UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

21412

Distr.
RESTRICTED

ISED/R. 56
27 December 1995

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

ORIGINAL: ENGLISH

POLICY ADVICE ON MEASURES FOR REDUCING AND PREVENTING THE ENVIRONMENTAL IMPACTS OF INDUSTRIAL AND MUNICIPAL ACTIVITIES IN THE KARASU RIVER BASIN IN THE BILECIK REGION OF TURKEY

SI/TUR/93/802

TURKEY

Terminal Report*

Prepared for the Government of Turkey
by the United Nations Industrial Development Organization

Based on the work of Dr. Walter M. Grayman, Prof. Soli Arceivala and
Dr. Scott B. Redman, UNIDO consultants.
Prof. Dr. Semra Siber Uluatam, Department of Civil Engineering,
METU, Ankara

Backstopping officer: Ralph (Skip) Luken, Environment and Energy Branch

* This document has not been edited.

V.95 60529

ABSTRACT

The Bilecik region of Turkey has a concentration of industries and municipalities that are a source of pollution to the Karasu River and its tributaries. The primary polluting industries are in three major groups: ceramics, metal industries and pulp and paper. The regions' population centers that contribute municipal waste are in Bilecik, Bozuyuk and Söğüt. While most of the industries are providing some form of waste water treatment prior to its discharge to the environment, in some cases this treatment is inadequate which compounds the lack of any municipal treatment facilities.

This study resulted from a request for assistance by the Government of Turkey to the United Nations Industrial Development Organization (UNIDO) for support in providing comprehensive and modern assessment techniques to study the activities resulting in water pollution of the Karasu River Basin. The study employed a systematic approach called "area-wide environmental quality management (AEQM)", emphasizing the water quality aspects of the environment. Alternative strategies for reducing pollution (improved pollution control and waste minimization practices) were studied in terms of their impacts on the environment, costs and implementation requirements. The aim was to develop a cost-effective strategy that is implementable and will protect the desired uses of the environment. During the course of the study, major industries were visited and analyzed and a mathematical model, QUAL2E, was applied to estimate water quality impacts of future growth and treatment alternatives.

The study has shown that the Karasu River water quality has the potential to improve from its present Class IV (poor quality) to Class I or Class II, after the following actions are taken:

(1) Industries invest approximately US $ 5.5 million (1995 prices) to meet the cost of treating increased volumes of wastewater owing to increased industrial production in the next 10 years (until year 2005) and in order to meet effluent standards.

(2) Iller Bank invests about US $ 10.7 million (1995 prices) in providing sewerage and sewage treatment plants for the three municipalities by the year 2000 in order to meet population estimates for a 10-year horizon.

A series of recommendations pertaining to institutional, regulatory, and implementation issues were made.

TABLE OF CONTENTS

		Page
Abstract		2
Table of Contents		3
List of Tables		4
List of Figures		5
Acknowledgments		6
Introduction		7
I.	Project Area Overview	9
II.	Study Methodology	12
III.	Water Resources of the Karasu River Basin	16
IV.	Industrial and Municipal Development	21
V.	Environmental Regulations	38
VI.	Water Quality Modeling	46
VII.	Analysis of Strategies	51
VIII.	Institutional Aspects	69
IX.	Conclusions and Recommendations	72
Annexes		
I.	Water Quality Data for the Karasu River Basin	76
II.	Analysis of the Aquatic Life in the Karasu River Basin	81
III.	Industrial Inventory for the Karasu River Basin	85
IV.	Comparison of Karasu Water Quality Data and Stream Criteria	97
V.	Parameterization of the QUAL2E Model to the Karasu River and Tributaries	101
VI.	Results of Application of the QUAL2E Model to the Karasu Basin	108
VII.	Municipal Sewer and Sewage Treatment Plant Cost Estimation Methods	113
VIII.	Project Contact List	115

LIST OF TABLES

No.	Table Title	Page
1.	Mean Values for Selected Parameters at the Six Sampling Stations	17
2.	Monthly Flow Statistics for the Karasu River at Vezirhan	19
3.	Drainage Areas at Key Stream Points in the Karasu Basin	20
4.	Type of Industries and Their Wastewater and Recycling Status	22
5.	Effluent Standards for Selected Parameters for Industry Groups in the Karasu	39
6.	Stream Water Quality Criteria	41
7.	Irrigation Water Criteria	42
8.	Classification of the Karasu River Basin Streams by DSI	43
9.	Point Loads for Present Situations and Future Strategies	52
10.	Growth Rate Estimates for Towns in the Karasu River Basin	59
11.	Estimated Investment Required for Industrial Wastewater Flows of Year 2005	66
12.	Cost Estimates for Municipal Sewers and Treatment Facilities in the Karasu Basin	68
13.	Annual Municipal O&M Sewer/Treatment Plant Costs	68
II-1	Summary of Aquatic Invertebrate Sampling Results in the Karasu River Basin	82
IV-1	Analysis of Water Quality Data by Sampling Station	98
V-1	Industrial Loadings Used in the STAND1 and FUTURE Strategies	104
V-2	QUAL2E Calibration Parameters	104
V-3	Aggregated Loadings for Calibration Runs	105
VII-1	Cost of Providing Sewerage Networks	114
VII-2	Sewage Treatment Costs	114

LIST OF FIGURES

No.	Figure Title	Page
1.	Karasu River Basin	10
2.	Areawide Environmental Quality Management Method as Applied in the Study	13
3.	Typical Water Reuse Arrangement in a Marble Factory	24
4.	Newspaper Article on Pollution in the Karasu River Basin	26
5.	A Potential Recycle Arrangement in the Ceramic Industry	28
6.	Wastewater Treatment Plant for a Paper Making Factory	29
7.	Typical Biopack Type Treatment Plant for Sewage Treatment	31
8.	Wastewater Treatment Plant for a Pulp and Paper Factory Using Straw	32
9.	Wastewater Treatment Plant for Plating Waste to Treat Cyanide and Chromium	35
10.	Wastewater Treatment Plant for a Factory Making Synthetic Carpets	37
11.	Schematic Representation of the Karasu River Basin in QUAL2E	48
12.	Stream Classifications Based on Modeling for Situation PRES1	55
13.	Stream Classifications Based on Modeling for Situation STAND1	56
14.	Stream Classifications Based on Modeling for Strategy FUTURE 1	61
15.	Stream Classifications Based on Modeling for Strategy FUTURE 2	62
16.	Stream Classifications Based on Modeling for Strategy FUTURE 3	64
17.	Stream Classifications Based on Modeling for Strategy FUTURE 4	65
V-1	Comparison of Simulated and Observed Water Quality Values	106
VI-1	Simulated Water Quality Profiles on the Kocadere-Karasu Rivers	109
VI-2	Simulated Water Quality Profiles on the Söğüt River	111

ACKNOWLEDGMENTS

During the course of the project, the study team received excellent cooperation from representatives of the government, industry, and educational institutions. The assistance of all of these people was invaluable and is gratefully acknowledged. We would especially like to acknowledge the contributions of the following individuals and groups.

The Eskisehir Chamber of Industry (Eskisehir Sanayi Organize) and its General Director, A. Ihsan Karamanli, served as local host for the study. They provided offices, and clerical and administrative assistance that were invaluable.

The General Directorate of State Hydraulic Works (DSI) provided extensive information on the water quality of the basin and conducted a special intensive water quality survey in direct response to the request of the study team. The cooperation of Ayhan Askin, Director of the Third Region Office in Eskisehir, in making this information available is much appreciated. The assistance of Sedat Oktas, Director of the Quality Control Division, and his staff in conducting the intensive survey and interpreting data proved to be of great help.

The assistance of Avni Karabulut, Director of Food and Environmental Health Control Division of the Bilecik Health Department in providing information and in helping to gain access to many of the industries in the region was invaluable.

The study team would also like to acknowledge the willingness of many industries in the region to discuss and demonstrate their processes and treatment facilities and to participate in the project workshop.

INTRODUCTION

The Bilecik region of Turkey has a concentration of industries and municipalities that are a source of pollution to the Karasu River and its tributaries. The primary polluting industries are in three major groups: ceramics, metal industries and pulp and paper. The region's population centers that contribute municipal waste are in Bilecik, Bozuyuk and Söğüt. While most of the industries are providing some form of wastewater treatment prior to its discharge to the environment, in some cases this treatment is inadequate which compounds the lack of any municipal treatment facilities.

Currently, the environmental impact of the industrial and municipal activities in the region is evaluated on a relatively disaggregated level. Industrial discharge quantity and quality are periodically tested and reported to the Bilecik Health Department. Stream water quality is periodically monitored by the General Directorate of State Hydraulic Works (DSI). There has been some preliminary application of simulation models and damage assessment techniques in the basin by the Middle East Technical University. However, this information has not been integrated to provide a comprehensive, area-wide assessment of the overall problem and potential solutions.

The Government of Turkey requested assistance from the United Nations Industrial Development Organization (UNIDO) for support in providing comprehensive and modern assessment techniques to study the activities resulting in water pollution of the Karasu River Basin. This need for comprehensive environmental assessment methods has been recognized in several actions undertaken by the Government of Turkey.

The specific aims of this study were:

1) To characterize the current situation related to the water quality in the Karasu River Basin;
2) To select a modern environmental assessment framework and methods for studying the problem;
3) To utilize these methodologies in an area-wide study to formulate and evaluate alternative strategies for mitigating the pollution problems;
4) To recommend an implementable plan for the Karasu River Basin,
5) To train local and national professionals in the use of the methodologies so that their further use in the region and nationally can continue.

Work was performed by a team of international experts in conjunction with the Civil Engineering Department at Middle East Technical University. This team is composed of: Dr. Walter M. Grayman, Consulting Engineer, U.S.A.; Professor Soli Arceivala, Chairman, AIC Watson, India; and Mr. Scott Redman, Wisconsin Department of Natural Resources, U.S.A. The National Project Coordinator was Professor Dr. Semra Siber Uluatam who headed the team from the Department of Civil Engineering at the Middle East Technical University.

A significant part of the project was technology transfer and involvement of governmental and local representatives in the planning process. Toward this end, a workshop was held on August 22, 1995 by the study team to report on the technical methodologies and findings of the study. Specific topics discussed included the aims and methodologies of the study, potential implementation procedures, and technical presentations on waste minimization and water quality modeling. A list of attendees at the workshop is presented in Annex VIII.

I. PROJECT AREA OVERVIEW

The project area is the Karasu River Basin in the western part of the Central Anatolia region of Turkey. It drains an area of approximately 1200 square kilometers and flows into the Sakarya River. Major towns and cities are the capital of the province, Bilecik, the major industrial center, Bozuyuk, and Söğüt. Primary features of the basin are shown in Figure 1.

The Karasu River mainstem traverses the central portion of the basin for a distance of approximately 60 kilometers. Progressing from the upstream end, the primary tributaries are the Kocadere (drainage area: 116 sq. km), the Sorgun Deresi (drainage area: 271 sq. km.) and the Söğüt Deresi (drainage area: 241 sq. km).

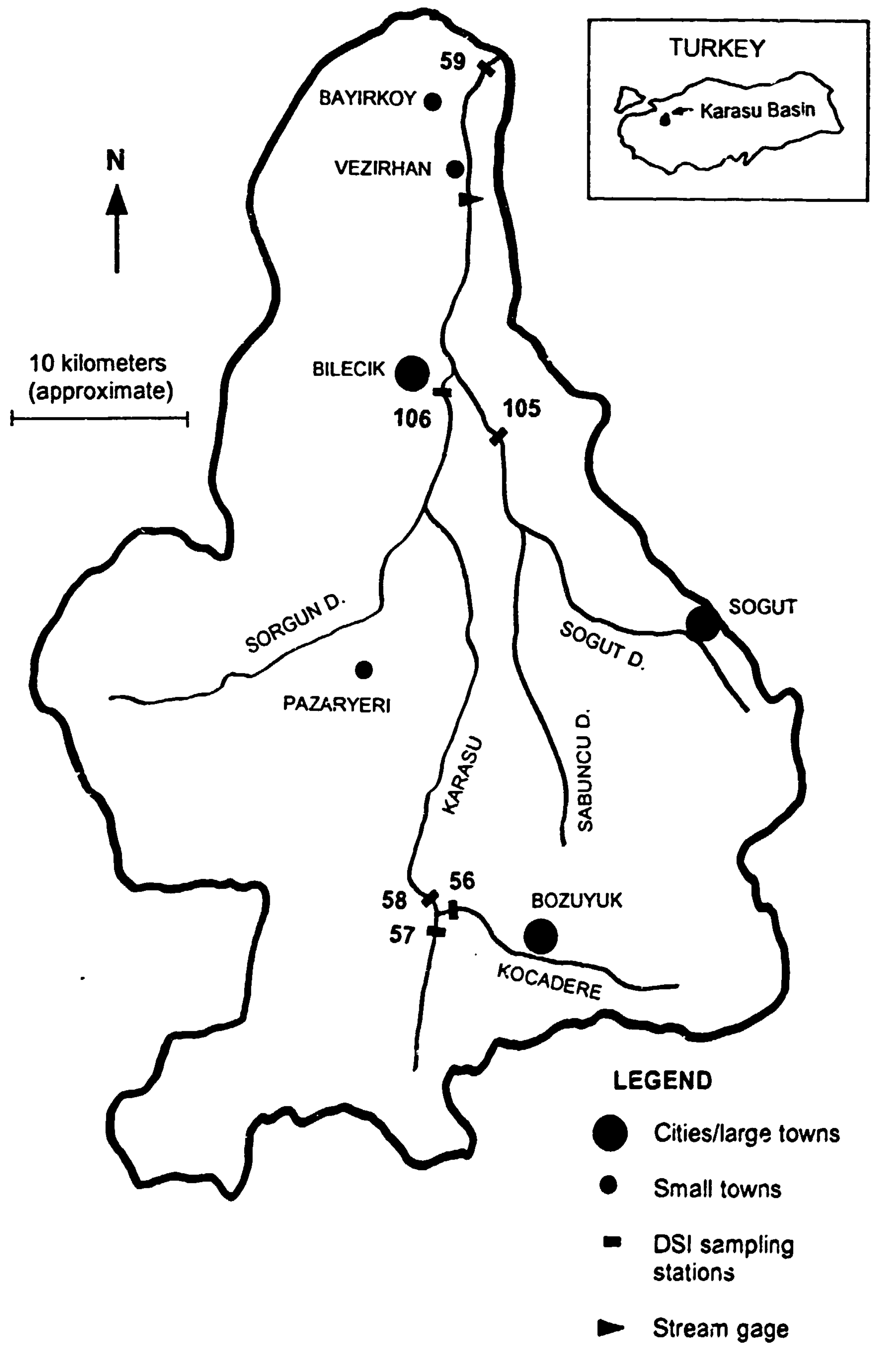
The headwaters of the Karasu River traverse a rural area with little development. The Kocadere is a partially canalized stream of moderate slope serving an urbanized area (Bozuyuk) with significant industrial development. After the confluence of the Karasu and the Kocadere, the Karasu follows a steep course with a narrow contributing watershed area with several small towns and villages. The next tributary, the Sorgun Deresi, drains a rural area with little development or agriculture. The Söğüt Deresi contains a significant industrial and residential area in the town of Söğüt near its headwaters and then flows through a hilly area with some agriculture prior to meeting the Karasu River 8 kilometers downstream of the confluence of the Sorgun Deresi and the Karasu. The Karasu River then progresses through a developed area containing the City of Bilecik, an Industrial Park downstream of Bilecik and other industries prior to its confluence with the Sakarya River.

The study area generally experiences cold and rainy winters and hot and dry summers. Based on meteorological records from Eskisehir, monthly mean temperatures vary between -1 °C in January and 21.5 °C in July. The mean precipitation at Eskisehir is 374 mm per year with approximately 75% of the precipitation occurring between November and May.

There is relatively little farming in the basin with the major crops being vegetables, fruit and poplar trees. The total irrigated area for the Basin (excluding the Söğüt) is approximately 2100 hectares.

The primary source of water for the region is groundwater which is considered to be plentiful.

Figure 1: Karasu River Basin



The uses of the rivers in the Basin are relatively limited. The Upper Karasu River (above the Kocadere) serves as both a habitat for trout and as a partial water supply for Bozuyuk. Other parts of the Karasu and the Söğüt provide water for irrigation and serve as a scenic resource.

A data base of water quality in the Karasu River Basin is available based on sampling performed by the General Directorate of State Hydraulic Works (DSI) at six stations in the basin. The Electrical Power Resources Survey and Development Administration maintains a streamgage on the Karasu River near Vezirhan, approximately 9 kilometers upstream of the mouth of the Karasu River.

II. STUDY METHODOLOGY

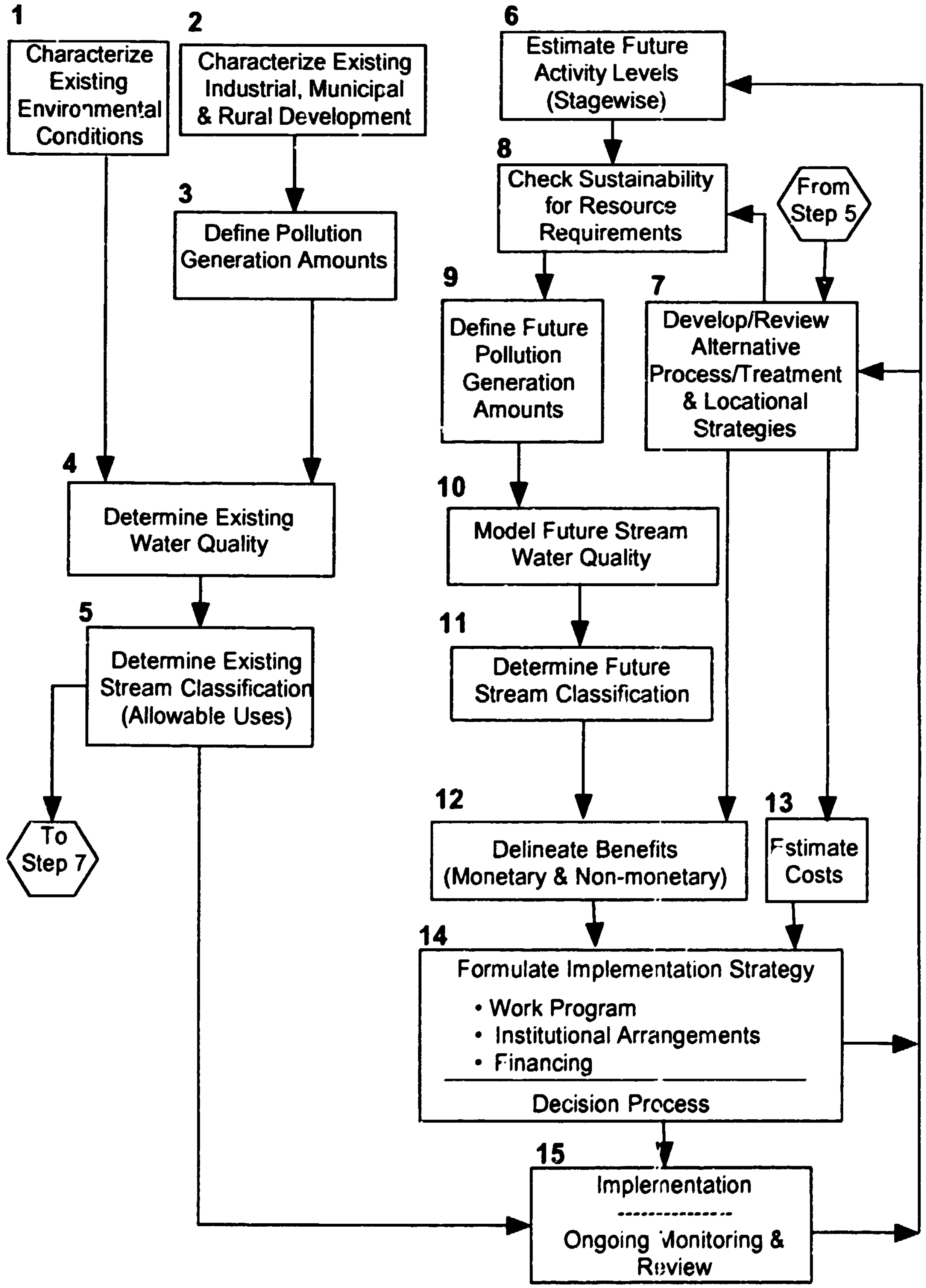
The study employed a systematic approach called "area-wide environmental quality management (AEQM)", emphasizing the water quality aspects of the environment. This approach is an adaptation of a planning method developed and applied over the past decade ("A Framework for Planning for Integrated Coastal Zone Management", B.T. Bower et al, NOAA, U.S. Dept. of Commerce, Washington, D.C., 1994). In the AEQM approach, the impacts of existing and future development upon the environment are examined. Alternative strategies for reducing pollution (improved pollution control and waste minimization practices) are studied in terms of their impacts on the environment, costs and implementation requirements. The aim is to develop a cost-effective strategy that is implementable and will protect the desired uses of the environment. The AEQM approach emphasizes both iterative analysis and involvement of the public. In iterative analysis, the actions taken during one step are dependent upon the results of previous steps, frequently resulting in re-examination of basic assumptions, methodologies and even goals. Involvement of the public and other stakeholders aids in leading to a strategy that is responsive to the collective desires and thus to a result that has a better chance of being implemented.

In the present study, the term "strategy" is used to define the management alternatives that are being studied. A strategy includes a specific set of actions including waste treatment actions, process changes, regulations, policies, and financial plans that together address the identified situation.

The general AEQM framework as applied in this project is shown schematically in Figure 2. Based on a preconceived understanding of the situation, an initial set of goals, boundaries, and analysis methodologies are defined. This includes the selection of modeling and assessment tools. As the understanding of the situation improves, this initial assessment may evolve and change, leading to refinement of the goals and methods. The steps in applying this methodology to the Karasu River Basin are summarized below and are described in greater detail in the chapters indicated:

i) A complete characterization of the existing environmental (water quality) conditions is developed. (Chapter III)

Figure 2
Areawide Environmental Quality Management (AEQM) Method as Applied in the Study



2) The existing industrial, municipal and other activities that may affect the environmental quality of the region are characterized. (Chapter IV)

3) Based on the identified activities, the current pollution generation rates are determined. In some cases, where current pollutant loading values are not known, field data may be used to estimate the loading values that would lead to the observed environmental conditions. (Chapter IV and VII)

4) Modeling and assessment tools along with available monitoring data are used to estimate the existing water quality. (Chapter III and VII)

5) Based on regulations and water quality criteria, streams are classified according to the uses that they may support. In Turkey, regulations and criteria are used to develop stream classifications which reflect the existing water quality. (Chapter V)

6) Future development (industrial and municipal) in the region is projected for selected future years. (Chapter VII)

7) A range of alternative future treatment/process strategies and in some cases locational strategies for facilities are identified. (Chapter VII)

8) The sustainability of the projected future development in conjunction with treatment/process alternatives is checked to ensure the availability of resources to support these combinations. (Chapter VII)

9) Based on the future development projections and a treatment/process strategy, the future pollution generation rates are determined. (Chapter VII)

10) Modeling and assessment tools are used to estimate the impacts of these pollution sources on the water quality in the streams. (Chapter VI and VII)

11) Based on regulations and water quality criteria, streams are classified according to the uses that they will support based on the future development and treatment/process

strategies. (Chapter V and VII)

12) Benefits accruing from a particular strategy are delineated. These could include benefits from increased usage of the streams due to improved quality or reductions in resource usage by industry due to resource recovery/waste minimization changes. (Chapter VII)

13) The costs of the alternative strategies are determined (Chapter VII)

14) Strategies for implementing and financing the alternative treatment/process works are identified, along with institutional needs and financing plans. A decision process involving stakeholders is followed to determine the viability and acceptability of the strategies and a plan for implementation is developed. (Chapter VIII and IX)

15) The plan is implemented with ongoing monitoring and review to ensure that the implementation stays on track.

It should be emphasized that the overall assessment/decision process should be an iterative, dynamic one that may lead to additional feedback loops. For example, the decision process leads to the acceptance of a specific strategy or may result in evaluation of other strategies or even modifications to the allowable future growth in the study area. Similarly, during the implementation process, unforeseen circumstances can lead to modifications in the selected implementation plan.

III. WATER RESOURCES OF THE KARASU RIVER BASIN

A. Water Quality

Data sources

Information on the water quality of the Karasu River Basin was developed based on routine government sampling, observations by the study team, participation in an intensive survey, examination of past reports and records, and discussions with Turkish personnel active in this field.

The General Directorate of State Hydraulic Works (DSI) has performed routine water quality sampling at six stations within the Karasu Basin. The locations of the stations are shown in Figure 1 and described in Annex I.

Sampling is performed on an approximately quarterly basis at each of these stations. Each sample is analyzed for several physical, inorganic, organic, bacteriological and biological parameters (see Annex I).

In order to develop a better understanding of the water quality, aquatic life, hydrology and development in the Karasu River Basin, a one-day intensive stream survey was conducted on May 23, 1995 by DSI with assistance from the study team. During this study, both hydraulic and water quality measurements were made at the 6 DSI sampling locations and 6 additional sites in the basin The data collected during this study was used in the parameterization and calibration of the water quality model used in the study.

Physical, chemical and bacteriological data

In order to develop an understanding of the water quality within the basin, several statistical and graphical analyses were performed. Details on these analyses are presented in Annex I. The mean values are summarized in Table 1 for selected parameters.

Table 1: Mean Values for Selected Parameters at the Six Sampling Stations

Parameter	Station 56	Station 57	Station 58	Station 106	Station 105	Station 59
Dissolved Oxygen (mg/l)	3.8	10.5	9.5	10.0	10.2	9.5
5-day BOD (mg/l)	48.4	1.6	4.9	3.9	3.6	22.7
Fecal Coliform #/100 ml	$4.9x10^6$	$1.1x10^3$	$3.6x10^5$	$7.9x10^4$	$1.9x10^4$	$6.5x10^4$
Total suspended solids (mg/l)	265	26	34	75	112	196
Total dissolved solids (mg/l)	540	255	470	316	398	363
Total Kjeldahl nitrogen (mg/l)	13.3	0.3	1.4	0.8	0.6	0.9

There are some very pronounced spatial trends in this data. Generally, the water quality of the Karasu River above the confluence with the Kocadere (Station 57) is quite good. The quality of the Kocadere (Station 56) is generally quite poor in terms of all parameters. Due to the influence of the Kocadere, the water quality on the mainstem of the Karasu River is significantly poorer at station 58 (immediately below the confluence) than at Station 57 (immediately above the confluence). Downstream of the Kocadere confluence, the river follows a moderate to steep course with little development until the town of Bilecik. As a result, there is some recovery in water quality apparent at Station 106 (upstream of Bilecik). The water quality at Station 105 (near the downstream end of the Söğüt River), is generally fair reflecting the development in the upstream stretches of the Söğüt. The water quality at Station 59 (near the downstream end of the Karasu River) again deteriorates due to industrial and other activity in that part of the river.

The results follow traditional seasonal variations. During the warmer months dissolved oxygen levels are lower and decrease as one moves downstream as opposed to the winter months when the D.O. levels increase slightly due to recovery. Solids concentrations do not follow any seasonal trends.

Long term historical trends were examined for the ten year period of record. Over that period, water quality varied randomly with little in the way of apparent trends.

Aquatic Life

In addition to sampling standard water quality parameters, DSI also performs biological sampling for aquatic invertebrates from the same six sampling stations. Samples are collected by disturbing an area of approximately one square meter and collecting invertebrates in a kick net. Samples are processed and organisms identified and approximate counts of individuals per taxa were determined. DSI calculated four indices of biological integrity based on the taxonomic counts. The details of these indices and other aspects of the analysis of the biological data are presented in Annex II and results summarized below.

Based on analysis of the biological data, the relative biological health of the water at the six sampling stations can be determined. On the mainstem of the Karasu River, the biological community indicates significantly better quality at Station 57 (upstream of the Kocadere) than at all downstream Karasu River stations (58, 106, and 59). Below the Kocadere on the mainstem of the Karasu, the stations may be ranked in order of decreasing health as: Station 106, Station 58, and Station 59. This ranking is consistent with the analysis of the water quality data in showing the negative impacts of the pollution from the Kocadere, some recovery in the middle part of the Karasu, and further degradation near the downstream end of the Karasu. The biological data can also be analyzed to determine the relative health between the mainstem and its tributaries. As expected, the water quality as measured by the biological indices is significantly better at Station 57 on the Karasu than at Station 56 on the Kocadere. When the biological indices are compared between Station 106 on the Karasu and Station 105 on the Söğüt, there is little significant difference in quality.

River Substrate

Based on observations during the sampling survey, the river substrate at Stations 57, 58, 106, 105, and 59 appear to be gravel and cobblestone with somewhat varying amounts of soft sediment at these stations. Of these locations, Station 59 appears to contain the greatest amount of soft sediment: a silt, with apparently high organic content. The substrate at Station 56, on the Kocadere, is apparently a mix of gravel and sand with a black, asphaltic-like sludge along the banks.

B. Hydrology

The Electrical Power Resources Survey and Development Administration maintains a streamgage on the Karasu River near Vezirhan, approximately 9 kilometers upstream of the mouth of the Karasu River where it empties into the Sakarya River. A nineteen year record of streamflow covering the period from October 1972 through September 1991 was analyzed. Mean monthly minimum, mean and maximum flows are presented in Table 2.

Table 2: Monthly Flow Statistics for the Karasu River at Vezirhan

Month	Minimum	Mean	Maximum
January	2.47	4.25	11.82
February	3.96	6.48	14.90
March	4.69	7.85	18.79
April	4.25	6.59	14.80
May	2.77	4.75	11.34
June	1.68	3.15	7.23
July	1.29	2.00	4.80
August	1.04	1.64	4.24
September	1.03	1.42	2.70
October	1.25	1.80	4.34
November	1.64	2.13	3.98
December	1.77	2.91	8.73

Overall mean flow for the nineteen year period was 3.74 cubic meters per second (m^3/sec). As shown, a smooth seasonal pattern exists with maximum flows occurring in March and low flows in September. During the nineteen year period, the analyzed values were as follows:

maximum daily flow:	73.50 m^3/sec
maximum monthly mean:	18.66 m^3/sec
minimum daily flow:	0.247 m^3/sec
minimum monthly mean:	0.293 m^3/sec
7 day/10 year low flow:	0.55 m^3/sec
30 day/10 year low flow:	0.80 m^3/sec
monthly flow frequency:	
exceeded 90% of the time:	1.25 m^3/sec
exceeded 50% of the time	2.30 m^3/sec
exceeded 10% of the time	6.10 m^3/sec

The streamflow statistics developed for the streamgage may be extended to other locations in the watershed based on the following assumptions: 1) the flow at the gage may be divided between natural flow, point discharges, and diversions; and 2) the natural flow is proportional to drainage area.

Drainage areas for key points in the basin are presented in Table 3. Areas were estimated by delineating drainage divides from topographical maps and measuring the resulting areas.

