Controlling Ammonia Pollution in the Upper Hornád River Watershed

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Purpose

The goal of this study is to develop a recommendation for a pollution control strategy to help protect the beneficial uses of The Upper Hornád River. The river is an increasingly important body of water in the eastern Slovak Republic. The river serves to supply domestic water and supports an important fishery. Also, as tourism begins to increase in the area, maintaining acceptable water quality in the river will become increasingly important. It is essential that the river water quality does not become impaired resulting in destroying important fisheries, making water impotable for domestic use, and driving away tourism and recreation along with the potential economic benefits these activities bring to the people of the local area.

The objective of the study is to create a water quality model to help prepare alternative solutions for protection of the Upper Hornád River. Various pollution control alternatives can be assessed using the water quality model. These alternatives can then be posed in community forums for discussion. When local acceptance of an alternative begins to form, implementation of the pollution controls should be easier to achieve than if the controls were mandated from the government.

Water Quality Criteria and Beneficial Uses of Waters

Water quality criteria specify concentrations of water constituents which, if not exceeded, are expected to result in protection of the beneficial uses of the water. Such criteria are derived from scientific facts obtained studies that measure effects of different concentrations on particular water uses. Often times these criteria are adopted by governments as standards, and therefore are binding to law. However, many criteria are not officially adopted as standards and are used for advisory purposes.

The criterion for ammonia that applies to streams in the Upper Hornád Watershed protects for the support of aquatic life. The following ammonia criteria have been adopted as standards in the Slovak Republic to protect aquatic life in rivers and streams (STN 75 72 21).

1. Below 0.3 mg/L = Very Clean Water
2. Below 0.5 mg/L = Clean Water
3. Below 1.5 mg/L = Polluted Water
4. Below 5.0 mg/L = High Level of Pollution
5. Over 5.0 mg/L = Very High Level of Pollution

Upper Hornád Watershed Characteristics

The study area covers the Upper Hornád River watershed upstream of Ruzín Reservoir in the eastern Slovak Republic (Figure 1). The Upper Hornád River accounts for 1146 square kilometers (59%) of the area that drains to Ruzín Reservoir.

The Upper Hornád River watershed was delineated into 17 subbasins for modeling analysis (Figure 2). These subbasins were named for the purposes of this report according to the major local stream or city within that area. Land cover data were obtained from the third hierarchy CORINE geographic information system coverage developed from the European Phare Project methodology. This land cover information was intersected with the subbasin delineation's to allow modeling of nonpoint source phosphorus loads within each area (Table 1).

Point source discharge locations were identified on the rivers and streams in the watershed. Only significant sources were used in the modeling based on a total annual loads of 0.3 metric tonnes of biological oxygen demanding substances. From this information, treatments levels were estimated and expected nutrient loads were compiled from published Technical literature (Table 2).

Review of Monitoring Data

Three types of monitoring data are required to develop the water quality model: climate, stream flows and concentration of water quality constituents. These data were compiled for the years of 1996 and 1997. Of the data received, the period from April 1996 to February 1997 contained sufficient data to run the model.

A review of the water quality data collected in the watershed showed that ammonia concentrations are generally the highest at the stations below the City of Spišská Nová Ves at Hornád River kilometer 124.6. This observation is expected since ammonia is generally found in high concentrations in municipal effluent. These data were collected by the Bodrog and Hornád River Watershed Management Company.

The two highest value of total phosphorus measured in the Hornád River for the study period were 1.505 NH_4-N mg/L in February 1997 at river kilometer 92.1 and 0.944 NH_4-N mg/L in June 1996 at river kilometer 124.6. Data collected on these dates represent the most critical conditions and were used for the model calibration and validation, respectively. These high ammonia values are considered a "Polluted Water" according to the official water quality standards adopted by the Slovak Republic (STN 75 72 21).

Water Quality Model Construct

QUAL2E is a comprehensive, one dimensional, steady-state stream water quality model supported by the United States Environmental Protection Agency (EPA, 1987). The model has been widely used to determine pollutant loading and response in rivers and streams. The model is capable of simulating up to 15 water quality constituents in any combination. QUAL2E was used in this study to model the accumulation, assimilation and routing of ammonia in the Upper Hornád River watershed. All other conventional constituents (e.g. other nitrogen forms, phosphorus, BOD) were also modeled to better represent the inter-relationships between these substances in flowing waters.

The river system was divided into 18 reaches for the modeling (Table 3). Each reach was selected based on locations of tributary inflows and assumed to generally represent uniform. Each reach is further divided into computational elements with a length of 1 kilometer, which have uniform steady-state concentrations of modeled constituents.

The model was calibrated using the data collected in with February 1997 and validated with June 1996. The first step in the analysis was to balance the flows for both modeled time periods. Flows within the watershed were balanced using gauged flow data from the same day as the water quality measurements were made and adjusting the incremental flow for each model reach accordingly. Climatic data from two meteorological stations were used to for specific model reaches and estimates were made for information that was not measured (Table 4).

Significant point source loading values measured and estimated (Table 2) were input into the appropriate model element according to the discharge location. Nonpoint source loading were input into each model element based on the area of land cover in each the subbasin. The third hierarchy of land covers from the CORINE geographical information system coverage was used with published studies which measured nonpoint source loading (Tables 5 and 6). Characteristics of the published study sites were matched as closely as possible to similar characteristics in the Hornád River watershed.

Model output was compared to data collected from stations at Hornád River kilometers 92.1, 100.7, 124.6, and 136.4 by the Bodrog and Hornád River Watershed Management Company. Calibration was conducted by adjusting process parameters (e.g. algal settling rate, maximum algal growth rate) in the model using the constant state variables from February 1997 described above (Table 7). Calibration adjustments of model parameters were made within acceptable ranges until model output reasonably matched measured concentrations (Figure 4). Validation was conducted by using the same parameter values determined through calibration with the state variables for June 1996 (Figure 5). The validation data showed that model performance can has an explained variance of 96% in predict measured conditions (Table 8).

Ammonia Loading Analysis

The calibrated water quality model was used to determine the effect of ammonia loads entering the river. The mapped results of the calibrated and validated models show that only two of the significant point sources are casuing the river to exceed class II standards Figures 6 & 7). Most of the impact from point sources comes from two municipal discharges: VK Spišská Nová Ves and VK Levoca. The river does not appear to assimilate much of this loading. (Figures 4 & 5). There are many different treatment methods that can be used to remove ammonia from municipal wastewater (Table 9).

Ammonia Loading Reductions

Establishing a strategy for meeting water quality standards assessing the reduction in loads of specific pollution control activities to achieve goal or targets. The calibrated water quality model was used to estimate the effect of various pollution controls on ammonia concentrations in the Upper Hornád River. The major source of ammonia loading to the river is domestic wastewater. The water quality model was run to test the predicted effect on for four wastewater treatment scenarios using the maximum expected reductions shown in the literature (Tables 9 & 10).

The first is to upgrade the Spišská Nová Ves facility. The treatment option tested with the model was bacterial assimulation. This treatment process varies depending on the actual situation it is applied. In general, it involes the removal of ammonia using different varieties of bacteria that go through ntrification and dentirtification processes. The process can easily be adapted as a part of the unit operations typically used for secondary treatment, thereby reducing the overall costs. The model predicts that upgrading the Spišská Nová Ves facility discharge using bacterial assimulation will result in meeting Class II standards for "Clean Water" everywhere on the Hornád River, but not on Levocský Creek (Figure 8).

The water quality model was also used to predict the effect of upgrading treatment for the domestic waste discharging to Levocský Creek from the City of Levoca. Again, the treatment option tested for ammonia removal with the model was bacterial assimulation. The model predicts that upgrading the Levoca facility discharge using bacterial assimulation will result in meeting Class II standards for "Clean Water" only on the Levocský Creek, but not on the Hornád River (Figure 9).

The water quality model was also used to predict the effect of upgrading treatment for both domestic waste facilities at the Cities of Levoca and Spišská Nová Ves. Again, the treatment option tested for ammonia removal with the model was bacterial assimulation. The model predicts that upgrading both the Levoca and Spišská Nová Ves wastewater treatment facility discharges using bacterial assimulation will result in meeting Class II standards for "Clean Water" for all waters in the Upper Hornád River Watershed (Figure 10).

Since it is obvious that these two wastewater treatment facilities must be upgraded to meet ammonia standards in the watershed, another treatment option was tested with the model. Even though bacterial; assimulation is a prefered option for ammonia removal due to it's lower relative cost and ease on integratiion into seconadry treatment operations, it will require more land area to apply. Limitations of land areas for building new treatment processes are common in urban areas. These limitation may forcethe look at using a different treatment option than bacterial assimulation. Air Stripping is another method of ammonia removal that is less costly than many other approaches, uses little land area for operation, and has a high removal efficiency (Table 9).

The water quality model was used to predict the effect of upgrading treatment using an air stripping operation for ammonia removal from both domestic wastewater treatment facilities at the Cities of Levoca and Spišská Nová Ves. The model predicts that upgrading both the Levoca and Spišská Nová Ves facilities discharges using will result in meeting Class II standards for "Clean Water" for all waters in the Upper Hornád River Watershed (Figure 11).

Recommended Pollution Reduction Strategy

In order to achieve "Clean Water" standards (Class II) in the Upper Hornád River watershed, both of the wastewater facilities at the Cities of Levoca and Spišská Nová Ves must be upgraded to remove ammonia from their discharges. The recommended treatment option is to integrate bactreial assimulation into the secondary treatment process. One complication to applying this recommendation is the financing structure for wastewater treatment used in the Slovak Republic. Currently, the communal management company must finance their own systems. In these cases, municipal wastes are defined as toxic wastes, so financial constraints apply. This situation makes it difficult for communities and industrial facilities to obtain funding to upgrade wastewater treatment facilities.

The best way to establish this strategy is through an iterative process between technical analysis and consultation with treatment plant managers. The process is started by introducing the results of receiving water quality from various treatment options from the water quality model. The information could also be presented in various public forums, community meetings, or special workshops for affected parties to help obtain public support. Suggested modifications to the treatment options could be tested with the model. Through this iterative process a consensus may be formed on what is achievable politically and economically. After the wastewater treatment faclities are upgraded, water quality monitoring should also be conducted to verify that the expected results are being achieved.

