The Effect of the Košice Wastewater Treatment Plant on the Hernad and Hornád Rivers

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Purpose

The goal of this study is to develop a recommendation for wastewater treatment to help protect the beneficial uses of the Lower Hornád River in southeastern Slovak Republic continuing as the Hernad River in northeastern Hungary. 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 assess alternative wastewater treatment levels for the City of Košice in the Slovak Republic for protection of these rivers. Different pollution control alternatives can be assessed using the water quality model. These alternatives are expected be presented by the non-governmental organizations, SOSNA and Holocen, to local authorities for selection of the best approach to pollution control.

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 criteria that apply to the Hornád and Hernad Rivers protects for the support of aquatic life. For the effects of wastewater treatment, the two most important criteria are for dissolved oxygen and ammonia. The same criteria for these constituents have been adopted as standards in both the Slovak Republic and Hungary to protect aquatic life. The goal is to achieve levels needed for "Clean Water".

For Ammonia:

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

For Dissolved Oxygen:

1. Above 7 mg/L = Very Clean Water
2. Above 6 mg/L = Clean Water
3. Above 5 mg/L = Polluted Water
4. Above 3 mg/L = High Level of Pollution
5. Below 3 mg/L = Very High Level of Pollution

Geographic Setting

The study area covers the Lower Horná d River from the confluence with the Svinka river downstream to the mouth of the Hernad River with the Sajo River. The reach of river studied has a length of 163 km.

Point source discharge locations were identified on the rivers and streams in the watershed. All direct discharges to the mainstem rivers were modeled. Land cover of the lower Horná d River watershed of the study reach was used to assess nonpoint source pollution for the modeling analysis. 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 watershed delineation to estimate nonpoint source pollutant loads (Table 1). Land cover data could not be obtained for the Hungarian portion of watershed along the Hernad River. Sine the terrain and general land uses are similar, nonpoint sources loading estimates derived for the Slovakian reach were assumed to be the same as in the Hungarian reach.

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 available for 1996. Data collected by the Slovak Hydrometeorological Institutes were available in the Horná d River. Data collected by volunteers for the International Water Monitoring Project were available for the Hernad River. This monitoring project is administered by the two non-governmental organizations, Holocen in Hungary and SOSNA in the Slovak Republic.

A review of the water quality data collected in the two rivers showed that dissolved oxygen concentrations were generally lowest in the summer months. Dissolved oxygen was measured at 6.2 mg/L at Hernad KM 65 on July 6, 1996 and at Horná d KM 18 on August 26, 1996. These low values correspond with the highest values measured for ammonia at Horná d KM 18 of 0.582 mg-N/L and 1.281 mg-N/L on June 24, 1996 and August 26, 1996, 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 17 reaches for the modeling (Table 2). Each reach was selected based on locations of the point sources, tributary inflows and locations of stations with water quality data. Each reach is assumed to generally represent uniform conditions. 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 and validated for periods where ammonia and dissolved oxygen were at the most critical levels. The model was calibrated using the data collected in with June 1996 and validated with August 1996. The first step in the analysis was to balance the flows for both modeled time periods. Flows within the Hornád watershed were balanced using gauged flow data averaged for the calibration months. Incremental flows from ungauged streams were determined balanced by adjusting the incremental flow for each model reach accordingly. Since flow data was not available in the Hernad reaches, the incremental flow was extended along those reaches according to river length. Climatic data from the Košice station was used to for the specific times modeled (Table 3).

Point source loading values for the Hornád River measured and estimated (Table 4) were input into the appropriate model element according to the discharge location. Point source data were not available for the Hernad River. 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 watershed.

Model output was compared to data collected from stations at Hornád River KM 18, 27, 39, 48 and Hernad KM 23, 55, and 65. 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 June 1996 described above (Tables 7, 8 and 9). Calibration adjustments of model parameters were made within acceptable ranges until model output reasonably matched measured concentrations. Validation was conducted by using the same parameter values determined through calibration with the state variables for August 1996

(Tables 10, 11 and 12).. The model performance was adequate for predicting measured dissolved oxygen and ammonia levels (Tables 13 and 14).

Loading Analysis

The calibrated water quality model was used to determine the effect of wastewater loads from Košice discharged to the Hornád River at KM 24.3. The calibration results show that "Clean Water" standards are met for dissolved oxygen, but not ammonia. Ammonia standard is violated for 47 kilometers, from the location of the Košice discharge downstream to Hernad KM 93 near Vilmány, Hungary.