Table 3: Drainage areas at key stream points in the Karasu Basin

Stream	KM	Description	Area (km^2)
Karasu	62.0	U/S end	16.5
	52.5	U/S of confluence with Kocadere	166.1
	28.0	U/S of confluence with Sorgun	390.8
	20.0	U/S of confluence with Söğüt	782.6
	9.0	At streamgage	1131.5
	0.0	Mouth	1209.1
Kocadere	14.0	U/S end	25.5
	0.0	Mouth	115.9
Söğüt D.	28.0	U/S end	25.1
	0.0	Mouth	241.2
Sorgun D.	10.0	Mid point	234.3
	0.0	Mouth	270.7

Another important factor affecting the hydrology of the basin is the slope of the rivers. Stream elevation information was determined from the government's 1:25000 scale topographical map series and slopes calculated from these values. Ranges of stream slopes for sections of the Karasu River and major tributaries are listed below:

Kocadere	0.4 - 0.6 %
Karasu (Kocadere to Sorgun)	0.5 - 5.0 %
Karasu (Sorgun to Söğüt)	0.8 - 4.0 %
Söğüt	1.0 - 2.1 %
Karasu (Söğüt to mouth)	0.3 - 1.0 %

IV. INDUSTRIAL AND MUNICIPAL DEVELOPMENT

A. Industrial Development in the Karasu River Basin

Overview

There is a total of 84 industrial units located in the Karasu River Basin. These units are grouped geographically by the Bilecik Health Department into seven zones. The number of units in each area is as follows:

Area	Symbol	No. of Industries	Closed
Bilecik (Bilecik Merkez Ilcesi)	(BMI)	6	1
Bilecik Ind. Park (Org. Sanayi Bilecik)	(OSB)	23	2
Vezirhan (Vezirhan Belediyesi)	(VB)	4	0
Bayirkoy (Bayirkoy Belediyesi)	(BB)	3	0
Bozuyuk (Bilecik Bozuyuk Ilcesi)	(BBI)	33	3
Söğüt (Bilecik Söğüt Ilcesi)	(BSI)	10	0
Sorgun (Bilecik Pazaryeri Ilcesi)	(BPI)	5	2
Total		84	8

Eight of these industries are closed. Thus, only 76 industries are functioning. The major clusters are located at Bozuyuk, Bilecik Organization Industrial Park, and in the vicinity of Söğüt.

The 76 functioning industries are grouped in Table 4 according to the product(s) manufactured or handled. The popular items of the region include ceramics, marble, and engineering (metals). Two large paper factories exist as does a synthetic carpet manufacturing unit. The rest of the industries are operating on a relatively smaller scale.

Out of the 76 industries only 54 units are reported to be producing any wastewater; the rest of the units are 'dry' operations. Out of these 54 units, some form of effluent treatment is provided by 38 units (70%) before discharge. This relatively high percentage is due to the fact that the ceramic and marble factories have selected wastewater treatment (using a simple settling tank or pond) for settling coarse particles before reuse or discharge of the effluent to the water courses. Some form of recycling is practiced by 18 units

Table 4: Type of Industries and their Wastewater and Recycling Status

TYPE OF INDUSTRIES	NUMBER OF UNITS	NO. OF UNITS PRODUCING WASTEWATER	NO. OF UNITS PROVIDING EFF. TREAT.	NO. OF UNITS PRACTISING SOME RECYC.
Ceramics, Refractors, Tiles	15	15	15	Nil
Marble, Granite	14	14	13	13
Cal carb/ Gypsum blocks	2	-	-	-
Metals & Eng. incl. Galv. Plating	19	14	7	2
Paper	2	2	2	2
Rubber Products	2	-	-	-
Wood Products	5	-	-	-
Chemicals, plastics, textile dye	4	2	-	-
Slaughter house/ meat	4	4 (intermittent)	-	-
Food, etc.	5	2	-	-
Carpets (synthetic)	1	1	1	1
Miscellaneous (stationary, med. gas)	2	-	-	-
TOTAL	76	54	38	18

The Industrial Park in Bilecik (Organize Sanayi) is proposing a combined effluent treatment plant (CETP) with a forecasted completion date of 1997. Upon its completion, the number of units with effluent treatment facilities will further increase from 38 to 61. There are also serious plans for expanding the Industrial Park to include a new section primarily oriented toward the textile industry. The proposed combined effluent treatment plant is intended to also include treatment of this new expansion.

A detailed inventory of the Industries is given in Annex III. For each industry, its location, product manufactured, work shifts per day, water consumption as well as its wastewater discharge and where it goes, and the existence or otherwise of a wastewater treatment facility are shown.

In order to develop a better understanding of the industries in the Karasu River Basin, several representative industries were visited and their processes and treatment facilities were studied. In the following sections, the characteristics of the major industrial groups are presented.

Marble cutting and polishing

In marble and granite cutting and polishing work, there are 14 units in the study area. The earlier single blade cutters have yielded place to the modern disc type cutters. Large quantities of water are used to keep the blades cool and much reuse of water is done in the cooling process. As the quality of reused water is not so important in the cooling process, the treatment before reuse is often in the form of plain or chemically aided settling in a settling tank or pond. More than 90% of the water can be recycled with the remaining 5 to 10% discharged to the river. The required make up water is equal to the discharge quantity.

Sludge removal from the settling tank or pond and its disposal is a problem. In most countries, the sludge is dumped since it is contaminated with iron from the cutting blades. If the contamination can be removed, the fine powder can be used in the paint industry as a filler or in the tire industry or in the manufacture of tile, cement, moulded objects or compressed blocks with resin for other uses.

In Italy, which has a large marble industry, there are companies which collect and landfill the sludges. Almost 100% of the water is recycled while sludges go to filter presses. Pressed sludges are carted away for landfilling. "Black" sludges coming from granites contain water that is alkaline due to the use of $CaCO_3$ with high pH of even 12.0. It is not neutralised and their suspended solids are settled using sulfuric acid or CO_2. The water coming from the "white" sludges are generally not treated prior to its discharge.

In Turkey, 90 - 95% of the water is reused in the larger factories. In some smaller ones, direct discharge without reuse may take place if there is an ample supply of fresh water. The sludge is generally dumped. Sometimes a tanker truck belonging to a municipality or a private company is used to take the sludge to a nearby dumping area. However, this is relatively expensive and generally not done unless firmly required by the authorities (e.g., Istanbul). It is suspected that in some cases, sludge is discharged directly to the river where it is carried downstream by high velocities and then deposited along with grit and sand in slower stretches of the river.

The water reuse situation at the TEKMAR facility (Discharger A-01 in Bilecik), which is the largest marble and granite factory in Turkey is shown in Figure 3. This factory produces approximately 100,000 square meters of marble per month and uses approximately 350 liters per

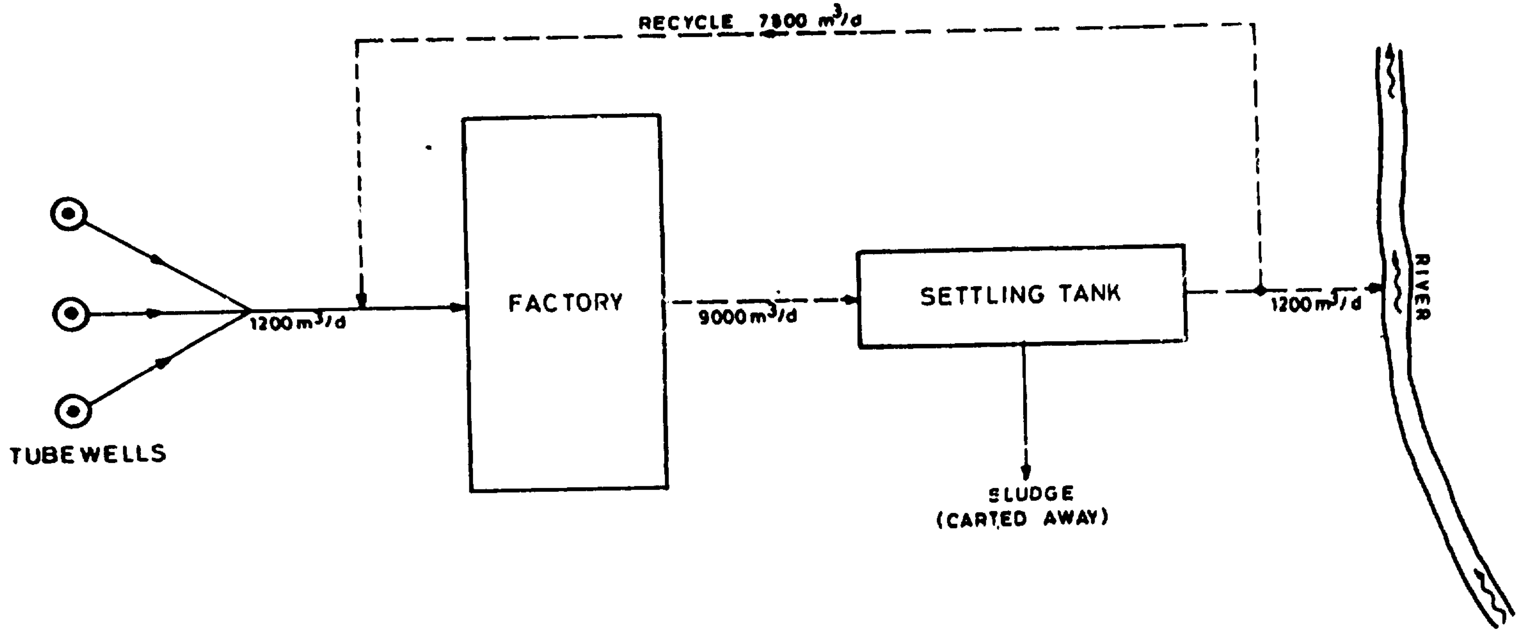


Figure 3
Typical Water Reuse Arrangement in a Marble Factory

square meter of marble. This value is greater than the industry average, presumably because of the ample availability of water. Sludge is reported to be carted away and deposited in natural depressions.

Farmers in the Karasu River Basin have complained that the fine marble suspended particles from factory effluents discharged into the rivers have affected the useability of river water for irrigation. One such complaint from farmers in the Yenikoy area (downstream of the town of Söğüt) is documented in a recent newspaper clipping (Figure 4).

Ceramics and refractory materials

The ceramics and refractory material industry is based on the rich mineral deposits consisting of magnesite, chromite, boron, pearlite, magnesium silicate, dolomite, gypsum, kaolin, feldspar, mica, and clay found in the Bilecik and Eskisehir regions of Turkey. The most common area of usage for magnesite products is the manufacture of refractory materials. Chromite is also used in the metallurgical and refractory materials industry. Earthenware-based industries in the region include the manufacture of roof tiles, bricks and firebricks, floor and wall tiles, and sanitary products. There are 15 units in the study area producing ceramics, refractory materials and tiles.

In the manufacture of floor and wall tiles, kaolin, feldspar quartz, and clay are utilized; sometimes in conjunction with powdered marble. A small amount of borax is added for glazes. All of the materials are fed along with water to the wet grinding machines (drums) to produce the required fine particles. At this stage, the water content is 35% and solids are 65%. The water is then evaporated by treating the paste in a spray drier. At this point, the moisture content is 3 - 5% in the powder which is then directed to a silo to feed the tile molds and subsequently to the presses. Thereafter, the tiles are dried at 120°C in long ovens to "set" them. To make white glazed bathroom tiles, a coating of alumina silicate is applied and heated to create the glaze.

In the manufacture process, much of the original water is consumed or lost through evaporation in the spray driers and ovens (20 to 100 liters/m^2 of tile). Only a small fraction of the water flows out as: (i) process water; (ii) cooling water; and (iii) general cleaning water. Domestic wastewater is generally conveyed to septic tanks. The quantity of flow discharged relative to the water intake quantity varies widely between factories from a low value of 5% in the case of the privately owned

Yeniköy Muhtarı Hüseyin Ayaz, "Her yere başvurduk. Sorunumuzu çözecek bir yetkili bulamadık" dedi.

Yeniköy'ün ölümü

● Bilecik merkeze bağlı Yeniköy'ün Muhtarı Hüseyin Ayaz, Söğüt İlçesi'ndeki mermer ocaklarının atıklarını köylerinden geçen dereye boşalttıklarını söyledi. Kirli sudan hem ürünlerinin hem de hayvanlarının zarar gördüğünü belirten Muhtar Hüseyin Ayaz, "Mermer ocakları arıtma tesislerini çalıştırsınlar. Topraklarımız mermer tozundan verimsiz hale geldi" dedi.

■ İbrahim ŞEN / BİLECİK, (hha)

Figure 4
Newspaper Article on Pollution in the Karasu River Basin

This clipping from the May 19, 1995 edition of a local newspaper, depicts the Mayor of the town of Yenikoy on the Sogut River describing the ill-effects of marble particles on irrigated land.

Semel Seramik (discharger A-06) to 16% in the case of the government owned Citosan Seramik (B-06). These two facilities have a similar tile production capacity and have an ample supply of groundwater.

At all facilities, the process water is treated by simple settling in a tank. However, it appears that at many facilities, the effluent does not meet government discharge standards for this industry type in terms of suspended solids. No reuse is practised in this industry. Some of the effluent could be reused without any pre-treatment in the wet grinding process. Presumably this is not done because of the relatively small amount of water used and the ample availability of groundwater supply. Sludge removal is infrequent (1 to 4 times per year) and the sludge is generally either carted away or dumped nearby. A possible reuse arrangement for the typical ceramic factory is shown in Figure 5.

Pulp and paper

There are only two factories in the pulp and paper category in the study area: Toprak Kagit San. Tic. A.S., Bozuyuk; and Marmara Kagit ve Ambalaj San. Tic. A.S., Vezirhan. Each of these factories is described below.

(i) The Toprak paper factory in Bozuyuk (discharger B-22) is less than 10 years old. It only produces paper (no pulp). Bleached paper pulp of soft and hardwoods imported from Finland and some unprinted newspaper are the primary raw materials. It manufactures tissue paper and writing paper for both domestic use and for export. There are approximately 500 workers in three shifts.

Water consumption at this plant is 12 - 15 tons per ton of paper produced. Half of this quantity is from groundwater (35 meters deep) and the balance is Karasu River water from upstream of the confluence with the Kocadere obtained from the Bozuyuk municipality by pipeline. Hardness of the surface water is 130 mg/l as $CaCO_3$. Total water intake is 2000 - 2500 m^3/day with a discharge of 1500 - 1900 m^3/day.

The treatment plant flow diagram is shown in Figure 6. Wastewater first goes to an equalization tank and then it is dosed with alum and polymers, flash mixed, flocculated and settled. The settled effluent is passed through a sand filter before discharge to the DSI Canal - Kocadere. The sludge from the settling tank is dewatered on a gravel bed to release the entrained water and the dried

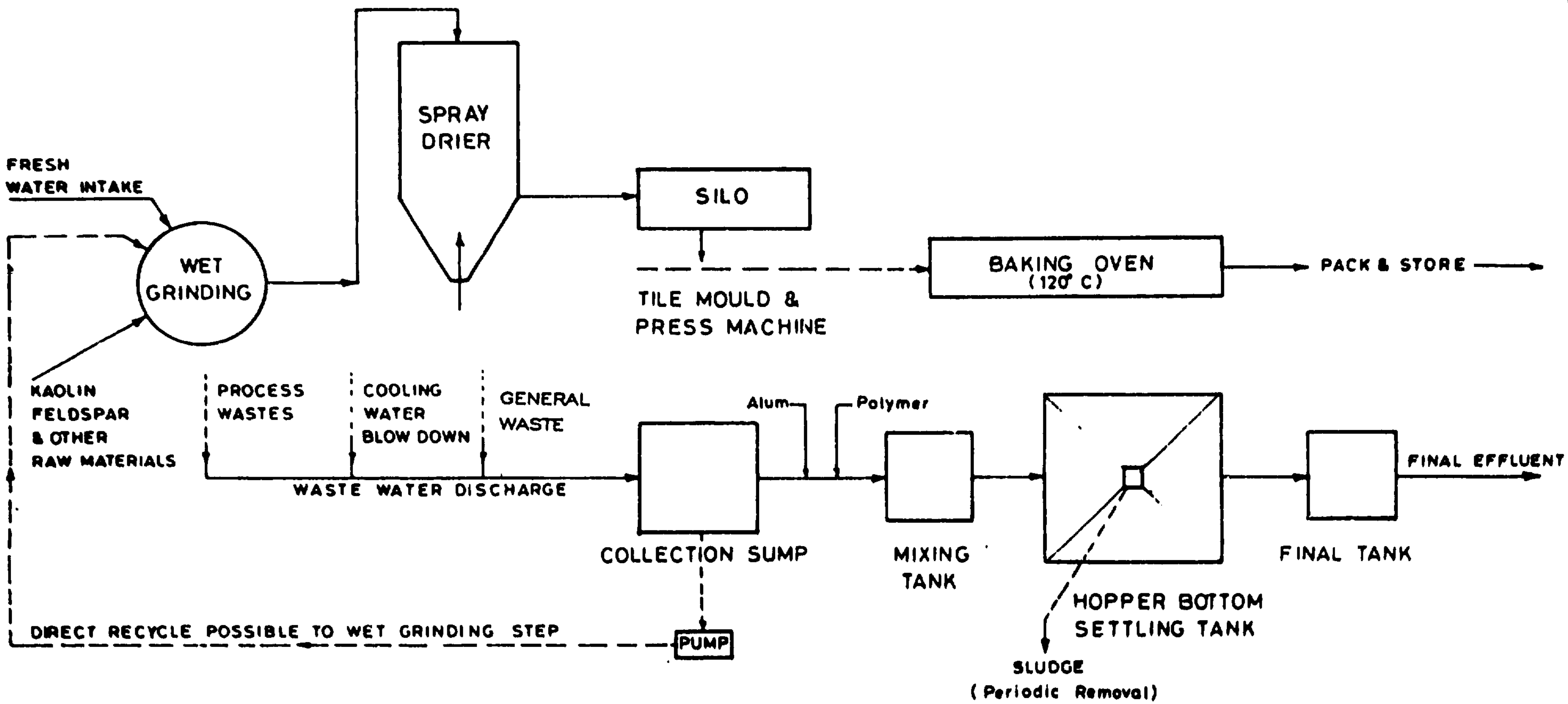


Figure 5
A Potential Recycle Arrangement in the Ceramic Industry

This arrangement would avoid treatment of the final effluent by using it directly in the wet-grinding step.

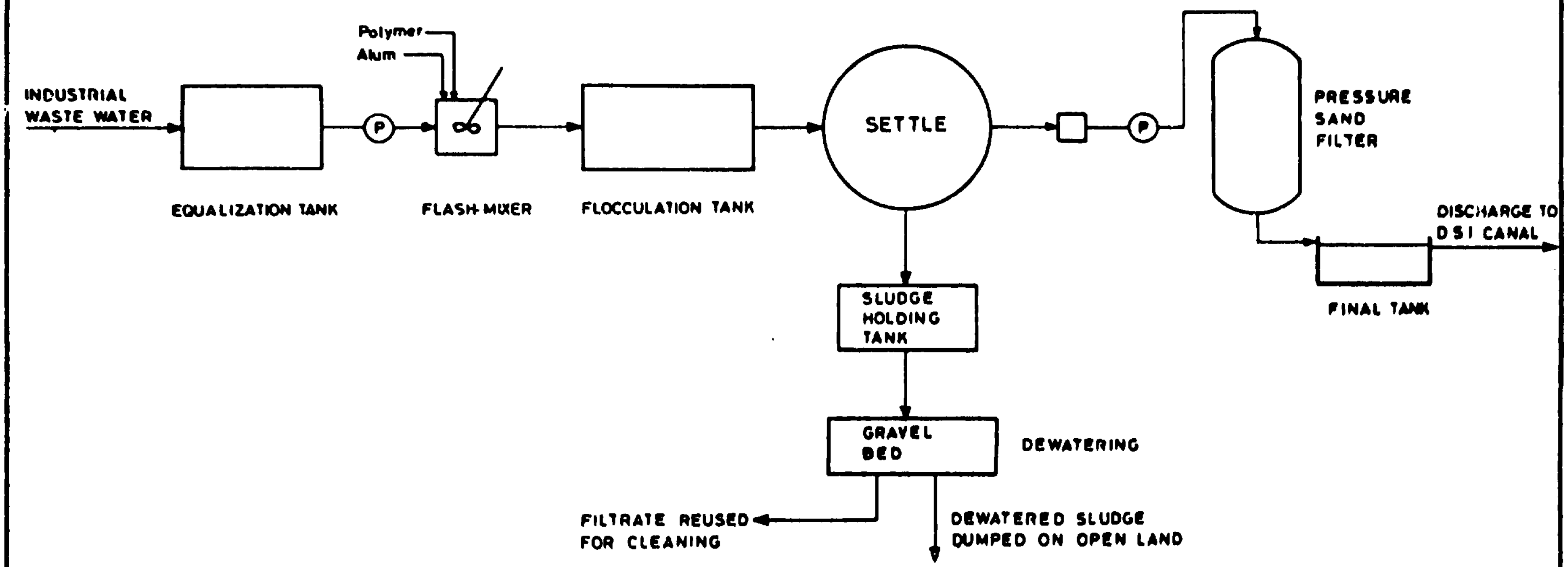


Figure 6
Wastewater Treatment Plant for a Paper Making Factory

sludge is dumped on open land. This sludge could be used in the making of carton boxes. The sand filters are backwashed using the final effluent while the backwash water from the filters go back to the start of the treatment plant.

The plant effluent is sampled periodically and is reported to be within the limits of the discharge standards for this type of industry. The plant also incorporates the use of "save-alls" and other recycling procedures typical in the manufacture of paper products.

Domestic sewage goes to an "extended aeration" type sewage treatment plant that serves this plant and two adjacent plants owned by the same company. This sewage treatment plant uses a BIO-PAK package plant (see Figure 7) which is typical of other package plants used in the region.

(ii) The Marmara paper and packaging plant (A-31) makes packaging material (liner and fluting) to make boxes. It is located just downstream of Vezirhan on the Karasu River. The raw materials used in the manufacturing process comprise 75% old packaging material and 25% semi-chemical cellulose from straw cooked with soda, caustic, and calcium hydroxide. No caustic recovery is done. When prices are favorable, pulp is sometimes imported from Finland. Water consumption of 120 m^3/hr (about 2500 m^3/d) is taken from its own wells.

Wastewater production is of the same order of magnitude. It is treated in a treatment plant consisting of a decantation (settling) system for reuse of the "white" waters (from paper forming machines) while some overflow mixes with other process wastes (black liquor from the pulp section) and general wastewaters (including domestic sewage) and goes to the main treatment plant (Figure 8). In the treatment plant there are vibrating sieves for grit/sand removal and fiber removal and recycle. The effluent is then dosed with acid and alum and goes to a primary settling tank followed by activated sludge, aeration and final settling. The sludge is returned to aeration while the surplus sludge is sent to a vacuum filter and dried. The final effluent is then held in a lagoon and partly recycled and partly discharged to the Karasu River.

There have been numerous complaints by downstream farmers that the plant effluent results in a significant degradation of the Karasu River in terms of both solids and biological activity resulting in severe difficulties in using the water for irrigation. This has led plant officials to recently construct an enlargement of the lagoon to provide storage of one month of the average plant effluent. This

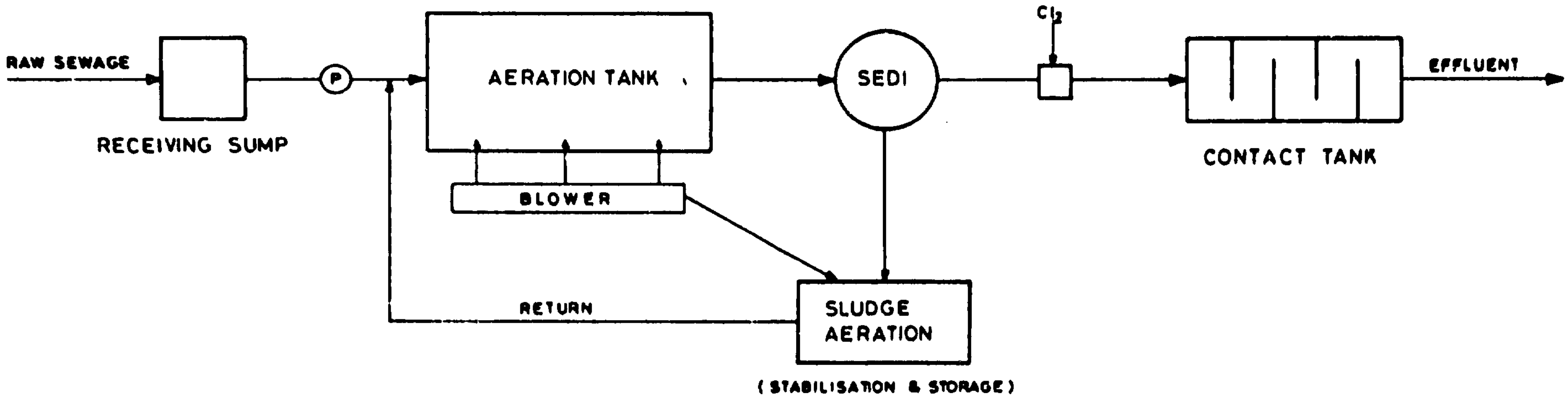


Figure 7
Typical Biopack Type Treatment Plant for Sewage Treatment
(500 person - 100 m^3/day)

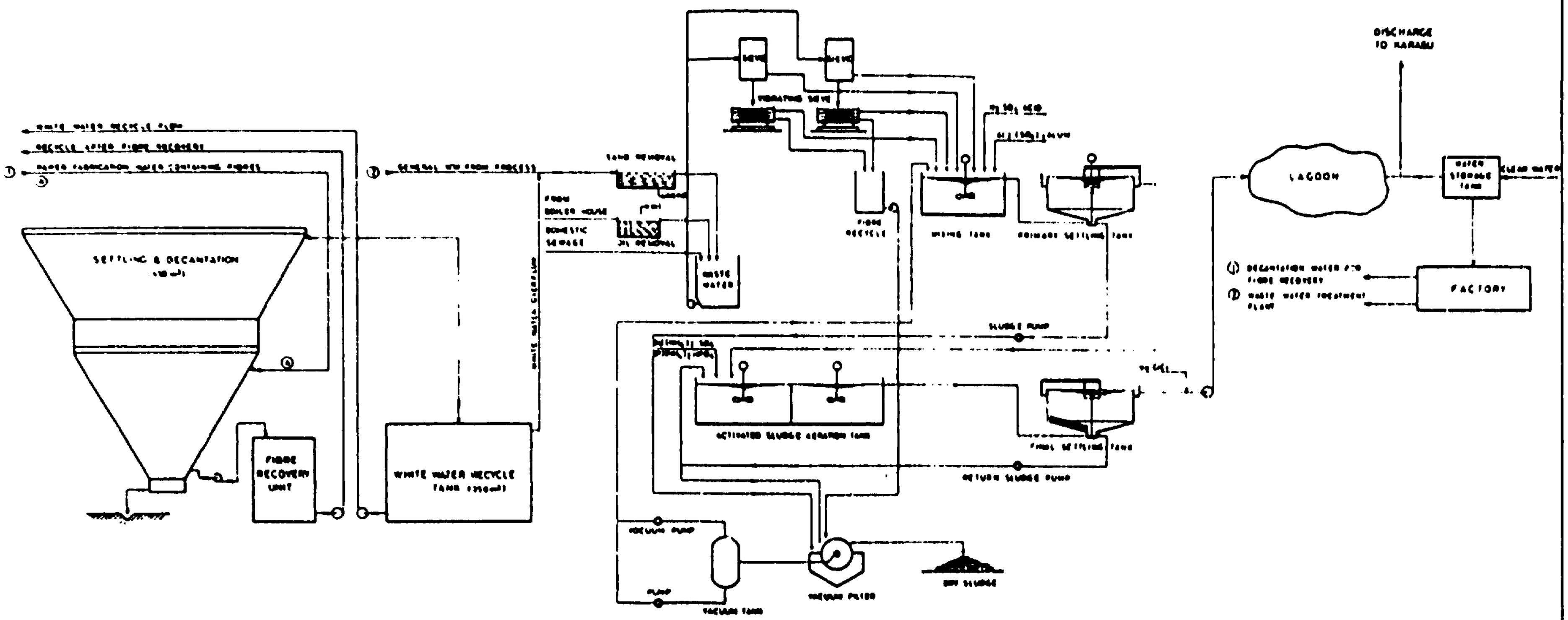


Figure 8
Wastewater Treatment Plant for a Pulp and Paper Factory Using Straw (Marmara Kagit ve Ambalaj San. A.S.)

enlargement of the lagoon provides further treatment and allows for storage of effluent during short periods of low flow in the river. Further enlargement could be provided if needed.

An expansion of the factory is currently being planned for which additional treatment facilities would be included in the form of anaerobic pre-treatment in a UASB (upflow anaerobic sludge blanket) type of unit before activated sludge. A pilot plant has already been installed to determine treatability. The study team noted that use of "clean technology" concepts such as waste minimization, better housekeeping, etc. should also be considered during such an expansion besides adequate waste treatment systems.

The plant effluent is analyzed periodically and generally exceeds allowable effluent concentrations for this industry group in terms of BOD, COD and suspended solids.

Metals and engineering

In this group of industries, there are 19 units of which 7 provide effluent treatment. The primary objective in studying these industries is to determine whether metals and metallic salts are discharged together with acids and alkalis used in the manufacturing and finishing processes. Some metal industries in the study area are dry operations on a relatively small scale.

Two large factories were selected for visit and review: Eczacibasi Artema Armatur in Bozuyuk (Plant B-13) and Turk Demir Dokum in Bozuyuk (Plant B-08 and B-09). These plants are described in detail below:

(i) The Eczacibasi Artema Armatur started production in 1984 manufacturing bathroom fixtures such as faucets using technology assistance from Finland. They now have a modern plant employing approximately 450 workers and an integrated design department and tool and die department. They consume more than 3000 tons per year of brass and their products are exported to the USA, Germany and others.

Their plating shop is a state-of-the-art facility involving full automation (robots) for nickel plating followed by chrome plating. Sand blasting is done to avoid the use of acids for cleaning, followed by ultra sound to avoid the use of solvents. The robots are programmed to dip the objects into the plating baths followed by rinses as necessary. A result of the automated plating process is a significant reduction in wastewater production. While the original manual plant discharged approximately 150 m^3/day, the new plant discharges only 40 m^3/day with commensurate savings in chemicals used in plating and waste treatment.

The treatment plant (see Figure 9) costed nearly US $ 1.0 million and is designed for 150 m^3/day capacity. It is designed for automatic operation (but was operating in a manual mode during the site visit due to a malfunction). The chromium and acidic wastes form one stream which is collected in a sump, and treated to reduce hexavalent and trivalent chromium by appropriate chemical addition. The cyanide and alkaline wastes constitute another stream which goes to a separate collection tank followed by alkaline chlorination to destroy the cyanide. Both of the streams are then mixed and settled in a sedimentation tank to precipitate chromium and other metals while the effluent, now free of chromium and cyanide, is discharged to the Kocadere.

The dry sludge from the filter press is reported to contain 7.5% chromium, 42% copper, 3.5 % nickel and 3.7% zinc. This sludge amounts to approximately 3 tons per month. It is held in plastic bags awaiting government approval for a disposal site since it is considered both toxic and hazardous. A new facility for the disposal of hazardous and toxic wastes is currently under construction by the government at Izmit (80 kilometers southeast of Istanbul) at a cost of approximately US $ 350 million. Upon its completion within a few years, this factory's waste could be transferred to the new facility if permitted.

