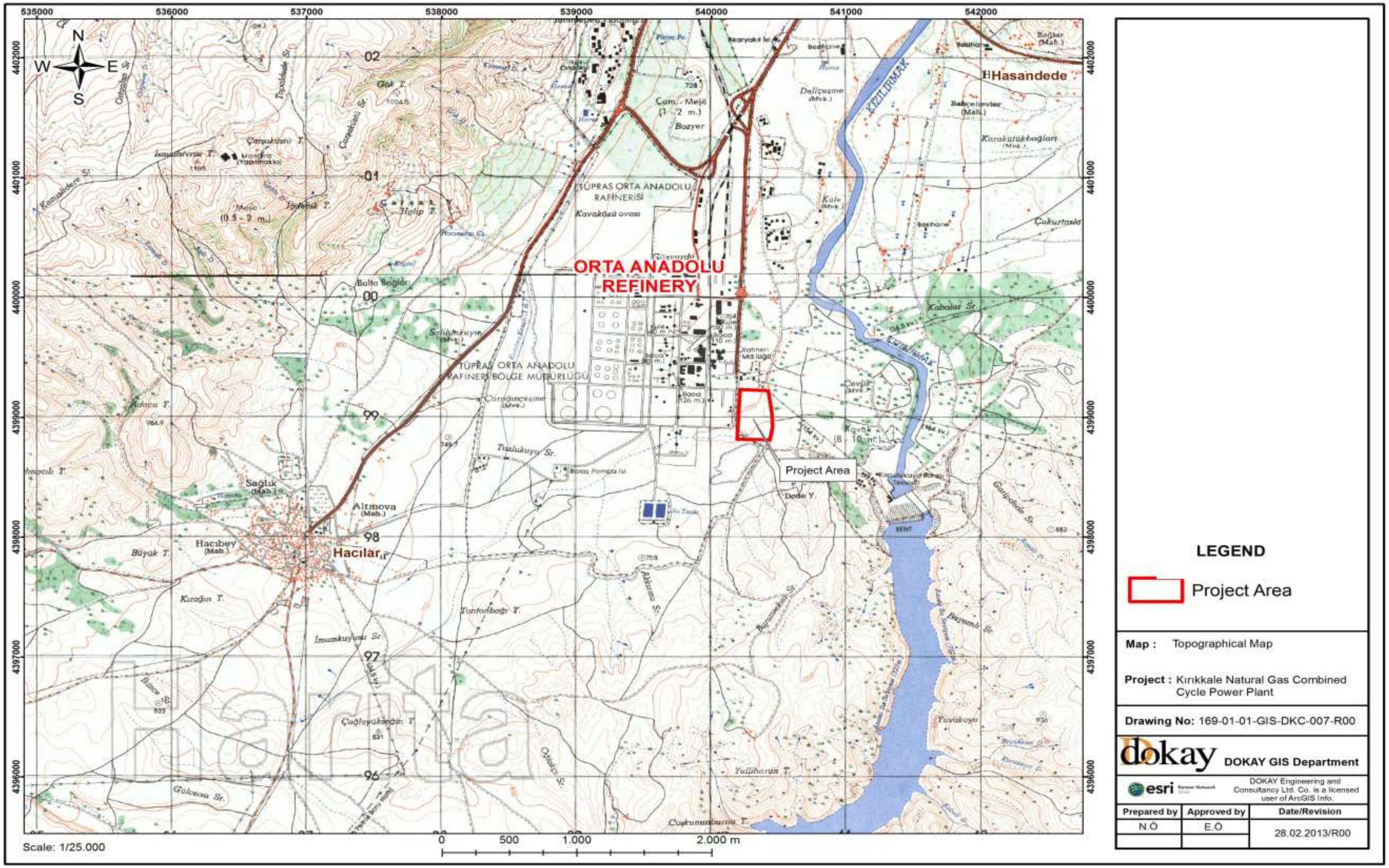
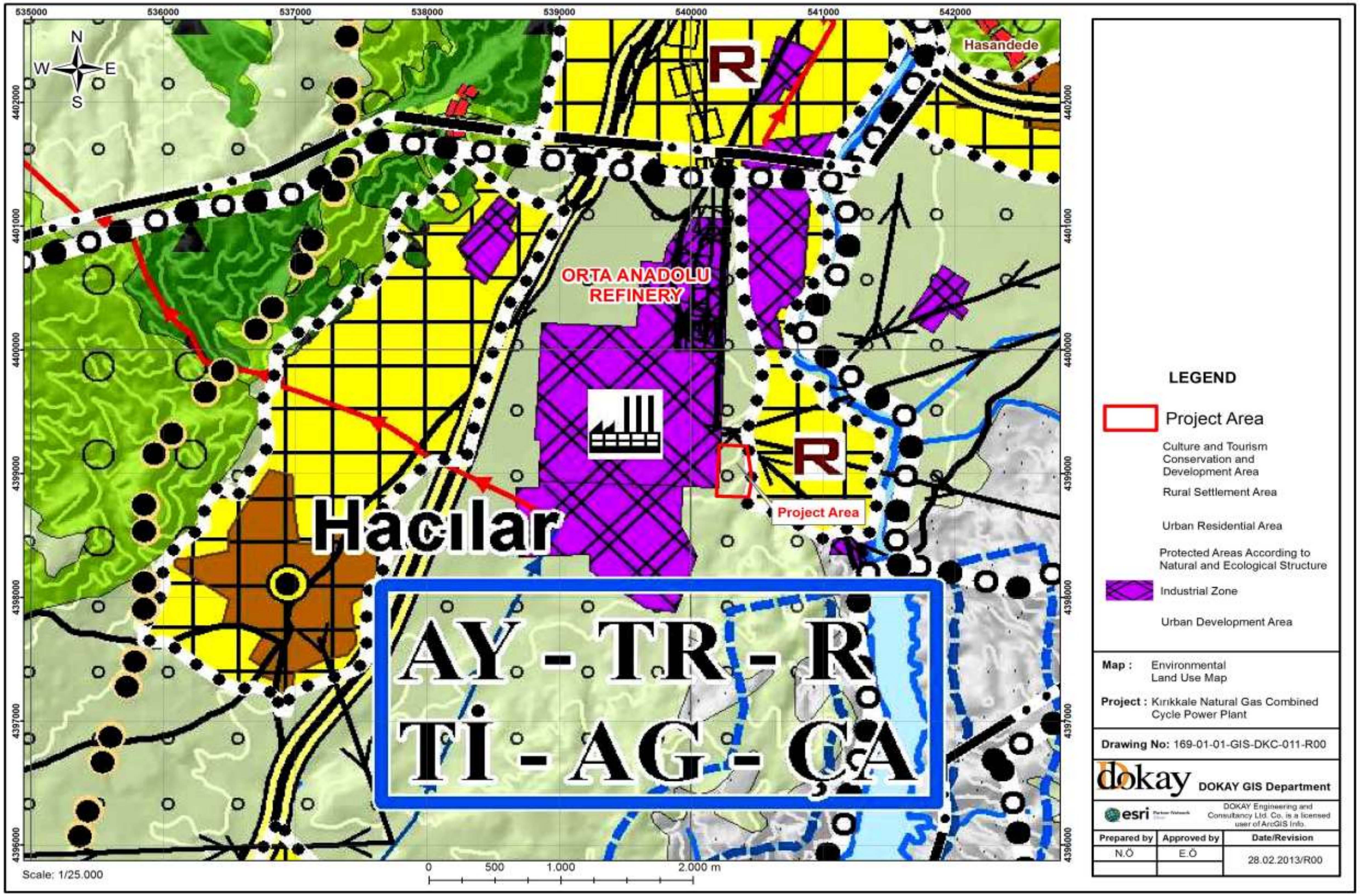
Annex A

Maps

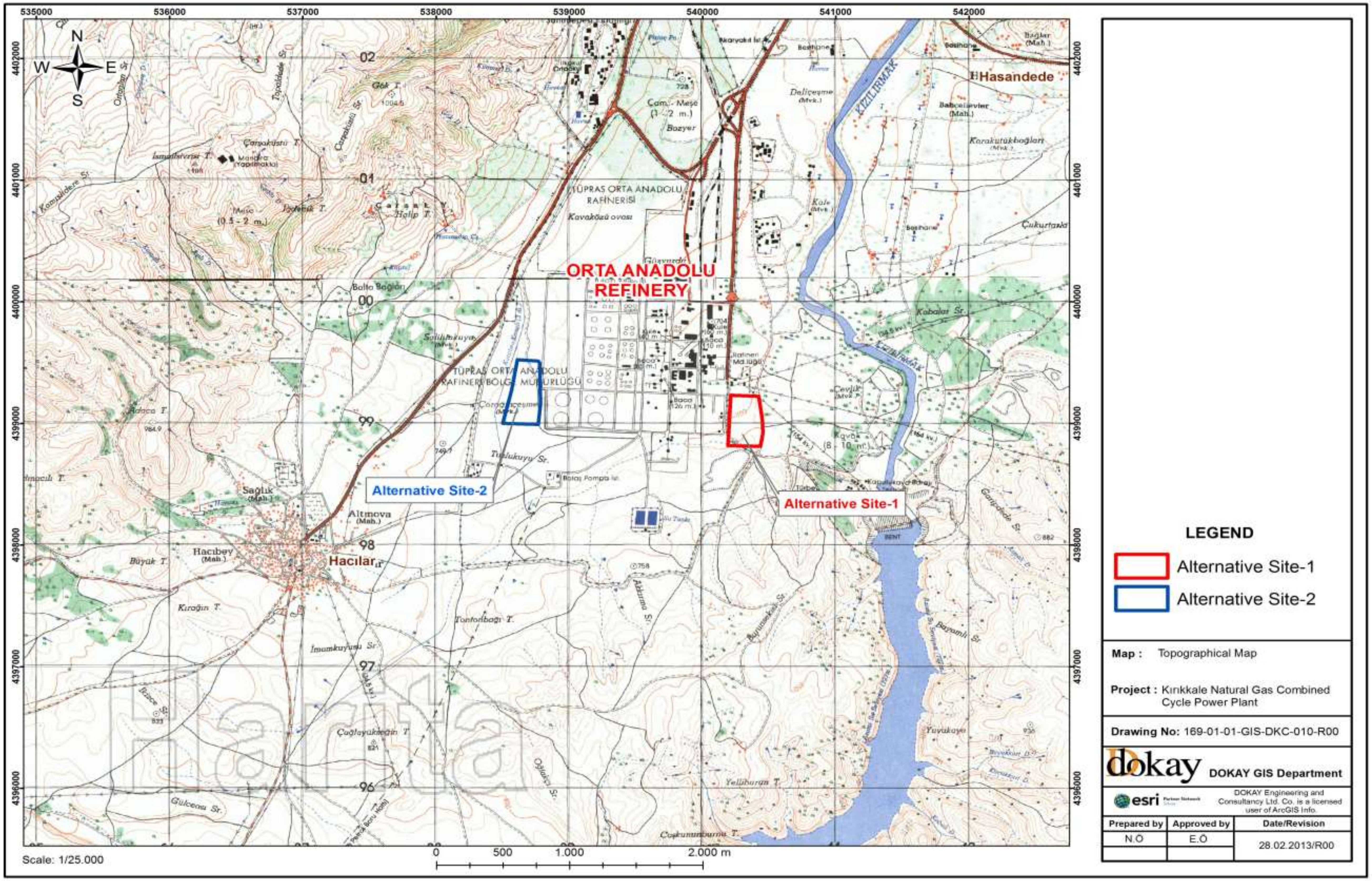
1. Topographical Map of the Project Area



