3.6 Structural and Non-Structural Measures

3.6.1 Water Supply Facility Plan

(1) Future Served Population

Water supply companies can serve almost 100 % of the population in the basin in the present, although the unit water use per capita per day is still low compared to the target plan.

Future population increase will create more water supply use. The future population in urban centers is expected to increase as follows:

Urban center	Increase in 1995 – 2015 (%)	Annual average (%)
Plovdiv	10	0.5
Pazardjik	20	1.0
Stara Zagora	10	0.5
Haskovo	15	0.75

Rural areas are expected to have an insignificant population growth.

By considering 100 % coverage, the served population in future can be summarized as follows:

WS company	Future served population (person)				
	present	2000	2005	2010	2015
Sofia	66,585	67,735	68,914	70,123	72,282
Plovdiv	734,167	747,285	760,735	774,524	798,832
Pazardjik	238,535	245,165	252,134	259,458	270,601
Smolian	38,811	39,218	39,636	40,064	41,026
Bratzigovo	12,182	12,309	12,439	12,572	12,873
Peshtera	22,787	23,292	23,810	24,341	25,206
Batak	7,530	7,643	7,758	7,877	8,102
Velingrad	43,649	44,306	44,980	45,670	46,977
Strara Zagora	265,681	270,555	275,553	280,677	289,617
Haskovo	267,841	275,114	282,664	290,502	302,489
Sliven	49,566	50,229	50,909	51,606	52,995
Total	1,747,334	1,782,852	1,819,532	1,857,413	1,921,000

(2) Future Water Demand

Future water demand is forecast based on the present unit water demand. The future water consumption is summarized below:

WS company	Present demand (m^3/y)	Future water demand (m^3/y)			
		2000	2005	2010	2015
Sofia	5,603,964	6,922,514	7,294,544	7,678,441	7,944,380
Plovdiv	68,222,400	70,917,368	73,582,065	76,329,321	79,161,857
Pazardjik	17,358,449	21,923,910	23,283,304	24,622,555	25,840,618
Smolian	2,824,318	3,507,110	3,660,205	3,802,120	3,917,710
Bratzigovo	799,685	853,616	885,333	917,765	950,935
Peshtera	1,658,235	1,827,846	1,894,554	1,954,567	2,043,691
Batak	494,306	530,030	552,211	575,027	598,501
Velingrad	3,176,385	3,476,916	3,579,032	3,667,325	3,808,825
Strara Zagora	31,309,167	25,675,708	26,652,853	27,660,675	28,700,186
Haskovo	17,582,378	24,602,086	26,102,628	27,568,610	28,885,711
Sliven	3,606,971	4,491,737	4,701,186	4,897,405	5,060,706
Total	152,636,259	164,728,841	172,187,915	179,673,812	186,913,119

(3) Potential of Water Sources

Water supply sources are the groundwater and the surface water, but the majority of water is the groundwater. It is found that the groundwater and the surface water potential are sufficient for all water supply systems in the basin.

The capacity of the existing facilities for groundwater and surface water utilization are compared to this water demand as follows:

Water sources (m^3/y)

Surface	Ground	Total
16,760,515	442,102,426	458,862,941

Future water demand (m^3/y)

2000	2005	2010	2015
164,728,841	172,187,915	179,673,812	186,913,119

It can be summarized that:

Master plan on water supply facilities:

- The existing facilities can produce sufficient water quantity for the future water demand in the basin until the target year 2015.
- The expansion or a new construction of water supply facilities is unnecessary.

(4) Water Supply Loss Reduction

The water supply loss in the basin is significantly high at 52 %. A water supply master plan is to focus on the improvement of this loss.

According to the design criteria as mentioned, the physical loss is to be reduced to 10 % and by considering the present condition, the reduction of administration loss to 10 % is proposed in this study, because the physical loss is to be reduced to 10% in the year 2015 according to the national policy on water supply. Therefore, the projection of water loss reduction is as follows:

Year	1995	2000	2005	2010	2015
Physical loss	32 %	27 %	21 %	16 %	10 %
Administration loss	20 %	18 %	15 %	13 %	10 %
Total loss (UFW)	52 %	45 %	36 %	29 %	20 %

Source : For physical loss, National Center for Regional Development and Housing Policy

(5) Improvement of the Unaccounted for Water (UFW)

1) Physical loss

The water supply master plan should focus at first on the leakage investigation in the urban and rural areas. Rehabilitation of the pipelines and the connections are considered as the main task to reduce this physical loss.

2) Administration loss

At present, the administration loss is expected to be 20% according to the water supply companies in the basin. The administration loss is considered as the losses from 1) Non-payment and 2) Inaccurate use of flat rate system and 3) Others including illegal connection, incorrect billing and inefficient direct collection of cash.

According to the target water loss reduction, a UFW improvement plan should consist of major items as follows:

- Renovation or rehabilitation of pipeline system;
- Installation of some more water meters;
- Replacement of inefficient water meters;
- Improvement of billing and collection system;
- Improvement of individual house connection;
- Enforcement or revision of penalty regulation;
- Revision of water tariff.

(6) Improvement of Water Quality

From the raw and the treated water quality as mentioned, the groundwater quality is generally good, although a high concentration of Ammonia, Nitrate and Nitrite are found along the river, a high concentration of Phosphate and Sulfate are found in SAZ major sub-basin and a slightly high concentration of Ferrous, Manganese, Calcium and Magnesium are found in almost the whole basin.

The wells with originally bad groundwater quality may make the treated water quality become higher than the drinking water standard. All these wells should be improved or relocated.

In addition, from a survey conducted by the JICA Study Team, the treated water was not acceptable for the users in the whole basin in contrast with the apparent treated water quality. The cause of this is attributed to the pipelines in the distribution system. Therefore, the improvement of pipelines is recommended.

Based on the groundwater data, following municipalities might have a potential of pollution of groundwater and the condition should be investigated in detail.

Class	Cities in Municipalities				
	Sofia	Plovdiv	Pazardjik	Haskovo	Stara Zagora
Class I		Plovdiv			Stara Zagora
Class II			Pazardjik	Haskovo, Dimitrovgrad	
Class III		Rakovski	Panagyurishte	Svilengrad	Radnevo, Galabovo
Class IV	Pirdop	Saedinenie, Parvomay	Belovo, Septemvri, Lessichevo	Harmanli, Simeonovgrad	Chirpan, Opan

It should be noted that the water supply source in Pirdop is surface water, not groundwater, and Dimitrovgrad water supply system belongs to the municipality, not Haskovo Water Supply Company.

Alternatives for the water quality improvement in the basin are proposed as follows:

- Improvement of the existing facilities;
- Treatment of the raw water by a municipal water supply treatment plant;
- Relocation of the groundwater sources;
- Conservation of the surface water;
- Protection of the groundwater sources from pollutants' intrusion;
- Rehabilitation of the pipelines including replacement of all of the asbestos pipes;
- Detailed investigation of the polluted groundwater sources and pipes.

In summary, the master plan for water supply should include non-structural and structural measures as follows:

Master plan for water supply:

1) Non-structural measures
    - The increase of the production of the existing facilities to meet the future water demand and to serve all population;
    - The investigation on the existing water supply facilities, the groundwater and surface water quality, the leakage, etc.;
    - The water loss reduction by the improvement of water supply administration;
    - The improvement of the water quality by water resources conservation.

2) Structural measures
    - The water loss reduction by the improvement of the physical loss;
    - The increase of the chemical dosing rate to improve treated water quality;
    - The rehabilitation of pipelines to increase the water quantity and to improve the water quality;
    - The relocation of the contaminated water sources to new cleaner sources;

- The change of some shallow wells to deep wells to avoid the pollutants from surface water.

(7) Project Cost Estimation

Project cost for the improvement works are roughly estimated as described below. However, detail investigation and study will be necessary to increase the accuracy of planning including cost estimation.

1) Chlorine dosing rate increase

Based on the assumption that the additional Chlorine dosing rate of 5 mg/l to remove the excess NH4 and the odor for the water demand in 2015 in the contaminated areas, improvement cost by a Chlorine dosing rate increase are roughly estimated as follows:

WS Company	Water Demand (m^3/d)	Improvement cost	
		US$/d	US$/year
Sofia	4,021	20	7,338
Plovdiv	159,050	795	290,266
Pazardjik	151,493	757	276,475
Haskovo	85,672	428	156,351
Dimitrovgrad	38,075	190	69,487
Stara Zagora	125,221	626	228,528
Total	563,533	2,818	1,028,448

This work should be done in the short-term plan (year 2001 – 2005) for all water supply companies.

2) Pipelines rehabilitation

Cost for replacement of asbestos pipes is roughly estimated as follows:

WS Company	Asbestos pipe (km)	Unit cost (US$/m)	Total cost (US$)
Sofia	243	15	3,645,000
Plovdiv	3,191	15	47,865,000
Pazardjik	1,432	15	21,480,000
Haskovo	1,063	15	15,945,000
Stara Zagora	1,716	15	25,740,000
Total	7,645		114,675,000

3) Relocation of contaminated groundwater sources

Detail investigation will be necessary to estimate the quantity and cost of relocating polluted groundwater wells.

(8) Phasing of Water Supply Improvement

The phasing of the master plan is divided into 4 parts, those are:

- Preparation period : year 1999 – 2000
- Short-term plan : year 2001 – 2005
- Medium term plan : year 2006 – 2010
- Long term plan : year 2011 – 2015

The phasing of water supply improvement is summarized as follows:

1) Preparation period : 1999 – 2000

- Investigation on the existing water supply facilities, the groundwater and surface water quality, the leakage, etc. for all water supply companies.

2) Short-term plan : 2001-2005

- Increase of the production capacity to meet the water demand until 2005 for all water supply companies;
- Monitoring of water supply quantity by the installation of water meters;

- Increase of the chemical dosing rate to improve the treated water quality for all municipalities with contaminated groundwater sources,
- Improvement of water loss : Physical loss to 27%
  Administration loss to 18%
- Replacement of the pipelines in Class I and II municipalities.

Summary of Rough Cost

a) Increase Chemical dosing = 1,028,000 US$/year

b) Replacement of pipelines (Class I and II) = 58,964,000 US$

Note : Classification of municipalities is as follows:

Class I : Plovdiv and Stara Zagora;

Class II : Pazardjik, Haskovo and Dimitrovgrad;

Class III : Nova Zagora, Panagyurishte, Radnevo, Peshtera, Svilengrad, Ihtiman, Rakovski, Assenovgrad, Stamboliyski, Harmanli, Galabovo and Hissarya;

Class IV : Simeonovgrad, Krichim, Sadovo, Saedinenie, Belovo and others.

3) Medium term plan : 2006-2010

- Increase of the production capacity to meet the water demand until 2010 for all water supply companies;
- Improvement of water loss : Physical loss to 16%
  Administration loss to 13%
- Replacement of the pipelines in Class III municipalities,
- Relocation of the contaminated wells in Class I and II municipalities,

Summary of Rough Cost

a) Replacement of pipelines (class III) = 20,141,000 US$/year

b) Relocation of wells (class I and II) = not estimated

4) Long term plan : 2011-2015

- Increase of the production capacity to meet the water demand until 2015 for all water supply companies;

- Improvement of water loss : Physical loss to 10%

  Administration loss to 10%
- Replacement of the pipelines in Class IV municipalities : The remaining municipalities in the basin,
- Relocation of the contaminated wells in class III and IV municipalities.

Summary of Rough Cost

a)	Replacement of pipelines (class IV)	=	35,570,000 US$/year
b)	Relocation of wells (class III and IV)	=	not estimated

3.6.2 Wastewater Treatment Facility Plan

(1) Review of the Municipal Wastewater Situation

<u>The original basic listing of 'towns'</u>

The municipal wastewater treatment systems planned within the River basin are those presented in the 'listing' of Table 3.6.1. This is essentially that of the 1989 Ministry of Construction's former 'Master-plan'. The priorities of the time may have been weighted on a regional basis, but the ministry's 5-year incremental budgets are updated and represented by the same political regions.

<u>The table of re-stated</u>

The original Table 3.6.1 listing has therefore been used as the basis of a summary restatement of the wastewater planning needs and priorities identified to date. This restatement is shown in Table 3.6.2 setting out some 'technical' references used when considering the Municipal Treatment Works planning priorities.

The Table also sets out for broad comparative purposes only, the potential impact of the respective propositions assuming: That the full 'PE' burden were collected and brought to the treatment works site; That treatment options would have:

1) A 30% mechanical BOD removal efficiency, assuming primary treatment only was applied;
2) An overall 90% BOD removal efficiency in the event full treatment was applied.

(2) Other Treatment Works (smaller works for villages etc.)

The Ministry plans of 1989 included a budget for some 24 smaller works in the Plovdiv and Haskovo area. Their planned sites were not defined in the data available to us. As reported, it is clear that some 600,000 persons living in the Maritza basin in smaller towns and villages with no organized sewage treatment plant.

From the population statistics, we gather:

1) In addition to the 'listed' towns, there are approximately 520 smaller sized towns and villages in the Maritza Basin accommodating some 620,000 persons; i.e. an average community population of 1192 persons;
2) Assuming 3.5 persons per household, we calculate that a typical community, averages about 340 households per village (although the 'median' village size is approximately 620: i.e.177 homes).

As far as we know, none of these are served with proper wastewater treatment; and few (if any) are served by a septic tank or equivalent system.

(3) Principal Criteria Applying in the First Stage 'Selection' Process

1) To have a high priority in the national & regional Planning;
2) Be a heavy discharger. Affecting/influencing quality of the discharge on the Main Stream River Maritza, and, by implication:
3) Have an effective impact in technical, socio-economic and environmental terms

(4) Prioritization of the Municipal Sewerage Collection & Treatment

Our prioritization of these listed towns is shown below. Staged for implementation in three groupings needed to meet a 15-year objective of the necessary river quality targets of Class I or Class II. Essentially the selection is 'catchment led' and based on the premise found that it is the Major Town Wastewater Treatment that is the Key to improving the surface water quality in the Maritza River Basin.

On the industrial side there is a clear 'hit list of some 10' industries to be targeted, but it is emphasized that:

1) It is by collecting and treating the Regular Municipal Effluent, that will achieve the main impact
2) The mere imposition of tougher industrial discharge controls (essential themselves) will go a long way but it is the Municipal treatment that is the vital key.
3) That, generally the sewerage collection/interception should be completed with the Treatment works as should 'full conventional treatment' (with nitrification). Mechanical treatment as a planned first stage seems to have insufficient an impact to meet the River improvement objectives.
4) It is in this way that the Bulk of the Maritza Urban Municipal Wastewater Burden can be intercepted and properly treated.

(5) Priority Project Wastewater Treatment Works Selection

We compiled the following list of First 'Priority Project Towns' where new or expanded Municipal Treatment Works are required: Assenovgrad, Dimitrovgrad, Haskovo, Pazardjik, Plovdiv, Stara Zagora, and Velingrad.

All of these will involve New Municipal Wastewater Treatment Works with the exception of Plovdiv. Some summary comments on the scope of the priority work and considerations at these locations are as follows:

1) Fast Tracking Action Needed

Up until now considerable delays have incurred in progressing Bulgarian wastewater projects since de-socialization. Funds for wastewater treatment projects are/have been available from such as Swiss Aid (slow implementation), the EBRD, the World Bank and (in the past 5 years) from the EC X-Border program. This project makes it possible to apply for yet further assistance.

To take advantage of these current funding opportunities, and set up a system whereby the funds can be used (as and when they remain available), a new fast-tracking mechanism is necessary.

2) At Stara Zagora, Dimitrovgrad and Haskovo

The wastewater systems at all 3 towns need urgent completion. These 3 towns are grouped together here because they are the 3 for which Bulgarian Committees have assumed funding will be allocated from the EC X-Border program. Some 11,000,000 ECU was available for a modest program if accepted by the Greeks & the Bulgarians.

The Haskovo Treatment Works has been partially built: This may well simplify matters and it should be possible to accelerate the work at this town. The need at Stara Zagora is especially urgent.

3) At Pazardjik

At Pazardjik the Treatment Works site is ready, previous work at the main site has 'prepared the way' but this stopped some time ago. The town collectors are designed and are partly complete.

4) At Velingrad

Velingrad is the center of a most important and relatively busy tourist town. The sewerage and wastewater treatment is of key economic and environmental importance. The town itself has some 90,000 beds occupied throughout the tourist season and nearby villages also attract business.

The main work to be undertaken here is that of a complete new feasibility study of the treatment needs and the existing sewers. This study so far has assumed that it will be economic to size the works at a PE level of around 180,000.

5) At Plovdiv

The Plovdiv Works are included on this 'first-priority' list mainly because it is one of the regional Key Towns. As such it contributes notably to the River Burden. This is no-doubt the reason why it was previously selected for the current Swiss Aid assistance.

As far as we can determine there may be a possibility that Further Treatment Capacity may be released/achievable at the present treatment works site if the sewerage quality was strengthened. At present the incoming Wastewater only averages some 91 mg/l of BOD, indicating the possibility of high levels of infiltration (Further study is urgently needed). In addition, the completion of the City collectors would notably improve the local river burden: Were the Northern Industrial Estate fed to the existing treatment works.

(6) Concept for the Facilities of Wastewater Treatment Plants

In this sub-section, a concept for the facilities of WWTP is discussed.

<u>Design flow rate of WWTP</u>

Main parameter for designing WWTP is the flow rate. The design flow rate is calculated by the following equation:

Design flow rate = (PE) × (unit flow rate per capita, 250 L/PE/day)

The unit flow rate per capita includes water consumption of household, commercial, public facilities, and recreation. Table 3.6.3 shows the design flow rate of the priority towns.

Selection of treatment method

There is many treatment methods and extension process. For this study, the following design conditions are used.

- The process is either primary or secondary treatment.
- The treatment method is only considered to well-developed one.
- Small treatment plants are considered to simple maintenance facilities.

Regarding above design condition, the treatment methods are classified by the flow rate.

Design Flow Rate	Treatment Method
> 15,000 m3/d	CAS (Conventional Activated Sludge System)
3,000 – 15,000 m3/d	OD (Oxidation Ditch system)
500 – 3,000 m3/d	PF (Percolating Filter System)
< 500 m3/d	Lagoon

The flow of CAS, OD, and PF are shown Fig 3.6.1

Facility layout plan

Fig 3.6.2 shows general layout of CAS, OD, and PF system. In order to extension process in the future, CAS method is kept enough space for nitrification/denitrification process.

(7) Wastewater Cost

The basis of our cost estimation approach was and data base was set out in section 3.8. In applying the costing data we found that the most applicable were the main collector costs data and the general Wastewater Treatment Cost Table Giving the unit cost ranges per 'PE' for 3 sizes of works.

In respect of the cost of the necessary collectors, we felt that the 'most authoritative' source of the financial needs was the original 1989 ministry data which was re-evaluated as Table 3.6.1. This data was therefore used as the basis and amended as appropriate following site visits and desk studies. It is however pointed out that the figures generated are only sufficient for the present Conceptual Budgetary Review. Further study and more detailed estimates, least cost solutions etc. are necessary on a town-by-town basis.

The estimated cost for wastewater treatment plants and necessary collectors are shown in Table 3.6.2 and Table 3.6.4.

In all cases:

- Treatment costs assume that standard conventional treatment will apply: The process priced by the above is that of an activated sludge plant but other process options should be considered at the more detailed planning stage.
- The discharge standard assumed is that which will apply when Bulgaria adopts the EC Urban Wastewater Directive.
- In our opinion none of these Municipal works could be regarded as discharging into 'sensitive' waters and hence it is quite unnecessary (and unaffordable) to treat to a higher standard. I.e. No nutrient removal measures are proposed.

For convenience, the following re-tabulates the first-stage budgetary costs in US$:

Town	Collectors	Full Treatment	Total
Assenovgrad	114,674	12,047,303	12,161,977
Dimitrovgrad	1,876,500	10,677,659	12,554,159
Haskovo	1,250,000	17,195,818	18,445,818
Pazardjik & Septemvri	5,854,000	19,923,835	25,777,835
Plovdiv	4,888,600	0	4,888,600
Stara Zagora	1,650,000	25,532,848	27,182,848
Velingrad	2,400,000	18,610,000	21,010,000
Totals	**18,063,774**	**103,987,463**	**122,021,237**

Notes:

The figures above include:

At Plovdiv, the current costs of the treatment works improvements & the North Collector and Sewering the remainder of the Town.

(8) Proposed Stage Program

Our proposed long-term program of the Wastewater Treatment Implementation requirements is set out with the other implementation recommendations in section 3.4.