(ii) The Turk Demir Dokum plant has produced panel radiators and hot water systems since 1988. The wastewater from the plant (500 to 600 m^3/day) is treated in a fully automatic treatment plant for chromium removal. Cyanide is not used at this facility.

The factory has been making efforts to reduce the use of acids and chromium. Chromium is converted from hexavalent to trivalent form by chemical precipitation in the treatment plant. The precipitated sludge goes to a filter press which is reported to result in a very dry sludge. The chromium containing sludge is currently being held on-site awaiting authorised disposal as a toxic and hazardous waste. The main effluent from the plant is analyzed once in two months and is reported to be well below effluent standards. As an indication of the quality of the effluent, a portion of the effluent is passed through a prominently displayed aquarium with fish. The domestic waste from the

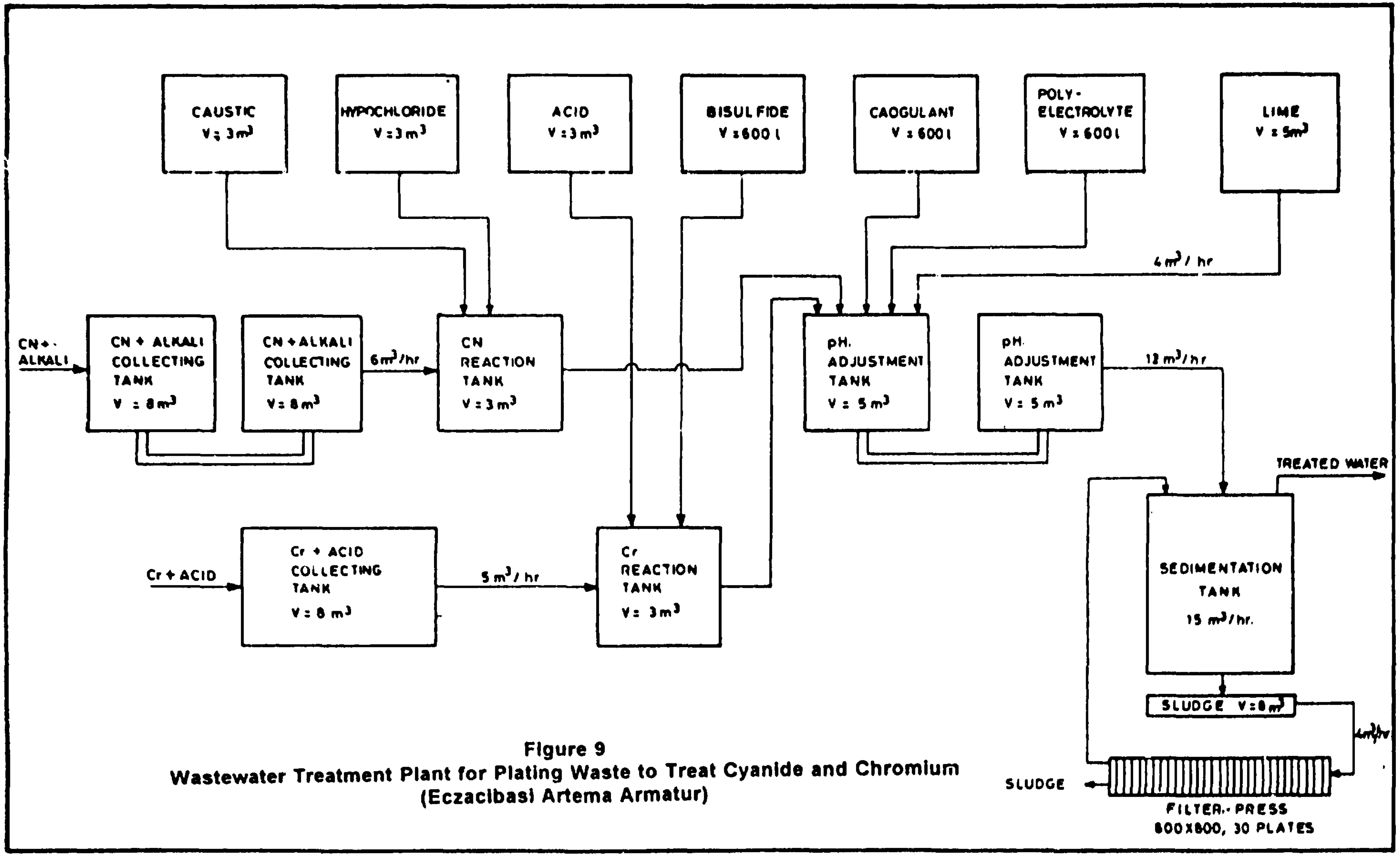


Figure 9
Wastewater Treatment Plant for Plating Waste to Treat Cyanide and Chromium
(Eczacibasi Artema Armatur)

plant (50 m^3/day) is discharged to Bozuyuk town sewers after treatment.

Synthetic carpets

There is a single synthetic carpet factory in the study area: Haliser Hali Ve Yer Dosemeleri San. Tic. A.C. in Bozuyuk (Plant B-07). This plant has produced synthetic, non-woven carpets since 1981 and currently employs approximately 300 workmen. It produces two types of carpets:

1) HALIFEX made from 100% polypropylene granules to which dyes are added and passed through an extrusion process. Example usage includes mats for cars.
2) HALISER made from 100% polyacrylic or polyamide to create tufted carpets for home use. The acrylic fibers are purchased ready-made, dye added and the carpets made.

The factory's water supply (400 m^3/day) is drawn from upstream wells. The wastewater from the factory (approximately 350 to 400 m^3/day) is colored and contains some acid. It is treated by a biological treatment system (capacity 600 m^3/day) with no reported discharge to the adjacent Kocadere. A diagram of the wastewater treatment facility is provided in Figure 10. It contains an equalization tank (closed to promote anaerobic action) followed by aeration together with settling and sludge return. This treatment is followed by sand filtration and storage in a lagoon. The under drainage (leachate) from this lagoon passes through the soil and is held in another lagoon at a lower level for later use in irrigation. The two lagoons together hold 25,000 m^3 of water (41.5 days capacity). Solid waste from the manufacturing process' Apre (latex) units is treated separately by calcium carbonate and carted away by another company for drying and grinding.

B. Municipal Development in the Karasu River Basin

The overwhelming majority of population in the Karasu River Basin is located in three population centers: Bozuyuk on the Kocadere; Bilecik the provincial capital located in the central portion of the basin; and Söğüt located on the western edge of the basin. Population from the 1990 census is listed below for these three municipalities:

BOZUYUK	33,162
BILECIK	23,273
SOGUT	9,470

No municipalities in the Karasu River basin provide centralized wastewater treatment.

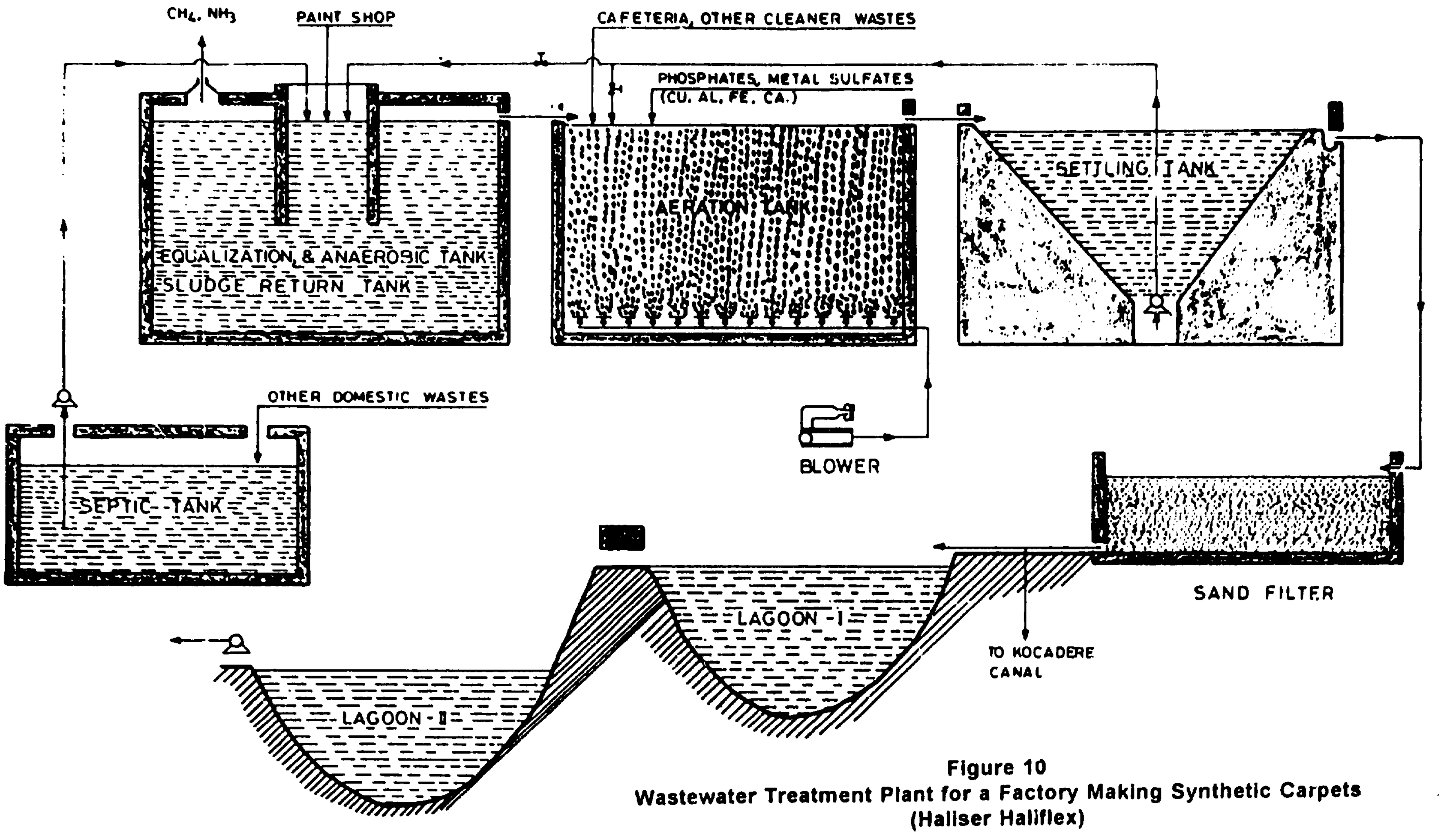


Figure 10
Wastewater Treatment Plant for a Factory Making Synthetic Carpets
(Haliser Haliflex)

V. ENVIRONMENTAL REGULATIONS

A. Water Quality and Environmental Standards and Regulations

The Government of Turkey has promulgated a series of water quality and environmental regulations and standards. These regulations and standards can be categorized as: effluent standards that stipulate the allowable pollutant concentrations that may be discharged into the nation's streams; stream standards that stipulate the allowable stream uses based on sampled water quality; and permit regulations that may stipulate the need for environmental impact assessments (EIA). Each of these regulations and standards are summarized below.

B. Effluent Standards

Effluent samples are required on a periodic basis from all entities that discharge into the nation's streams. The samples are analyzed through agencies such as the DSI Water Quality Section, the TUBITAK Research Centre in Marmara, and various University Departments. Some analysis is also carried out by the Health Department Laboratories in the Region. The frequency of sampling and measurement depends upon the volume of flow being discharged and varies from once a year for discharges of less than 50 m^3/day to daily for discharges exceeding 10,000 m^3 per day. If standards are exceeded, an increased frequency of sampling can be specified.

Effluent standards are based on the type of industry (or municipality). A summary of the Turkish Effluent Discharge standards for the major industrial categories present in the Karasu Basin is presented in Table 5 for selected parameters. These standards presume that the natural river courses provide a minimum dilution of 1:10 to the wastewaters discharged which is generally the case in the Karasu Basin.

Table 5: Effluent Standards for Selected Parameters for Industry Groups in the Karasu

Product Group	BOD (mg/l)	COD (mg/l)	Susp. Solids (mg/l)	Oil&Grease (mg/l)
Ceramics	-	80	100	-
Paper (from paper & straw)	270	870	80	-
Thin paper (from cellulose)	40	120	-	-
Metal products	-	200	125	20
Flour & macaroni	60	250	120	-
Meat	-	200	100	30
Carpets	120	300	160	10
Industrial Parks	100	160	200	20
Domestic wastewater	45	100	30	-

A limited amount of effluent data was available from the Bilecik Health Department. Examination of this data showed that in almost all cases the effluent values were quite low and in compliance with the effluent regulations. This finding is in contrast to ad hoc observations made by various governmental officials and to evidence provided by stream sampling data. Additionally, some effluent values do not appear to be compatible with one another. These discrepancies may be due to various possible reasons: either the treatment given to the wastewater is of a very high degree; or the sampling is defective; or the analysis itself is inaccurate. Accurate effluent data is an important aspect of any water quality management planning and the national government should take steps to assure reliable information.

C. Stream Standards

Stream standards are used to divide the nation's waters into stream classifications. These classifications are based on water quality measurements. There is not a process whereby a desired stream use is predefined (based on potential) and effluents controlled in order to support this use. Rather, the classification is made in a passive way based on the sampling data.

Water body classifications are associated with various uses. Water classifications are:

I: High quality waters, can be used for:
(a) drinking, with disinfection
(b) recreation including swimming
(c) trout production
(d) domestic animal production
(e) other uses

II: Little polluted waters, can be used for
(a) drinking, with proper advanced treatment
(b) recreation, excluding swimming
(c) fish production, except trout
(d) irrigation, if standards of the technical regulation (7 January, 1991 Official Gazette) are met
(e) other purposes different from those identified for Class I

III: Polluted waters, can be used for industrial water supply (except for the food and textile industries), with proper treatment

IV: Very polluted waters, not to be used for any of the purposes identified for Classes I through III above.

Governmental agencies determine classifications based on available sampling data. Classifications are determined based on the following four groups of parameters:

Physical and inorganic -- comprised of temperature, pH, dissolved oxygen, percent oxygen saturation, chloride, sulfate, ammonia-nitrogen, nitrite-nitrogen, nitrate-nitrogen, total phosphorus, total dissolved solids, color, and sodium;

Organic -- comprised of COD, BOD, organic carbon, total Kjeldahl nitrogen, oil and grease, methylene blue active materials, phenolic solids, mineral oils, and total pesticides;

Inorganic pollution -- comprised of mercury, cadmium, lead, arsenic, copper, total chromium, hexavalent chromium, cobalt, nickel, zinc, total cyanide, fluoride, chlorine, sulfur, iron, manganese, boron, selenium, barium, aluminum, and alpha- and beta-radioactivity; and

Bacteriological -- comprised of fecal coliform and total coliform.

For each parameter, the value that is met 90% of the time (90% percentile value) is compared to the criteria listed in Table 6 to determine the classification for that parameter.

Table 6: Stream Water Quality Criteria

Water Quality Parameter	Water Quality Class I	II	III
PHYSICAL & INORGANIC CHEMICAL PARAMETERS			
1. Temperature (°C)	25.	25.	30.
2. pH	6.5 - 8.5	6.5 - 8.5	6.0 - 9.0
3. Dissolved oxygen (mg/l)	8.	6.	3.
4. Oxygen (%)	90	70	40
5. Chloride - Cl (mg/l)	25	200	400
6. Sulfate SO4 (mg/l)	200	200	400
7. Ammonia nitrogen NH4 (mg/l)	0.2	1.	2.
8. Nitrite nitrogen NO2 (mg/l)	0.002	0.01	0.05
9. Nitrate nitrogen NO3 (mg/l)	5	10	20
10. Total phosphorous PO4 (mg/l)	0.02	0.16	0.65
11. Total dissolved solids (mg/l)	500	1500	5000
12. Color	5	50	30
13. Sodium (mg/l)	125	125	250
ORGANIC PARAMETERS			
1. Chemical oxygen demand COD (mg/l)	25	50	70
2. Biological oxygen demand BOD (mg/l)	4	8	20
3. Organic carbon (mg/l)	5	8	12
4. Total Kjeldahl nitrogen TKN (mg/l)	0.5	1.5	5.
5. Oil and grease (mg/l)	0.02	0.3	0.5
6. MBAS (mg/l)	0.05	0.2	1.
7. Phenolic solids (mg/l)	0.002	0.01	0.1
8. Mineral oils (mg/l)	0.02	0.1	0.5
9. Total pesticides (mg/l)	0.001	0.01	0.1
INORGANIC PARAMETERS			
1. Mercury Hg (ug/l)	0.1	0.5	2.
2. Cadmium Cd (ug/l)	3	5	10
3. Lead Pb (ug/l)	10	20	50
4. Arsenic As (ug/l)	20	50	100
5. Copper Cu (mg/l)	20	50	200
6. Chromium Cr total (ug/l)	20	50	200
7. Chromium Hexavalent (ug/l)	-	20	50
8. Cobalt Co (ug/l)	10	20	200
9. Nickel Ni (ug/l)	20	50	200
10. Zinc Zn (ug/l)	200	500	2000
11. Cyanide CN total (ug/l)	10	50	100
12. Fluoride Fl (ug/l)	1000	1500	2000
13. Chlorine Cl2 (ug/l)	10	10	50
14. Sulfur S (ug/l)	2	2	10
15. Iron Fe (ug/l)	300	1000	5000
16. Manganese Mn (ug/l)	100	500	3000
17. Boron B (ug/l)	1000	1000	1000
18. Selenium Se (ug/l)	10	10	20
19. Barium Ba (ug/l)	1000	2000	2000
20. Aluminum Al (mg/l)	0.3	0.3	1.
21. Radioactivity alpha (pC/l)	1	10	10
22. Radioactivity beta (pC/l)	10	100	100
BACTERIOLOGICAL PARAMETERS			
1. Fecal coliform (#/100 ml)	10	200	2000
2. Total coliform (#/100 ml)	100	20000	100000

Note: Concentrations exceeding (or outside of the range) the class III values are assigned as Class IV waters.

The class for each parameter group is then assigned as the lowest classification (Class IV is lowest) for a parameter in that group. The waters are then characterized by the classifications for the four groups. The lowest of the four classifications is then used as the final classification for determining appropriate uses of the water.

In a recently published paper on the classification scheme (N. Ince and O. Yenigun, "A Critical Review of the Water Classification System in Turkey: A Case Study on Meric Basin", Environmental Management, Vol. 19, No. 4, 1995), the authors conclude that the use of the four separate groupings of parameters is irrelevant and that the classification of the waters may be controlled by violations of standards in relatively insignificant parameters. They also compared the Turkish standards to those of the European Community (EC) countries and found that many of the Turkish limits are much stricter than even the target values in the EC standards. They conclude that, "the Turkish act needs some modifications in the quality classification process, for better and more economical management of water resources".

A separate set of standards was promulgated (7 January 1991 Official Gazette, pages 31 to 40) for waters to be used for irrigation. Table 7 contains the criteria for irrigation water use. The first three classes range from extremely good to useable for irrigation purposes. Class IV is described as useable with difficulties. Class V is described as harmful and should not be used for irrigation. The regulations also provide for limits on total loadings of substances via irrigation water (kg/ha) and technical limits (i.e., type of irrigation system allowed, treatment required) for the use of wastewaters from various industries in the irrigation of various crops.

Table 7: Irrigation Water Criteria

Parameter	Class I	Class II	Class III	Class IV	Class V
Conductivity (μmhos/cm)	250	750	2000	3000	> 3000
TSS (mg/L)	20	30	45	60	> 60
Fecal coliform (per 100 ml)	2	20	100	1000	> 1000
% Sodium	< 20	40	60	80	> 80
Sodium Adsorption Ratio	< 10	18	26	> 26	
BOD (mg/L)	25	50	100	200	> 200
pH	6.5-8.5	6.5-8.5	6.5-8.5	6-9	<6 or >9
Temperature (° C)	30	30	35	40	> 40
Sodium carbonate residual (mg/L)	< 1.25	2.5	> 2.5		

Parameter	Class I	Class II	Class III	Class IV	Class V
Chloride (mg/L)	4	7	12	20	> 20
Sulfate (mg/L)	4	7	12	20	> 20
Nitrate or Ammonia-Nitrogen (mg/L)	5	10	30	50	> 50
Total Salt (mg/L)	175	525	1400	2100	> 2100

For the Karasu system, the Directorate of State Hydraulic Works (DSI) classified streams in 1992. These classifications are summarized in Table 8. By taking the lowest class of water for each section of the river basin, the Karasu River above the Kocadere is classified as Class III waters while the remainder of the system falls into the lowest class, Class IV.

Table 8: Classification of the Karasu River Basin Streams by DSI

	Karasu upstream of Kocadere	Kocadere	Karasu from Kocadere to Söğüt	Söğüt	Karasu from Söğüt to Sakarya
A: Physical	**III**	**IV**	**IV**	**IV**	**IV**
B: Organic	**III**	**IV**	**III**	**III**	**IV**
C: Inorganic	**I**	**I**	**I**	**I**	**III**
D: Bacteriological	**III**	**IV**	**IV**	**IV**	**IV**
Overall Rating	**III**	**IV**	**IV**	**IV**	**IV**

An analysis of the historical water quality sampling data collected at the six DSI sampling stations provided further detail on the water quality in the streams relative to the stream standards. The results of this analysis are presented in Annex V.

In order to understand the importance of water quality impairments to human and ecological uses of the water, many governments develop standards associated with supporting specific uses of the water. Turkey's standards for irrigation water quality are examples of this. Additionally, the European Economic Community (EEC) has developed water quality standards for drinking water, bathing and aquatic life protection. These criteria and standards, as they apply to the Karasu Basin, are discussed below.

The primary uses (or potential uses) for all or part of the Karasu River and its tributaries include irrigation, contact recreation (bathing), and aquatic life support. The Turkish regulations clearly delineate the water quality requirements for irrigation. These may be summarized as follows in terms of the key water quality parameters monitored in the Karasu.

Parameter	Concentration Range for which Water is Useable or Better	Concentration Range for which Water is Useable with Difficulties
BOD (mg/l)	≤ 100	101 to 200
E. coli (per 100 ml)	≤ 100	101 to 1000
Suspended solids (mg/l)	≤ 45	46 to 60

However, there are no explicit criteria in Turkish law set out for contact recreation or aquatic life. In order to determine the usability of the Karasu River and its tributaries for these uses, criteria in use in the European Economic Community (EEC) were consulted.

The EEC's environmental legislation specifies microbiological criteria for bathing water. Mandatory limits for E.coli density of no more than 2000 ml per 100 ml and a total coliform density of no more than 10,000 per 100 ml. are specified. Guidelines (which are more restrictive than the mandatory criteria but do not necessarily need to be met) include E. coli density of no more than 100 per 100 ml, total coliform density of no more than 500 per 100 ml, and enterococci of no more than 100 per 100 ml.

EEC legislation provides dissolved oxygen criteria and other criteria for the protection of Salmonid waters. These criteria require that dissolved oxygen be maintained at or above 9 mg/l at least 50% of the time and at or above 6 mg/l at all times. The EEC guideline criteria (not mandatory) specify that dissolved oxygen should be maintained above 7 mg/l at all times. Other criteria promulgated by the EEC to protect Salmonid waters include guidelines for suspended solids (25 mg/l), temperatures below 21.5 °C at all times and below 10 °C during sensitive life cycle periods (mandatory), BOD below 3 mg/l (guidelines), and ammonium below 1 mg/l (mandatory) and below 0.04 mg/l (guidelines). Criteria were also promulgated for nitrite, copper, zinc, petroleum hydrocarbons, phenolics, and phosphorus.

When the Turkish irrigation standards and the EEC criteria are applied to the Karasu River, most of the basin is found to be unfit for any of the three potential uses: irrigation, contact recreation and aquatic life. Only the upper Karasu (above the confluence with the Kocadere) qualifies for these uses. Uses are impaired primarily by E. coli (for irrigation and recreation) and suspended solids (for irrigation and aquatic life). In addition, aquatic life support, especially a Salmonid fishery, is likely impaired by somewhat elevated temperatures and BOD.

D. EIA and permit regulations

Environmental Impact Assessment procedures have been laid down recently for specified industries, infrastructure projects and development projects.

For expansions, only an Initial Environmental Examination (IEE) Report is necessary and has to be submitted to the "Local Environmental Committee" for permission. Only if a serious environmental problem is anticipated, is the case referred to the Environment Ministry.

Legally speaking, permission is required prior to discharge of all polluted waters from the Environmental General Directorate. A discharge permit so given is valid for 3 years. An order dated September 27, 1994 states that control will be enforced irrespective of public or private sector, and all industries are required to notify before 28 October 1994 the likely completion dates of their wastewater treatment plants. The actual situation would be determined by a Committee and factory operation may be stopped if considered necessary. For those dischargers in operation prior to the passage of the law, new permits must be applied for and issued within three years of the 28 October 1994 registration date.

About 40 permits were issued nationwide in the past one year. The processing time takes approximately 60 working days and involves a series of meetings, reports and reviews by various Ministries.

VI. WATER QUALITY MODELING

A. QUAL2E Model

In order to investigate the impacts of alternative strategies on the waters of the Karasu River Basin, water quality modeling techniques were used. In such modeling, the physical characteristics of the streams that affect the movement and transformation of pollutants in the stream are represented in a mathematical model. After verification of the model, it may then be used to study the effect of various strategies on the resulting water quality of the stream.

A variety of proven mathematical models are available for use in such studies. For this study the U.S. Environmental Protection Agency's QUAL2E model was selected. This model has evolved from the original QUAL-I model developed for the Texas Water Board in 1971. QUAL2E (and its predecessors) has the distinction of being the most widely used water quality modeling package in the world. This proven record contributes to the confidence in applying the model.

QUAL2E can be used to simulate any or all of the following constituents:

Dissolved oxygen	Nitrite as N
Biochemical oxygen demand	Organic phosphorous as P
Temperature	Dissolved phosphorous as P
Algae as Chlorophyll a	Coliform
Organic nitrogen as N	Non conservative constituent
Ammonia as N	Conservative constituent

Nitrate as N

The model is applicable to dendritic stream networks where transport processes in the longitudinal direction are predominant. It is primarily a steady state model (flows and loads do not vary over time) though it does contain a feature to allow for study of diurnal effects on dissolved oxygen.

QUAL2E represents a stream by a series of reaches. Each reach is homogeneous in terms of hydraulic characteristics (slope, cross-sections, etc.) and biological/chemical rate coefficients. A reach is subdivided into a series of computational elements of length Δx. For each computational element, a hydrologic balance can be written in terms of flow entering from the upstream end, external sources or withdrawals, and outflow through the downstream end. A similar materials balance can be written accounting for both transport and dispersion as the movers of mass through the element. Mass can be added or removed from the element through external sources or withdrawals and through internal sinks or sources. Each computational element is represented as a completely mixed system. The overall stream system is built as a series of linked reaches; each composed of a series of computational elements of the same length.

QUAL2E solves the one-dimensional advection-dispersion mass transport equation through numerical integration for each water quality constituent. This equation includes the effects of advection, dispersion, dilution, constituent reactions and interactions, and sources and sinks. The relationship between flow and channel characteristics (velocity and depth) can be represented by equations of the form $V = aQ^b$ and $D = cQ^d$ where V, Q and D are velocity, flow and depth respectively and a, b, c, and d are fitting parameters or by use of Manning's equation in conjunction with a trapezoidal representation of the channel.

Within QUAL2E, the complete oxygen balance cycle can be represented. Coliform and non-conservative constituents are modeled by a first order exponential decay function of the form: $C_{out} = C_{in} * e^{-kt}$ where C_{out} and C_{in} are concentrations entering and leaving the computational element (due to decay only), k is the decay coefficient, and t is the travel time through the element. For conservative constituents, neither decay nor interaction with other constituents is assumed.

B. Representation of the Karasu River Basin in QUAL2E

The Karasu River is represented in QUAL2E as a mainstem starting on the Kocadere in Bozuyuk and then progressing from the confluence of the Kocadere and the Karasu to the mouth of the Karasu with the Söğüt Deresi represented as a tributary. Both the Karasu River above its confluence with the Kocadere and the Sorgun Deresi are represented as point loads to the mainstem rather than being explicitly modeled because of the relatively pristine nature of both reaches. A computational element size of ½ kilometer was selected for the model and the river system was represented by 11 reaches. The schematic representation of the river as represented in QUAL2E is illustrated in Figure 11.

Loadings to the river may be classified as: 1) headwaters; 2) non-modeled tributaries; 3) incremental or non-point sources; 4) diversions; and 5) man-induced point sources. Headwater loadings are introduced at the upstream end of all start reaches. The tributaries that are not explicitly modeled include the upstream reach of the Karasu River, the Sorgun Deresi, and the Sabuncu tributary to the Söğüt Deresi entering at a point approximately 10 kilometers above the mouth of the Söğüt. At diversions, water is extracted from the river. There is a single major seasonal diversion on the river. Man-induced point sources were grouped and introduced into the model at five locations within the river system, as follows:

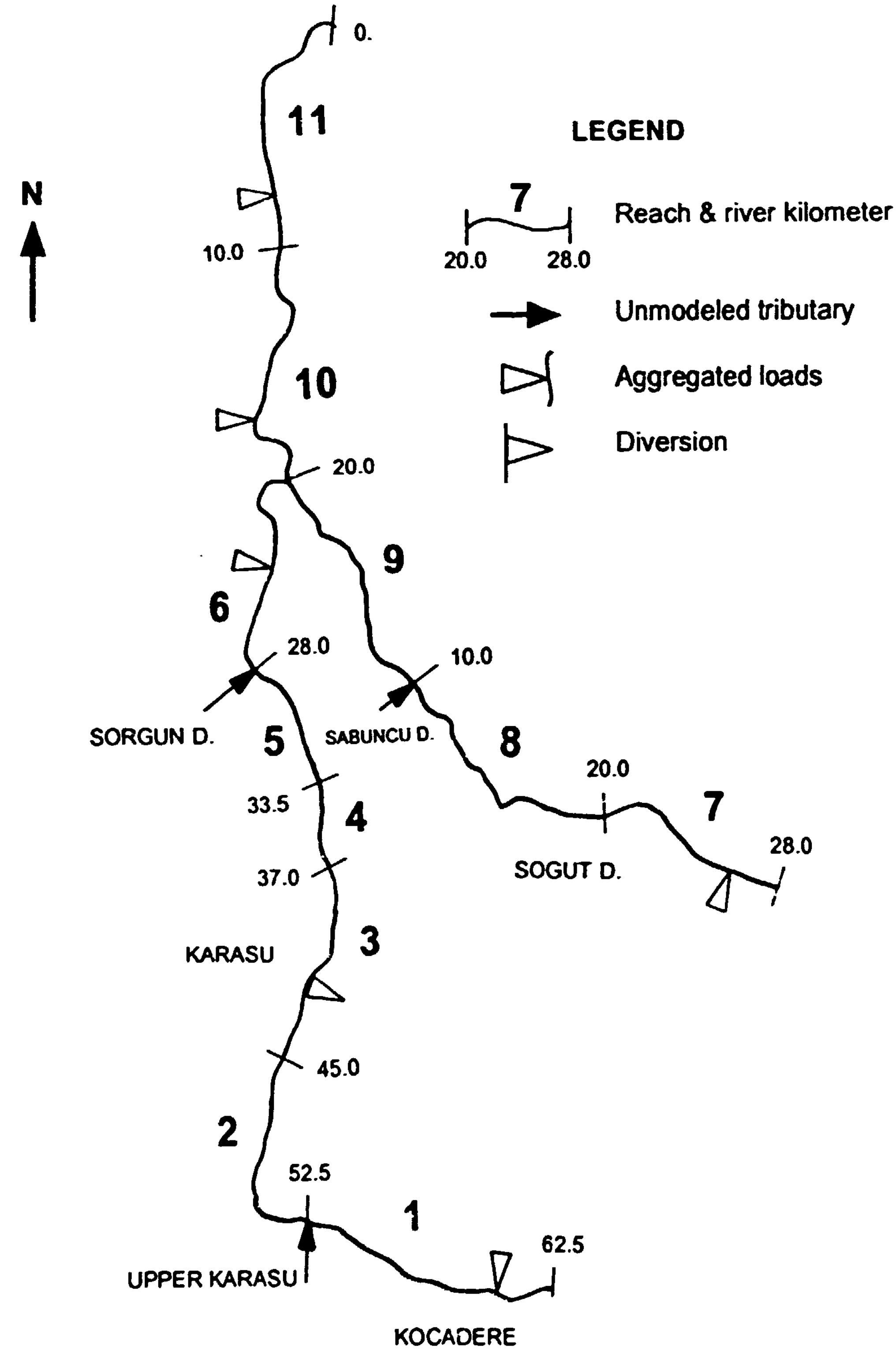
1) At a point that is 8 kilometers above the confluence of the Kocadere and the Karasu. Since the Kocadere and Karasu were treated as a single mainstem within the model, the loading point was represented as river kilometer 60.5 (i.e., 60.5 kilometers above the mouth of the Karasu). This loading point represents all 13 dischargers on the Kocadere. These dischargers are located at various points from 2.9 to 10.2 kilometers above the Kocadere mouth with the majority in the stretch from kilometer 5.6 to 10.2.