Recommendations for Further Study

This report should be considered as the first step in the cleanup of pollution. As with all modeling exercises, the analysis presented here used many assumptions to provide results. It is simply not practical to measure every parameter needed for the model. As such, there are many improvements that could be made in the model and predictions with more monitoring data and more sophisticated techniques. Below is listed some recommendations that could be pursued:

Enhanced monitoring of streams within the watershed. Only two parties are now monitoring a limited number of stations in the watershed. The monitoring program coordinated by SOSNA does not collect data during winter months. Increasing the number of stations to include the mouths of each on the tributary subbasins could provide be used to recalibrate the model. At a minimum, the monitoring of the water downstream of the treatment facilities should be increased both spatially and temporally to assess effectiveness of the controls.

Obtain local land use export loading values. All of the loading estimates for nonpoint sources was obtained from data published in the literature. Even though efforts were made to select values based on similarities in other factors (e.g. weather, crop types, etc), actual export loading values are likely to be somewhat different. Local gray literature may have better estimates of these values. Also, some monitoring of specific land covers may be used to obtaining better values.

Additional monitoring data from point sources. The data obtained for the point sources was limited. Many of the effluent concentrations and treatment levels were assumed based on the information obtained. Only mean values were used for the modeling. Knowledge of daily maximum values for each of the input parameters would greatly improve the modeling estimate. A distribution of effluent concentrations and flows over time would allow assessment of risks.

Stochastic modeling should be conducted to provide risk assessment of viable approaches. The results presented are given in deterministic answers. These are simple to understand, but do not reflect the variability associated with various constituents used in the model. The model used was calibrated using the worst case situation measured of the data obtained. There was other periods of time for which water quality pollutant levels were lower. Knowledge of the distribution of these variables could be used in a Monte Carlo modeling approach to give answers described in risk-based terms. This type of analysis would provide results related to the frequency that a particular criterion would be exceeded, instead of the absolute result provided by modeling steady state at critical conditions.

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Table 1. Land Cover Areas of Subbasins Modeled in the Upper Hornád River Basin

Subbasin Name	**Area**	**Urban**		**Agriculture**		**Forested**	
	hectares	hectares	Percent	hectares	Percent	hectares	Percent
Bellanovce	2,778	221	8%	213	8%	2,345	84%
Branisko	11,232	4,188	37%	5,611	50%	1,433	13%
Brusník	4,214	214	5%	530	13%	3,469	82%
Gánovský	3,344	485	15%	1,829	55%	1,029	31%
Holubnica	6,004	528	9%	501	8%	4,975	83%
Kolinovce	5,011	744	15%	1,529	31%	2,737	55%
Levocský	15,425	1,944	13%	5,197	34%	8,284	54%
Markušovce	2,206	646	29%	321	15%	1,238	56%
Matejovce	12,468	3,998	32%	5,213	42%	3,258	26%
Olenava	6,809	3,787	56%	1,361	20%	1,661	24%
Richnava	9,471	395	4%	6,350	67%	2,726	29%
Sliavnik	1,209	85	7%	272	22%	851	70%
Slovinský	7,694	411	5%	3,615	47%	3,667	48%
Tomášovce	6,651	487	7%	252	4%	5,912	89%
Vel'ká-Biela	4,512	6	>1%	466	10%	4,040	90%
Vernársky	4,089	146	4%	414	15%	3,529	86%
Vidkartovce	11,442	272	2%	2,617	23%	8,552	75%
Entire Basin	114,557	18,558	16%	36,292	32%	59,707	52%

Table 2. Characteristics of Significant Point Sources in the Upper Hornád Watershed ①

Facility Name ②	Location ②	Waste Type ⑥	Treatment Level ③	Flow (m^3/s) ②	BOD_5 (mg/L) ②	Org-N (mg/L) ④	NH_3 (mg/L) ④	NO_2 (mg/L) ④	NO_3 (mg/L) ④	Org-P (mg/L) ⑤	PO_4 (mg/L) ④
Verejná kanalizácia Spišská Nová Ves	Hornád km 127.4	Domestic	Secondary	0.2550	14.0	6.1	7.9	0.19	1.30	0.50	1.60
Verejná kanalizácia Levoca	Levocský km 15.2	Domestic	Secondary	0.0530	20.0	6.1	7.9	0.19	1.30	0.50	1.60
Farma ošípaných Sp. Vlachy	Hornád km 109.7	Animal	None	0.0009	60.0	39.2	80.0	0.08	30.80	1.00	3.30
Sp. kamenopriemysel Sp. Vlachy	Hornád km 107.2	Quarry + Domestic	Dilution of Raw 4:1	0.0003	43.7	3.8	6.3	0.02	0.05	0.80	2.50
Verejná kanalizácia Sp. Vlachy	Branisko km 1.4	Domestic	Secondary	0.0011	28.0	6.1	7.9	0.19	1.30	0.50	1.60
Zelba Solvinky Odtok z odkaliska(2pts)	Slovinský km 4.4	Mining	NA	0.0059	3.7	0.2	0.2	0.09	2.70	0.02	0.05
Verejná kanalizácia Krompachy (pt 1)	Slovinský km 0.9	Domestic	Primary	0.0025	90.0	13.0	22.0	0.06	0.19	1.60	7.70
Verejná kanalizácia Krompachy (pt 2)	Hornád km 98.8	Domestic	Raw	0.0110	140.0	15.0	25.0	0.06	0.19	3.00	10.00
Verejná kanalizácia Krompachy (pt 3)	Hornád km 97.2	Domestic	Primary	0.0025	84.9	13.0	22.0	0.06	0.19	1.60	7.70
Kovohuty Krompachy (pt 1)	Hornád km 97.8	Mining	NA	0.0231	5.9	0.2	0.4	0.04	4.20	0.03	0.15
Kovohuty Krompachy (pt 2)	Hornád km 97.5	Mining	NA	0.0319	5.9	0.2	0.4	0.04	4.20	0.03	0.15
SEZ Krompachy	Hornád km 96.6	Power Plant	NA	0.0315	5.7	0.2	0.4	0.04	4.20	0.03	0.15

Verejná kanalizácia Margecany	Hornád km 83.2	Domestic	Raw	0.0030	187.0	15.0	25.0	0.06	0.19	3.00	10.00

Footnotes to Table 2:

NA = Not Applicable for nutrients. Used background ambient water quality data provided by Bodrog and Hornád River Watershed Management Company.

① Significant is defined as point sources with a annual mean load greater than 0.3 metric tonnes per year.
② Information provided by by Bodrog and Hornád River Watershed Management Company.
③ Assumed from the BOD_5 levels (for domestic wastewater per Leo, et al. 1984 and Thomann, 1972).
④ Estimated from assumed treatment (for domestic wastewater per Mueller, et al. 1982 and Metacalf and Eddy, 1972 for swine wastewater per Gupta and Kelley, 1990).
⑤ Difference between Total P and Ortho-P (for domestic wastewater per Mueller, et al. 1982).
⑥ Information provided by Nadacia SOSNA

Table 3. Modeled Stream Geometry of the Upper Hornád Basin

Reach Number	**Reach Name**	**Length** (km)	**Begin Reach** (km)	**End Reach** (km)
1	Hornád River - Vidkartovce	18	178	160
2	Vernársky Potok	14	14	0
3	Hornád River - Spišsky Sliavnik	7	160	153
4	Gánovsky Potok	11	11	0
5	Hornád River - Bellanovce	5	153	148
6	Vel'ká Biela Voda	19	10	0
7	Hornád River - Spišske Tomášovce	13	148	135
8	Hornád River - Holbnica	5	135	130
9	Brusník Potok	19	19	0
10	Hornád River - Markušovce	7	130	123
11	Upper Levocský Potok	10	28	18
12	Lower Levocský Potok	18	18	0
13	Hornád River - Matejovce	9	123	114
14	Hornád River - Olenava	7	114	107
15	Branisko Potok	20	20	0
16	Hornád River - Kolinovce	8	107	99
17	Slovinský Potok	16	16	0
18	Hornád River - Richnava	16	99	83

Table 4. Climate Values Used in Stream Model

Weather Station	Reaches Applied to	Monthly Mean from ④	Cloud Cover (fraction of sky)	Dry Air Temperature (degree C)	Dew Point Temperature (degree C)①	Solar Radiation (Langley/hr)②	Wind Speed (meter/second) ③
Gánovce (730 m elevation)	1 through 12	June 1996	0.58	15.2	11.4	140	8
		July 1996	0.60	14.5	11.4	140	8
		Feb. 1997	0.49	-1.4	-5.4	80	8
Spišská Vlachy (388 m elevation)	13 through 18	June 1996	0.60	16.7	9.8	140	8
		July 1996	0.69	15.6	9.7	140	8
		Feb. 1997	0.57	-2.5	-5.3	80	8

Footnotes to Table 4:

① Mean of daily values calculated from daily mean relative humidity and air temperature (Linsley, et al. 1982)
② Data not available. Used monthly mean from Spokane, Washington, which has a similar continental weather and latitude.
③ Data not available. Used annual mean from Spokane, Washington, which has a similar continental weather and latitude
④ Data on Barometric pressure not available. Used median of acceptable range for the model (1000 millibars)

Table 5. Non-Point Source Loading Rates used for Phosphorus Species, Biochemical Oxygen Demand, and Total Suspended Solids

Land Cover Type	CORINE **Level 3 Code**	**Dissolved Phosphorus Loading**		**Organic Phosphorus Loading**		**BOD_5 Loading**		**TSS Loading**	
		(kg/ha/yr)	Reference	(kg/ha/yr)	Reference	(kg/ha/yr)	Reference	(kg/ha/yr)	Reference
Discontinuous Urban Fabric	112	0.63	8	0.47	8	19	12	210	12
Industrial/Commercial Units	121	2.39	1	1.78	1	19	12	210	12
Mineral Extraction Sites	131	0.87	1	9.20	1	19	12	210	12
Dump Sites	132	0.87	1	9.20	1	19	12	210	12
Sport and Leisure Activities	142	0.63	8	0.47	8	19	12	210	12
Non-irrigated Arable Land	211	0.22	3	0.43	3	18	10	450	6
Fruit Trees and Berry Farms	222	1.10	8	1.14	8	18	10	450	6
Pasture Lands	231	0.40	5	0.45	5	11	10	340	6
Cultivated Agriculture	242	0.32	2	0.33	2	18	10	450	6
Agriculture in Areas with Mostly Natural Vegetation	243	0.63	4	0.23	4	11	10	340	6
Broad-leaved Forest Lands	311	0.16	11	0.12	11	5	10	85	6
Coniferous Forest Lands	312	0.19	9	0.13	9	5	10	85	6
Mixed Forest Lands	313	0.27	7	0.01	7	5	10	85	6
Natural Grasslands	321	0.31	3	0.04	3	5	10	85	6
Schrublands	324	0.27	7	0.01	7	5	10	85	6

References:

1. Betson, 1978.
2. Burwell, et al. 1974.
3. Burwell, et al. 1975.
4. Campbell, 1978.
5. Chichester, et al. 1979.
7. Krebs and Golley, 1977.
8. Reckhow, 1980.
9. Salminen and Beschta, 1991.
10. Shahane, 1982.
11. Timmons, et al. 1977.