TABLE 3.6.1 WASTEWATER INVESTMENT PLAN OF MARITZA RIVER BASIN IN 1989

(Costs updated in US $ 1000s)

LOCATION	New Sewers			New or Extended Treatment Works		
	1995	2000	2010	1995	2000	2010
Sofia Area						
1 Ihtiman	1,440				1,000	
2 Dolna Banya (Samokov)			720			2,000
3 Kostenetz	2,160			2,500	1,000	
4 Srednogorie		2,400			1,500	
Plovdiv area						
1 Belovo		4,800			2,000	1,000
2 Septemvri		1,440			2,500	7,500
3 Pazardjik	1,440	2,400	2,400	10,000	2,500	2,500
4 Parvomay			1,920			2,000
5 Plovdiv	3,600	3,600	3,360	5,000		5,000
6 Karlovo	240			3,000		
7 Sopot		1,680		1,000	1,000	
8 Streltcha			1,440			1,000
9 Panagiurishte			7,200		2,500	4,500
10 Hisaria		2,400	2,640		1,000	1,000
11 Assenovgrad		7,200		2,500	2,500	
12 Velingrad	2,400			4,000	1,000	8,000
13 Rakitovo			1,200		1,000	1,000
14 Peshtera		960		4,000	2,000	
15 Batak			1,200		1,000	1,000
16 Bratzigovo			960		1,000	1,000
17 Devin		2,400	1,200		1,000	1,000
18 Borino village		960			500	
19 Tchepelare			1,690			
20 Lucky			1,200			1,000
21 Perushtitza		720			500	750
22 Kritchim		1,680	2,400		500	750
23 Stamboliiski			1,200		1,000	1,000
24 Kaloyanovo village						1,000
25 2 modern waste water treatment facilities				1,000	500	1,000
Haskovo area						
1 Dimitrovgrad	1,200	1,200		7,500	1,500	
2 Harmanli			3,840			4,000
3 Radnevo						
4 Galabovo			7,200			3,500
5 Stara Zagora	720	720		7,500	5,000	7,500
6 Tchirpan			2,160		1,500	4,500
7 Simeonovgrad			6,000			1,500
8 4 modern waste water treatment facilities						500
9 Haskovo	720		720	2,500	5,000	12,500
1 StaroZagorski Bani				1,000		
Bourgas area						
1 Nova Zagora	3,360			1,000		
Totals in US$	21,800	37,800	74,450	52,500	41,000	82,000

TABLE 3.6.2 WASTEWATER TREATMENT SYSTEMS PRIORITIZATION RANKINGS FOR LISTED TOWNS

AREA	Initial Design P.E.s	River	Ranking Criteria								COSTS (US$)			IMPACT In terms of the BOD applied to the Watercourse			Total Project COSTS (US$)	
Town	Per Stated Criteria	Catchment	Ministry of Construction Programme of 1989 : New Wastewater Treatment, Modernisation & Extension			By Bulkgarian Water Laboratory Analysis (On a 5 point scale)	JICA Interim Report (Dec 1997) Municipal Treatment Works Priorities			Treatment Works Site Immediately Available	Main Collectors	Primary Treatment Only	SecondaryT reatment Only	BODs from the PE in the sewered area Kg. per day (56 g per PE)	BODs in Kg.per day Following Primary Treatment (@ 30% Removal Rate)	BODs in Kg per day Following Secondary Treatment (90% Removal Rate)	Collection & Primary Treatment	Collection and Secondary Treatment
			5 Year	10 Year	15 Year		5 Year	10 Year	15 Year									
Sofia Area																		
1 Ihtiman	42,000	TOP-2		x		A			x	Yes	1,440,000	-----	1,180,190	2,352	1,646	235	—	2,620,190
3 Kostenetz, (Town+Village)+Dolny Banya+Maritsa	19,152	MU 1 - 8 MU1 - 10	x	x						No	2,160,000	1,954,663	4,117,680	1,073	751	107	4,114,663	6,277,680
Plovdiv area																		
1 Belovo	9,036	MU1 - 3		x	x				x	No	4,800,000	943,666	1,987,920	506	354	51	5,743,666	6,787,920
3 Pazardjik & Septemvri	161,482	MU 2 - 2 MU1 - 2	x	x	x	A	x			Yes	5,854,000	9,189,185	19,923,835	9,043	6,330	904	15,043,185	25,777,835
4 Parvomay	36,000	MM2 - 13			x	B		x		No	192,000	3,041,878	6,408,000	2,016	1,411	202	3,233,878	6,600,000
7 Sopot & Karlovo	70,308	STR - 3	x	x		B				No	2,500,000	4,654,054	9,804,200	3,937	2,756	394	7,154,054	12,304,200
8 Streltcha	9,108	LUD - 3			x	D				No	1,400,000	951,185	2,003,760	510	357	51	2,351,185	3,403,760
9 Panagiurishte	181,000	LUD - 2		x	x	B		x		Yes	400,000	3,137,948	6,202,579	10,136	7,095	1,014	3,537,948	6,602,579
10 Hisaria	30,000	STR - 1		x	x	A				No	0	2,705,790	5,700,000	1,680	1,176	168	2,705,790	5,700,000
11 Assenovgrad	95,562	CPE - 1	x	x		A	x			No	114,674	5,598,452	12,047,303	5,351	3,746	535	5,713,127	12,161,977
12 Velingrad+Rakitovo+Dorkovo+Constantovo	181,000	CPI - 3	x	x	x	A			x	No	2,400,000	8,583,241	18,610,036	10,136	7,095	1,014	10,983,241	21,010,036
14 Peshtera	11,504	STA	x	x		A			x	-	960,000	—	—	644	451	64	—	—
15 Batak	8,046	STA		x	x	C				No	120,000	847,915	1,786,212	451	315	45	967,915	1,906,212
16 Bratzigovo	9,000	STA		x	x	C				No	960,000	939,906	1,980,000	504	353	50	1,899,906	2,940,000
17 Devin	11,054	VAC - 4		x	x	A				No	3,600,000	1,101,043	2,319,450	619	433	62	4,701,043	5,919,450
18 Borino - village	5,202	VAC - 3		x		B				No	960,000			291	204	29	—	—
19 Tchepelare	11,268	CPE - 3			x	C				No	1,690,000	1,123,273	2,365,280	631	442	63	2,813,273	4,056,280
20 Lucky	6,228	CPE - 2			x					No	1,200,000	739,108	1,557,000	349	244	35	1,939,108	2,757,000
21 Perushtitza	10,080	VAC - 1		x	x	C				No	720,000	474,700	1,000,000	564	395	56	1,194,700	1,720,000
22 Kritchim	15,770	VAC - 1		x	x	C			x	No	2,400,000	1,631,952	3,437,860	883	618	88	4,031,952	5,837,860
23 Stamboliiski	25,200	MM1 - 12		x	x	B		x		No	1,200,000	2,213,051	4,662,000	1,411	988	141	3,413,051	5,862,000
24 Kaloyanovo - village	5,062	MM1 - 2			x	B				No				283	198	28		
25 20 packaged waste water treatment facilities			x	x	x					No								
Haskovo area																		
1 Dimitrovgrad	91,000	MM3-4	x	x		A	x			Yes	1,867,500	5,098,181	10,677,659	5,096	3,567	510	6,965,681	12,545,159
2 Harmanli	38,430	HAR- 1			x	B				No	3,840,000	3,192,476	6,725,250	2,152	1,506	215	7,032,476	10,565,250
3 Radnevo	27,000	SA2 - 6		x		R		x		Yes	0	2,435,211	5,130,000	1,512	1,058	151	2,435,211	5,130,000
4 Galabovo	17,100	SA2 - 4			x	C		x		No	7,200,000	1,688,413	3,556,800	958	670	96	8,888,413	10,756,800
5 Stara Zagora	270,000	SA2 - 7	x	x	x	A	x			No	1,650,000	12,061,699	25,532,846	15.120	10,584	1,512	13,711,699	27,182,846
6 Tchirpan	35,460	MM2 - 13		x	x	B	x			No	2,160,000	3,029,915	6,382,800	1,986	1,390	199	5,188,915	8,542,800
7 Simeonovgrad	14,940	MM3 - 1			x	C				No	6,000,000	1,560,244	3,286,800	837	586	84	7,560,244	9,286,800
8 4 module waste water treatment facilities					x					No								
9 Haskovo	150,000	HAR - 2	x	x	x	A	x			Yes	1,250,000	8,055,369	17,195,818	8,400	5,880	840	9,305,369	18,445,818
Bourgas area																		
1 Nova Zagora	--------	SA2 - 6	x	-	-	R		x		No	3,360,000		2,900,000	..			—	6,260,000

TABLE 3.6.3 DESIGN FLOWRATE AND TREATMENT PROCESS OF WWTP FOR THE PRIORITY TOWNS

River Basin		Catchment	Town	Present Pop	Future Pop	PE	Priority Order 1st	Priority Order 2nd	Priority Order 3rd	WWTP Design Flowrate *1 (m^3/day)	Wastewater Treatment Process *2
Maritza	Up-stream	MU2-2	Pazardjik /Septembvri	90,286	108,343	194,000	X			48,500	C.A.S
Maritza	Up-stream	MM1-9	Plovdiv	344,336	378,770	—	X			—	—
Maritza	Up-stream	CPE-1	Assenovgrad	52,360	57,596	115,000	X			28,800	C.A.S
Maritza	Up-stream	MM1-12	Stamboliiski	13,155	14,471	30,000		X		7,500	O.D
Maritza	Up-stream	MM1-2	Kaloyanovo - Village	2,812	3,374	6,000			X	1,500	P.F
Maritza	Up-stream	STA	Peshtera	18,900	20,790	—			X	—	—
Maritza	Up-stream	STA	Batak	4,468	4,915	10,000			X	2,500	P.F
Maritza	Up-stream	STA	Bratzigovo	5,022	5,524	11,000			X	2,800	P.F
Maritza	Mid-stream	MM3-9	Dimitrovgrad	50,977	61,172	109,000	X			27,300	C.A.S
Maritza	Mid-stream	MM2-15	Sadovo	2,647	2,912	—		X		—	—
Maritza	Mid-stream	MM2-13	Parvomai	16,690	18,359	41,000		X		10,300	O.D
Maritza	Mid-stream	MM2-1	Chirpan	19,694	23,633	43,000		X		10,800	O.D
Maritza	Mid-stream	MM3-1	Simeonovgrad	8,265	9,918	18,000			X	4,500	O.D
Maritza	Down-stream	HAR-2	Haskovo	80,959	89,055	165,000	X			41,300	C.A.S
Maritza	Down-stream	HAR-1	Harmanly	21,559	26,949	48,000		X		12,000	O.D
Sazliyka		SAZ-7	Stara Zagora	149,666	164,633	297,000	X			74,300	C.A.S
Sazliyka		SAZ-6	Radnevo	14,203	17,044	32,000		X		8,000	O.D
Sazliyka		SAZ-4	Galabovo	9,473	11,368	21,000		X		5,300	O.D
Sazliyka		SAZ-6	Nova Zagora	26,658	29,324	—			X	—	—
Other than Prioritized Region		CPE-2	Lukki	3,437	3,781	7,000			X	1,800	P.F
Other than Prioritized Region		CPE-3	Chepelare	6,085	6,694	14,000			X	3,500	P.F
Other than Prioritized Region		CPI-2	Rakitovo	8,672	9,539	—			X	—	—
Other than Prioritized Region		LUD-3	Streltcha	5,063	5,569	11,000			X	2,800	P.F
Other than Prioritized Region		MU1-3	Belovo	5,016	5,518	—			X	—	—
Other than Prioritized Region		MU1-8 /MU1-10	Kostinetz /Dolna Banya	15,667	19,584	24,000			X	6,000	O.D
Other than Prioritized Region		STR-3	Sopot/Karlovo	39,065	42,972	84,000			X	21,000	C.A.S
Other than Prioritized Region		TOP-2	Ihitman	12,860	14,146	—			X	—	—
Other than Prioritized Region		VAC-1	Perushtitza	5,535	6,089	12,000			X	3,000	P.F
Other than Prioritized Region		VAC-1	Kritchin	8,875	9,763	19,000			X	4,800	O.D
Other than Prioritized Region		VAC-3	Borino - Village	2,884	3,172	6,000			X	1,500	P.F
Other than Prioritized Region		VAC-4	Devin	6,141	6,755	13,000			X	3,300	P.F
Other than Prioritized Region			20 Packed Wastewater			—			X	—	—
Other than Prioritized Region			4 Module wastewater treatment facilities			—			X	—	—
Other		CPI-3	Velingrad	50,000	55,000	181,000	X			45,300	C.A.S
Other		STR-1	Hissarya	8,959	9,855	35,000		X		8,800	O.D
Other		LUD-2	Panagjurishte	20,944	23,038	42,000		X		10,500	O.D
Other		TOP-3	Pirdop/Zlatiza	14,008	15,409	—		X		—	—

*1 average design flow of 250 L/PE・day

*2 The treatment process is determined by the design flowrate

15,000m^3/d<flowrate	C.A.S:conventional activated sludge system
3,000m^3/d<flowrate<15,000m^3/d	O.D :oxidation ditch system
flowrate<3,000m^3/d	P.F :percolating filter system

TABLE 3.6.4 BUDGET ESTIMATES FOR WASTEWATER COLLECTION AND TREATMENT AT THE MAIN TOWNS

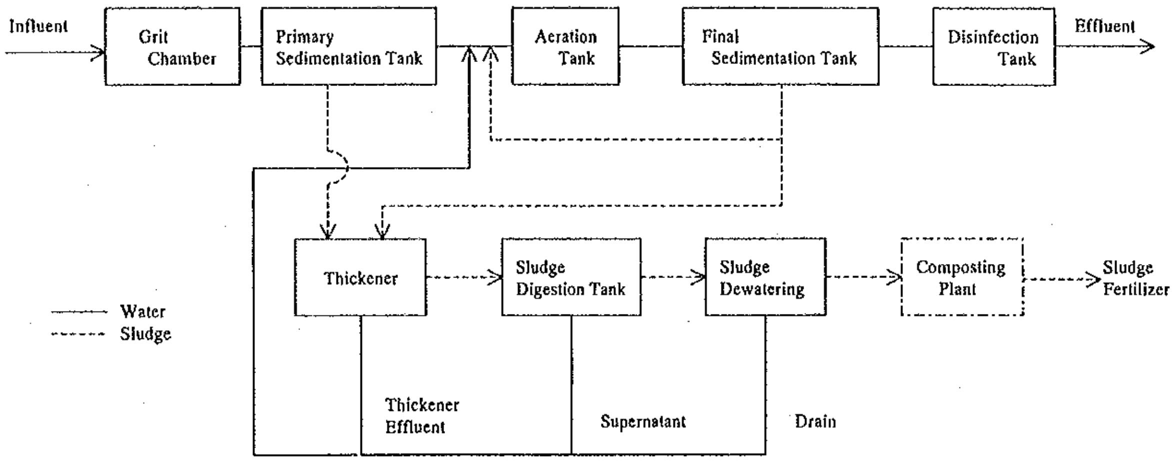
ITEM	Assenovgrad		Dimitrograd		Haskovo		Panagiuriste		Pazardjic & Septembrevi		Stara Zagora		Velingrad+Rakitovo+ Dorkovo+Constantovo	
	PRIMARY	PRIMARY & SECONDARY	PRIMARY	PRIMARY & SECONDARY	PRIMARY	PRIMARY & SECONDARY	PRIMARY	PRIMARY & SECONDARY	PRIMARY	PRIMARY & SECONDARY	PRIMARY	PRIMARY & SECONDARY	PRIMARY	PRIMARY & SECONDARY
UNIT RATES (US$ PER PE) FOR:														
Raw WW Pumping	1.2	1.2	0.88	0.88	1.2	1.2	1.2	1.2			1.00	1.00		
Screening	4.29	4.29	4.29	4.29	4.29	4.29	5.10	5.10	4.29	4.29	2.01	2.01	4.29	4.29
Grit removal	1.93	1.93	1.93	1.93	1.93	1.93	3.20	3.20	1.93	1.93	1.72	1.72	1.93	1.93
Primary sedimentation	1.51	1.51	1.34	1.34	1.51	1.51	2.40	2.40	1.51	1.51	1.20	1.20	1.51	1.51
Activated sludge		22.02		19.82		22.02		26.40		22.02		17.30		22.02
Final Clarification		4.52		4.07		3.80		7.10		3.80		3.90		3.80
Return Sludge		0.92		0.92		0.92		3.40		0.92		0.50		0.92
Interconnecting services	2.00	3.76	2.00	3.76	2.00	3.76	2.00	6.30	2.00	3.76	1.40	4.50	2.00	3.76
Admin Building	1.64	1.64	1.30	1.30	1.64	1.64	3.80	3.80	1.64	1.64	1.10	1.10	1.64	1.64
Roads & Landscaping	0.30	0.68	0.30	0.68	0.30	0.68	0.50	1.80	0.30	0.68	0.40	1.20	0.30	0.68
Electrical services	9.00	13.98	9.00	13.98	9.00	13.98	13.00	18.40	9.00	13.98	8.00	12.60	9.00	13.98
Sludge Stabilisation	16.00	23.76	15.00	21.00	16.00	23.76	27.00	32.80	16.00	23.76	15.00	18.90	16.00	23.76
Others	4.00	9.89	4.00	9.89	4.00	9.89	6.00	15.00	4.00	9.89	3.00	7.80	4.00	9.89
General items (10%)	4.19	9.01	4.00	8.39	4.19	8.94	6.42	12.69	4.07	8.82	3.48	7.37	4.07	8.82
Sub Total	46.06	99.11	44.04	92.25	46.06	98.32	70.62	139.59	44.74	97.00	38.31	81.10	44.74	97.00
Fees 6%	2.76	5.95	2.64	5.53	2.76	5.90	4.24	8.38	2.68	5.82	2.30	4.87	2.68	5.82
Total $ per PE	48.82	105.06	46.69	97.78	48.82	104.22	74.86	147.97	47.42	102.82	40.61	85.97	47.42	102.82

Population Equivalent	114,674		109,200		165,000		41,919		193,778		297,000		181,000	
Treatment Works Costs	5,598,452	12,047,303	5,098,181	10,677,659	8,055,369	17,195,818	3,137,948	6,202,579	9,189,185	19,923,835	12,061,699	25,532,846	8,583,241	18,610,036
Primary Collector Costs	7,200,000	7,200,000	1,867,500	1,867,500	1,250,000	1,250,000	400,000	400,000	5,854,000	5,854,000	1,650,000	1,650,000	2,400,000	2,400,000
Planning Budget (US $)	**12,798,452**	**19,247,303**	**6,965,681**	**12,545,159**	**9,305,369**	**18,445,818**	**3,537,948**	**6,602,579**	**15,043,185**	**25,777,835**	**13,711,699**	**27,182,846**	**10,983,241**	**21,010,036**

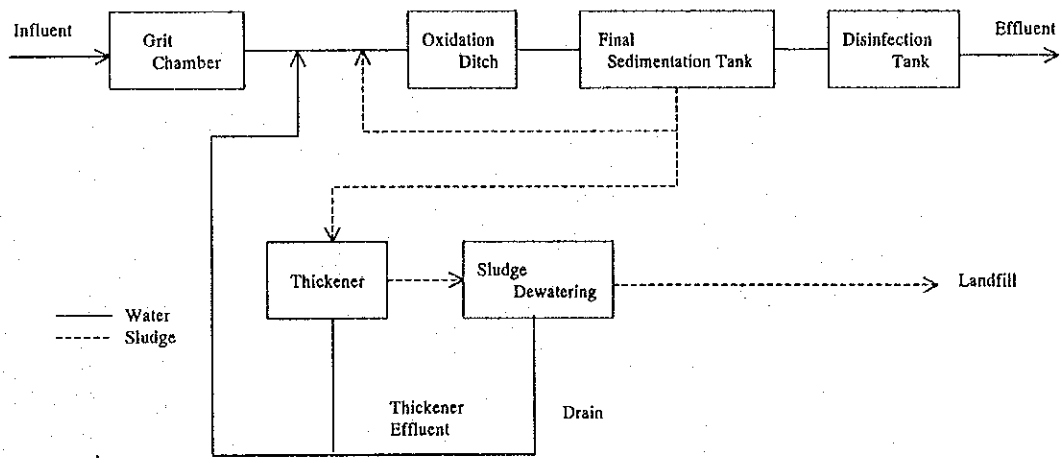
Budget costs:

Exclude land costs, site access roadways and external services such as power feeders, water services etc.
Include allowances for the main wastewater collectors from the respective centres of Municipal Development
Exclude Geotechnical Site investigations

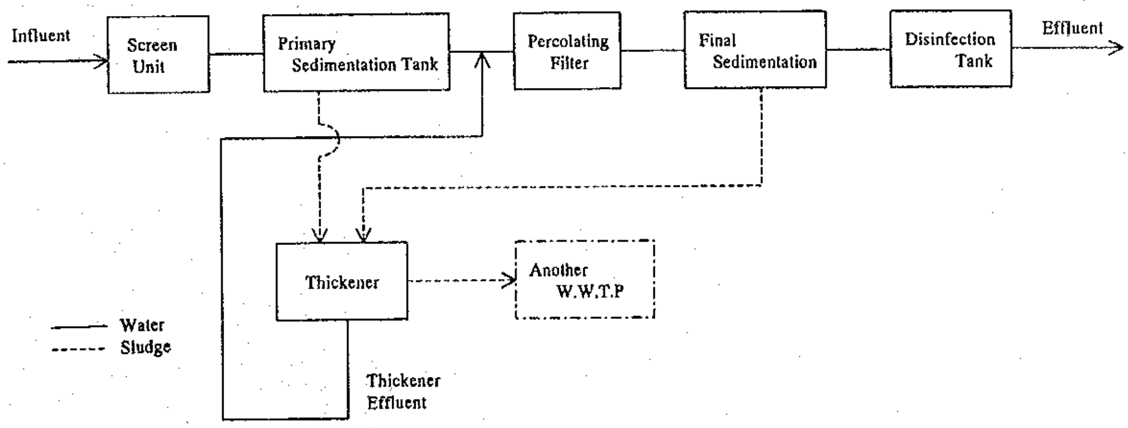
Assume 'standard tender & construction site conditions' & typical prices @ international rates but after adjustment for Bulgarian conditions.