The calibrated water quality model was used to estimate the effect of various pollution controls on Košice Wastewater Treatment Plant in the Hernad and Hornád Rivers. The major source of biological oxygen demand and ammonia loading to the river is wastewater from this facility. The water quality model was run to test the predicted effect on for several wastewater treatment unit operations and processes using the median expected removal efficiencies (Metcalf & Eddy, 1972). Information collected in 1997 on the raw wastewater entering the facility was used to determine existing treatment removal efficiency. The pollutant removal expected from other treatments were applied to the raw wastewater information to estimate the effluent concentrations of various constituents from these treatments. The estimated effluent concentrations were then run in the calibrated models to estimate their effect on the rivers.

The loading analysis results show that three of the treatment options evaluated will result in meeting the "Clean Water" standard for ammonia (Table 15). All three of these treatment unit operations can be expensive. The least expensive of the three, air stripping, would not provide additional removal of nutrients and oxygen demanding substances. Since the Hernad ultimately drains to the Danube River, the more costly treatment options of ion exchange and reverse osmosis should be considered. Studies done for the Environmental Program for the Danube River Basin financed by the PHARE-program of the EC-Commission show the need for additional nutrient removal from municipal wastewater treatment plants for protection of the Danube River and the Black Sea (Zessner et al. 1998).

One complication to improving the pollutant load from the Košice discharge 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 facilities 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:

Obtain information on flows and land use on the Hungarian side of the watershed
Requests for information to run the model from various parties in Hungary was unsuccessful. It is likely that more information exists, but unavailable for this purpose for unknown reasons. Without these data, several assumptions had to be made in model development. Additional time spent in locating and obtaining data from Hungary could be used to improve the model.

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 and Holocen 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 Košice wastewater discharge 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. 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 in the Lower Horná d River Watershed

Land Cover Type	CORINE Level 3 Code	Area (hectares)	Percent of Total
Urban Areas Overall	1XX	4033	11.0
Continuous Urban Fabric	111	43	0.1
Discontinuous Urban Fabric	112	2508	6.8
Industrial/Commercial Units	121	1121	3.1
Roads and Railways	122	92	0.3
Mineral Extraction Sites	131	29	0.1
Dump Sites	132	32	0.1
Construction Sites	133	33	0.1
Green Urban Areas	141	46	0.1
Sport and Leisure Activities	142	129	0.4
Agricultural Areas Overall	2XX	27001	73.6
Non-irrigated Arable Land	211	14259	38.9
Vineyards	221	47	0.1
Fruit Trees and Berry Farms	222	172	0.5
Pasture Lands	231	1903	5.2
Cultivated Agriculture	242	548	1.5
Agriculture in Areas with Mostly Natural Vegetation	243	10072	27.5
Forested Areas Overall	3XX	5627	15.3
Broad-leaved Forest Lands	311	2813	7.7
Coniferous Forest Lands	312	99	0.3
Mixed Forest Lands	313	824	2.2
Schrublands	324	1891	5.2
Total Area Overall	All Codes	36662	100

Table 2. Modeled Stream Geometry of the Lower Horná d and Hernad Rivers

Reach Number	**Length** (km)	**Begin Reach**	**End Reach**
1	10	Horná d KM 48	Horná d KM 38
2	11	Horná d KM 38	Horná d KM 27
3	5	Horná d KM 27	Horná d KM 22
4	5	Horná d KM 22	Horná d KM 17
5	7	Horná d KM 17	Horná d KM 10
6	10	Horná d KM 10	Horná d at Hungary Border
7	10	Hernad at Hungary Border	Hernad KM 105
8	10	Hernad KM 105	Hernad KM 95
9	10	Hernad KM 95	Hernad KM 85
10	10	Hernad KM 85	Hernad KM 75
11	10	Hernad KM 75	Hernad KM 65
12	10	Hernad KM 65	Hernad KM 55
13	10	Hernad KM 55	Hernad KM 45
14	10	Hernad KM 45	Hernad KM 35
15	10	Hernad KM 35	Hernad KM 25
16	10	Hernad KM 25	Hernad KM 15
17	15	Hernad KM 15	Hernad at Sajo River