6. Horner, et al. 1986.

12. U.S. EPA, 1983.

Table 6. Non-Point Source Loading Rates used for Nitrogen Species

Land Cover Type	CORINE **Level 3 Code**	**Ammonia Loading**		**Nitrate Loading**		**Nitrite Loading**		**Organic Nitrogen Loading**	
		(kg/ha/yr)	Reference	(kg/ha/yr)	Reference	(kg/ha/yr)	Reference	(kg/ha/yr)	Reference
Discontinuous Urban Fabric	112	0.33	7	2.04	7	0.0408	10	3.14	7
Industrial/Commercial Units	121	0.83	1	5.62	1	0.1124	10	8.50	1
Mineral Extraction Sites	131	0.44	1	3.14	1	0.0628	10	9.20	1
Dump Sites	132	0.44	1	3.14	1	0.0628	10	9.20	1
Sport and Leisure Activities	142	0.33	7	2.04	7	0.0408	10	3.14	7
Non-irrigated Arable Land	211	0.29	3	1.57	3	0.0314	10	0.71	3
Fruit Trees and Berry Farms	222	1.35	7	1.08	7	0.0216	10	6.57	7
Pasture Lands	231	0.43	8	0.96	8	0.0192	10	2.89	8
Cultivated Agriculture	242	1.37	2	1.19	2	0.0238	10	7.08	2
Agriculture in Areas with Mostly Natural Vegetation	243	0.09	4	0.09	4	0.0018	10	1.92	4
Broad-leaved Forest Lands	311	0.19	9	0.09	9	0.0018	10	1.64	9
Coniferous Forest Lands	312	0.03	5	0.004	5	0.0001	10	0.06	5
Mixed Forest Lands	313	0.28	5	0.13	5	0.0026	10	0.82	5
Natural Grasslands	321	0.80	6	1.00	6	0.0200	10	1.67	3
Schrublands	324	0.28	5	0.13	5	0.0026	10	0.82	5

References:

7. Betson, 1978.
8. Burwell, et al. 1974
9. Burwell, et al. 1975.
10. Campbell, 1978.
11. Gosz, 1978.

7. Reckhow, 1980.
8. Schuman, et al. 1973.
9. Timmons, et al. 1977.
10. Assume 2% of Nitrate Value per mean Proportion Observed at Rudniansky Potok (not affected by a municipal point source)