Conventional Activated Sludge System



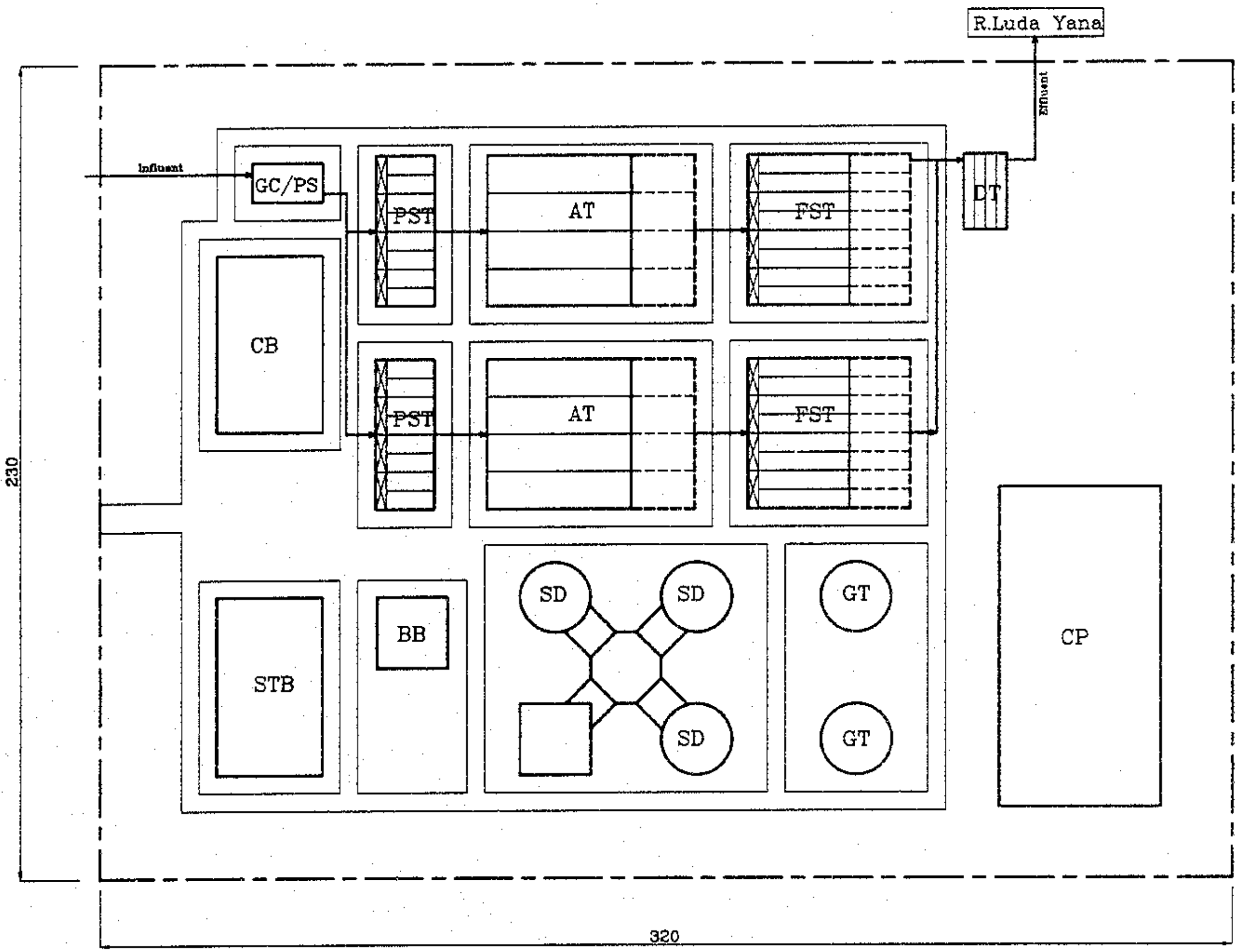
Oxidation Ditch System



Percolating Filter System

FIG.3.6.1 FLOW OF TREATMENT SYSTEMS

Town:Pazardjik/Septembvri
PE:194,000
Flowrate:48,500m³/day



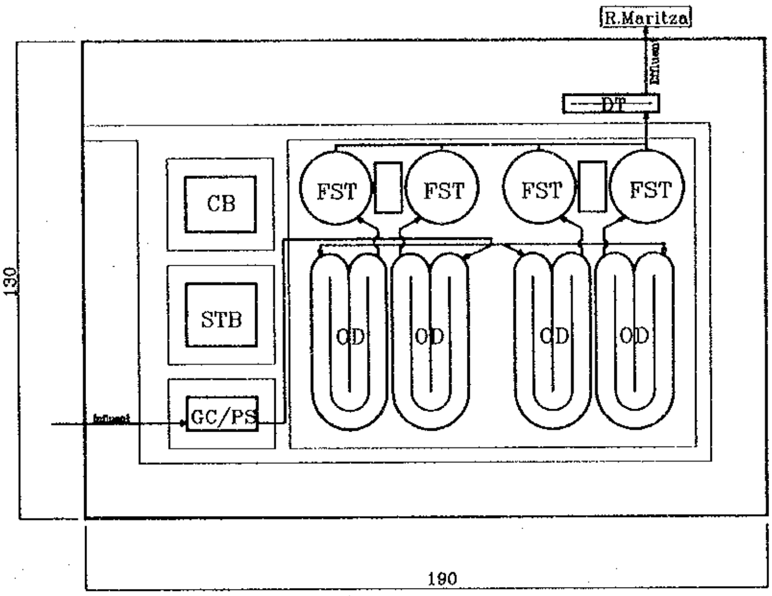
LEGEND

G C:Grit Chamber
P S:Pomp Station
PST:Primary Sedimentaition Tank
A T:Aeration Tank
FST:Final Sedimentaition Tank
D T:Disinfection Tank
C B:Control Building
STB:Sludge Treatment Building
B B:Blower Building
C P:Composting
——:Futuer Expansion

Conventional Activated Sludge System

FIG.3.6.2 LAYOUT OF TREATMENT PLANTS (1)

Town:Parvomai
PE:41,000
Flowrate:9,300m³/day

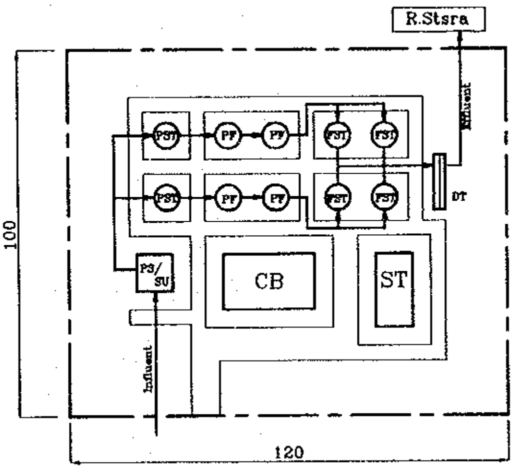


LEGEND

G C:Grit Chamber
P S:Pomp Station
O D:Oxidaition Ditch
FST:Final Sedimention Tank
D T:Disinfection Tank
C B:Control Building
STB:Sludge Treatment Building

Oxidation Ditch System

Town:Batak
PE:10,000
Flowrate:2,500m³/day



LEGEND

P S:Pomp Station
S U:Screen Unit
PST:Praimary Sedimentation Tank
P F:Percolating Filter
FST:Final Sedimentaition Tank
D T:Disinfection Tank
C B:Control Building
S T:Sludge Thickener

Percolating Filter System

FIG.3.6.2 LAYOUT OF TREATMENT PLANTS (2)

3.7
INSTITUTIONAL STRUCTURE PLAN

3.7 Institutional Structure Plan

3.7.1 Background

Bulgaria announced its intention to join the European Community in 1991 and Parliament ratified it in 1993. The main political endeavors of the Government are to ensure that Bulgaria meets EC accession criteria in all economic and social fields as set out in the Government Program Bulgaria 2001. The Government has taken energetic steps in adopting environmental legislation in line with EC requirements and reform of the water resource management sector. A major reform in the water resources management sector in Bulgaria will be introduced by the new Water Act. According to a draft of the new Water Act MoEW shall establish the necessary river basin organization, funds and proposes concession defined in this act at a basin level as follows:

- North West Region - centered at Vratza, covering the water catchment territory of the Iskal river and within the national boundaries - the rivers to the west of it,
- Southwest region - centered at Balgoevgrad covering the water catchment areas of the Mesta and Struma rivers,
- Central Northern Region - centerd in Pleven covering the water catchment areas of the Vit, Ossam, Yantra and Russenski Lom rivers,
- Central Southern Region - centered in Plovdiv covering the water catchment areas of the Maritza, Tundja and Arda rivers,
- Northeast Region - centered in Vratza covering the water catchment areas of the rivers in the Dobrudja, Ludogorie rivers and the rivers flowing into the Black Sea from Cape Emine to the north boarder including the internal marine water and territorial aquatory,
- Souteast Region - centered in Burgas including the rivers flowing into the Black Sea from Cape Emine to the southern border including internal marine waters and territorial aquatory,

The River Basin Organizations are legal persons and incorporate:

- A Basin Agency,
- A Basin Council.

The River Basin Agency is to:

- Elaborate river basin management plans,
- Issue permit for water use of waters and water objects and for discharge into the respective water bodies,
- Control compliance with the requirements and conditions of the permits issued and granted concessions in the territory of the respective basins,
- Maintain the water and water economy register and the registers of the issued permits,
- Collect permit taxes issued by them,
- Manage and operate the water economy facilities and systems,
- Carry out technical activities in relation to water quality and quantity control in the water objects which are public government property,
- Supervise the status of the water economy systems and facilities issue recommendations and control compliance with them.

The River Basin Council shall comprise of representatives from the followings:

- Ministry of Environment and Waters/River Basin Agency,
- Ministry of Regional Development and Urbanization,
- Ministry of Agriculture, Forest and Agrarian Reform,
- Ministry of Public Health,
- Mayors of major towns and settlements,
- the water users,
- NGO,

- District administration,

The Basin Council shall cooperate with the River Basin Agency in implementing the National Water Economy Plan, which shall be prepared by MoEW and approved by Parliament.

3.7.2 Structure Plan for the Maritza River

(1) Managing Organization

A River Basin Agency and a River Basin Council shall be established under the MoEW for the Maritza river basin due to the new Water Act. In order to perform successfully their functions as a river basin management organization, the River Basin Agency shall require setting up the followings:

- A comprehensive decision support system based on information collection system with a database, monitoring systems and assessment tools,
- Facilities to monitor water quality, quantity and hydrological conditions,
- A training program for required staff for the River Basin Agency.

(2) Establishment of a Project Implementation Unit

The actual situation regarding the implementation of large-scale projects in the environmental field may be characterized by a few important facts. The country has:

- Only limited experience in the reform towards a market economy;
- Limited experience in the economic management & allocation of public goods especially water resources;
- Limited experience in project implementation under international and national

competitive bidding procedures.

For this particular reasons it is necessary to establish a Project Implementation Unit (PIU) for the implementation and execution of the identified projects, including structural and non-structural measures.

The basic functions of the PIU should be:

- To act as a focal point for implementation of Maritza river basin projects.
- To act liaison with the Ministry of Environment and Waters and the Ministry of Regional Development and Public Works, other government agencies, local authorities, and the Maritza River Basin Management Organization during the project implementation phases.
- To act as liaison between the Basin Managing Organization and international funding agencies, which will fund the identified structural and non-structural measures.
- To assist and carry out the procurement of necessary goods and services.

(3) Technical Assistance for Setting up the River Basin Management Organization

In its reform process, Bulgaria experiences an acute necessity of relevant trained experts in integrated management of the river basin. For this reason, technical assistance is required.

The form of the technical assistance may vary from a number of short term assignments by various international experts to one long term assignment of an international expert in the River Basin Management Organization. For optimal use of external expertise the following provisions should be made:

- Definition of the responsibilities of the expert in the management body of the River Basin Management Organization and its decision making process.

- Provision of technical assistance should be given enough authority and possibility to assume responsibility for the start up activity,
- Solution of different problems, which are expected to be experienced countrywide, be applied to the other river basin councils thus reproducing and multiplying the effects of the exercise.

(4) Required Training Program for Local Experts

The professional experience of almost two thirds of the water management experts within MoEW and affiliated structures was accumulated under the central planned economy in Bulgaria, in respective sector ministries. There is a lack of experience for applying an integrated environmental management approach. The requirements may be described as short term and long term solutions:

- The short term training demand arises from the fact that the River Basin Councils will require expertise which is not to be found in the current situation
- The long term training demand is due to the fact that the principles, theory and practice of integrated management of water resources are not covered by current study courses.

MoEW shall prepare:

- New procedures for the operation of the River Basin Agency and the Regional Inspectorates for Environment and Water,
- Establish an integrated monitoring system,
- Develop and maintain the database to support decision making and an integrated approach to the management of water resources and environment;

(5) Project Implementation

Upon acceptance of the feasibility study the further project related activities could be summarized as follows:

- Negotiations with financial agencies concerning investment participation;
- Elaboration of design and tender documents for priority projects;
- Pre-qualification and short listing of contractors;
- Invitation of submission of bids;
- Evaluation of the bidder's offers;
- Negotiations and contract award;
- Construction work and related supervision of construction work.

3.8

PROJECT COST

3.8 Project Cost

3.8.1 Cost Models

Cost models were developed for following items:

- Sewers
- Pumping stations
- Wastewater treatment works (and their elements)
- Operation & maintenance Costs

(1) Basis for the Cost Model

Basis for the cost model is summarized (in brief);

Exchange Rate Applied: The Bulgarian Leva exchange rate has just stabilized following a period of excessive inflation (some 1000% since 1990).

The rate used sets the data base at late 1997 prices, and are based on:

1 US$ = 114 J Yen = 1730 Leva

We note wide variation in Bulgarian Construction Industry prices:

The recent transition in the economy has been so deep and dramatic that there is insufficient historical cost data in respect of major infrastructure projects completed to 'international standard'. Accordingly we have used cost models based on similar works elsewhere in Eastern Europe (East Germany, Poland & Hungary).

The target of the work of setting up the base models was to facilitate broad-brush preliminary budgets to be arrived at for general planning purposes and to target a capability of 20% accuracy for a feasibility study (e.g. For a Priority project).

Capital Costs included allowances for all estimated costs to completion based on similar projects with inclusion for such as Implementation administration costs, performance bonding, & 'guarantee' costs, meeting the quality standards typically demanded of internationally funded public works. Costs adjusted for the current Bulgarian labor market and accessing, as far as possible Bulgarian resources and using modern plant and construction techniques.

The respective economic parameters associated with the figures are :

- Civil works: Annually 0.2 % of Capital Cost
- Electro-mechanical plant: Annually 5 % of Capital Costs
- Insurance costs: Annually 0.1% of Capital Costs
- Life of treatment plant: 20 Years
- Life of pumping plant: 20 Years
- Life of chemical plant: 15 Years
- Live of vehicles: 7 Years

(2) Model Structure

The wastewater systems model has been structured to enable the JICA team to use the model to broadly appraise the costs of:

- Urban wastewater reticulation
- Individual (trunk) sewers & collectors
- Pumping stations
- Wastewater treatment works developments, constructed in stages or in total

- Elements of treatment installations, tanks etc. to allow for appraisal of special cases and any particular industrial treatment need
- Operational equipment (e.g., Sludge disposal equipment.)
- Operation & maintenance costs
- Local construction and imported 'plant'

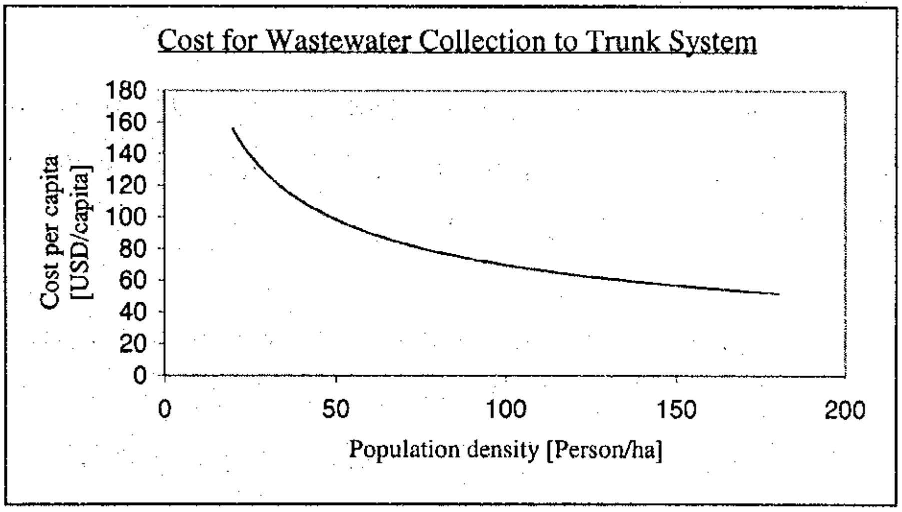
(3) Budgetary Municipal Costs

Sewers

Individual sewer runs/rising mains budgetary unit rates at 'average' depth:
Based on a comparison of Unit Rates from Poland and Hungry, tempered by some individual Bulgarian figures the following table has been derived for circular sewers.

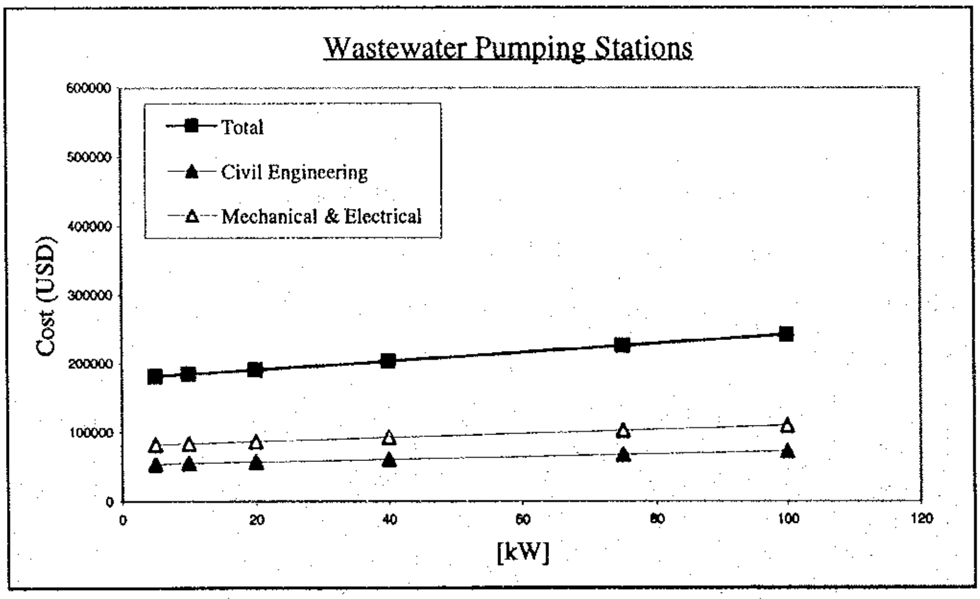
Dia. mm	US $ per m.	Dia. mm	US $ per m.	Dia. mm	US $ per m.	Dia. mm	US $ per m.	Dia. mm	US $ per m.
150	58	500	147	900	293	1500	655	2100	1141
200	74	600	162	1000	309	1600	662	2200	1229
300	88	700	218	1100	430	1700	717	2400	1472
400	110	800	250	1200	552	1800	773		

North-eastern European Rates adopted for EC PHARE equate to the following:



Pumping Stations

Pumping stations are modeled as follows in terms of Civil Works & Installed Power. This will enable the chart to be used for budgetary appraisal of staged costs. The original reference base for this chart is based on 5 detailed cost examples. The points plotted show a close 'fit'.



Wastewater Treatment Works

Recent 'all-in' Wastewater Treatment Plant cost models for smaller wastewater treatment plants are available and are reasonably reliable. These have been used (adjusted for local conditions) in the following graphic models.

For the larger treatment works built on 'green field sites, the most reliable data base has been constructed in tabular form from a model for German Wastewater treatment plants heavily influenced by the recent intensive wastewater treatment program in East Germany.

This latter cost tabulation, adjusted for Bulgaria, is tabulated below with separate mention of the base contract costs, cost ranges etc., to enable the table to be used for adjusting estimated for the 'non-Standard 'situation'.

The following Cost model tabulation gives net costs in US$ per PE (population Equivalent):

Costs are exclusive of land costs, power supply and other services to the site, access roadways, inlet pumping, sludge treatment & the wastewater outfall aqueduct.

	10,000 PE US $ Range		100,000 PE US $ Range		500,000 PE US $ Range	
Screening	6.44	6.44	4.29	4.29	1.07	1.07
Grit Removal	4.83	4.83	1.93	1.93	1.61	1.61
Primary Sedimentation	3.01	3.01	1.51	1.51	0.75	0.75
Activated Sludge	33.04	33.04	22.02	22.02	13.22	13.22
Final Clarification	10.85	10.85	4.52	4.52	3.62	3.62
Return Sludge Pumping	4.59	4.59	0.92	0.92	0.37	0.37
P-Precipitation	5.27	5.27	1.35	1.35	0.72	0.72
Interconnecting Services	5.27	12.05	3.76	7.53	2.71	6.03
Administration Buildings	5.47	5.47	1.64	1.64	0.55	0.55
Roads & Landscaping	0.85	3.73	0.68	2.97	0.51	1.69
Electric Serv. & Controls	25.63	51.25	13.98	25.63	9.32	13.98
Sludge Stabilization	42.11	42.10	23.76	23.76	15.12	15.12
Others	18.38	36.76	9.89	18.38	6.69	9.89
General Items	12.21	16.02	6.58	8.52	4.06	5.03
Sub-Total	177.96	235.41	96.84	124.98	60.32	73.65
Engineering Etc.	6%	6%	6%	6%	5%	5%
Totals	188.64	249.53	102.66	132.48	63.34	77.33
Median Total (US $ / PE)	219.09		117.57		70.33	

Smaller Wastewater Treatment Works

Costs of recent smaller municipal wastewater treatment plants have been modeled as a series of cost curves in Fig. 3.8.1. The 'points' marked on the curves themselves are those upon which a statistic was available for analysis in the original instance.

For flexibility, and to enable probable 'foreign' and 'local' budgets to be arrived at, the cost of civil works and the treatment 'plant' have been separated.

Sludge Works

Costs of sludge treatment works are similarly set out in the curves of Fig. 3.8.2.

Extended Treatment

In the event that 'nutrient removal' is planned, initially or as a future planning option / financial contingency, Fig. 3.8.3 shows costs generated for this or separate upgrading an existing works.

Running Costs

For running costs we propose to use the World Bank Model prepared for use in Central Europe. This is reproduced in Table 3.8.1.

3.8.2 Project Cost

The project costs of this study are summarized as follows;.

		Costs (US$ 1000)
1)	Construction of municipal wastewater treatment plants (refer to Table 3.8.2)	
	- 1st Stage towns	122,021
	- 2nd Stage towns	36,437
	- 3rd Stage towns	55,272
	Total cost for WWTP	213,730
2)	Rehabilitation of water supply systems	
	- 1st Stage water supply systems	64,104
	- 2nd Stage water supply systems	20,141
	- 3rd Stage water supply systems	35,570
	Total cost for WS systems	119,815
3)	Strengthening of meteo-hydrological monitoring networks	360
	Grand total	333,905

Above cost will be checked again and revised, if necessary, in the next study stage in Bulgaria.

