E.4 GROUNDWATER AND SOIL

(1) Geochemical atlas project for soil and groundwater

The sampling points of soil and ground water in Geochemical Atlas of Slovakia are shown in Map E.4-1 and E.4-2. Regarding groundwater quality, Map E.4-3,4,5,6 and7 show comparison between the result or this project and the drinking water standard (STN 75 7111) for major indicators of groundwater pollution such as NO3, NH4, As, Cd and Pb.

(2) SHMU groundwater monitoring

The monitoring points of groundwater quality by SHMU is shown in Map E.4-8. Further, longterm change in groundwater quality was analyzed based on the following formula for each elements. These results are shown on the Figure E.4-1,2,3,4,5 and 6.

Cfi = Cai / Cni -1

where

Cfi : contamination factor of i component

Cai : anallytical value of the i-th component

Cni : value of the i-th component permitted by Slovak Standard

(3) Groundwater analysis methodology

To explain methodology of groundwater analysis, flow chart is shown in Figure E.4-7. As the essence of the analysis, groundwater vulnerability analysis was conducted.

(4) Prioritization of Public Water Supply Connection Development

Public water supply (PWS) connection rate in Banska Bistrica Krej is relatively high at more than90%. However, PWS connection rate in Nitra kraj is relatively low at around 70%. Most of the households which are not connected with PWS use shallow groundwater from their own well. To supply clean drinking water for every house by improvement of PWS connection rate in the whole area is highly recommended. The priority and urgency of the PWS development shall be judged based on the following 4 factors.

1) PWS connection rate (P)

2) Current groundwater quality condition (C)

3) Groundwater quality change with time (G)

4) Vulnerability for groundwater contamination (V)

The area which PWS connection rate is low, groundwater condition is bad, groundwater quality is going bad and vulnerability is high, shall be given high priority for the improvement of PWS connection rate. As an example, priority for the PWS connection improvement for each Okres was calculated by using following formula. Ratings, varying from 1 to 10, are intended to reflect the condition of each factor.

Priority rate = P+C+G+V

The calculation result is shown on the Table E-4-1 Priority for Public Water Connection Rate Improvement. As shown on this table, Okres Levice and Nove Zamky is rated bad and priority for PWS connection improvement is high. On the contrary, Okres Brezno and Revuca are rated good and priority is low.

This example was conducted for each Okres levels, but this methodology can be applied for each Obec levels. The rate for each factor in each Obec levels can be estimated from same figure above and priority can be judged by the same method. In this Study, GIS spacial analysis technique was not used for this calculation, but these figures shall be given by digital forms. The estimation of each factor can be calculated by using this GIS spacial analysis technique.

I	able E.4 - 1	Priority for	Public Water (Connection Rate	e Improvement	a an
	PWS Connection Rate	Current groundwater quality	Groundwater quality change with time	Vulnerability	Rating	Priotity
Brezno	4	5	4	3	16	Very low
Banska Bistrica	4	4	4	2	14	Middle
Zvolen	3	3	3	1	10	High
Revuca	3	5	4	5	17	Very Low
Detva	3	3	3	3	12	Middle
Banska Stiavnica	4	2	3	2	11	High
Ziar nad Hronom	4	3	3	3	13	Middle
Zarnovica	4	3	3	4	14	Low
Zlate Molavce	1	4	3	4	12	Middle
Levice	2	2	2	1	7	Very High
Nove Zamky	3	2	2	1	8	Very High

ble E.4 - 1 Priority for Public Water Connection Rate Improvement

Rating table

<connection rate=""></connection>	<groundwater quality=""></groundwater>	<gw change="" quality=""></gw>	<vulnerability></vulnerability>
100% : 5	Very good : 5	Going well :	5 Very Low: 5
90 - 99% : 4	Good : 4	Slightly going well :	4 Low :4
80 - 90% : 3	Moderate : 3	Stable	3 Moderate : 3
70 - 80% : 2	Bad : 2	Slightly going bad :	2 High : 2
less than 70% : 1	Verv bad	Going bad :	1 Very High: 1

(5) Condition of Old Mining Areas

1) Banska Stiavnica

Banska Stiavnica and surroundings are the historical mining area having history of more than 1000 years. The main mineral sources in this area are Au, Ag, Pb, Zn, Sb and Cu. These minerals are produced from ore of sulfide, carbonate and oxide. Most of the mining was stopped in the beginning of 90-ties and only one mining works has been continued in Banska Hodrusa. There is many patchy information about soil and groundwater quality contamination in this area. Highly polluted soils by heavy metals (Pb, Zn, Cd, As and Se) and high acidic soils area found to be distributed in the Alluvial soils in this district (Ref to 16-6). Very High concentration of Zn, Cd and Pb was found in the river sediments (GSSR data). Very strongly acid water came out from some dumps. However, main groundwater discharge to the Hron river through tunnel from the central mining area is pH-neutral and dose not contain heavy metal. Further, many old dumps can be found in this area (some one is recorded some one can only distinguished from topographic features), but many old dump site has been covered by green and can be distinguished slight plant difference from other site.

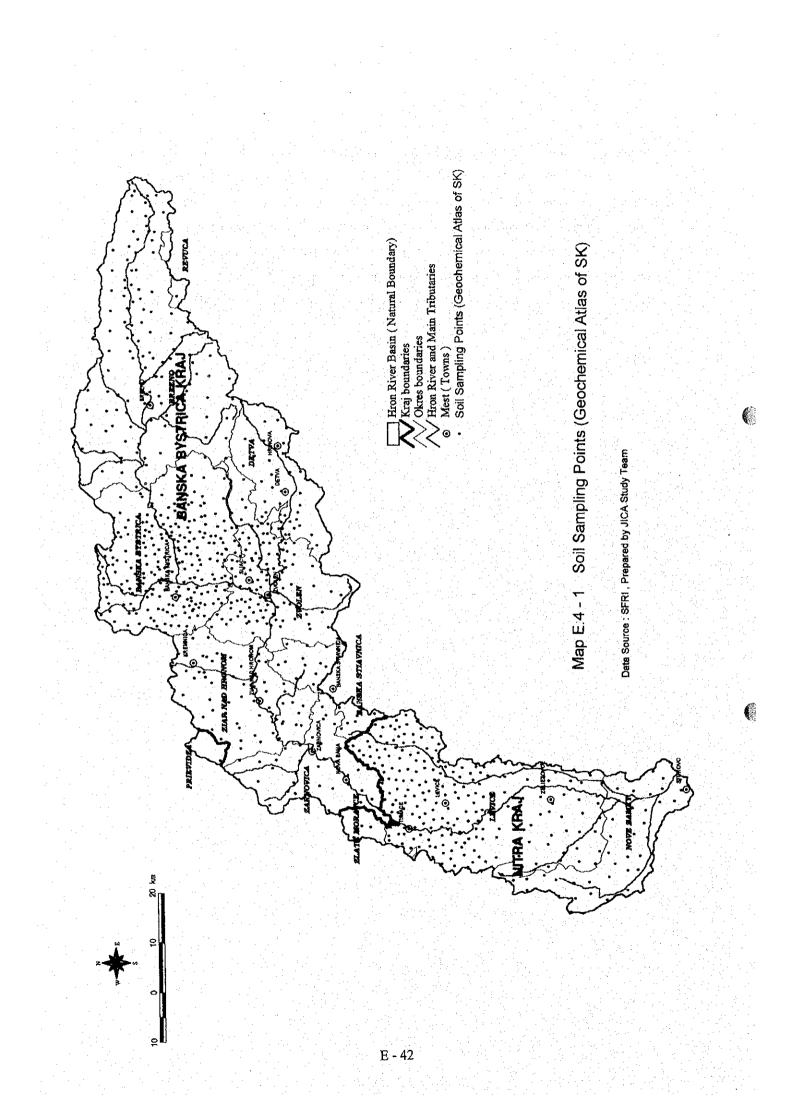
2) Vajskova

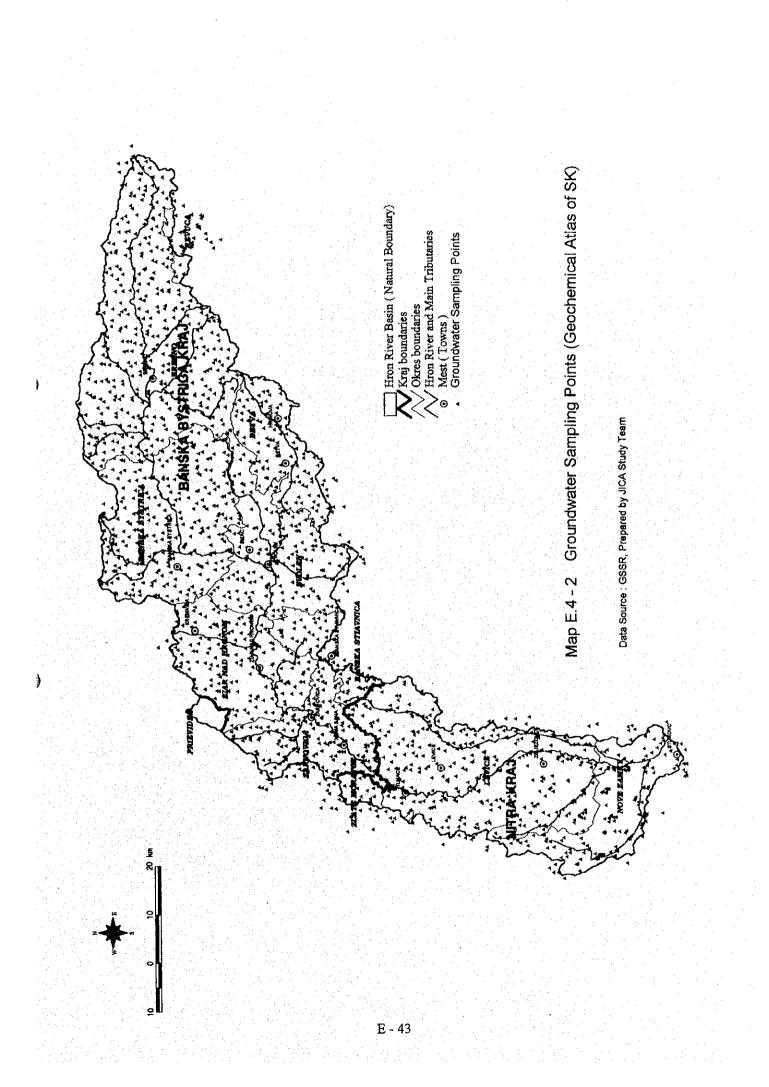
There was big antimony mine and smelting factory in this area. The mining activity has been stopped already. In this site some study was conducted and some contamination by As znd Sb was found in soil and groundwater.