2) At river kilometer 24.5 on the Karasu. This point load represents two dischargers located in the near vicinity of that river kilometer.

3) At river kilometer 17.0 on the Karasu. This point load represents three dischargers including the Bilecik municipal waste and the Bilecik Industrial Park located from river kilometer 15 to 18.

4) At river kilometer 8.0 on the Karasu. This point represents three dischargers; two of them including a major discharger at kilometer 8.0 and a smaller discharger at river kilometer 3.0.

Figure 11: Schematic Representation of the Karasu River Basin in QUAL2E



5) At river kilometer 26.0 on the Söğüt Deresi. This point load represents 8 dischargers located between river kilometer 21.0 and 28.0 on the Söğüt.

C. Model Parameterization and Calibration

Various data sources were used to develop the parameters needed by the QUAL2E model. In some cases, these parameters were directly measured in the field or from maps while in other cases, the parameters were inferred by adjusting the parameter values until the output results of the model approximated observed values in the field. The latter process is generally referred to as model calibration.

In parameterization and calibration, extensive use was made of the water quality and hydraulic data collected during a 1-day intensive survey in May 1995. Specifically, this data set was used to estimate rate coefficients and to estimate loadings at the five loading points described in the previous section. Since these loads were estimated by calculating the load needed to produce the observed in-stream concentrations, it is not possible to determine the exact source of the loads. Thus, in most cases, the loads could emanate from several industries, from municipal waste or from non-point sources. During the intensive survey, there was little evidence of significant non-point contributions. It was a relatively dry period and for those stretches of the river where there were no known point sources (upper Karasu and Sorgun), in-stream concentrations of most parameters were quite low indicating little influence by non-point sources. However, during other periods, the impact of non-point sources relative to point sources could be more significant. The relatively barren, hilly topography contributes to erosion and resulting elevated solids loadings. Additionally, the name Karasu means "black water" in Turkish suggesting a relatively high historic silt load in the river.

The following water quality parameters were selected for modeling: dissolved oxygen (D.O.) and biological oxygen demand (BOD), total suspended solids; and fecal coliform. The parameterization process is described in Annex V for the hydraulic and water quality parameters used in QUAL2E

VII. ANALYSIS OF STRATEGIES

A. Introduction

The essence of the area-wide environmental quality method (AEQM) is the examination of present environmental conditions and alternative future strategies in terms of their impacts on the environment and desired uses of the environment, technical solutions and their costs for mitigating negative impacts, and institutional plans for implementing these solutions.

A series of strategies were developed and analyzed to represent both existing conditions and alternative future actions. For each of these strategies, streamflow conditions corresponding to the average streamflow during the month of September were used. September was selected because it is (on average) the lowest flow month. Additionally, the average streamflow during September at the flow gage at Vezirhan is 1.43 cubic meters per second which is only slightly greater than the low flow monthly streamflow of 1.26 cubic meters per second that is exceeded 90% of the time. In other words, 10% of the time, monthly streamflow is less than this value which can be said to correspond to the allowable 10% violations allowed in stream quality classification. Streamflow values for each reach were determined by linearly interpolating the flow at the streamgage based on drainage area for each reach and tributary. The same reaction coefficients and headwater, incremental and tributary water quality from the calibration runs were used in all model runs.

For each strategy, point source loadings were determined. The methodology used in determining these loadings are described in the following sections. The resulting loads at each of the five point source locations are presented for each strategy in Table 9 for BOD, D.O., total suspended solids and fecal coliform. The results of the simulations are discussed in the following sections.

Table 9: Point Loads for Present Situ:.tions and Future Strategies

Point Load #	1	2	3	4	5
Stream	Kocadere	Karasu	Karasu	Karasu	Söğüt
River Km.	60.5	24.5	17.0	8.0	26.0
PRES1 situation					
Flow (m^3/sec)	0.134	0.014	0.051	0.024	0.016
D.O. (mg/l)	4.3	7.0	3.5	7.0	4.9
Fecal Col. (#/100ml)	1.88×10^7	0	7.4×10^5	3.3×10^7	2.33×10^6
BOD (mg/l)	81.7	250.	102	2482	60.2
TSS (mg/l)	222.	3913	637	5774	1225
BOD (kg/day)	946	302	449	5147	83
TSS (kg/day)	2570	4733	2807	11973	1693
STAND1 situation					
Flow (m^3/sec)	0.134	0.014	0.051	0.024	0.016
D.O. (mg/l)	4.3	7.0	3.5	7.0	4.9
Fecal Col. (#/100ml)	5.7×10^6	0	7×10^6	0	4.4×10^6
BOD (mg/l)	122.3	14.6	170.2	262.8	87.8
TSS (mg/l)	29.5	97.2	58.8	80.8	56.1
BOD (kg/day)	1416	18	750	545	121
TSS (kg/day)	342	118	259	168	78
FUTURE1 strategy					
Flow (m^3/sec)	0.225	0.034	0.082	0.043	0.032
D.O. (mg/l)	4.7	7.0	3.85	7.0	5.5
Fecal Col. (#/100ml)	4.7×10^6	0	6.3×10^6	0	3.0×10^6
BOD (mg/l)	102.6	8.4	162.6	263.0	60.0
TSS (mg/l)	38.2	98.9	73.7	81.3	69.9
BOD (kg/day)	1999	25	1153	977	166
TSS (kg/day)	744	291	522	302	194
FUTURE2 and FUTURE3 strategies (differ only in the sediment oxygen demand)					
Flow (m^3/sec)	0.277	0.034	0.145	0.043	0.064
D.O. (mg/l)	7.0	7.0	7.0	7.0	7.0
Fecal Col. (#/100ml)	5.66×10^4	0	7.91×10^4	0	6.52×10^4
BOD (mg/l)	24.4	8.4	44.5	263.0	19.7
TSS (mg/l)	31.1	98.9	41.7	81.3	35.0
BOD (kg/day)	584	25	557	977	109
TSS (kg/day)	744	291	522	302	194

FUTURE4 strategy same as FUTURE3 strategy except that all fecal coliform point loadings are zero.

B. Present Conditions

Description of present situations

Two cases were analyzed based on present conditions in the basin. In the first case, point source loadings were estimated based on matching the observed water quality in the streams. This case is most representative of the actual present loading conditions. In the second case, it was assumed that all industries were discharging at the effluent limits and that municipal waste was untreated. Details on these two cases are presented below.

1) Present conditions (Situation PRES1): In this case, current average loading conditions were estimated utilizing the stream water quality data for the 5-year period from 1991 to 1995. These estimates were made by calculating the loading that would result in the observed in-stream water quality for each set of water quality sampling data available from DSI and then averaging these loads over all sampling events. Since loadings were only calculated for the five aggregated point load points, it is not possible to identify the actual loads corresponding to each separate industry or municipality or to ascertain the amount of the loading due to non-point sources.

2) Present discharge flow assuming all industries meet effluent standards (Situation STAND1): In this case, loadings were calculated for all industries assuming that they discharge at a concentration that will just meet the existing effluent standards for their particular product category. For municipalities, no treatment was assumed and a loading rate of 250 liters per capita per day, 50 grams of BOD per capita per day, fecal coliform of 10^7 per 100 ml, and dissolved oxygen of 2 mg/l. The percentage of the total population's waste that is currently discharged to the stream was estimated based on current usage of septic systems. This information is summarized below.

Municipality	1995 Population	% of waste reaching stream
Bozuyuk	35,000	75 %
Bilecik	25,000	50 %
Söğüt	10,000	20 %

Analysis of present condition situations

The point source loadings for BOD, TSS and fecal coliform are summarized in Table 9 for the two situations representing present conditions. The resulting predicted in-stream concentrations for BOD, D.O., TSS and fecal coliform are presented in Annex VI.

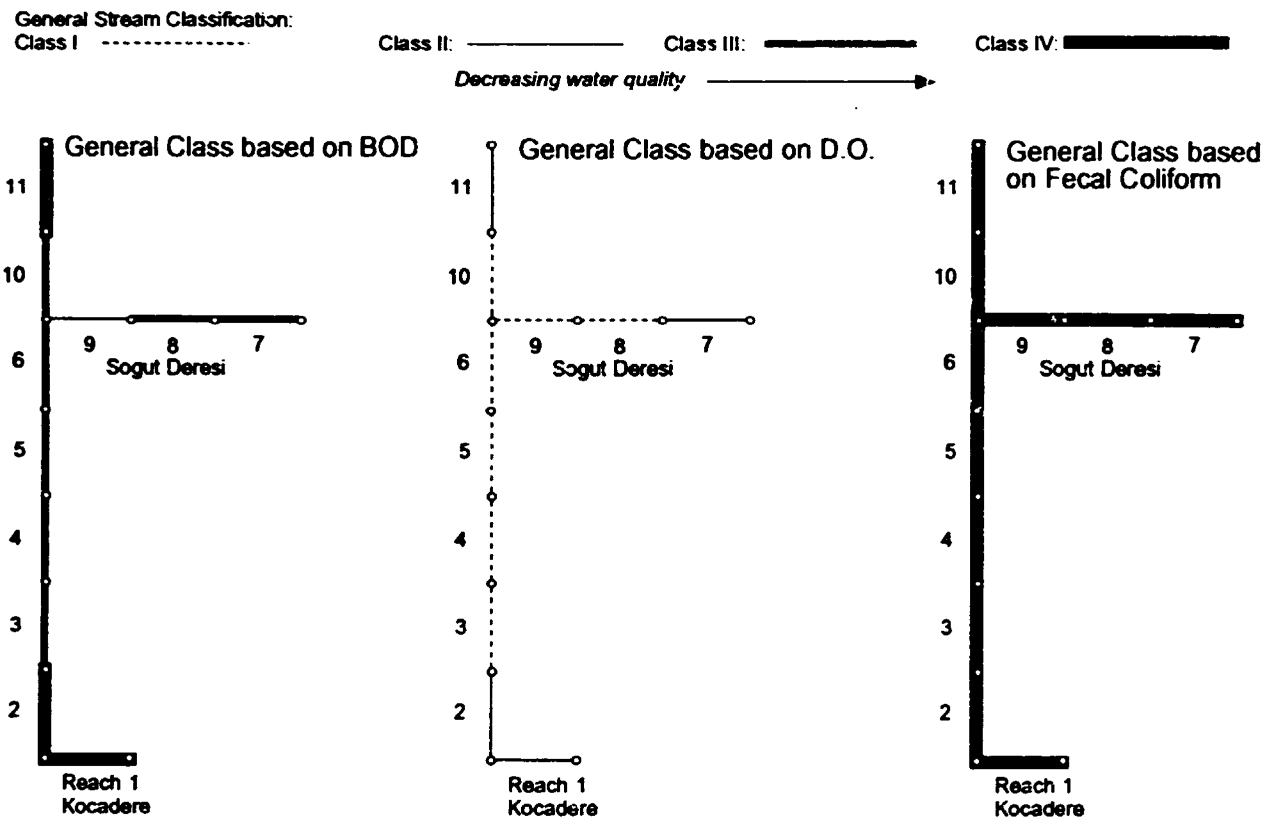
In order to illustrate how the predicted concentrations affect stream uses, each reach has been classified according to its stream category based on each of the four simulated constituents. A reach is assigned its category based on the maximum value in the reach (except for D.O. where the minimum value is used). Both general stream categories and categories associated with irrigation are analyzed. The results of this analysis are shown in Figures 12 and 13 for situations PRES1 and STAND1 respectively. The results of the analysis are summarized below for each of the constituents:

1) BOD: For the Kocadere, the Söğüt Deresi and the middle section of the Karasu River, the BOD loads based on meeting standards (STAND1) are slightly higher than the loadings inferred from the stream data (PRES1) and the corresponding in-stream BOD concentrations are quite close. For the lower Karasu River, the inferred BOD values from the PRES1 situation are an order of magnitude higher than standards (STAND1) indicating that one or more dischargers in the most downstream reach of the Karasu are far exceeding the effluent standards. The resulting BOD concentrations in the stream result in poor water quality in the Kocadere and in the Karasu reach immediately downstream of the Kocadere and in the most downstream reach of the Karasu. All of these reaches are classified in the lowest general water quality category (IV) based on BOD.

2) Dissolved oxygen: There is negligible difference between the predicted in-stream D.O. concentration for situation PRES1 and STAND1 with the exception of the most downstream reach on the Karasu where there is a difference of approximately 0.5 mg/l. All reaches are classified as Class I (very high quality) or II (high quality) in terms of dissolved oxygen.

3) Total suspended solids: For all point source loadings, the estimated TSS loadings based on in-stream data (PRES1) are much higher than loadings based on meeting effluent standards

Figure 12
Stream Classifications Based on Modeling for Situation PRES1



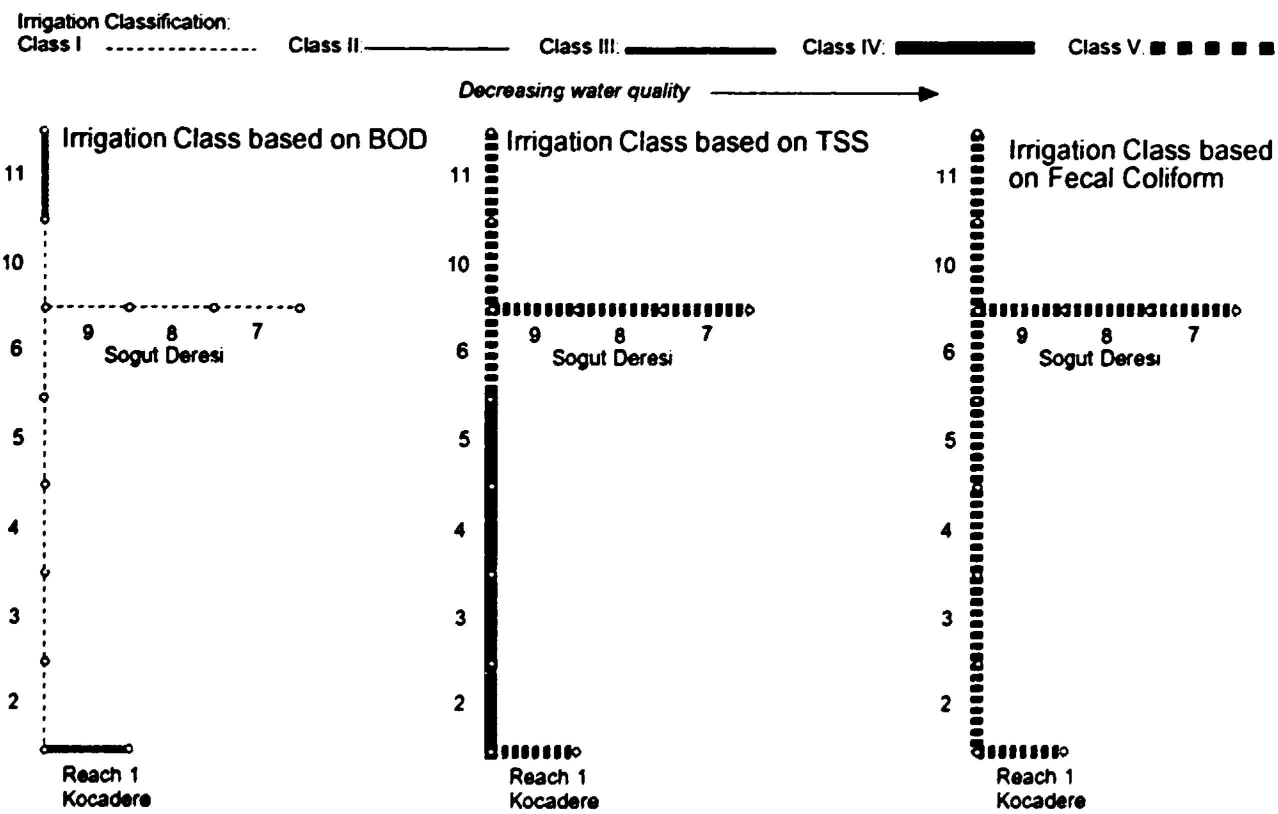
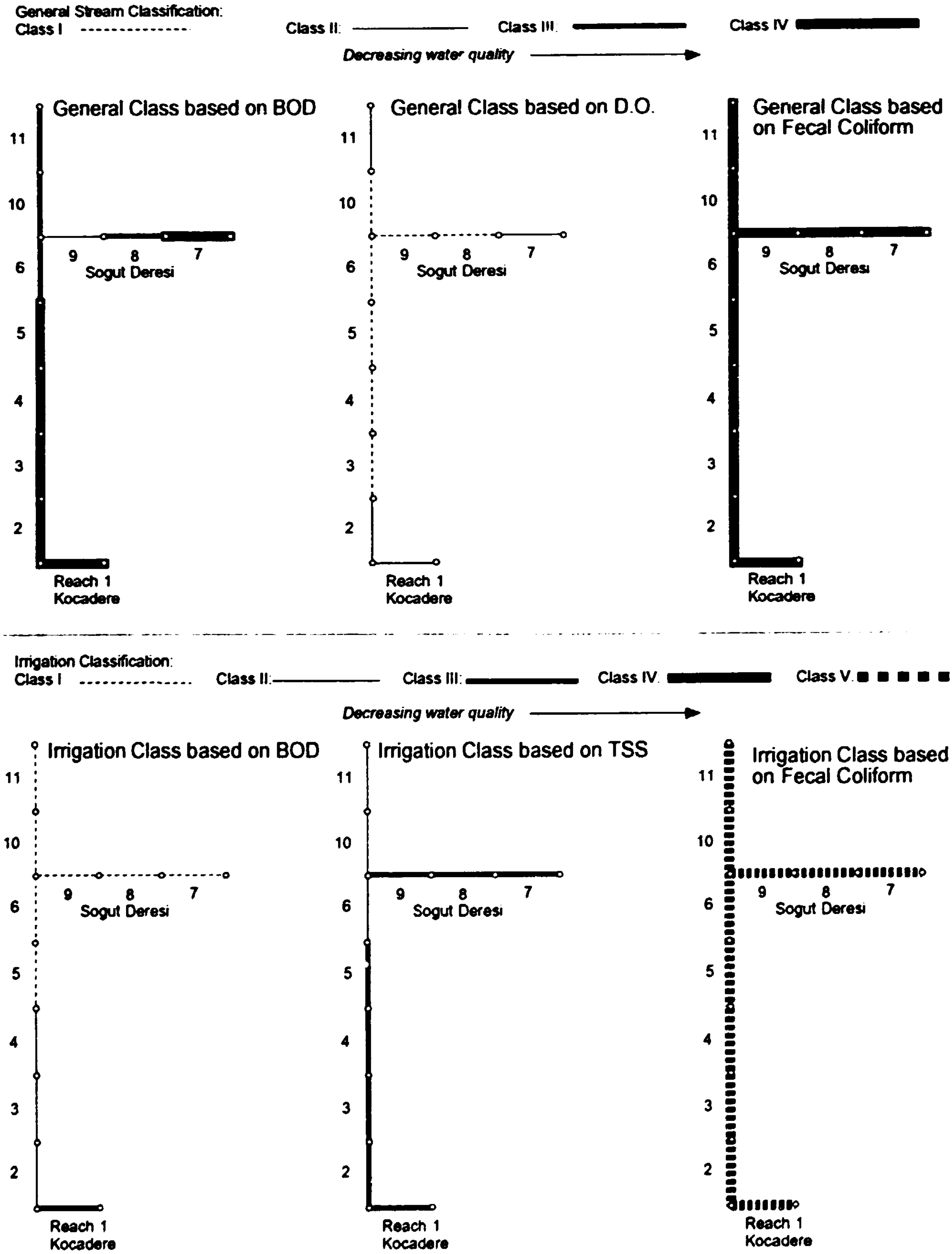


Figure 13
Stream Classifications Based on Modeling for Situation STAND1



(STAND1), generally by a multiplicative factor of 10 to 40. Though some of this difference may undoubtably be due to non-point contributions (erosion and overland flow) it is quite definite that a significant number of industries in the basin are not meeting their TSS effluent standards. This results in predicted TSS in-stream concentrations for PRES1 that are much higher than for STAND1. In terms of impact on stream categorization, the high TSS concentrations for PRES1 result in the majority of the stream system (Kocadere, Söğüt and the lower Karasu) being in category V for irrigation (harmful and should not be used for irrigation). The remaining portions of the Karasu are in category IV which limits the usefulness of the water for irrigation.

4) Fecal coliform: For the majority of the river, the fecal coliform levels in the effluents for PRES1 are only slightly higher than those in STAND1. The major exception is in the most downstream reach of the Karasu where a very high level of coliform is being discharged by one or more dischargers resulting in a significant elevation of coliform from STAND1 to PRES1. For all reaches, the high level of fecal coliform results in a very poor water quality in terms of coliform. All reaches are assigned to general water quality classification IV and irrigation classification V. Both of these classifications are the lowest categories and should result in extreme limitations on the use of the river.

Summary

In summary, the analysis shows that in most cases for BOD and fecal coliform, industries are meeting effluent standards and that the predicted contribution from the untreated municipal waste is relatively accurate. The primary exception to this is in the most downstream reach of the Karasu (from 0 to 10 kilometers from the mouth) where one or more dischargers are far exceeding the effluent standards. In terms of TSS, the analysis indicates that discharges far exceed the effluent limits in all areas of the river basin by a wide margin. Though some of this exceedance is due to non-point sources, the wide margin suggests that many industries are seriously exceeding the allowable effluent concentrations for solids.

In terms of impacts on the river, the levels of BOD and dissolved oxygen do not seriously impair the uses of the river. However, in terms of coliform and TSS, the high levels generally place the river in the lowest water quality classifications severely limiting the uses of the river.

C. Future Strategies

Description of Strategies

A series of additive future strategies were studied. These future strategies assume that: 1) future growth rate for municipalities will continue at the same rate experienced over the past 50 years; 2) future growth rate for industries in the basin will continue at the national average experienced during the past 10 years for each of the industry groups; 3) all industries will expand/improve their treatment facilities so as to meet effluent standards; and 4) for strategies 2 through 4 that municipalities will construct secondary treatment plants and sewer systems that will serve the entire municipality. The water quality impacts were examined for each strategy based on growth estimates for the year 2005. An initial strategy in which industrial growth would be allowed without any expansion/improvement of their treatment facilities was not considered because such a strategy would not be consistent with present regulations and would lead to an obvious degradation of the water quality of the receiving streams.

The four future strategies are as follows:

Future strategy 1: Industrial growth with all industry meeting effluent standards. (Assumes municipal wastewater increases proportionally to municipal growth but no additional sewers or treatment facilities are constructed.)

Future strategy 2: Future strategy 1 + municipal growth, fully sewered municipalities and secondary treatment.

Future strategy 3: Future strategy 2 + elimination of sediment oxygen demand.

Future strategy 4: Future strategy 3 + disinfection added at all municipal treatment works and bacterial contamination reduced in rural areas.

Estimates of future expansion for industry were made based on 1984 -1994 growth rates by the State Planning Organisation's Official Report for the following 3 sectors:

	Industry	10 years growth rate (1984-94)
1.	Marble and Ceramics	140%
2.	Pulp and paper	80%
3.	Metals/Engineering	50-60%

Growth rates for the three towns and their population estimates are given in Table 10.

Table 10: Growth Rate Estimates for Towns in the Karasu River Basin

Town	1990 Population	Percent Growth Rate per year since 1945	Estimated Population in Year			
			2000	**2005**	2010	2020
BOZUYUK	33,162	3.33	46,016	**54,205**	63,851	88,600
BILECIK	23,273	3.63	33,243	**39,731**	47,486	67,829
SOGUT	9,470	2.89	12,592	**14,519**	16,742	22,261

Water quality impacts of future strategies

The point source loadings for BOD, TSS and fecal coliform are summarized in Table 9 for the primary future strategy. The resulting predicted in-stream concentrations for BOD, D.O., TSS and fecal coliform are shown in Annex VI. In order to illustrate how the predicted concentrations affect stream uses, each reach has been classified according to its stream category based on each of the four simulated constituents. A reach is assigned its category based on the maximum value in the reach (except for D.O. where the minimum value is used). Both general stream categories and categories associated with irrigation are analyzed. The results of this analysis are shown in Figure 14 - 17 for the four future strategies and are summarized below:

Future Strategy 1:

In future strategy 1, industrial treatment is assumed to be expanded to accommodate future industrial growth and to meet current effluent standards for each industrial type. Municipal loadings are assumed to increase at the same rate as municipal growth but no municipal treatment is provided. As illustrated in Figure 14, this strategy is effective in mitigating those constituents that are primarily contributed by industry, namely total suspended solids. Under this strategy, most reaches are classified as irrigation Class III for suspended solids which is of sufficiently high quality for most irrigation requirements. For BOD, all reaches are classified as Irrigation Class I, II or III which is again acceptable for most irrigation. However, because of the absence of municipal treatment, most reaches have relatively high BOD levels and are classified as General Class IV waters which are unacceptable for most uses. For D.O., all reaches are classified as general Classification I or II with the exception of the Kocadere which is in Class III. The most serious condition under this strategy is the high levels of fecal coliform. Under this strategy, all reaches are classified in General Class IV and Irrigation Class V, the lowest possible water quality ratings. This strategy illustrates that an approach that only deals with industrial treatment will not be effective in cleaning up the water quality in the Karasu River Basin.

Future Strategy 2:

In future strategy 2, in addition to the industrial treatment provided in future strategy 1, the three major municipal areas are assumed to be fully sewered and secondary treatment is provided without post disinfection. As illustrated in Figure 15, there are some significant improvements in water quality between future strategy 1 and future strategy 2. Under this strategy BOD levels are reduced so that all reaches are assigned to Irrigation Class I for BOD and General Class I, II or III for BOD. Both D.O. and suspended solids improve slightly; the latter because of the additional low solids dilution water provided from the municipal flow. However, fecal coliform levels which were generally reduced by about 99% are still high enough that most reaches are still classified in General Class IV and Irrigation Class V, with only a few reaches in the middle Karasu improving to General Class III and Irrigation Class IV.