TABLE 3.8.1 TREATMENT PLANT EFFICIENCIES AND OPERATIONAL COSTS

	WASTEWATER TREATMENT EFFICIENCIES AND COST									SLUDGE TREATMENT COSTS			
	BOD5		SS		Tot P		Tot N		Total costs	SP	Dewatering	Anaerobic Stab. +	Dewatering +
	%	g/m3	%	g/m3	%	g/m3	%	g/m3	US $/m3	g Ds/m3	US $/m3	US $/m3	US $/m3
RAW(WWTP influent)	0	250	0	250	0	12	0	48			0.192 US $/kg	0.267 US $/kg	0.509 US $/kg
1.MECHANICAL	30	175	60	100	15	10	15	40	0.16	125	0.02	0.03	0.06
2.CHEMICAL													
a.High load	50	125	80	50	70	3.6	25	36	0.19	250	0.05	0.07	0.13
b.Low load	70	75	90	25	90	1.2	30	34	0.22	350	0.07	0.09	0.18
3.BIOLOGICAL													
a.High load	70	75	80	50	30	8.4	25	36	0.23	185	0.04	0.05	0.09
b.Low load	~90	20	90	25	30	8.4	30	34	0.26	205	0.04	0.05	0.1
4.BIOLOGICAL / CHEMICAL													
a.Simultaneous precipitation	~90	20	~90	20	~90	1	35	31	0.29	250	0.05	0.07	0.13
b.Pre-precipitation	~95	10	~95	15	~95	0.5	35	31	0.29	380	0.07	0.1	0.19
5.BIOLOGICAL / CHEMICAL, N-REMOVAL													
a.Predenitrific./ simult. precip. Based on activated sludge	~95	10	~97	10	~90	1	70	15	0.44	275	0.05	0.07	0.14
b.Postdenitrific./ pre-precip. Based on biofilm process	~97	5	~97	10	~95	0.5	85	7.5	0.4	380	0.07	0.1	0.19

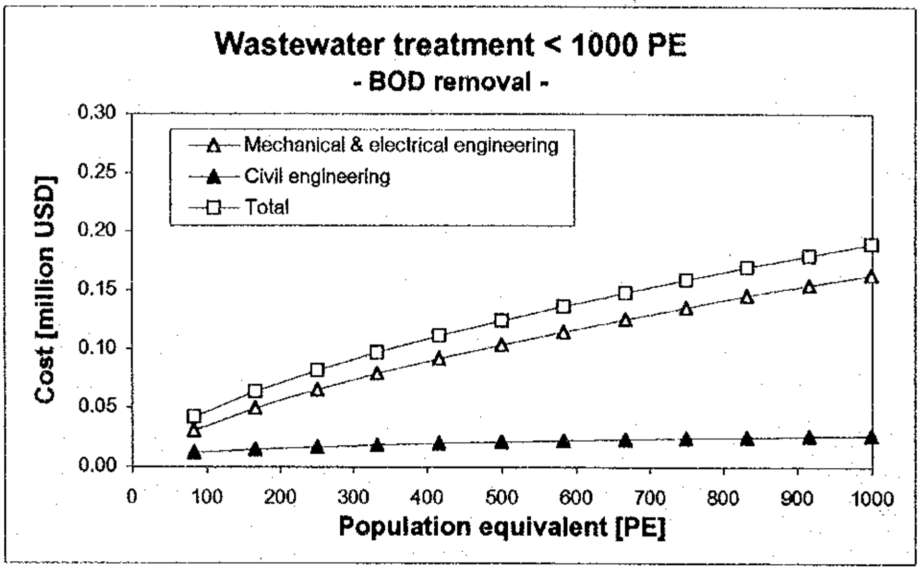
2a Chemical high load - Chemiccally enhanced mechanical
2b Chemical low load - Traditional chemical treatment - primary
3a Biological high load - activated sludge with sludge load = 0.5 kg BOD5
3b Biological normal load - activated sludgae with sludge load = 0.2 kg Bod5
4a Biological / chemical - Simultaneous precipitation in normally loaded activated
4b Biological / chemical - Pre-precipitaion followed by normally loaded activated
5a Biological / chemical incl. N-removal - Predenitrification/simultaneous precipitation in activated sludge plant with total
5b Biological / chemical incl. N-removal - Pre-precipitation followed by biofilm process with post-denitrification and external carbon

Source: Document of the World Bank, "Municipal Wastewater in Central and Eastern Europe: Present situation and cost-effective development strategies", Part II/1

TABLE 3.8.2 SUMMARY OF CONSTRUCTION COST OF MUNICIPAL WASTEWATER TREATMENT PLANTS

	Town	Costs (US$ 1000)			
		Main collectors	Primary treatment only	Primary and secondary treatment	Total cost
1.	**1st Stage Towns**	**18,034**	**0**	**103,987**	**122,021**
1-1	Pazardjik with Septemvri	5,854	-	19,924	25,778
1-2	Plovdiv	4,889	-	-	-
1-3	Assenovgrad	115	-	12,047	12,162
1-4	Dimitrovdrad	1,877	-	10,678	12,554
1-5	Haskovo	1,250	-	17,196	18,446
1-6	Stara Zagora	1,650	-	25,533	27,183
1-7	Velingrad/Rakitovo	2,400	-	18,610	21,010
2.	**2nd Stage Towns**	**14,992**	**21,445**	**0**	**36,437**
2-1	Stamboliyski	1,200	2,213	-	3,413
2-2	Parvomay	192	3,042	-	3,234
2-3	Chirpan	2,160	3,030	-	5,190
2-4	Harmanli	3,840	3,192	-	7,032
2-5	Radnevo	0	2,435	-	2,435
2-6	Galabovo	7,200	1,688	-	8,888
2-7	Hissarya	0	2,706	-	2,706
2-8	Panagyurishte	400	3,138	-	3,538
3.	**3rd Stage Towns**	**34,270**	**16,922**	**4,080**	**55,272**
3-1	Peshtera	960	-	-	960
3-2	Batak	120	848	-	968
3-3	Bratzigovo	960	940	-	1,900
3-4	Simeonovgrad	6,000	1,560	-	7,560
3-5	Nova Zagora	3,360	-	2,900	6,260
3-6	Lakki	1,200	739	-	1,939
3-7	Chepelare	1,690	1,123	-	2,813
3-8	Strelcha	1,400	951	-	2,351
3-9	Belovo	4,800	944	-	5,744
3-10	Kostenetz with Dolna Banya	2,160	1,955	-	4,115
3-11	Sopot with Karlovo	2,500	4,654	-	7,154
3-12	Ihitiman	1,440	-	1,180	2,620
3-13	Perushtitza	720	475	-	1,195
3-14	Krichim	2,400	1,632	-	4,032
3-15	Borino - village	960	-	-	960
3-16	Devin	3,600	1,101	-	4,701
	Total	**67,296**	**38,366**	**108,068**	**213,730**

FIG. 3.8.1 BASIC WASTEWATER TREATMENT WORKS COST (1/2)



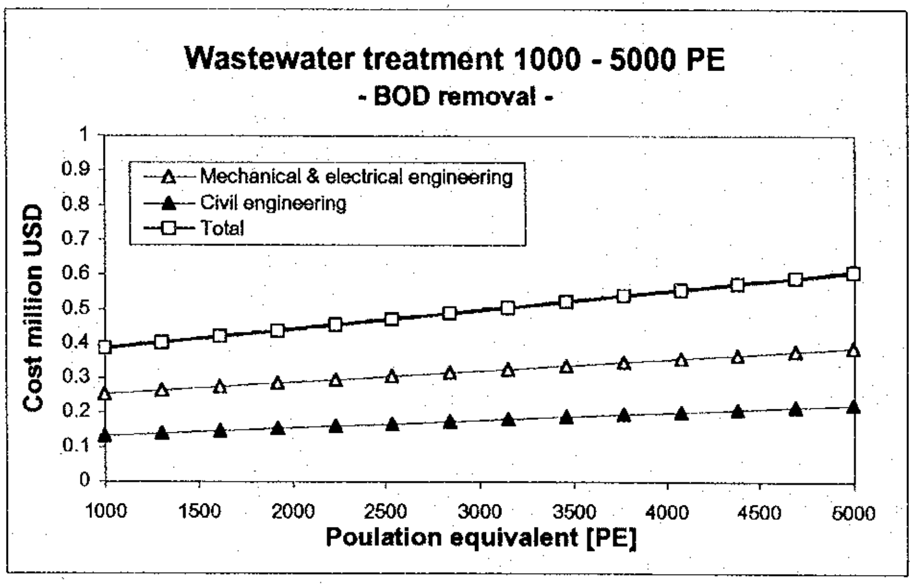
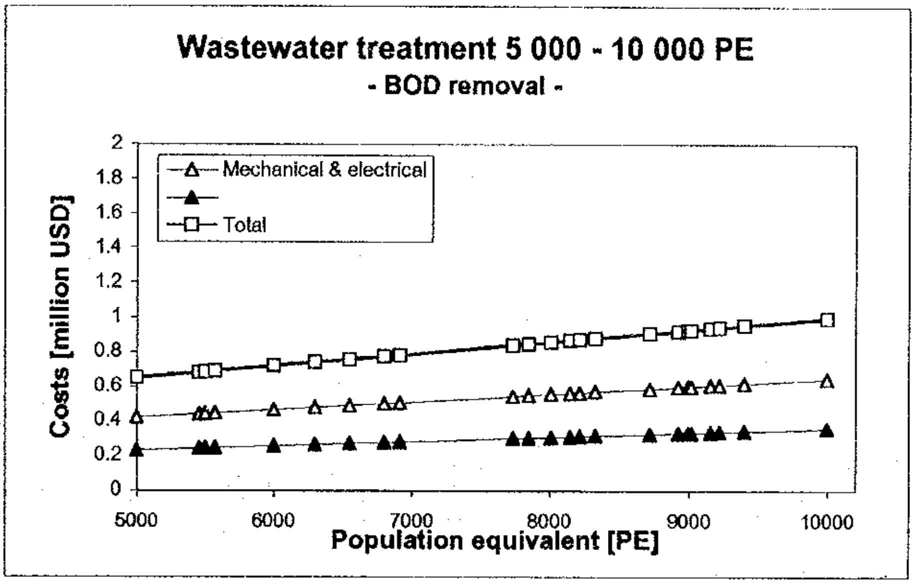


FIG. 3.8.1 BASIC WASTEWATER TREATMENT WORKS COST (2/2)



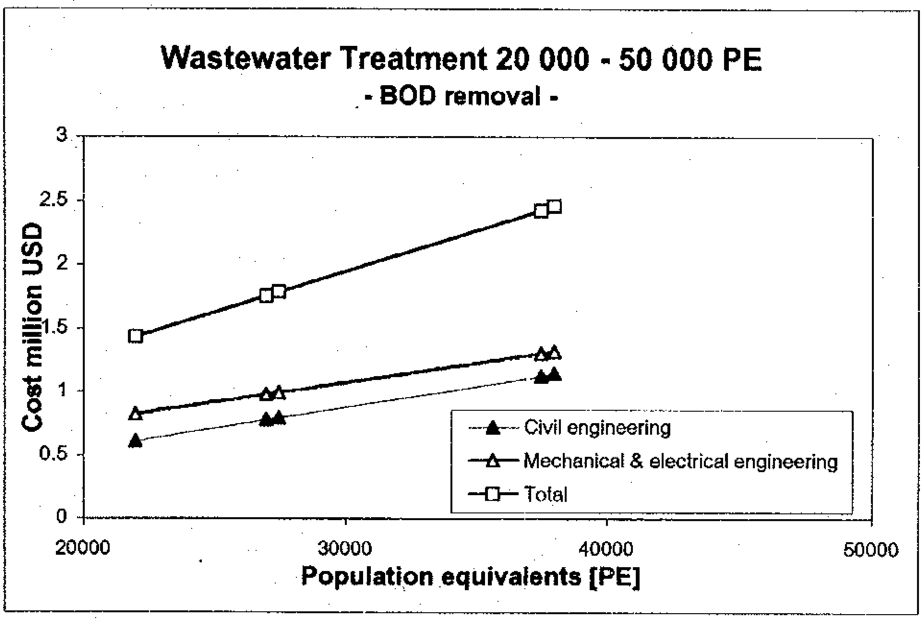
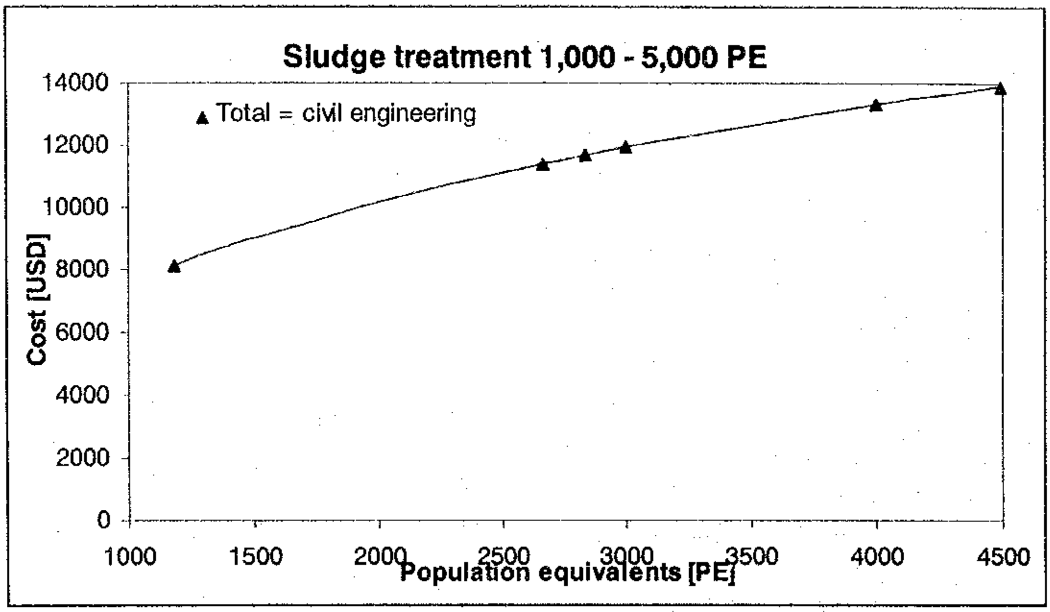


FIG. 3.8.2 SLUDGE TREATMENT COST CURVES (1/2)



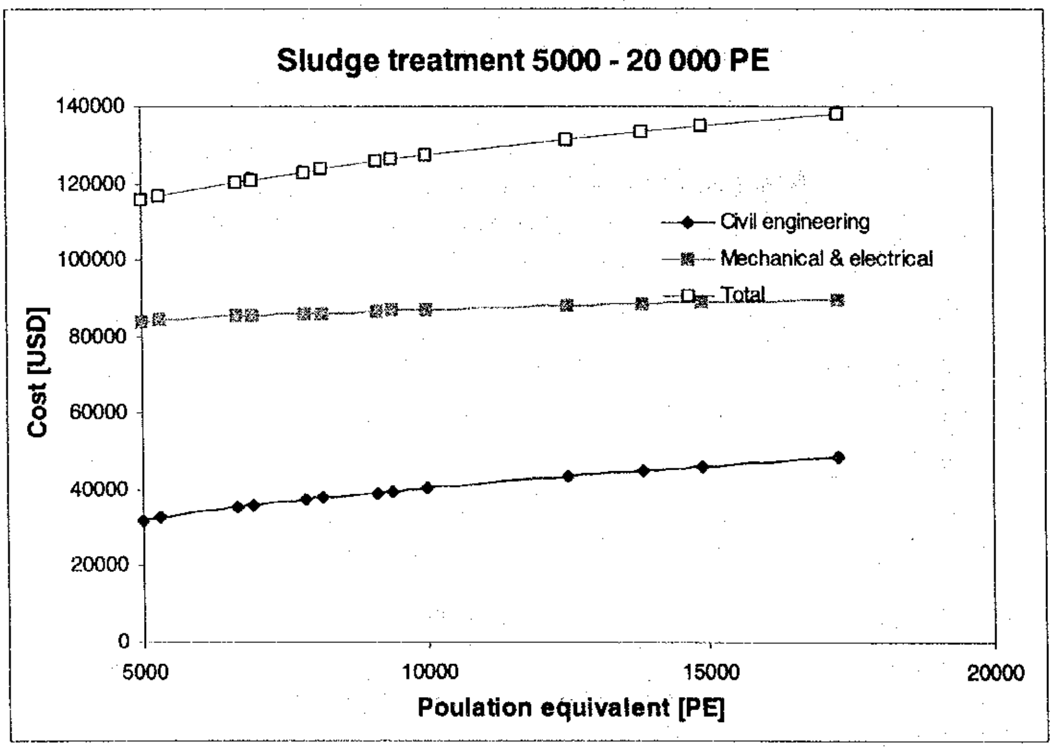


FIG. 3.8.2 SLUDGE TREATMENT COST CURVES (2/2)

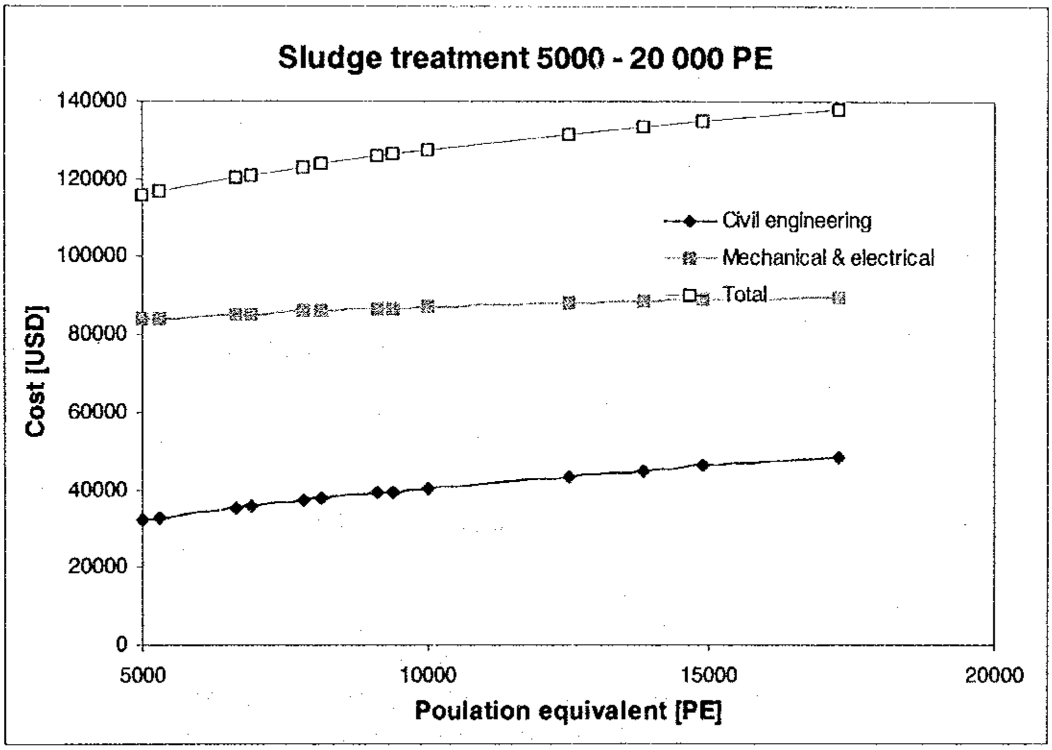
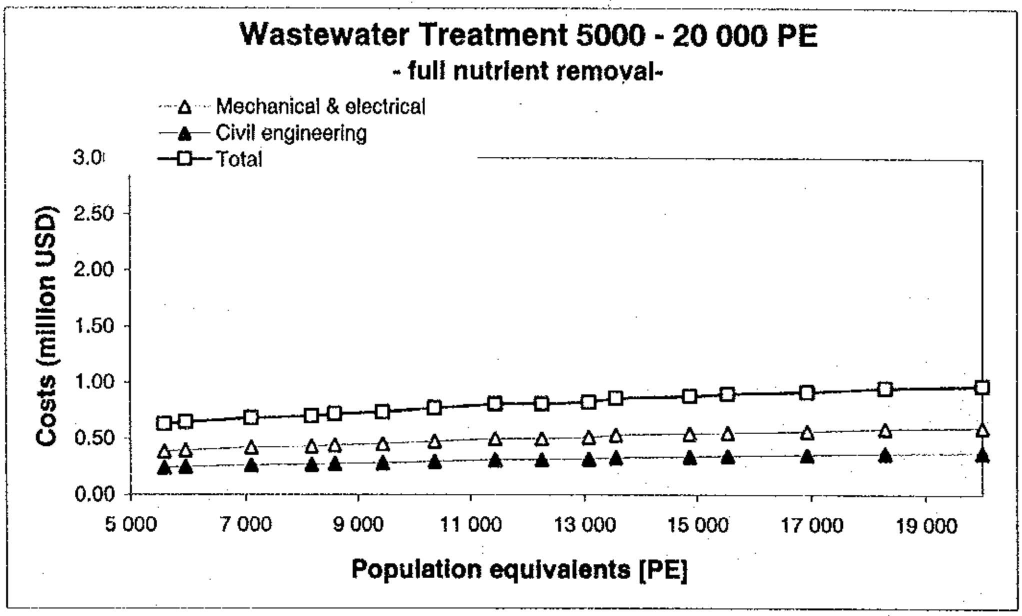


FIG. 3.8.3 WASTEWATER TREATMENT COST CURVES (1/2)