12. Long, 1979.

Table 7. Input File for Calibrated QUAL2E Model

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TITLE01              Upper Hornad 2/97 Flow
TITLE02
TITLE03  NO          CONSERVATIVE MINERAL I
TITLE04  NO          CONSERVATIVE MINERAL II
TITLE05  NO          CONSERVATIVE MINERAL III
TITLE06  NO          TEMPERATURE
TITLE07  YES         5-DAY BIOCHEMICAL OXYGEN DEMAND
TITLE08  YES         ALGAE AS CHL-A IN UG/L
TITLE09  YES         PHOSPHORUS CYCLE AS P IN MG/L
TITLE10                (ORGANIC-P; DISSOLVED-P)
TITLE11  YES         NITROGEN CYCLE AS N IN MG/L
TITLE12                (ORGANIC-N; AMMONIA-N; NITRITE-N;' NITRATE-N)
TITLE13  YES         DISSOLVED OXYGEN IN MG/L
TITLE14  NO          FECAL COLIFORM IN NO./100 ML
TITLE15  NO          ARBITRARY NON-CONSERVATIVE
ENDTITLE
LIST DATA INPUT
NO WRITE OPTIONAL SUMMARY
NO FLOW AUGMENTATION
STEADY STATE
NO TRAP CHANNELS
NO PRINT LCD/SOLAR DATA
NO PLOT DO AND BOD DATA
FIXED DNSTM CONC (YES=1)=        0.          5D-ULT BOD CONV K COEF  =      1.46
INPUT METRIC            =        1.          OUTPUT METRIC           =        1.
NUMBER OF REACHES       =        18          NUMBER OF JUNCTIONS     =         7
NUM OF HEADWATERS       =         8          NUMBER OF POINT LOADS   =        11
TIME STEP (HOURS)       =         0          LNTH. COMP. ELEMENT (DX)=        1.
MAXIMUM ROUTE TIME (HRS)=       30.          TIME INC. FOR RPT2 (HRS)=         0
LATITUDE OF BASIN (DEG) =       49.          LONGITUDE OF BASIN (DEG)=       21.
STANDARD MARIDIAN (DEG) =       0.0          DAY OF YEAR START TIME  =        1.
EVAP. COEF.,(AE)        = 0.0000068          EVAP. COEF.,(BE)        = 0.0000027
ELEV. OF BASIN (ELEV)   =       500          DUST ATTENUATION COEF.  =      0.13
ENDATA1
O UPTAKE BY NH3 OXID(MG O/MG N)=   3.50  O UPTAKE BY NO2 OXID(MG O/MG N)=   1.00
O PROD  BY ALGAE (MG O/MG A)   =   1.60  O UPTAKE BY ALGAE (MG O/MG A)  =   2.00
N CONTENT OF ALGAE (MG N/MG A) =  0.080  P CONTENT OF ALGAE (MG O/MG A) =  0.015
ALG MAX SPEC GROWTH RATE(1/DAY)=    3.0  ALGAE RESPIRATION RATE (1/DAY) =  0.300
N HALF SATURATION CONST (MG/L) =  0.150  P HALF SATURATION CONST (MG/L) =  0.025
LIN ALG SHADE CO (1/H-UGCHA/L) = 0.0050  NLIN SHADE (1/H-(UGCHA/L)**2/3)= 0.0165
LIGHT FUNCTION OPTION (LFNOPT) =     1.  LIGHT SATURATION COEF (INT/MIN)=   0.03
DAILY AVERAGING OPTION (LAVOPT)=     2.  LIGHT AVERAGING FACTOR (AFACT) =   0.92
NUMBER OF DAYLIGHT HOURS (DLH) =  12.00  TOTAL DAILY SOLAR RADTN (INT)  = 400.00
ALGY GROWTH CALC OPTION(LGROPT)=     1.  ALGAL PREF FOR NH3-N (PREFN)   =   0.90
ALG/TEMP SOLR RAD FACTOR(TFACT)=   0.45  NITRIFICATION INHIBITION COEF  =   0.60
ENDATA1A
ENDATA1B
STREAM REACH      1.RCH=  VIDKARTOVCE      FROM         178.    TO          160.
STREAM REACH      2.RCH= VERNARSKY         FROM          14.    TO             0
STREAM REACH      3.RCH= SLIAVNIK          FROM         160.    TO          153.
STREAM REACH      4.RCH=        GANOVSKY   FROM          11.    TO             0
STREAM REACH      5.RCH=      BELLANOVCE   FROM         153.    TO          148.
STREAM REACH      6.RCH=     VELKA-BIELA   FROM          19.    TO             0
STREAM REACH      7.RCH=       TOMASOVCE   FROM         148.    TO          135.
STREAM REACH      8.RCH=        HOLBINCA   FROM         135.    TO          130.
STREAM REACH      9.RCH=         BRUSNIK   FROM          19.    TO             0
STREAM REACH     10.RCH=      MARKUSOVCE   FROM         130.    TO          123.
STREAM REACH     11.RCH=  UPPER-LEVOCSKY   FROM          28.    TO           18.
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STREAM REACH     12.RCH=  LOWER-LEVOCSKY   FROM          18.    TO             0
STREAM REACH     13.RCH=       MATEJOVCE   FROM         123.    TO          114.
STREAM REACH     14.RCH=         OLCNAVA   FROM         114.    TO          107.
STREAM REACH     15.RCH=        BRANISKO   FROM          20.    TO             0
STREAM REACH     16.RCH=       KOLINOVCE   FROM         107.    TO           99.
STREAM REACH     17.RCH=       SLOVINSKY   FROM          16.    TO             0
STREAM REACH     18.RCH=        RICHNAVA   FROM          99.    TO           83.
ENDATA2
ENDATA3
FLAG FIELD RCH=   1.       18.          1.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.3.
FLAG FIELD RCH=   2.       14.          1.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=   3.        7.          4.2.2.2.2.2.3.
FLAG FIELD RCH=   4.       11.          1.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=   5.        5.          4.2.2.2.3.
FLAG FIELD RCH=   6.       19.          1.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=   7.       13.          4.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=   8.        5.          2.2.2.2.3.
FLAG FIELD RCH=   9.       19.          1.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  10.        7.          4.2.2.6.2.2.3.
FLAG FIELD RCH=  11.       10.          1.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  12.       18.          2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  13.        9.          4.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  14.        7.          2.2.2.2.2.6.3.
FLAG FIELD RCH=  15.       20.          1.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.6.
FLAG FIELD RCH=  16.        8.          4.6.2.2.2.2.2.3.
FLAG FIELD RCH=  17.       16.          1.2.2.2.2.2.2.2.2.6.2.2.2.2.2.6.
FLAG FIELD RCH=  18.       16.          4.6.6.6.2.2.2.2.2.2.2.2.2.2.6.5.
ENDATA4
HYDRAULICS RCH=   1.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=   2.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=   3.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=   4.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=   5.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=   6.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=   7.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=   8.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=   9.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=  10.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=  11.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=  12.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=  13.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=  14.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=  15.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=  16.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=  17.    120.00      0.28      0.35      0.48      0.58      0.03
HYDRAULICS RCH=  18.    120.00      0.28      0.35      0.48      0.58      0.03
ENDATA5
REACT COEF RCH=   1.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=   2.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=   3.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=   4.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=   5.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=   6.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=   7.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=   8.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=   9.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=  10.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=  11.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=  12.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=  13.       1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=  14.       1.     0.1     0.5  3.       0       0       0
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REACT COEF RCH=  15.      1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=  16.      1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=  17.      1.     0.1     0.5  3.       0       0       0
REACT COEF RCH=  18.      1.     0.1     0.5  3.       0       0       0
ENDATA6
N AND P COEF   RCH=   1.      0      0    0.3   100.   1.00   0.25    20.      0
N AND P COEF   RCH=   2.   0.03      0    0.3   100.   1.00   0.25    20.      0
N AND P COEF   RCH=   3.   0.03      0    0.3   100.   1.00   0.25    20.      0
N AND P COEF   RCH=   4.   0.03      0    0.3   100.   1.00   0.25    20.      0
N AND P COEF   RCH=   5.   0.03      0    0.3   100.   1.00   0.25    20.      0
N AND P COEF   RCH=   6.   0.03      0    0.3   100.   1.00   0.25    20.      0
N AND P COEF   RCH=   7.   0.03      0    0.3   100.   1.00   0.25    20.      0
N AND P COEF   RCH=   8.   0.03      0    0.8    10.   1.00   0.25      0      0
N AND P COEF   RCH=   9.   0.03      0    0.8    10.   1.00   0.25      0      0
N AND P COEF   RCH=  10.   0.03      0    0.8    10.   1.00   0.25      0      0
N AND P COEF   RCH=  11.   0.03      0    0.3    10.   1.00   0.25      0      0
N AND P COEF   RCH=  12.   0.03      0    0.3    10.   1.00   0.25      0      0
N AND P COEF   RCH=  13.   0.03      0    0.3    10.   1.00   0.25      0      0
N AND P COEF   RCH=  14.   0.03      0    0.3    10.   1.00   0.25      0    80.
N AND P COEF   RCH=  15.   0.03      0    0.3    10.   1.00   0.25      0      0
N AND P COEF   RCH=  16.   0.03      0    0.3    10.   1.00   0.25      0    80.
N AND P COEF   RCH=  17.   0.03      0    0.3    10.   1.00   0.25      0      0
N AND P COEF   RCH=  18.   0.03      0    0.3    10.   1.00   0.25      0    80.
ENDATA6A
ALG/OTHER COEF RCH=   1.  50.00    0.9  0.330   0.00   0.00   0.00   0.00
ALG/OTHER COEF RCH=   2.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=   3.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=   4.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=   5.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=   6.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=   7.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=   8.  50.00   0.10  0.330      0      0      0      0
ALG/OTHER COEF RCH=   9.  50.00   0.10  0.330      0      0      0      0
ALG/OTHER COEF RCH=  10.  50.00   0.10  0.330      0      0      0      0
ALG/OTHER COEF RCH=  11.  50.00   0.10  0.330      0      0      0      0
ALG/OTHER COEF RCH=  12.  50.00   0.10  0.330      0      0      0      0
ALG/OTHER COEF RCH=  13.  50.00   0.10  0.330      0      0      0      0
ALG/OTHER COEF RCH=  14.  50.00   0.10  0.330      0      0      0      0
ALG/OTHER COEF RCH=  15.  50.00   0.10  0.330      0      0      0      0
ALG/OTHER COEF RCH=  16.  50.00   0.10  0.330      0      0      0      0
ALG/OTHER COEF RCH=  17.  50.00   0.10  0.330      0      0      0      0
ALG/OTHER COEF RCH=  18.  50.00   0.10  0.330      0      0      0      0
ENDATA6B
INITIAL COND-1 RCH=   1.    0.1     6.      0   0.00   0.00   0.00   0.00   0.00
INITIAL COND-1 RCH=   2.    0.1     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=   3.    0.1     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=   4.    0.1     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=   5.    0.1     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=   6.    0.1     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=   7.    0.1     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=   8.    0.1     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=   9.    0.1     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=  10.    1.0     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=  11.    1.0     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=  12.    1.0     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=  13.    1.0     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=  14.    0.1     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=  15.    0.1     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=  16.    0.1     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=  17.    2.0     6.      0      0      0      0      0      0
INITIAL COND-1 RCH=  18.    0.1     6.      0      0      0      0      0      0
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ENDATA7
INITIAL COND-2 RCH=   1.   0.00   0.00   0.00   0.00   0.00   0.00   0.00
INITIAL COND-2 RCH=   2.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=   3.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=   4.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=   5.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=   6.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=   7.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=   8.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=   9.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=  10.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=  11.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=  12.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=  13.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=  14.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=  15.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=  16.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=  17.      0      0      0      0      0      0      0
INITIAL COND-2 RCH=  18.      0      0      0      0      0      0      0
ENDATA7A
INCR INFLOW-1  RCH=   1.  0.575     1.    6.  1.85  0.00  0.00  0.00  0.00  0.00
INCR INFLOW-1  RCH=   2.  0.244     1.    6.  2.07     0     0     0     0     0
INCR INFLOW-1  RCH=   3.  0.029     1.    6.  2.06     0     0     0     0     0
INCR INFLOW-1  RCH=   4.  0.140     1.    6.  4.05     0     0     0     0     0
INCR INFLOW-1  RCH=   5.  0.066     1.    6.  1.81     0     0     0     0     0
INCR INFLOW-1  RCH=   6.  0.246     1.    6.  1.45     0     0     0     0     0
INCR INFLOW-1  RCH=   7.  0.411     1.    6.  1.85     0     0     0     0     0
INCR INFLOW-1  RCH=   8.  0.156     1.    6.  3.52     0     0     0     0     0
INCR INFLOW-1  RCH=   9.  0.118     1.    6.  3.52     0     0     0     0     0
INCR INFLOW-1  RCH=  10.  0.094     1.    6.  4.30     0     0     0     0     0
INCR INFLOW-1  RCH=  11.  0.244     1.    6.  2.80     0     0     0     0     0
INCR INFLOW-1  RCH=  12.  0.244     1.    6.  2.80     0     0     0     0     0
INCR INFLOW-1  RCH=  13.  0.534     1.    6.  5.65     0     0     0     0     0
INCR INFLOW-1  RCH=  14.  0.291     1.    6.  6.05     0     0     0     0     0
INCR INFLOW-1  RCH=  15.  0.490     1.    6.  8.32     0     0     0     0     0
INCR INFLOW-1  RCH=  16.  0.160     1.    6. 10.78     0     0     0     0     0
INCR INFLOW-1  RCH=  17.  0.330     1.    6.  2.94     0     0     0     0     0
INCR INFLOW-1  RCH=  18.  0.303     1.    6. 12.70     0     0     0     0     0
ENDATA8
INCR INFLOW-2  RCH=   1.      0  0.286  0.065  0.001  0.063  0.023  0.088
INCR INFLOW-2  RCH=   2.      0  0.345  0.090  0.001  0.073  0.020  0.104
INCR INFLOW-2  RCH=   3.      0  0.409  0.084  0.002  0.086  0.026  0.095
INCR INFLOW-2  RCH=   4.      0  0.712  0.096  0.004  0.203  0.106  0.184
INCR INFLOW-2  RCH=   5.      0  0.292  0.079  0.002  0.098  0.021  0.080
INCR INFLOW-2  RCH=   6.      0  0.235  0.068  0.001  0.046  0.011  0.072
INCR INFLOW-2  RCH=   7.      0  0.339  0.085  0.002  0.110  0.027  0.100
INCR INFLOW-2  RCH=   8.      0  0.540  0.136  0.004  0.182  0.043  0.151
INCR INFLOW-2  RCH=   9.      0  0.564  0.147  0.003  0.165  0.041  0.160
INCR INFLOW-2  RCH=  10.      0  0.711  0.116  0.006  0.301  0.078  0.180
INCR INFLOW-2  RCH=  11.      0  0.423  0.067  0.003  0.158  0.063  0.110
INCR INFLOW-2  RCH=  12.      0  0.423  0.067  0.003  0.158  0.063  0.110
INCR INFLOW-2  RCH=  13.      0  0.891  0.121  0.009  0.463  0.154  0.190
INCR INFLOW-2  RCH=  14.      0  0.971  0.107  0.010  0.524  0.145  0.221
INCR INFLOW-2  RCH=  15.      0  1.394  0.144  0.012  0.599  0.203  0.333
INCR INFLOW-2  RCH=  16.      0  1.469  0.218  0.011  0.572  0.231  0.434
INCR INFLOW-2  RCH=  17.      0  0.422  0.063  0.003  0.129  0.064  0.121
INCR INFLOW-2  RCH=  18.      0  1.781  0.225  0.012  0.621  0.312  0.536
ENDATA8A
STREAM JUNCTION         1     JNC=              1        18        33        32
STREAM JUNCTION         2     JNC=              2        39        51        50
STREAM JUNCTION         3     JNC=              3        55        75        74
```