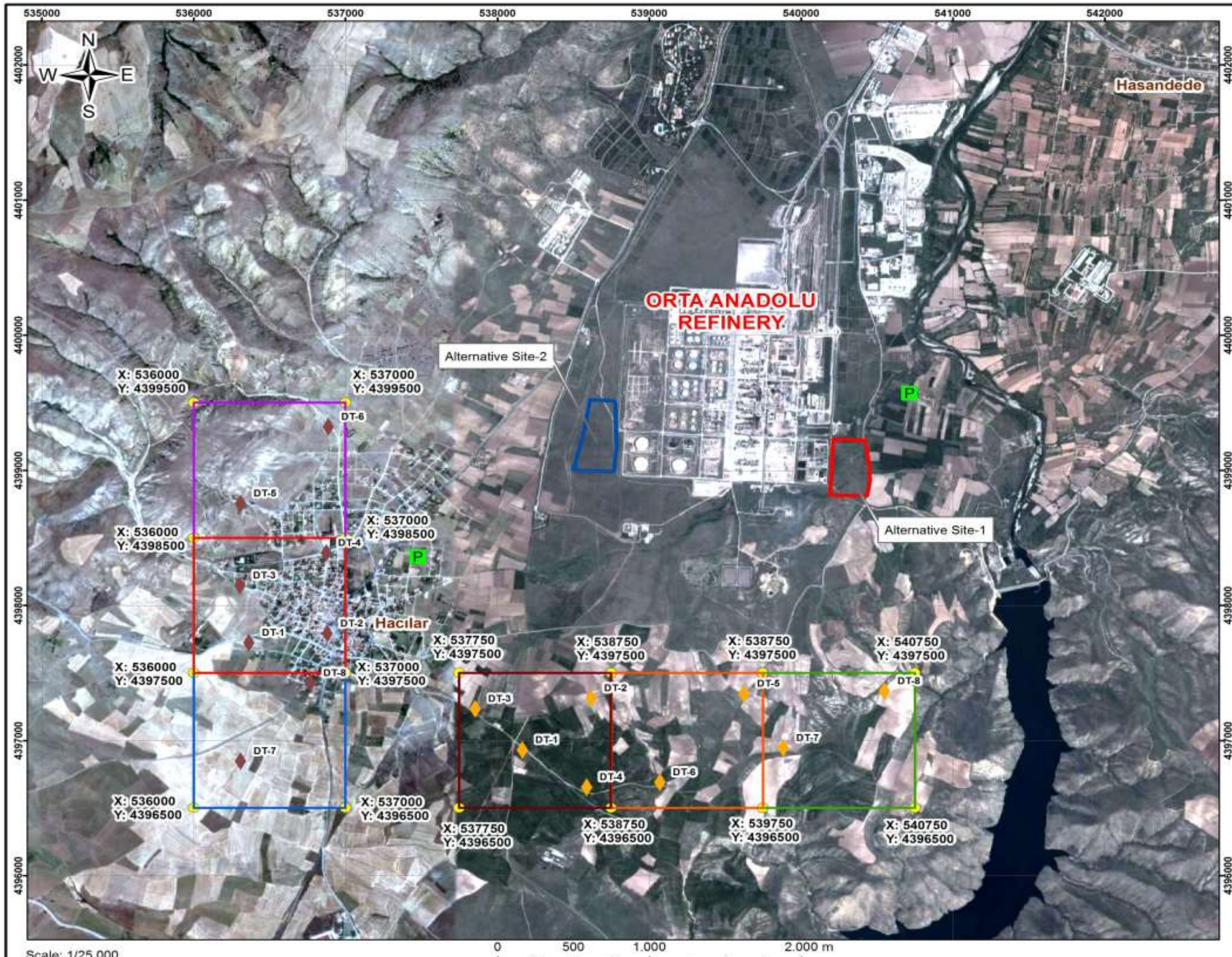
2. Environmental Master Plan



3. Alternative Project Sites



4. Emission Monitoring Locations



Scale: 1/25.000

LEGEND

- P — PM_{10} Measurement Locations
- Site Corner Points
- Alternative Site-1 DT Measurement Location
- Alternative Site-2 DT Measurement Location
- Alternative Site-1
- Alternative Site-2
- Alternative Site-1 Area-1
- Alternative Site-1 Area-2
- Alternative Site-1 Area-3
- Alternative Site-2 Area-1
- Alternative Site-2 Area-2
- Alternative Site-2 Area-3

Alternative Site-1 DT Measurement Location		
ADI	**X**	**Y**
DT-1	538167	4396928
DT-2	538620	4397312
DT-3	537856	4397233
DT-4	538589	4396653
DT-5	539626	4397345
DT-6	539073	4396688
DT-7	539885	4396942
DT-8	540552	4397364
Alternative Site-2 DT Measurement Location		
DT-1	536366	4397722
DT-2	536881	4397791
DT-3	536307	4398146
DT-4	536875	4398387
DT-5	536309	4398752
DT-6	536889	4399321
DT-7	536310	4396845
DT-8	536770	4397424
PM 10 Measurement Locations		
PM10-1	537477	4398359
PM10-2	540716	4399571
ED50 UTM Zone 36		

Map : Satellite Map Showing Measurement Locations

Project : Kırıkkale Natural Gas Combined Cycle Power Plant

Drawing No: 169-01-01-GIS-DKC-006-R00

DOKAY GIS Department

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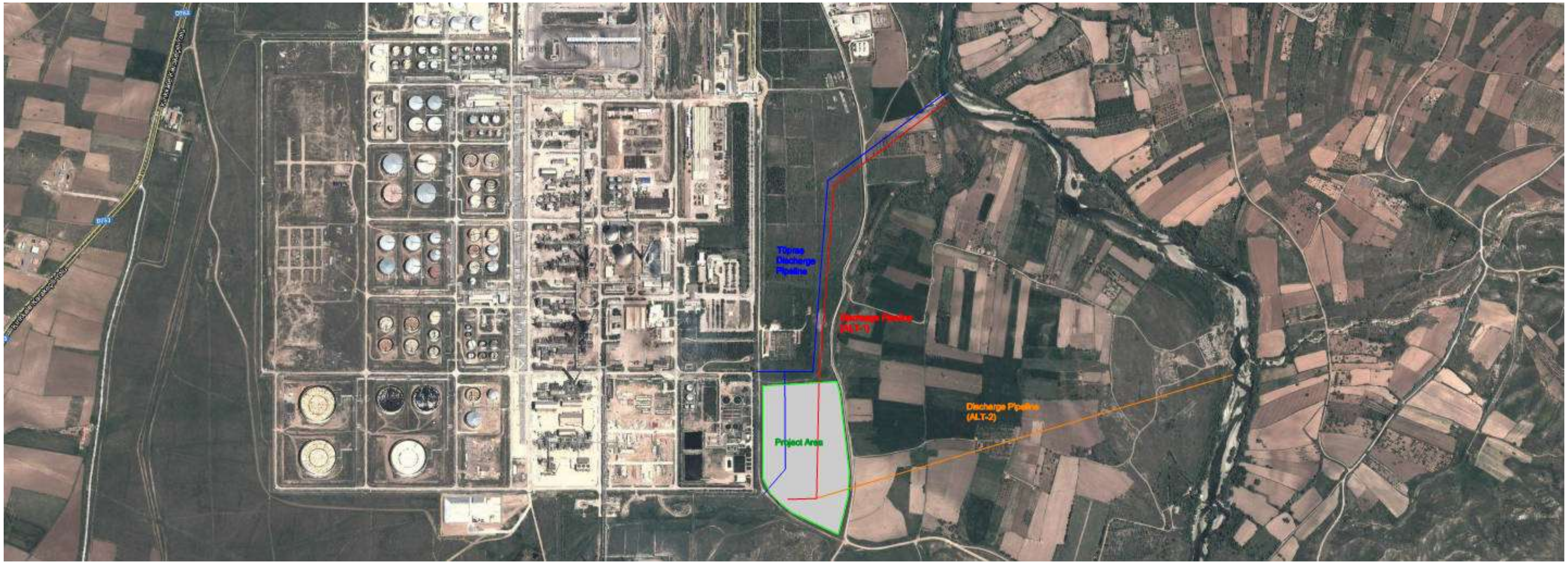
Prepared by	Approved by	Date/Revision
N.Ö	E.Ö	28.02.2013/R00

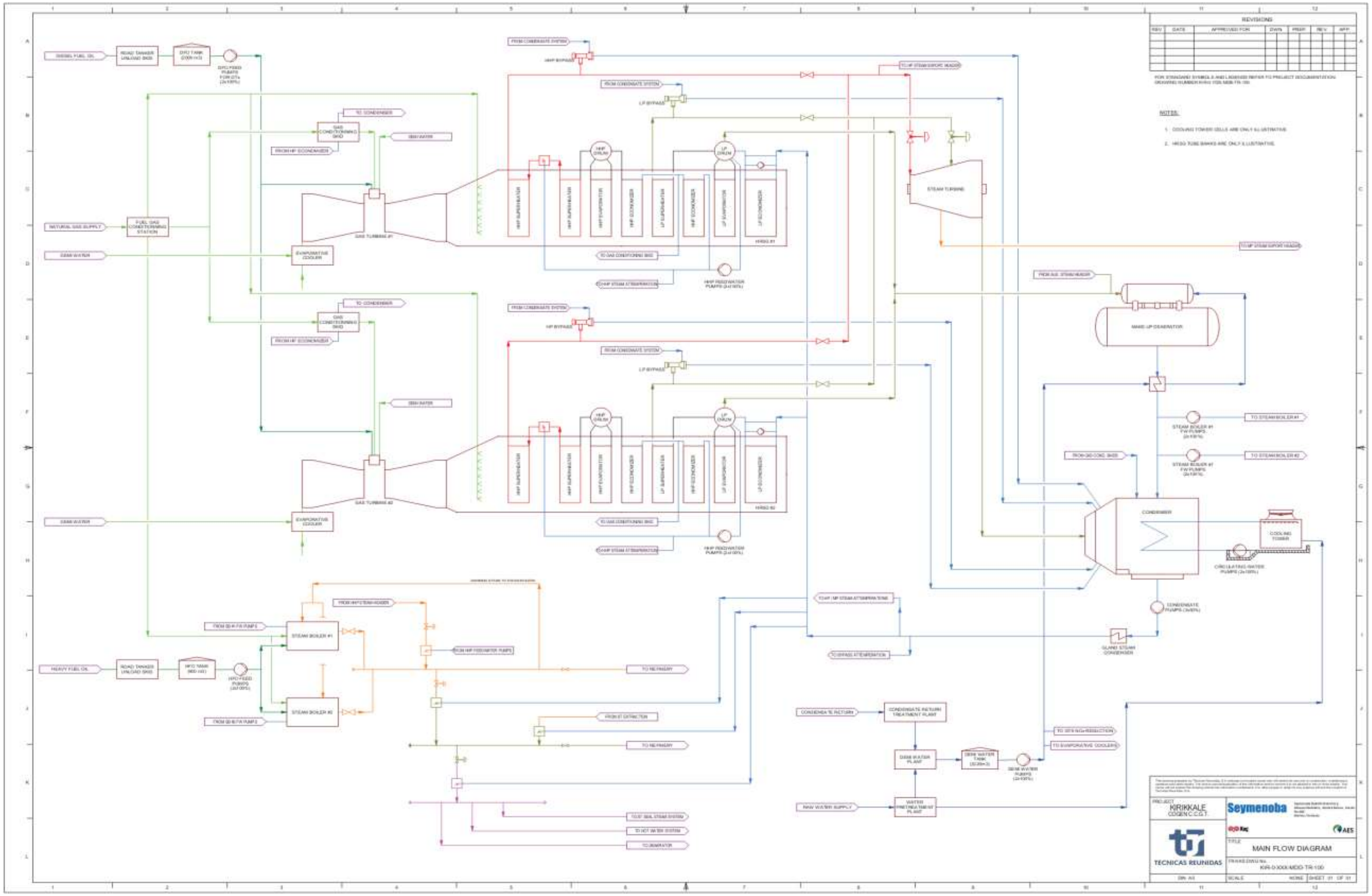
5. Alternative Wastewater Discharge Pipelines