Figure 14
Stream Classifications Based on Modeling for Strategy FUTURE 1

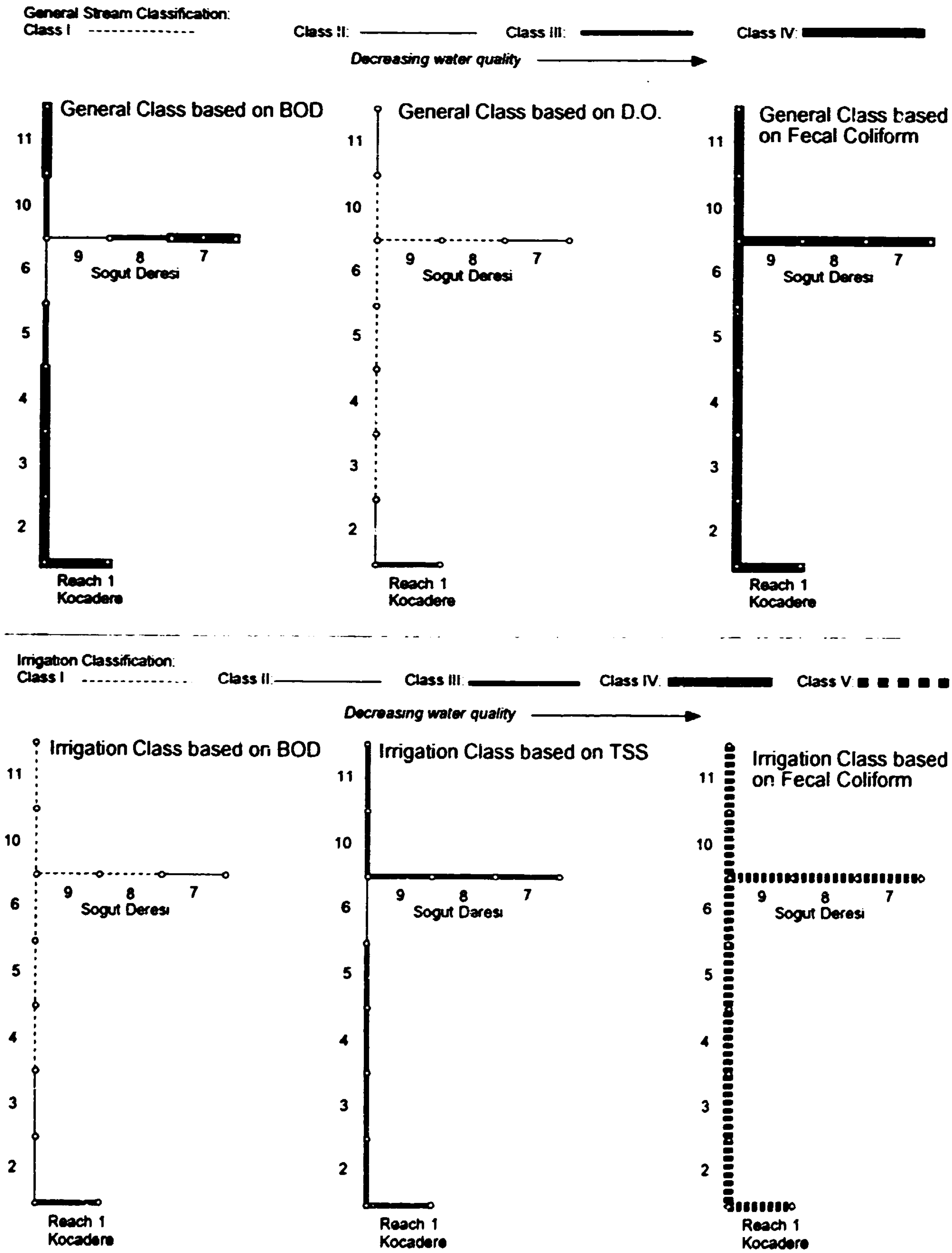
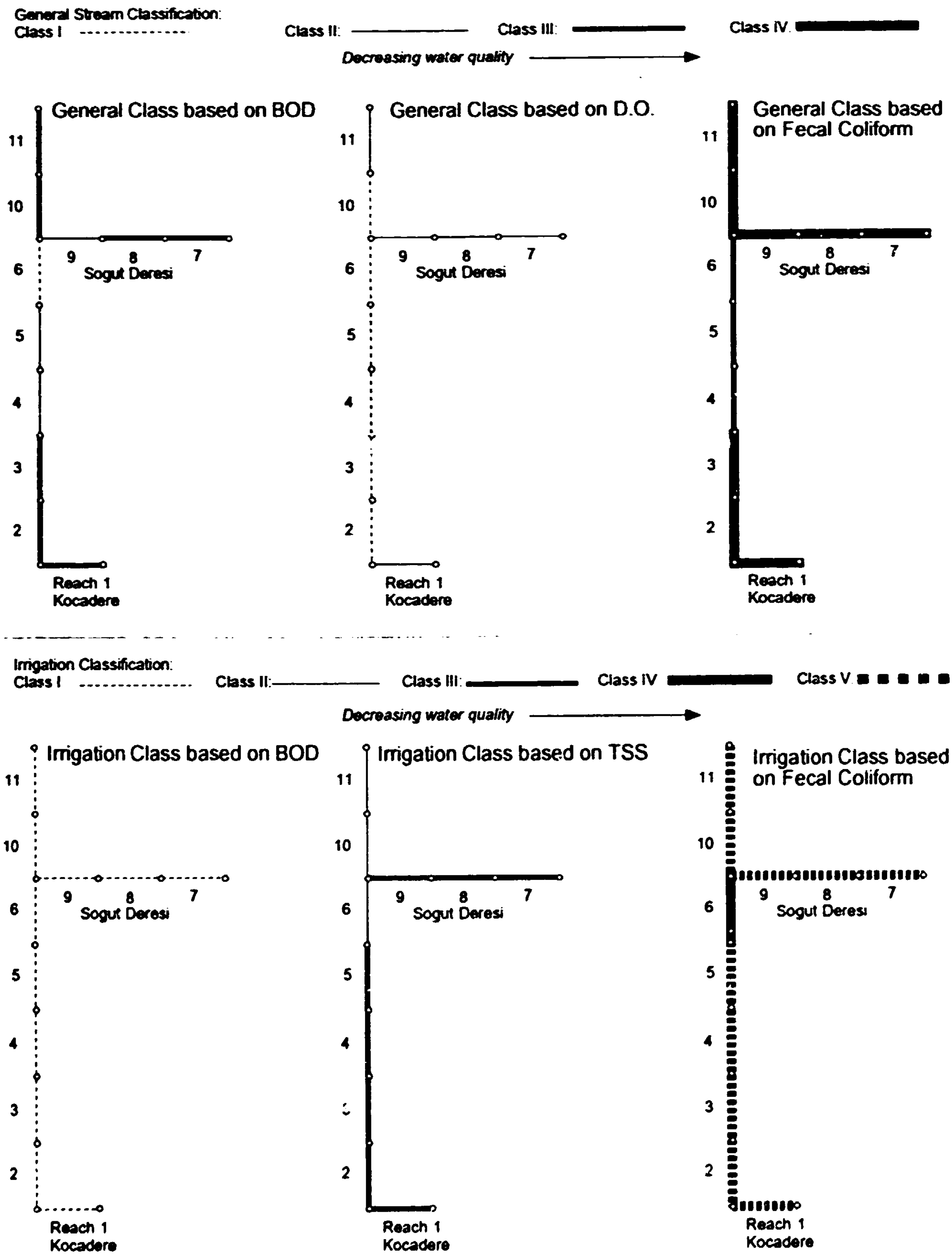


Figure 15
Stream Classifications Based on Modeling for Strategy FUTURE 2



Future Strategy 3:

In future strategy III, the contaminated sediments containing high levels of organics resulting in significant sediment oxygen demand are assumed to be removed either through natural scour or through removal. This action affects only the predicted dissolved oxygen with all reaches being raised to General Class I with the exception of the Kocadere which is in General Class II. The resulting stream classifications are shown in Figure 16.

Future Strategy 4:

In future strategy 4, some form of post disinfection is added at the three municipal treatment plants along with some reduction in coliform loading in rural areas. As would be expected, this strategy reduces fecal coliform levels so that all reaches are classified as General Class II and Irrigation Class II waters as shown in Figure 17.

In summary, the proposed future improvements in industrial and municipal treatment facilities (Future strategy 2) would result in very significant improvements in the water quality. However, in order to support the use of the water resources for irrigation and any contact uses, further disinfection of the effluents at municipalities and other sources of sanitary wastes would be required to further lower the coliform levels (Future strategy 4).

Industrial Costs

The future strategy detailed in the previous section assumes that: 1) over the next 10 years industries will grow at a rate reflective of the national average growth rate for specific industry groups during the past decade; 2) the rate of waste production will be proportional to that growth rate; and 3) treatment facilities will be expanded and upgraded so that they meet the effluent standards for the specific industry group. Some reduction in requirements might actually occur owing to process changes and if the industries attempted some "Waste Minimization" approaches. On the other hand costs would increase if the discharge standards were made stricter. However, assuming current requirements will continue, the costs to be incurred by industries on waste water treatment can be roughly estimated as shown below in Table 11.

Figure 16
Stream Classifications Based on Modeling for Strategy FUTURE 3

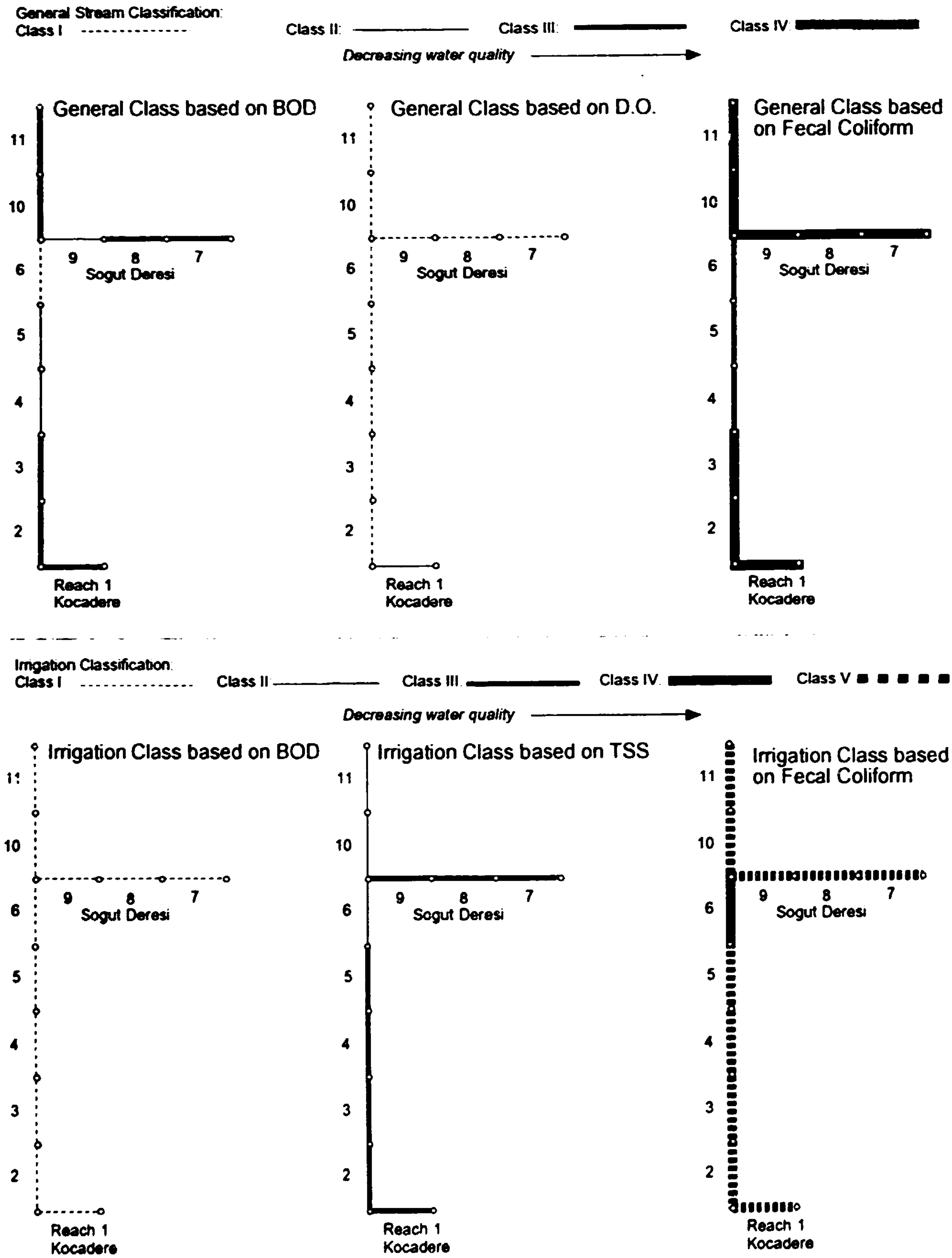
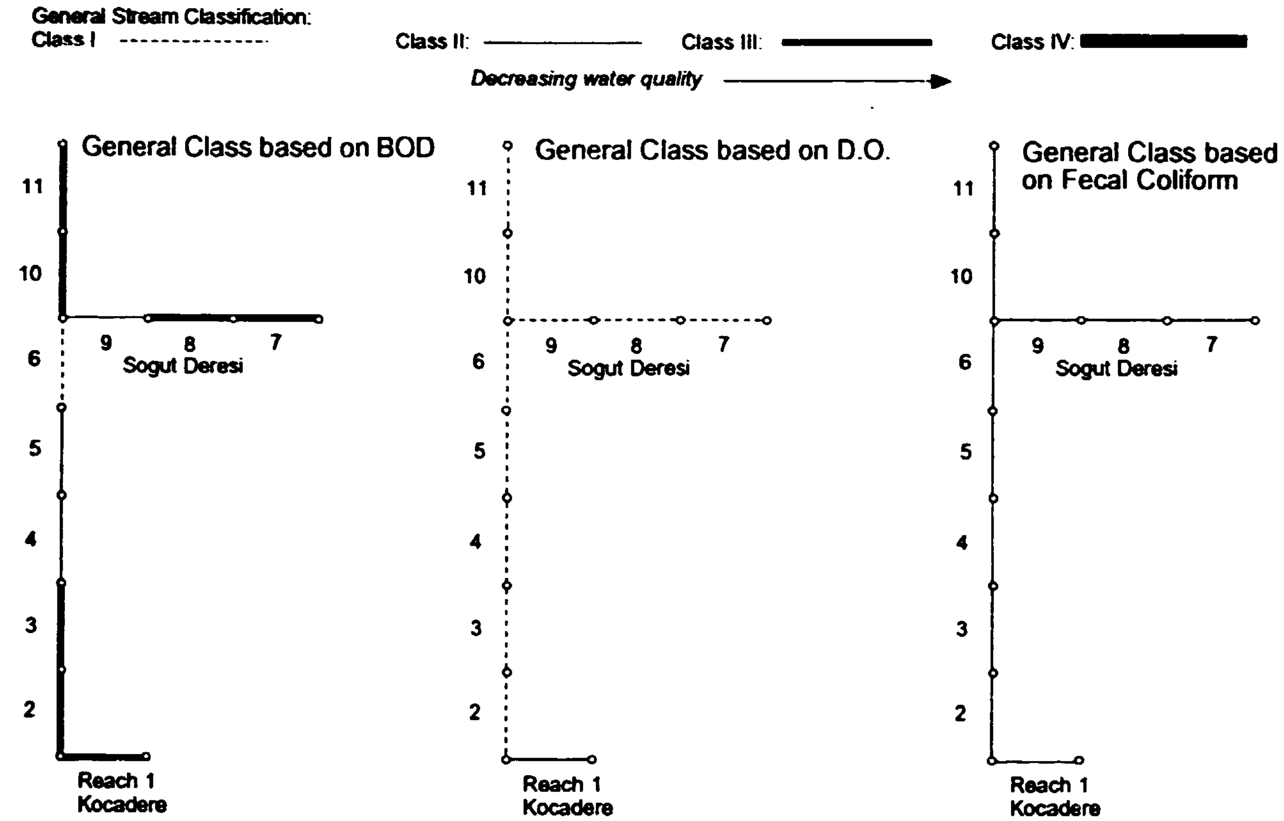


Figure 17
Stream Classifications Based on Modeling for Strategy FUTURE 4



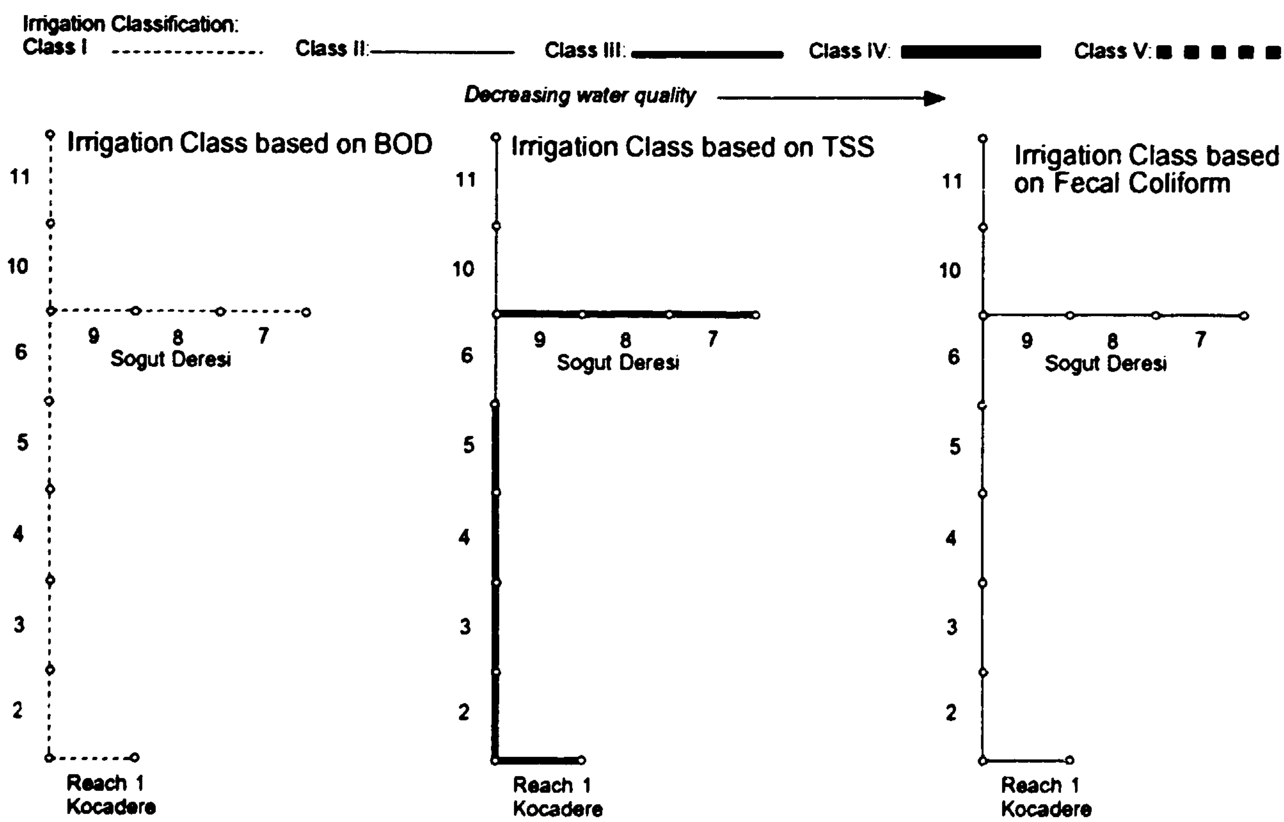


Table 11: Estimated Investment Required for Industrial Wastewater Flows of Year 2005

Major Industries in the Karasu Basin	Estimated total 1995 wastewater flows, m^3/d	Estimated additional wastewater flow (m^3/d) by year 2005	Assumed capital costs of wastewater treatment US $ per m^3/d	Investment required to meet discharge standards (US $ million)
Marble cutting and polishing	1,550	2170	60	0.13
Ceramics	2,815	3941	30	0.12
Pulp and paper	3,900	3120	1000	3.12
Metal Plating	550	330	4000	1.34
Bilecik Industrial Park	1,200	960	800	0.77
TOTAL			US$ 5.5 Million	

Thus, an estimated investment of US $ 5.5 million will need to be incurred by the industries in the Karasu Basin to provide wastewater treatment at a level to meet current discharge standards of Turkey. This assumes that industries have treatment facilities currently in place that are capable of meeting current effluent standards. The above figures are only order of magnitude figures as they have been based on several assumptions as stated. Nonetheless, these figures indicate that major costs will lie in treating Pulp and Paper and Metal Plating wastes.

Municipal Costs

The municipalities in the Karasu River Basin currently do not have municipal treatment works. Domestic sewage is either discharged to septic systems and/or makes its way to the riverine system through a partial sewer system or through natural water courses. In future strategies 2 through 4, it is assumed that 100% of the three municipalities will be sewered and that the waste will be treated by secondary treatment plants prior to discharge to the stream. In future strategy 2, it is assumed that no post disinfection will occur prior to discharge to the river. Post disinfection is added in future strategy 4.

Capital costs for municipalities include costs of the sewer system and the treatment facilities. Sewerage and sewage treatment facilities in towns in Turkey are provided by the Iller Bankasi which has a large engineering staff for the purpose and secures the capital funding from Governmental and/or international sources. Once the facilities are constructed, the concerned municipalities are required to operate them from their own funds.

The information used in the development of average cost functions for municipal sewer systems and sewage treatment plants are provided in Annex VII and summarized below.

Sewer systems: US $ 55/person (1995 prices)

Sewage treatment plants: US $ 40/person (1995 prices)

In the case of the Karasu River Basin, three municipalities are large enough to be considered for sewerage and treatment: Bozuyuk, Bilecik and Söğüt. These have, however, not yet figured in Iller Bankasi's list of priorities as they do not have touristic potential or any identified serious health problems.

An average 1995 cost of US $ 40 per person works out to US $ 200 per m^3 sewage flow on the basis of 200 l/person/day. Cost estimates for the three towns in the Karasu Basin were based on the assumption that construction would occur in 5 years (Year 2000) and that design would be based on population estimates for the year 2010 given in Table 10.

While the treatment would have to be provided for the full population, the sewerage network would have to take account of the fact that a part of the network already exists. Thus, sewerage and sewage treatment costs would be estimated as shown in Table 12. The total capital investment required to be made by the year 2000 to serve the towns equals US $ 10.7 million.

Table 12: Cost Estimates for Municipal Sewer and Treatment Facilities in the Karasu Basin

ITEM	BOZUYUK	BILECIK	SOGUT
1990 population	33,162	23,273	9,470
Percentage already sewered	75%	50%	20%
Balance of 1990 population to be sewered	8,290	11,636	7,536
Population growth between 1990 and 2010	30,690	24,213	7,272
Total population to be sewered	38,980	35,849	14,808
Sewer Network cost, $ million, (@ US $ 55 per person)	2.14	1.97	0.81
Full 2010 population to be provided treatment	63,851	47,486	16,742
Treatment cost, $ million (@ 45 per person)	2.87	2.14	0.74
Total cost of sewer network and sewage treatment to serve 2010 population, $ million	5.01	4.11	1.55

Annual operations and maintenance (O&M) costs for the municipal sewer/treatment facilities are estimated at 7.5% without disinfection and approximately 50% higher with the addition of disinfection. Resulting costs are shown in Table 13.

Table 13: Annual Municipal O&M Sewer/Treatment Plant Costs (US $ 1995)

Town	Without Disinfection	With Disinfection
Bozuyuk	380,000	570,000
Bilecik	310,000	465,000
Söğüt	120,000	180,000
TOTAL	810,000	1,215,000

VIII. INSTITUTIONAL ASPECTS

A. Organizations Involved

Under the Turkish system of government, legislative powers lie within Parliament working in concert with Ministries at the central level while implementation is done at the Provincial level headed by the Provincial Governor. In view of the multi-disciplinary nature of environmental work, various Ministries and Organizations are involved, some of which are listed below:

	Organisation	Control Aspect
1.	Environment Ministry	- Environmental Impact Assessment - Grant of permit (3 year validity) giving conditions under which operation of an industry is permitted - Applicability of discharge standards - New legislation for toxic and hazardous wastes - Assist "Local Environmental Committees" in Provinces
2.	Health Ministry	- Environmental Health Department and Branches in the Provinces - Laboratory facilities - Industrial Wastes sampling and analysis and review of all periodic reports received from industries and other analytical laboratories.
3.	State Hydraulic Works (DSI)	- Periodical flow measurement in rivers. Hydrology. - Sampling and analysis of river waters (Physical, chemical and biological) - Classification of river waters - Ground water monitoring and other data
4.	Ministry of Agriculture (including Fisheries)	- Agricultural issues - Waters used for Fisheries and other "Water Products"
5.	Iller Bankasi	- Provision of sewage treatment facilities for towns
6.	Ministry of Industry	- Industrial planning and facilitation of growth. Data collection and dissemination. Awareness and incentives through industry associations.
7.	State Planning Authority	- Overall countrywide planning. Statistical analysis of all input-output data. Monitoring of growth in all sectors.
8.	Tourism Ministry	- Tourism promotion
9.	Ministry of Village Affairs	- Plan and provide water supply for rural areas (groundwater supplies).
10	Universities & TUBITAK	- Higher education in environmental engineering, sciences & management. Promotion of awareness through education. Laboratory and project preparation services.

B. Institutional Coordination

There are a large number of organizations involved in the environmental field in Turkey including the governmental and public sector organizations listed above and many private consulting and construction companies. Obviously a significant level of coordination is required in order to achieve the common goal of a better environment.

Since most of the industries in the Karasu River Basin were established prior to 1991, they have not been subjected to the rigorous environmental impact assessment (EIA) procedures now required by the Ministry of Environment and as a result their permits were issued on an ad hoc basis. The industries that were established prior to 1991 were required to register by 1994 and will require new permits to be issued under the provision of the new law by 1997. It is hoped that when the industries come up for renewal by 1997, or earlier if expansion is planned, that various environmental aspects will be considered. In the case of new industries wishing to establish in the Karasu Basin, their site selection and plans will also be reviewed keeping in view the existing and desired water resources of the basin. Thus, a higher level of coordination is needed and expected to be achieved in the near future, and it is hoped that actions will be less "reactive" and more "proactive" than have been the case in the past.

An informal beginning can be made immediately with greater coordination between DSI, the Health Ministry, and the Environment Ministry in regard to industrial wastewater sampling and analysis where frequently the effluent analysis data is not consistent with DSI's stream water quality data. If the organizations work in unison, then the effluent and stream water quality data can be used to detect offenders. Analytical quality control (AQC) competence of the various laboratories used by industry for sampling and analysis is also necessary to ensure greater dependability in the results of the sampling.

Since municipal sewerage and sewage treatment plant priorities are determined by the Iller Bankasi, coordination between the above agencies (DSI and the Health and Environment Ministry) and Iller Bankasi is also essential. Such coordination is needed to assure that Iller Bankasi is cognizant of the degraded water quality situation in much of the Karasu Basin and the significant component of the loading due to the untreated municipal waste.

One of the challenges facing the organizations is how to ensure better operation of existing waste treatment plants of the industries. Once the capital investment is made, the operation of the plant cannot be assumed to be satisfactory. For example, it is suspected that sludge is occasionally released directly into the river even though this is forbidden. Some unannounced environmental compliance "audits" would be advantageous to undertake in the future.

Groundwater pollution is likely to occur where simple, unlined "lagoons" are used for waste treatment. DSI's groundwater quality monitoring is currently limited to some portions of the Kocadere; it needs to be extended to other areas as well, especially where lagoons are in use. Additionally, a decision is needed to determine which organization should be responsible for determining whether existing or proposed lagoons need lining for the protection of the groundwater. Turkey is a country rich in groundwater resources which cannot afford to be polluted. Institutional coordination is essential for environmental protection.

An additional institutional complexity will be introduced shortly when the newly proposed regulations for control of toxic and hazardous waste disposal will become law. Even greater coordination between various agencies will be required, including new ones to control handling and transport (and possible accidents) in conveying such wastes from the factories to the approved disposal sites. The selection and approval procedures for special disposal sites will involve a large number of agencies. Also, in order to ensure the social well-being of the general public, their cooperation and involvement in the planning process is needed.

Finally, very few industries have made any attempt as yet in introducing water conservation, reuse and waste minimization concepts in their work. Continuous efforts will be necessary to bring "awareness" to responsible officials and workers. Universities, specific industry associations and factory management will have to make joint efforts to lead toward "sustainable development". Mere use of traditional "end-of-pipe" technology will not suffice.

IX. CONCLUSIONS AND RECOMMENDATIONS

A. Current Situation

Major industries in the Karasu River Basin all provide some form of wastewater treatment at considerable capital investment in order to strive to meet discharge standards. However, the operation of many of these plants appears to be inadequate resulting in the Karasu River system falling into the Government's lowest water quality classifications (Class IV general water and Class V irrigation waters). A part of this responsibility must be shared by the cities and towns located in the basin (especially Bozuyuk, Bilecik and Söğüt) which discharge their untreated domestic wastewaters to the river via sewers, septic tanks or natural drainage. Thus a potentially excellent water resource such as the Karasu River (which supports trout fish in its uppermost reaches) now has severe pockets of pollution and is made unfit for other beneficial uses as it moves downstream from Bozuyuk and through other industrially and municipally developed areas.

B. Recommended Measures

Several measures can be taken to improve the situation, some in the very near future and some later on. Some measures are required to comply with existing regulations while others reflect upon the extent of river water quality improvement desired and their affordability.

Measures recommended for action in the near future (1 - 3 years)

(1) A common effluent treatment plant for the 23 industries located in the Bilecik Organize Sanayi. This becomes all the more important as the second phase of the Industrial Park involving textile factories is launched in the near future.

(2) Upgrading of the waste treatment facilities existing in the following industries in order to meet industry effluent standards:

- All marble factories
- All ceramic factories
- The pulp and paper factory at Vezirhan (Marmara Kagit ve Ambalaj)

(3) Sewerage and sewage treatment at the 3 major towns: Bozuyuk, Bilecik and Söğüt.

(4) DSI's water quality sampling programme to continue with the addition of the following:
- A new station located at the flowgage near Vezirhan to provide information prior to the industrial facilities downstream of the gage;
- Routine groundwater monitoring for potential contamination especially in the vicinity of wastewater lagoons;
- Periodic analysis of the sediment on the stream bed.

(5) Until new government regulated facilities for safe disposal of toxic and hazardous wastes are available, special care will have to be provided for such wastes (e.g., chromium bearing sludges from plating wastes produced in the Bozuyuk area which are today stacked on the ground in plastic bags). Hazardous solid wastes should under no circumstances be mixed with domestic solid wastes (garbage) for common disposal, discharged directly to the river, or dumped on the ground where groundwater pollution may result.

Measures recommended for medium term action (3 - 5 years)

(1) Better institutional coordination is required between governmental organizations (DSI, Ministry of Health and Ministry of Environment) for better enforcement of effluent discharge standards. The Health Ministry's effluent data is frequently not consistent with the in-stream river quality as measured by DSI. The two organizations must work together closely to locate the offenders. Coordination with Iller Bankasi is also necessary due to the significant impacts of untreated municipal wastes. While formal mechanisms for such cooperation are being developed, informal actions can be implemented between these organizations in the near term to compare data to identify offenders and to develop pollution control priorities.

(2) As industrial growth occurs, wastewater treatment facilities will need to be expanded. This will provide an opportunity for enforcement agencies to remove any deficiencies in treatment to ensure that discharge standards are always met. The standards themselves will need some review by the government to ensure that they are reasonable and possibly to ensure that they are in accord with European Economic Community (EEC). The treatment facilities will also

need to comply with new standards for toxic and hazardous wastes and applicable requirements for Environmental Impact Assessments (EIA).

(3) As industry and population growth occurs, a higher degree of waste removal will be required in order to ensure the water quality in the streams. In order to meet these further reductions in loadings, greater reliance will have to be placed on other measures such as waste minimization, recycling and resource conservation in the manufacturing processes themselves. An example of waste minimization in the Karasu Basin in the plating industry in Bozuyuk is already in place. Another example of waste minimization through recycling has been suggested in this report for the ceramic industry. An increasing number of such opportunities will have to be found. Industry-wide associations, universities, and environmental protection agencies will be able to help through advocacy, awareness and incentives.

(4) Turkey should review and consider revisions in their water quality standards to bring them more closely in line with criteria and standards of the European Economic Community. The regulations should encourage the management of waters to attain all reasonable and desired uses of a water body. In this more proactive approach to water quality regulation, waters would be classified based on their potential or desired uses (e.g., irrigation, recreation, etc.) and the water quality criteria then specified for various parameters to support these uses.

C. Resultant Costs

The water quality modeling exercise carried out during this study has shown that the Karasu River water quality has the potential to improve from its present Class IV (poor quality) to Class I or Class II, after the following actions are taken:

(1) Industries invest approximately US $ 5.5. million (1995 prices) to meet the cost of treating increased volumes of wastewater owing to increased industrial production in the next 10 years (until year 2005) and in order to meet effluent standards. The major bulk of expenditure will be in the pulp and paper and metal plating industries.

(2) Iller Bank invests about US $ 10.7 million (1995 prices) in providing sewerage and sewage treatment plants for the three towns by the year 2000 in order to meet population estimates for a 10-year horizon. The capacity of the three towns to meet the annual O&M costs (estimated at 7-8% of capital costs) will have to be ensured. If disinfection of effluent by chlorine or other means is done in order to reduce the bacterial levels in the streams, then O&M costs will increase by 50% over the above estimated annual costs. Affordability will again need to be determined along with other possible health effects of disinfection. Decision makers will need to balance these increased costs against the potential improvements in river water quality in assessing disinfection or other further advanced waste treatment improvements.

ANNEX I

WATER QUALITY DATA FOR THE KARASU RIVER BASIN

The General Directorate of State Hydraulic Works (DSI) has performed routine water quality sampling at six stations within the Karasu Basin. The following information is listed below relative to this sampling program: 1) the location of the stations; 2) the frequency of sampling over the period from 1986 to 1994; 3) the water quality parameters that were sampled during some or all of the sampling events; and 4) water quality data and mean, minimum and maximum values for selected parameters at each of the six stations.

