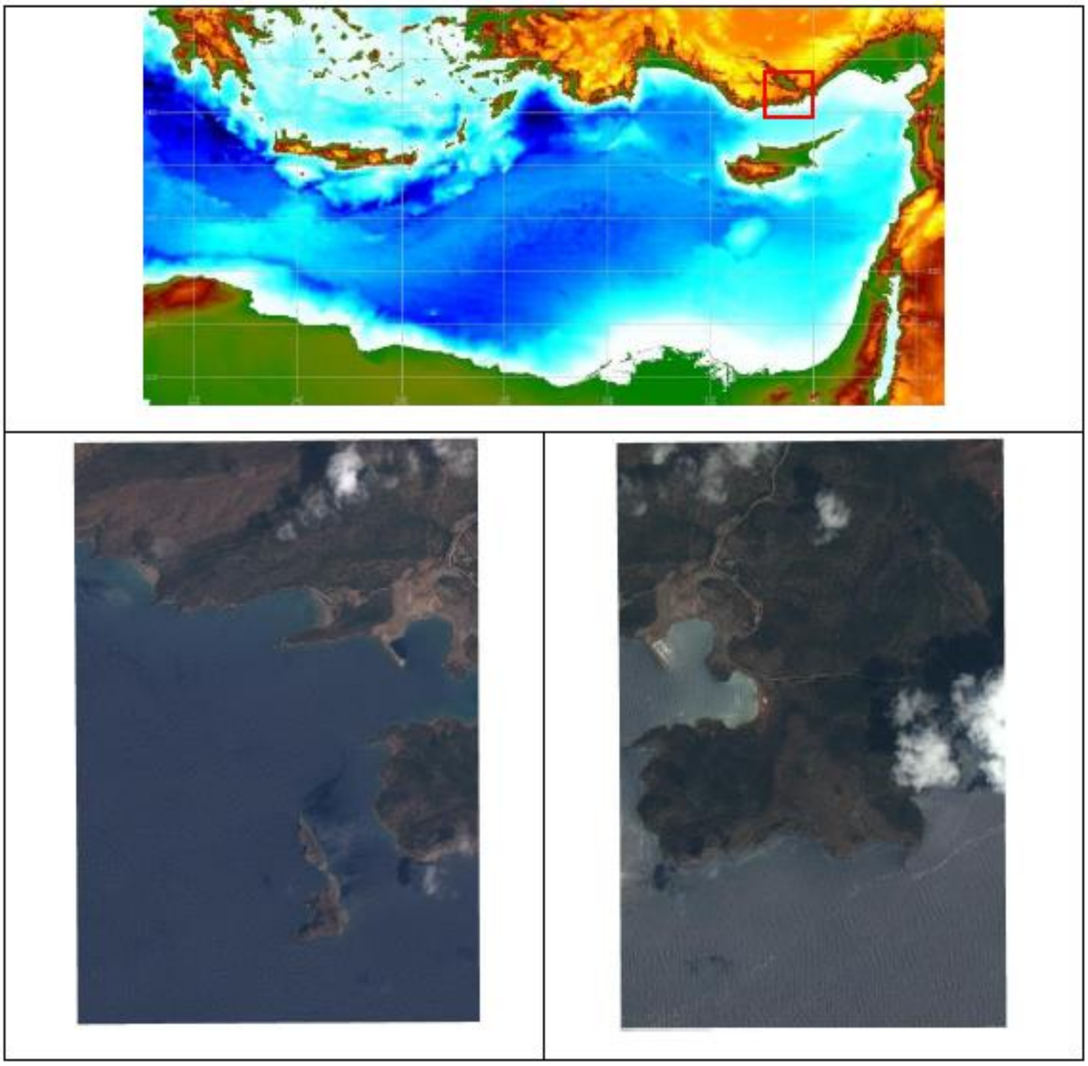


Figure 5/4.17 – Gebco image from Domain B (top) and satellite images of Domain D (bottom), [5/17]

The grid size of largest domain named Domain B was chosen as 405m. According to the principles of nested analyses, the boundary of a smaller domain should involve the previous larger domain and the smaller domain should have one-third grid size of the previous larger domain. As a result of this, the grid size of Domains C and D is 135m and 45m, respectively. Site specific bathymetric data [5/11] has been used for generation of domains C and D.

On-site GPS measurements were made by METU for the topographic model of the site to be used in the analysis.

Numerical Modeling

Tsunami numerical modeling by NAMI DANCE is based on the solution of nonlinear form of the long wave equations with respect to related initial and boundary conditions. There were several numerical solutions of long wave equations for tsunamis. In general the explicit numerical solution of Nonlinear Shallow Water (NSW) Equations are preferable for the use since it consumes reasonable computer time and memory, and also provides the results in acceptable error limit. The most important development in tsunami modeling has been achieved by Profs. Shuto and Imamura by developing model TUNAMI N2 and opened to the use of tsunami scientists under the umbrella of UNESCO [5/46, 5/47, 5/48]. NAMI DANCE has been developed by Profs. Zaytsev, Chernov, Yalciner, Pelinovsky and Kurkin using the identical computational procedures of TUNAMI N2. Both codes determine the tsunami source characteristics from earthquake rupture characteristics. The codes compute all necessary parameters of tsunami behavior in shallow water and in the inundation zone allowing for a better understanding of the effect of tsunamis according to bathymetric and topographical conditions. Both codes are cross tested also verified in international workshops specifically organized for testing and verifications of tsunami models [5/49, 5/50]. These models have been applied all over the world (some of the references are [5/51, 5/52, 5/53, 5/54, 5/55, 5/56, 5/57, 5/58]).

A Validation and Verification document of NAMI DANCE is available [5/59].

The simulations for tsunami analysis of Akkuyu NPP site have been performed by using the numerical code NAMI DANCE by following the below summarized strategy:

1) Bathymetry and Topography data of Eastern Mediterranean (405m grid size) , and development of high resolution bathymetry and topography data of near site area in nested domains (135m and 45m)
2) Determination of tsunami sources which may possible effect Akkuyu site
3) Performing single domain simulations in Eastern Mediterranean for all important tsunami sources
4) Selecting critical tsunami sources for the simulations of nested domain simulations
5) Performing nested domain simulations and computation of the tsunami parameters at site
6) Comparison of the results and performing logic tree analysis
7) Determination of critical conditions under tsunami attack at site
8) Conclusion on probable maximum tsunami parameters at site.

Tsunami simulation runs have been performed for the remaining list of sources for getting preliminary results in a coarse (single Domain B) bathymetric grid. The results of the preliminary simulations including all pertinent source parameters are available in [5/17].

Among the selected tsunami sources, s01-365 is located in the region defined by the 365 AD historical tsunami, s32 and RUN-7 are located in the region of 1222 historical tsunami. According to the recent findings on the Ecemiş fault, two tsunami sources RUN-8 and s42 (Ecemiş) are selected in the region of the suspected southern extension of Ecemiş fault in the sea.

After evaluating the results of single domain analyses, the tsunami sources RUN-1, RUN-7 and S42- Ecemiş were identified as the critical sources that possess the highest potential to cause large effect in Akkuyu region. The propagation of tsunamis from these sources are analyzed in more detail by using nested bathymetric domains (Domain C and Domain D as nested) in order to compute more accurate values of tsunami parameters for Akkuyu region with finer grid size.

Tsunamis generated by other causes

In addition to the seismically induced tsunami, the WorleyParsons report [5/17] includes evaluation of non-seismically induced tsunamis.

Although the earthquake induced tsunami is the critical tsunami generation mechanism that will control the design basis flood at the site for completeness purposes other non-seismically induced generation mechanisms have been considered.

Landslides

Apart from the possible seismic tsunami sources a landslide sources have been considered in the tsunami simulations. According to the marine surveys and their published results in peer reviewed journal, it is seen that there may be landslide possibilities at offshore Nile delta. It was noted in Garziglia et al. [5/20] that:

"Seven mass-transport deposits (MTDs) were recognized from the upper to the mid slope, downstream from imprecated scars (~30 km-long, ~200 m high) running along the shelf edge nearby the Rosetta canyon at Northwest of Nile Delta. Extending on surfaces between 200 and 5000 km^2, with estimated volumes from 3 to 500 km^3, these MTDs represent about 40% (up to 90% locally) of the total Pleistocene–Holocene sedimentary thickness. Three types of MTDs can be distinguished on the basis of their scale. Each has also a distinctive internal configuration and distribution within the Rosetta depositional setting. Age estimates of two MTDs point towards relationships between climate and submarine mass failures through sea-level changes, sediment supply, or a combination of both. Additionally, the presence of gas in the sediment and earthquake shaking may have concurred to trigger large-scale failures on the low slope angles (1°–2°). of the Rosetta area."