```
STREAM JUNCTION         4     JNC=              4        92       112       111
STREAM JUNCTION         5     JNC=              5       118       147       146
STREAM JUNCTION         6     JNC=              6       162       183       182
STREAM JUNCTION         7     JNC=              7       190       207       206
ENDATA9
HEADWTR-1 HDW=  1.0  VIDKARTOVCE       0.076    1.    6. 0.103     0     0     0
HEADWTR-1 HDW=  2.0 VERNARSKY          0.027    1.    6. 0.148     0     0     0
HEADWTR-1 HDW=  3.0        GANOVSKY    0.027    1.    6. 0.368     0     0     0
HEADWTR-1 HDW=  4.0     VELKA-BIELA    0.030    1.    6. 0.076     0     0     0
HEADWTR-1 HDW=  5.0         BRUSNIK    0.013    1.    6. 0.185     0     0     0
HEADWTR-1 HDW=  6.0  UPPER-LEVOCSKY    0.029    1.    6. 0.200     0     0     0
HEADWTR-1 HDW=  7.0        BRANISKO    0.029    1.    6. 0.416     0     0     0
HEADWTR-1 HDW=  8.0       SLOVINSKY    0.049    1.    6. 0.184     0     0     0
ENDATA10
HEADWTR-2 HDW=  1.0     0     0     0 0.016 0.0040.0000 0.004 0.001 0.005
HEADWTR-2 HDW=  2.0     0     0     0 0.025 0.0060.0001 0.005 0.001 0.007
HEADWTR-2 HDW=  3.0     0     0     0 0.065 0.0090.0003 0.018 0.010 0.017
HEADWTR-2 HDW=  4.0     0     0     0 0.012 0.0040.0000 0.002 0.001 0.004
HEADWTR-2 HDW=  5.0     0     0     0 0.030 0.0080.0001 0.009 0.002 0.008
HEADWTR-2 HDW=  6.0     0     0     0 0.030 0.0050.0002 0.011 0.005 0.008
HEADWTR-2 HDW=  7.0     0     0     0 0.070 0.0070.0006 0.030 0.010 0.017
HEADWTR-2 HDW=  8.0     0     0     0 0.026 0.0040.0001 0.008 0.004 0.008