Water Quality Sampling Stations and Parameters

Station	ID	Location	River Kilometer
12-03-00-056	56	Kocadere U/S of confluence with Karasu River	0.5
12-03-00-057	57	Karasu River U/S of confluence with Kocadere	53.0
12-03-00-058	58	Karasu River D/S of confluence with Kocadere	52.0
12-03-00-059	59	Karasu River U/S of confluence with Sakarya River	1.0
12-03-00-105	105	Söğüt Deresi U/S of confluence with Karasu River	1.0
12-03-00-106	106	Karasu River U/S of confluence with Söğüt Deresi	21.0

	Stations					
Year	56	57	58	59	105	106
1994	X	X		X		
1993	X	X		X		
1992	X			X	X	X
1991	X	X	X	X	X	X
1990	X	X	X	X	X	X
1989	X			X	X	X
1988	X			X	X	X
1987	X			X	X	X
1986	X			X	X	X
1986	X			X		

Water Quality Parameters Sampled in the Karasu River Basin
(Samples are not analyzed for all parameters during every sampling event)

Abbrev.	Parameter	Abbrev.	Parameter
Q	Flow (m^3/sec)	T	Temperature (C)
pH	pH	EC	Conductivity
TDS	Total dissolved solids(mg/l)	SS	Suspended solids (mg/l)
M-Al	Methyl Orange Alk. (mg/l)	Cl	Chloride (mg/l)
NH3-N	Ammonia Nitrogen (mg/l)	NO2-N	Nitrite nitrogen (mg/l)

NO3-N	Nitrate nitrogen (mg/l)	DO	Dissolved oxygen (mg/l)
pV	Permanganate value (mg/l)	BOD5	Bio. oxygen demand (mg/l)
TH	Total hardness	o-PO4	Orthc phosphate (mg/l)
SO4	Sulfate (mg/l)	Fe	Iron (mg/l)
Mn	Manganese (mg/l)	Na	Sodium (mg/l)
K	Potassium (mg/l)	Ca	Calcium (mg/l)
Mg	Magnesium (mg/l)	CN	Cyanide (mg/l)
COD	Chemical oxygen demand (mg/l)	TKN	Total Kjeldahl Nitr. (mg/l)
B	Boron (mg/l)	Fen	Phenol (mg/l)
F	Fluoride (mg/l)	BMNP	Biological index
TBI	Biological index	ASPT	Biological index

Water Quality Data

STATION 56

YEAR	MO.	Q	T	TDS	TSS	TKN	DO	BOD5	COD	E-Coli	T-Coli
1986	1	0.20	7	510	398	14.6	6.3		92		
1986	2	0.22	14	563	263	17.4	4.0	58	180		
1986	3	0.29	11	566	288	9.3	3.9	47	52		
1986	4	0.17	17	644	833	15.1	2.5	68	78		
1986	6	0.10	22	601	328	35.0	1.1	120	271		
1986	7	0.03	22	689	224	36.4	1.1	117	358		
1986	8	0.09	23	589	512	32.5	1.1	127	263		
1987	4	0.62	18	528	1971		2.5	22			
1987	7	0.19	27	659	411		1.7	100			
1987	10	0.12	17	669	88		4.2				
1990	3	0.48	12	500	157	6.6	5.2	21	78	4.0E+06	1.1E+07
1990	6	0.21	19	618	166	16.5	3.2	54	78	1.1E+07	3.0E+07
1990	9	0.17	16	465	141	9.7	3.3	44	112	1.0E+06	1.2E+07
1990	12	0.23	6	550	400	14.7	5.7	37	118	1.0E+06	1.0E+06
1991	3	0.29	13	666	93	8.1	4.0	31	106	5.0E+05	1.0E+07
1991	6	0.38	18	551	70	13.1	3.2	27	78	6.0E+06	2.0E+07
1991	9	0.14	17	477	44	9.8	3.4	27	73	6.0E+06	2.0E+07
1991	12	0.19	8	577	54	11.5	5.3	39	95	5.0E+06	1.0E+07
1992	2	0.29	13	562	86	9.4	4.6	18	95	1.0E+06	1.0E+07
1992	5	0.53	16	505	100	4.1	2.4	17	95	4.0E+05	2.0E+06
1992	8	0.21	19	503	320	14.6	1.2	68	190	2.0E+07	6.0E+07
1992	11	0.23	10	500	25	12.8	5.3	32	62	3.0E+06	3.0E+06
1993	2	0.59	6	463	60	6.1	7.8	40	59		
1993	5	0.58	15	470	163	7.4	3.7	40	140		
1993	8	0.22	17	396	30	7.5	3.6	20	73		
1994	2	0.71	9	435	77	5.8	6.0	14	67		
1994	8	0.27	16	387	56	7.1	4.0	12	95		
1994	11	0.44	9	484	66	8.5	5.6	58	143		
	Avg.	0.29	15	540	265	13.3	3.8	48	122	4.9E+06	1.6E+07
	Min	0.03	6	387	25	4.1	1.1	12	52	4.0E+05	1.0E+06
	Max	0.71	27	689	1971	36.4	7.8	127	358	2.0E+07	6.0E+07

STATION 58

YEAR	MO.	Q	T	TDS	TSS	TKN	DO	BOD5	COD	E-Coli	T-Coli
1990	3	2.95	13	294	43	1.0	10.1	3	34	2.0E+04	5.0E+04
1990	6	2.24	16	302	14	1.1	9.2	5	<20	5.0E+04	1.0E+05
1990	9	1.55	14	316	62	1.4	9.7	4	<20	4.0E+04	9.0E+05

1990	12	1.44	7	317	42	2.1	10.7	7	<20	1.0E+04	7.0E+05
1991	3	2.03	18	319	28	1.1	9.2	4	45	5.0E+04	5.0E+05
1991	6	2.30	16	295	27	1.6	8.4	4	28	1.0E+04	1.0E+06
1991	9	1.58	16	278	24	1.4	8.6	5	<20	7.0E+05	1.0E+05
1991	12	1.36	9	297	36	1.4	10.4	7	22	2.0E+06	6.0E+06
	Avg.	1.93	13	302	35	1.4	9.5	5	16	3.6E+05	1.2E+06
	Min	1.36	7	278	14	1.0	8.4	3	0	1.0E+04	5.0E+04
	Max	2.95	18	319	62	2.1	10.7	7	45	2.0E+06	6.0E+06

STATION 57

YEAR	MO.	Q	T	TDS	TSS	TKN	DO	BOD5	COD	E-Coli	T-Coli
1990	3	2.47	13	238	35	0.3	10.3	1	<20	2.0E+02	1.0E+03
1990	6	2.03	15	259	52	0.2	10.6	1	<20	2.2E+03	2.5E+03
1990	9	1.38	13	273	2	0.3	9.3	1	<20	3.0E+03	4.0E+03
1990	12	1.21	8	273	19	0.3	12.4	3	<20	5.0E+02	1.0E+03
1991	3	1.75	12	271	28	0.2	10.8	2	22	1.0E+03	1.0E+04
1991	6	1.92	15	259	16	0.2	9.7	1	22	1.0E+02	1.0E+04
1991	9	1.44	14	242	26	0.4	9.5	2	<20	2.0E+03	5.0E+03
1991	12	1.17	8	256	19	0.2	11.8	3	<20	8.0E+01	2.0E+03
1993	2	1.28	7	261	19	0.2	11.6	2	14		
1993	5	2.40	13	251	64	0.4	10.6	1	14		
1993	8	1.42	15	253	26	0.7	8.8	2	17		
1994	2	1.59	10	222	21	0.4	10.8	2	14		
1994	8	0.12	14	253	13	0.5	9.2	1	14		
1994	11	0.96	7	254	22	0.4	11.5	2	11		
	Avg.	1.51	12	255	26	0.3	10.5	2	9	1.1E+03	4.4E+03
	Min	0.12	7	222	2	0.2	8.8	1	0	8.0E+01	1.0E+03
	Max	2.47	15	273	64	0.7	12.4	3	22	3.0E+03	1.0E+04

STATION 106

YEAR	MO.	Q	T	TDS	TSS	TKN	DO	BOD5	COD	E-Coli	T-Coli
1986	1	3.15	10	284	228	0.8	11.2	5	<20		
1986	2	3.91	13	275	64	2.0	11.0	5	<20		
1986	3	3.68	9	317	55	0.5	12.4	5	<20		
1986	4	2.75	14	282	369	0.2	9.5	3	28		
1986	6	1.76	21	300	91	0.8	8.4	3	<20		
1986	7	1.22	21	244	110	1.0	8.6	4	<20		
1986	8	1.00	21	284	62	0.5	8.0	2	34		
1987	1	1.25	12	330	52		11.0	1			
1987	7	1.97	22	339	26		8.1	2			
1987	10	2.00	19	314	51		9.4	3			
1989	1		6	318	23		13.1	6			
1989	4	1.52	18	316	56		9.5				
1989	7	0.93	22	339	44		9.6	8			
1989	10	1.66	14	348	44		10.6	3			
1990	3	4.53	15	317	69	0.6	10.6	3	45	1.0E+04	2.0E+05
1990	6	2.46	20	322	37	0.2	8.7	3	<20	2.0E+04	2.0E+05
1990	9	1.30	16	349	87	2.4	8.8		34	5.0E+05	1.0E+06
1990	12	2.19	6	349	17	0.6	11.8	5	34	1.0E+03	5.0E+04
1991	3	2.77	15	351	52	0.5	10.2	6	45	2.0E+04	1.0E+05
1991	6	3.04	18	335	26	0.3	9.3	2	34	2.0E+04	1.0E+05
1991	9	1.30	18	321	63	0.4	9.0	2	<20	2.0E+04	2.0E+05
1991	12	1.82	9	327	31	0.8	11.5	7	39	4.0E+04	3.0E+05
	Avg.	2.20	15	316	75	0.8	10.0	4	19	7.9E+04	2.7E+05
	Min	0.93	6	244	17	0.2	8.0	1	0	1.0E+03	5.0E+04
	Max	4.53	22	351	369	2.4	13.1	8	45	5.0E+05	1.0E+06

STATION 105

YEAR	MO.	Q	T	TDS	TSS	TKN	DO	BOD5	COD	E-Coli	T-Coli
1986	1	0.58	10	334	92	0.6	11.2	2	<20		
1986	2	0.80	14	289	12	1.3	11.5	1	<20		
1986	3	0.82	10	319	179	0.5	11.2	4	<20		
1986	4	0.21	14	367	196	0.2	9.4	5	50		
1986	6	0.02	21	414	37	0.7	8.3	2	<20		
1986	7	0.01	22	434	63	0.7	8.5	2	22		
1986	8	0.01	18	453	26	0.5	8.0	1	<20		
1989	1		4	387	459		13.5				
1989	4	0.01	21	511	85		10.5				
1990	3	0.99	16	309	73	0.6	10.5	3	24	8.0E+03	1.5E+05
1990	6	0.06	20	455	3	0.0	7.5	3	<20	1.0E+05	3.0E+05
1990	9	0.01	17	480	25	0.2	9.3	1	<20	5.0E+03	1.0E+04
1990	12	0.21	5	483	108	2.2	11.5	9	<20	3.0E+03	8.0E+04
1991	3	0.29	15	340	81	0.3	11.5	5	28	6.0E+03	6.0E+05
1991	6	0.29	21	376	333	0.2	8.6	8	34	6.0E+03	3.0E+05
1991	12	0.14	7	409	18	1.1	11.7	4	<20	6.0E+03	4.0E+04
	Avg.	0.30	14	398	112	0.6	10.2	4	11	1.9E+04	2.1E+05
	Min	0.01	4	289	3	0.0	7.5	1	0	3.0E+03	1.0E+04
	Max	0.99	22	511	459	2.2	13.5	9	50	1.0E+05	6.0E+05

STATION 59

YEAR	MO.	Q	T	TDS	TSS	TKN	DO	BOD5	COD	E-Coli	T-Coli
1985	1	2.38	10	379	100	1.9	10.3		72		
1985	3	4.13	9	364	122	0.9	10.8	16	60		
1985	6	2.63	18	333	252	1.0	9.4	2	20		
1985	8	0.39	22	311	101	0.8	8.0	2	20		
1985	11	1.70	13	322	52	0.5	10.0	2	20		
1985	12	1.72	11	226	194	0.5	10.8	3	20		
1986	1	3.31	6	306	170	1.3	11.8	10	24		
1986	2	5.35	9	304	100	1.3	11.8	5	<20		
1986	3	5.51	10	286	108	1.3	11.8	5	<20		
1986	4	2.93	17	258	53	0.2	11.2	3	<20		
1986	6	2.20	23	270		0.9	8.2	4	34		
1986	7	0.39	27	281	73	1.4	9.8	1	28		
1987	1	3.66	8	349	162		11.0	10			
1987	4	7.48	15	316	152		9.5	12			
1987	7	0.79	25	350	76		7.6	3			
1987	10	1.58	16	387	1714		9.7				
1988	1	2.88	4	345	126		12.4				
1988	4	3.98	11	356	226		10.6				
1988	7	1.78	21	330			7.8	20			
1988	10	1.60	15	360	130		9.8	2			
1989	1		5	357	60		12.5	8			
1989	4	0.81	19	349	125		7.8	9			
1989	7	0.10	23	399	220		6.6	14			
1989	10	1.77	13	393	178		10.1	13			
1990	3	5.22	14	329	110	0.8	11.0	5	22	2.0E+04	2.0E+05
1990	6	1.12	21	364	86	0.5	8.2	5	34	2.0E+04	5.0E+05
1990	9	0.57	18	400	280	0.4	7.0	55	78	8.0E+04	3.0E+05
1990	12	1.85	6	386	129	0.8	11.6	15	50	3.0E+04	2.0E+05
1991	3	2.79	13	405	128	0.3	9.0	38	106	1.0E+04	2.0E+05
1991	6	2.48	19	360	130	0.4	9.2	3	28	1.0E+05	1.0E+06
1991	9	0.37	20	470	108	0.5	5.1	42	118	7.0E+04	3.0E+06
1991	12	2.02	8	375	101	0.4	10.8		90	2.0E+04	1.0E+05
1992	2	2.25	5	410	127	1.2	11.9	24	112	1.0E+04	6.0E+04

1992	5	5.33	15	344	106	0.5	9.4	13	78	1.0E+03	5.0E+04
1992	8	0.42	23	356	73	0.6	5.2	11	56	3.5E+05	1.4E+06
1992	11	2.05	10	359	69	1.1	10.5	6	28		
1993	2	3.55	5	393	209	0.8	11.6	56	168		
1993	5	6.48	17	318	504	0.6	10.1	12	64		
1993	8	0.29	26	791	489		1.8	302	1098		
1994	2	4.93	10	308	210	0.9	11.4	13	76		
1994	8	1.25	23	492	244	3.5	3.6	49	330		
1994	11	1.65	5	443	253	1.3	12.8	47	196		
	Avg.	2.53	14	363	196	0.9	9.5	23	101	6.5E+04	6.3E+05
	Min	0.10	4	226	52	0.2	1.8	1	0	1.0E+03	5.0E+04
	Max	7.48	27	791	1714	3.5	12.8	302	1098	3.5E+05	3.0E+06

ANNEX II

ANALYSIS OF AQUATIC LIFE IN THE KARASU RIVER BASIN

Over the period of 13 September 1989 to 29 November 1994, the Third Region Directorate of State Hydraulic Works (DSI) performed biological sampling for aquatic invertebrates on 11 separate dates. The samples were collected from the same six sampling stations where water quality parameters were analyzed though not all locations were sampled on each sampling episode. Samples were collected by disturbing an area of approximately one square meter and collecting invertebrates in a kick net. Samples were processed and organisms identified and approximate counts of individuals per taxa were determined. Counts were approximated using the semi-quantitative method of the North West Water Rivers Division (England):

1 = 1 individual
2 = 2 to 5 individuals
3 = 6 to 20 individuals
4 = 21 to 100 individuals
5 = 100 to 500 individuals
6 = more than 500 individuals.

Individuals were identified to a family and/or genus.

DSI calculated four indices of biological integrity based on the taxonomic counts. These indices are all described in "The Use of Biological Data in River Quality Classification" (North West Water, 1982):

Biological Monitoring Working Party Score (BMWP): calculated by summing scores for various taxa, where a score is the product of the semi-quantitative count (i.e., 0 to 5) and the appropriate factor for the genus/family intolerance of organic contamination. Higher scores generally indicate better water quality.

Extended Trend Biotic Index (TBI): determined by the presence/absence of species from taxonomic groups that are more or less sensitive to organic pollution (i.e., with Plecopterans considered indicative of good water quality and tubificids and chironomids indicative of poor water quality) and the total number of taxonomic groups represented in the sample. Values of this index range from 0 to 15, with higher values indicating better water quality.

Biologically Inferred NWC Class (NWC): A system devised by North West Water (1982) to combine information from the BMWP, TBI, and a community description class (based on community dominance by organisms that are more or less intolerant of organic pollution). This index parallels the English system for water classification according to chemical and physical character and defines a water along a scale from 1 (best quality) to 4 (worst quality).

Average Score Per Taxa (ASPT): calculated as the BMWP score divided by the number of taxa observed. This normalization of the BMWP takes into account sample size/organism counts which may artificially elevate BMWP scores.

In addition to these indices, it is also instructive to indicate water quality simply by the number of taxa represented (as indicated on DSI's data collection sheets). Table 1 summarizes the results of DSI's sampling of aquatic invertebrates in the Karasu River basin. (Values given are the mean value for all samples from the station and, in parentheses, the range of values observed.)

Table II-1: Summary of Aquatic Invertebrate Sampling Results in the Karasu River Basin

Measure of Biological Integrity	Station 57	Station 56	Station 58	Station 106	Station 105	Station 59
BWMP	52 (31-78)	6.8 (0-25)	13.3 (10-16)	19 (13-29)	24.4 (12-53)	5 (0-13)
TBI	7.4 (7-8)	2.3 (0-7)	4.3 (2-6)	5.7 (4-7)	6 (5-7)	2.6 (0-5)
NWC	1.7 (1.25-2)	3.3 (2-4)	2.8 (2.5-3.5)	2.5 (2-3)	2.25 (1.8-2.5)	3.6 (2.5-4)
ASPT	5.6 (4.2-6.7)	1.8 (0-4.2)	4.2 (3.5-5)	4.1 (3.2-5.8)	4.2 (3.2-5.9)	1.9 (0-4)
# Taxa	9.9 (7-13)	2.3 (0-7)	4.3 (3-5)	5.5 (4-6)	6.2 (3-10)	2.2 (0-5)

Using two-tailed t-tests to compare biological community characteristics between pairs of data collected during individual sampling episodes, the following statistically significant ($p<0.05$) differences between the stations were found:

Station 57: Biological community indicates significantly better quality at Station 57 than at all downstream Karasu River stations (58, 106, and 59). Statistically significant differences were observed with all indices in comparisons of Station 57 with Stations 106 and 59. Statistically significant differences were observed with the BMWP and ASPT indices in comparison of Station 57 and 58, however, the number of taxa approaches statistical significance ($p=0.057$) for this comparison as well. (Stations 57 and 58 share only three sampling dates; this limits power of the statistical test.)

Biological community indicates significantly better quality in the upstream Karasu River than in the Kocadere (Station 59), by all indices.

Station 58: Biological community indicates significantly worse quality at Station 58 than downstream at Station 106, by BMWP index and number of taxa (only three shared data points for comparison).

Biological community data indicate no statistically significant difference between Stations 58 and 59. This may be a result of the limited number of shared sampling episodes (3) as much as of the relative similarity of the biological community at these two locations. As seen in the Table 1, Station 58 appears to be of better quality than Station 59, but this apparent difference is not statistically significant.

Stations 58 and 56 have only one shared data point. This does not support a statistical evaluation of the differences in communities.

Station 106: Significantly better quality than downstream Station 59 was indicated by BMWP and ASPT indices and the number of taxa. No statistically significant difference was found by the TBI and NWC (although probabilities of 0.08 and 0.10, respectively, approach significance).

No statistically significant difference was found between Station 106 on Karasu River and Station 106 on the Söğüt River.

ANNEX III

INDUSTRIAL INVENTORY FOR THE KARASU RIVER BASIN

The inventory provided in this annex contains detailed information on each industrial unit in the Karasu River Basin.

INDUSTRIAL INVENTORY

No.	Area	INDUSTRY NAME	LOCATION	PRODUCT	WORK. SHIFTS	WATER CONS. m3/day	IND. WASTE DIS. m3/day	DISCHARGE GOES TO	RIVER KM.	TREAT. PLAN STATUS	DOM. SEW. GOES TO	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12	13
A01	BMI	Tekmar Mermer Granit San. Tic. A.S.	Near Asagikoy	Marble	3	1200 m3/d	1200	Karasu	24.5	2 plants. Some recycle done. Sludge is dumped on land.	Istayon town sewers	
A02	BMI	Bilmertas Mermercilik San. Tic. A.S.			-							closed
A03	BMI	Bilecik Belediye Mezbahasi	Near Asagikoy	Meat	2 d/wk	NA	Intermittent. 35 m3/day average.	Karasu	24.5	Nil	Karasu	2 days/week
A04	BMI	Tekel Hublon-Sarap Fabrikasi	At Istasyonu	Beer Hops and wine	1	NA	3-4 m3/d in Oct. only when grapes crushed	Karasu		Nil	Istasyon town sewers	Seasonal. 3 mo/yr. Solid waste used as animal feed.
A05	BMI	Bil-Yem-Tes San. Tic. A.S.	Bilecik Centre	Animal feed	2	NA	Nil	Nil		Nil	Bilecik town sewers	Dry industry
A06	BMI	Serel Seramik Sanayi A.S.	After Bilecik	Ceramic	3	200 to 300. All from wells.	10	Karasu via Pelitozu dere	15.0	Settling tank Capacity = 400 m3.	To septic tank	No reuse
		ORGANIZE SANAYII										
A07	OSB	Birlas Birlik Lastik San. Tic. A.S.	Org. San. Park	Rubber	3							

INDUSTRIAL INVENTORY

No	Area	INDUSTRY NAME	LOCATION	PRODUCT	WORK SHIFTS	WATER CONS. m3/day	IND. WASTE DIS. m3/day	DISCHARGE GOES TO	RIVER KM.	TREAT. PLAN STATUS	DOM. SEW. GOES TO	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12	13
A08	OSB	Cevren Elektronik San. A.S.	Org. San. Park									Closed
A09	OSB	Borusan Granit San. Tic. A.S.	Org. San. Park	Granite 18000 20000 m2/mo	-	230				Black water from granite cutting is neutralized		
A10	OSB	Site Suni Kosele San. Tic. A.S.	Org. San. Park	Art. Rubber	-							
A11	OSB	Aslanoglu Kereste San. Tic. A.S.	Org. San. Park	Poles	-							
A12	OSB	Ferro Alasim San.	Org. San. Park		-							
A13	OSB	Metko Kimya San. Tic. A.S.	Org. San. Park	Chem	-							Closed
A14	OSB	Matel Hammadde San. Tic. A.S.	Org. San. Park	Metal	-							
A15	OSB	Evren Metal San. Tic. A.S.	Org. San. Park	Metal	-							

INDUSTRIAL INVENTORY												
No.	Area	INDUSTRY NAME	LOCATION	PRODUCT	WORK. SHIFTS	WATER CONS. m3/day	IND. WASTE DIS. m3/day	DISCHARGE GOES TO	RIVER KM.	TREAT. PLAN STATUS	DOM. SEW. GOES TO	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12	13
A16	OSB	Rector Incorp San. Tic. A.S.	Org. San. Park	Prefab. Str.								
A17	OSB	Seranit Seramik San. A.S.	Org. San. Park	Ceramic	-							
A18	OSB	Silkar Mermer Granit A.S.	Org. San. Park	Marble/Gran.	-					Decantation & filter press. High quality effluent.		
A19	OSB	Miner Otomotiv San. Tic. A.S	Org. San. Park	Auto ancill.	-							
A20	OSB	Birlik Galvaniz Sac San. Tic. A.S.	Org. San. Park	Galvinizing	-	30	20					
A21	OSB	Menetral Su Urunleri San. Tic. A.S	Org. San. Park	Snails	-							
A22	OSB	Kaim Muhendislik San. Tic. A.S	Org. San. Park	Engineering	-							
A23	OSB	Mapeks Gida San. Tic. A.S.	Org. San. Park	Food	-							

INDUSTRIAL INVENTORY												
No.	Area	INDUSTRY NAME	LOCATION	PRODUCT	WORK. SHIFTS	WATER CONS. m3/day	IND. WASTE DIS. m3/day	DISCHARGE GOES TO	RIVER KM.	TREAT. PLAN STATUS	DOM. SEW. GOES TO	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12	13
A24	OSB	Cesan Vinc San. Tic. A.S.	Org. San. Park	Machine	-							
A25	OSB	Arslan Aliminyum San. Tic. A.S.	Org. San. Park	Aluminium	-	20	10					
A26	OSB	Toprak Sen. ve Iz. San. Maden Zengin. Tes.	Org. San. Park	Ceramic (Kaolin & Feldspar)	-							
A27	OSB	Tez-Dok San A S	Org. San. Park	Metal	-							
A28	OSB	C C S Su Sayaclar San Tic. A.S	Org San Park	Watermeter	-							
A29	OSB	Tamas Plastik San A S	Org San Park	Plastic	-							
		ORGANIZE SANAYII TOTAL			2 to 3	1300	?	Karasu	17.0	Nil	Karasu	CETP planned
A30	VB	Sakarya Mermer San. Tic. A.S.	Vezirhan	Marble	2	36	30	Karasu	8.0	Settle & reuse. Sludge dumped on surrounding land.	Septic tank	Similar to Tekmar (A-01)

INDUSTRIAL INVENTORY												
No	Area	INDUSTRY NAME	LOCATION	PRODUCT	WORK SHIFTS	WATER CONS. m3/day	IND. WASTE DIS. m3/day	DISCHARGE GOES TO	RIVER KM.	TREAT. PLAN STATUS	DOM. SEW. GOES TO	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12	13
A31	VB	Marmara Kagit ve Ambalaj San. Tic. A.S.	After Vezirhan	Paper	3	2500	2000	Karasu	8.5	Exists. Also lagoon. No mercury used.		Poor effluent. Complaints from farmers downstream
A32	VB	Demisas Dokum Emaye Mam San. Tic A S	Vezirhan	Metal press	3	NA	Nil			Cooling water reused	septic tank / soil	
A33	VB	Vezir Madencilik San. A S. Mermer Fab.	Kayabeli	Marble	1 or 2	NA	Assumed 30			Settle / evaporate in natural pond	Septic tank	No recycle ?
A34	BB	Kadem Kirtasiye San Tic A.S.	Bayirkoy	Notebooks	1	NA	Nil				Septic tank	Dry industry
A35	BB	Habas Sinai ve Tibbi Gazlar Istihsal End A S.	Bayirkoy	Medical gas	3	NA	Nil			Salty waste water discharged through natural pond	Baykirkoy town sewers	Check pond
A36	BB	Tekersan Jant San Tic A S	Bayirkoy	Wheel Caps	1	39	25	?	3.0	Extended Aeration	Extended aeration	11 m3/d domestic, 25 m3/d industrial. Reuse partly in gardens
B01	BBI	Boztas Tugla Keremit San Tic. A S	Bozuyuk	Roof tiles/bricks	1	NA	Nil			Nil	Town sewers	Dry industry

INDUSTRIAL INVENTORY												
No.	Area	INDUSTRY NAME	LOCATION	PRODUCT	WORK SHIFTS	WATER CONS. m3/day	IND. WASTE DIS. m3/day	DISCHARGE GOES TO	RIVER KM	TREAT. PLAN STATUS	DOM. SEW. GOES TO	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12	13
B02	BBI	Koyluoglu Makina Kimyas San. A.S.	Bozuyuk	Machine parts	3	na	Nil			Nil	Town sewers	Dry industry
B03	BBI	Tikvesli Gida San. Tic	Bozuyuk	Food	closed							Closed
B04	BBI	Atalay Tugla Kiremit San. Tic. A S.	Bozuyuk	Poles	closed							Closed
B05	BBI	Boz-Kim Bozuyuk Kimya San. A.C.	Bozuyuk	Chem.	closed							Closed
B06	BBI	Citosan Bozuyuk Seramic Sanayı A.S.	Bozuyuk	Ceramics	3	1200 to 1500	Process 200 Cooling 100	Koca Dere	4.7	Settle & discharge	Septic tank	No recycle
B07	BBI	Haliser Halı ve Yer Dosemeleri San Tic. A S	Bozuyuk	Carpets	2 or 3	550 (all from wells)	450	Zero discharge to Koca Dere	10.2	Chem + Bio + store in pond for reuse in irrigation	6 m3/d to common treatment plant	Much recycle in irrigation. Also evap. & seepage from ponds.
B08	BBI	Turk Demir Dokum Panel Rad. San. Tic A.S	Bozuyuk	Radiators	2	604	510	Koca Dere DSI Canal	7.4	Exists. Sludge with chrome is stored at site.	50 m3/d to town sewers	B-08 & B-09 operated together
B09	BBI	Turk Demir Dokum Sofben San. A.S	Bozuyuk	Hot water pipes	2			(See B-08)	7.4			

INDUSTRIAL INVENTORY

No.	Area	INDUSTRY NAME	LOCATION	PRODUCT	WORK SHIFTS	WATER CONS. m3/day	IND. WASTE DIS. m3/day	DISCHARGE GOES TO	RIVER KM.	TREAT. PLAN STATUS	DOM. SEW. GOES TO	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12	13
B10	BBI	Demirer Kablo San. Tic. A.S.	Bozuyuk	Copper cables	3	NA				Nil	30 m3/d to Biopak unit	Closed system for boiler
B11	BBI	Ak-Al Tekstil San. Tic. A.S.	Bozuyuk	Textile dye	2	NA				Nil	Septic tank	To be checked
B12	BBI	ABS Alci Blok San. A.S.	Bozuyuk	Gypsum blocks	3	NA	Nil			Nil	Septic tank	Dry
B13	BBI	Ecz. Yapi Gerecleri San. Artema Armatur Gr.	Bozuyuk	Bathroom fixtures.	2	350	40	Koca Dere	7.4	30 m3/day Cr removal by alk-cl. 10 m3/day precipitated for Cr removal	Septic tank	3 T/mo. sludge containing Cr stored in plastic bags at site.
B14	BBI	Ecz. Yapi Gerecleri San. VITRA Seramik Gr.	Bozuyuk	Ceramic toilets	3	500 + 100	500	Cay Suyu & Koca Dere	8.5	Settling tank	Biopak unit	Some recycle. Also garden in summer. (Also see B-17)
B15	BBI	Ecz. Yapi Ger. ESAN Hammadde Haz. San.	Bozuyuk	Kaolin	2	600	450	Koca Dere	8.5	Settling tank	Septic tank	Treated along with B-16
B16	BBI	Ecz. Yapi Ger. Firit Tesisleri San. Tic. A.S.	Bozuyuk	Ceramic	2		(See B-15)		8.5			
B17	BBI	Eczacibasi EKS Karo Seramik San. A.S.	Bozuyuk	Ceramics	3	NA		Koca Dere	8.5	Treated together with Vitra (B-14)		Also see B-14