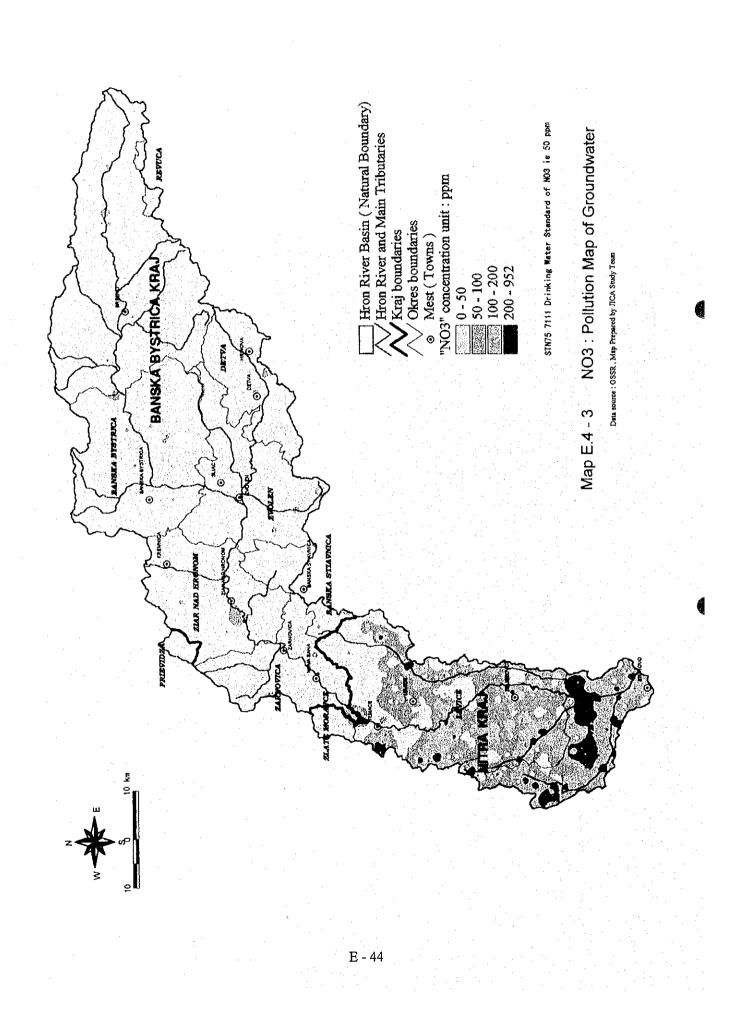
3) Spaia Dolina and Lubietova

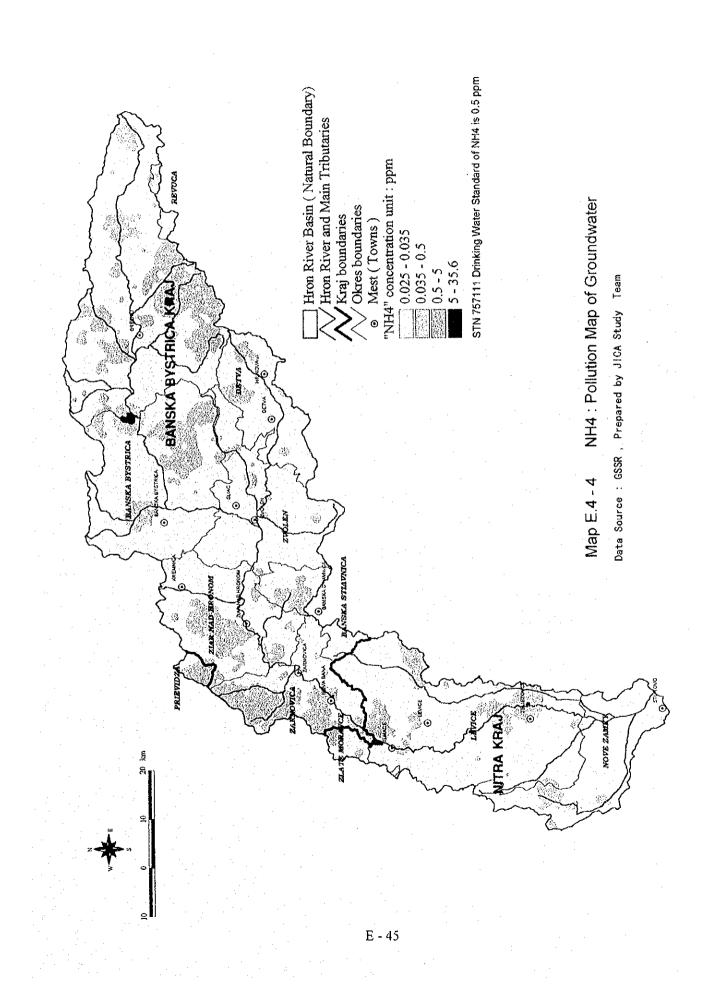
Spania Dolina is a historical mine from 15 centuries but activity has been stopped already. The main products of his mine is copper. The dump in this area is very big because more than 500 years material has been accumulated. However, effluent from this dumping site shows relatively high alkaline and electrical conductivity around 10 000µs/cm. In other countries, most of the mine effluent shows very high acid and it is most harmful matter for the surroundings. However,

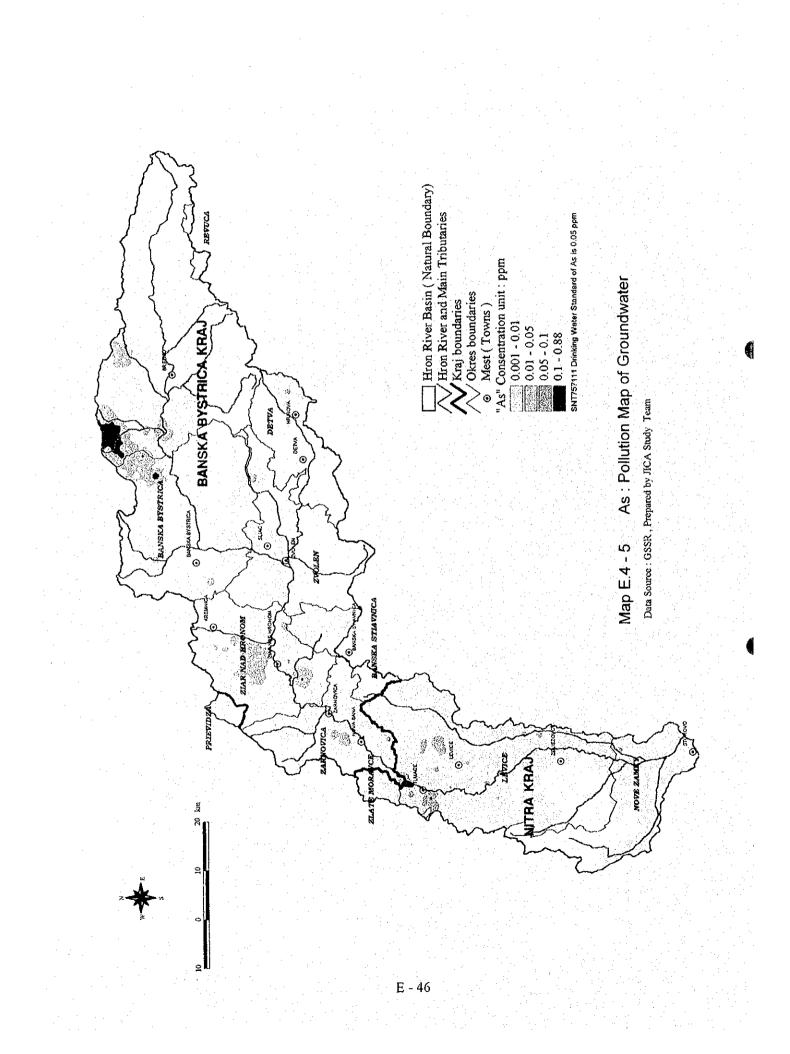
in the study area, only few effluent shows high acidic. There may be only little sulfide in the ore in the study area, it may be the reason of the acidity of effluent from mining dump. Lubietova is also the old historical mine from 15 centuries and it was the one of typical mining site in the western Carpatians. However, also this mining was closed now. The main products of the mine is copper too. It is said that around 2 % of copper has been remain in the mining dump. On the surface of the stone near the dump, some green copper mineral can be found. The concentration of its copper was not clear but it may cause some pollution for the surface water and groundwater.