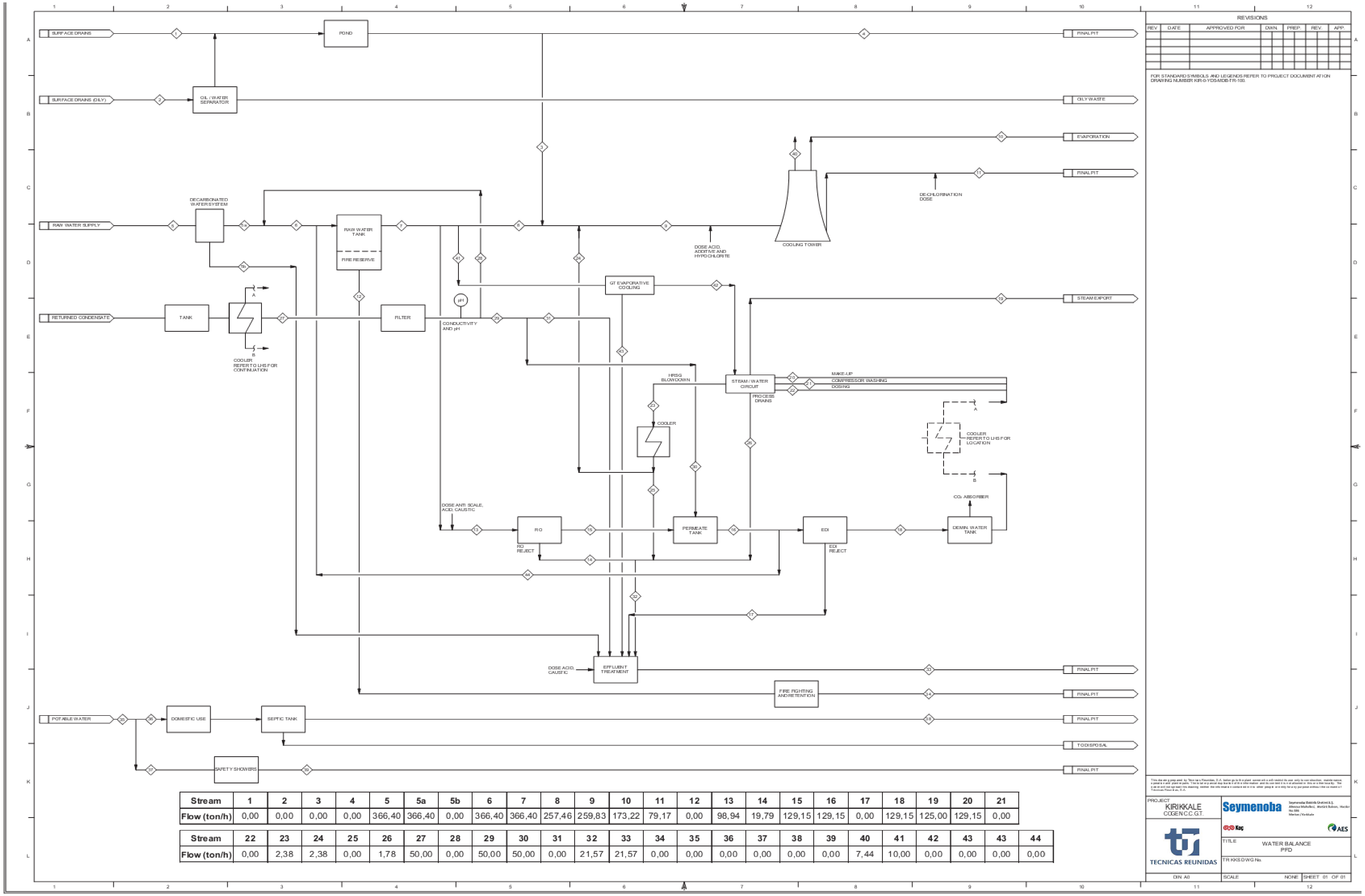
Annex B

Layouts

1. Main Flow Diagram of the Plant



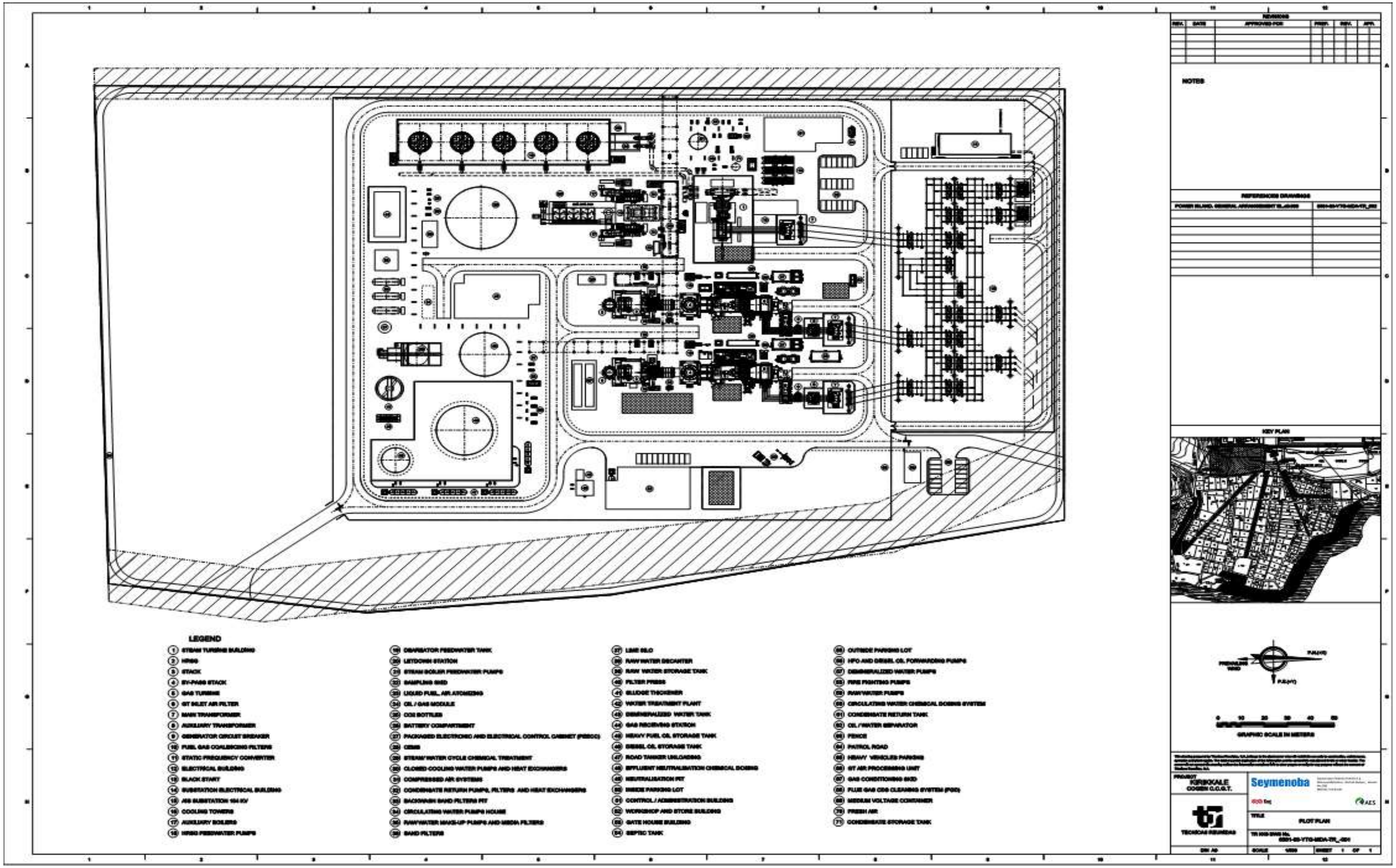
2. Water Balance Diagram of the Plant



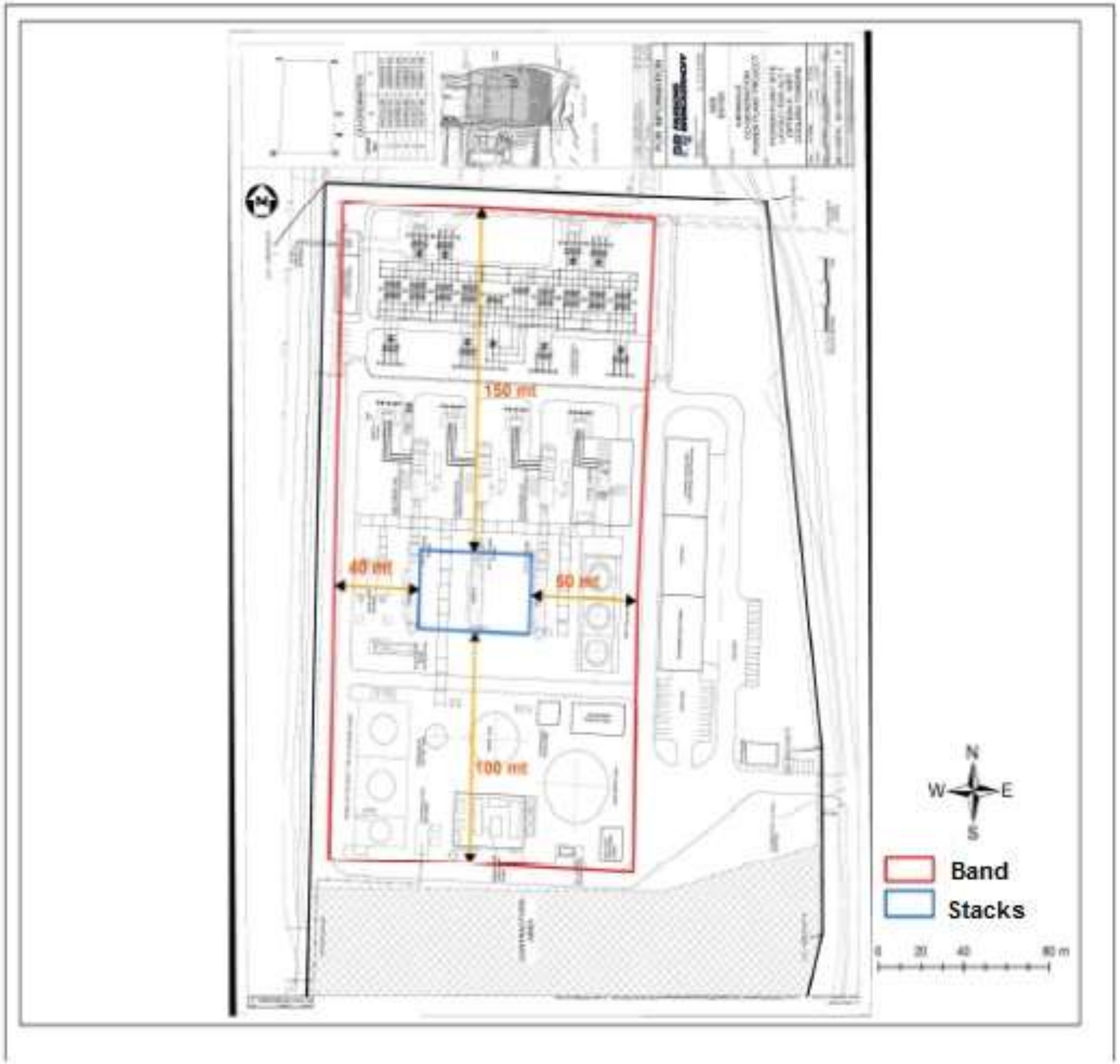
Stream	1	2	3	4	5	5a	5b	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Flow (ton/h)	0,00	0,00	0,00	0,00	366,40	366,40	0,00	366,40	366,40	257,46	259,83	173,22	79,17	0,00	98,94	19,79	129,15	129,15	0,00	129,15	125,00	129,15	0,00