ENDATA10A
POINTLD-1 PTL=    1VK SP. NOVA-    0  0.2550    5.  6.00  14.0  0.00  0.00  0.00
POINTLD-1 PTL=    2   VK LEVOCA    0  0.0530    5.  6.00  20.0     0     0     0
POINTLD-1 PTL=    3FARM SP. VLA    0  0.0009    5.  6.00  60.0     0     0     0
POINTLD-1 PTL=    4VK SP. VLACH    0  0.0011    5.  6.00  28.0     0     0     0
POINTLD-1 PTL=    5VK KAMEN VLA    0  0.0003    5.  6.00  43.7     0     0     0
POINTLD-1 PTL=    6ZELBA SOLVIN    0  0.0059    5.  6.00   3.7     0     0     0
POINTLD-1 PTL=    7VK KROMPACHY    0  0.0025    5.  6.00  90.0     0     0     0
POINTLD-1 PTL=    8VK KROMPACHY    0  0.0110    5.  6.00 140.0     0     0     0
POINTLD-1 PTL=    9VK3+KOVOHUT     0  0.0575    5.  6.00   9.3     0     0     0
POINTLD-1 PTL=   10SEZ KROMPACH    0  0.0315    5.  6.00   5.7     0     0     0
POINTLD-1 PTL=   11VK MARGECANY    0  0.0030    5.  6.00 187.0     0     0     0
ENDATA11
POINTLD-2  PTL=    1   0.0   0.0   0.0   6.1   7.9  0.19  1.30  0.50  1.60
POINTLD-2  PTL=    2     0     0   0.0   6.1   7.9  0.19  1.30  0.50  1.60
POINTLD-2  PTL=    3     0     0   0.0  39.2  80.0  0.08 30.80  1.00  3.30
POINTLD-2  PTL=    4     0     0   0.0   6.1   7.9  0.19  1.30  0.50  1.60
POINTLD-2  PTL=    5     0     0   0.0   3.8   6.3  0.02  0.05  0.80  2.50
POINTLD-2  PTL=    6     0     0   0.0   0.2   0.2  0.09  2.70  0.02  0.05
POINTLD-2  PTL=    7     0     0   0.0  13.0  22.0  0.06  0.19  1.60  7.70
POINTLD-2  PTL=    8     0     0   0.0  15.0  25.0  0.06  0.19  3.00 10.00