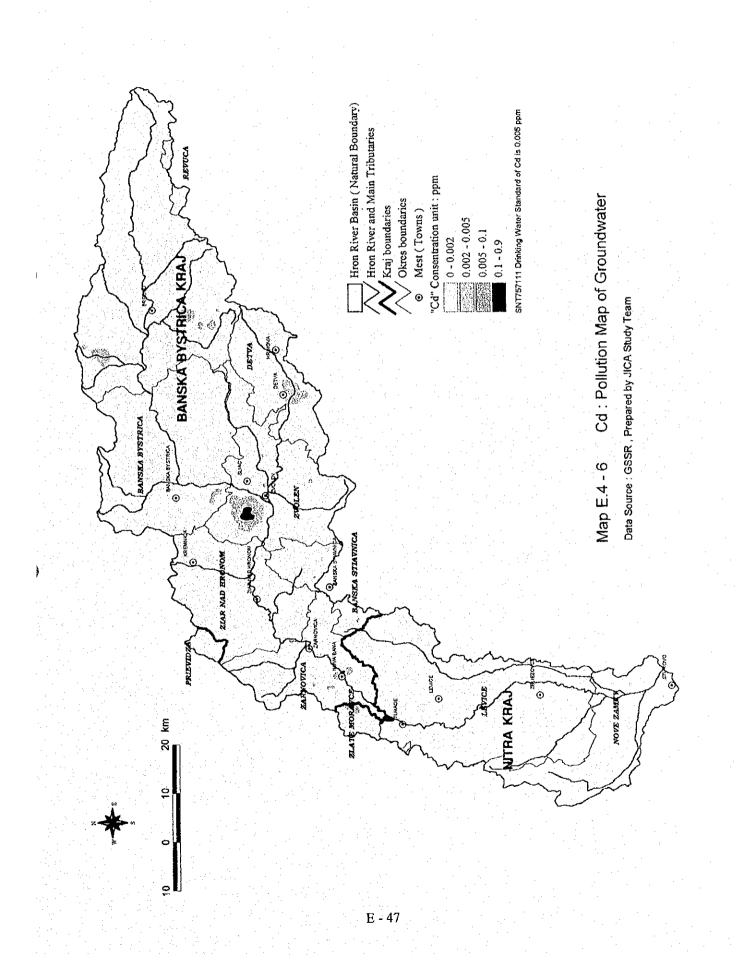


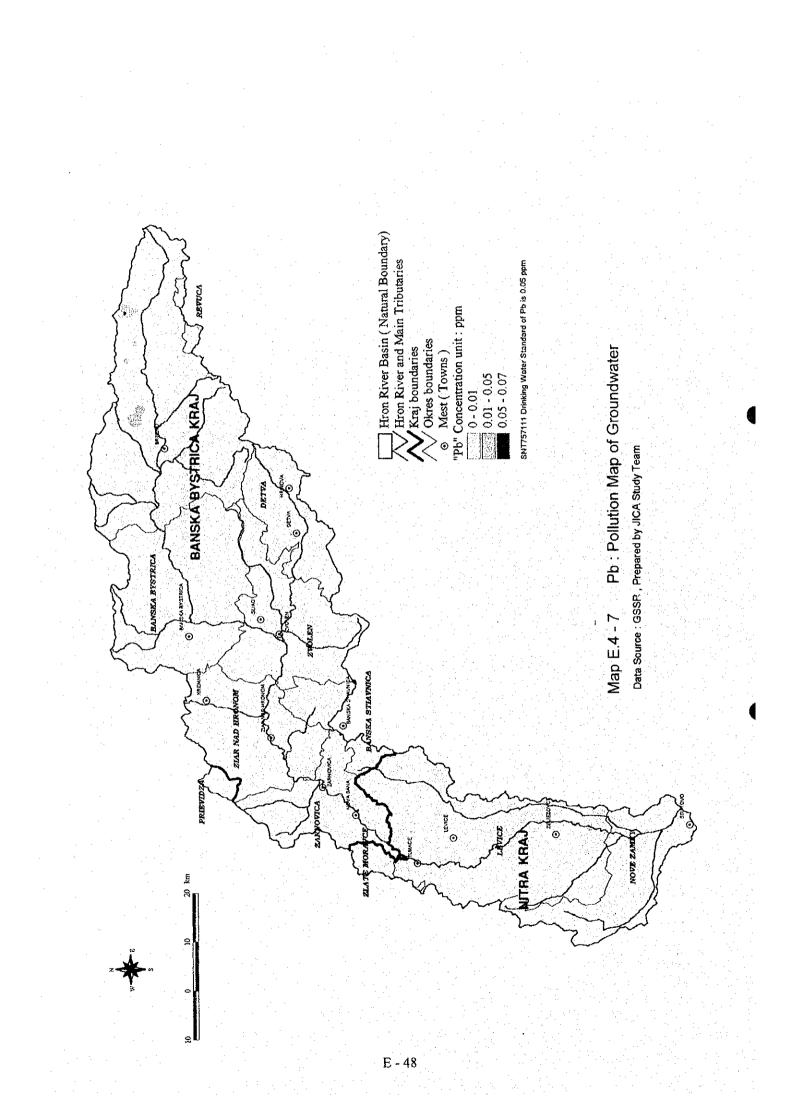


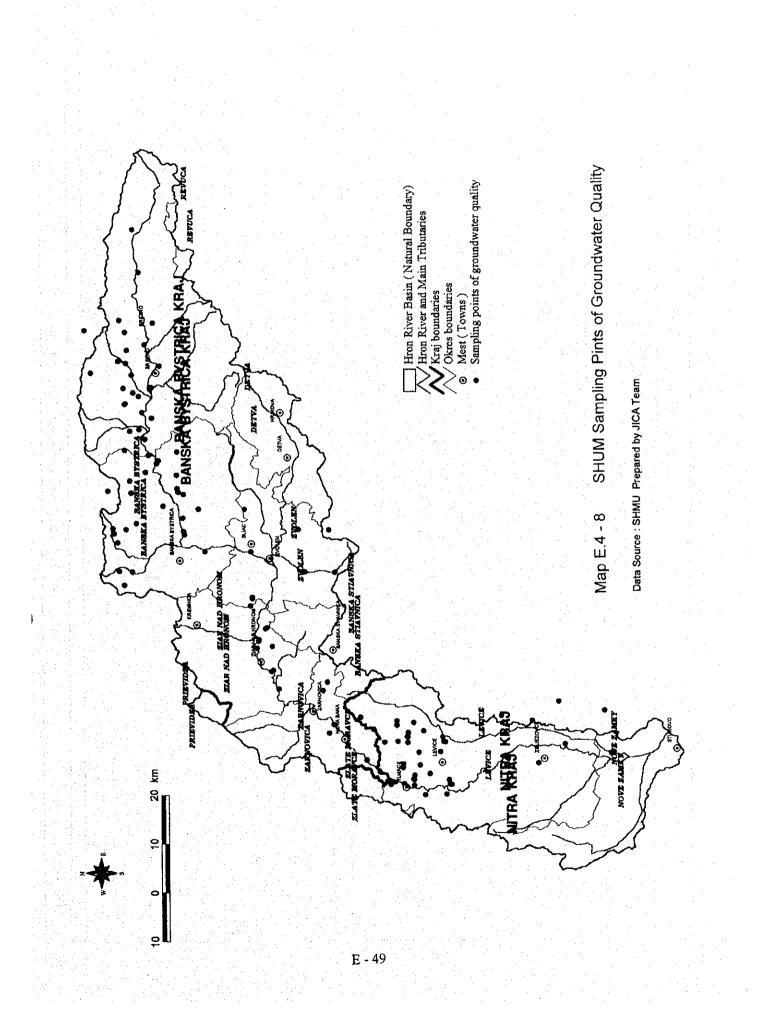


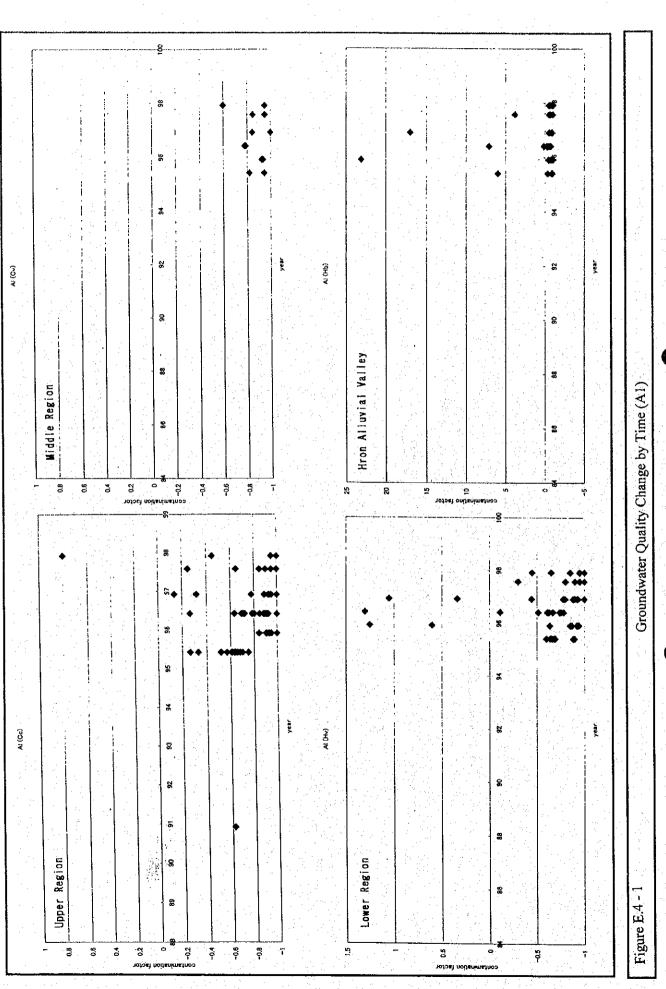


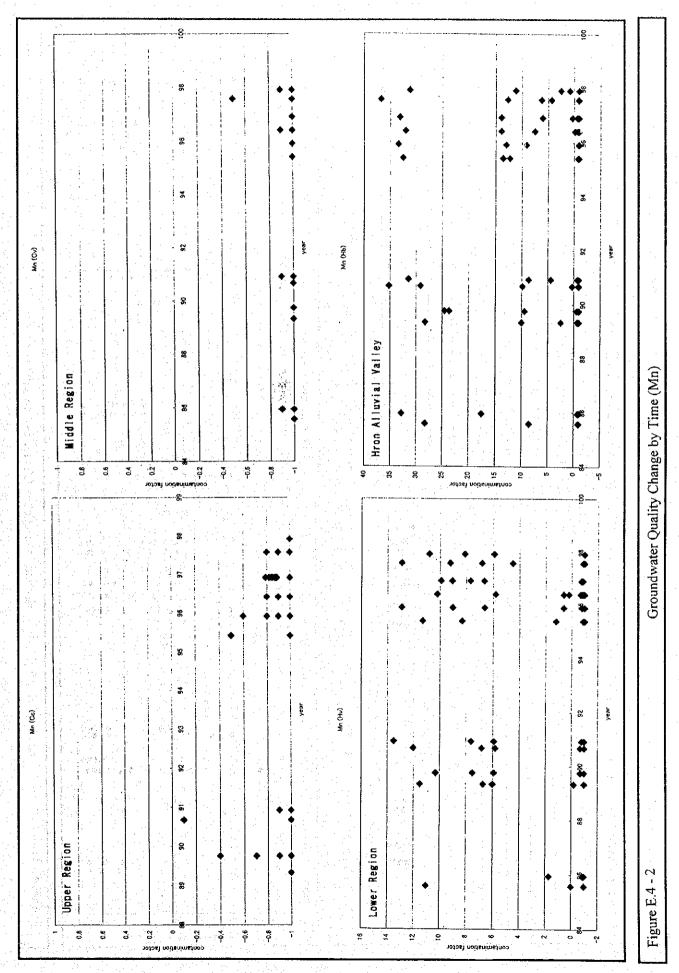




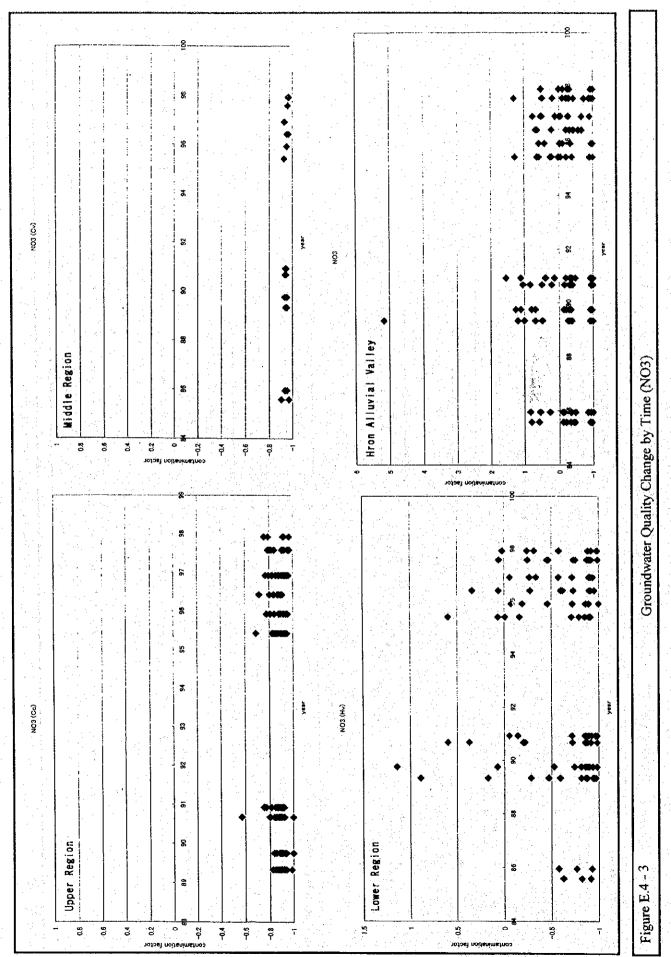








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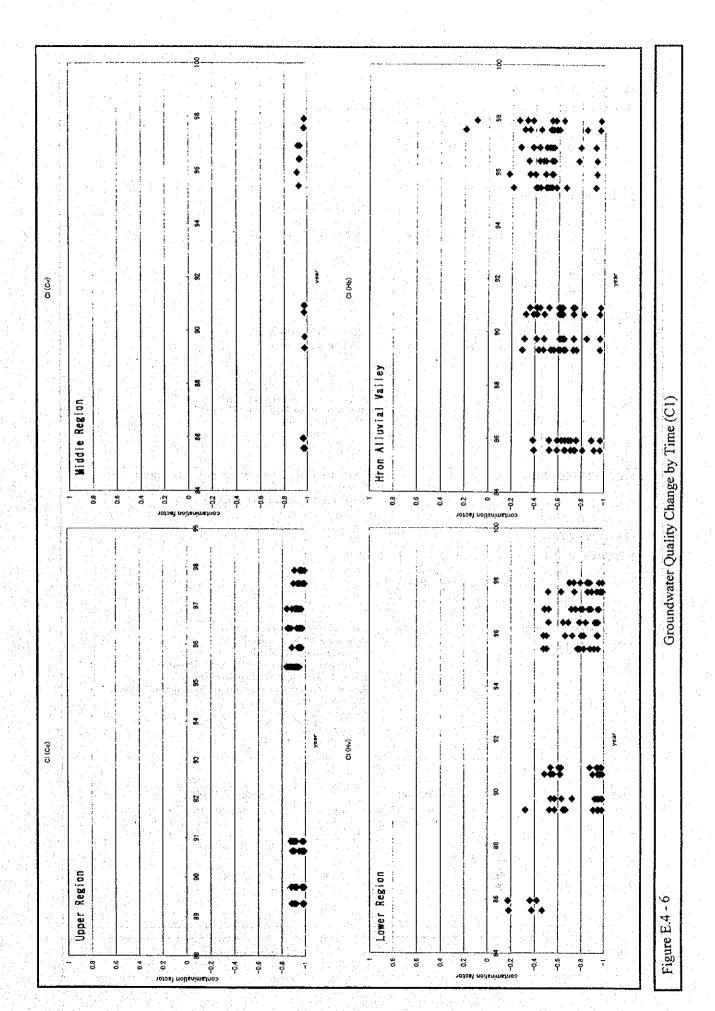
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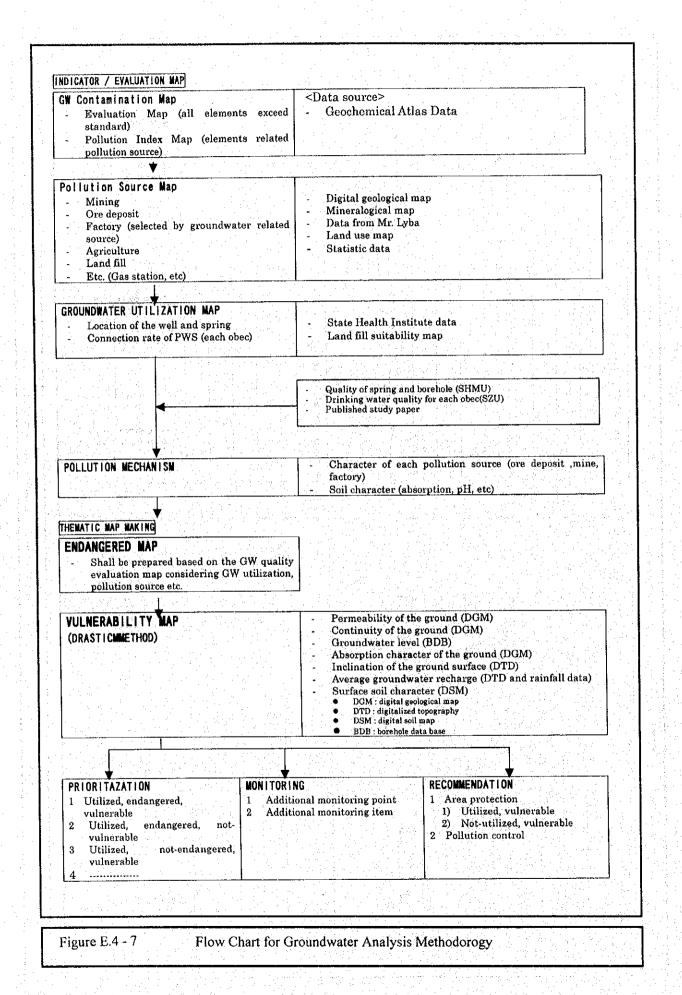
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E.5 ENVIRONMENTAL WATER QUALITY STANDARDS

Comparison of Surface Water Quality Standards Between Slovakia and Japan (No.1) Table E.5 - 1

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Slovakia: STN 75 7221 Classification of Water Quality Japan: Environmental quality standard for water pollution in Japan

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Slovakia, STN 75-7221. Classification of Water Quality Japan, Environmental quality standard for water pollution in Japan

Comparison of Surface Water Quality Standards Between Slovakia and Japan (No.2) Table E.5 - 2

1

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Permissible water quality in surface water based on the Slovak Government Order No. 232/1994	quality in su vernment Or	ter quality in surface water base Government Order No. 232/1994	ased on the 1994	Slovak	Environmentar years, standard for water pollution
· · · · · · · · · · · · · · · · · · ·					in Japan
			Valid	Valid values	
			in water	in other	Valid values for mublic water
		• • •	courses	surface	
Indicator	Symbol	Unit		waters	
Vitrite nitrogen	N-N02-	mg/l	0.005	0.02	U
Nitrate nitrogen	N-NO3-	mg/l	3.4	7)
Fluorides	ц.	1/gmr	0.5] 1	0.8
Cvanides total	cy-	ng/l	*	0.2	*
Mercurv	Ηg	. Ng⊔	0.1	0.5	0.5
Cadmium	Cd	Λgμ	5	10	0.01
Lead	Pb	hgu	20	50	10
Arsenic	As	1/2n	20	50	10
Chromium (VI)	CrIV	Van.	10	20	50
Selenium	Se	hgy	10	50	10
C	70	han.	100	0.05	0.01