Stream	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	43	44
Flow (ton/h)	0,00	2,38	2,38	0,00	1,78	50,00	0,00	50,00	50,00	0,00	21,57	21,57	0,00	0,00	0,00	0,00	0,00	0,00	7,44	10,00	0,00	0,00	0,00	0,00

3. Plot Plan of the Project



4. Health Protection Band



Annex C
Air Quality Modeling Study

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KIRIKKALE COGENERATION POWER PLANT PROJECT

AIR QUALITY MODELING STUDY REPORT

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2013
ANKARA

KIRIKKALE COGENERATION POWER PLANT PROJECT

AIR QUALITY MODELING STUDY REPORT

PROJECT NO: 169.02.02

APRIL 2013

REVISION LOG

		Revizyon Numarası Revision Number		
		0	1	2
Tarih Date		22.02.2013	18.04.2013	
Rapor Adı Report Title	Air Quality Modeling Study			
Hazırlayan(lar) Prepared by	Emre ÖZTOPRAK			
Teknik Kontrol Technical Control	Ayşegül Pelin ELÇİ			
Kalite Kontrol Quality Control	Yeşim AŞTI			
Şirket Müdürü Director	Prof. Dr. Coşkun YURTERİ			

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

%	Percent
µg/m³	Microgram/cubic meter
µm	Micrometer
AERMOD	AERMOD Modeling System
kPP	Kirikkale Power Plant
CEM	Continuous Emission Monitoring
Cd	Cadmium
CO	Carbon monoxide
Cr	Chromium
EU	European Union
FGD	Flue Gas Desulfurization
GLC	Ground Level Concentration
HCl	Hydrogen chloride
HF	Hydrogen fluoride
kg	Kilogram
Kcal	Kilocalorie
kJ	Kilojoule
km	Kilometer
LTL	Long Term Limit
m	meter
m/s	meter/second
mg	Milligram
mg/Nm³	Milligram/normal cubic meter
Ni	Nickel
NO	Nitrogen monoxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
O_2	Oxygen

RAMAQ	Regulation on the Assessment and Management of Air Quality
RCIAP	Regulation on the Control of Industrial Air Pollution
SO_2	Sulfur dioxide
STL	Short Term Limit
TPP	Existing Tupras Power Plant
WHO	World Health Organization

1. INTRODUCTION

This report was prepared with the aim of estimating the dispersions of air emissions to be originated from Kırıkkale Cogeneration Power Plant (KCPP) Project via AERMOD dispersion model.

Contribution to air pollution level and air quality levels in the impact area of the Project were estimated by air quality modeling studies and compared with the pertinent standards. The results of the modeling study were assessed according to the Turkish Regulation on the Assessment and Management of Air Quality (RAMAQ), EU Council Directive 2008/50/EC and WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide.

The following section briefly explains the fuel to be used, amount and type of emissions to be originated from the proposed KCPP and the associated mitigation measures to keep emissions at the minimum level. Section 3 presents information about emission and air quality monitoring to be performed in the scope of the proposed KCPP operation period. Air quality standards are presented in Section 4. Determination of the stack height in line with Turkish Regulation is explained in Section 5. Method and emission values used in the modeling study are discussed in Section 6. Current air quality values measured in the vicinity of the Project Site are presented in Section 7. Results of the modeling study carried out in line with Turkish Legislation and overall assessment of their possible impacts to the air quality of the region are illustrated in Section 8 and Section 9.

2. EMISSION AND EMISSION CONTROL

2.1. Fuel to be Used

It is predicted that the proposed KCPP will use natural gas as main fuel. Diesel oil in gas turbines and heavy fuel oil (HFO) in auxiliary boiler will only be used in case of natural gas supply problems. The approximate consumption of natural gas will be 29.64 ton/hour and calorific value of the natural gas is 49.070 kj/kg. Nominal thermal power of the KCPP will approximately be 460.2 MW_t.

2.2. Emissions

In this section, emissions to be originated from the proposed KCPP, the associated mitigation measures and control technologies to minimize the emissions are summarized. Two gas turbines with one steam turbine and two auxiliary boilers will be established at KCPP. Natural gas will be used in both gas turbines in normal operation conditions. In case of natural gas supply problems, an emergency situation, diesel oil will only be used at one gas turbine and HFO will only be used at one auxiliary boiler.

Since the main fuel to be used at the proposed Project is natural gas, main pollutants to be resulting from combustion process would be NO_x and CO emissions. Since the sulphur and ash content of natural gas is very low, SO_2 and dust emissions will be in negligible amount.

Pollutants to be originated from the KCPP during emergency case, diesel oil and HFO combustion, will be NO_X, CO, SO_2 and dust.

Amount of pollutants and the characteristics of the stack gas are summarized in Table 1 for natural gas operations and Table 2 for diesel oil and HFO operations.

Table 1. Mass Flow Rates and Concentrations of Pollutants for Natural Gas Conditions

Parameter	Values[1]	Limit Values		
		Concentration[2] (mg/Nm³)	*Concentration[3] (mg/Nm³)*	*Mass Flow Rate[4] (kg/hour)*
NO_x	33 mg/Nm³ (dry, 15% O_2) 18.12 kg/h (as NO_2)	50	50	40
CO	62 mg/Nm³ (dry, 15% O_2) 34.04 kg/h	100	100	500
Stack Gas Flow Rate	710,000 m³/h (stack) 550,000 Nm³/h (dry)	-	-	-

Parameter	Values[1]	Limit Values		
		Concentration[2] (mg/Nm³)	*Concentration[3] (mg/Nm³)*	*Mass Flow Rate[4] (kg/hour)*
Stack Gas Temperature	80 C	-	-	-
Stack Gas Velocity	15 m/s		-	
Stack Inner Diameter	4,1 m	-	-	-

(1) *There are two stacks in the proposed Project. The values given are design values of the proposed Project sent by the Project owner.*

(2) *Limits for pollutant concentration values stipulated in the EU Directive numbered 2010/75/EU.*

(3) *Limits for pollutant concentration values stipulated in the Turkish Regulation for Large Combustion Plants.*

(4) *Limits that define whether air quality modeling study is required or not (RCIAP, Annex-2).*

Table 2. Mass Flow Rates and Concentrations of Pollutants for Diesel Oil Conditions

Parameter	Value[1]		Limit Values		
	Gas Turbine	**Auxiliary Boiler**	*Concentration(2) (mg/Nm³)*	*Concentration(3) (mg/Nm³)*	*Mass Flow Rate(4) (kg/hour)*
NO_x	33 mg/Nm³ (dry, 3% O_2) 18.12 kg/h (as NO_2)	150 mg/Nm³ (dry, 3% O_2) 30 kg/h (as NO_2)	50 (for gas turbine) 300 (for auxiliary boiler)	120 (for gas turbine) 400 (for auxiliary boiler)	40
CO	62 mg/Nm³ (dry, 3 % O_2) 34.4 kg/h	80 mg/Nm³ (dry, 3% O_2) 16 kg/h	100 (for gas turbine) - (for auxiliary boiler)	100 (for gas turbine) 80 (for auxiliary boiler)	500
SO_2	100 mg/Nm³ (dry, 3 % O_2) 54,91 kg/h	200 mg/Nm³ (dry, 3% O_2) 40 kg/h	- (for gas turbine) 350 (for auxiliary boiler)	- (for gas turbine) 850 (for auxiliary boiler)	60
Dust	20 mg/Nm³ (dry, 3% O_2) 11 kg/h	20 mg/Nm³ (dry, 3% O_2) 4 kg/h	- (for gas turbine) 20 (for auxiliary boiler)	- (for gas turbine) 50 (for auxiliary boiler)	10
Stack Gas Flow Rate	710,000 m³/h (stack) 550,000 Nm³/h (dry)	334,800 m³/h (stack) 200,000 Nm³/h (dry)	-	-	-
Stack Gas Temperature	80 C	184 C	-	-	-
Stack Gas Velocity	15 m/s	25 m/s		-	
Stack Internal Diameter	4.1 m	2.2 m	-	-	-

(1) *There are one gas turbine stack and one auxiliary stack during emergency situation in the proposed power plant. The values given in the column titled as "Value" are design values of the proposed power plant.*

(2) *Limits for pollutant concentration values stipulated in the EU Directive numbered 2010/75/EU.*

(3) *Limits for pollutant concentration values stipulated in the Turkish Regulation for Large Combustion Plants.*

(4) *Limits that define whether air quality modeling study is required or not (RCIAP, Annex-2).*

2.2.1. SO_2 Emissions

The amount of SO_2 emissions originating from combustion units depend on sulphur contents of fuel. Since the sulphur content of natural gas very low, SO_2 emissions will be in negligible amount.

During emergency case, SO_2 emissions will occur due to combustion of diesel oil in one gas turbine and of HFO in one auxiliary boiler. In order to control SO_2 emissions, Flue Gas Desulphurization (FGD) unit will be established for auxiliary boiler emissions.

Since mass flow rate of the SO_2 of the proposed plant, during natural gas supply problems, is expected as 94.91 kg/h (54.91 kg/ + 40 kg/h) (see Table 2), an air quality modeling study was carried out regarding the SO_2 emissions.

2.2.2. NO_X Emissions

There are two factors causing NO_x emissions through combustion process. First one of these factors is the nitrogen content of the fuel. Nevertheless, other NO_x emission source of higher concern is the oxidation of free nitrogen in the air at high temperature during combustion. The factors, which will determine the mentioned emissions from the proposed Project are boiler firing technique, combustion temperature and pressure, etc. Control of NO_x emissions will be ensured via low-NO_x burner system to be established at the proposed Project.

According to Turkish Regulation on Large Combustion Plants, stack gas NO_x emission limit for natural gas fired gas turbines is 50 mg/Nm^3 on the basis of 15% O_2 in volume. NO_x emissions of the proposed plant will be approximately 33 mg/Nm^3 in dry base; thus the emission complies with the pertinent limit value stipulated in both Turkish Regulation and EU Directive (see Table 1 and Table 2).