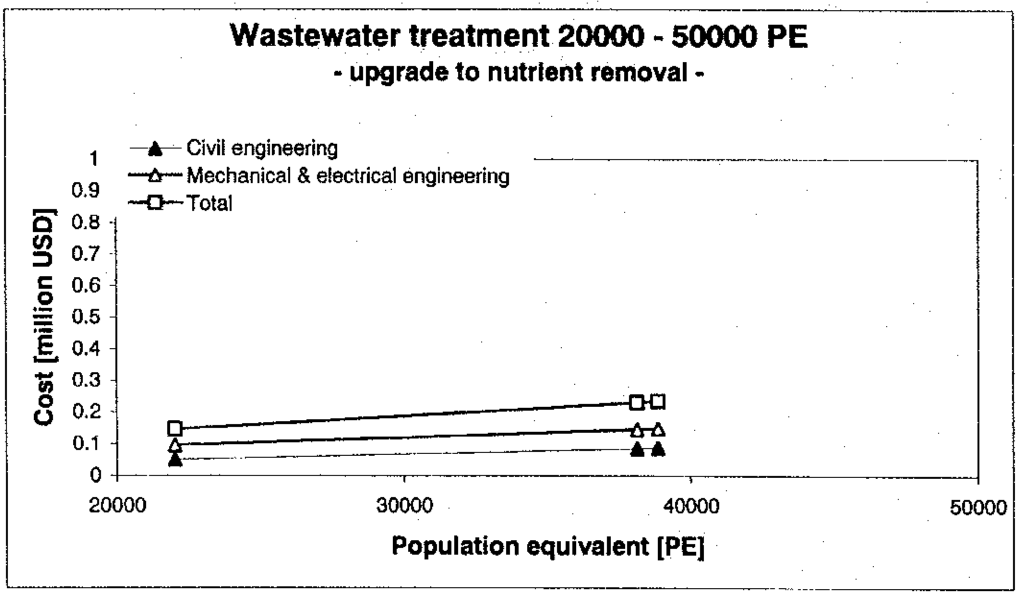
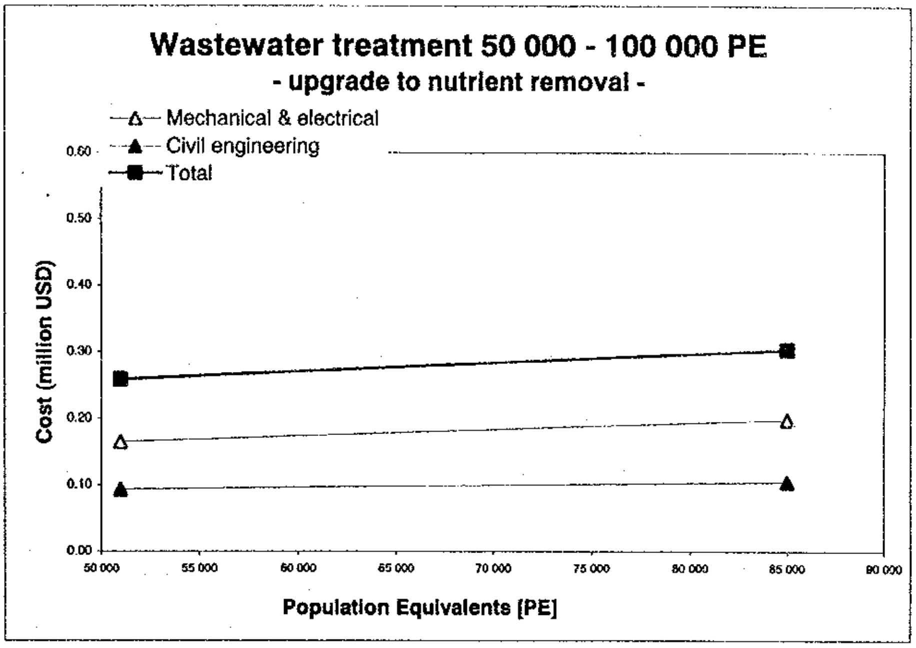


FIG. 3.8.3 WASTEWATER TREATMENT COST CURVES (2/2)



3.9

HYDRODYNAMIC MODEL

3.9 Hydrodynamic Model

3.9.1 Software for Hydrodynamic Modeling

Danish Hydraulic Institute's widely used software MIKE 11 has been used for precipitation-runoff (NAM) and hydrodynamic (HD) modeling. The NAM module comprises a conceptual precipitation-runoff model and the HD module comprises an unsteady, non-uniform, one-dimensional fully dynamic river flow model.

3.9.2 Simulation Years and Network

(1) Simulation Years

Two years have been selected for hydrodynamic modeling which are:

- 1995 which represents average year (1963-1995) in terms of precipitation and
- 1994 when runoff was the lowest in recent historical years.

(2) Simulation Network

River network for hydrodynamic modeling is shown in Fig. 3.9.1. Considering availability of cross-sectional as well as monitoring data and condition of river water quality, a few of the major tributaries flowing through steep mountainous regions have been substituted by short side branches. The model has been set up for a total length of 532.5 km (251.5 km along the Maritza mainstream and 281.0 km along the major tributaries) consisting of:

- 10 river courses: 3 along the Maritza mainstream and 7 for the major tributaries;
- 13 side branches: 8 along the Maritza mainstream and 5 along the major tributaries;
- 20 nodes: 15 along the Maritza mainstream and 5 along the major tributaries;
- 21 sub-catchments: 9 along the Maritza mainstream and 12 along the tributaries and

- 7 dams: the effect of the major dams has been considered under disturbed condition.

3.9.3 Precipitation-Runoff (NAM) Modeling

(1) Model Set Up

The total Maritza river basin comprises 16 major basins – 6 along Maritza mainstream and 10 along major tributaries. The 16 major basins have again been sub-divided into a total of 110 sub-basins: 77 along Maritza mainstream and 33 along major tributaries. Details of the sub-basins are summarized in Table 3.9.1 and are shown in Fig. 3.9.2. For precipitation-runoff modeling, the 110 sub-basins has been grouped into 21 sub-catchments. To account for the effect of snow storage at high elevation, each sub-catchment has again been sub-divided according to elevation range (Table 3.9.2). GIS database has been used in abstracting all the necessary information. It is found that about 21% of the sub-catchment areas of the total Maritza river basin has an elevation greater than 1,000 m with 7% (of the total Maritza basin) lying above elevation 1,500 m.

Daily measured precipitation and temperature data of the representative 22 meteorological stations and estimated monthly potential evaporation rates of the 16 major basins have been used. Considering effect of snow melting, daily precipitation and temperature data have been updated for areas with elevations above 1,000 m using relations between elevation and meteorological parameters.

(2) Basin Parameters and Calibration

The basin parameters have been estimated using landuse, topographic and hydrogeological information as abstracted from GIS database and updated through calibration at hydrometric station 72460 (Bachkovo) on Chepelarska river for the year 1995 (average year) under natural condition. The main basin parameters for precipitation-runoff modeling are listed in Table 3.9.3. Degree day coefficient represent the parameter for snow melting.

Simulated and measured hydrographs are shown in Fig. 3.9.3. It can be seen that the simulated hydrographs fit the measured hydrographs quite well throughout the year 1995 - especially during low flow period which is of major concern from water quality viewpoint.

3.9.4 Hydrodynamic (HD) Modeling

(1) Model Set Up

Actual river cross-sections (surveyed by JICA and collected from NIMH) have been used to set up the hydrodynamic model. As for Manning's roughness coefficient, different values have been applied for different river courses which vary from 0.038 to 0.042. A space step of 2-km and a time step of 5-minute have been used.

(2) Hydrometric Stations for Calibration

Calibration has been made for 1994-1995 against daily measured discharge data at 12 hydrometric stations: 6 along the Maritza mainstream and 6 along the major tributaries. Since the objective of the hydrodynamic model is to apply it for water quality model development, calibration of the hydrodynamic model against measured water level (which bears little importance) has not been carried out. Locations of the hydrometric stations are shown in Fig. 3.9.1.

(3) Simulation Results for Natural Condition (1994-1995)

The following criteria / assumptions have been applied for hydrodynamic modeling under natural condition:

- Total watershed (100%) of the Maritza river basin contributes to natural runoff.
- There is no dam or control point in the Maritza river system.
- There is no disturbance in natural river flow due to water use by irrigation systems or other intake facilities.
- There is no inter-basin transfer of water.
- Base flow is under natural condition.

Simulated discharge hydrographs (*Simulated-Natural*) along with the measured ones (*Measured-NIMH*) are shown in Fig. 3.9.4. It can be seen that natural river flow is likely to be much higher than disturbed (measured) river flow.

(4) Simulation Results for Disturbed Condition and Model Calibration (1994-1995)

The following criteria / assumptions have been applied for hydrodynamic modeling under disturbed condition:

- Catchments of the dams do not contribute to runoff.
- Outflows from the dams including inter-basin water transfer are consumed by irrigation systems and other water use facilities. As such, discharges from the dams do not contribute to the river flow.
- The Maritza river system is highly disturbed by a complex water use network. To keep the model simple, integrated effect of the disturbances in natural river flow due to water uses by the irrigation systems and other intake facilities have been substituted by percentage of water usage for each of the major basin. For 1995 (average year), water use ratio of 30-60% and for 1994 (severe drought year), water use ratio of 35-85% (with seasonal variation) have been used.
- Base flow is under disturbed condition.

Simulated discharge hydrographs (*Simulated-Disturbed*) have been compared with the measured ones (*Measured-NIMH*) and is shown in Fig. 3.9.4. Although, the hydrodynamic model doesn't predict peak flows well, but it bears less importance viewing from river water quality.

In general, the model predicts low flow quite well - on which, the main concentration has been paid for. This implies that the calibrated hydrodynamic model for 1994-1995 is well suited for water quality model development.

TABLE 3.9.1 SUB-BASIN AREAS OF MARITZA RIVER SYSTEM (DETAILED) (1/2)

SUB-BASINS ALONG MARITZA MAINSTREAM

Main Maritza		Sub-Basin	
Name	Index	Index	Area (km2)
Maritza Upstream 1	MU1	MU1-1	244
		MU1-2	119
		MU1-3	134
		MU1-4	36
		MU1-5	105
		MU1-6	29
		MU1-7	88
		MU1-8	6
		MU1-9	146
		MU1-10	266
		Sub-Total	1,173
Maritza Upstream 2	MU2	MU2-1	71
		MU2-2	37
		MU2-3	21
		MU2-4	56
		MU2-5	197
		MU2-6	47
		Sub-Total	429
Maritza Midstream 1	MM1	MM1-1	19
		MM1-2	340
		MM1-3	12
		MM1-4	22
		MM1-5	431
		MM1-6	43
		MM1-7	102
		MM1-8	34
		MM1-9	251
		MM1-10	205
		MM1-11	40
		MM1-12	19
		Sub-Total	1,518
Maritza Midstream 2	MM2	MM2-1	99
		MM2-2	23
		MM2-3	303
		MM2-4	68
		MM2-5	153
		MM2-6	152
		MM2-7	2
		MM2-8	242
		MM2-9	117
		MM2-10	88
		MM2-11	7
		MM2-12	291
		MM2-13	106
		MM2-14	253
		MM2-15	80
		MM2-16	9
		Sub-Total	1,993

Main Maritza		Sub-Basin	
Name	Index	Index	Area (km2)
Maritza Midstream 3	MM3	MM3-1	157
		MM3-2	338
		MM3-3	125
		MM3-4	145
		MM3-5	45
		MM3-6	4
		MM3-7	40
		MM3-8	6
		MM3-9	156
		MM3-10	285
		MM3-11	58
		MM3-12	217
		Sub-Total	1,576
Maritza Downstream	MD	MD1	3
		MD2	3
		MD3	2
		MD4	4
		MD5	67
		MD6	46
		MD7	128
		MD8	195
		MD9	96
		MD10	95
		MD11	55
		MD12	56
		MD13	88
		MD14	41
		MD15	15
		MD16	73
		MD1-17	119
		MD1-18	42
		MD1-19	394
		MD-20	37
		MD-21	75
		Sub-Total	1,634

TABLE 3.9.1 SUB-BASIN AREAS OF MARITZA RIVER SYSTEM (DETAILED) (2/2)

SUB-BASINS ALONG MAJOR TRIBUTARIES

Major Tributary		Sub-Basin	
Name	Index	Index	Area (km2)
Chepinska	CPI	CPI-1	171
		CPI-2	235
		CPI-3	513
		Sub-Total	919
Topolnitza	TOP	TOP-1	410
		TOP-2	669
		TOP-3	588
		TOP-4	190
		Sub-Total	1,857
Luda Yana	LUD	LUD-1	212
		LUD-2	363
		LUD-3	164
		Sub-Total	739
Stara	STA	-	366
Vacha	VAC	VAC-1	612
		VAC-2	237
		VAC-3	428
		VAC-4	412
		Sub-Total	1,689
Pyassachnik	PYA	-	419

Major Tributary		Sub-Basin	
Name	Index	Index	Area (km2)
Chepelarska	CPE	CPE-1	195
		CPE-2	335
		CPE-3	449
		Sub-Total	979
Stryama	STR	STR-1	608
		STR-2	244
		STR-3	842
		Sub-Total	1,694
Sazliyka	SAZ	SAZ-1	109
		SAZ-2	319
		SAZ-3	653
		SAZ-4	440
		SAZ-5	30
		SAZ-6	611
		SAZ-7	1,156
		SAZ-8	25
		Sub-Total	3,343
Harmanliyska	HAR	HAR-1	177
		HAR-2	167
		HAR-3	642
		Sub-Total	986

TABLE 3.9.2 SUB-CATCHMENTS FOR PRECIPITATION-RUNOFF MODELING (NATURAL CONDITION)

Sub-Catchment		Total Area	Sub-Divided Sub-Catchment Area According to Elevation Range (km2)		
No.	Name	(km2)	EL. < 1,000 m	EL. 1,000 - 1,500 m	EL. > 1,500 m
1	MU1	1,173	714	209	250
2	CPI	919	265	488	166
3	MU2	429	409	20	
4	STA	366	185	137	44
5	VAC	1,689	307	758	624
6	MM1	1,518	1,366	117	35
7	CPE	979	271	537	171
8	MM2	1,993	1,971	22	
9	MM3	1,576	1,576		
10	MD	1,634	1,634		
11	TOP-2, 3 & 4	1,447	1,070	326	51
12	TOP-1	410	404	6	
13	LUD-2 & 3	527	435	92	
14	LUD-1	212	212		
15	PYA	419	392	27	
16	STR-2 & 3´	828	523	206	99
17	STR-1´	866	866		
18	SAZ-7	1,156	1,156		
19	SAZ-6	611	611		
20	SAZ-1, 2, 3, 4, 5 & 8	1,576	1,576		
21	HAR	986	986		
1 to 21	Total Maritza	21,314	16,929	2,945	1,440
	Percent (%)	100	79	14	7

TABLE 3.9.3 PARAMETERS FOR PRECIPITATION-RUNOFF (NAM) MODELING

Applied Fixed Parameters (Same for all Major Basins) in NAM Model :

1) Time constant for routting interflow and overland flow = 20 hours
2) Root zone threshold for overland flow = Runoff coefficient
3) Root zone threshold for interflow = 0.0
4) Root zone threshold for ground water recharge = 0.0
5) Capillary flux = 0.0 m
6) Minimum groundwater depth = 0.0 m

Applied Initial Conditions in NAM Model :

1) Water content in surface and root zone storage = 0.0 m
2) Overland flow and interflow = 0.0 mm/hr
3) Initial GW depth = GW depth for baseflow

RUNOFF PARAMETERS FOR DIFFERENT LANDUSE CATEGORIES

Basin Parameter		Runoff Parameter by Landuse Category					
		Forest	Grassland	Irrigated Area (including Fruit Tree)	Non-Irrigated Area (including Bare Land)	Water Body	Urban Area
Runoff Coefficient	Initial Estimation	0.31	0.33	0.35	0.20	1.00	0.50
	Updated / Calibrated	0.54	0.58	0.61	0.35	1.00	0.88
Root Zone Storage (mm)		150	80	100	60	0	50

Note : No NAM setup for irrigation area

APPLIED BASIN PARAMETERS FOR PRECIPITATION-RUNOFF MODELING

Major Basin		Surface Water Zone Related Parameters					Ground Water Zone Related Parameters		
Index	Name	Runoff Coefficient	Root Zone Storage (mm)	Surface Zone Storage (mm)	Degree Day Coefficient (mm/°C/day)	Interflow Routing Time (hr)	Baseflow Routing Time (hr)	Groundwater Depth for BF (m)	Specific Yield
	MARITZA MAINSTREAM	0.48	86	10	2	750	1000	5	0.09
MU	Upstream Basin of the Mainstream	0.52	106	10	2	750	1000	6	0.09
MU1	Upper sub-basin	0.51	112	10	2	750	1000	7	0.08
MU2	Lower sub-basin	0.54	88	10	2	750	1000	5	0.13
MM	Mid-stream Basin of the Mainstream	0.48	81	10	2	750	1000	4	0.10
MM1	Upper Sub-basin	0.53	87	10	2	750	1000	5	0.11
MM2	Middle sub-basin	0.41	79	10	2	750	1000	4	0.11
MM3	Lower sub-basin	0.40	77	10	2	750	1000	4	0.08
MD	Downstream Basin of the Mainstream	0.46	82	10	2	750	1000	4	0.08
	MAJOR TRIBUTARIES	0.51	102	10	2	750	1000	6	0.07
TOP	Topolnitza River	0.50	106	10	2	750	1000	7	0.06
LUD	Luda Yana River	0.48	97	10	2	750	1000	6	0.07
PYA	Pyassachnik River	0.50	97	10	2	750	1000	5	0.09
STR	Stryama River	0.50	96	10	2	750	1000	6	0.09
CPI	Chepinska River	0.53	124	10	2	750	1000	7	0.06
STA	Stara River	0.52	112	10	2	750	1000	6	0.06
VAC	Vacha River	0.52	123	10	2	750	1000	7	0.06
CPE	Chepelarska River	0.51	122	10	2	750	1000	7	0.06
HAR	Harmanliyska River	0.39	83	10	2	750	1000	4	0.07
SAZ	Sazliyka River	0.49	86	10	2	750	1000	4	0.08
	Total Maritza Basin	0.50	96	10	2	750	1000	5	0.08