* Below the limit of sensitivity of specification

Ē.6 WATER QUALITY NUMERICAL MODEL

1. **OUTLINE OF THE MODEL**

A water quality simulation model for BOD have been established based on the following equation which is a modification of the Phelps equation.

$$Ll = \left(L_u - \frac{L_a}{K_r}\right) \exp\left(-K_r t\right) + \frac{L_a}{K_r}$$

Where,

L: Ultimate BOD (mg/l)

Subscripts .

u: Value at an upstream point 1:

Value at a downstream point

- BOD diminution rate of river water (/day) **K**.:
- $(=K_1+K_3)$
- **K**₁: Diminution rate associating the consumption of dissolved oxygen (/day)
- Diminution rate including sedimentation without consumption of dissolved K₃: oxygen (/day)
- BOD supplied from the river bed (mg/l/day) L_a:

It is difficult to apply the above equation directly for water quality simulation of a river having many inflows from tributaries and drains that frequently increase the river flowrate. Since the above equation can be only applied to a reach with a constant flowrate, many reaches have to be defined in accordance with such inflows.

To simplify and to establish a concrete simulation model, it is assumed that there are many water flows in a reach. These water flows consist of a basic flow from an upper reach, inflows from tributaries and drains, and inflow/outflow of subsurface water, that have constant flowrates. BOD concentration (L) cab be interpreted as the pollution load on the basis of such assumptions. Pollution load of the base flow decreases as it flows down to a lower end of the reach. This change can be simulated by the above equation. Flowrates and pollution loads of water flows are summed up separately for the reach. Finally, the summed pollution load is divided by the summed flowrate to obtain a water quality value at the lower end of the reach.

The concept of the above-mentioned method for the BOD simulation model is described below.