Since the total mass flow rate of NO_2 emission to be originated from the proposed KCPP will be 36.24 kg/h for natural gas conditions and 48 kg/h for liquid fuel (diesel oil and HFO) conditions, an air quality modeling study was carried out to estimate contribution of NO_2 emissions to ambient air quality. Method and study results are explained in the associated sections.

2.2.3. CO Emissions

CO emissions are formed as a result of incomplete combustion of fuel. The control of CO is accomplished by providing adequate fuel residence time and high temperature to ensure complete combustion.

The limit value for CO emissions in gas turbines stipulated in both Turkish Regulation and EU Directive is 100 mg/Nm^3. CO emission to be emitted from each stacks of the proposed plant will be planned as 62 mg/Nm^3 and thus the emissions will be in compliance with the both the national legislation and EU Directive.

Possible CO emissions as mass flow rate to be originating from the proposed plant are expected as approximately 68.8 kg/h for natural gas conditions and 50.4 kg/h for (diesel oil and HFO) conditions. Air quality modeling study was carried out regarding the CO emissions.

2.2.4. Dust Emissions

The amount of dust emissions originating from combustion units depend on ash contents of fuel. In this regard, fuels with lower ash content generate lower amount of dust emissions.

On the other hand, incomplete combustion yields in high amount of dust emissions due to the initially unburned hydrocarbons. Use of diesel oil with low ash content will help to keep dust emissions at the minimum level. Since mass flow rate of the dust of the proposed plant is expected as 12.21 kg/h (11.1 kg/h + 1.11 kg/h) (see Table 1), an air quality modeling was carried out regarding the dust emissions. Due to low ash content of natural gas, modeling studies was carried out only for diesel oil conditions.

3. MONITORING OF EMISSIONS

As it can be seen from the previous section, the amount of air pollutants in stack gases will comply with the limits given in both Turkish Regulation and EU Directives. Continuous monitoring of stack gas emissions is emphasized in Article 18 of the Turkish Regulation on Large Combustion Plants. In this context, "Continuous Emission Monitoring-CEM" system will be established and operated in line with the Continuous Emission Monitoring Systems Communique for each stack to measure the value of NO_x and CO emissions. In this system, there will be electronic equipment used for the measurement of NO_x, CO and O_2 concentrations as well as stack gas flow rate, temperature and pressure at the stack.

During the operation period of the proposed KCPP, ambient air quality parameters, especially NO_x and CO, will be continuously measured at one location within the impact area of the Project determined and approved by the associated authority. In addition to the concentrations of NO_x and CO emissions, this ambient air quality continuous measurement station will also monitor meteorological parameters such as wind direction and speed. Measurement results will be sent to Kırıkkale Governorate via online network.

Consequently, it will be possible to determine whether the emissions from the proposed plant have an effect on the ambient GLC values.

4. AIR QUALITY STANDARDS

Regulation on the Assessment and Management of Air Quality (RAMAQ) aims to improve air quality gradually. Therefore, two types of air quality standards for gaseous pollutants and particulate matters are mentioned: transition period limit values and target limit values. Transition period limit values came into force as of 06.06.2008 and will decrease gradually by 01.01.2014. Transition period limit values will be abolished by 01.01.2014. Target limit values, mentioned in RAMAQ Annex-1, will be in force as of 01.01.2014. Target limit values are presented in Table 3.

European Union directives and World Health Organization have also limit values/standards for air pollution prevention. EU Council Directive 2008/50/EC relating to health based standards and objectives for a number of pollutants in ambient air. WHO is mentioned to standards in “Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide” document. IFC Guidelines refers to WHO standards to evaluate ambient air quality. These limit values are presented in Table 2.

Table 3. Limit Values Stipulated in the Regulation on the Assessment and Management of Air Quality

Parameter	Averaging Period	RAMAQ Limit Values ($\mu g/m^3$)	EU Limit Values ($\mu g/m^3$)[1]	WHO Standards ($\mu g/m^3$)[2]
NO_2	1 hour (for the protection of the human health)	200 (not to be exceeded more than 18 times a calendar year)[1]	200 (not to be exceeded more than 18 times a calendar year)	200
	Calendar year (for the protection of the human health)	40	40	40
CO	Maximum 8-hour average (for the protection of the human health)	10,000	10.000	-
SO_2	1 hour (for the protection of the human health)	350 (not to be exceeded more than 24 times a calendar year)[1]	350 (not to be exceeded more than 24 times a calendar year)	-
	24hours (for the protection of the human health)	125 (not to be exceeded more than 3 times a calendar year)[2]	125 (not to be exceeded more than 3 times a calendar year)	20
	Calendar year and winter (for the protection of ecosystems)	20	20	-
PM_{10}	24 hours (for the protection of the human health)	50 (not to be exceeded more than 35 times a calendar year)[4]	50 (not to be exceeded more than 35 times a calendar year)[3]	50

	Calendar year (for the protection of the human health)	40	40	20

1 It can be defined as the value not to be exceeded by 99.79% of the results when they are sorted with respect to magnitude.

5. DETERMINATION OF THE STACK HEIGHT

Stack height of the proposed KCPP is determined with the help of the PK 3781 software developed in line with German Regulation (TA Luft) and VDI 3781 standard and Annex-4 the Turkish Regulation on Control of Industrial Air Pollution (RCIAP) prior to air quality modeling studies. Calculation procedure is presented in the diagrams given in the RCIAP. Stack height determination study is carried out with the consideration of parameters such as stack diameter, stack gas temperature, stack gas flow rate and pollutant emission.

The letter "d", in the chart, represents the stack diameter (m) while "t" represents the stack gas temperature (^{0}C) and for the proposed plant, these values are 3.7 m and 80 ^{0}C, respectively. Similarly, "R" represents the volumetric flow rate of the stack gas (in dry basis) under normal conditions (Nm^3/hr) while "Q" represents the mass flow rate of the air polluters (kg/hr). For the proposed power plant these values are 550,000 Nm^3/hour and the values presented in Table 1, respectively. Furthermore, "s" value is an emission factor used for the determination of the stack height mentioned in the Table 4.1 of RCIAP Annex-4. In this regard "Q/s" values calculated for each pollutant are presented in Table 4.

Table 4. Calculated "Q/s" Values for Various Pollutants

Parameter	Q (kg/hour)	s	"Q/s" (kg/hour)
NO_2	10.8	0.1	108
CO	34.04	7.5	4.5

As seen in Table 4, the maximum "Q/s" value is that of the NO_2 parameter. For the consideration of the worst case scenario, "Q/s" (108 kg/hr) value of NO_2 was used in the stack height determination. In the light of the values specified above, the study performed for the determination of the stack height of the proposed plant is shown with a red line on the chart given in Figure 1. In this regard, the stack height (H') is obtained as 13 m.

Additionally, stack height, which is determined by considering the articles in Annex-4 of the RCIAP and the topography, is calculated by using the formula "H=H'+J". J value in the formula is determined by using the chart given in Annex-4 of the RCIAP. "J'" represents the average elevation difference of an area with 10H' radius where the stack location is at the center. For the proposed project area, J' value was calculated by subtracting the elevation of the stack location from the average of the elevations the area with 10H' (10 x 13 = 130 m) radius, where the stack location is at the center. At the end of the calculation, J' was found as approximately 10 m. "J'/H'" value is calculated as approximately 0.76 (10/13 = 0.76). As seen in the Figure 2, when J'/H' value is higher than 0.3, the value of J/J' is found as 1 from the chart. As a result, "J" value is calculated as 10 m (10 x 1 = 10).