There are seven possible landslides at offshore Nile Delta indicated in Garziglia [5/20]. These landslide areas are shown in Figure 5/4.18.

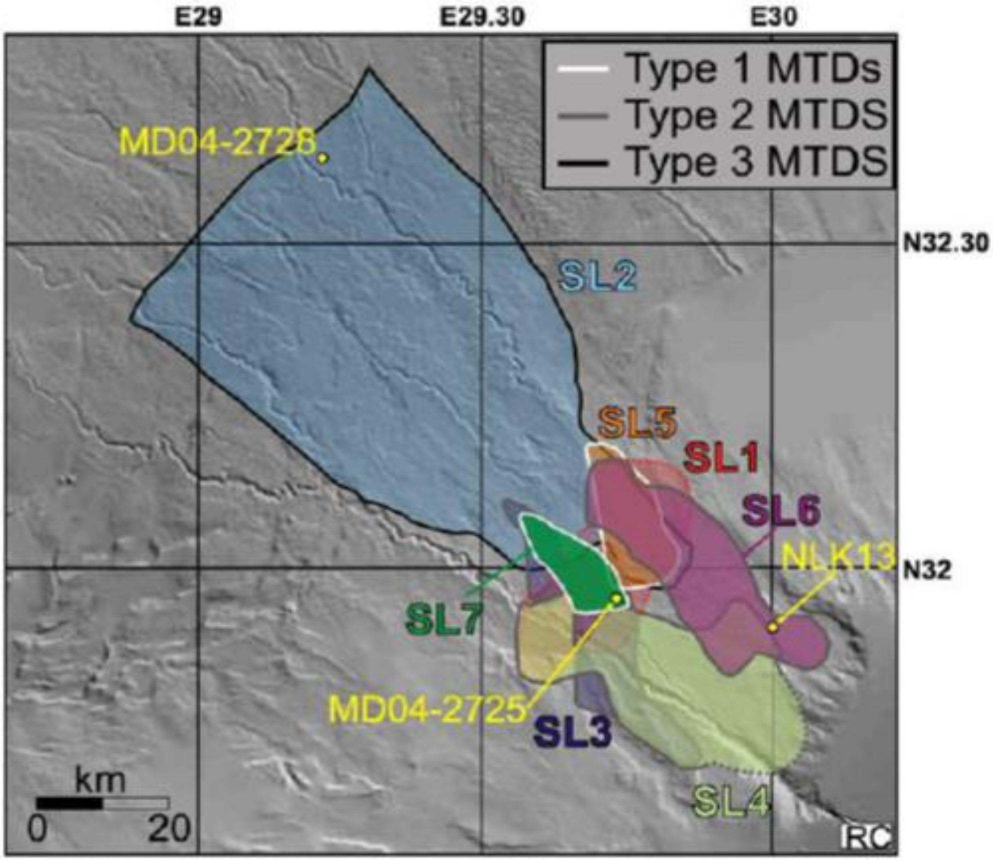


Figure 5/4.18 – Map showing areal distributions of MTDs on the Rosetta slope. White, grey and black contour colors refer, respectively; to type 1, type 2 and type 3 MTDs. SL1 contoured in red is not associated, to any MTD types. Locations of MD04-2728, MD04-2725 and NLK13 are core collected respectively from SL2, SL7 and SL6

One of these slides called SL2 is chosen to be one of the worst case of landslide possibility which may be effective for Akkuyu NPP site. This is the largest landslide identified and presented in Garziglia [5/20]. It is given in the paper that SL2 has a minimum surface area and volume of ~5000 km^2 and ~500 km^3, respectively. The mean thickness is 70m and run out distance is 150 km fem SE to NW direction. Such values are on the order of 20 to 30 times greater than the other identified MTDs.

In the submarine landslide case, maximum 100 m thickness is estimated for sliding material in SL2 landslide.

According to the simulation results, the first tsunami wave from the simulated SL2 landslide arrives in Akkuyu at about 70 to 80 minutes after the origin time.

The Landslide at offshore Nile Delta is simulated in nested domains, B, C, and D with the same grid sizes and boundaries as used in seismically induced tsunami simulations.

The results obtained after 300 minutes of simulation show that the maximum water elevation near the study area is 2 meters which is well into the limits of the earthquake induced tsunami.

Volcanic activity

The volcanic arc in the range of 1000 km from Akkuyu is in the Aegean sea and covers the islands Milos, Antimilos, Antiparos, Santorini, Christiana, Colombus, Kos, Yali, Nisiros and neighbor islands. Those may be assumed as the possible volcanic source of candidate tsunamis in the region. The Santorini eruption in the year of 1350-1410 BC is the most known and most effecting one. Santorini eruption caused caldera collapse and generated the largest Aegean tsunami(s) in the history. This eruption is mentioned in ancient Egyptian records. Nowadays, ashes of Santorini are found in the Nile delta and in the offshore drilling performed at the bottom of Eastern Mediterranean and in Sinop offshore in the Black Sea and also at the bottom of some lakes in Anatolia.

However, the location of the volcanos (being far distanced from Akkuyu) and their size show that any tsunami generated by the volcano can be effective in Eastern Mediterranean but will not be as effective as the co-seismic tsunamis in the area of Akkuyu.

Sea Level Changes due to Additional Effects

National statistical geodetic data (TUDKA-99) has been analyzed in order to define the sea level changes in the area. The extreme maximum and minimum sea levels were determined for different probability levels.

Analysis of the setup due to wind, storm wave and barometric/Coriolis effects and tidal variation has been performed and values to be used in the tsunami hazard assessment were estimated. Out of these the wave setup (representing the increased water level at the coastline) due to storm was estimated to be 1.6m with return period 100 years. It should be noted that the wave setup during storm is 1.74 when wind set up is included. The positive amplitude of tide is 0.15m and setup due to barometric/coriolis effect is 0.14m as well [5/11] indicates that, “The sea level rise observed from the measurements is approximately +7.2 mm per year where the effects of crustal movements are not included”. In the same report, the extreme value statistics for the annual maximum sea level data between 30.05.2003 - 16.09.2011 (TUDKA-99 Datum) indicates that the sea level rise is 92cm for the 100 years return period. The attached nature report [5/59], provided a detailed comparative analysis of range of sea level rises using all related studies and projects. The comparative summary given in [5/59] also concluded that the recent study by Martin Vermeer and Stefan Rahmstorf, in contrast, yields a central estimate of 124 centimeters by 2100 and 114 centimeters by 2095 which may cover 23 cm rise of sea level due to ocean expansion. The summary of the above studies provides that the sea level rise will increase (72 cm) or (92 cm) or 114 cm in 100 years. When taking the average of these values, 93 cm can be obtained. In the estimation of sea level rise in the coming 100 years, the value of 100 cm for long term sea level rise is selected in the maximum water level estimations.

Discussion on the Results

As already stated above the initial results over the coarse bathymetric grid, pointed out that sources RUN-1, RUN-7 and S42-ECEMIS cause higher water level, flow depth and stronger current velocities near Akkuyu region. These three sources were simulated in nested domains leading to the result that the tsunami parameters for Akkuyu region are controlled by source RUN-7.

That source has been further evaluated using alternative values for some input parameters like fault kinematics, slip displacement and/or mean sea water level. This has been done in order to take into account the epistemic uncertainty relevant to the level of knowledge available in the informed technical community for the parameters of that source. In line with the latest IAEA guidance [5/42], the epistemic uncertainty is captured by using different alternatives for its tsunamigenic potential thus leading to generation of a logic tree which forms the basis of the final analysis.

The computed maximum amplitude of the tsunami wave height is 3.0 m and arrival time is 60 minute for the case of RUN-1 (with the dip angle 10^o and slip displacement 15m). In the case of RUN-1a (with the dip angle 10^o and slip displacement 15m) these values are 3.6m and 60 min.

In the cases of RUN-7, RUN-7b, RUN-7c, RUN-7d the tsunami wave heights are 6.1m, 6.9m, 8.1m, 6.9m and the arrival time is 16 min respectively.

In the cases of RUN-8a and RUN-8b the tsunami wave heights are 6.2m, 6.2m, and the arrival time is 0 min respectively.

In the case of scenario S42-ECEMIS, the tsunami wave height at Akkuyu is 3.3m and arrival time is 0min.