River flowrate Q_n in a reach "n" is described by the following equation.

$$Q_n = Q_0 + \sum_{i=1}^n \left(Q_i + Q_{0i} - Q_{1i} \right)$$
$$Q_i = \sum_{j=1}^n Q_{ij}$$

Where,

Q _n :	River flowrate in a reach "n"
Q ₀ :	River flowrate at the upper end of whole reaches
Q _i :	Total flowrate of inflow tributaries in reach "i"
Qij :	Flowrate of inflow tributary "j"
m :	Number of tributaries in reach "i"
Q_{0i} :	Flowrate of inflow subsurface tributary "j"
Q _{1i} :	Intake volume in reach "i"

Pollution load run-off L_n in reach "n" is described by the following equation.

$$L_{n} = L_{n-1} \exp\left(-K_{m}t_{n}\right) + \sum_{j=1}^{m} L_{nj} \exp\left(-K_{m}t_{nj}\right) + L_{0n} - L_{1n}$$
(1)

Where,

)

i.	L _n ,	Pollution load run-off (ultimate BOD) in reach "n"
	L_{n-1} :	Pollution load of run-off (ultimate BOD) in reach "n-1)
1	L _{ni} :	Pollution load of inflow tributary "j"
	t _n :	Flow time in reach "n"
	t _{ni} :	Flow time from the inflow point "j" to the lower end of reach "n"

$$t_{ni} = d_{ni} / v$$

Where,

Flow length between inflow point "j" and the lower end of reach "n" \mathbf{d}_{nj} : v_n: Average flow velocity in reach "n"

 K_{rn} : BOD diminution rate of river water in reach "n"

 $K_r = K_1 + K_3$

Where,

Deoxygenation coefficient **K**₁ :

K ₃ :	Diminution rate including	sedimentation	without	consumption
	of dissolved oxygen			

- $L_{0n}: \\ L_{1n}:$ Pollution load of inflow subsurface water in reach "n"
 - Pollution load of intake volume in reach "n"

Then, river water quality in reach "n" is estimated by the following equation.

 $C_n = L_n / Q_n$

 C_n :

Where,

Concentration of BOD (uultimate BOD) in reach "n"

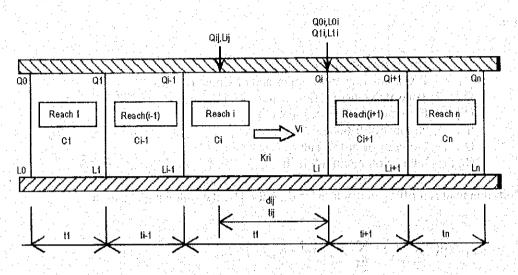


Figure E.6 - 1 Concept of Modelling

Based on the above concept, the study team simulated the annual average BOD concentration of the Hron River in 1996.

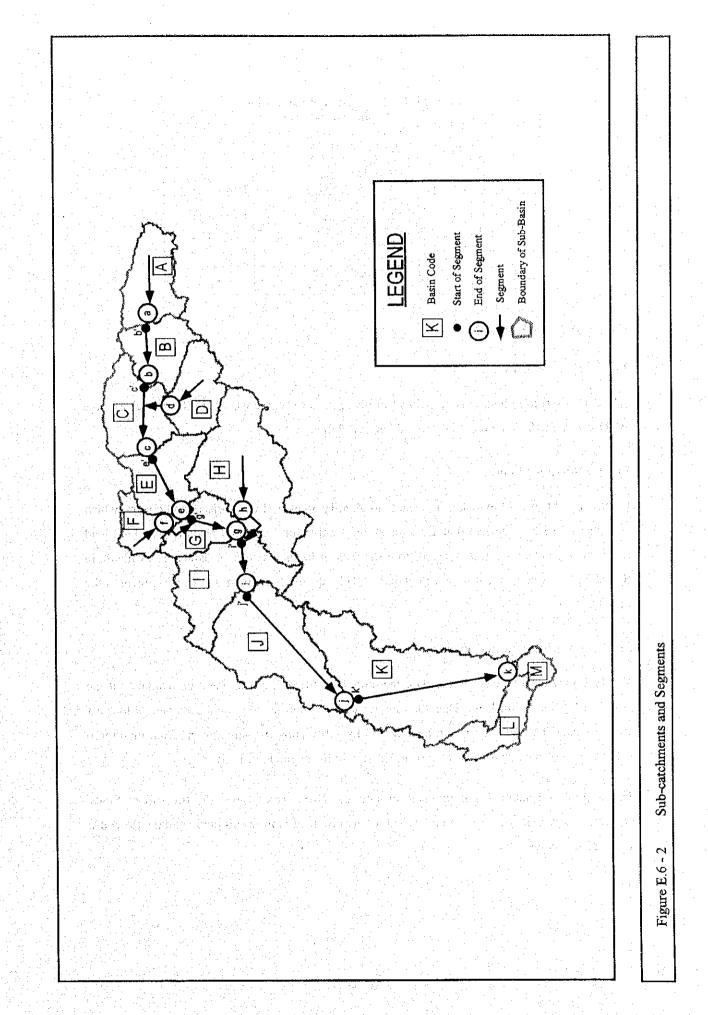
2. MODEL DEVELOPMENT

(1) Catchment Description

The entire basin of the Hron Rive was divided into 13 sub-basins as shown in Figure E.6 - 2 and Table E.6 - 1 in order to evaluate BOD concentration of the main stream which flows through 8 basins of A, B, C, E, G, I, J, and K. The lower ends of each segments are the points of water quality and flowrate measurement conducted by SHMU. These points are also the representative points to evaluate the water quality in these segments:

In this model, the final reach of Hron River Basin is assumed to be "K". Sub-Basins "L" and "M" were ignored, because available flowrate and water quality data at the estuary do not exist for the year 1996.

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Basin	Segment	Representative Point (code of monitoring station)	Remarks
A	source - a	a (6995, R014000D)	
B	b'-b	b (7015, R025010D)	and the second second
C .	C'-C	c (7081, D048000D)	
D	source - d	d (7045, R036500D)	flow into C
e E	e'-e	e (7160, D09510D)	
F	source - f	f (7155, R095020D)	flow into G
G	g'-g	g (n/a, R112000D)	
H	source - h	h (7230, R153500D)	flow into I
- I	i'-I	I (7260, R185000D)	
	j '-j	j (7296, R234000D)	
K	k-k	k (7335, R340000D)	

Data Background

1) Point Sources

(2)

GIS data determines locations of effluent discharging into segments, where the annual average BOD values in 1996 monitored by SUMU are available.

2) Non-point Sources

Corline Land Cover Map makes it possible to identify areas of 4 categorised land covers, which are artificial surface, agricultural area, forest and semi-natural area and wetland. The Unit load for each of 4 categories was referred from the data in Japan because no data were available in Slovakia. It is assumed that these calculated BOD loads are discharged into each segment at the middle.

3) **River Flowrate and Velocity**

Yearly flowrates are based on the data monitored by SHMU, but no data are available at the points of "g" and "h" in 1996. Then the fowrate at "h" was assumed to be the average of the past 10 years data. The data at "g" can be acquired by subtracting the value of "h" from monitored value at "7240" located downstream from "h" (i.e. in the segment of i' - i).

The Report of Danube Environmental Programme Hron River Basin Pre-Investment Study presents a flow-velocity curve. Velocity values are obtained is from this curve and the flowrates as identified above.

4) BOD Diminution Rate (K_r)

The BOD reduction in the river water is described as a function of BOD diminution rate (K_r) and flow time (1). The values of K_r can be estimated by substituting the measured values of BOD and flowrate into Equation (1).

(3) Model Calibration

The values for K_r were determined through the calibration of the model as 0.1 through 0.6 (/day). The value was assumed to be appropriate if the simulated BOD value was within the range of monthly monitored BOD concentration values at each point in 1996.

3. **RESULT OF THE MODEL**

(1) Simulated BOD Concentration

Table E.6 - 2 and Figure E.6 - 3 summarise the result of the simulation after the calibration. The detailed description of each segment is given in Table E.6 - 3 through E.6 - 9.

	S	egment	Data	Obser	ved Data				BOD	D Load in Se	gment		Simulated	Estimated
Basin	From	' To	Distance	Ave. BOD	Flow Rate	Flow Velocity	Kr	Inflow from Previous Basin	Non-point Source	Point Source	Inflow from Other Basin	Tolal	BOD Concentration	Un- monitored Load
	(km)	(km)	(m)	(mg/l)	(m3/s)	(m/s)	(1/day)	(kg/day)	(kg/day)	(kg/day)	(kg/day)	(kg/day)	- (nig/i)	(kg/đay)
8	243.4	223.3	20 100	2.4	8.3	0.8	0.20	921	236	4	0	1 161	1.6	560
C	223.3	200,8	22 500	3.0	14.7	1.0	0.20	1 527	754	386	769	3 436	. 2.7	375
Е	200,8	175.2	25 600	6.0	28.6	1.2	0.10	3 401	685	697	0	4 783	2.0	9 811
G	175.2	154.1	21 100	7.6	30.6	1.3	0.10	14 199	539	2 991	945	18 673	7.1	1 421
	154.1	131.5	22 600	4.4	43.7	0.9	0,59	13 539	932	582	1 484	16 537	4.4	76
J	131.5	74.2	57 300	4.3	50.0	0.9	0.10	14 020	1 421	241	0	15 683	3.6	2 894
K	74.2	10.9	63 300	3.9	53.0	0.9	0.10	12 894	2 477	946	0	16 316	3.6	1 542

Table E.6 - 2 Summary of Simulated BOD Concentration

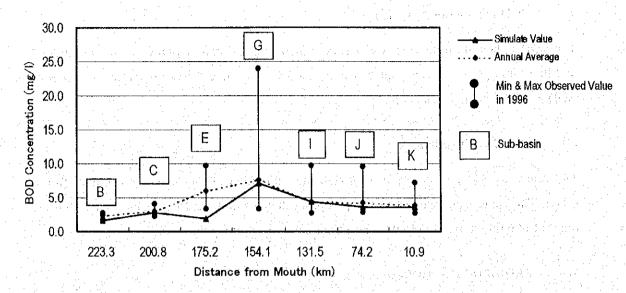


Figure E.6 - 3 Comparison of Simulated and Observed BOD Concentrations

(2) Discussion

1) Basin B (Segment b' - b) and Basin C (Segment c' - c)

Although the simulated values are within the range of observed the data, the monitored load is too small as compared with the estimated un-monitored load. These basins have no large factories and sewerage treatment plants, then un-treated domestic sewage is likely to be a main source of un-monitored load.

2) Basin E (Segment e' - e)

The simulated result at Basin E has a big difference from observed values. And its change in the BOD value from the upper basin is opposite; observed values show increase and simulate one show decrease, although a minimum value of K, was used and the estimated un-monitored load is more than 10 times as much as monitored one. It is evident that a large amount of BOD load remains un-monitored in this basin.