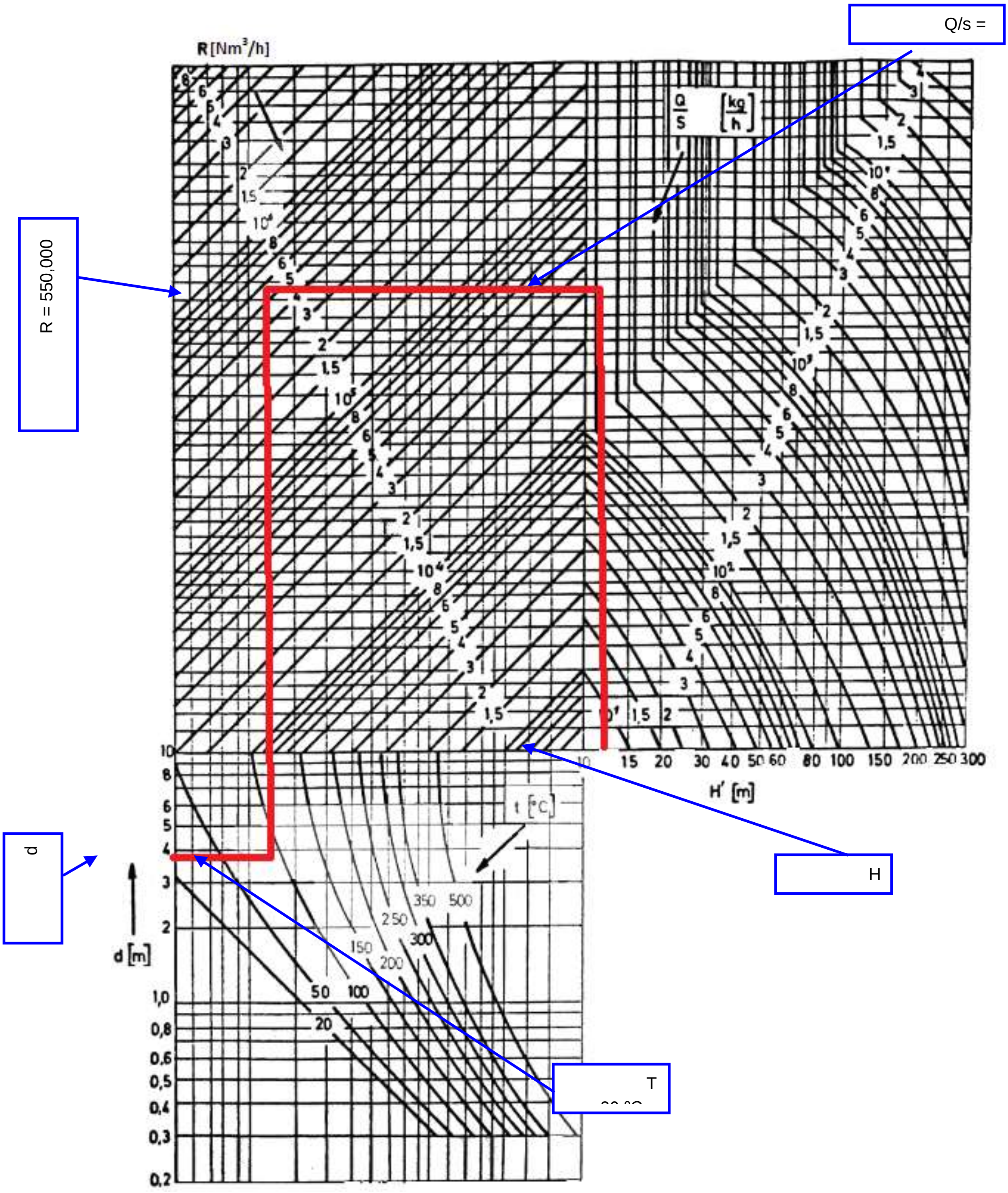

Figure 1. Chart Used for the Determination of the Stack Height

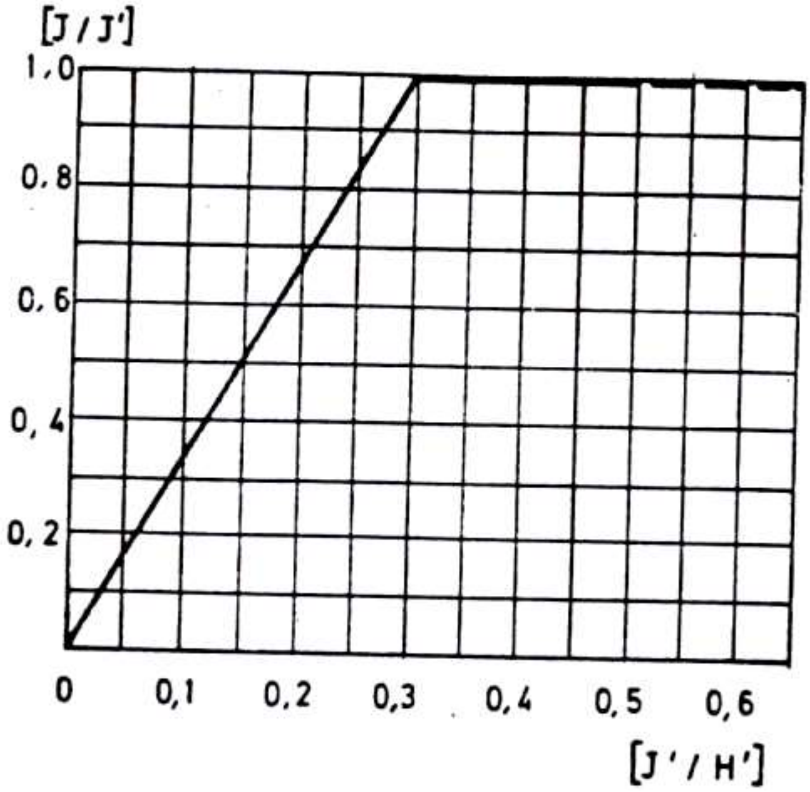

Figure 2. Chart Used for the Determination of “J” Value

Consequently, the H value (H’ + J = H) is determined as 23 m by considering the topographical conditions. In order to ensure homogenous dispersion of emissions, regarding pre-modeling studies, it is determined that the stack height will be 50 m.

6. METHODS USED IN MODELING STUDIES

By modeling studies, it is found out how the pollutants to be generated from the stack of the power plant (NO_2, CO, SO_2 and dust) will disperse in the study area (17.5 km in west-east direction, 17.5 km in north-south direction) under the influence of meteorological conditions. Also, GLC's are estimated. While the impact area defined in the RCIAP for the modeling study is an area with a radius of 50 times of the stack height (5 km x 5 km), an area of 17.5 km x 17.5 km which already covers the impact area, defined in the RCIAP, was used in this modeling study.

6.1. Definition of the Dispersion Model

Air quality dispersion modeling studies was carried out by Ennotes Çevre Mühendislik Danışmanlık Elektrik Proje Taahhüt San. ve Tic. Ltd. Şti. (ENNOTES[1]) via "Lakes Environmental AERMOD View" software (Licence No: ISCAY0003767).

AERMOD model is one of the most developed computer models estimating hourly, daily and yearly GLC's on the basis of the real time values. Model comprises the calculations of different dispersion models for different sources (point, volume, line) from isolated stacks to fugitive pollutants. Additionally, it considers conditions like aerodynamic waves and turbulence.

AERMOD model is working in a network system defined by the user and calculations are made for corner points of each receiving environment segments forming the network. The network system used by AERMOD model can be defined as polar or Cartesian. Additionally, detailed calculations can be made at the discrete receptor points, which can be determined out of the network system. In the model, there is also an option for hilly areas. AERMOD model uses four different data given below:

- Wind direction, wind speed, temperature, atmospheric sounding observations, hourly meteorological data set including wind profile exponential and potential vertical temperature difference.
- Coordinates and heights of each element in the network system defined as receiving environment.
- Data sets including source coordinates based on a starting point determined by the user, source height, diameter, emission rate, temperature and flow rate.

The results of the model are suitable for the preparation of dispersion maps including whole dispersion area. Therefore, the assessment of regional air quality under different scenarios (e.g. different treatment conditions, various pollution sources or varying

[1] *ENNOTES is sub-contractor of DOKAY-ÇED.*

seasonal conditions) is possible. The modeling study that estimates gas pollutants and dust concentrations in ambient air by the help of mathematical calculations is comprised of following items:

- “Dispersion Area” for analyzed source is determined.
- A rectangular grid system for the determined dispersion area is prepared with a grid system of 250 m x 250 m or 500 m x 500 m and information on latitude, longitude and elevation is obtained. The corners of these grids are nodes.
- Information about the pollutant sources in the dispersion area is obtained.
- Hourly meteorological data of a representative year is obtained.

Hourly, daily and annual average GLC values of pollutants in the ambient air can be estimated by being run of the model after transferring the information stated in the above steps. Model inputs used in this study are given in the following sections.

6.2. Meteorological Data Set

Long term meteorological data needed for modeling studies is obtained from the regional meteorological stations. In this study, Kırıkkale Meteorological Station is considered as suitable and the meteorological data recorded in this station was used in the modeling study. Since upper air observation values of the region are not measured by the Kırıkkale Meteorological Station, the upper air observation records were obtained from Ankara Meteorological Station which is the nearest ravinsonde station. Meteorological data year to be used in the modeling study was chosen by comparing long term wind direction frequency distribution to the last 10 years wind direction frequency distribution. Year 2011 was determined as the most suitable year for emission dispersion observations. Long term and year 2011 wind direction distribution diagrams are shown in Figure 3.

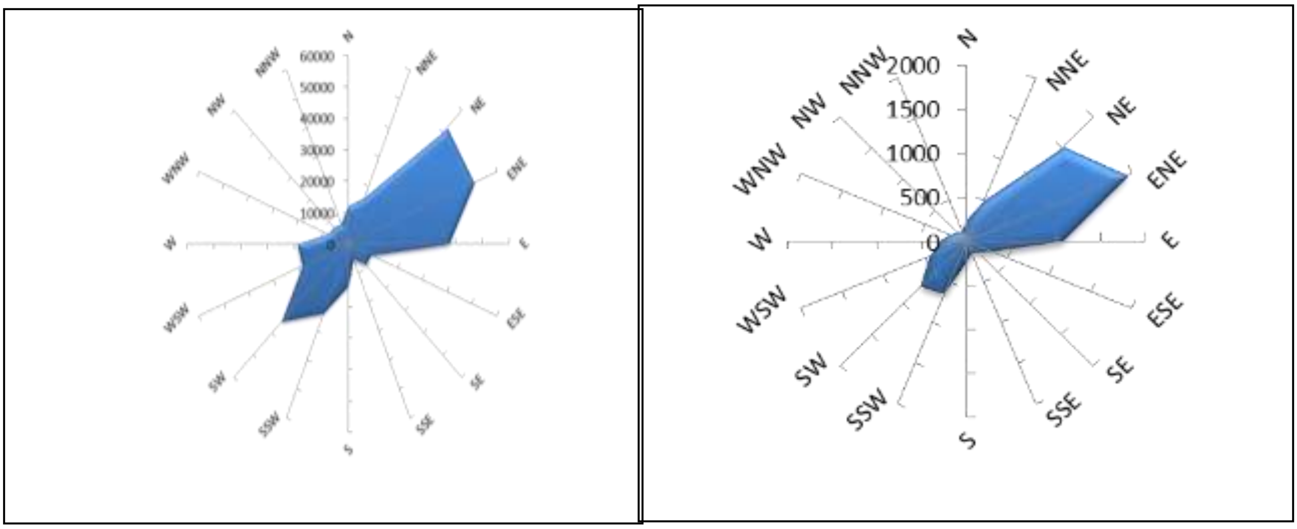

Figure 3. Wind Direction Frequency Distribution Diagrams

6.3. Grid System

As mentioned in the preceding sections, determination of a study area and dividing up this area into receiving environment segments are necessary for AERMOD model. Rectangular area defined as study area for this study is selected by considering the proposed plant to be located at the center. The network system is within the 17.5 km × 17.5 km area in east-west and north-south directions and it includes nodes with 250 m intervals.

Hourly GLC values of NO_2, CO, SO_2 and PM_{10} were estimated at each node (corners of the receiving environment segments). For each node, GLC corresponding to LTL and STL values defined in the RCIAP is calculated and compared with the stipulated limit values.

6.4. Source Parameters Used in the Modeling Studies

As mentioned in Section 2, primary emissions to be emitted from the proposed Project are NO_2 and CO during normal operation condition, natural gas combustions. On the other hand, SO_2, NO_2, dust and CO emissions will occur during diesel oil and HFO combustion, in emergency situation. Therefore, NO_2 and CO emissions dispersions were studied in the modeling studies for normal operating conditions whereas SO_2, NO_2, dust and CO emissions dispersions were studied in the modeling studies for emergency situations. GLC values estimated via modeling study regarding emissions of proposed KCPP are compared with the limit values given in the Turkish RAMAQ, EU Directive and WHO Guidelines. Source parameters and corresponding values used in the modeling study are presented in Table 5 and Table 6.

In addition to the possible effects of the proposed plant, emissions of the Tüpraş Kırıkkale Refinery which is within the impact area of the Project were also considered in the modeling studies for cumulative assessment. Emission values and other parameters belonging to the Tüpraş Kırıkkale Refinery are presented in Table 7.

Table 5. Mass Flow Rates and Concentrations of Pollutants for Natural Gas (

Parameter	Source Values*
NO_2 (g/s)	3.01
CO (g/s)	9.46
Stack Gas Exit Velocity (m/s)	15
Stack Gas Exit Temperature (^oC)	80
Stack Height (m)	50
Stack Inner Diameter (m)	4.1

* *There are two stacks in the proposed Project.* The values represent each stack and are given by the project owner.

Table 6. Mass Flow Rates and Concentrations of Pollutants for Liquid Fuel (Diesel Oil and HFO)

Parameter	Source Values*	
	Gas Turbine	Auxiliary Boiler
NO_2 (g/s)	3.01	5
CO (g/s)	9.46	4.44
SO_2 (g/s)	15.25	11.11
Dust (g/s)	3.05	1.11
Stack Gas Exit Velocity (m/s)	15	25
Stack Gas Exit Temperature (^oC)	80	184
Stack Height (m)	50	50
Stack Inner Diameter (m)	4.1	2.2

**There are one gas turbine stack and one auxiliary stack in the proposed power plant during liquid fuel combustion in natural gas supply problems.* The values represent each stack and are given by the project owner.