In order to calculate the representative value for the tsunami wave height through deterministic analysis, s logic tree has been developed from cases (rupture parameters) RUN-7, RUN-7b, RUN-7c, RUN-7d (with the weights 0.1, 0.1, 0.6 and 0.2 respectively). As a result of the logic tree analysis the deterministically defined tsunami wave height is estimated to be 7.54m at Akkuyu site. This value does not cover the water level rise due to wind, wave, storm, tide, barometric/coriolis effects.

In addition to the deterministic study, a probabilistic tsunami hazard assessment (PTHA) has been made in [5/17]. It assigns annual activity rates for the tsunamigenic sources in the deterministic study based upon the annual activity rate estimates used in the probabilistic seismic hazard analysis of the site. The idea is to provide the deterministic results with certain probability level. However, as stated in IAEA SSG-18 [5/42] *“the probabilistic tsunami hazard assessment is not the current practice applied by States for assessing tsunami hazards. Methods for the assessment of tsunami hazards using probabilistic approaches have been proposed, although standard evaluation procedures have not yet been developed.*”, the results of the PTHA should be treated with the understanding that it is unique study with practically no benchmarks and any assessment needs to be made in a rational way.

5.4.12.1.3Tsunami Hazard Results

Going back to the tsunami investigations described in the previous subsections, Table 5/4.11 provides the parameters evaluated by the different studies. Obviously, all studies concentrated on the tsunami wave height and the most popular sea level change components while other parameters were not (or were only partially) defined.

The results in the table provide different values that may be attributed to different and sometimes distinct: methodological basis applied, software codes used, input data used and regulatory and technical requirements. The difference between the tsunami wave height obtained by the two METU studies is also explicable because while the two controlling tsunamigenic sources have had similar maximal magnitude estimates, the site-source distance of the controlling source in 2011 (Run7) is much shorter than the one in 1979 (R1). The final design coastal flooding will be integrating all parameters provided in Table 5/4.11.

Table 5/4.11 – Comparative Table of Tsunami Parameters determined by different Akkuyu NPP Site studies

Characteristics	METU 1979 [5/19]	MorTransProject [5/18]	METU 2011 [5/17]
Maximum positive tide, m	0.7	0.3	0.15
Maximum wave setup*, m	2.4	1.76	1.74
Maximum positive tsunami wave height, m	3.2	3.55	7.54
Long term sea level rise, m	-	-	1.00
Barometric and Coriolis Effects	-	-	0.14

** including wind setup*

The Istanbul Technical University Department of Geological Engineering was contracted by WorleyParsons in order to conduct paleotsunami studies in Akkuyu and near-by area. This information will be included in the Site Parameters Report and also will be taken into account to determine PMT value.

All tsunami hazard analyses presented here are provided in order to demonstrate that the tsunami hazard assessment of Akkuyu NPP site has been performed with care following the highest professional practice and standards and using different expert groups that represent the epistemic uncertainty in different way. Ultimately the tsunami design characteristics that will find place in the Site Parameters Report will be determined with the integration of all that knowledge in order to provide for a robustly determined design basis.

5.4.12.2 Seiches

Seiches are long-period standing oscillations in an enclosed basin or in a locally isolated part of a basin [5/34]. Abnormal oscillations of the water level occur with a period of approximately a few minutes to a few tens of minutes depending on the forcing energy input to the basin, and the topography of the basin. The amplitude of the forcing fluctuations may be anything from a few ten centimeters up to around 2 m. Within the framework of the METU study [5/17] a seiche hazard analysis has been performed for Akkuyu NPP site. The study domain for the numerical applications is chosen as bounded by the longitudes 32.104° E and 35° E and the latitudes 34.7125° N and 36.3958° N. The grid size is selected as 150 m.The time step chosen for the application is 0.10sec. and the computations are carried out for duration of 440 min in real time.

The approximate values of the periods of seiche oscillations in Anamur Cyprus Island channel can be selected from the peaks of the spectrum curves of the water surface elevation data of each record. The preliminary estimations of the periods of seiche oscillations for Akkuyu region (in Anamur Cyprus Island channel) can be estimated as 47, 46, 43, 41, 39, 35, 32, 31, 28, 26 minutes. According to the performed simulations [5/17] it is expected that in case there are seiche oscillations within the Anamur – Cyprus Island channel, the initial wave would be amplified in the region of Akkuyu NPP site approximately 2-2.5 times. In any case the seiche induced wave height will be lower than the one generated from a tsunami event.

5.4.13 BATHYMETRY, SEDIMENTATION AND SEE CURRENTS AT AKKUYU BAY

5.4.13.1 Bathymetry

Fugro Seastar 8200 DGPS equipment was used during survey in order to supply accurate and precise positioning data with decimeter level of accuracy. Positioning data was transferred to IXSEA MRU continuously with a serial connection to gather precise heading data.

Bathymetry survey resulted in bathymetry charts in DWG and PDF format with 1/500 (up to 50 m WD), 1/1000 (more than 50 m WD) and 1/5000 (all area) scale which are enclosed in materials by Principal’s Contractor [5/12]. Chart list names and distribution for 1/500 and 1/1000 scale are shown in Figure 5/4.19.

WD is about 10m at the entrance of the western bay whereas WD is about 22 m at the entrance of eastern bay. There exists a shallow section in between Beşparmak Island and mainland at the eastern part of the survey area where as the WD decreases to ≈22 m at this section. At the eastern entrance of the area in between Beşparmak Island and mainland water depth is about 70 m and decreases rapidly to 22 m in the mid of mainland and Beşparmak Island. At the southwest of the survey area the WD is about 113 m and it is about 109m at southeast corner of the survey area.

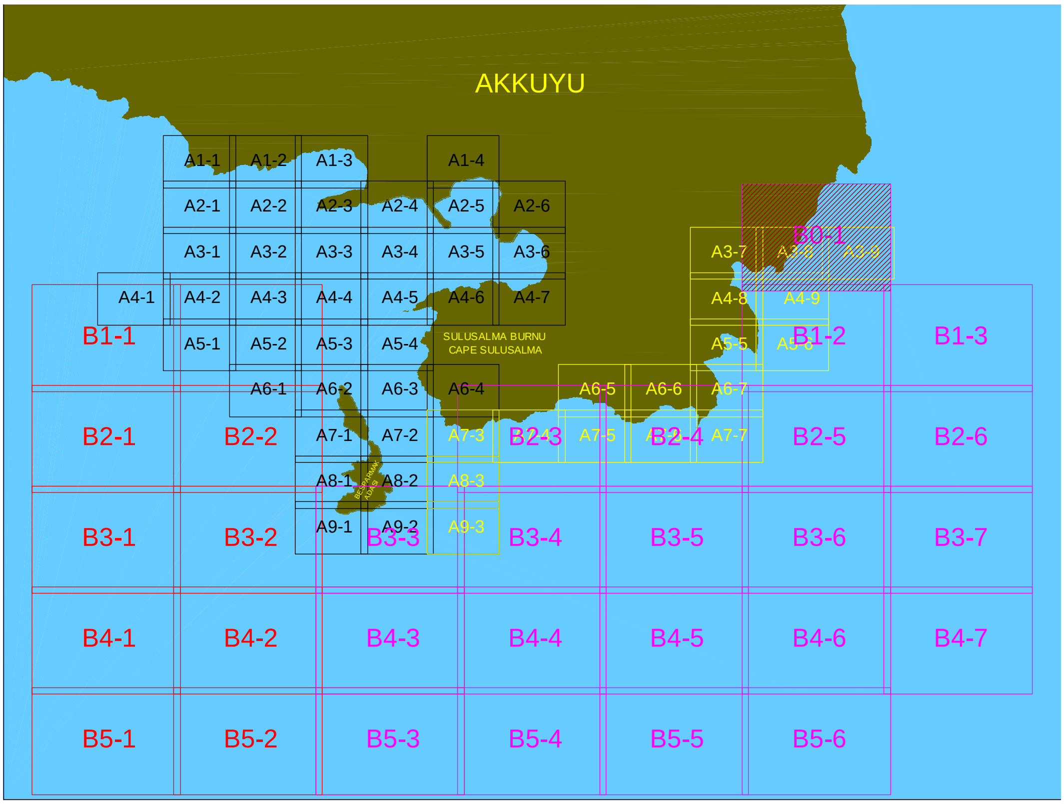


Figure 5/4.19 – Chart Names and Distribution for 1/500 and 1/1000 Scale

5.4.13.2 Bottom Gradient in the Shallow Zone

In order to evaluate the bottom gradient in the shallow zone 3 profiles were extracted from MB Bathymetry Data (1 profile for western bay and 2 profiles for eastern bay) as shown in Figure 5/4.20).