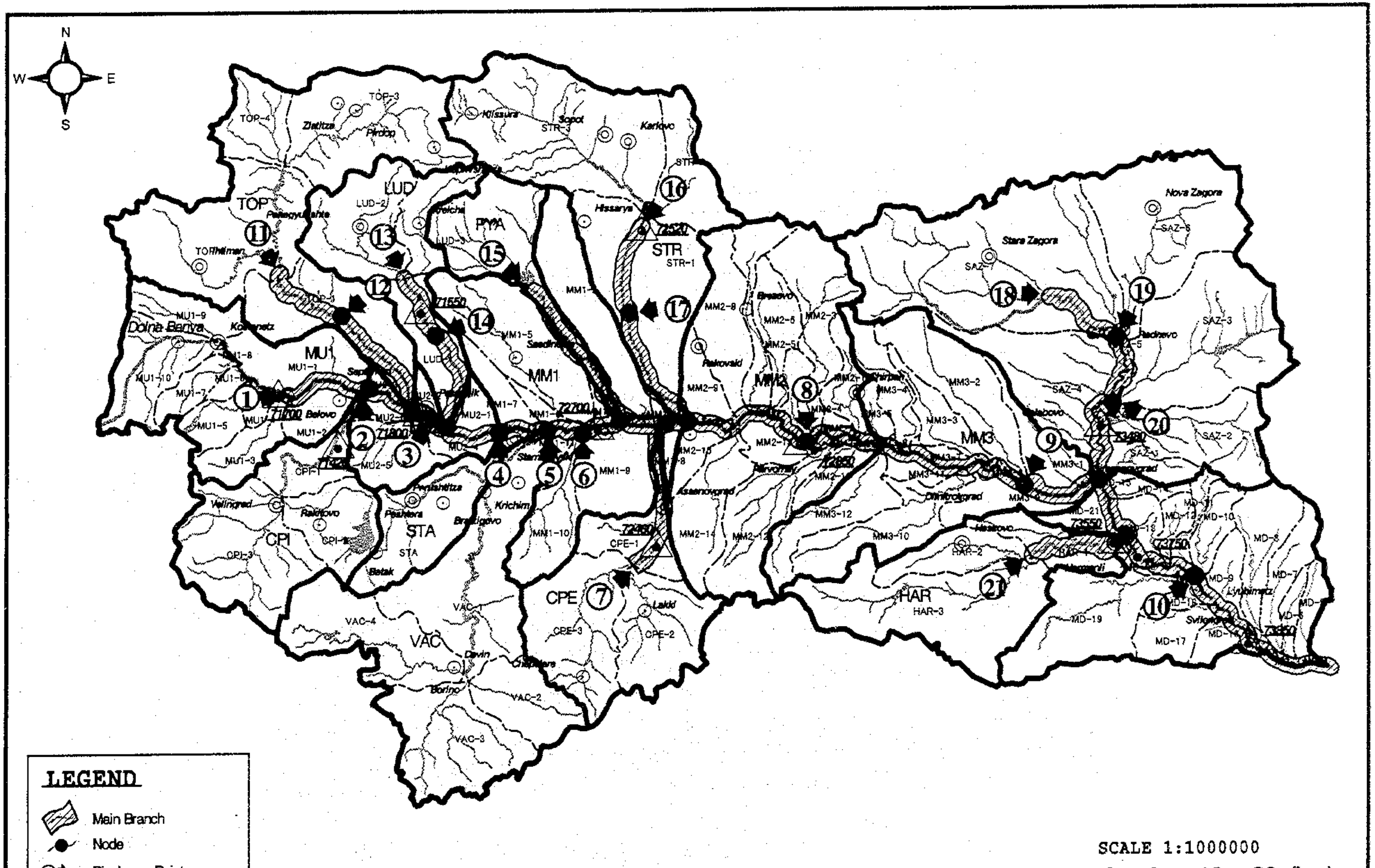


FIG. 3.9.1 RIVER NETWORK FOR HYDRODYNAMIC MODELING

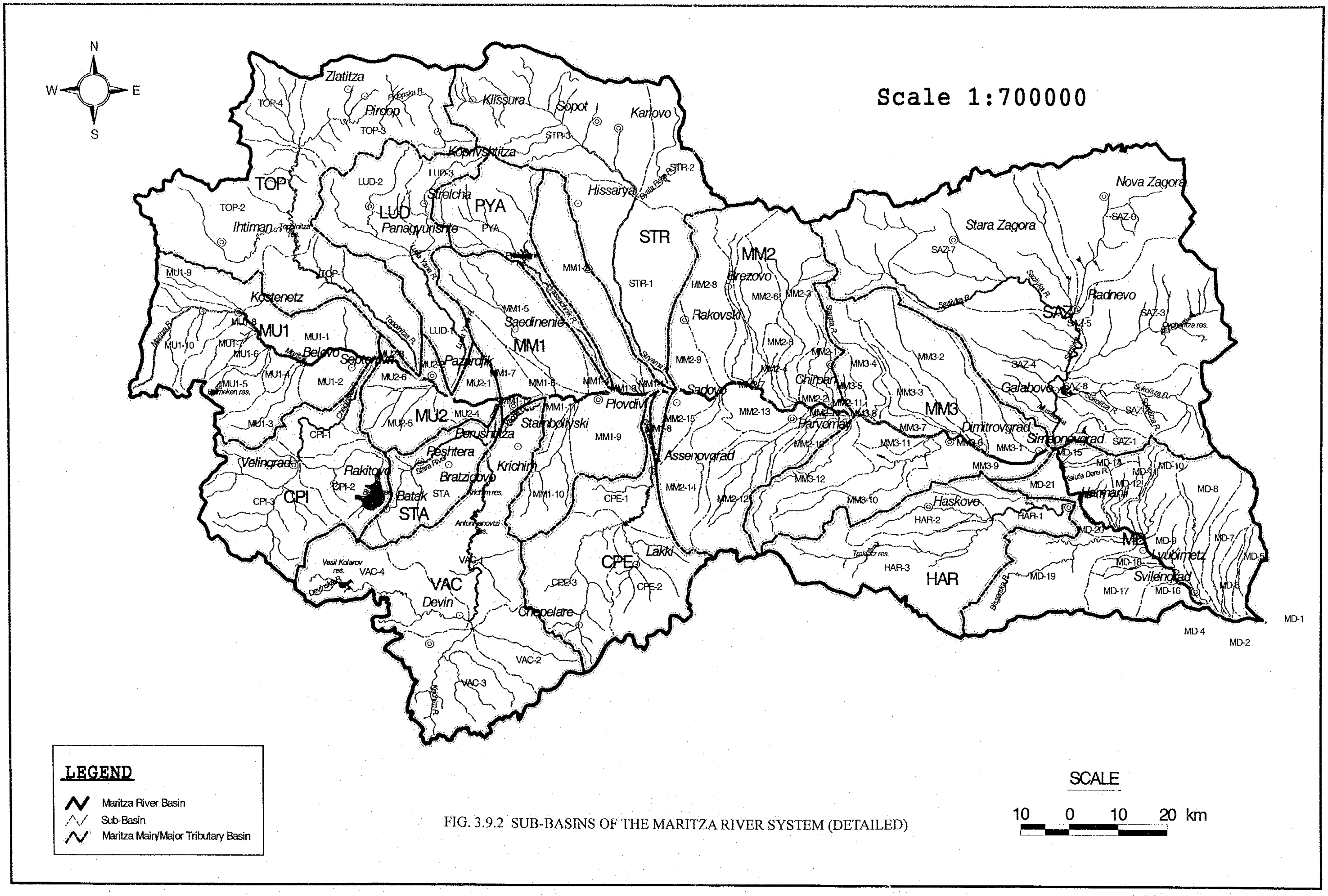
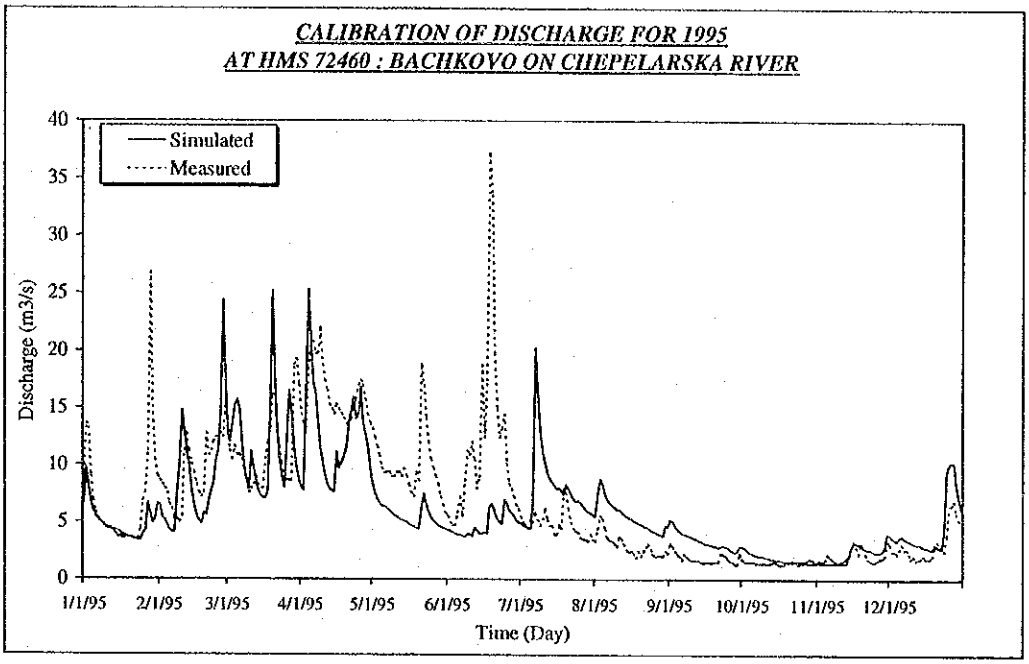


FIG. 3.9.2 SUB-BASINS OF THE MARITZA RIVER SYSTEM (DETAILED)



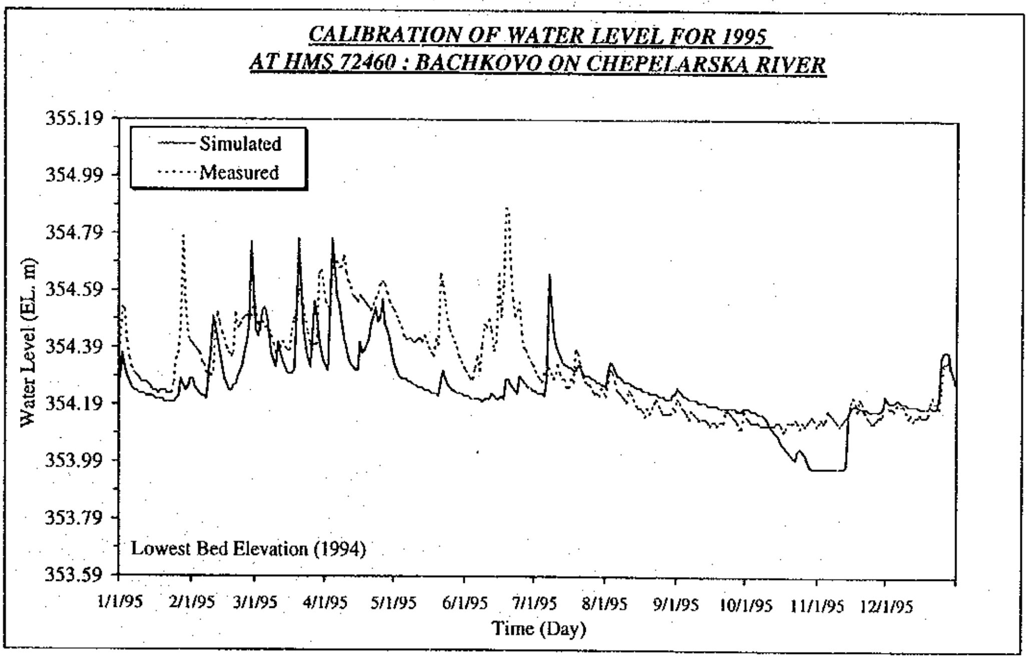
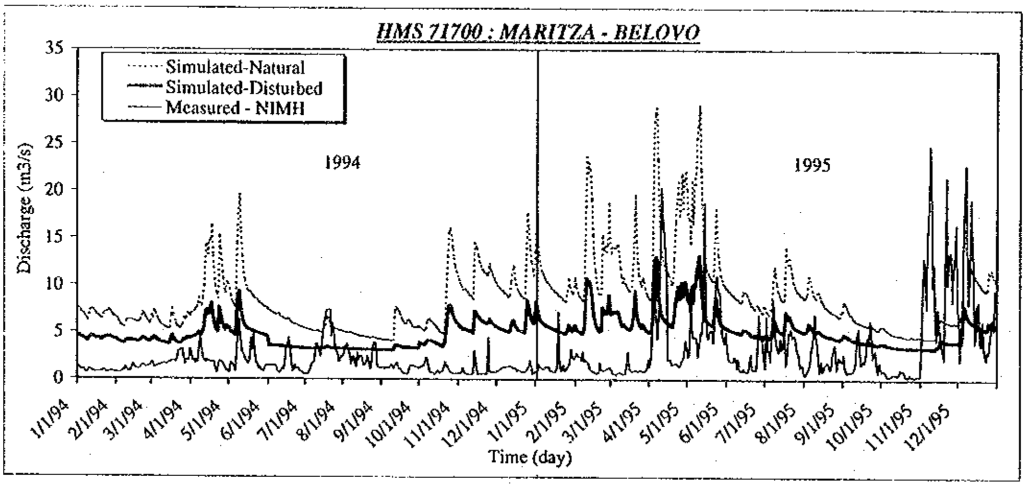
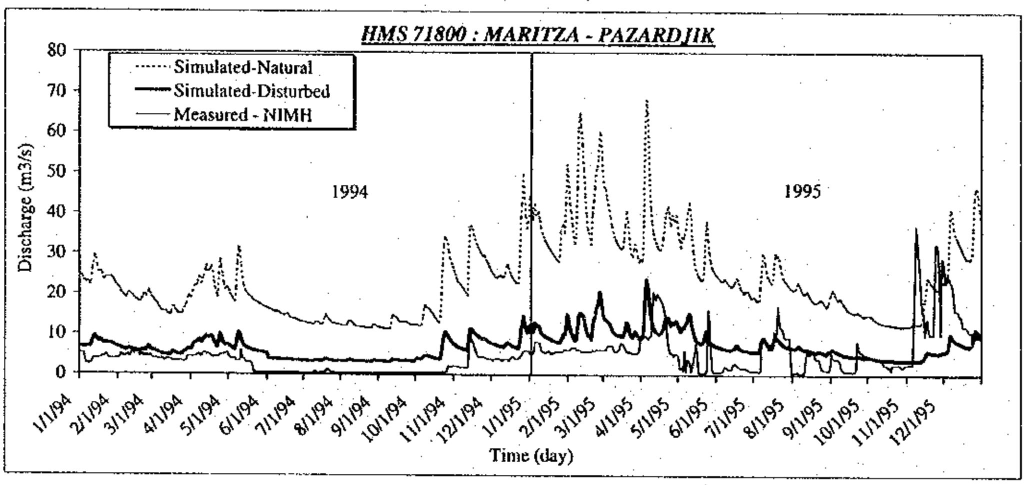


FIG. 3.9.3 CALIBRATION OF NAM MODEL AT BACHKOVO ON CHEPELARSKA





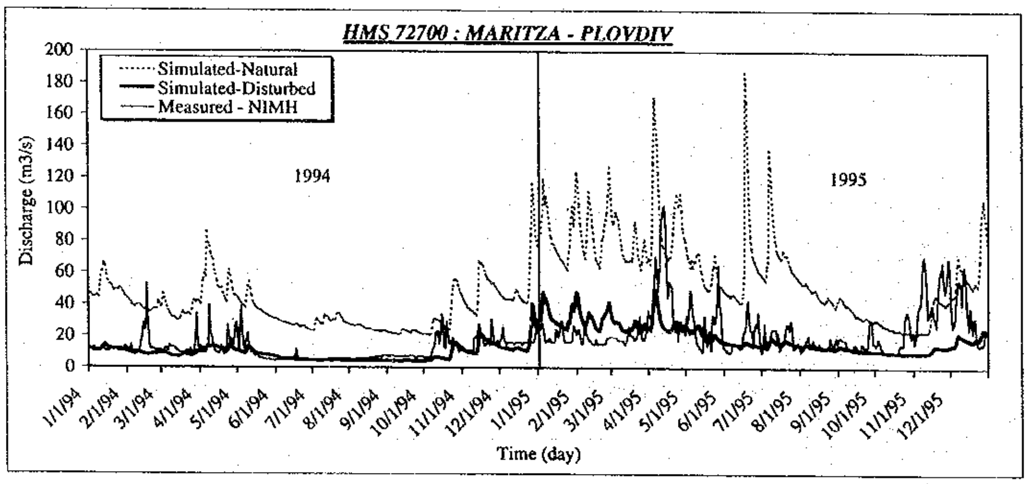
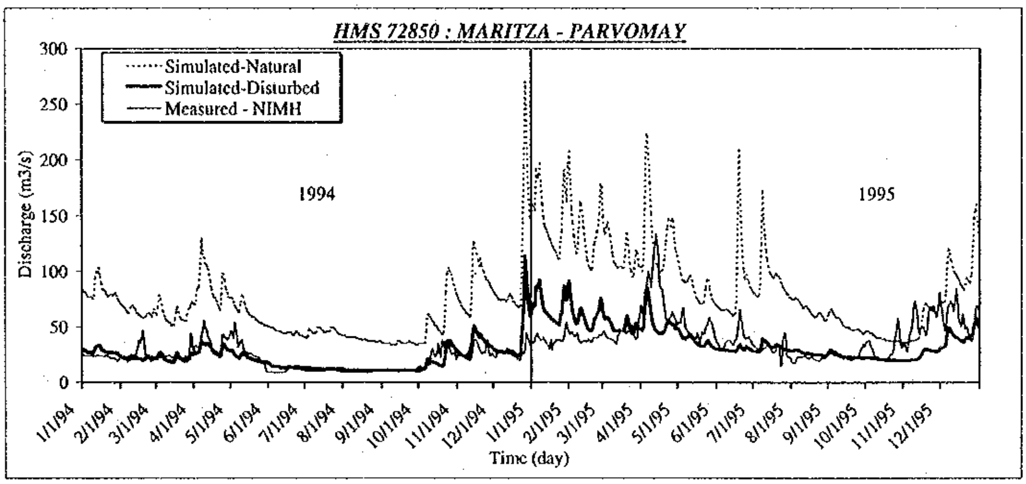
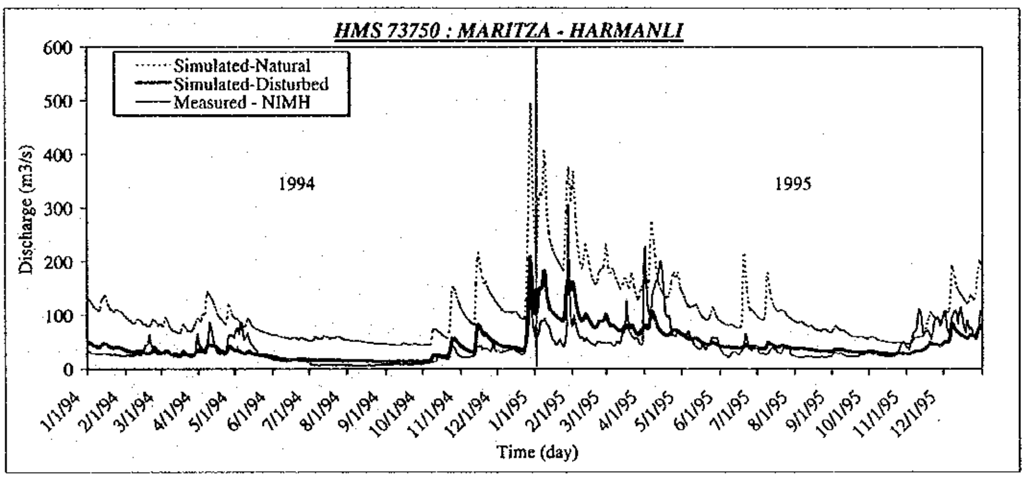


FIG. 3.9.4 SIMULATED AND MEASURED HYDROGRAPHS (1994-1995) (1/4)





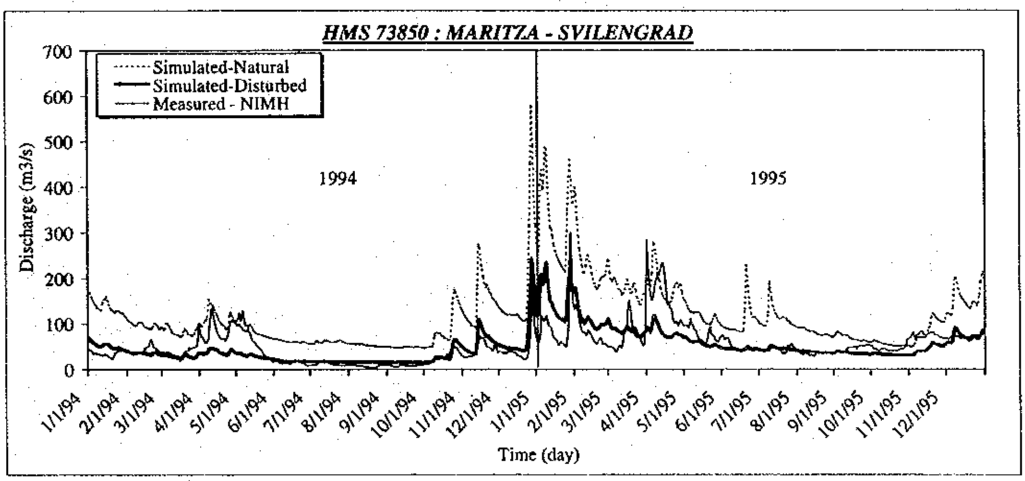
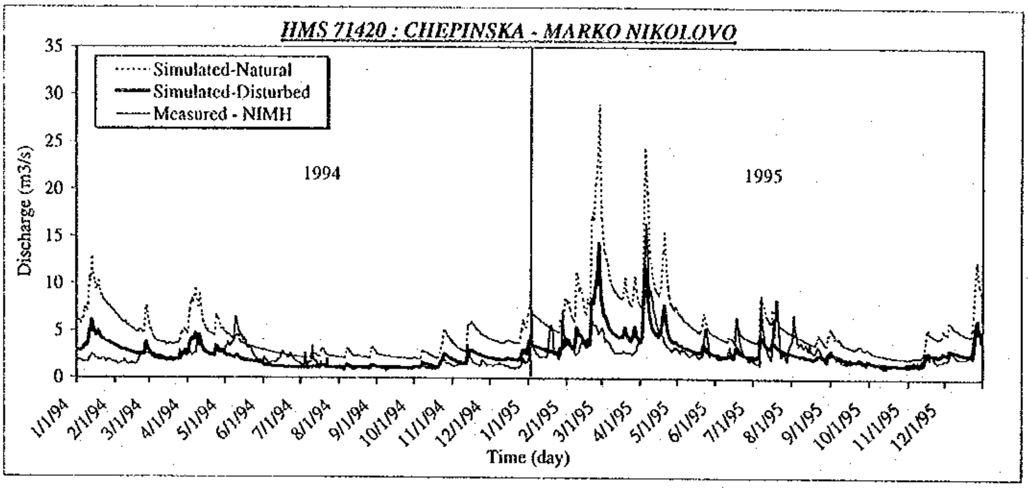
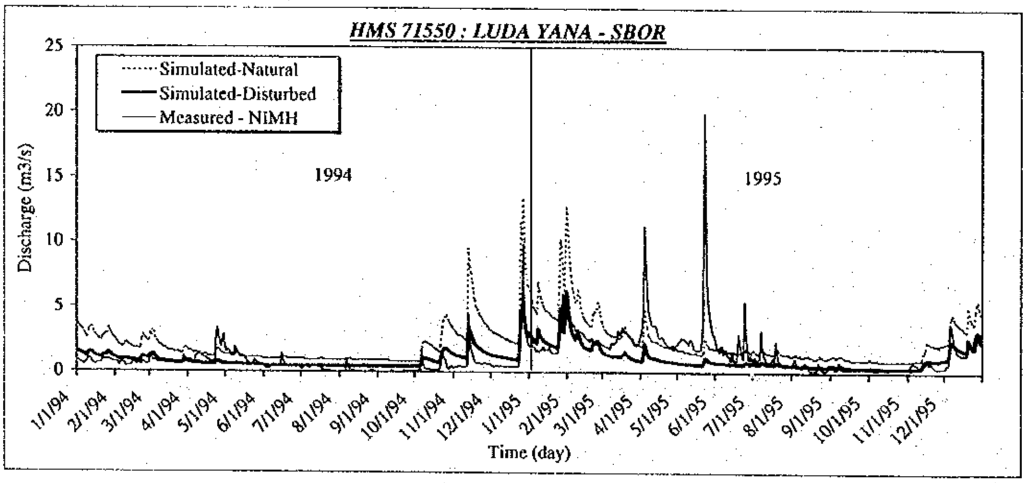


FIG. 3.9.4 SIMULATED AND MEASURED HYDROGRAPHS (1994-1995) (2/4)