Table 7. Emission Values of Tüpraş Kırıkkale Refinery (Existing Facility)

Stack Name	NO_2 (g/s)	CO (g/s)	Stack Gas Exit Velocity (m/s)	Stack Gas Exit Temperature (^oC)	Stack Height (m)	Stack Inner Diameter (m)
TStack1	5.62	1.43	6.6	303	130	4.00
TStack2	0.84	-	11.6	190	54	1.44
TStack3	1.74	0.03	4.3	226	118	3.50
TStack4	8.59	0.1	16.3	131	120	2.40
TStack5	-	-	1.8	736	52	1.80
TStack6	0.19	0.44	5.2	239	45	1.00
TStack7	1.67	0.09	4.2	228	50	2.30
TStack8	0.91	0.03	4.6	163	50	3.00
TStack9	3.06	0.11	6.9	165	110	4.00
TStack10	0.49	-	9.1	231	50	1.50
TStack11	-	0.07	1.6	255	52	1.20

7. ASSESSMENT OF BASELINE AIR QUALITY

With the aim of determining air quality of region, NO_2, SO_2, HCl ve HF concentrations were measured at eight different sampling points which have the highest air quality contribution values, in the impact area of KCPP for 2 months (2 period) by passive sampling method in accordance with RCIAP principals. First period measurements were carried out between 18.04.2012 and 17.05.2012 and the second period were carried out between 17.05.2012 and 12.06.2012 dates. Measurement results are presented in the EIA Report while NO_2 measurement results are presented Table 8 of the Report.

Table 8. Results of Air Quality Monitoring Studies

	Location No	Coordinates	NO_2 Measurement Results ($\mu g/m^3$)		
			1. Period	**2. Period**	**Average**
Measurement Locations	DT-1	538284 / 4397799	3.72	3.18	3.45
	DT-2	538107 / 4397011	3.62	2.34	2.98
	DT-3	537849 / 4397215	-*	-*	-
	DT-4	538238 / 4396812	-*	3.50	3.5
	DT-5	539508 / 4397741	3.79	*	3.79
	DT-6	539192 / 4396628	3.62	2.01	2.82
	DT-7	539349 / 4397660	4.53	2.22	3.38
	DT-8	539993 / 4397992	2.38	0.65	1.52
Average			**3.61**	**2.31**	**-**

* *Measurement result was not reported since diffusion tube had been lost on the site.*

8. RESULTS OF THE MODELING STUDIES

Modeling studies were carried out for various pollutants to be emitted from the stacks of the KCPP during normal operational conditions (natural gas utilization) and during emergency situation (unavailability of natural gas-diesel oil and HFO utilization). Since the KCPP will be replaced with the existing Tüpraş Power Plant (TPP), a modeling study was performed for the emissions of TPP in order to compare the GLC values due to KCPP and TPP. In order to assess possible impacts of the KCPP on the regional air quality, modeling study was performed for different scenarios given below:

- KCPP (Operational condition) (Scenario-1)
- Existing Tüpraş Power Plant (TPP)
- KCPP (Operational condition) + Tüpraş Kırıkkale Refinery - without TPP (Cumulative) (Scenario-2)
- KCPP (Emergency Situation) (Scenario-3)
- KCPP (Emergency Situation) + Tüpraş Kırıkkale Refinery - without TPP (Cumulative) (Scenario-4)

GLC's of NO_2 and CO calculated with the help of modeling studies for Scneario-1 and Scenario-2 are presented in Table 9 together with the associated limit values stipulated in Turkish Legislation, EU Directive and WHO Guidelines (see Table 3). Moreover, GLC's of NO_2, CO, SO_2 and PM_{10} estimated by modeling study for Scenario-3 and Scenario-4 are presented in Table 10. GLC values estimated for Scenario-1 at the diffusion tube locations are presented in Table 11.

Table 9. GLC Values Determined from the Modeling Studies (Normal Operating Conditions - Natural Gas Combustion)

Parameter	Period	GLC Values (μg/m^3)			National and International Limit Values (μg/m^3)
		Scenario-1 KCPP (Operational Condition)	Scenario-2 Cumulative	Existing TPP	
NO_2	*Hourly (99.78%)*	52.80 (537719, 4400368)	101.11 (538469, 4401368)	64.89 (536969, 4400368)	200
	Daily (max.)	8.77 (536469, 4398618)	13.77 (536219, 4398118)	9.77 (536969, 4400368)	-
	Annual	0.80 (536469, 4398618)	2.27 (536969, 4399118)	1.08 (536469, 4399618)	40
CO	*Daily* 8-hours average *(max.)*	63.19 (536469, 4398618)	63.19 (536469, 4398618)	0.22 (536469, 4399368)	10,000

Table 10. GLC Values Determined from the Modeling Studies (Emergency Situation-Diesel Oil and HFO Combustion)

Parameter	Period	GLC Values (µg/m^3)		National and International Limit Values (µg/m^3)
		Scenario-3 KCPP (Emergency Situation)	Scenario-4 Cumulative	
NO_2	*Hourly (99.78%)*	87.80 (537219, 4400118)	142.00 (538469, 4401368)	200
	Daily (max.)	13.00 (537219, 4400118)	17.93 (538469, 4401368)	-
	Annual	1.52 (539969, 4398868)	2.98 (536909, 4399118)	40
CO	*Daily* 8-hours average *(max.)*	45.52 (536469, 4398618)	46.38 (536469, 4398618)	10.000
SO_2	*Hourly (99.73%)*	237.85 (537219, 4400118	671.84 (538219, 4400618)	350
	Daily (99,18%.)	28.02 (536719, 4398868)	73.23 (537719, 4400118)	125
	Annual	4.57 (536719, 4399118)	15.38 (537469, 4399368)	20
PM	*Daily (%90,41)*	1.89 (536719, 4399368)	1.98 (536719, 4399118)	50
	Annual	0.67 (536719, 4399118)	0.77 (536719, 4398868)	40

Table 11. GLC Values Determined from the Modeling Studies for Measurement Points

	Location No	Coordinates	Monthly NO_2 GLC Values (µg/m^3) (Scenario-1)
SKHKKY Uyarınca Belirlenen Ölçüm Lokasyonları	DT-1	538284 / 4397799	0.36
	DT-2	538107 / 4397011	0.30
	DT-3	537849 / 4397215	0.32
	DT-4	538238 / 4396812	0.30
	DT-5	539508 / 4397741	0.52
	DT-6	539192 / 4396628	0.49
	DT-7	539349 / 4397660	0.50
	DT-8	539993 / 4397992	0.42

8.1. Ground Level NO_2 Concentrations

Estimated ground level NO_2 concentration values for all scenarios are summarized in Table 9, Table 10 and Table 11. Moreover, dispersions of NO_2 GLC values are shown in Figure 4 to Figure 18.

Pollutant dispersion is mainly in the west and the southwest directions of the plant due to the effects of the prevailing winds and the topography.

As seen in Table 9, hourly and annual GLC values of NO_2 estimated via modeling studies are 52.80 µg/m^3 and 0.80 µg/m^3, respectively. These values are significantly lower than the associated limits to be complied with the national and international limit values. In addition to the possible individual impacts of the KCPP, cumulative impacts of the proposed facility together with the existing emission source, namely Tüpraş Kırıkkale Refinery are also estimated. According to the results of cumulative scenario (Scenario-2), hourly and annual GLC values of NO_2 are calculated as 101.11 µg/m^3 and 2.27 µg/m^3 (see Table 9). Calculated GLC values for cumulative scenario are also incompliance with both national and international limit values.

Estimated GLC values for existing TPP are also shown in Table 9. According to the results, hourly and annual GLC values of NO_2 are calculated as 64.89 µg/m^3 and 1.08 µg/m^3, respectively. Existing TPP is utilizing refinery gas. With the realization of the KCPP, the existing TPP will be decommissioned. Therefore, starting from the operation of the KCPP, it is expected that air quality of the region will be improved since GLC values of NO_2 due to the KCPP is lower than those of TPP and there will be no SO_2 emissions.

During emergency situation, KCPP will utilize diesel oil and HFO in one gas turbine and one auxiliary boiler. GLC values of NO_2 will also be calculated via modeling study for emergency situation and the values are presented in Table 10. According to this table, hourly and annual GLC values of NO_2 estimated via modeling studies for Scenario-3 are 87.80 µg/m^3 and 1.52 µg/m^3, respectively. These values are significantly lower than the associated limits to be complied with the national and international limit values. In addition to the possible individual impacts of the KCPP, cumulative impacts of the proposed facility together with the existing emission source, namely Tüpraş Kırıkkale Refinery are also estimated. According to the results of cumulative scenario (Scenario-4), hourly and annual GLC values of NO_2 are calculated as 142.00 µg/m^3 and 2.98 µg/m^3 (see Table 10). Calculated GLC values for cumulative scenario are also incompliance with both national and international limit values.

In order to assess cumulative impacts on air quality measurement locations, GLC values were also calculated at the diffusion tube locations (see Table 8). The highest NO_2 concentration was obtained at DT-7 location as 4.53 µg/m^3 by the air quality measurement study (see Table 8). Monthly GLC value of NO_2 calculated via dispersion model at this location is 0.50 µg/m^3. Cumulative NO_2 concentration calculated at this location as a result of modeling and measurements is 5,03 µg/m^3. Contribution of KCPP to the cumulative ambient air quality of this location is estimated to be 10%.

In accordance with Table 8, the highest monthly GLC value among eight DT locations was calculated at DT-5 location as 0.52 µg/m^3 by modeling study. The highest ambient air quality value at this point obtained during measurement period is 3.79 µg/m^3. The cumulative monthly NO_2 concentration, regarding the measurement and modeling results, is calculated as 4.31 µg/m^3. Contribution of KCPP to the cumulative ambient air quality of this location is estimated to be 12%.

As result, estimated GLC values of NO_2 in the vicinity of the proposed Project are well below the limit values stipulated in the RAMAQ, EU Directives and WHO Guidelines. Therefore, it is expected that NO_2 emission values to be originated from the Project will not cause any significant adverse effects in the vicinity of the proposed plant.

Figure 4. Hourly Average GLC Dispersion of NO_2 for KCPP (Scenario-1)

Figure 5. Daily Average Maximum GLC Dispersion of NO_2 for KCPP (Scenario-1)

Figure 6. Annual Average GLC Dispersion of NO_2 for KCPP (Scenario-1)

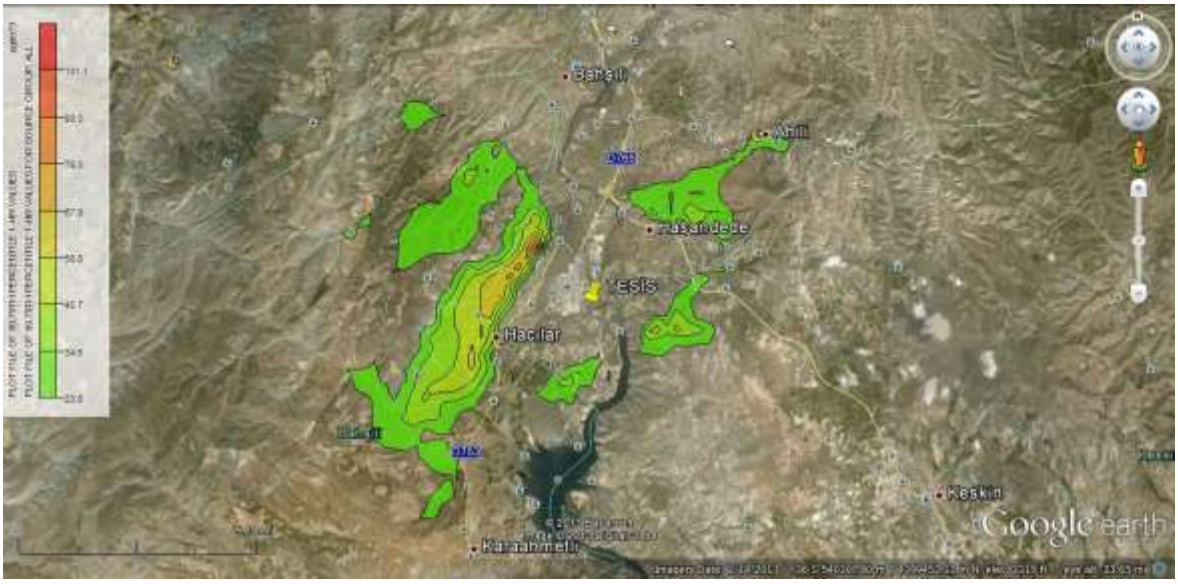

Figure 7. Hourly Average GLC Dispersion of NO_2 for Cumulative Scenario (Scenario-2)