Wbay line representing the bottom profile along the western bay has 1526.8m of length with the azimuth of 250°.

Ebay1 line representing the bottom profile along the eastern bay has 1056.1m of length with the azimuth of 250°.

Ebay2 line representing the western bottom profile along the eastern bay has 1180.2m of length with the azimuth of 250°.

Bottom gradients along Wbay are represented at Figure 5/4.21.

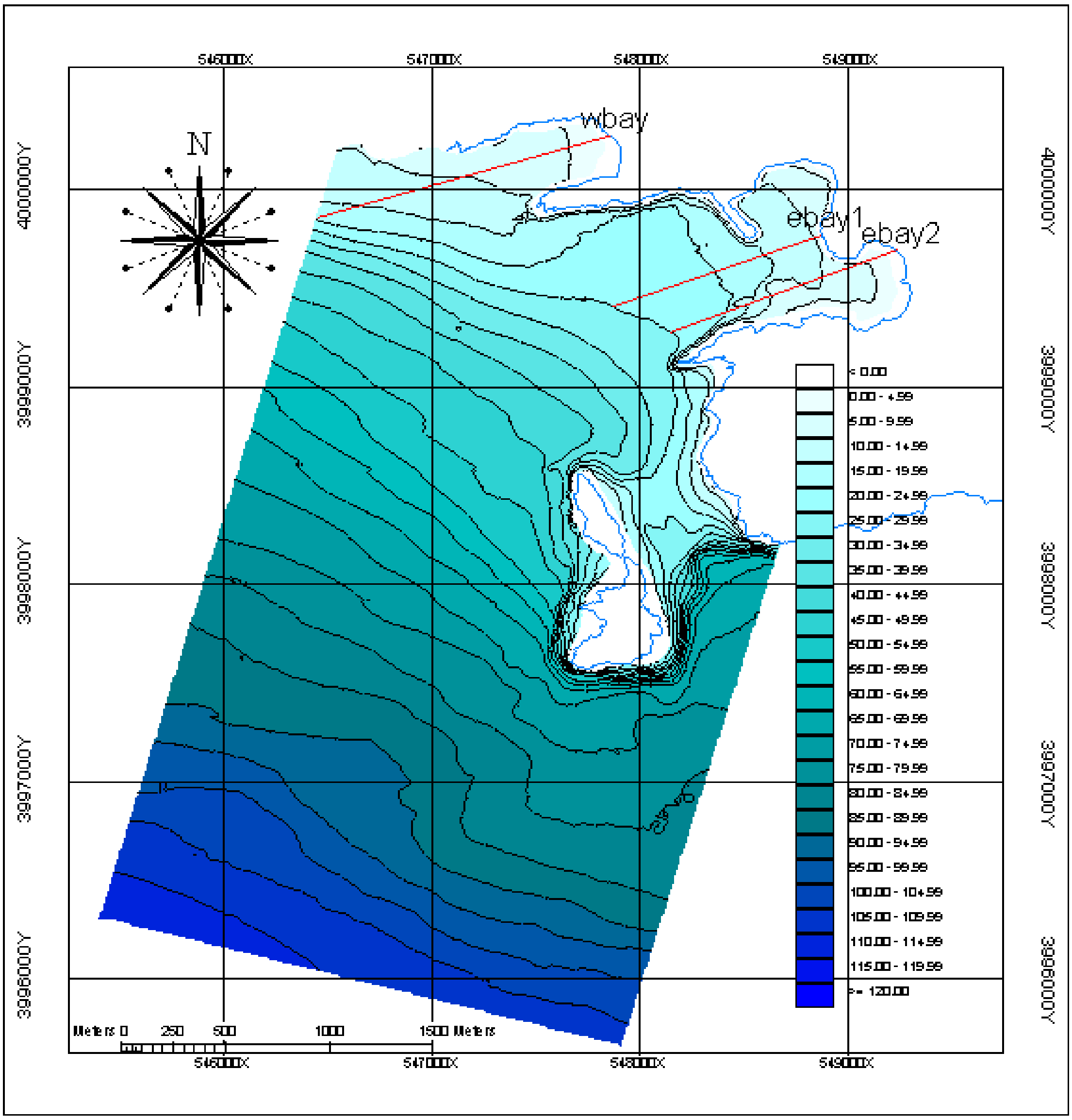


Figure 5/4.20 - Profiles for the Evaluation of the Bottom Gradient in Shallow Zone

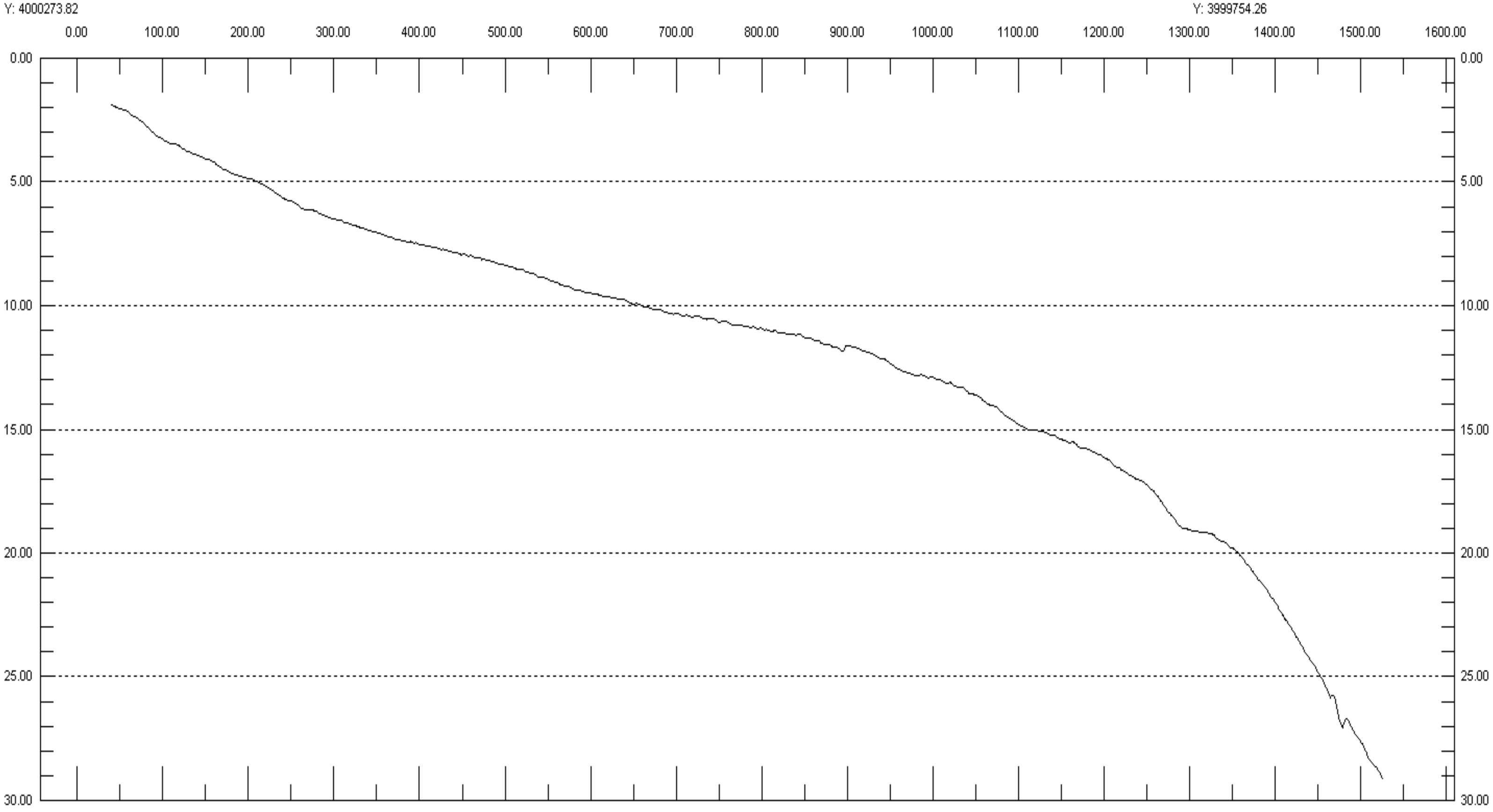


Figure 5/4.21 – Bottom Gradient Along Western Profile (Wbay)

5.4.13.3 Types of Bottom Processes in the Currents and Deformation Processes of the Seabed and the Akkuyu Bay Coast in the Site Vicinity, Dynamics of Currents in the Coastal Zone, the Characteristics of Displacement Currents Along the Shore, Shore Slope Deformation, Seasonal Reshaping of the Shoreline Profile

Two of three bays located at east and west side of the Akkuyu NPP site have sandy beaches. The surface runoff during precipitation to the sea is from these bays. The sediment suspension and bed load by surface run off is not significant. Since the climate in the region is hot and there is no rain during summer season, any significant sediment input from land to the sea is not expected. Hence the main activity of the topography and bathymetry change (deformation processes) nearby NPP site depends mainly on the wind at sandy land areas and the long shore current and other wind or tide induced circulation system in the sea areas. The long shore and cross shore (onshore offshore) sediment transport (bed load and or suspended sediment transport) occur in the east and west bays of NPP site. In order to describe the seasonal change of the sea bottom, the recent measurements taken in July 2011 and October 2011 can be analyzed.