INDUSTRIAL INVENTORY												
No.	Area	INDUSTRY NAME	LOCATION	PRODUCT	WORK. SHIFTS	WATER CONS. m3/day	IND. WASTE DIS. m3/day	DISCHARGE GOES TO	RIVER KM.	TREAT. PLAN STATUS	DOM. SEW. GOES TO	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12	13
B18	BBI	Toprak Seniteri ve Izalator San. Tic. A.S.	Bozuyuk	Iso/Cera.	3	1500	975	Koca Dere	10.2	Exists	Extended aeration plant	
B19	BBI	Toprak Seramik Sanayi A.S.	Bozuyuk	Ceramics	3	345	250	Koca Dere	10.2	Exists	70 m3/d to extended aeration plant	
B22	BBI	Toprak Kagit San. Tic. A.S.	Bozuyuk	Paper	3	2000 to 2500	1500 to 1900	Koca Dere	10.2	"Save-alls" + settle + chem + filter + sludge	Extended aeration plant	Recycling done
B23	BBI	Ram-Tas Kereste San. A.S.	Bozuyuk	Telephone poles	1	NA	Nil			Nil	Septic tank	Dry industry
B24	BBI	Armasan Armatur San. A.S.	Bozuyuk	Motor windings	2	NA	Nil			Nil	Septic tank	Dry indust. /
B25	BBI	Danisment Makina Kimya San. Tic. A.S.	Bozuyuk	Wash Mach.	1	NA	Nil			Nil	Septic Tank	Dry Industry
B26	BBI	Eti Gida San. Tic. A.S.	Bozuyuk	Biscuits	3	70	70 (Assumed)		8.5	Nil	Septic tank	Assumed to be meeting food standards
B27	BBI	Idas Istanbul Dosemeleri San. A.S.	Bozuyuk	Beds	2	NA	Nil			Nil	Septic tank	Dry

INDUSTRIAL INVENTORY

No.	Area	INDUSTRY NAME	LOCATION	PRODUCT	WORK SHIFTS	WATER CONS. m3/day	IND. WASTE DIS. m3/day	DISCHARGE GOES TO	RIVER KM.	TREAT. PLAN STATUS	DOM. SEW. GOES TO	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12	13
B28	BBI	El-Bir Teneke San. Tic. A.S.	Bozuyuk	Metal boxes	2	NA	Nil			Nil	Septic tank	Dry
B29	BBI	Afyon Mermer San. Tic. A.S.	Bozuyuk	Marble	2	NA	25	Koca Dere	5.6	Pond settle + partial recycle	Septic tank	Reuse ?
B30	BBI	Mumcu Kereste San. A.C.	Bozuyuk	Wood planks	2	NA	Nil			Nil	Septic tank	Dry
B31	BBI	Kose Kardesler Damper ve Karasor San	Bozuyuk	Truck Damp.	2	NA	Nil			Nil	Septic tank	Dry
B32	BBI	Sontas Mermer San. A.S.	Bozuyuk	Marble	2	NA	Assumed 30	Koca Dere	7.4	Settling pond + recycle	?	Some recycle
B33	BBI	Bozuyuk Belediye Mezbahasi	Bozuyuk	Meat	2 d/wk	NA	Intermittent	Partly to Koca Dere & partly to soil	2.9	Nil	?	60 - 70 animals per week
B34	BBI	Tekin Maden. San. Ltd. Sti. Kirec ve Pis. O	Bozuyuk - Asagi Akmutlu Village	Calcium carbonate	1 or 2	NA	Nil			Nil	Soak pits	Dry
B35	BBI	Tekin Mad. San. Ltd. Sti. Toz Torba Kirec Fb	Bozuyuk	Calcium oxide	2	NA	Nil			Nil	Town sewers	Dry

INDUSTRIAL INVENTORY												
No.	Area	INDUSTRY NAME	LOCATION	PRODUCT	WORK .	WATER CONS.	IND. WASTE DIS.	DISCHARGE	RIVER	TREAT. PLAN	DOM. SEW.	REMARKS
					SHIFTS	m3/day	m3/day	GOES TO	KM.	STATUS	GOES TO	
1	2	3	4	5	6	7	8	9	10	11	12	13
C02	BSI	Sogut Seramik San. A.S.	Sogut	Ceramics	3	800	200	Sogut Dere	26	Settling tanks. Supernatant to natural lake.		
C03	BSI	Sormas Refrakter Malzemeleri San. Tic. A.S.	Dereboyu	Refractory bricks	2	140	130	Sogut Dere	26	Nil	Dareboyun &Sogut Dere	
C04	BSI	Sormer Mermer San.	Dereboyu	Marble	2	NA	Assumed 25	Sogut Dere	26	Ponds, settle, some recycle, evap. & seepage	Septic tank	New unit. Need to visit
C05	BSI	Gokmersan Mermer San. A.S.	Near Sogut	Marble	2	NA	Assumed 25			Ponds, settle, some recycle, evap. & seepage	Septic tank	Recycling done
C06	BSI	Kabeloglu Mermer San. A.S.	Near Sogut	Marble	2	NA	Assumed 25			Ponds, settle, some recycle, evap. & seepage	Septic tank	Recycling done
C07	BSI	Kurtay Tunc Mermer San. A.S.	Near Sogut	Marble	2	300	90	Sogut Dere	26	Ponds, settle, some recycle, evap. & seepage	Septic tank	
C08	BSI	Ozsogut Mermercilik San. Tic. A.S.	Near Sogut	Marble	2	200	60	Sogut Dere	26		Septic tank	

INDUSTRIAL INVENTORY												
No.	Area	INDUSTRY NAME	LOCATION	PRODUCT	WORK. SHIFTS	WATER CONS. m3/day	IND. WASTE DIS. m3/day	DISCHARGE GOES TO	RIVER KM.	TREAT. PLAN STATUS	DOM. SEW. GOES TO	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12	13
C09	BSI	Yildizlar Mermer San. A.S.	Near Sogut	Marble	2	14.4	4.5	Sogut Dere	26		Septic tank	
C10	BSI	Cift Yildiz Mermer San. Tic. A.S.	Near Sogut	Marble	2	5	4	Sogut Dere	26			
C11	BSI	Sogut Belediye Mezbahasi	Near Sogut	Meat	1 d/wk	NA	Intermittent. Negligible.					4 - 5 animals per week
D01	BPI	Kartop Tugla San. Tic. A.S.	Pazaryeri	Bricks	2	NA	Nil				Septic tank	Dry
D02	BPI	Sol-Koop Serbetciolu Fabrikasi	Pazaryeri	Hops	1	NA	Nil			Nil	Town sewer	Dry
D03	BPI	Efes Pilsen Serbetciolu San.	Pazaryeri	Malt	Closed							Closed
D04	BPI	Karakoy Un Fabrikasi	Pazaryeri	Flour	Closed							par
D05	BPI	Pazaryeri Belediye Mezbahasi	Pazaryeri	Meat	1 d/wk	NA	Intermittent			Nil	Nil	3 - 4 animals per week

ANNEX IV

COMPARISON OF KARASU WATER QUALITY DATA AND STREAM CRITERIA

An analysis of the historical water quality sampling data collected at the six DSI sampling stations, provided detail on the water quality in the streams relative to the stream standards. In Table IV-1, for each station and for each parameter that is subject to the Turkish stream standards, the following information is provided: the number of samples; mean, minimum and maximum values; and the number of samples that are in violation for each classification I, II and III.

Table IV-1: Analysis of Water Quality Data by Sampling Station

STATION 56

Param.	N	Minimum	Average	Maximum	# of Violations I	II	III
Temp.	28	6	14.73	27	1	1	0
pH	28	7.5	7.69	8.3	0	0	0
TDS	28	387	540	689	18	0	0
Cl	28	22.3	40.6	75.2	25	0	0
NO2-N	28	0.003	0.118	0.278	28	20	19
NO3-N	28	0	0.98	2.65	0	0	0
D.O.	28	1.1	3.8	7.8	28	25	8
BOD5	26	11.7	48.4	126.7	26	26	22
SO4	18	29.1	60.6	80	0	0	0
Fe	18	0.56	1.26	3	18	9	0
Mn	12	0.02	0.254	0.35	11	0	0
Na	25	20.7	46.2	86.9	0	0	0
CN	10	0	0	<0.01	0	0	0
COD	25	52	122	358	25	25	21
TKN	25	4.1	13.3	36.4	25	25	24
B	25	0.02	0.42	1.2	2	2	2
F	18	0.1	0.42	0.8	0	0	0
E Coli	12	$4x10^5$	$4.9x10^6$	$2x10^7$	12	12	12
T Coli	12	$1x10^6$	$1.6x10^7$	$6x10^7$	12	12	12

STATION 57

Param.	N	Minimum	Average	Maximum	No. of Violations I	II	III
Temp.	14	7	11.5	15	0	0	0
pH	14	7.7	8.2	8.5	0	0	0
TDS	14	222	255	273	0	0	0
Cl	14	1.8	3.1	4.4	0	0	0
NO2-N	14	0.003	0.029	0.036	14	11	0
NO3-N	14	0.65	1.1	1.4	0	0	0
D.O.	14	8.8	10.5	12.4	0	0	0
BOD5	14	0.7	1.65	3.2	0	0	0
SO4	14	2.5	5.7	11	0	0	0
Fe	14	0.1	0.45	1.18	10	1	0
Mn	8	0.01	0.03	0.08	0	0	0
Na	14	1.92	2.46	3.83	0	0	0
CN	6			<0.01	0	0	0
COD	14			22.4	0	0	0
TKN	14	0.15	0.32	0.65	1	0	0
B	14	0	0.032	0.2	0	0	0
F	14	0	0.29	0.1	0	0	0
E Coli	8	80	1135	3000	8	5	2
T Coli	8	1000	4437	10000	8	0	0

Table IV-1: Analysis of Water Quality Data by Sampling Station (continued)

STATION 58

Param.	N	Minimum	Average	Maximum	No. of Violations I	II	III
Temp.	8	7	13.4	18	0	0	0
pH	8	7.9	8.1	8.2	0	0	0
TDS	8	441	47	500	0	0	0
Cl	8	5.8	8.7	12.4	0	0	0
NO2-N	8	0.002	0.047	0.12	7	7	3
NO3-N	8	0.7	0.96	1.4	0	0	0
D.O.	8	8.4	9.5	10.7	0	0	0
BOD5	8	3.2	4.9	7.2	6	0	0
SO4	8	10	15.2	20	0	0	0
Fe	8	0.32	0.47	0.64	8	0	0
Mn	2	0.08	0.085	0.09	0	0	0
Na	8	4.79	7.85	11.5	0	0	0
CN	0						
COD	8			44.8	4	0	0
TKN	8	0.95	1.38	2.07	8	2	0
B	8	0	0.085	0.41	0	0	0
F	8	0	0.062	0.2	0	0	0
E Coli	8	10000	$3.6x10^5$	$2x10^6$	8	8	8
T Coli	8	50000	$1.2x10^6$	$6x10^6$	8	8	3

STATION 59

Param.	N	Minimum	Average	Maximum	No. of Violations I	II	III
Temp.	42	4	14.3	26.5	2	2	0
pH	42	7.5	8.15	8.6	2	2	0
TDS	42	22.6	362.7	791	1	0	0
Cl	42	6	13.6	32.9	2	0	0
NO2-N	42	0	0.047	0.108	41	40	18
NO3-N	42	0.05	1.89	15	1	0	0
D.O.	42	1.8	9.51	12.8	9	4	1
BOD5	37	1.4	22.7	302	27	21	8
SO4	18	25	29.1	39	0	0	0
Fe	18	0.4	1.8	7.8	18	12	1
Mn	12	0.07	0.321	0.72	11	2	0
Na	28	8.05	18.82	92	0	0	0
CN	9			<0.01	0	0	0
COD	30	0	101	1098	21	16	13
TKN	29	0.22	0.91	3.54	19	2	0
B	25	0	0.124	0.47	0	0	0
F	18	0	0.111	0.4	0	0	0
E Coli	11	1000	64636	$3.5x10^5$	11	11	10
T Coli	11	50000	$6.3x10^5$	$3x10^6$	11	11	8

Table IV-1: Analysis of Water Quality Data by Sampling Station (continued)

STATION 105

Param.	N	Minimum	Average	Maximum	No. of Violations I	II	III
Temp.	16	3.5	14.3	21.5	0	0	0
pH	16	7.5	8.1	8.8	1	1	0
TDS	16	289	398	511	1	0	0
Cl	16	8.7	19	43.5	3	0	0
NO2-N	16	0.002	0.06	0.197	15	14	19
NO3-N	16	1.35	1.85	2.8	0	0	0
D.O.	16	7.5	10.17	13.5	1	0	0
BOD5	14	1	3.57	9.4	4	1	0
SO4	7	29	23.7	60	0	0	0
Fe	7	0.06	0.43	1.22	4	1	0
Mn	1	0.03	0.03	0.03	0	0	0
Na	14	10.35	24.42	38.61	0	0	0
CN	0						
COD	14			50.4	3	1	0
TKN	14	0.02	0.634	2.17	7	1	0
B	14	0	0.102	0.3	0	0	0
F	7	0.1	0.2	0.3	0	0	0
E Coli	7	3000	19143	10000	7	7	7
T Coli	7	10000	$2.1x10^5$	60000	7	6	4

STATION 106

Param.	N	Minimum	Average	Maximum	No. of Violations I	II	III
Temp.	22	5.5	15.2	22	0	0	0
pH	22	7.9	8.3	8.6	1	1	0
TDS	22	244	316	351	0	0	0
Cl	22	6.2	9	13.7	0	0	0
NO2-N	22	0.001	0.039	0.114	21	21	5
NO3-N	22	1	1.511	2.5	0	0	0
D.O.	22	8	10	13.1	0	0	0
BOD5	20	0.9	3.91	8.4	8	1	0
SO4	8	17.4	21.5	26.4	0	0	0
Fe	8	0.26	0.64	1.16	7	1	0
Mn	2	0.07	0.075	0.08	0	0	0
Na	15	6.44	9.06	12.94	0	0	0
CN	0						
COD	15	0	19.4	44.8	6	0	0
TKN	15	0.22	0.77	2.36	8	2	0
B	15	0	0.035	0.21	0	0	0
F	8	0	0.125	0.4	0	0	0
E Coli	8	1000	78875	$5x10^5$	8	8	7
T Coli	8	50000	$2.7x10^5$	$1x10^6$	8	3	5

ANNEX V

PARAMETERIZATION OF THE QUAL2E MODEL TO THE KARASU RIVER AND TRIBUTARIES

The parameterization process is described below for the hydraulic and water quality parameters used in QUAL2E.

Hydraulic parameters:

1) Stream slope: Stream elevation information was determined from the government's 1:25000 scale topographical map series and slopes calculated from these values.

2) Stream cross sections: Cross sectional measurements were made during the intensive survey. Based on these data, the streams were represented as trapezoids with the bottom width and side slopes determined from the measured cross sections. In some cases, cross-sectional data were modified based on observations during the stream survey if the location of the measurements were not representative of the reach.

3) Roughness coefficient: Manning's roughness coefficients were estimated based on comparison of photographs taken during the intensive survey to representative pictures in the classical reference, "Open-Channel Hydraulics" (Ven Te Chow, McGraw-Hill, New York, 1959). A value of 0.05 was selected for all reaches.

4) Streamflows: For the calibration runs of the model, headwater and tributary streamflows were estimated based on measurements made during the intensive survey. Incremental streamflows and the streamflow for the Sabuncu tributary to the Söğüt were estimated based on the measured streamflows and were spatially distributed based on drainage areas calculated from topographical maps. For production runs of the model, the streamflow record at the Vezirhan gage was statistically analyzed. Flows at other locations were estimated by assuming a constant flow per area ratio.

5) Dispersion coefficients: A value of 200, representative of streams of this type, was used for this dimensionless constant.

Rate Coefficients:

1) Reaeration coefficient: Two methods of determining reaeration coefficients were investigated in the model, the Tsivoglou-Wallace method based on stream slope, and the Owens, Edwards, Gibbs method based on water depth and velocity. Though the two methods resulted in significant variation in the calculated coefficients and the Tsivoglou-Wallace method resulted in a wide variation between reaches, the ability to represent the field measured values for D.O. did not differ greatly. The Owens-Edwards-Gibbs method was selected for use in the model because of its greater stability.

2) Deoxygenation coefficient: The standard value of 0.23/day was utilized in the study for all reaches and resulted in a good representation of the observed BOD values.

3) Nitrogen-Phosphorous-Algal cycle: The effects of these constituents on the oxygen balance were not included in the modeling. This decision was initially based on the lack of loading information for these constituents and the short system residence times due to relatively high velocities. The ability to calibrate the model without the inclusion of these constituents confirmed the adequacy of this assumption.

4) Coliform die-away: A value of 4.4/day was selected for the die-away rate for coliform based on comparison of coliform data collected during the intensive study at pairs of adjacent stations.

Loading data:

1) Headwaters: Sampling data collected at the headwaters of the Kocadere and Söğüt Deresi during the intensive survey were used to determine headwater loading rates for 5-day BOD, dissolved oxygen, total suspended solids, fecal coliform and

temperature. Because of the variability of temperature over the period of a day, a constant stream temperature was assumed throughout the basin.

2) Tributaries: Sampling data collected for the Upper Karasu and the Sorgun Deresi during the intensive survey were used to determine tributary loading rates for these tributaries. The headwater data was used to estimate loadings for the Sabuncu tributary to the Söğüt Deresi.

3) Incremental: The headwater data was used to estimate loadings for the incremental flows.

4) Diversion: Since no active diversion of water was observed during the intensive study, the diversion flow rate was set at zero for the calibration runs. For production runs, the diversion was set at 0.24 m^3/sec for present conditions and 0.56 m^3/sec for the year 2005 strategy.

5) Point loadings: The stream sampling results from the intensive survey were used to estimate point loadings for the calibration runs. Because of the relatively dense sampling pattern, the proximity of the sampling sites to the point loads and the short travel times from the point loads to the sampling locations (minimizing the effects of decay), this method of determining point loads was quite effective. Methods of estimating loadings for the various present situations and future strategies are described in the main part of this report.

Table V-1 lists the year 1995 and year 2005 loadings by individual industry. The 1995 values listed here assume that all industries are meeting effluent standards and that a set portion of the untreated municipal waste is being discharged to the streams.

Table V-1: Industrial Loadings Used in the STAND1 and FUTURE Strategies

Ind. No.	1995 Ind. Cat.	1995 Q m3/d	1995 BOD kg/d	1995 SS kg/d	2005 F.Col #/100ml	2005 Q m3/d	2005 BOD kg/d	2005 SS kg/d	2005 F.Col #/100ml
A01	CER	1200		120		2904	0	290.4	
A03	MEAT	35	18			48.3	24.8	0	
A06	CER	10		1		24.2	0	2.4	
OSB	Ind.Pk.	1300	130	260		2600	260	520	
A30	CER	30		3		72.6	0	7.3	
A31	PAP	2000	540	160		3620	977.4	289.6	
A36	MET	25		3		41	0	4.9	
B06	CER	200		20		484	0	48.4	
B08	MET	510		63.7		836.4	0	104.5	
B13	MET	40		22		65.6	0	36.1	
B14/B17	CER	500		50		1210	0	121	
B15/B16	CER	450		45		1089	0	108.9	
B18	CER	975		100		2359.5	0	242	
B19	CER	250		25		605	0	60.5	
B22	PAP	1900	76			3439	137.6	0	
B26	FOOD	70	4.2	8.4		96.6	5.8	11.6	
B29	CER	25		2.5		60.5	0	6.0	
B32	CER	25		2.5		60.5	0	6.0	
B33	MEAT	50				69	0	0	
C02	CER	200		20		484	0	48.4	
C03	CER	130		13		314.6	0	31.5	
C04	CER	100		10		242	0	24.2	
C07	CER	300		30		726	0	72.6	
C08	CER	60		6		145.2	0	14.5	
C09	CER	5		0.5		12.1	0	1.2	
C10	CER	4		0.4		9.68	0	1.0	
Bilecik	MUN	3125	625		10^7	8687	347		10^5
Bozuyuk	MUN	6562	1312		10^7	12512	500		10^5
Söğüt	MUN	625	125		10^7	3325	133		10^5

The hydraulic and water quality parameters used in all runs of the QUAL2E model are presented in Table V-2:

Table V-2: QUAL2E Calibration Parameters

Rch #	Stream Name	U/S Km.	D/S Km.	Bottom Width (m)	Side Slope (m/m)	Stream Slope (m/m)	Sed. O_2 Demand
1	Kocadere	62.5	52.5	3.0	1.3	0.00515	15
2	Karasu	52.5	45.0	0.83	4.6	0.00893	0
3	Karasu	45.0	37.0	0.83	4.6	0.0085	0
4	Karasu	37.0	33.5	0.1	5.2	0.04629	0
5	Karasu	33.5	28.0	0.25	6.4	0.01818	0
6	Karasu	28.0	20.0	0.25	6.4	0.01187	0
7	Söğüt	28.0	20.0	2.0	0.75	0.01754	15
8	Söğüt	20.0	10.0	1.0	1.3	0.0191	0
9	Söğüt	10.0	0.0	0.67	2.0	0.0012	0
10	Karasu	20.0	10.0	0.23	6.4	0.0075	0
11	Karasu	10.0	0.0	0.23	6.4	0.00421	15

The aggregated loadings used in the calibration runs of the QUAL2E model are presented in Table V-3.

Table V-3: Aggregated Loadings for Calibration Runs

Rch #	Point Source	Flow m3/sec	Temp °C	D.O. mg/l	BOD mg/l	TSS mg/l	E.Coli #/ml
1	Kocadere-1	0.134	21.0	4.3	57.5	718.0	8300.
3	Upper Karasu	2.504	21.0	8.8	1.02	44.0	25.
5	Sorgun	0.43	21.0	8.6	1.79	9.0	2.
6	Mid Karasu	0.014	21.0	7.0	15.0	9598.0	0.
7	Söğüt	0.016	21.0	4.9	51.4	331.0	19000.
8	Söğüt Trib	0.084	21.0	8.5	2.0	30.0	2.
9	Bilecik	0.051	21.0	3.5	163.0	1693.0	25000.
10	Lower Karasu	0.024	21.0	2.0	3921.0	15675.0	999999.

A comparison of the water quality as predicted by the calibrated model and the stream sampling results are shown in Figure V-1. As illustrated, the predicted values are in close agreement for BOD, total suspended solids and fecal coliform.

For dissolved oxygen, two potential anomalies were identified: 1) the predicted dissolved oxygen sags in the Kocadere reach below Bozuyuk and in the most downstream reach of the Karasu River were not as pronounced as observed in the field; and 2) the predicted dissolved oxygen in the Karasu River in reaches 2, 3, 4 and 5 approached saturation value which was greater than observed in the field. For the former case, very significant benthic deposits were observed during the intensive survey and when a sediment oxygen demand (SOD) was introduced into the model, the resulting predicted D.O. reproduced the observed values. In the latter case, there are few known loadings in reaches 2, 3, 4 and 5 and a very steep slope suggesting that the river would be expected to approach saturation value for dissolved oxygen. Since the measured dissolved oxygen was constant over those reaches, though approximately 1 mg/l below saturation, it is conceivable that the meter used in the sampling study was reading consistently low for that range.

Figure V-1: Comparison of Simulated and Observed Water Quality Values
Kocadere - Karasu Rivers

Simulated results ———— Fields Results ●

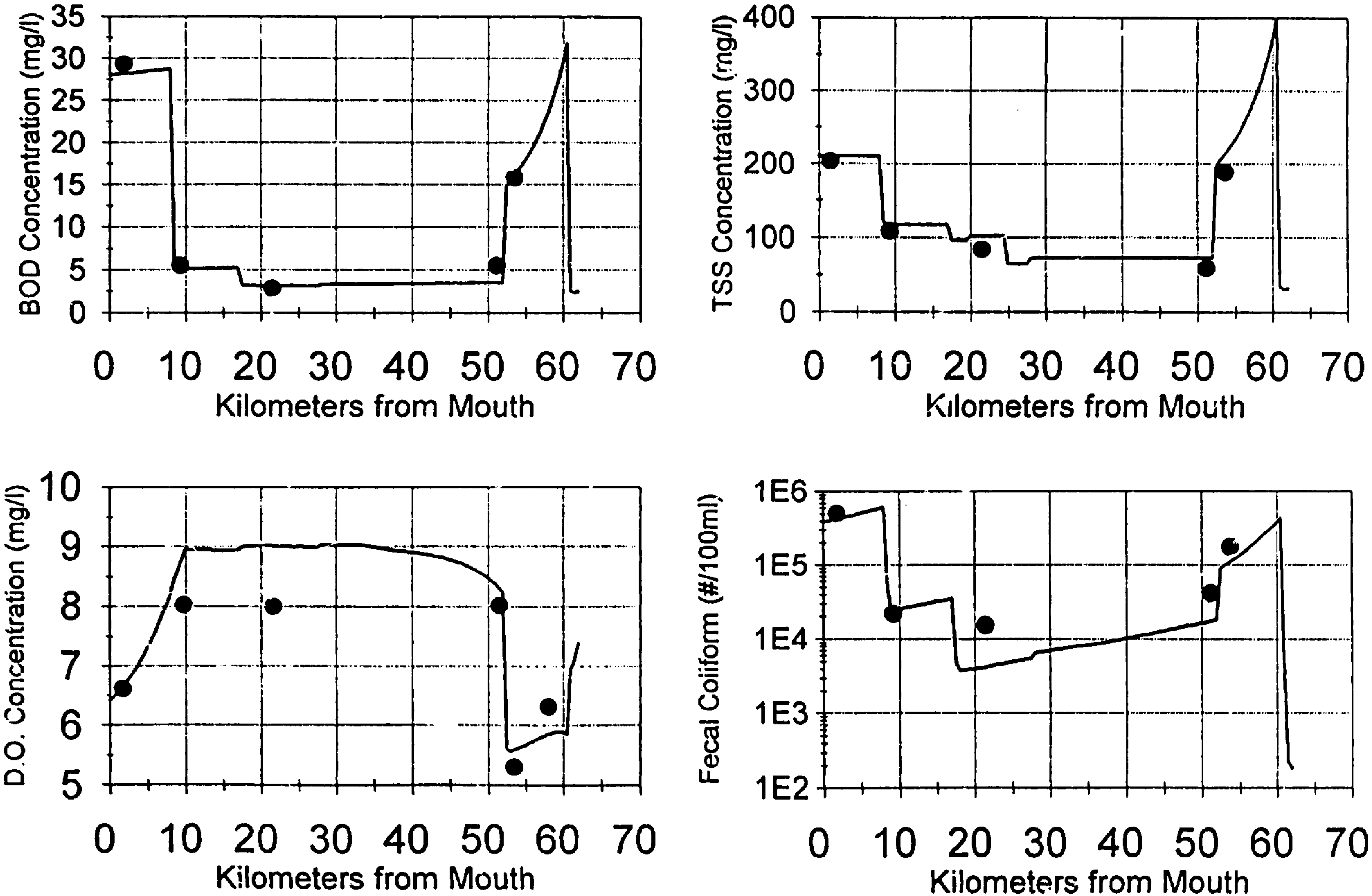
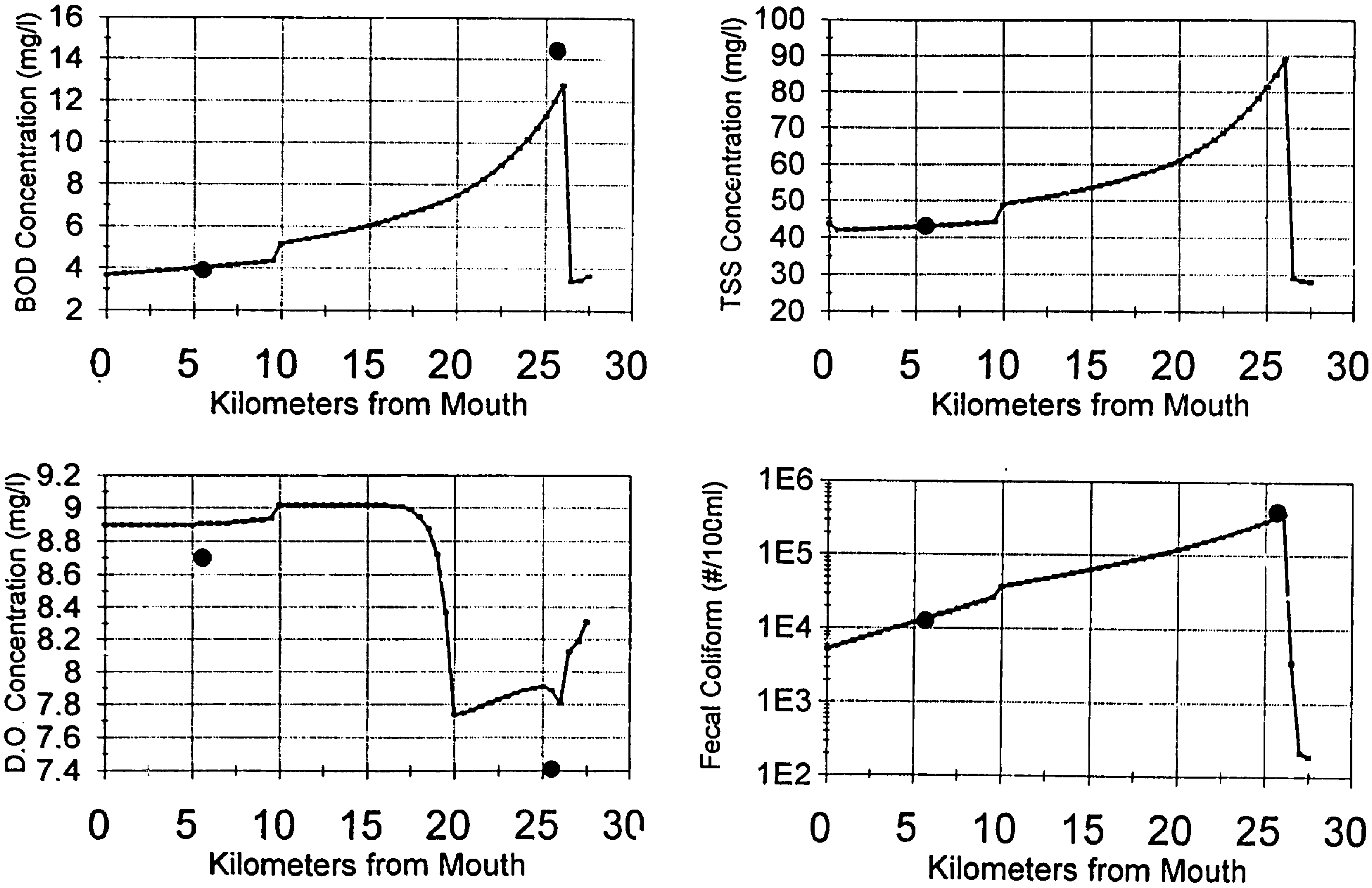


Figure V-1(continued): Comparison of Simulated and Observed Water Quality Values
Söğüt River

Simulated results ——— Fields Results ●



ANNEX VI

RESULTS OF APPLICATION OF THE QUAL2E MODEL TO THE KARASU BASIN

PRES1 situation: In this situation, current average loading conditions were estimated utilizing the stream water quality data for the 5-year period from 1991 to 1995.

STAND1 situation: In this situation, loadings were calculated for all industries assuming that they discharge at a concentration that will just meet the existing effluent standards for their particular product category. For municipalities, no treatment was assumed and a percentage of the domestic waste was assumed to reach the stream.