3) Basin G (Segment g' - g)

In this basin, there is no big difference between simulated and monitored values, the estimated un-monitored load was calculated to be about a half of the monitored load. Its source may be direct inflows of un-treated domestic sewage from urbanised area in Banska Bystrica.

4) Basin I (Segment i' - i)

A high diminution rate (K_r) has been applied to this basin as a result of the calibration. It means that this basin has a high self-purification capacity. It seems that un-identified small tributaries inflows exist in this segment.

5) Basin J (Segment j' - j) and Basin K (Segment k' - k)

Although there are no large differences between the simulated and the monitored values of BOD concentration, estimated un-monitored BOD loads are high as compared with other basins. These basins are dominated by agricultural areas, and the BOD unit load might be higher than assumed one.

(3) Conclusion

3

This water quality simulation study was attempted with an original intention of developing a reliable model to be used mainly for evaluating the effects of water quality improvement measures such as strengthening the wastewater treatment. However, it became apparent during this study that more accurate data were needed to develop a reliable model to serve for the originally intended purpose. The most needed data for the improvement of the model are that for BOD load particularly for the sub-basin E (between Dubova and Banska Bystrica). In this section of the Hron River, it is considered that a large amount of BOD load is not monitored and identified yet. It can be said that this finding demonstrated the necessity and usefulness of this kind of model analysis, although this study has not achieved the original purpose.

Table E.6 - 3Detailed Description of Basin B

Basin B				· · ·	e e la companya de la		
From (km)	To (km)		·				
243.4	223.3						
IZIAGI			1	Lanuuse [Area	Unit Load	Non-Point Load
Data				Data	(km2)	(kg/day/km2)	(kg/day)
Flowrate	(m3/day)			Artificial Surface	1.6	3,83	6.17
Velocity	(m/s)	0.8		Agricutural Area	32.1	2.37	76.00
Distance	(m)	20100		Forest & Natural	85.2	2.00	170.44
Kr	(1/day)	0.2	and the second second	Wetland	0.0	0.0	0.00
· .				Total	118.9		252.61
Previous I	Racin						
rievious							
D	terina (n. 1997). Maria ang ang ang ang ang ang ang ang ang an	Flavoreta	DOD	BOD	Flow Distance	Flow Time	BOD Load
Previous	Flowrate	Flowrate	BOD Load	Concentration	and the second sec		at reach
Basin	(m3/s)	(m3/day)	(kg/day)	(mg/l)	(m)	(day)	(kg/day)
A	5.078	438,739.2	1052.97	2,4	20100	0.291	921.0
		450,7 05.21	1002.07	<u> </u>	20100	0.201	
Diffuse So	purce			r			
							BOD Load
			BOD Load		Flow Distance	Flow Time	at reach
			(kg/day)		(m)	(day)	(kg/day)
1. 11 A.		den deren er de			40000	0.44F	
<u> </u>			252.61		10050	0.145	236.2
Point Sou	rce	n an		an a	n de la companya de Esta de la companya de		
				BOD			BOD Load
Hron	GIS No	Effluent	BOD Load	Concentration	Flow Distance	Flow Time	at reach
(km)		(m3/day)	(kg/day)	 Maximum production of the second secon	(m)	(day)	(kg/day)
				(mg/l)			
243.0	7	178.9	3.95		19700	0.285	
Total		178.9	3.9			<u> </u>	3.5
Simulated	BOD at R	each					
	D.11					Estimated	
Previous	Diffuse	Point Source	Other Basin	Total BOD Load	BOD	Un-monitored	(中国) (14)
Basin	Source	(kg/day)	(kg/day)	(kg/day)	Concentration	BOD Load	
(kg/day)	(kg/day)	(3 //			(mg/l)	(kg/day)	
921.0	236.2	35	-	1160.7	1.6		2.4
	1.7	a a cara a c	<u>,</u>	A			
		5,R025010D	Υ . Ι				
		BOD					
Elourato	Elouroto	· · · · · · ·	1. (1)			and the second second second	and the second

Flowrate (m3/s)	Flowrate (m3/day)	BOD Concentration (mg/l)
8.3	717,120.0	2.4

1... m

ŕn.

Table E.6 - 4Detailed Description of Basin C

Basin C	<u></u>
From (km)	To (km)
223.3	200.8

W 334443

Data		
Flowrate	(m3/day)	T
Velocity	(m/s)	1
Distance	(m)	22500
Kr	(1/day)	0.2

and the second			1.10
Lanuuse	Area	Unit Load	Non-Point Load
Data	(km2)	(kg/day/km2)	(kg/day)
Artificial Surface	15,4	3.83	58.98
Agricutural Area	74.6	2.37	176.80
Forest & Natural	282.5	2.00	565.00
Wetland	0.0	0.0	0.00
Total	372.5		800.78

Inflow from Previous Basin

Previous Basin	Flowrate (m3/s)	Flowrate (m3/day)	BOD Load (kg/day)	BOD Concentration (mg/l)	Flow Distance (m)	Flow Time (day)	BOD Load at reach (kg/day)
Bara	8.3	717,120.0	1721.09	2.4	22500	0.260	1526.6

Diffuse Source

2		BOD Load (kg/day)		Flow Distance (m)	Flow Time (day)	BOD Load at reach (kg/day)
		800.78	and the part of the	11250	0.130	754.2

Point Source

 $\mathcal{A} = \mathcal{A}$

Hron (km)	Branch (km)	GIS No	Effluent (m3/day)	BOD (kg/day)	Flow Distance (m)	Flow Time (day)	BOD at reach (kg/day)
221.8		14	11577.6	229.84	21000	0.243	205.5
216.5	1.4	28	426.1	4.38	17100	0.198	4.0
216.2		19	3456.0	15.56	15400	0.178	14.3
214.4		33	1684.8	92.03	13600	0.157	85.6
203.5		46	3888.0	77.75	2700	0.031	76.6
Total			21032.5	419.56			386,0

Inflow from Basin D

	Merge at	Total Flow	Total Flow	BOD Load	BOD	Flow Distance	Flow Time	BOD at reach
	(km)	(m3/s)	(m3/day)	(kg/day)	(mg/l)	(m)	(day)	(kg/day)
L	215.0	3.31	285,984.0	829.35	2,9	14200	0.164	768.9

Simulated BOD at Reach

Previous Basin (kg/day)	Diffuse Source (kg/day)	Point Source (kg/day)	Other Basin (kg/day)	Total BOD Load (kg/day)	BOD Concentration (mg/l)	Estimated Un-monitored BOD Load (kg/day)	
1526.6	754.2	386	768.9	3435.7	2.7	374.5	1

end gen

3.0

Observed Data (7081,D048000D)

Flowrate	Flowrate	BOD
(m3/s)	(m3/day)	(mg/l)
14.7	1,270,080.0	3.0

Table E.6 - 5 Detailed Description of Basin E

Basin E From (km) To (km) 200.8 175,2

River Data			
Flowrate	(m3/day)	Γ	- 1 A.
Velocity	(m/s)		1.2
Distance	(m)	;	25600
Kr	(1/day)		0.1

Lanuuse	Area	Unit Load	Non-Point Load
Data	(km2)	(kg/day/km2)	(kg/day)
Artificial Surface	16.1	3,83	61.66
Agricutural Area	102.7	2.37	243.40
Forest & Natural	210.0	2.00	420.00
Wetland		0.0	0.00
Total	328.8	e de la destructione	725.06

Sec.

Previous Basin

Previous Basin	Flowrate (m3/s)	Flowrate (m3/day)	BOD Load (kg/day)	BOD Concentration (mg/l)	Flow Distance (m)	Flow Time (day)	BOD Load at reach (kg/day)
С	14.7	1,270,080.0	3810.24	3.0	25600	0.247	3599.7

Diffuse Source

		BOD Load (kg/day)	Flow Distance (m)	Flow Time (day)	BOD Load at reach (kg/day)
1. A. A. A. A.		725.06	12800	0.123	704.7

Point Source

Hron (km)	Branch (km)	GIS No	Effluent (m3/day)	BOD (kg/day)	Flow Distance (m)	Flow Time (day)	BOD at reach (kg/day)
192.7	3.0	51	302.4	9.07	20500	0,198	8.7
185.8	0.2	54	1425,6	43.32	10800	0.104	42.3
185.7	1.5	55	432.0	17.29	12000	0.116	16.8
183,8		61	28339.2	654.22	8600	0.083	641.8
181.1	1.2	66	142,6	1.42	7100	0.068	
Total			30641.8	725.32			711.0

Flow from Other Basin

ſ	Merge at	Total Flow	Total Flow	BOD Load	BOD	Flow Distance	Flow Time	BOD at reach
	(km)	(m3/s)	(m3/day)	(kg/day)	(mg/l)	(m)	(day)	(kg/day)
Ī					North Anna Chairtean Anna Anna Anna Anna Anna Anna Anna A		이 문화 목소리가	

Simulated BOD at Reach

Previous Basin (kg/day)	Diffuse Source (kg/day)	Point Source (kg/day)	Other Basin (kg/day)	Total BOD Load (kg/day)	BOD Concentration (mg/l)	Estimated Un-monitored BOD Load (kg/day)	
3599.7	704.7	711	0	.5015,4	2.0	9810,8	6,0

Observed Data (7160, D09510D)

Total Flow	Total Flow	BOD
(m3/s)	(m3/day)	(mg/l)
28.6	2,471,040.0	6.0

Table E.6 - 6 Detailed Description of Basin G

Basin G	
From (km)	To (km)
175.2	154.1

e de poste de la composición de la comp	an an taon an t		Lanuuse		Area	Unit Load	Non-Point Load
River Data				Data	(km2)	(kg/day/km2)	(kg/day)
Flowrate	(m3/day)	1.1 C.A.		Artificial Surface	24.7	3,83	94.60
Velocity	(m/s)	1.3		Agricutural Area	107.5	2.37	254.78
Distance	(m)	21100		Forest & Natural	100.6	2.00	201.20
Kr	(1/day)	0.1		Wetland		0.0	0.00
				Total	232.8		550.58

Previous Basin

Previous B	a 3111					· · · · ·	and the second second
Previous Basin	Flowrate (m3/s)	Flowrate (m3/day)	BOD Load (kg/day)	BOD Concentration (mg/l)	Flow Distance (m)	Flow Time (day)	BOD Load at reach (kg/day)
F	28.6	2,471,040.0	14826.24	6.0	21100	0.188	14198.