In order to assess the coastal zone deformation near the NPP location 3 predefined coastal areas as shown in Figure 5/4.22 were surveyed with RTK positioning system. Each survey area was surveyed from minus 1 m WD to 1 m elevation.

In order to perform the topographic survey, reference benchmarks in the survey areas were located and LEICA SYSTEM 12OO GPS was installed on reference benchmark N.002.

VHF modem was used to send RTK corrections to rover station and to record the height data in range between minus 1 m and 1 m height accordingly.

When the ground elevation measured in July 2011 is subtracted from the ground elevation taken in October 2011, the net change (erosion and deposition areas) can be determined. Figure 5/4.22 shows those areas in three bays (measurement areas).

The typical summer profiles (accumulation of sand by cross shore weak waves) of the coastal areas are seen in this figure. It is seen from these figures that the onshore offshore sediment movement is dominant in summer time in the region.

When the morphology related to sediment accumulation in the east and west bays are examined, it is seen that there is no significant magnitude long shore sediment transport. When the old morphology of the central bay (harbor area) is taken into account, the small area consisted of coarse sediment is accumulated in the last 25 years. It shows weak sediment transport in the central bay. But the sediment transport up to 10 m water depth in cross shore direction leads to seasonal changes of the sea bottom topography.

During strong storm the sea bottom sediment movement can be expected at up to 25 m water depth.

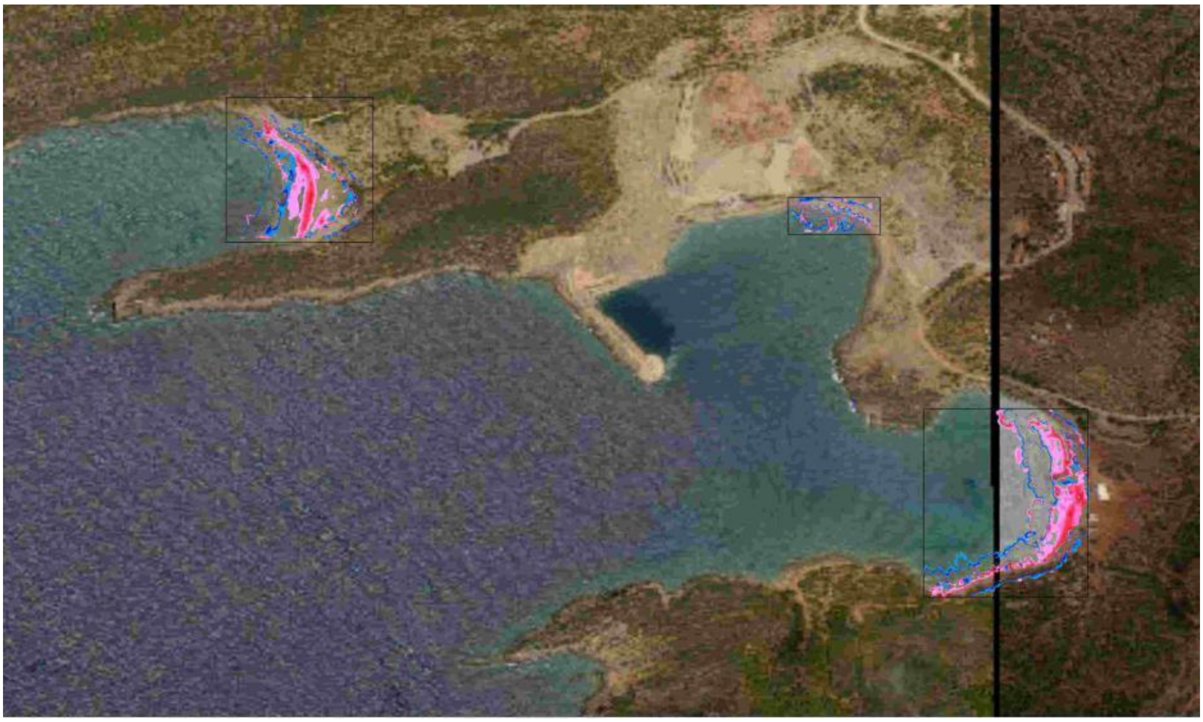


Figure 5/4.22 - Close Up View of the Bathymetry and Topography Change Between July 2011 and October 2011 (Red Areas Are Deposition and Blue Areas Are Erosion Areas)

5.4.13.4 Currents

The current measurements have been conducted during the Physical Oceanography Studies performed by METU Institute of Marine Research Center (May, 1979*a*, 1984) and Model Studies of Cooling Water Sea Intake and Outlet of Akkuyu NPP (*Ciray et al.*, 1980) [5/11].

According to the general characteristics of the eastern Mediterranean and morphological, meteorological, hydrodynamic and hydrological characteristics of Akkuyu region, the currents generally are generated by means of tide, wind and density variations. The local current patterns at the site depend on tidal flow, wind-driven circulation and morphological characteristics.

Observations of overall current patterns in and around the bay were carried out using moored current meters at two stations and also by lagrangian measurement by tracking drogues. Drogues of different depths 5 m, 10 m, 15 m were used. Duration of tracking varied between 4 and 10 hours for each run.

A sample flow pattern under the wind from NE with 10-15 knots on December 21, 1977 at 15:15-16:20 is shown in Figure 5/4.23 METU (1979) [5/19] from drogue measurements made between November 1977 and June 1978.

The current patterns observed using drogues indicate a system of currents which is influenced by several factors: local winds, tide, geometry of the site, and possibly, large-scale oscillations in this section of the Mediterranean.

The data show that the highest average current speeds occur between the islands and the shore, and also offshore of the mouth of bay south of İnceburun. This is as expected, because of the channelization of flow in this region. Very low speeds, 2-5 cm/s were common in the smaller bay, north of İnceburun, which are due to blockage of flow by the coastline mouth of the bay.

The data also show that in general the speeds are smaller at 15 m than at 10 m or 5 m depths; however, this is not always the case. As it has already been stated, the Dec, 21 data shows a 17.3 cm/s flow at 15 m water depth, while at the same location the speed at 5 m depth was 15 cm/s. The current direction shows an extreme variability (Figure 5/4.23).

According to the information based on limited duration of current measurements in Akkuyu Bay, it seems that the current speeds are sufficiently low and don’t show large differences at various depths. These currents are not sufficient for sediment transport but they are one of the probable causes of mixing, dispersion and convection in the bay.