Future strategy 1: Industrial growth with all industry meeting effluent standards. (Assumes municipal wastewater increases proportionally to municipal growth but no additional sewers or treatment facilities are constructed.)

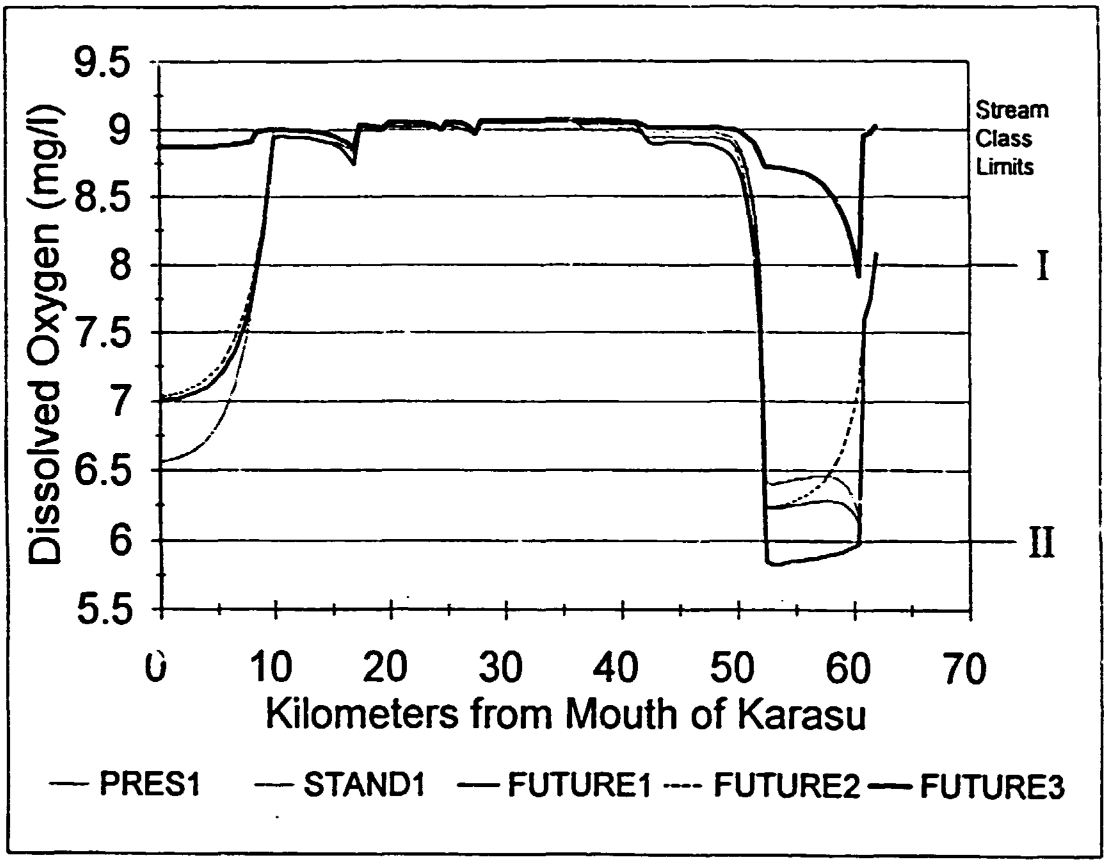
Future strategy 2: Future strategy 1 + municipal growth, fully sewered municipalities and secondary treatment.

Future strategy 3: Future strategy 2 + elimination of sediment oxygen demand.

Future strategy 4: Future strategy 3 + disinfection added at all municipal treatment works and bacterial contamination reduced in rural areas.

The simulated stream profiles for each of the strategies for dissolved oxygen, BOD, total suspended solids and fecal coliform are presented in Figures VI-1 and VI-2 for the Kocadere-Karasu and the Söğüt respectively.

Figure VI-1
Simulated Water Quality Profiles on the Kocadere - Karasu Rivers



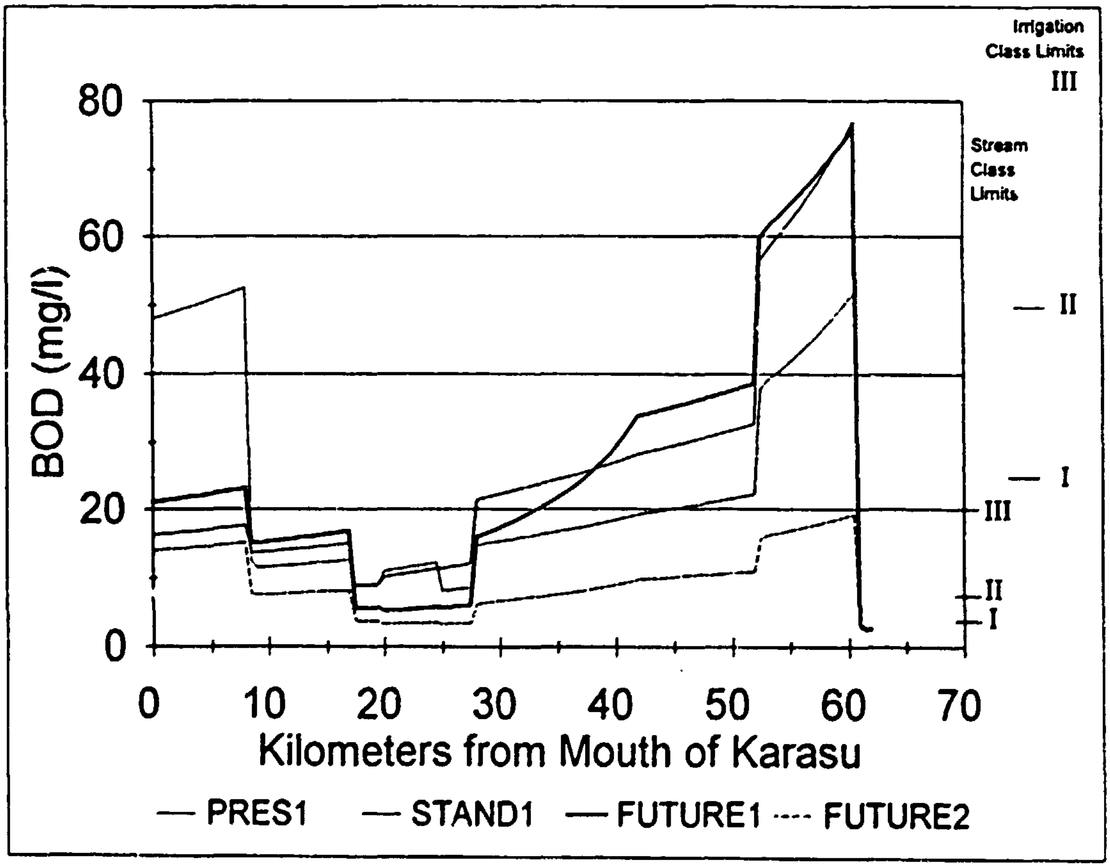
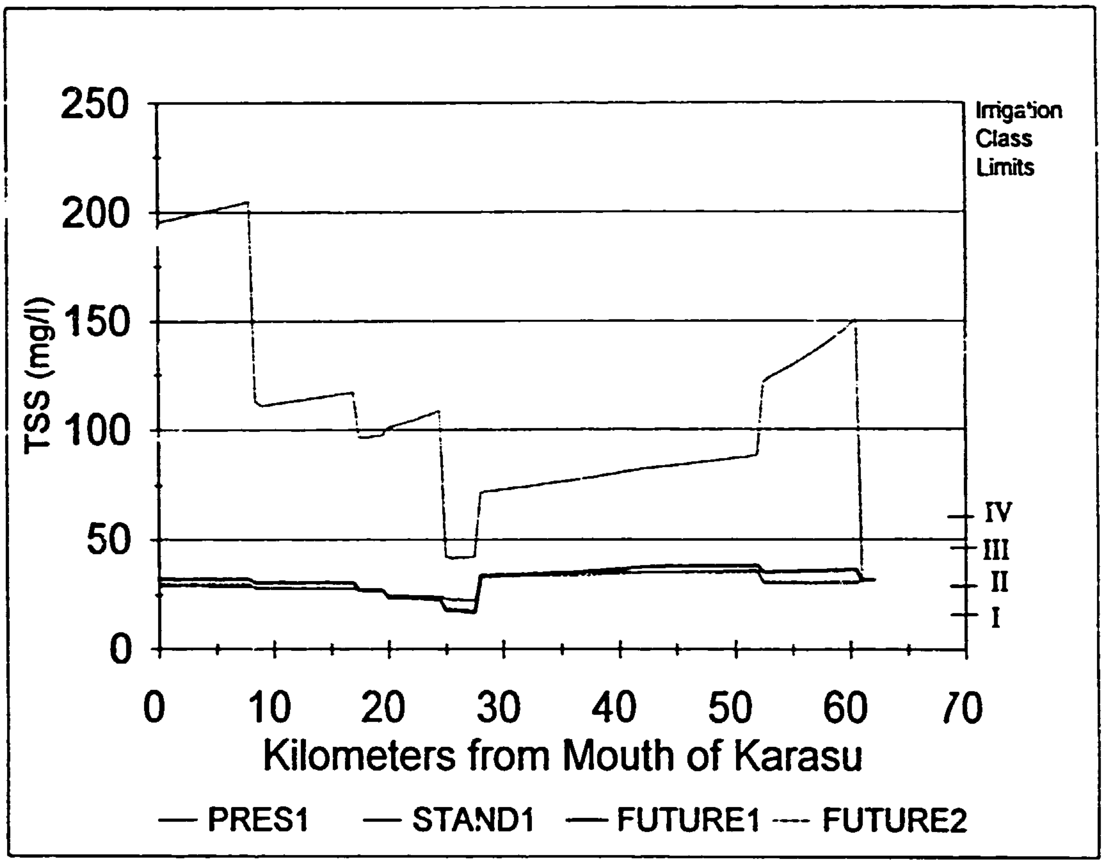


Figure VI-1
Simulated Water Quality Profiles on the Kocadere - Karasu Rivers (continued)



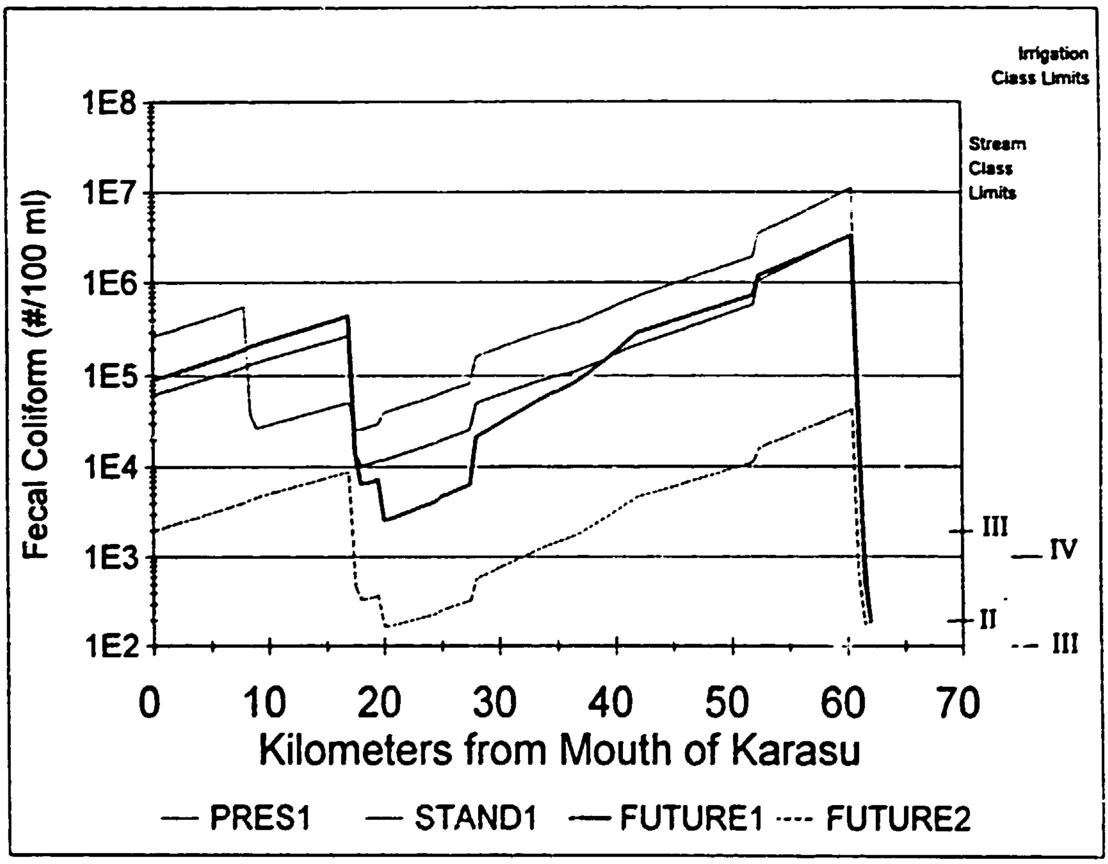
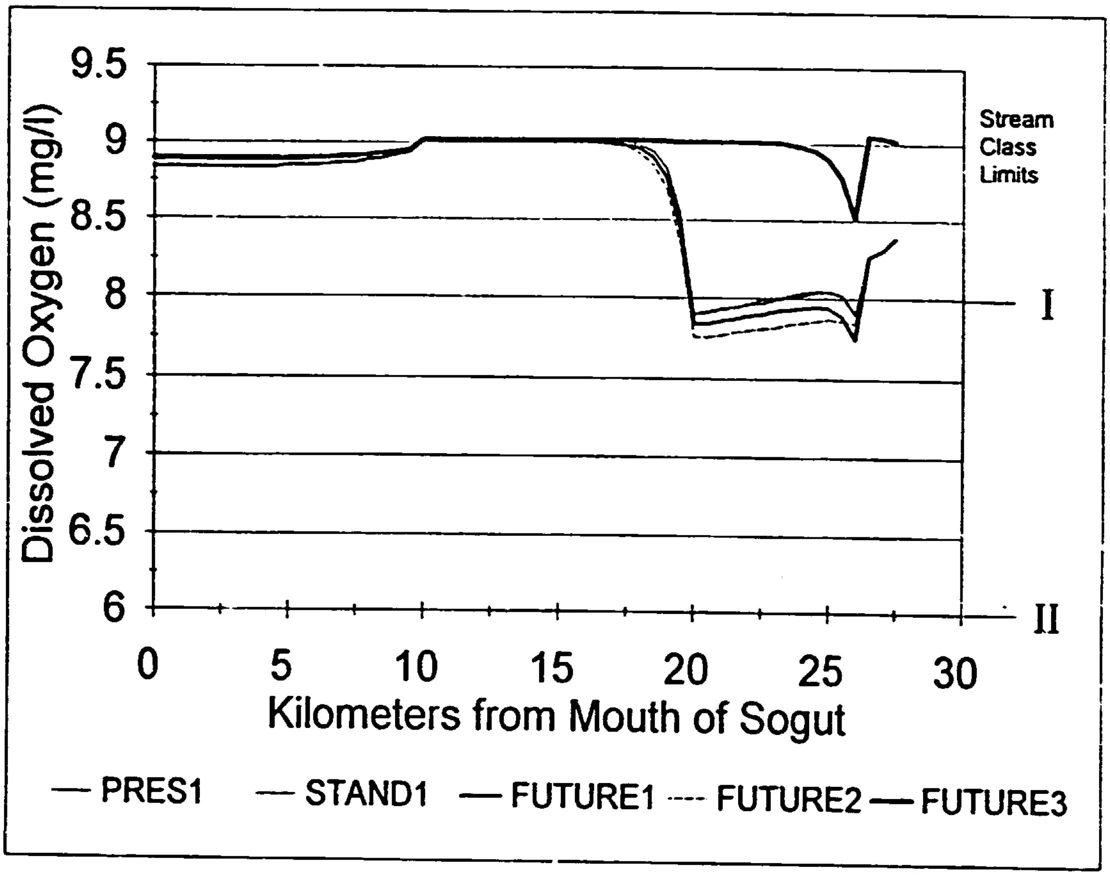


Figure VI-2
Simulated Water Quality Profiles on the Sögüt River



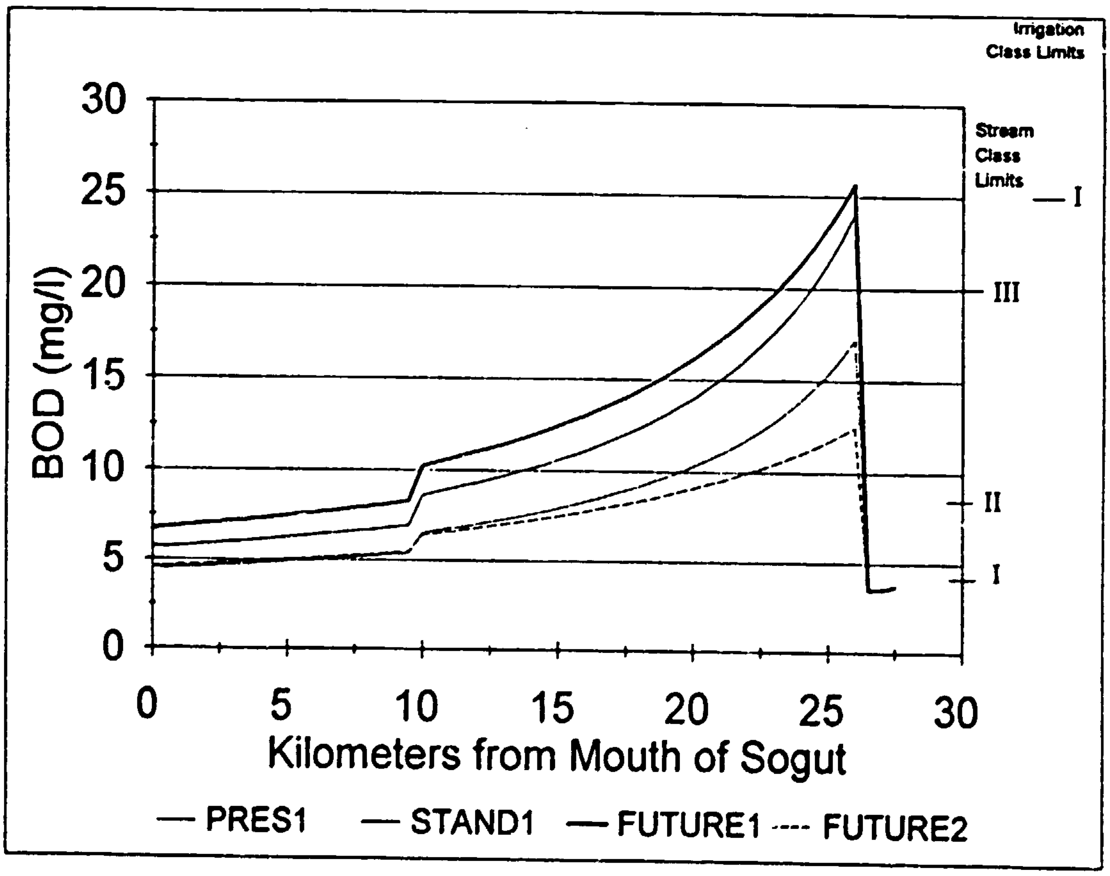
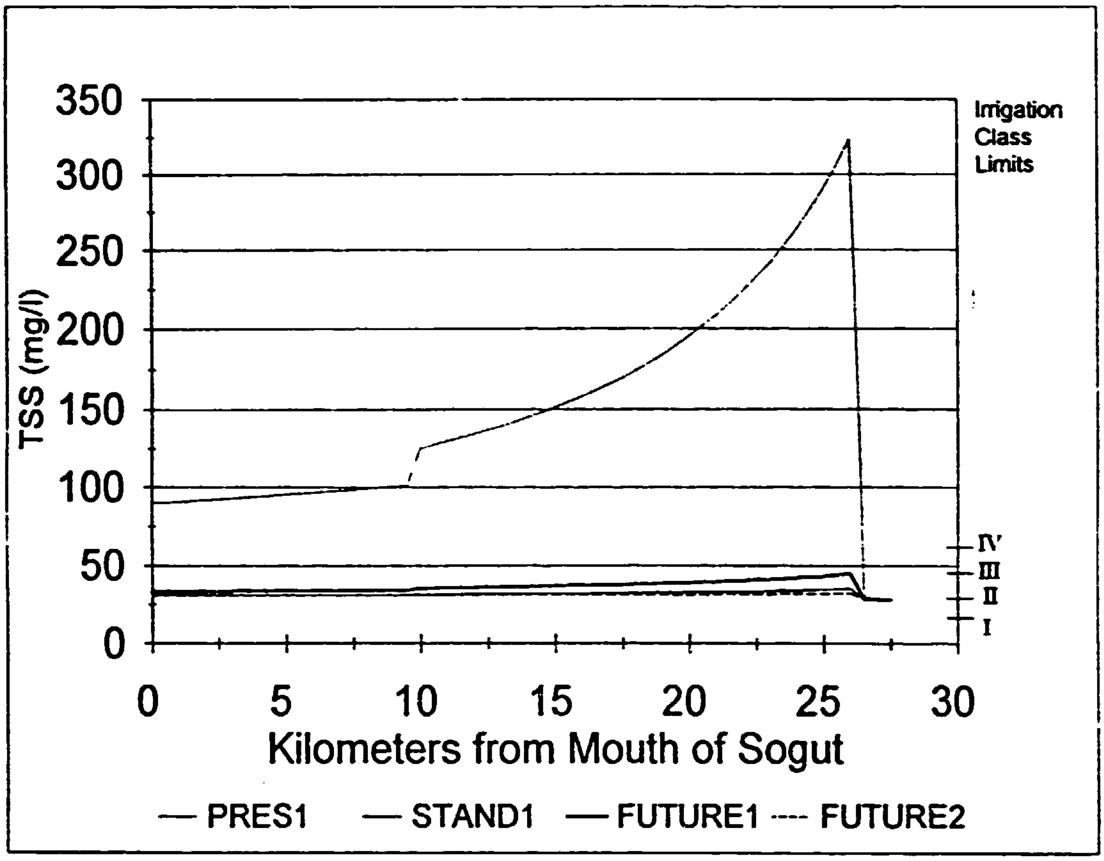
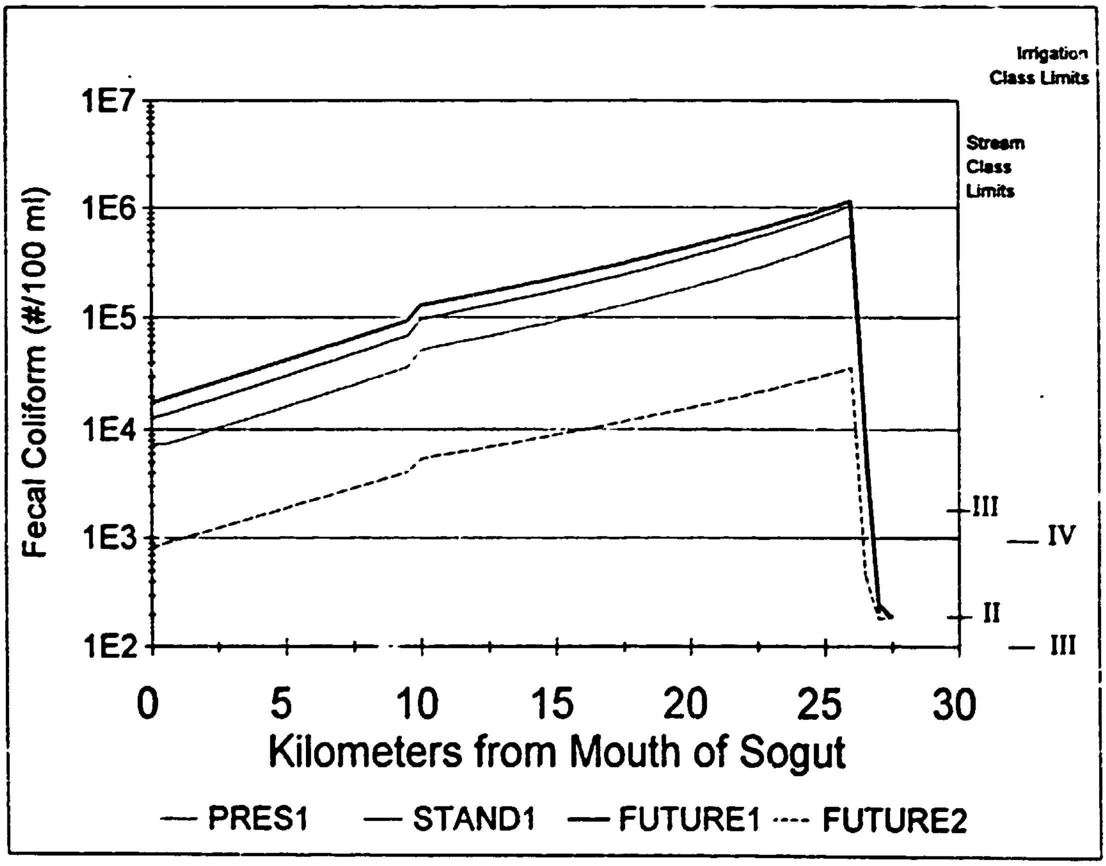


Figure VI-2
Simulated Water Quality Profiles on the Söğüt River (continued)





ANNEX VII

MUNICIPAL SEWER AND SEWAGE TREATMENT PLANT COST ESTIMATION METHODS

The Iller Bankasi provided the following information relative to the design period and typical costs of providing sewerage networks and sewage treatment facilities.

Design period:	Generally, 35 years for sewer networks and 10 - 15 years for the 1st phase of sewage treatment plants.
Population estimation:	Based on historical records since 1945 of the actual percent growth per year for the town in question.

Processes used and final effluent discharge standards

Extended Aeration (E.A.):	20 BOD/20 SS
Activated Sludge (A.S.):	30 BOD/30 SS
Trickling Filters (T.F.):	Same as A.S. Plastic media preferred
Waste Stabilization Ponds (W.S.P.):	Not preferred for discharge to Rivers and Coastlines as efficiencies in winter are low.

Actually, Activated Sludge Process is preferred nowadays as it is felt that better discharge standards would have to be met as Turkey joins the European Common Market.

The cost of providing sewerage networks is dependent mainly on the terrain and topography of the area and the size and density of population and its layout. Sewage flow is assumed as 200 l/person/day The costs, therefore, range widely (1.5 to 3.7 to even 5 mill TL/person). Two examples are given in Table VII-1 for 1995.

Table VII-1: Cost of Providing Sewerage Networks (1995)

	Town	Terrain	Design Population	Total Sewers Length, KM	TL/KM/ Person	TL/Person	US $ Per Person
1.	ELAZIG	Relatively easy	658,100	241	6.0	1.46 million	34.4
2.	ARAKLI	Difficult terrain	45,000	25	146.0	3.65 million.	87.0

The capital costs of constructing sewage treatment plants for Turkish towns depended mainly on the process used and to a smaller extent on the population served, topography and soil conditions. However, the range of variation was relatively narrow: from US $ 35 to 45 per person (1995 costs). The flow is assumed as 200 l/person/day. Table VII-2 below gives some recent examples.

Table VII-2: Sewage Treatment Costs

	Town	Process	Usual Discharge Standard	TL per person (1994)	$ per person (1994-95)
1.	In general	A. S.	30/30	TL 1.5 mill.	$ 35.7
		Extended Aeration	20/20		
2.	Izmit (5 plants for 1 million people)	A. S.	30/30 To Izmit Bay through two small outfalls	-	$ 47.6 (1995 bids) all foreign bids
3.	Burhaniye (West Coast) 100,000 people in summer	A. S.	30/30	-	$ 45/person (1995)
4.	Eskisehir Municipality (300,000 people)	A. S.	(Degremont Design)	TL 1.8 million/person (1993-94)	$ 43/person (1993-94)

An average 1995 cost of US $ 40 per person works out to US $ 200 per m^3 sewage flow on the basis of 200 l/person/day.

APPENDIX VIII

PROJECT CONTACT LIST

The following organizations/people were contacted during the conduct of the study:

TOPRAK Paper Manuf. Co.
A. Osman Cort - Production Manager (Writing & printing paper dept.)
M. Serdar Savas - Production Chief

ECZACIBASI Yapi Gerecleri
Ertan Ozkan - Production Chief
A. Turan Gunes - Director

Eskisehir Sanayi Odasi, Organize Sanayi Bolgesi Mudurlugu
A. Ihsan Karamanli - Director

Municipality of Bozuyuk
Mehmet Talat Bakkalcioglu - Major

DSI at Eskisehir
Sedat Oktas - Director of the Quality Control Division
Miss E. Iyigun - Chemical Engineer

Health Department
Avni Karabulut - Director of Food And Environmental Health Control Division

Ministry Of Environment
Zeynep Yontem - Deputy General Director (Environ.Pollution Prevention and Control)
Sami Agirgun - Assistant General Director (Environ.l Pollution Prevention and Control)
Cetin Sucikaran - Province Director

General Directorate of Iller Bank
Ayhan Durusu - Deputy Head of Sewarage Department

Haliser/ Halifleks
Mustafa Asim Kocak - Storage Chief

SEREL Seramik ve Tic. A.S.
Etem Ozmen - Director of Quality Control

MARMARA Kagit ve Ambalaj San. Tic. Anonim Sirketi
Erdal Sukan - Director

TEKMAR Mermer-Granit San.
Turgut Ozen - Director

TRUVA Mermer
A. Halit Beseli - Architect

A one day workshop on the project was held on August 22, 1995 to present the methodology used in the study and preliminary results, and to elicit comments and suggestions from the workshop attendees. The following people attended this workshop:

Lutfi Cakir	Bilecik Organize Sanayi
Haldun Lutfullahoglu	Bilecik Organize Sanayi
Huseyin Basturk	Bilecik Health Department
Avni Karabulut	Bilecik Health Department
A. Ihsan Karamanli	Eskisehir Organize Sanayi
Birser Gunduz	DSI
Emine Iyigun	DSI
Zuleyha Kocbug	DSI
Muyesser Cevik	ECZACIBASI Artema
Celal Baltaci	ECZACIBASI Artema
Ismail Gaga	Ministry of Agriculture
Fazli Akyil	Haliser
Bayram Turkmen	Haliser
Tuncay Sagir	Eczacibasi Vitra
Mehmet Kilinc	DSI
Erdem Albek	Anadolu University
Hulya Mutlu	Ministry of Environment
Cetin Sucikaran	Ministry of Environment
Serap Kara	Anadolu University
Erdal Akatay	Citosan Seramic
Nevzat Kirag	Osmangazi University
I. Murat Turan	Osmangazi University
Hakan Yilmaz	Osmangazi University
Mizan Dogan	Osmangazi University
A. Mustafa Cabar	Arslan Aluminium
Zafer Orgut	Söğüt Seramik
Uygur Sendil	METU
M.W. Sendil	METU
Ahmet Binzat	Birlik Galvaniz
Rustem Guven	Marmara Kagit
Ibrahim Dus	Tekersan
Ismail Arslan	Serel Seramik
Kaya Vardarli	Serel Seramik
Edip Cankurt	Hisarlar Mak.
Teoman Giray	Tulomsas
Erol Demiroz	Tulomsas
Tomris Ertuin	Eskisehir Cimento Fab.