Diffuse Source

			BOD Load (kg/day)	Flow Distance (m)	Flow Time (day)	BOD Load at reach (kg/day)
			550.58	10550	0.094	538.8
Point Sour	Ce					

Hron (km)	Branch (km)	GIS No	Effluent (m3/day)	BOD (kg/day)	Flow Distance (m)	Flow Time (day)	BOD at reach (kg/day)
171.5		86	111.5	1.62	17400	0.155	1.6
168,4	3.2	89	51978.2	3094.05	17500	0.156	2985.0
165.6		91	235.6	4.25	11500	0.102	4.1
Total			52325.4	3099.92			2990.7
Flow from	Basin F						

Flow from Basin F

Merge at	Total Flow	Total Flow	BOD Load	BOD	Flow Distance	Flow Time	BOD at reach
(km)	(m3/s)	(m3/day)	(kg/day)	(mg/l)	(m)	(day)	(kg/day)
175.0	3.356	289,958.4	985,86	3.4	20900	0.186	

Simulated BOD at Reach

	Previous Basin (kg/day)	Diffuse Source (kg/day)	Point Source (kg/day)	Other Basin (kg/day)	Total BOD Load (kg/day)	BOD Concentration (mg/l)	Estimated Un-monitored BOD Load (kg/day)	
L	14198.6	538.8	2990.7	944.5	18672.6	71	1420.6	

Observed Data (XXXX, R112000D)

Total Flow	Total Flow	BOD
(m3/s)	(m3/day)	(mg/l)
30.6	2,643,840.0	7.6

7.6

Table E.6 - 7Detailed Description of Basin I

Basin I	
From (km)	To (km)
154.1	131.5

River Data		
Flowrate	(m3/day)	1.05
Velocity	(m/s)	0.9
Distance	(m)	22600
Kr	(1/day)	0.59

Landuse Data	Area (km2)	Unit Load (kg/day.km2)	Non-Point Load (kg/day)
Artificial Surface	15,3	3.83	58.60
Agricutural Area	168.9	2.37	400.29
Forest & Natural	338.1	2.00	676.20
Wetland		0.0	0,00
Total	522.3		1135.09

Previous Basin

Previous Basin	Flowrate (m3/s)	Flowrate (m3/day)	BOD Load (kg/day)	BOD Concentration (mg/l)	Flow Distance (m)	Flow Time (day)	BOD Load at reach (kg/day)
G	30,6	2,643,840.0	20093.18	7.6	22600	0.291	13538.6

Diffuse Source

BOD Load (kg/day)	Flow Distance (m)	Flow Time (day)	BOD Load at reach (kg/day)
1135.09	11300	0.145	931.7

Point Source

Hron (km)	Branch (km)	GIS No	Effluent (m3/day)	BOD (kg/day)	Flow Distance (m)	Flow Time (day)	BOD at reach (kg/day)
154.0	0.0	167	394.5	39.75	22500	0.289	26.8
153,8	1.8	124	4640.4	71.37	24100	0.310	46.8
153.3		138	24239.3	537.75	21800	0.280	367.4
135.0	2.5	118	328.3	8.22	6000	0.077	7.4
135.0	13.5	150	3153.6	179.64	17000	0.219	133.5
Total			32756.1	836.74			581.9

Flow from Basin H

Merge at	Total Flow	Total Flo w	BOD Load	BOD	Flow Distance	Flow Time	BOD at reach
(km)	(m3/s)	(m3/day)	(kg/day)	(mg/l)	(m)	(day)	(kg/day)
154.0	7.07	610,848.0	2199.05	3.6	22500	0.289	1484.3

Simulated BOD at Reach

Previous Basin (kg/day)	Diffuse Source (kg/day)	Point Source (kg/day)	Other Basin (kg/day)	Total BOD Load (kg/day)	BOD Concentration (mg/l)	Estimated Un-monitored BOD Load (kg/day)	
13538.6	931.7	581.9	1484.3	16536,5	4.4	76.5	

Observed Data (7260, R185000D)

Total Flow	Total Flow	BOD
(m3/s)	(m3/day)	(mg/l)
43.7	3,775,680.0	4.4

4.4

Table E.6 - 8 Detailed Description of Basin J

Basin J	
From (km)	To (km)
131.5	74.2

50 4,320,000.0

4.3

River				Landuse	Area (km2)	Unit Load (kg/day/km2)	Non-Point Load
Data				Data			(kg/day)
Flowrate	(m3/day)			Artificial Surface	28.8	3.83	110.3
Velocity	(m/s)	0.9	an an an Anna Anna Anna Anna Anna Anna	Agricutural Area	243.1	2.37	576.1
Distance	(m)	57300		Forest & Natural	430.4	2.00	860.8
Kr](1/day)	0.1		Wetland	0.4	0.0	0.0
Draviava D	Doolo		en genoùezho Geografie	Total	702.7	international de la companya de la c	1547,2
Previous E	basin T	r	lation de la companya de la company Esta de la companya de				
Previous	Flowrate	Flowrate	BOD Load	BOD	Flow Distance	Flow Time	BOD Load
Basin	(m3/s)	(m3/day)	(kg/day)	Concentration			at reach
Dasin		(IIIS/uay)	(ny/uay)	(mg/l)	(m)	(day)	(kg/day)
	43.7	3,775,680.0	16612.99	4.4	57300	0.737	14020
Diffuse So	urce						
		, and a star to the		and the second second			BOD Load
			BOD Load		Flow Distance	Flow Time	at reach
n en ser ser ser			(kg/day)		(m)	(day)	(kg/day)
			1547.25		28650	0.368	(kg/uay) 1421
Point Sour			1017120		<u></u>		1.166.1
	r						an a
Hron	Branch	GIS No	Effluent	BOD	Flow Distance	Flow Time	BOD at read
(km)	1 5 (km) 1975		(m3/day)	(kg/day)	(m)	(day)	(kg/day)
128.9		155	11059.2	142.96	54700	0.703	121.
126.8		154	5616.0	50.55	52600	0.676	43.
118.0		158	259.2	12.96	43800	0.563	11
115.3	5.1	162	406.1	22.85	46200	0.594	19
115.3	2.1	163	639.2	4.47	43200	0.556	3
106.3	2.7	173	840,3		34800	0.448	3.
106.1		169	259.2	20.74	31900	0.410	18
93.2		178	2160.0	19.45	19000	0,244	18
Total			21239.1	277.67			240
Flow from	Other Basin	an a					
Merge at	Total Flow	Total Flow	BOD Load	BOD			
(km)	(m3/s)	(m3/day)	(kg/day)	(mg/l)	Flow Distance	Flow Time	BOD at read
(i)ii).	(mors)	(morday)	(Ky/uay)	(mgn)	16 (m) 16 6	(day)	(kg/day)
		-	-		-	anti a serencia. A tradicio de la composición de la comp	•
Simulated	BOD at Read	:h					
Previous Basin (kg/day)	Diffuse Source (kg/day)	(kg/day)	Other Basin (kg/day)	Total BOD Load (kg/day)	BOD Concentration (mg/l)	Estimated Un-monitored BOD Load (kg/day)	
14020.4	1421.4	240,7	0	15682.5	3.6	2893.5	4
Observed	Data (7296, F	R234000D)					
Total Flow (m3/s)	Total Flow (m3/day)	BOD (mg/l)	· · · · · · · · · · · · · · · · · · ·				
	4 000 000 0		la de la de la	a de la complete de l	 Mathematical 		an a

Table E.6 - 9 Detailed Description of Basin K

	Basin K		•
-	From (km)	To (km)	
	74.2	2 10.9	
1	/4.2	<u>10.9</u>	

	and the second second	ga tradenti.		Lane
River Data			an a	Data
Flowrate	(m3/day)			Artific
Velocity	(m/s)	0,9		Agric
Distance	(m)	63300		Fores
Kr	(1/day)	0.1		Wetla

Landuse Data	Area (km2)	Unit Load (kg/day/km2)	Non-Point Load (kg/day)
Artificial Surface	65.5	3,83	250,87
Agricutural Area	915.3	2.37	2169.26
Forest & Natural	150.2	2.00	300,40
Wetland	2.2	0.0	0.00
Total	1133.2		2720.53

Previous Basin

Previous Basin	Flöwrate (m3/s)	Flowrate (m3/day)	BOD Load (kg/day)	BOD Concentration (mg/l)	Flow Distance (m)	Flow Time (day)	BOD Load at reach (kg/day)
J	50	4,320,000.0	15552.00	3.6	63300	0.814	12893.8

Diffuse Source

		BOD Load (kg/day)		Flow Distance (m)	Flow Time (day)	BOD Load at reach (kg/day)
		2720.53	a an ar an	31650	0.407	2477.1
Point Sour	<u>^</u>					

Point Source

I OILL OVUI	Men ya ana ba ana a			法公司公司 化二乙基乙烯			요즘 것을 다 보물 것이.
Hron (km)	Branch (km)	GIS No	Effluent (m3/day)	BOD (kg/day)	Flow Distance (m)	Flow Time (day)	BOD at reach (kg/day)
73.4		183	1909.4	79.42	62500	0.804	66.0
62.2		186	302.4	8.47	51300	0.660	7.3
54.2	2.2	188	35424.0	956.44	45500	0.585	835.9
40.9	1.5	196	1356.5	28.77	31500	0.405	26.2
36.8		189	60.8	0.79	25900	0.333	0.7
14.7	12.3	212	13.8	9.81	16100	0.207	9.4
Total			39066.9	1083.7			945.5

Flow from Other Basin

Flow from	Uther Basin		이 공장에 가지?				
Merge at	Total Flow	Total Flow	BOD Load	BOD	Flow Distance	Flow Time	BOD at reach
(km)	(m3/s)	(m3/day)	(kg/day)	(mg/l)	(m)	(day)	(kg/day)
1월 1688 B				•	an an a r a bhairt	an an an ' airs an an	

Simulated BOD at Reach

Previous					BOD	Estimated	
Basin	Diffuse Source			Total BOD Load	Concentration	Un-monitored	
(kg/day)	(kg/day)	(kg/day)	(kg/day)	(kg/day)	(mg/l)	BOD Load (kg/day)	
12893.8	2477.1	945,5	0	16316.4	3.6		3

Observed Data (7335, R340000D)

	Total Flow	
(m3/s)	(m3/day)	(mg/l) 3,9
53	4,579,200.0	-

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國家研究的總統統

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E.7 INVESTMENT PROGRAMMES OF POVODIE HRONA AND STVAK

EXPLANATORY TEXT

1.