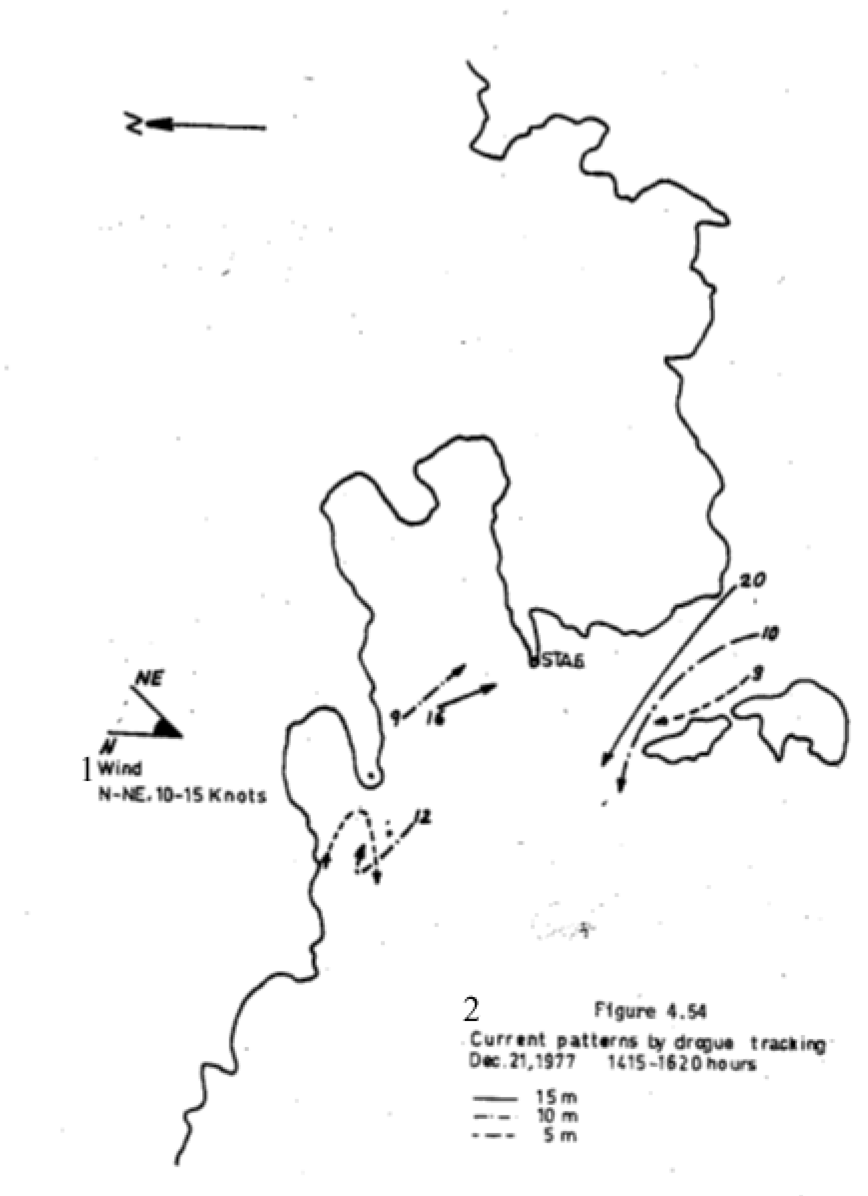


Figure 5/4.23 – A Sample Flow Pattern Under the Wind From NE With 10-15 Knots on December 21, 1977 At 15:15-16:20

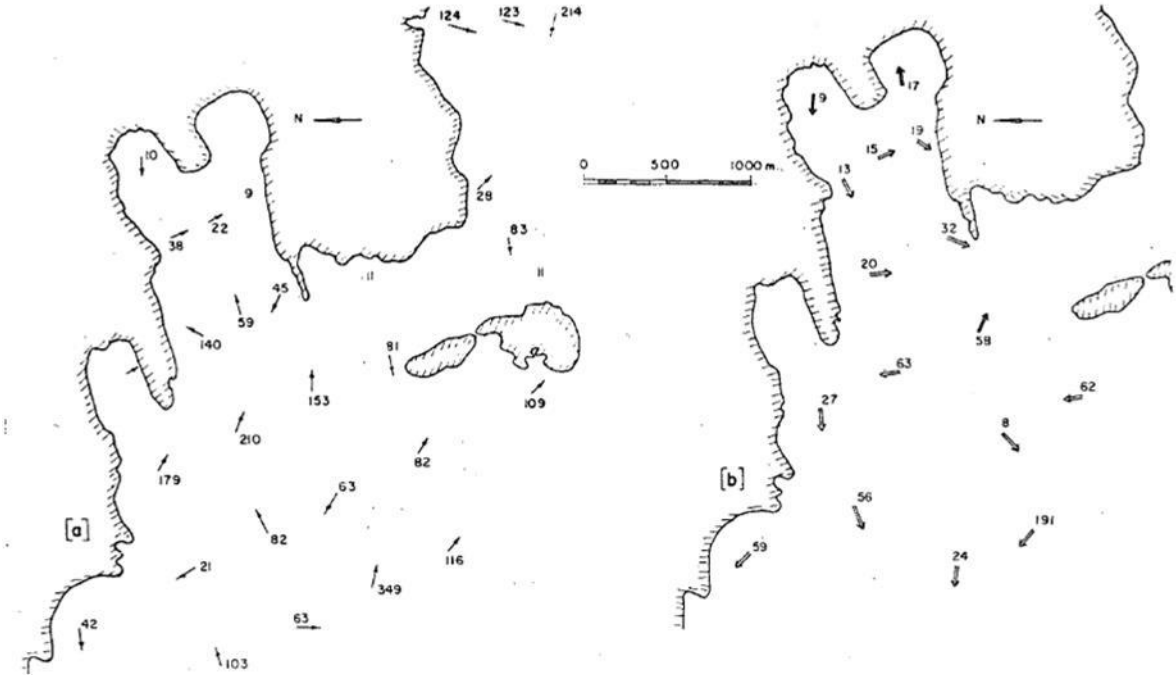


Figure 5/4.23 – Current Characteristics of Akkuyu Bay; 0.5 m Below the Surface (A), 1 m Above the Bottom (B) (METU, 1979a) [5/35]

The mean current sweeping at the mouth of Akkuyu bay is small in magnitude. It is westerly current whose speed rarely exceeds 5 cm/s. The weakness of the flow is attributable to the blocking effect of headlands such as Sulusalma Cape on the external mean westerly motion that is generally of greater intensity.

The coastline configuration and flow separation due to the presence of headlands such as Sulusalma Cape are expected to contribute further to the formation of small gyres in and around Akkuyu bay.

The weakness of the mean flow, high intensity reversing currents and the existence of gyres, all point out to the possibility of the local trapping and slow dispersion of local wastes and accidental releases resulting in long residence times of materials introduced externally.

While the westerly mean flow is detectable at the relatively smooth coastline extending from Mersin to Göksu river, its magnitude is found to be significantly reduced in the near shore areas west of the Göksu river delta.

In order to evaluate the current structure of Akkuyu Bay, three stations were installed in 2011 to monitor the current speed, current direction and other parameters to observe the water circulation in Akkuyu Bay (Figure 5/4.24).

Location of RDCP1 is selected to monitor the nearshore currents at eastern bay, location of RDCP2 is selected to monitor the nearshore currents at western bay, location of RDCP is selected to monitor the general current structure of the Akkuyu Bay. Collected data for each current measurement station are given in materials from Principal's Contractor [5/3].