Figure 8. Daily Average Maximum GLC Dispersion of NO_2 for Cumulative Scenario (Scenario-2)

Figure 9. Annual Average GLC Dispersion of NO_2 for Cumulative Scenario (Scenario-2)

Figure 10. Hourly Average GLC Dispersion of NO_2 for TPP

Figure 11. Daily Average Maximum GLC Dispersion of NO_2 for TPP

Figure 12. Annual Average GLC Dispersion of NO_2 for TPP

Figure 13. Hourly Average GLC Dispersion of NO_2 for KCPP (Scenario-3)

Figure 14. Daily Average Maximum GLC Dispersion of NO_2 for KCPP (Scenario-3)

Figure 15. Annual Average GLC Dispersion of NO_2 for KCPP (Scenario-3)

Figure 16. Hourly Average GLC Dispersion of NO_2 for Cumulative Scenario (Scenario-4)

Figure 17. Daily Average Maximum GLC Dispersion of NO_2 for Cumulative Scenario (Scenario-4)

Figure 18. Annual Average GLC Dispersion of NO_2 for Cumulative Scenario (Scenario-4)

8.2. Ground Level CO Concentrations

Estimated ground level CO concentration values for all scenarios are summarized in Table 9, Table 10 and Table 11. Moreover, dispersions of CO GLC values are shown in Figure 19 to Figure 23.

Pollutant dispersion is mainly in the west, southwest, east and southeast directions of the plant due to the effects of the prevailing winds and the topography.

As seen in Table 9, daily 8-hours GLC value of CO estimated via modeling studies is 63.19 μg/m^3. The value is significantly lower than the associated limits to be complied with the national and international limit value. In addition to the possible individual impacts of the KCPP, cumulative impacts of the proposed facility together with the existing emission source, namely Tüpraş Kırıkkale Refinery are also estimated. According to the results of cumulative scenario (Scenario-2), daily 8-hours GLC value of CO is calculated as 63.19 μg/m^3 (see Table 9). Calculated GLC value for cumulative scenario is also incompliance with both national and international limit value.

During emergency situation, KCPP will utilize diesel oil and HFO in one gas turbine and one auxiliary boiler. GLC value of CO will also be calculated via modeling study for emergency situation and the values is presented in Table 10. According to this table, daily 8-hours GLC value of CO estimated via modeling studies for Scenario-3 is 45.52. This value is significantly lower than the associated limits to be complied with the national and international limit value. In addition to the possible individual impacts of the KCPP, cumulative impacts of the proposed facility together with the existing emission source, namely Tüpraş Kırıkkale Refinery are also estimated. According to the results of cumulative scenario (Scenario-4), daily 8-hours GLC value of CO is calculated as 46.38 μg/m^3 (see Table 10). Calculated GLC value for cumulative scenario is also incompliance with both national and international limit value.

As result, estimated GLC values of CO in the vicinity of the proposed Project are well below the limit values stipulated in the RAMAQ, EU Directives and WHO Guidelines. Therefore, it is expected that CO emission values to be originated from the Project will not cause any significant adverse effects in the vicinity of the proposed plant.

Figure 19. Daily 8 Hours Average GLC Dispersion of CO for KCPP (Scenario-1)

Figure 20. Daily 8 Hours Average Maximum GLC Dispersion of CO for Cumulative Scenario (Scenario-2)

Figure 21. Daily 8 Hours Average Maximum GLC Dispersion of CO for TPP

Figure 22. Daily 8 Hours Average GLC Dispersion of CO for KCPP (Scenario-3)

Figure 23. Daily 8 Hours Average Maximum GLC Dispersion of CO for Cumulative Scenario (Scenario-4)

8.3. Ground Level SO_2 Concentrations

Estimated ground level SO_2 concentration values for Scenario-3 and Scenario-4 in emergency situation are summarized in Table 10. Moreover, dispersions of SO_2 GLC values are shown in Figure 24 to Figure 29.

Pollutant dispersion is mainly in the west and the southwest directions of the plant due to the effects of the prevailing winds and the topography.

As seen in Table 10, hourly, daily and annual GLC values of SO_2 estimated via modeling studies for Scenario-3 are 237.85 μg/m^3, 28.02 μg/m^3 and 4.57 μg/m^3, respectively. These values are significantly lower than the associated limits to be complied with the national and international limit values. In addition to the possible individual impacts of the KCPP, cumulative impacts of the proposed facility together with the existing emission source, namely Tüpraş Kırıkkale Refinery (Secanrio-4) are also estimated. According to the results of cumulative scenario, hourly, daily and annual GLC values of SO_2 are calculated as 671.84 μg/m^3, 73.23 μg/m^3 and 15.38 μg/m^3, respectively. Calculated hourly GLC value for cumulative scenario exceeds target limit value. According to model results, it is understood that existing refinery has already exceed limit values.

As result, estimated GLC values of SO_2 in the vicinity of the proposed Project are well below the limit values stipulated in the RAMAQ, EU Directives and WHO Guidelines. Therefore, it is expected that SO_2 emission values to be originated from the Project will not cause any significant adverse effects in the vicinity of the proposed plant.

Figure 24. Hourly Average GLC Dispersion of SO_2 for KCPP (Scenario-3)

Figure 25. Daily Average Maximum GLC Dispersion of SO_2 for KCPP (Scenario-3)

Figure 26. Annual Average GLC Dispersion of SO_2 for KCPP (Scenario-3)

Figure 27. Hourly Average GLC Dispersion of SO_2 for Cumulative Scenario (Scenario-4)

Figure 28. Daily Average Maximum GLC Dispersion of SO_2 for Cumulative Scenario (Scenario-4)

Figure 29. Annual Average GLC Dispersion of SO_2 for Cumulative Scenario (Scenario-4)

8.4. Ground Level PM_{10} Concentrations

Estimated ground level PM_{10} concentration values for Scenaario-3 and Scenario-4 are summarized in Table 10. Moreover, dispersions of PM_{10} GLC values are shown in Figure 30 to Figure 33.

Pollutant dispersion is mainly in the west and the southwest directions of the plant due to the effects of the prevailing winds and the topography.

As seen in Table 10, daily and annual GLC values of PM_{10} estimated via modeling studies are 1.89 $\mu g/m^3$ and 0.67 $\mu g/m^3$ respectively. These values are significantly lower than the associated limits to be complied with the national and international limit values. In addition to the possible individual impacts of the KCPP, cumulative impacts of the proposed facility together with the existing emission source, namely Tüpraş Kırıkkale Refinery (Scenario-4) are also estimated. According to the results of cumulative scenario, daily and annual GLC values of PM_{10} are calculated as 1.98 $\mu g/m^3$ and 0.77 $\mu g/m^3$, respectively. Calculated GLC values for cumulative scenario are also incompliance with both national and international limit values.

As result, estimated GLC values of PM_{10} at the vicinity of the project are well below the limit values stipulated in the RAMAQ, EU Directives and WHO Guidelines. Therefore, PM_{10} emission values to be originated from the project will not cause any significant adverse effects in the vicinity of the proposed plant and in the settlement areas.

Figure 30. Daily Average Maximum GLC Dispersion of PM_{10} for KCPP (Scenario-3)

Figure 31. Annual Average GLC Dispersion of S PM_{10} for KCPP (Scenario-3)

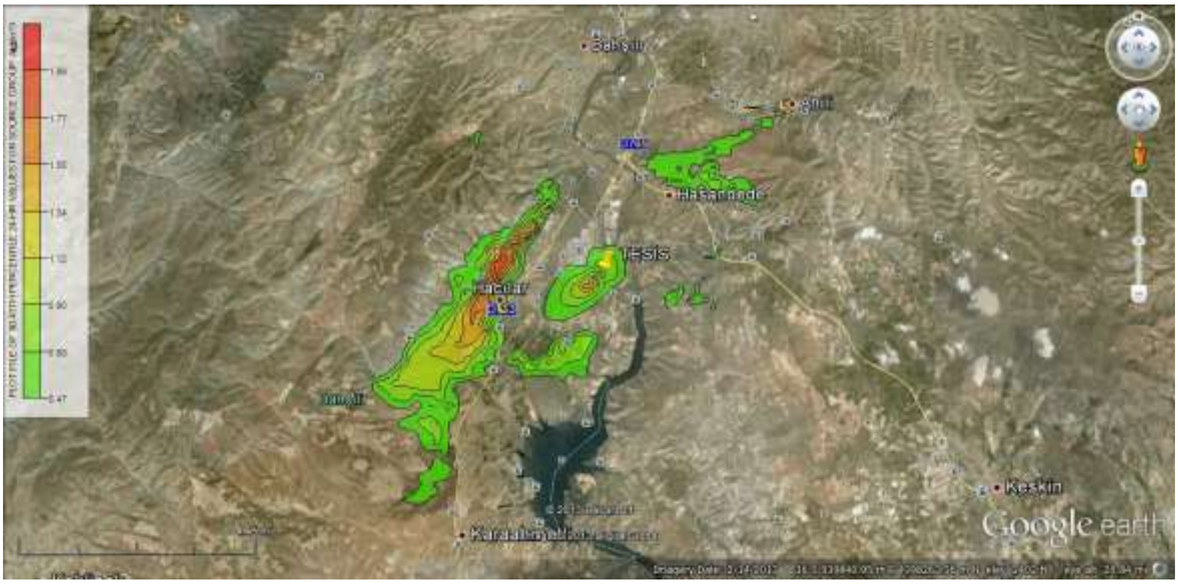

Figure 32. Daily Average Maximum GLC Dispersion of PM_{10} for Cumulative Scenario (Scenario-4)

Figure 33. Annual Average GLC Dispersion of PM_{10} for Cumulative Scenario (Scenario-4)

9. CONCLUSION

GLC values calculated with the help of dispersion model are presented in Section 8.

The hourly and annual GLC limit values for NO_2 parameter stipulated in the RAMAQ, EU Directives and WHO Guidelines are 200 μg/m^3 and 40 μg/m^3, respectively. Cumulative hourly and annual GLC values of NO_2 are 101,11 μg/m^3 and 2.27 μg/m^3, respectively. These values are significantly below the associated limit values stipulated in the RAMAQ, EU Directives and WHO Guidelines.

Maximum daily 8-hour average limit value for CO parameter set forth by the RAMAQ and EU Directives are 10,000 μg/m^3. Cumulative GLC value calculated via modeling study is 63.19 μg/m^3, and the value is significantly below the associated limit value.

As a result, it is expected that the proposed KCPP will not have any important adverse impact on the air quality within the dispersion area regarding individual scenario and cumulative scenario results.