POINTLD-2  PTL=    9     0     0   0.0   0.7   1.3  0.04  4.04  0.09  0.45
POINTLD-2  PTL=   10     0     0   0.0   0.2   0.4  0.04  4.20  0.03  0.15
POINTLD-2  PTL=   11     0     0   0.0  15.0  25.0  0.06  0.19  3.00 10.00
ENDATA11A
ENDATA12
ENDATA13
ENDATA13A
LOCAL CLIMATOLOGY02    97    0       80.     0.5       0       0  1000.0      8.
```

Table 8. Explained Variance of Measured versus Predicted Total Phosphorus

Model Run	**Date**	**Hornád River Kilometer**	**Measured Ammonia** (mg NH_4-N/L)	**Predicted Ammonia** (mg NH_4-N/L)	**Coefficient of Determination**
Calibration	7/96	136.4	0.164	0.160	0.41
		124.6	0.936	0.940	
		100.7	0.546	0.650	
		92.1	1.505	0.660	
Validation	2/97	136.4	0.140	0.210	0.96
		124.6	0.944	0.640	
		100.7	0.452	0.440	
		92.1	0.429	0.430	

Table 9. Maximum Nitrogen Reductions Expected from Various Wastewater Treatment Operations or Processes (adapted after Metcalf & Eddy, 1991).

Treatment Operation or Process	**Percent Reduction**			**Relative Cost**
	Ammonia-N	Nitrate-N	Organic-N	
Conventional Primary Treatment	0%	0%	20%	Low
Conventional Secondary Treatment	10%	5%	50%	Low
Electrodialysis	50%	50%	100%	High
Bacterial Assimilation	70%	5%	0%	Medium
Reverse Osmosis	90%	90%	90%	High
Air Stripping	95%	0%	0%	Medium
Ammonium Ion Exchange	97%	0%	5%	High

Table 10. Maximum Predicted Concentrations of Ammonia Using Different Levels of Wastewater Treatment

Wastewater Pollution Control(s)	**River Kilometer of Predicted Maximum Concentration**	**Predicted Ammonia Concentration** (mg NH_4-N/L)