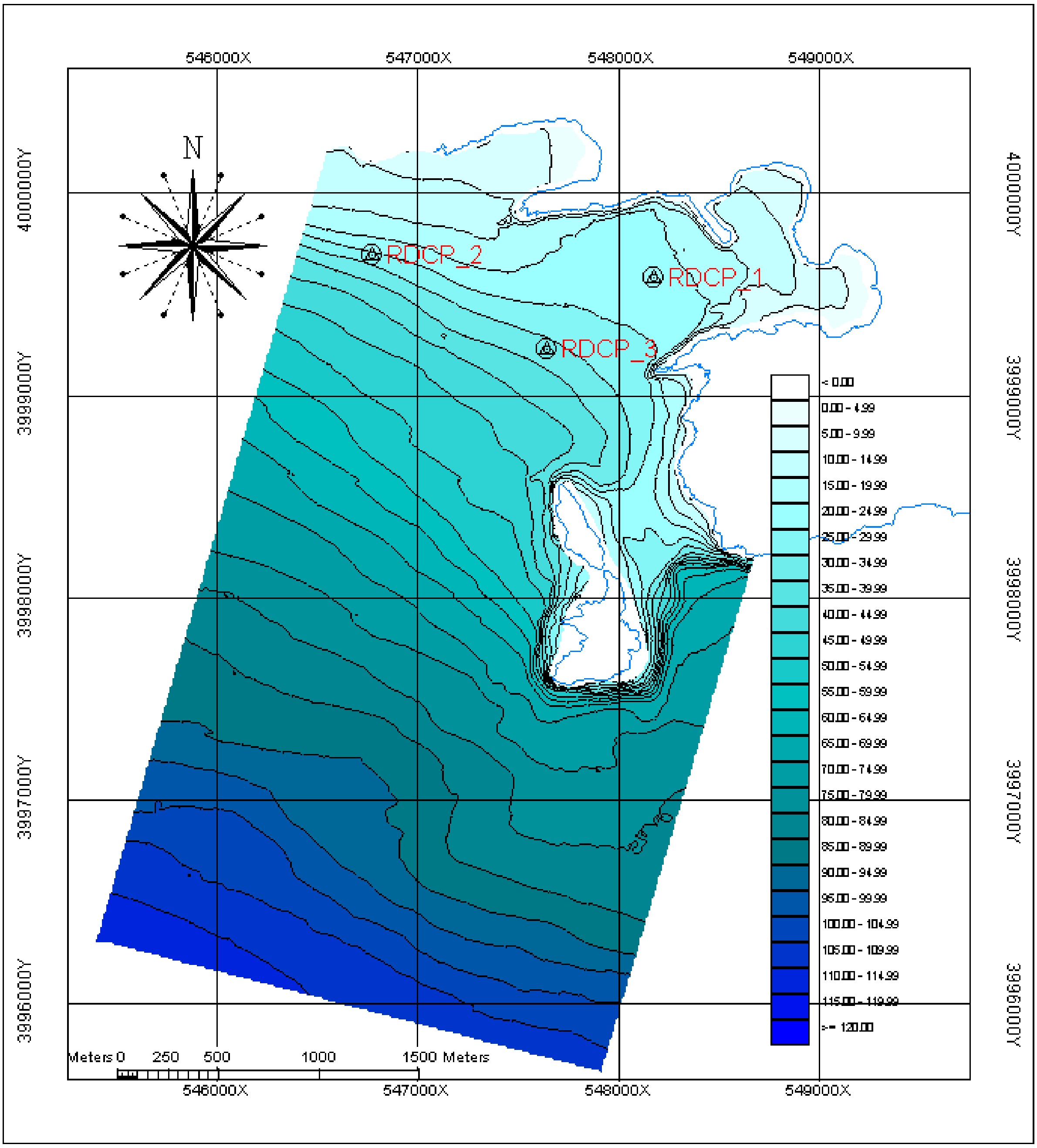


Figure 5/4.24 – Location of Current Measurement Stations RDCP-1, RDCP-2, RDCP-3

2011 current monitoring results point out that it may be considered that continuous water exchange occurred along the water column also during the strong winds.

During this measurement period surface current shows a typical pattern such that surface current is towards the N-NE-E inside to eastern bay generally between 09:00-23:00 and during night time current is directed out of Akkuyu Bay to S-SW direction especially under the influence of strong sea breeze system.

Surface current speeds are mainly affected by wind formation of the survey area especially during autumn time with strong winds.

It is considered that during strong southern winds with long fetch distances, although the surface current is directed towards to the inside of Akkuyu Bays, the current exchange continues in the mid water column along both directions at lower speeds. On the other hand during strong northern winds, surface current is directed to the south (out of Akkuyu Bay) and the current exchange continues in the mid water column along both directions with lower speeds

While surface currents reaches up to 130 cm/s in the area depending on the wind speeds, current speeds at the bottom and mid layer can reach up to 40 cm/s in the area. It is considered that the shoreline formation is also one of the main elements effecting the current direction in the area.

5.4.13.5 Turbidity and Bottom Sediments

No survey was performed previously in the area in order to investigate the turbidity of sea water in the area.

During the present study water samples were collected from 10 locations. Results of turbidity measurement are given in Table 5/4.12.

Table 5/4.12 - Results from Turbidity Measurements

Station	Water Layer, g/m^3	
	Surface	Deep
1	1.85	1.38
2	1.30	<MDL
3	1.30	1.93
4	1.28	1.84
5	0.93	1.14
6	1.58	1.15
7	1.70	1.93
8	1.85	0.60
9	0.72	1.33
10	1.34	1.78

The flows of drift suspension at nearshore area close to Akkuyu NPP site are investigated determining the representative annual wave climate of the region and approximating the amounts of sediment transported alongshore under the action of these waves assuming a straight shoreline with parallel bottom contours. The resulting bottom slope around 5 m water depth is 0.061.

To investigate alongshore sediment transport rates at the Akkuyu NPP site due to wind waves from different directions in a year, a probabilistic approach is utilized for the wind wave data. Effects of smaller but more frequent waves are considered to be more appropriate to use rather than higher waves with less frequency.

The representative deep water wave parameters for the directions from the sea between ESE and W, are computed and given in Table 5/4.13.

For the calculation of alongshore sediment transport rate, several mathematical expressions are available. Among those the most commonly used formulas are 1) the CERC formula (Q) (SPM, 1984), and 2) the Kamphuis (1991) [5/11] formula:

$$Q = \frac{K}{16 \cdot (\rho_s /(\rho - 1) \cdot (1-p)} \cdot \sqrt{\frac{g}{\gamma_b}} \cdot H_b^{5/2} \cdot \sin(2\alpha_b)\text{, m}^3\text{/s CERC Formula,}$$

where:

- Q is the volume of sediment moving alongshore per unit time;
- *K* is the dimensionless empirical proportionality coefficient presented by SPM (1984) [5/11]. In recent studies, Schoonees and Theron (1993, 1996) [5/11] reexamined the 46 most reliable of the 240 existing field measurements that have been compiled to determine a K value of approximately 0.2;
- ρ_s is sediment density taken as 2.650 kg/m^3 for quartz-density sand;
- ρ is the water density (1.025 kg/m^3);
- g is the gravitational acceleration (9.806 m/s^2);
- p is the in-place sediment porosity taken as 0.4.

The breaker index (γ_b) is taken as 0.78 for flat beaches.

Table 5/4.13 - Deep Water Significant Wave Parameters Exceeding 12 Hours in a Year for All Directions and Respective Closure Depths [5/11]

Direction	Deep Water Significant Wave Parameters,12 hrs/yr		Closure Depth, D_c, m	
	$H_{s0.12}$, m	T_s, s	(Hallermeier, 1978)	(CUR, 1990)
ENE	2.45	6.34	4.54	3.92
E	1.53	5.00	2.83	2.44
ESE	0.83	3.68	1.53	1.32
SE	0.71	3.42	1.32	1.14
SSE	0.56	3.04	1.04	0.90

Direction	Deep Water Significant Wave Parameters,12 hrs/yr		Closure Depth, D_c, m	
	$H_{s0.12}$, m	T_s, s	(Hallermeier, 1978)	(CUR, 1990)
S	1.08	4.21	2.00	1.73
SSW	2.18	5.98	4.04	3.49
SW	3.31	7.37	6.14	5.30
WSW	5.49	9.49	10.18	8.79
W	3.63	7.71	6.72	5.80

H_b and α_b are the significant breaking wave height and breaking wave angle respectively. Breaking wave heights and breaking approach angles of the representative deep water wave parameters of the respective directions are obtained from the breaking charts given in SPM (1984).

$$Q = 7.3 \cdot H_b^2 \cdot T^{3/2} \cdot m_b^{3/4} \cdot D_{50}^{-1/4} \cdot \sin^{3/5}(2\alpha_b),\ m^3/s \qquad \text{Kamphuis Formula.}$$

In the formula, median particle size in surf zone (D_{50}) is assumed to be 0.2 mm with respect to recent sediment samples taken from the site and the beach bottom slope (m_b) at the depths of breaking taken as 0.061 for the site. The in-place sediment porosity is taken as 0.40.

The gross amount of sediment transported alongshore at the Akkuyu NPP site in a year is approximated as 449416.1 m^3 and 212036.5 m^3 according to CERC and Kamphuis formulas, respectively. It is also seen that the amount of sediment transported from E to S directions are not significant compared to the amounts of sediment transported from SSW to W directions, hence, the net amount of sediment transported alongshore at the Akkuyu NPP site in a year is approximated as 444894.5 m^3 and 209799.5 m^3 from West to East according to CERC and Kamphuis formulas, respectively.

The depth beyond which no significant long shore or cross-shore transports take place due to littoral transport processes is called as the closure depth (Karsten, 2004 [5/11]).

As it is seen from Table 5/4.13, the closure depth for the project area is less than 10.2 m which is the closure depth for the dominant wave direction, WSW. The littoral transport under wave action for all directions beyond this depth is expected to be insignificant.

In order to evaluate the sediment distribution of the Akkuyu Bay, sediment samples were collected at 30 locations and subjected to laboratory analysis.

To determine the grain size distribution of the Akkuyu Bay; Sieve/Hydrometer Analyzes have been used. Laboratory test results and sediment distribution map with 1/5000 scale are available in [5/6] and [5/7], respectively.