The Study Team received English translations of the ongoing and proposed investment programmes of Povodie Hrona (Tables E.7 - 1 to E.7 - 3) and StVaK (Table E.7 - 4) only at the very end of the study (after completion of work in Slovakia) – and no comparable information for the lower part of the Basin was obtained from ZsVaK. Therefore there was no time to evaluate and discuss these proposals with the staff of these organisations, nor to compare the proposals with the findings and proposals of the REMP study. Nevertheless these investment programmes are included in the REMP report, at the request of SVP OZ PH and StVaK and to provide an indication of the scale of the investment required in the water sector in the Hron River basin.

Because evaluation (technical, environmental and financial) of these investment programmes was not undertaken, it must be stated that inclusion of these tables in the REMP report does <u>not</u> imply that the Study Team supports all the proposals and cost estimates. Any engineering works on streams and rivers to regulate their flow will require consideration of any negative environmental impacts, including flood risk. Even proposed works to improve ecological conditions in the lower part of the Basin will need to be designed carefully, and to include monitoring programmes, to ensure that they have the desired positive impact. Similarly the Study Team cannot endorse the prioritisation of the wastewater schemes implied by Table E.7 – 4. Nevertheless the results of the REMP Study Team do concur with the message conveyed by Table E.7 – 4, that Banska Bystrica STP and sewerage connections are a priority and that significant investment in wastewater treatment systems is required within the Basin. Table E. 7 - 1 Investment Programme of Povodie Hrona for the year 1999

								· · ·		
No	Name		Date (month.year)	(I	Fulli	Full investment cost	nt cost	Finan	Financial need in year 1999	year 1999
			Start – finish		(ti)	(thousand Sk)	Sk)		(thousand Sk)	Sk)
	Construction starting before 1.1.1999									
1.	MVE (Small hydro-power station) Zvolen		11.97 - 12.99				84 254			41 304
2.	Lukavica, regulation of stream, Lukavica		11.97 - 11.99	idi a			5.154			3 196
	Construction to start in year 1999			1					· .	
	Belianska Reservoir, reconstruction		10.99 - 10.01				11 000			1 000
2.	Hrinova Reservoir, reconstruction of manipulation(?)		08.99 - 10.99				427			400
	equipment	1		· · ·				- - -		
	Preparatory work					:				
	Vlkanová – Radvan, antiflood protection									300
5	Brezno, roof for operations department						- *		•••	15
3.	Ziar nad Hronom, extension of operations department	· · ·			in Viet Je		 			235
4.	Zvolen, restoration of the Slatina River									150
5.	Hrinova Reservoir, fish management - heating of water			 · ·					· . ·	20
	Other investment needs			 						
 i	Kamenín, Ziar nad Hronom+MVE (Small hydro-power									468
	station) channelling of Hron									
2	Lukavica - Dolná Miciná, regulation of Lukavica stream									70
3.	Kyncel'ová, regulation of Senického stream							-		S
4	Waterworks Dobrá Niva, limnographic station						and the second			30
5.	Reservoir Dobrá Niva			1						50
6.	Reservoirs in the area of Banska Stiavnica									50
	Summary						100 835			47 293

Source: Povodie Hrona Banská Bystrica, October 1999

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Table E.7 -2 Proposed Investment Programme of Povodie Hrona for the year 2000

°,		Date (month.year)	Full investment charge	Financial need in year 2000
•		start – finish	(thousand Sk)	(thousand SK)
	Construction starting before 1.1.2000			
1.	Belianska Reservoir-reconstruction	10.99 - 10.01	11 943	5 000
	Construction start ing in year 2000			
1	PH BB - VhR, reconstruction of store rooms	05.00 - 11.00	350	350
1	Brezuo, roof of operations department a second s	05.00 - 10.00	433	420
m.	Psiare, prevention of seepages through OH(?)	06.00 - 10.01	2 500	400
4	Hrinová Reservoir, fish management - heating of water	07.00 - 10.00	140	120
S.	Waterworks Velké Kozmálovce, fishway for the Hron	08.00 - 09.01	3 100	2 500
9	Zvolen, pollution control equipment (e.g. ?boom for oil spill	07.00 - 11.00	1 960	1 950
	containment/arrestment for the Hron)			
1	Tek. Brezuica, pollution control equipment (e.g. ?boom for oil spill	08.00 - 11.00	3 556	3 556
-	containment/arrestment for the Hron)			
8.	Sokolec, pollution control equipment (e.g. ?boom for oil spill	08.00 - 11.00	1 927	1 927
	containment/arrestment for the Hron)			
- * 	Preparatory Work	· · ·		
1.1	Vlkanová – Radvan, autiflood protection for the Hron			400
<u>1</u>	Zvolen, Restoration of the Slatina River			200
3.	Ziar nad Hronom, Extenion of operations department, PH			100
4.	Zeliezovce, ecological water management systems for the Hron			300
5.	Hrinová, regulation of River Slatina as far as Reservoir			150
6	Windšachtská Reservoir – reconstruction			500
۲. ۲	Rozgrund Reservoir-reconstruction			300
<u></u>	Dobrá Niva waterworks, operational equipment/department of PH	-		150
	Summary	-	25 909	18 333

Source: Povodie Hrona Banská Bystrica, October 1999

Table E.7 - 3 Investment Proposals of Povodie Hrona until 2005

No.	Name	Year	Full investment
		Start – finish	charge (mil. Sk)
	Psiare – reconstruction of stream regulation (engineering works) on the river Hron	1998-2000	20,0
2.	Zvolen -improvement of the flow of the Slatina	1998-2001	60,0
Э.	B. Bystrica-Kremnièka – channel regulation of the River Hron (?to be	1000 7001	C CC
4	developed by the regional centre for B.Bystrica-Lyoten) Waterworks Slatinka on the River Slatina	1998-2001	30,0 2 700,0
5.	Protective measures for the regeneration of the branches of the lower		
	River Hron at Kamenin, Biôa	1999-2002	45,0
9	Reconstruction and landcaping of Podlu ianky	1999-2002	60,0
7.	B. Bystrica protection of floodplain (town area) Stage I (Srnková - division area)	1999-2002	80,0
%	B. Bystrica protection of floodplain Stage II	2000-0004	300.5
	(Alternative II - water management only		800,0
6	Hroneek Waterworks on the Kamenistý potok (brook)	2000-2003	2 900,0
10.	Sliaè – Vlkanová – stream regulation (engineering works) on the river		
	Hron (to be developed by the regional centre for B.Bystrica-Zvolen)	2001-2004	60 , 0
11.	Brezno - protection of intravilan (town area) and protective measure		
	of water basin of the river Hron	2001-2004	50,0
12.	Bíða – Pohronský Ruskov, improvement of the flow	2002-2005	100,0
13.		2002-2005	0,06
14.	F 1 1	2003-2005	30,0
	works) on the river Hron		
15.		2005	30,0
			7355,0

Source: Povodie Hrona Banská Bystrica, October 1999

 Table E.7 – 4
 StVaK's Financial Proposals for Construction of Wastewater Treatment Plants and Sewers to the year 2005

1977

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Year Full investm Start – finish Full investm 1988-2000 1 1998-2000 1 1998-2000 1 1998-2002 1 2000-2003 4 2001-2003 4 2001-2004 1 2002-2004 1 2002-2004 1 2002-2004 1 2002-2004 1 2002-2004 1 2002-2004 1 2002-2004 1 2002-2004 1 2002-2004 1 2002-2004 1 2002-2004 1 2002-2004 1 2002-2004 1 2002-2004 1 2002-2003 2 2002-2003 1 2002-2003 1 2002-2003 1 2002-2003 1				ω	ш,	сř	فر	0	o,	o,	4	مر	ð	U,	<u>o</u>	.		Ň	∞_		બુ	ų	<u>, </u>	¢
	Full investment	cost	(mil. Sk)	156,3	80,1	279,2	483,6	100,0	20,0	40,0	42,4	75,9	115,6	17,2	35,0	1 099,1	-	114,5	130,8	63,1	50,2	71,2	11,7	0 200 0
Name iská Bystrica, extension of Sewage Treatment Plant (STP) iská Stiavnica, sewerage network and STP iská Stiavnica, sewerage network and STP ien, extension of Sewage Treatment Plant Zno, 'tremoval of sewerage inlets? ine, connection of Sewage system ?(to STP) mic, sewerage inlets? mic, sewerage network and STP mica, sewerage network and STP va, extension of STP bietová, sewerage network and STP va, extension of STP val Bystrica, sewerage network and STP iská Bystrica, reconstruction and completion of sewerage vork stá, sewerage network and STP vork in ad Hronom, reconstruction of sewerage network in ad Hronom, reconstruction of sewerage network in ad Hronom, reconstruction of sewerage network	Vear	Start – finish		1988-2000	1990-2000	1998-2002	2000-2003	2001-2003	2000-2001	2001-2004	2002-2004	2002-2004	2002-2004	2002-2003	2002-2004	2002-2005		2002-2004	2002-2004	2002-2004	2002-2004	2000-2002	2002-2003	
Bar Bar Bar Bar Bar Bar Bar Bar Bar Cycl Slo Vyl Bar Bar Nov Vyl Vyl Nov Vyl Nov Nov Nov Nov Nov Nov Nov Nov Nov Nov	Nome			Banská Bystrica, extension of Sewage Treatment Plant (STP)	Banská Štiavnica, sewerage network and SIP	Banská Bystrica, sewage collectors A	Zvolen, extension of Sewage Treatment Plant	Brezno, ?removal of sewerage inlets?	Vylme, connection of sewage system ?(to STP)	Kremnica, sewerage network and STP	Detva, extension of STP	Slovenská L'upca, sewerage network and STP	L'ubietová, sewerage network and STP	Podbrezová, intensification of STP	Valaská, sewerage network and STP	Banská Bystrica, reconstruction and completion of sewerage	network	Zvolen, sewerage network system	Banská Bystrica, sewerage collector AE	Ziar had Hronom, reconstruction of sewerage network	Predajná, sewerage network and STP	Vyhne, sewerage network	Nová Bana, completion of sewerage network	

Source: StVaK Banská Bystrica, October 1999