No Further Wastewater Treatment	Levocský km 15	1.20
Bacterial Assimulation at Spišská Nová Ves	Hornád km 127	0.95
Bacterial Assimulation at Levoca	Levocský km 15	1.20
Bacterial Assimulation at Spišská Nová Ves and Levoca	Levocský km 15	0.40

Air Stripping at Spišská Nová Ves and Levoca	Hornád km 83	0.26

Figure 1. Study Area of Upper Hornád River Watershed in the Slovak Republic

Figure 2. Subbasins of the Upper Hornád River Watershed

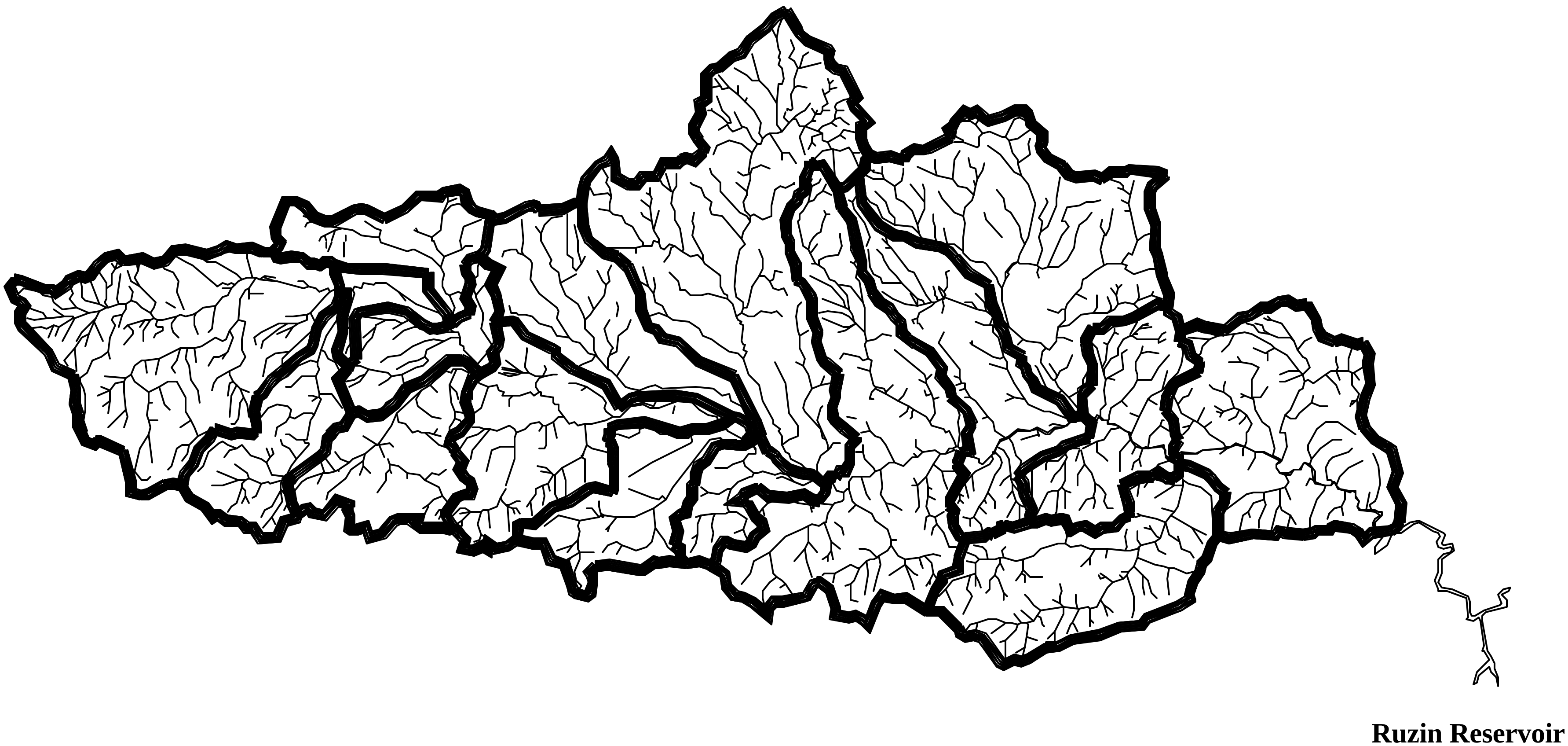
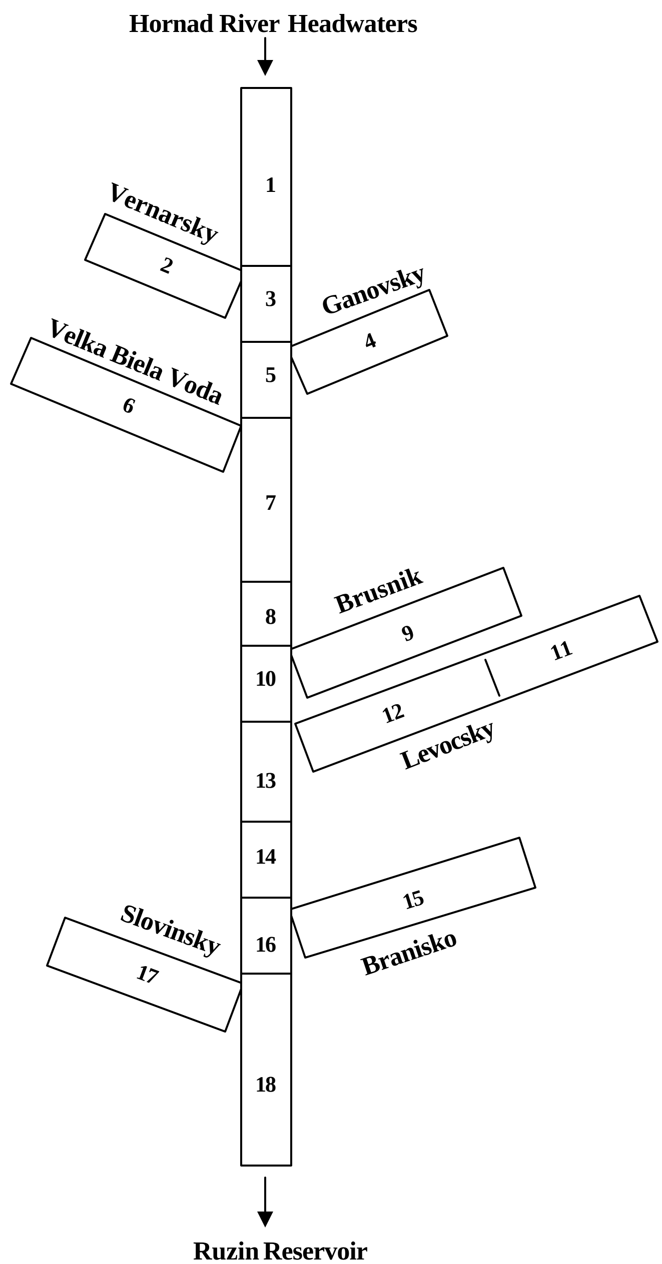


Figure 3. Schematic of the Modeled Stream Geometry



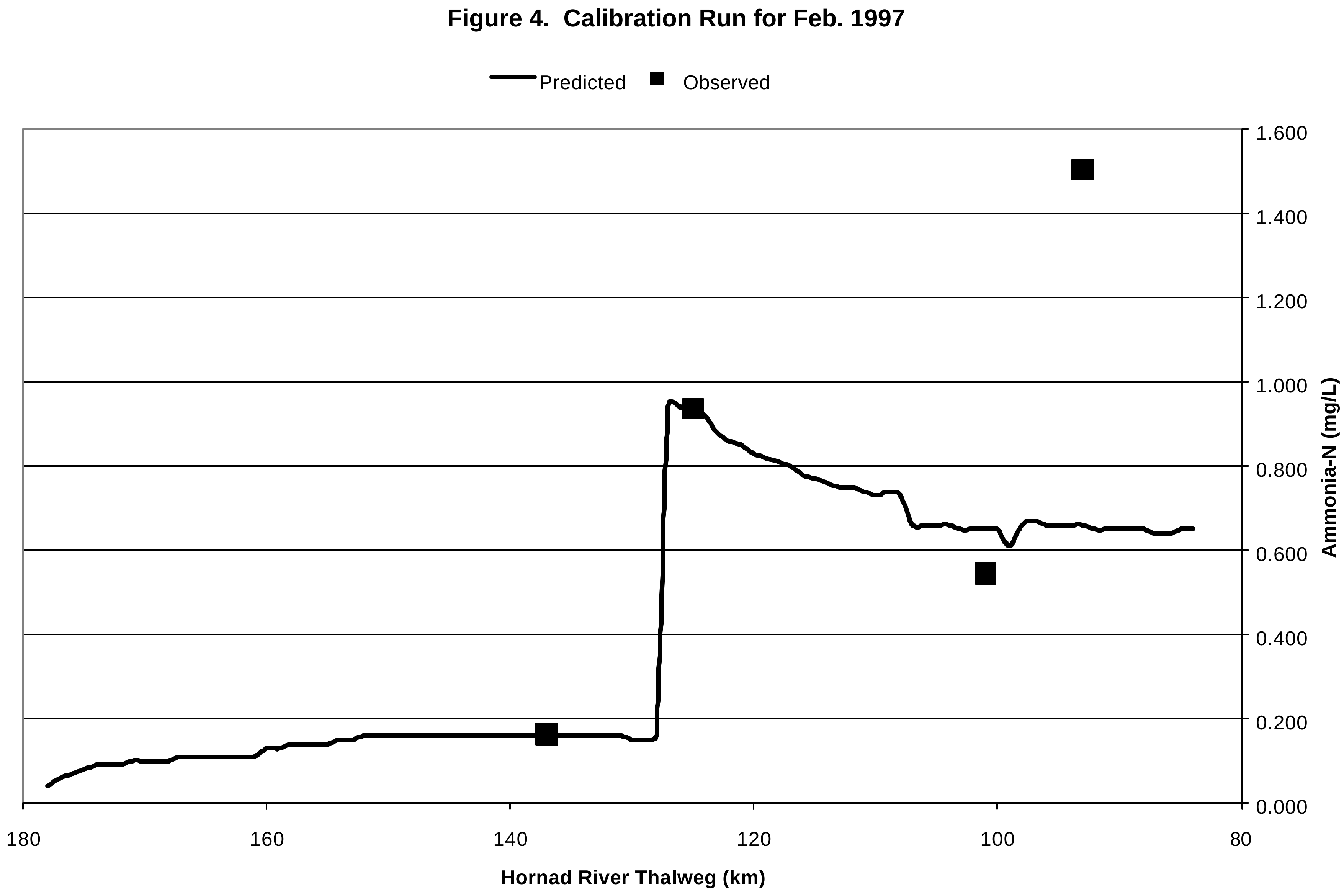


Figure 4. Calibration Run for Feb. 1997
Predicted
Observed
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
Ammonia-N (mg/L)
180
160
140
120
100
80
Hornad River Thalweg (km)

Figure 5. Validation Run for June 1996

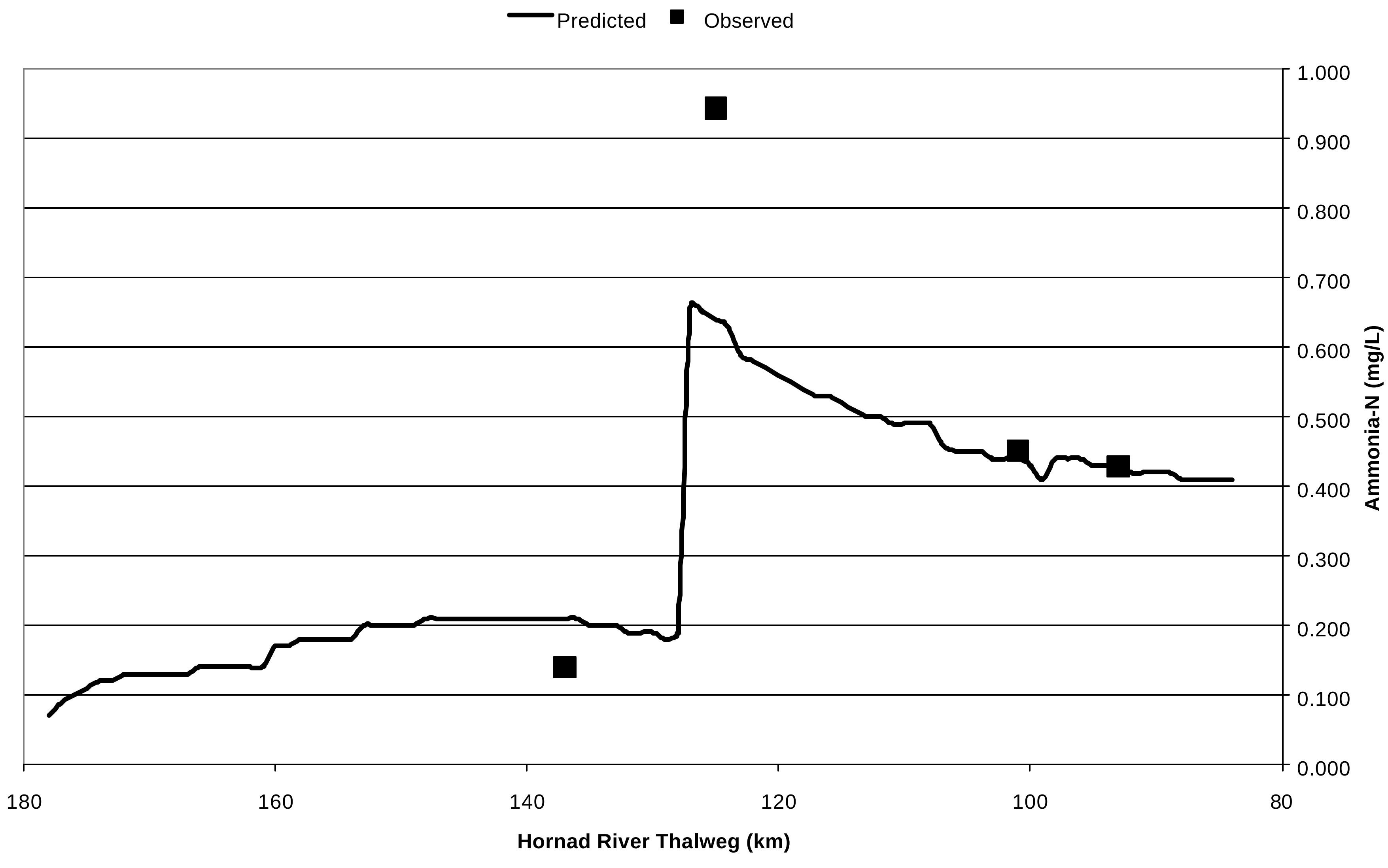


Figure 6. Map of the Calibration Run

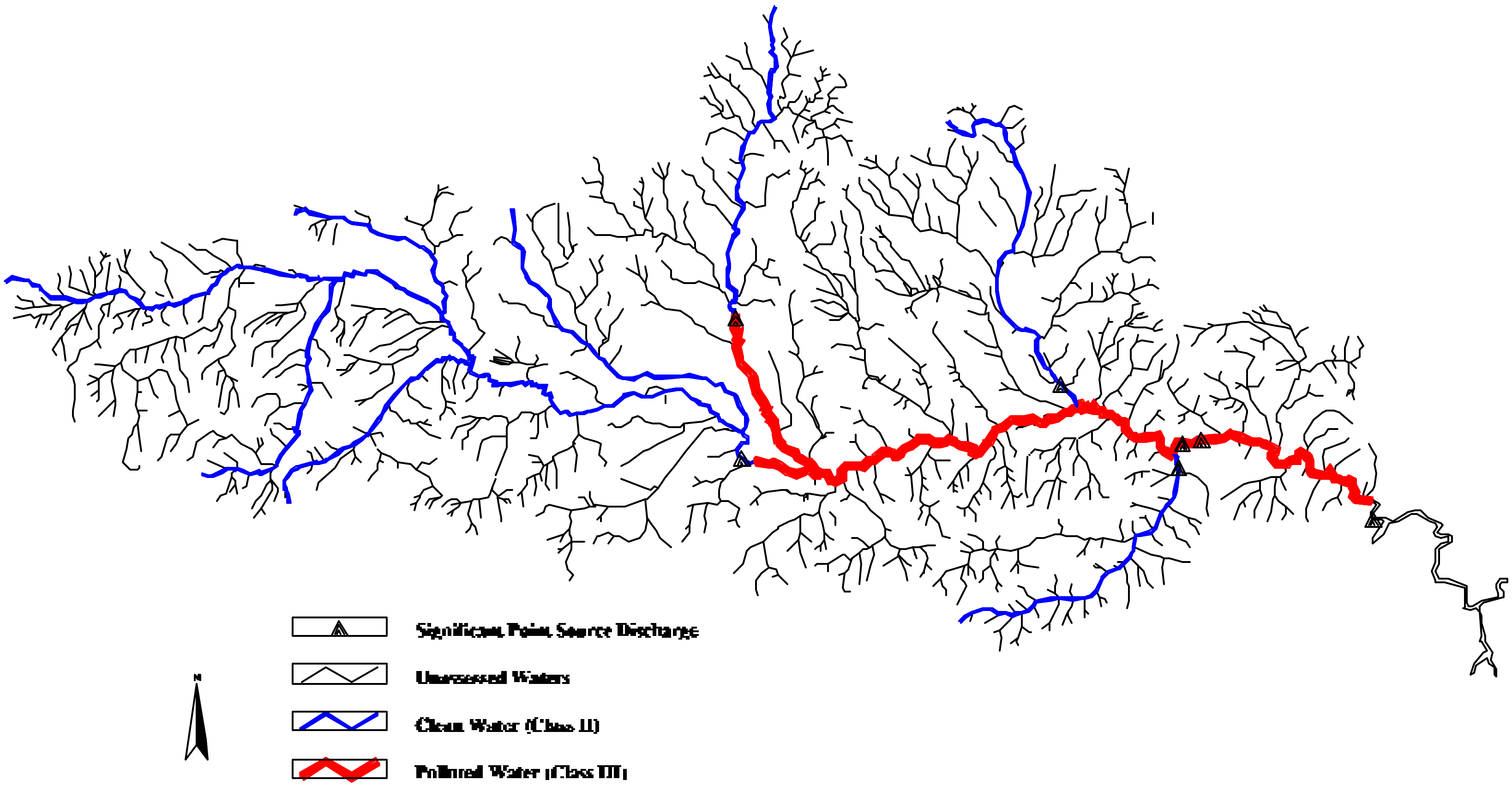


Figure 7. Map of the Validation Run

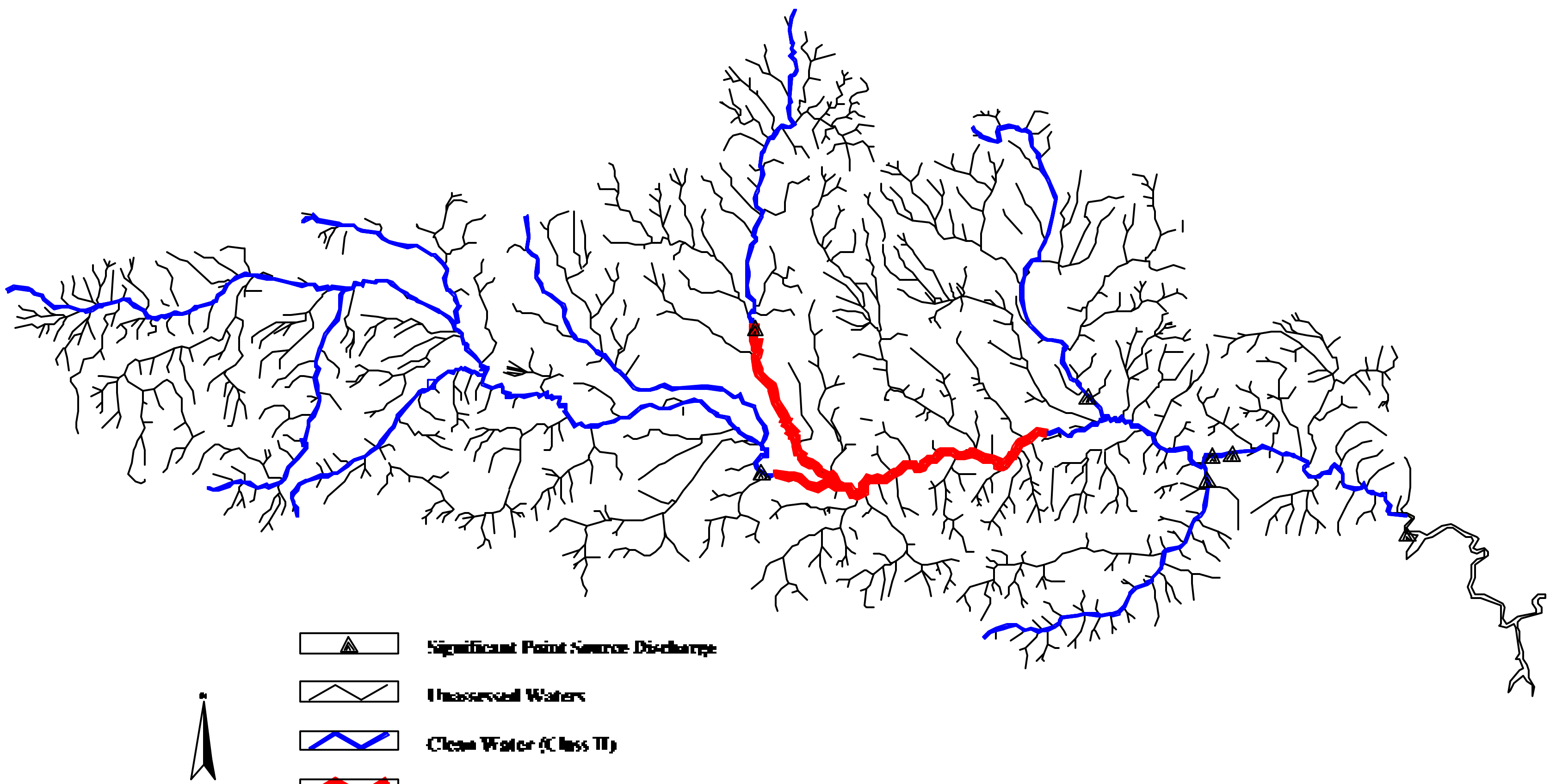


Figure 8. Map of Watershed Ammonia with Bacterial Assimulation Treatment at Spišská Nová Ves

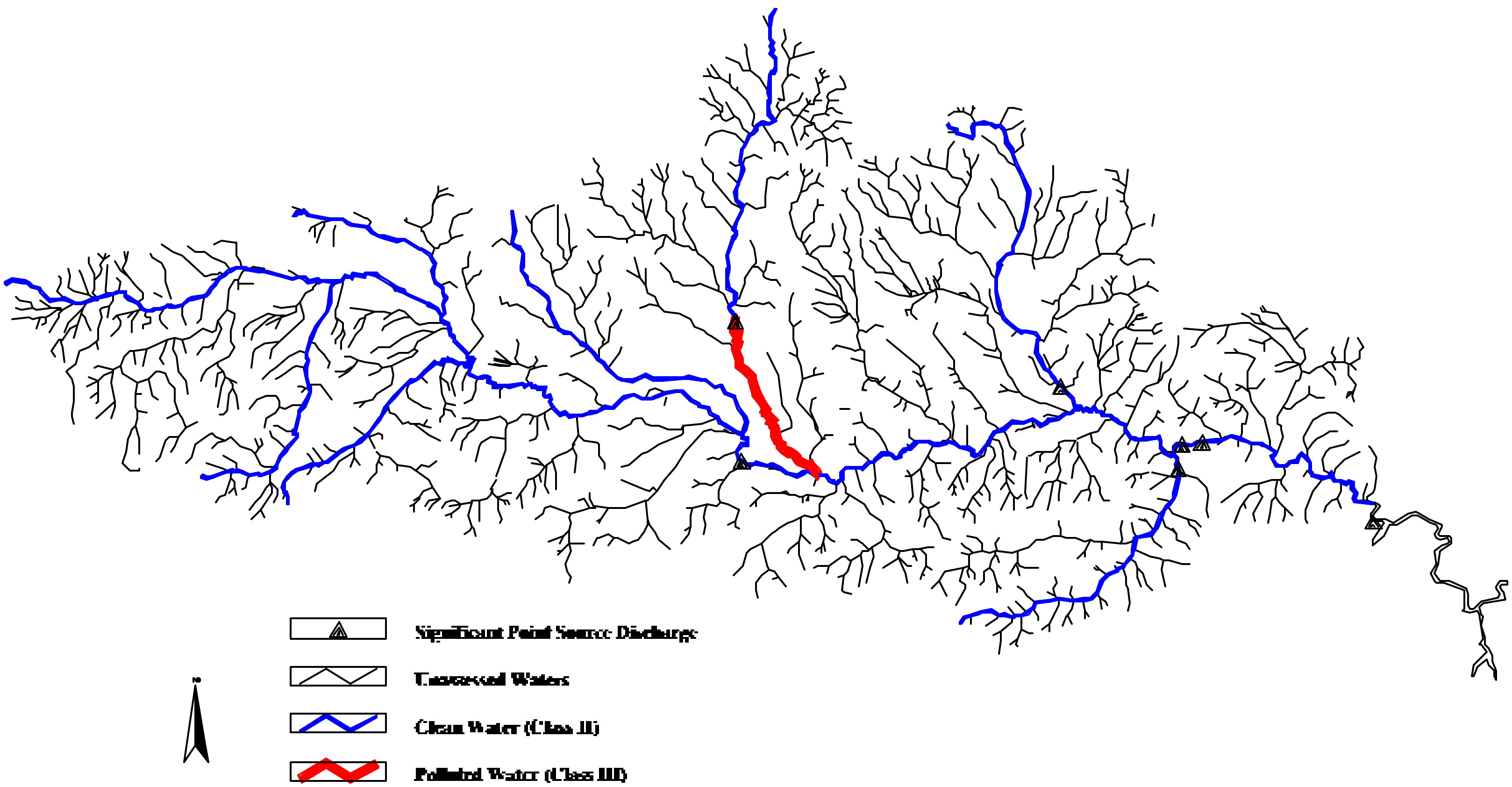


Figure 9. Map of Watershed Ammonia with Bacterial Assimulation Treatment at Levoca

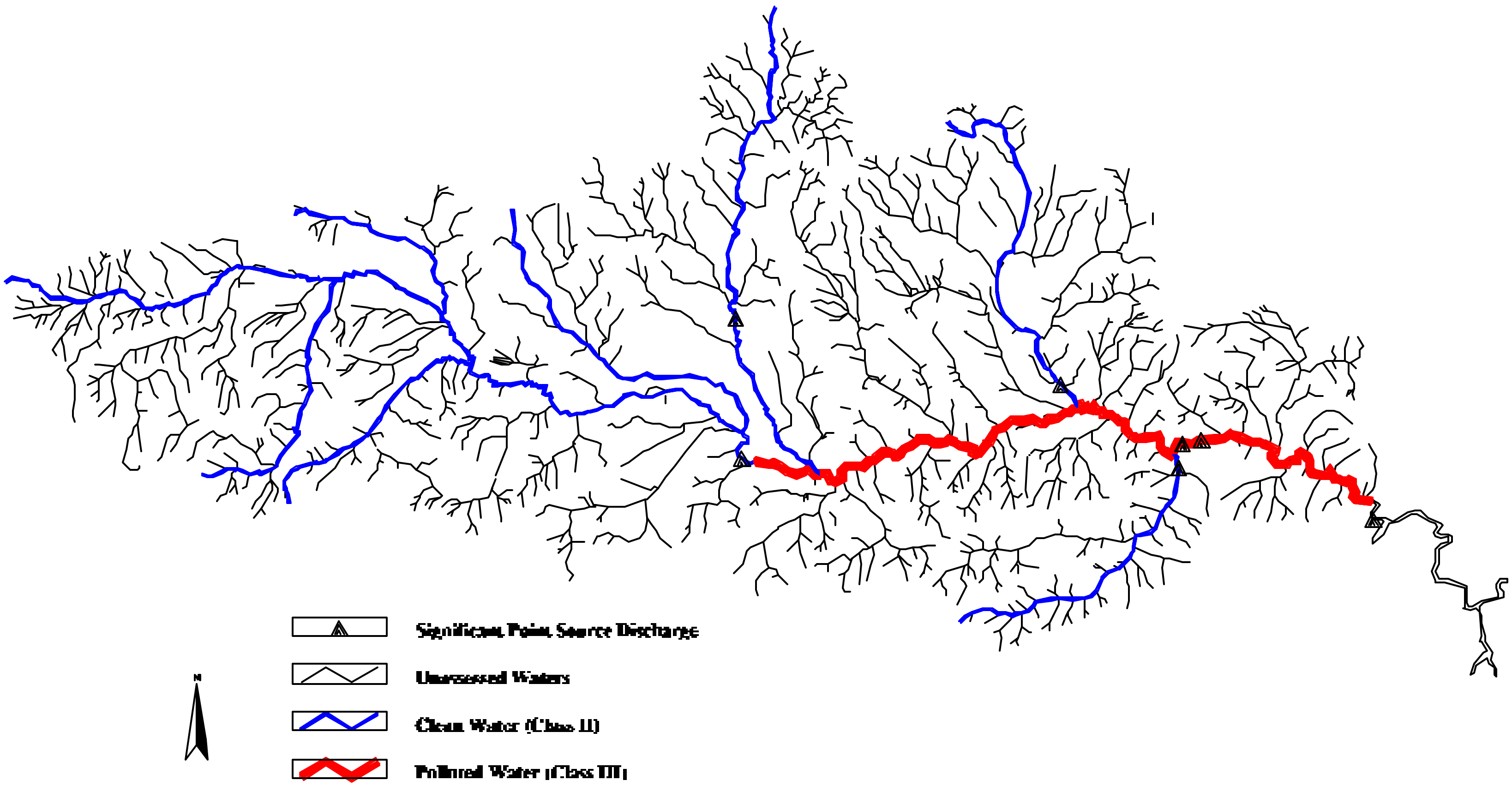


Figure 10. Map of Watershed Ammonia with Bacterial Assimulation Treatment at Spišská Nová Ves and Levoca

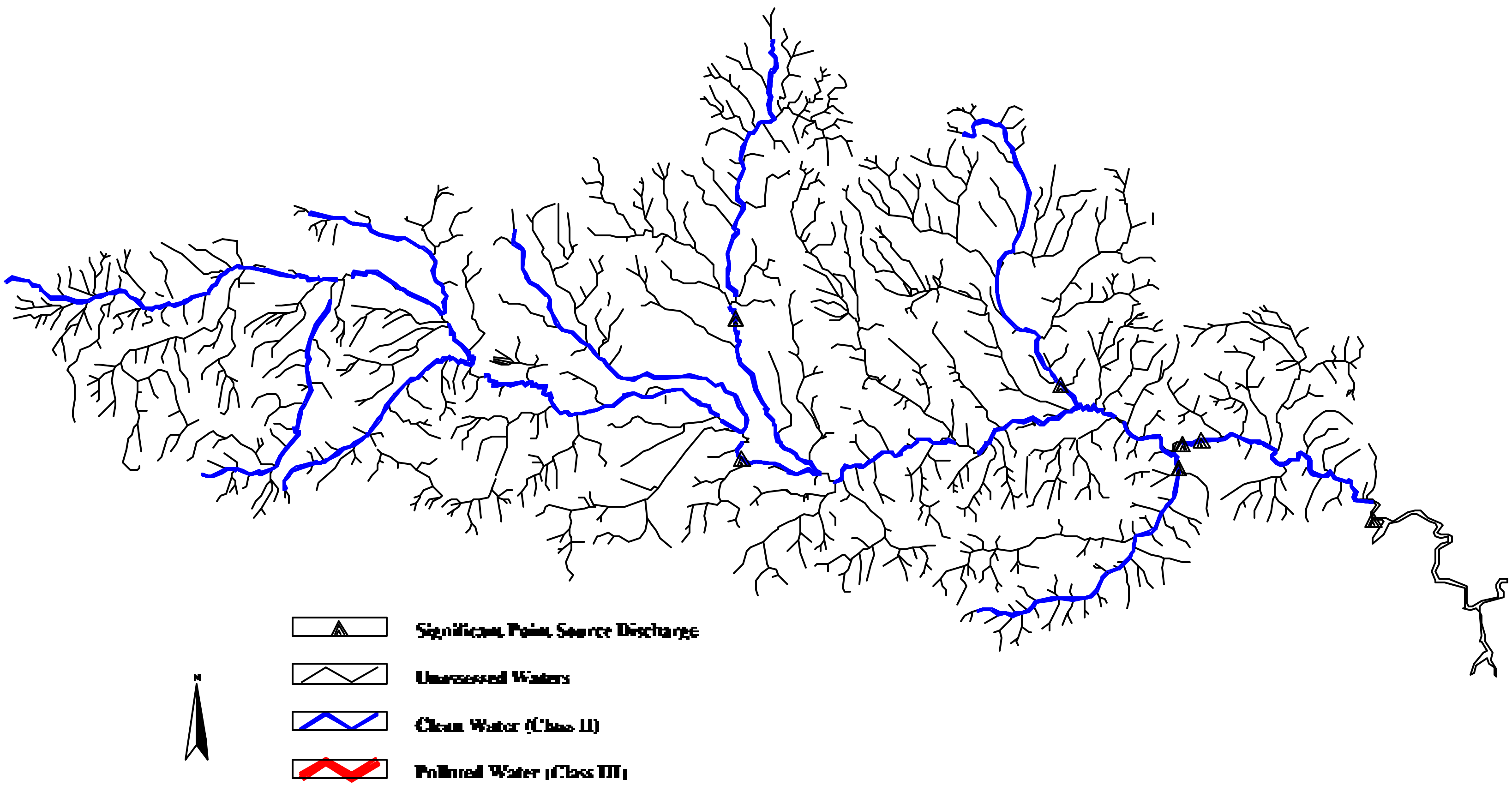


Figure 11. Map of Watershed Ammonia with Air Stripping Treatment at Spišská Nová Ves and Levoca