According to the test results, it is determined that the seafloor is mainly composed of sandy material in the shallower areas which are closer to the shoreline. On the West Bay side that is represented by Stations GEO-4, GEO-5, GEO-6, the main sediment type has been found as Silty

Sand (SM) from approximately 800 900 m from the shoreline to the offshore. On the middle section of the study area and the western part of the East Bay similar conditions observed. The sediment type of the seafloor is found as SM from the shoreline to the 25 m of water depth (Stations GEO-2, GEO-3, and GEO-7). Although it has been also classified as sand, as it can be seen from the stations GEO-1 and GEO-8, the seafloor of the eastern part of the East Bay is mainly composed of poorly graded, uniform sand with little or no silt (SP). To the offshore part of the project area, main bottom sediment type is grading to silt (ML). Except stations GEO-16 and GEO-26 which are described as silty sand and located in between the Beşparmak Island and the mainland and very close to the southern cape of the island accordingly, all of the middle and southeast part of the area is covered by silt. Within the limits of silt dominated areas, the sand portion of the bottom sediments increases gradationally when it is closer to the shore or the Beşparmak Island as it is expected. The effect that the wind and wave action has on the rocks forming the shoreline, causes fragmentation and the size of the soil particles consisting by that erosional process, decreases gradationally to the offshore. The test results indicate that, on the stations GEO-10, GEO-17, GEO-20, GEO-25, GEO-27, GEO-28 and GEO-29 the seafloor is consisting of Sandy Silt. These stations are closer to the shoreline or the island located in the eastern part of the project area. On the other hand, the sediment samples from stations GEO-12, GEO-13, GEO-14, GEO-18, GEO-19 and GEO-22 which are further away from the shore are classified as Silt. The bottom type of the stations exactly in between these is determined as Silt with Little Sand. On the southwest part of the area, there are three stations (stations GEO-23, GEO-24, GEO-30) where the seafloor is classified as Low Plasticity Clay (CL) The location of the clayey seafloor shows again that, the grain sizes are getting finer gradationally from the shoreline to the offshore part in the project area.

Highest amounts of dolomite are encountered in sample no 20 and 26. These samples should have been affected by dolomitization processes. Presence of dolomite indicates high amounts of Mg. It can be interpreted that meteoric water enriched with Mg circulates in the environment.

Two carbonate minerals prevail in recent sediments, orthorhombic aragonite and trigonal calcite. Calcite shows marked differences in the magnesium content. Low-Mg calcite (LMC) and High-Mg calcite (HMC) are usually separated by a value of 4 mol % MgCO, The mineralogical composition of modem carbonate sediments depends on that of the skeletal and non-skeletal grains and the mineralogy of early cements. Common minerals are aragonite, magnesian calcite, followed by subordinate minerals like calcite and dolomite. Stable Low-Mg calcite dominates in many non-marine carbonates and is by far the most abundant carbonate mineral in deep-sea carbonates. The mineralogical composition of tropical and non-tropical shelf carbonates is strongly controlled by water temperatures. Shallow-marine tropical carbonates are mainly composed of metastable aragonite and calcite with high Mg concentrations. Non-tropical carbonates consist predominantly of High-Mg calcite (and minor aragonite) in shallow warm-temperate settings, and HMC and LMC in cool-temperate environments" (Flugel, 2004 [5/11]).

5.4.13.6 Velocities and Directions of Flows in the Nearshore Zone during High Water and Low Water, on the Surface and in Depths

Surface and bottom current speed and directions are extracted from RDCP1 and RDCP2 location (Figure 5/3.7) during high and low water times.

During high tides, average bottom current speed is 5.75 cm/s for RDCP1 location and 8.08 cm/s for RDCP2 location. Maximum bottom current speed is measured as 29.01 (305.46^{o}) cm/s for RDCP1 and 20.80 cm/s (275.73^{o}) for RDCP2 during high tide. Minimum bottom current speed is measured as 0.52 cm/s (23.56^{o}) for RDCP1 and 0.59 (56.54^{o}) for RDCP2 during high tide.

During high tide times, average surface current speed is 56.93 cm/s for RDCP1 location and 56.71 cm/s for RDCP2 location. Maximum surface current speed is measured as 80.46 (256.31^{o}) cm/s for RDCP1 and 91.76 cm/s (284.33^{o}) for RDCP2 during high tide. Minimum bottom current speed is measured as 3.88 cm/s (221.35^{o}) for RDCP1 and 7.39 cm/s (25.34^{o}) for RDCP2 during high tide.

As it could be seen from the high tides bottom current scatter graph for RDCP1 location, current direction does not show a dominant direction.

As it could be seen from the high tides bottom current scatter graph for RDCP2 location, current direction is mainly distributed through the northern directions most dominant in NW and NE section.

As it could be seen from the high tides bottom current scatter graph for RDCP1 and RDCP2 location, most of the measurements are distributed through NW-E sections. It is considered that the dominant wind directions may be the main parameter effecting the surface current direction at high tides.

According to the data it is observed that during low tides, average bottom current speed is 6.76 cm/s for RDCP1 location and 6.87 cm/s for RDCP2 location. Maximum bottom current speed is measured as 19.94 cm/s (289.71^{o}) for RDCP1 and 17.9^{o} (277.89^{o}) for RDCP2 during low tide. Minimum bottom current speed is measured as 1.31 cm/s (345.26^{o}) for RDCP1 and 0.34 cm/s (346.97^{o}) for RDCP2 during low tide.

During low tide times, average surface current speed is 50.89 cm/s for RDCP1 location and 54.67 cm/s for RDCP2 location. Maximum surface current speed is measured as 76.76 cm/s (65.08^o for RDCP1 and 90.70 cm/s (269.85^o) for RDCP2 during low tide. Minimum bottom current speed is measured as 3.34 (331.6^o) cm/s for RDCP1 and 1.36 (302.23^o) cm/s for RDCP2 during low tide.

As it could be seen from the low tides bottom current scatter graph for RDCP1 location, although current direction does not show a dominant direction maximum currents occurred at southern directions.

As it could be seen from the low tides bottom current scatter graph for RDCP2 location, current direction does not show a dominant direction.

As it could be seen from the low tides bottom current scatter graph for RDCP1 and RDCP2 location, the directions are distributed across the NW - SE axes.

Characteristics dealing with drainage areas, hydromorphological characteristics of drainage systems and channels are reported in the relevant Design (General Layout) section of this document.

Specifics of vegetation are reported in the relevant (Ecological Effects – Chapter 7) chapter of this document.

Data collected for the sea coast doesn’t contain information earlier than the last 50-years period, because the Turkish side doesn’t have such information for their sea coast.

5.5 CONCLUSION

The report provides data on the hydrological conditions at and around Akkuyu NPP site. Long-term data (more than 20 years) of maximum and average precipitation at two nearby stations have been analyzed and probabilistic extreme precipitation values have been estimated.

On-site precipitation measurements have started in 2011. Their results will be analyzed and compared with the data from the nearby stations in the Site Parameters Report. A study was performed to analyze the availability of drinking and utility water. Although preliminary results show that sufficient water resources with adequate water quality would be available from existing wells and springs in the vicinity of the site, a desalination facility at the Akkuyu site is planned to be constructed. Service water supply will be assured by direct intake from the Mediterranean Sea and subsequent discharge back to the sea. For this purpose, studies were performed to analyze the quality of the seawater with regard to chemical composition and water temperature. Potential contamination of seawater due to regular, small routine liquid releases as well as gas-aerosol discharges from the NPP has been studied. Dispersion calculation of such releases has been performed applying mathematical methods. These calculations were supported by sea water currents measurements in and around the Akkuyu bay.

Flooding of the Akkuyu site was investigated by considering the following scenarios: effects of local Probable Maximum Precipitation (PMP), Probable Maximum Floods (PMF) on streams and rivers, potential dam failures, probable maximum surge and seiche flooding, probable maximum tsunami and channel diversion flooding. Each of these flooding scenarios was investigated in conjunction with other flooding and meteorological events, such as wind generated waves, tides etc.

From the evaluations performed it is clear that the potential for the flooding of the site is due to tsunamis. Because of this reason, the combination of concurrent flooding scenarios have been performed in relation to the tsunami hazard assessment.

It can be concluded that as a result of the performed analyzes there are no adverse hydrological conditions that may in any way jeopardize the safety of Akkuyu NPP or provide a basis for significant radiological impact of the plant to the environment. The design basis flood parameters of Akkuyu NPP site will be based on the ongoing flood analyzes studies and will be provided in the Site Parameters Report.

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