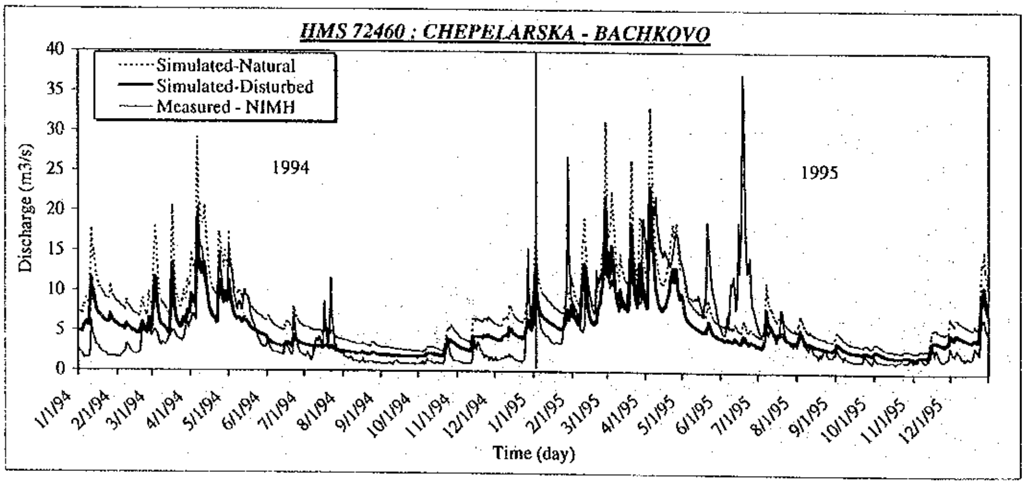
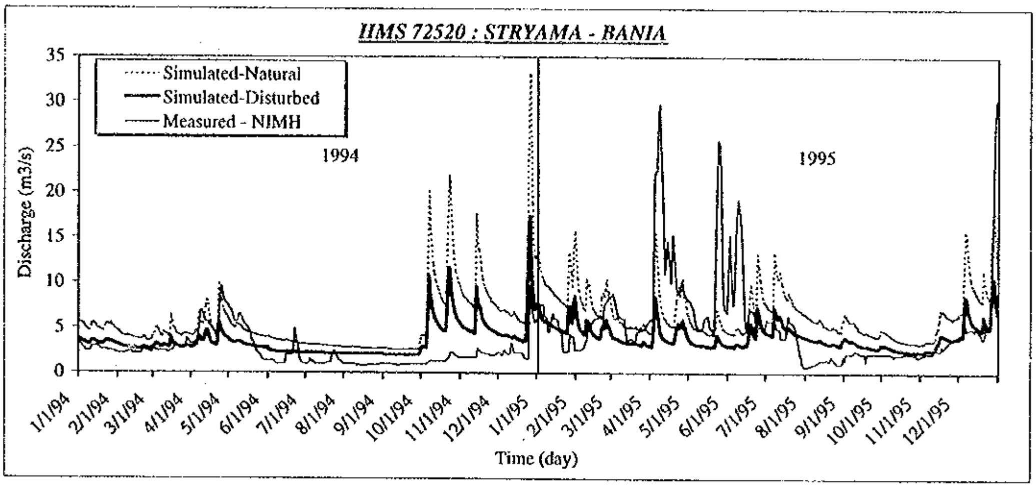
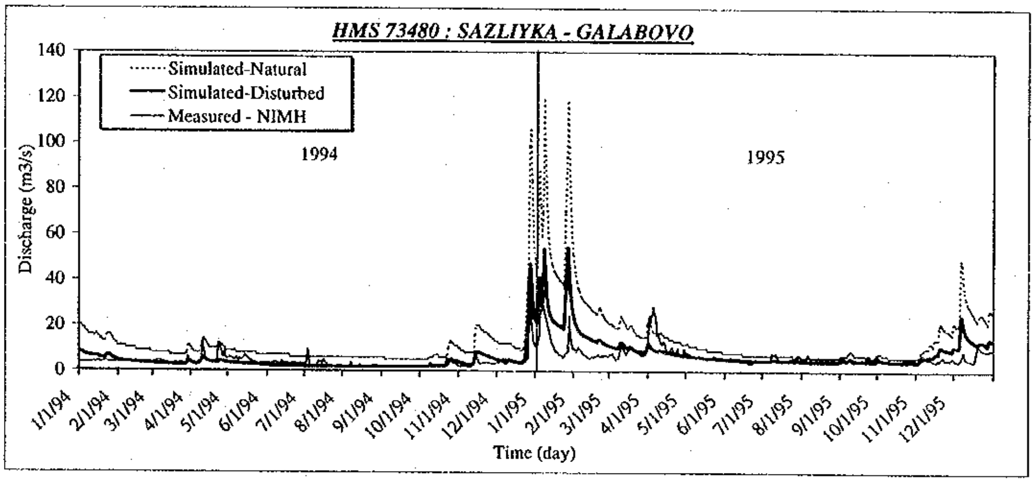


FIG. 3.9.4 SIMULATED AND MEASURED HYDROGRAPHS (1994-1995) (3/4)





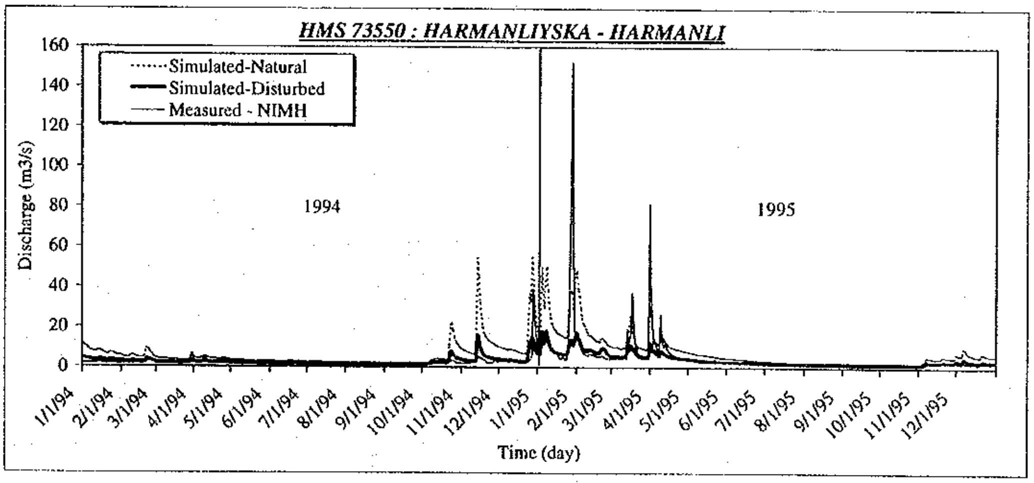


FIG. 3.9.4 SIMULATED AND MEASURED HYDROGRAPHS (1994-1995) (4/4)

3.10
WATER QUALITY SIMULATION

3.10 Water Quality Simulation

The water quality of the Maritza River was simulated in the year 1994 and 1995 using MIKE 11 model system from DHI.

The calibration of water quality (WQ) model is made on the average hydraulic year if 1995. Dry year 1994 is chosen for verification. The loading in 1995 is estimated, and assumed the same amount of load as one in 1994. WQ simulation is applied to water quality management such as pollution reduction.

3.10.1 Simulation of Water Quality during a Normal/Drought Year

The load to the river is together with the hydrodynamic the two most important parameters for making a successful simulation. The load of BOD, total N, NH4 and NO3 is shown in Table 3.10.1.

In total 104.8 tons BOD, 47.0 tons total N, and 28.3 tons NH4-N are estimated to enter the river system per day.

The domestic loads contribute with 46 % of the BOD load, followed by the industries with 34 %. The remaining 20 % of the BOD load derive from livestock.

The nitrogen load is dominated by industries and especially by two fertilizer factories Agrobiochim in Stara Zagora and SC Neohim in Dimitrovgrad. The industrial load, contribute with 33 % of the total N load. Livestock is estimated to contribute with 28 % of the N load and the domestic load is estimated to be 19 %.

A more comprehensive description of the 1995 load can be found in Chapter 2.5.

A two-year simulation of the water quality through the years 1994 and 1995 has been conducted. The simulated concentrations was compared with the measured concentrations of BOD, NH4-N and oxygen form 11 stations along the Main Maritza River and 7 stations from the tributaries.

BOD in the upper part of the Maritza River is simulated well compared with the measured concentrations. However, the simulated BOD concentrations in the lower part of the river downstream Dimitrovgrad are too low. The NH4-N concentrations in the upper part agree with the measured values. In the lower part however the NH4 concentrations are simulated too high during 1994. The monitoring data of NH4-N from 1994 and 1995 in this part of the river show the same concentration level although the discharge in 1994 was about half the discharge in 1995. Assuming the same loading for the two years the concentration in 1994 should have been twice as high as in 1995. The assumption of 1994 and 1995 having the same load may therefore be wrong for the lower part of the river.

The simulated oxygen concentrations agree well with the measured values for the main Maritza River and tributaries.

The simulated concentration of BOD, NH4 and oxygen agrees well with the measured values in 1995. However, for 1994 the simulated concentrations of BOD and especially NH4 in Sazliyka are higher than the measured concentration.

The higher simulated concentrations in Sazliyka River explain the elevated simulated concentrations of NH4 in 1994.

Based on these findings the model may be regarded as calibrated on 1995 data and verified on 1994 data.

3.10.2 Criteria for Future Water Quality

The future water quality should in general fulfil the Class II for BOD, NH4 and oxygen during a normal hydraulic year. NO3 was calibrated and verified. However, NH4 is much more serious problem than NO3, shown in Fig 2.5.7 and Fig 2.5.8. Therefore, NH4 is selected to represent as inorganic nitrogen compound.

A higher class, however, may be feasible for specific part of the river where the discharge is low and the load is high. Sazliyka River is such an example, see Chapter 3.4.

In Table 3.10.2, the concentration ranges for the three classes are listed.

3.10.3 Definition of Alternative Reduction in Loading of BOD and Total Nitrogen

In chapter 3.6, different alternatives is defined for implementation of treatment of the domestic sewage form totally 34 cities in the basin, including a future population of totally 1,268,900.

The proposed alternatives suggest the implementation in three steps until year 2015. The first step covering the most important polluters having no constraints in term locations of the treatment facilities.

Second phase include important polluting cities without identified locations for treatment facilities. Second phase is scheduled to implementation in year 2010.

Third phase include smaller cities mainly discharging to tributaries. Third phase is planed implemented in the years 2010 to 2015.

The water quality in year 2015 with a 10 % increase in population centered around the major cities has been calculated. This simulation serves as reference for the simulations with treatment.

No change in the industrial or agricultural load has been included in any of the future simulations. The industrial production will increase during the next 15 years, but so will implementation of cleaner and more economical technology. Combined with implementation of proper treatment, the load form the industries are assumed to be at the 1995 level until year 2015.

It, however, demands the Bulgarian Parliament and authorities to pass laws and implement measures encouraging present and future industries to use cleaner technologies at their facilities and to implement the necessary treatment.

The load from livestock is assumed to remain on the 1995 level though an increase in the number of livestock can be expected from the 1995 level to the level from 1989. Again it is a question of legislation and law enforcement whether the future increase in number of animals is counter balanced by a proper handling of the manure which reduce the load to the river system.

The objective for modeling the future water quality is to find the most optimal combination or combinations of treatment fulfilling the general criteria of meeting class two water qualities.

A scheme of different combinations of treatment have therefore been set up, see Table 3.10.3.

A series of three alternatives only treating the domestic sewage in the all the priority cities, by implementing primary- and secondary treatment of the 1st cities and/or primary + secondary treatment or only primary treatment at the 2nd and 3rd priority cities. No nitrification is included in these alternatives.

A second series of three alternatives have been set up with the same treatment of the domestic load as in the first series but including different treatment of the 10 or 20 most polluting industries. In two of the simulations, a reduction in BOD load from the livestock is also included. In the basin are two fertilizer factories, which are the biggest point polluters of total N. In two of the three simulations the emission of total N from these factories are reduced by 90 %.

A last alternative have been set up adding nitrification at the treatment plants in Stara Zagora and Haskovo after primary and secondary treatment.

The load reduction with primary, primary and secondary treatment with and without nitrification is listed in Table 3.10.4.

The load of BOD is estimated to be slightly higher in 2015 without implementation of treatment compared with 1995.

Implementing two step treatment on 1st priority cities reduce the BOD load with 23 % (Alt. 1_1D), whereas implementation of primary and secondary treatment on all priority cities will reduce the BOD load with 33 %, see Table 3.10.5. The most extensive reduction is achieved in alternative 3_3 and 3_4 with a combination of a reduction in load from cities, industries and livestock.

The reduction in total N and NH4 is minimal when not including either nitrification (4_3) or reduction in emission from the two fertilizer factories.

The load from Maritza River in terms of BOD, total N and total NH4 are presented in Fig. 3.10.1 to 3.10.3.

3.10.4 Presentation of Future Water Quality according to Alternatives

The model simulations of the alternatives cover the years 1994 and 1995. The result in term of water classes is presented in Table 3.10.6 to 3.10.8.

An examination of the time series show the lowest concentrations of oxygen are found in mid August. At this time of the year, the temperature at its highest giving the lowest oxygen concentrations on the same time as the discharge in the river is low.

The model results are therefore also presented as planplots of the concentrations mid. August for a selection of the most important simulations, see Fig. 3.10.4 to 3.10.7.

Blue colors indicate concentrations with class I, green colors indicate class II concentrations, yellow colors indicate class III and read and black colors indicate concentrations above class III.

<u>BOD</u>

After implementing 1st stage, class II condition was reached for BOD in the modeled part of the river system except for Sazliyka, shown in Fig. 3.10.4, alternative 1_1D. Sazliyka River downstream Radnevo just manages to reach classes II for BOD, whereas upstream Radnevo the BOD concentration level reach class III or more.

Implementing alternative 3_3 or 4_3 will improve the condition in the upper part of Sazliyka River so also this part can reach class II condition for BOD. Alternatives 3_3 and 4_3 include reduction of the industrial BOD load from the top 10 industries with 90 % and a 30 % BOD reduction of the to 10-20 highest BOD emitting industries. In addition to the reduction of the industrial load, a reduction of the BOD load form livestock of 30 % is included in alternatives 3_3 and 4_3.

All other combinations listed in Table 3.10.5 do not apply if class II in the upper part of the Sazliyka River was to be meet.

<u>Total NH4-N</u>

The ammonia concentration for the most important simulations is presented in Fig. 3.10.5 and 3.10.7.

The situation in year 2015 shows that the lower parts of Maritza River downstream

Dimitrovgrad meet class III or class II. The rest of the main Maritza river meet class II except for a section downstream Pazardjik, Stamboliyski and Plovdiv.

The tributaries Harmanliyska, Sazliyka and Luda Yana all are in class III or above class III. As can be seen from Table 3.10.4, alternatives 1_1D to 3_3D introduce treatment without nitrification. This will not reduce the NH4 load, on the contrary a slight increase may be expected as a part of the former non-sewed population around the priority cities are connected to the treatment plants. This will decrease the NH4 infiltration to the groundwater but slightly increase the NH4 load to the river.

Implementation of treatment without nitrification will therefore not improve the above condition for NH4.

In alternative 2_3 and 3_3 the TN load from the fertilizer factories in Dimitrovgrad and Stara Zagora are reduced 90 % resulting in an improvement in Sazliyka river and the lower part of Maritza river. The improvements are sufficient so class II is meet downstream Dimitrovgrad in Maritza River. However, in Sazliyka River the NH4 concentration is still in class III or above class III.

A final simulation (alternative 4_3) was made implementing nitrification on the domestic sewage at Stara Zagora and Haskovo in an attempt to improve the condition to meet class II for NH4 in Sazliyka and Harmanliyska Rivers. The results are presented in Fig. 3.10.7. For Harmanliyska River, class II is met but for Sazliyka River the improvement is not sufficient to meet class II. The improvement is however sufficient to meet class III downstream Galabovo.

If further improvements have to be made in for NH4 in Sazliyka River, other industries other than the fertilizer factories have to reduce their NH4 load. The load from livestock in the area has to be reduced as well.

Oxygen

The oxygen condition in year 2015 is meeting class II in main Maritza River and all tributaries except Sazliyka River. In Maritza River down stream of Sazliyka River O2 concentration, however, will be depressed. It should be noted that the above description only covers the modeled part of the river.

The worst conditions are found in the lower part of Sazliyka River where the river become slowly flowing. The reaeration, therefore, is lower than in the upper part of the river, where the slope of the terrain is high resulting in a higher reaeration.

Though concentrations of BOD and especially NH4 are lower in this part of the river, the concentrations are sufficient high to create an oxygen deficit in the water.

Implementing two-stage treatment of domestic load on the 1st priority towns will improve the condition. It may meet class II may in Sazliyka River, downstream of Stara Zagora and Radnevo. In the down stream of Radnevo, O2 concentration decreases to Class III or below Class III. As described in above, higher reaeration combined with a reduction in BOD load explains Class II in the upper part of Sazliyka River.

Further improvements of the oxygen condition in Sazliyka river, is achieved by reducing the BOD load from industries and livestock see alternative 3_3 Fig. 3.10.6, however class II is still not met at a stretch close to the conjunction with Maritza river.

Implementing nitrification at the treatment plant in Stara Zagora will improve this situation. The lower part of Sazliyka River also meets class II.

Carrying capacity in Sazliyka River versus future classification

Sazliyka River is the part of the river system in Maritza basin, which is most severely effected by human activities when focused on BOD, NH4 and O2.

Due to the low discharge in Sazliyka River, Class II can not be achieved for NH4, BOD and O2 without special measures in addition to BOD reduction of domestic load.

One way to solve this problem is to accept a higher class in restricted areas of the river. Another possibility is to set up more strict rules for emission of load into this part of the river than for the rest of the basin.

3.10.5 Evaluation of Proposed Alternative Load Reductions

Reduction of domestic BOD

The simulations of the proposed alternatives for reduction of the load in Maritza Basin have reviled that a reduction of domestic BOD from the priority cities without nitrification will result in class II for BOD and O2 in the modeled part of the basin with the exception of Sazliyka River.

For NH4, class II is not reached just down streams the cities of Stamboliyski, Pazardjik and Plovdiv, the lower part of Maritza River, Sazliyka and Harmanliyska Rivers.

The proposed BOD reduction of domestic sources will give class II condition for oxygen except for Sazliyka River.

The proposed alternatives only reducing the domestic BOD do not fulfil the goal for the future water quality in Sazliyka River, Harmanliyska and part of Maritza River.

Reduction of domestic BOD combined with reduction in BOD from industry and livestock

Reduction of the BOD load, which includes the top 10 industries, will improve the BOD classification in Sazliyka to be between class I-III.

Further BOD reduction including top 10-20 industries and livestock in farms will generate class II condition in Sazliyka River. However the class II for NH4 and O2 is not meet in this tributary, as well as these reductions do not apply for class II of NH4 in Harmanliyska

Reduction of BOD from domestic, industry and livestock, and reduction of NH4 from fertilizer factory

Reduction of BOD alone, do not create class II for NH4 and O2 in Sazliyka River or class II for NH4 in lower part of Maritza river.

BOD reduction plus 90 % reduction of NH4 emission from the fertilizer factory will create class II for NH4 in the lower part of Maritza River and improve the situation for NH4 and oxygen in Sazliyka river.

However, class II for NH4 is not met in Sazliyka River, Harmanliyska River and just down stream the cities of Stamboliyski, Pazardjik and Plovdiv.

In Sazliyka River O2 condition is improved but class II for O2 is not fulfilled.

Reduction of BOD from domestic, industry, and livestock, reduction of NH4 from fertilizer factory, and nitrification of domestic load in Stara Zagora and Haskovo

This alternative fulfil the requirements for class II of BOD and O2 in the modeled rivers, however class II for NH4 is still too high in Sazliyka River and down stream of Stamboliyski, Pazardjik and Plovdiv.

Tributaries not covered by the model

The model covers the main Maritza, Sazliyka, Harmanliyska, and lower part of Stryama, Pyassachnik, Luda Yana, Topolnitza, and Chepelarska River.

The model does not cover tributaries such as Vacha, Stara, Pothook, and Chepinska River because of a lack of data availability. These river catchments have several 3rd priority towns, which are indicated by yellow color in Fig. 3.10.4 to 3.10.7.

The reduction of BOD and TN load from these towns will be limited effect, or no effect on the modeled part of the river. The reason is that BOD and NH4 will be mineralized or turned into NO3 when the water enters Maritza River.

However, it is recommended these tributaries be included for the model in the future because towns selected as 3rd priority are located.

TABLE 3.10.1 DAILY AVERAGE LOAD OF BOD, TN, NH4 AND NO3 BROKEN DOWN INTO DIFFERENT TYPES

Type of source	No. or area	Kg BOD/day	Kg TN/day	Kg NH4-N/day	Kg NO3-N/day
Domestic	City + village: 502	47800	8900	4500	1500
Industries	Number: 248	36100	15600	14000	-
Livestock	Pig, Cow, Fowls	20900	13300	9800	-
Non point forest & grassland	Area km2: 8.950		2200		2200
Non point arable land	Area km2: 10.300		7000		7000
Sum		**104800**	**47000**	**28300**	**10700**

TABLE 3.10.2 CRITERIA FOR BULGARIAN WATER CLASSES

Parameter	Class I	Class II	Class III	Beyond Class III
BOD g/m3	Below 5	5 to 15	15 to 25	Over 25
Total NH4-N, g/m3	Below 0.1	0.1 to 2	2 to 5	Over 5
Oxygen g/m3	Over 6	4 to 6	2 to 4	Below 2

TABLE 3.10.3 ALTERNATIVES SET UP FOR MODELING OF WATER QUALITY

(Numbers indicate percent reduction of load)

Alternative	BOD Reduction in %									TN Red. %
	Domestic				Industry			Livestock		2 Fertilizer Industries
	Priority Order			Nitrification	Most Loaded Industry			Farm	Other	
	1st	2nd	3rd		1 - 10	11- 20	other			
2015 or 0_3	0	0	0	0	0	0	0	0	0	0
1_1D	90	0	0	0	0	0	0	0	0	0
1_3D	90	90	90	0	0	0	0	0	0	0
2_3D	90	90	30	0	0	0	0	0	0	0
3_3D	90	30	30	0	0	0	0	0	0	0
1_3	90	90	90	0	30	0	0	0	0	0
2_3	90	90	30	0	30	30	0	30	0	90
3_3	90	30	30	0	90	30	0	30	30	90
4_3	90	30	30	90	90	30	0	30	30	90

TABLE 3.10.4 REDUCTION OF BOD, TN AND NH4-N LOAD ACCORDING TO TREATMENT

Treatment	**BOD Red. %**	**TN Red. %**	**NH4 Red. %**
Primary	30	15	0
Primary + secondary	90	30	8
Primary + sec. + nitrification	90	30	90

TABLE 3.10.5 % REDUCTION IN LOADING IN YEAR 2015 BY DIFFERENT ALTERNATIVES

%	**1995**	**2015**	**1_1D**	**1_3D**	**2_3D**	**3_3D**	**1_3**	**2_3**	**3_3**	**4_3**
BOD	-5	0	-23	-33	-28	-24	-40	-38	-50	-50
TN	-2	0	-3	-3	-3	-3	-9	-36	-38	-38
NH4	-2	0	1	2	2	2	-4	-39	-38	-41

TABLE 3.10.6 BOD CLASSES ACCORDING TO IMPLEMENTED LOAD REDUCTION

III*: beyond class III

River/ tributaries	2015	1_1D	1_3D	2_3D	3_3D	1_3	2_3	3_3	4_3
Maritza upper MU	I-II	I-II	I-II	I-II	I-II	I-II	I-II	I-II	I-II
Maritza mid MM	II	I-II	I-II	I-II	I-II	I-II	I-II	I-II	I-II
Maritza low MD	II-III	I-II	I	I	I	I	I	I	I
Sazliyka	II-III*	II-III*	II-III*	II-III*	II-III*	I-III*	I-III*	I-II	I-II
Harmanliyska	III	I	I	I	I	I	I	I	I
Stryama	I-II	I-II	I	I	I	I	I	I	I
Pyassachnik	I	I	I	I	I	I	I	I	I
Luda Yana	II	II	I-II	II	II	I-II	I-II	I-II	I-II
Topolnitza r.	I	I	I	I	I	I	I	I	I
Chepelarska r.	II	I	I	I	I	I	I	I	I

TABLE 3.10.7 NH4 CLASSES ACCORDING TO IMPLEMENTED LOAD REDUCTION.

III*: beyond class III

River/ tributaries	2015	1_1D	1_3D	2_3D	3_3D	1_3	2_3	3_3	4_3
Maritza upper MU	II-III	II-III	II-III	II-III	II-III	II-III	II-III	II-III	II-III
Maritza mid MM	II-III	II-III	II-III	II-III	II-III	II-III	II-III	II-III	II-III
Maritza low MD	II-III	II-III	II-III	II-III	II-III	II-III	II	II	II
Sazliyka	III*	III*	III*	III*	III*	III*	III-III*	III-III*	III-III*
Harmanliyska	III	III	III	III	III	III	III	III	II
Stryama	II	II	II	II	II	II	II	II	II
Pyassachnik	II	II	II	II	II	II	II	II	II
Luda Yana	III	III	III	III	III	III	III	III	II
Topolnitza r.	II	II	II	II	II	II	II	II	II
Chepelarska r.	II	II	II	II	II	II	II	II	II

TABLE 3.10.8 OXYGEN CLASSES ACCORDING TO IMPLEMENTED LOAD REDUCTION

III*: beyond class III

River/ tributaries	2015	1_1D	1_3D	2_3D	3_3D	1_3	2_3	3_3	4_3
Maritza upper MU	I	I	I	I	I	I	I	I	I
Maritza mid MM	I-II	I-II	I-II	I-II	I-II	I-II	I	I	I
Maritza low MD	I-II	I-II	I-II	I-II	I-II	I-II	I	I	I
Sazliyka	III-III*	II-III*	II-III*	II-III*	II-III*	II-III*	I-III	I-III	I-II
Harmanliyska	II	II	II	II	II	I	I	I	I
Stryama	I	I	I	I	I	I	I	I	I
Pyassachnik	I	I	I	I	I	I	I	I	I
Luda Yana	I	I	I	I	I	I	I	I	I
Topolnitza r.	I	I	I	I	I	I	I	I	I
Chepelarska r.	I	I	I	I	I	I	I	I	I

(See Table 3.10.3)

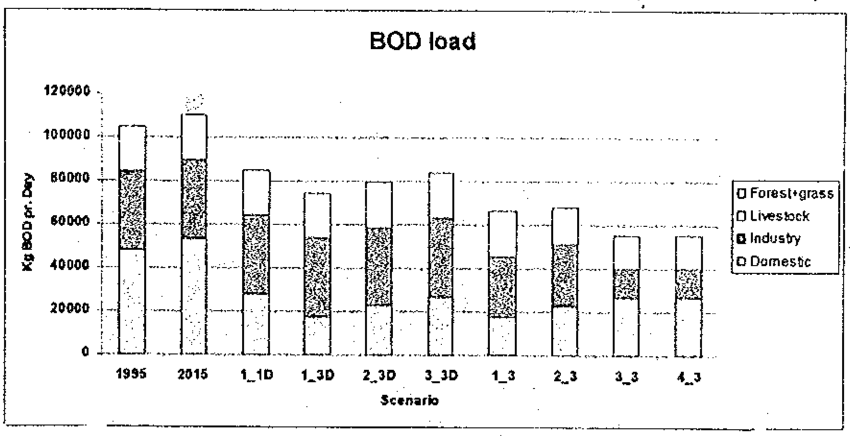


FIG 3.10.1 LOAD OF BOD AS FUNCTION OF DIFFERENT ALTERNATIVES

(See Table 3.10.3)

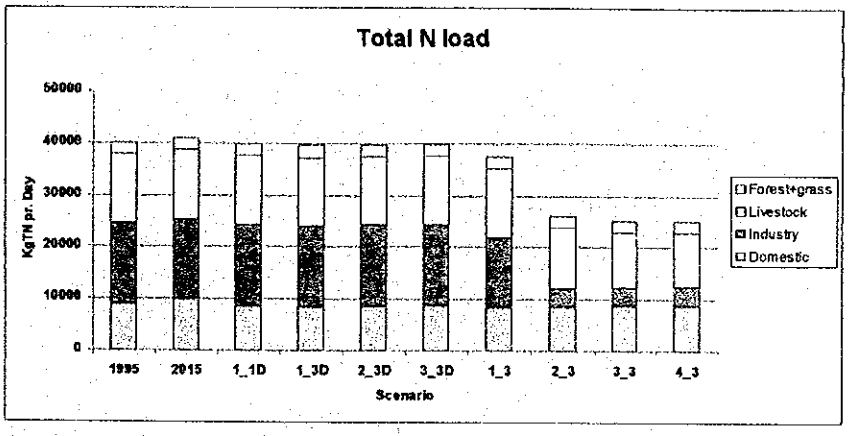


FIG 3.10.2 LOAD OF TOTAL N AS FUNCTION OF DIFFERENT ALTERNATIVES

(See Table 3.10.3)

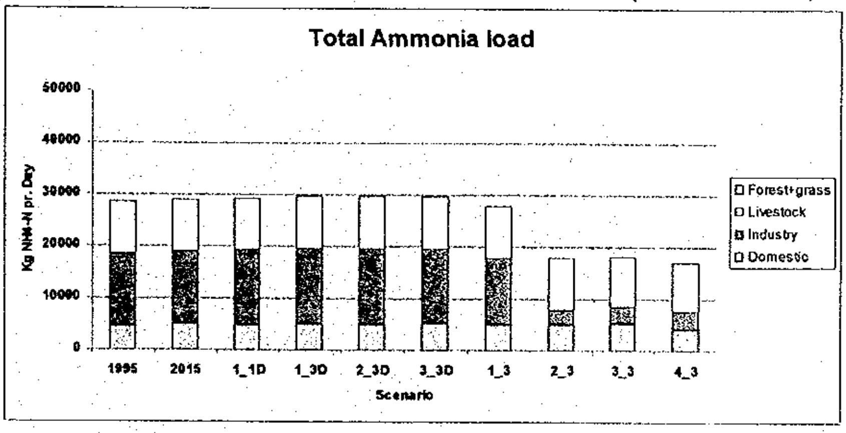


FIG 3.10.3 LOAD OF NH4-N AS FUNCTION OF DIFFERENT ALTERNATIVES

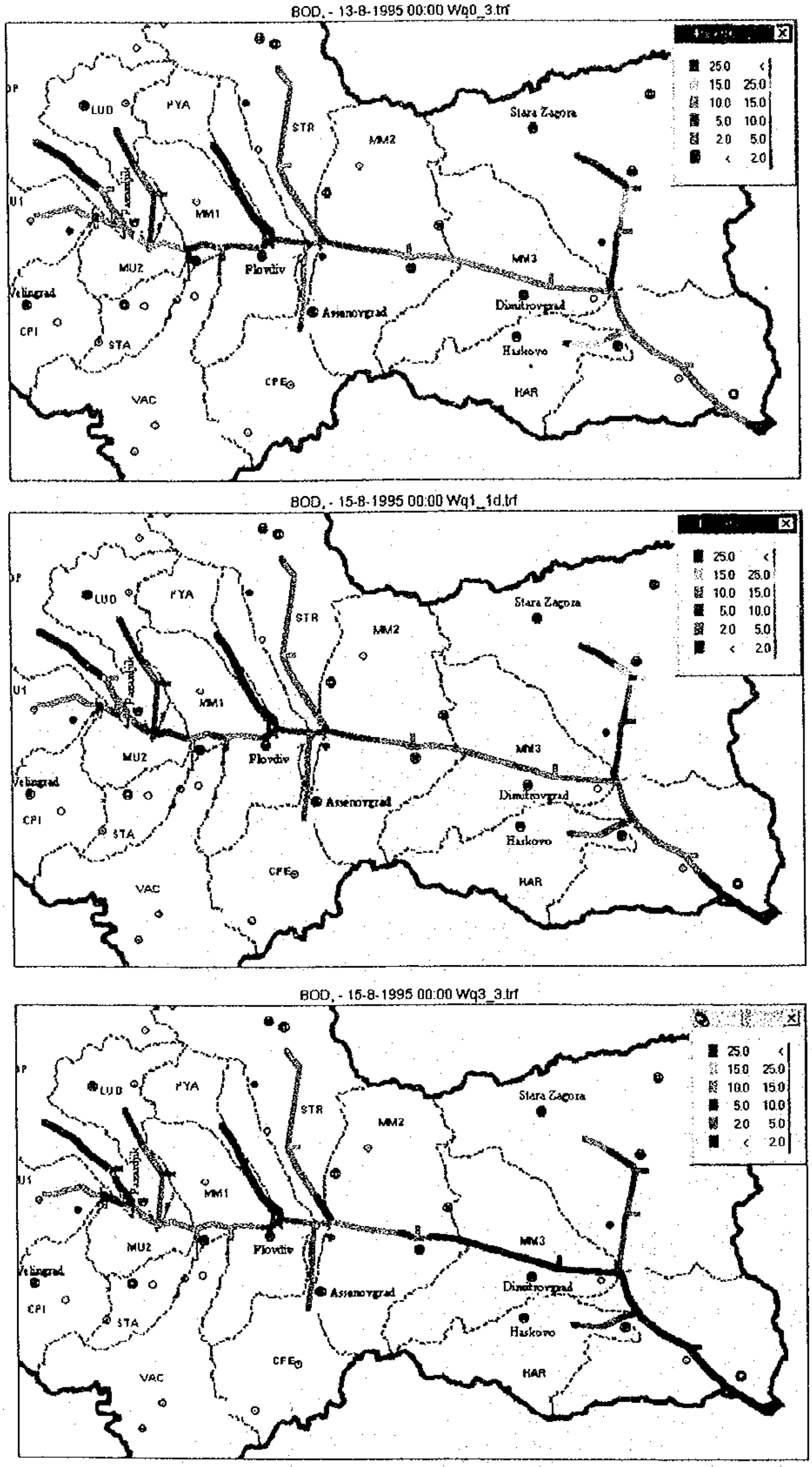


FIG 3.10.4 SIMULATED BOD IN MID OF AUGUST
FOR ALTERNATIVES 2015, 1_1D, AND 3_3

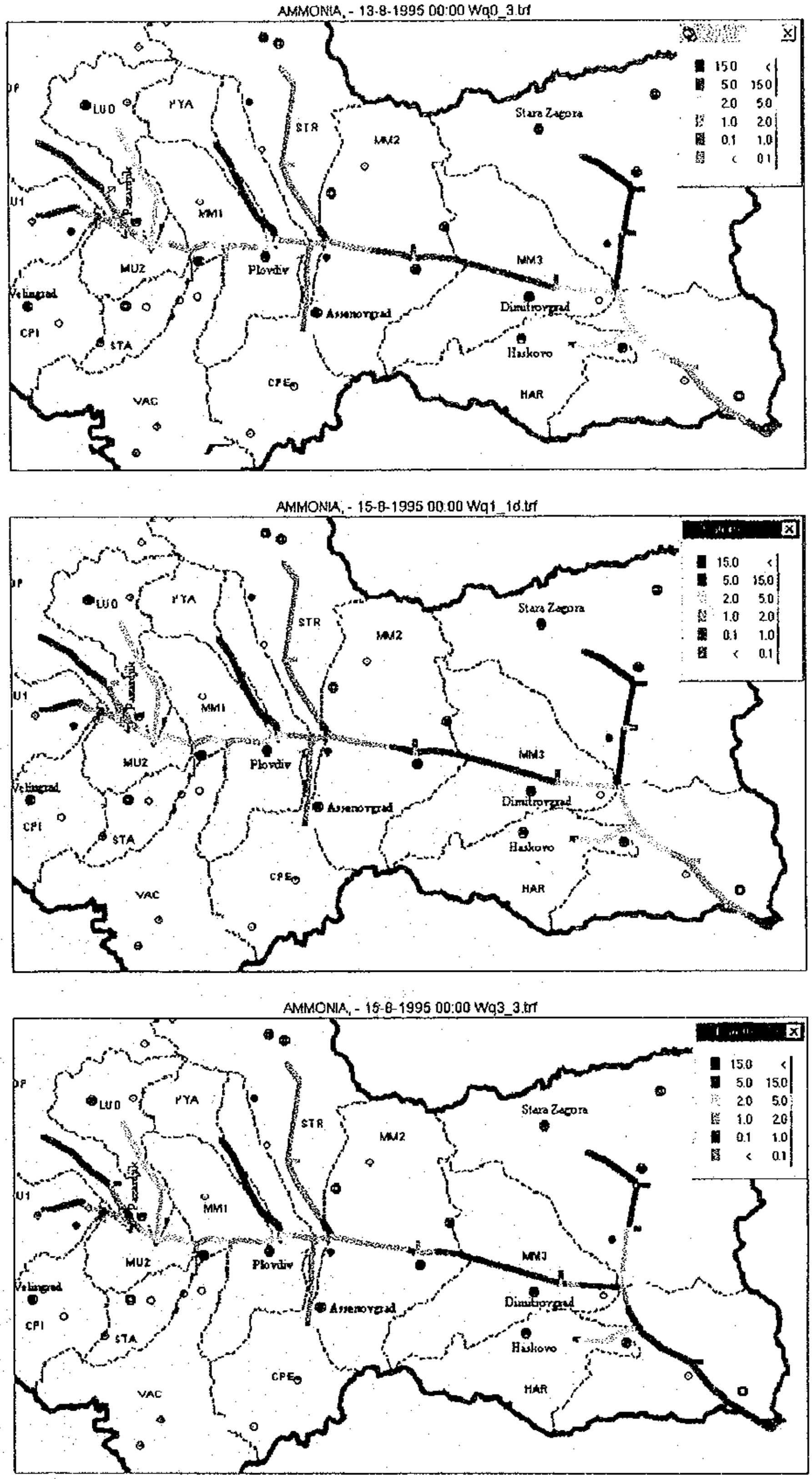


FIG 3.10.5 SIMULATED TOTAL NH4 IN MID OF AUGUST FOR ALTERNATIVES 2015, 1_1D, AND 3_3

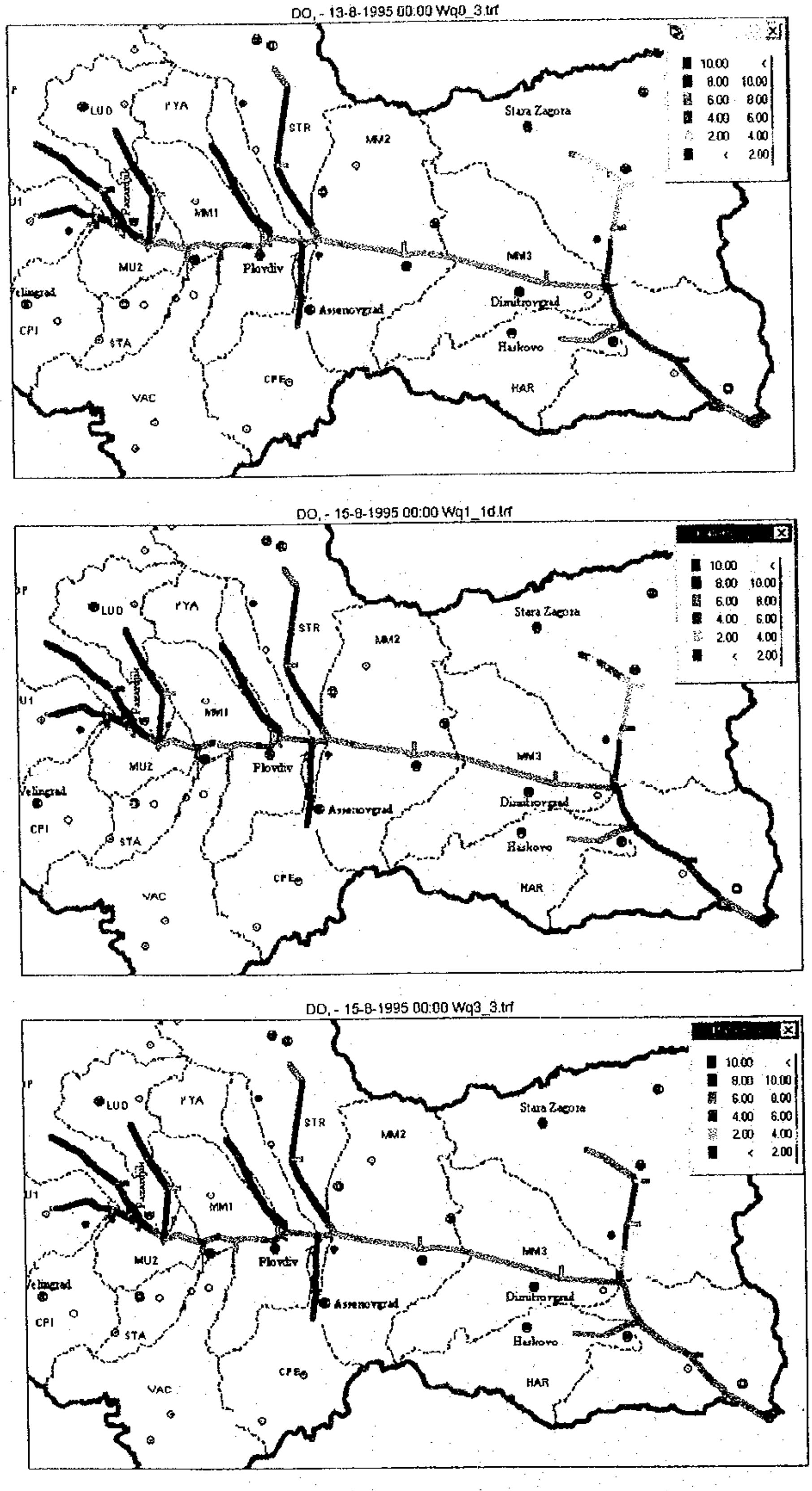
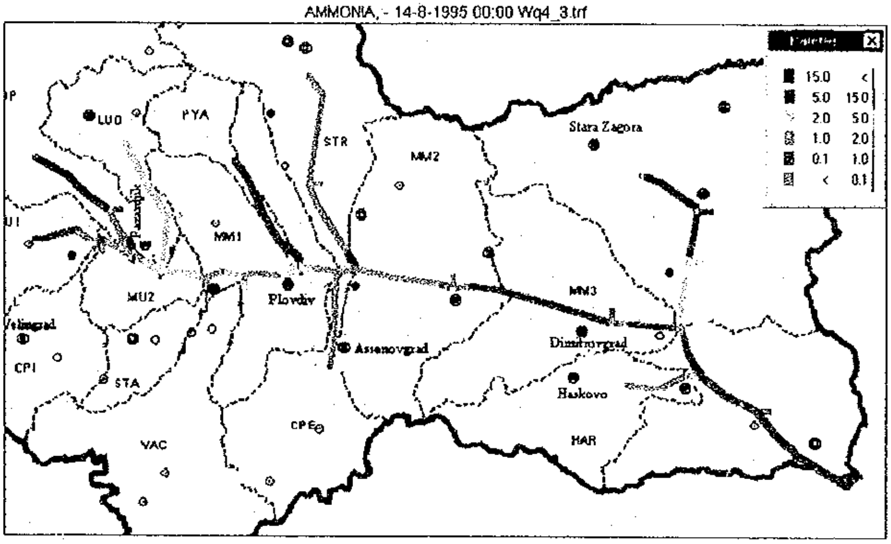


FIG 3.10.6 SIMULATED OXYGEN IN MID OF AUGUST
FOR ALTERNATIVES 2015, 1_1D, AND 3_3

AMMONIA, - 14-8-1995 00:00 Wq4_3.trf



DO, - 14-8-1995 00:00 Wq4_3.trf

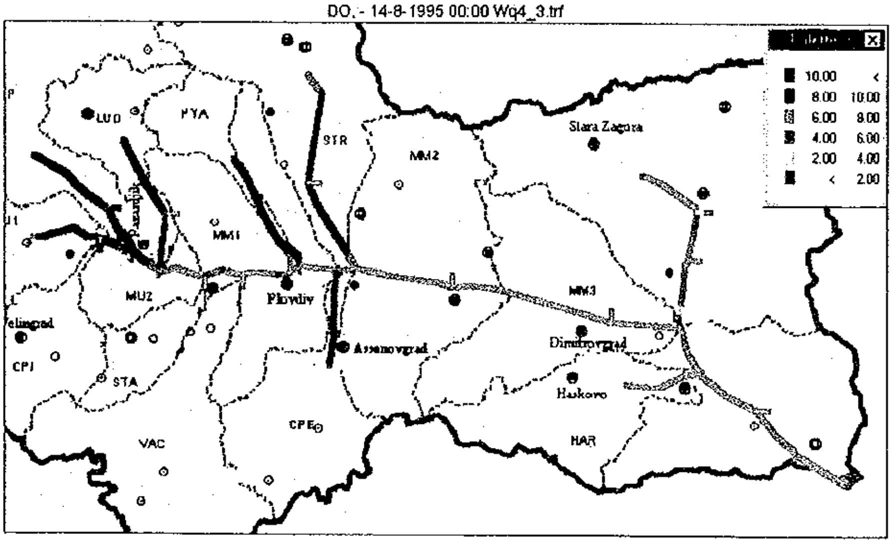


FIG 3.10.7 SIMULATED AMMONIA AND OXYGEN IN MID OF AUGUST FOR ALTERNATIVES 4_3D