Table 3. Climate Values Used in Lower Hornád and Hernad Rivers Model

Weather Station ⑤	Dates Used for Mean ④	Cloud Cover (%) ⑤	Dry Air Temperature (degree C) ⑤	Dew Point Temperature (degree C) ①	Solar Radiation (Langley/hr) ②	Wind Speed (m/sec) ③
Košice, Slovak Republic	August 15 to August 31, 1996	71%	23.2 C	14.0 C	140	8
	June 15 to June 30, 1996	69%	20.3 C	10.8 C	140	8

Footnotes to Table:

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)
⑤ All data collected mid-day at 1400 hours

Table 4. Characteristics of Point Sources discharging to the Lower Hornád River

Facility Name ①	Hornád Location ①	Waste Type ⑤	Flow (m^3/s) ①②	BOD_5 (mg/L) ①	Org-N (mg/L) ③	NH_3 (mg/L) ③	NO_2 (mg/L) ③	NO_3 (mg/L) ③	Org-P (mg/L) ④	PO_4 (mg/L) ③
Bana Baòkov	Km 36.7	Mining	0.00353	1.7	6.1	7.9	0.19	1.30	0.50	1.60
Agrokov	Km 35.1	Agriculture	0.00001	51.0	39.2	80.0	0.08	30.80	1.00	3.30
Obchod S Palivami	Km 34.7	Domestic	0.00003	150.0	15.0	25.0	0.06	0.15	3.00	10.00
ŽSR	Km 33.5	Domestic	0.00266	6.5	6.1	7.9	0.19	1.30	0.50	1.60
Verejna kanalizacia Košice #1	Km 32.1	Domestic	0.00239	4.0	6.1	7.9	0.19	1.30	0.50	1.60
Cassoviamilk	Km 31.8	Dairy	0.00025	4.9	6.1	7.9	0.19	1.30	0.50	1.60
Verejna kanalizacia Košice #2	Km 24.3	Domestic	1.24961	30.0	5.4⑤	6.2①	0.3⑤	3.3⑤	0.21①	0.69①

Footnotes:

① Information provided by the Slovak Hydrometeorological Institute.

② Flows derived from total annual measured flow volume.

③ Estimated from assumed treatment based on BOD_5 levels and wastetype (Leo, et al. 1984, Thomann, 1972, Mueller, et al. 1982, Metacalf and Eddy, 1972).

④ Difference between Total P and Ortho-P (for domestic wastewater per Mueller, et al. 1982).

⑤ Information provided by Nadacia SOSNA

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
Continuous Urban Fabric	111	0.63	8	0.47	8	19	12	210	12
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
Roads and Railways	122	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
Green Urban Areas	141	0.63	8	0.47	8	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
Vineyards	221	1.10	8	1.14	8	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
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.
6. Horner, et al. 1986.
7. Krebs and Golley, 1977.
8. Reckhow, 1980.
9. Salminen and Beschta, 1991.
10. Shahane, 1982.
11. Timmons, et al. 1977.
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
Continuous Urban Fabric	111	0.33	7	2.04	7	0.0408	10	3.14	7
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
Roads and Railways	122	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
Green Urban Areas	141	0.33	7	2.04	7	0.0408	10	3.14	7
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
Vineyards	221	1.35	7	1.08	7	0.0216	10	6.57	7
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
Schrublands	324	0.28	5	0.13	5	0.0026	10	0.82	5

References:

1. Betson, 1978.
2. Burwell, et al. 1974
3. Burwell, et al. 1975.
4. Campbell, 1978.
5. Gosz, 1978.
6. Long, 1979.
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 (a stream not affected by a point source)

Table 7. Concentrations for Parameters Used in Model Calibration

Description	Reach/ element	Temperature		DO		BOD	
		C	Reference	mg/L	Reference	mg/L	Reference
Hornád KM 48	Headwater	17	1	8.5	1	5.3	1
Hornád KM 39	1/9	18	2	8.6	2	5.7	2
Hornád KM 27	2/11	17	3	9.0	3	3.6	3
Hornád KM 18	4/4	17	4	7.4	4	5.6	4
Hernad KM 65	11/10	22	5	6.2	5	4.7	8
Hernad KM 55	12/10	22	6	7.2	6	4.7	8
Hernad KM 23	16/3	23	7	8.2	7	4.7	8

References:

1. Slovak Hydrometeorological Institute Station H165000D
2. Slovak Hydrometeorological Institute Station H171000D
3. Slovak Hydrometeorological Institute Station H372000D
4. Slovak Hydrometeorological Institute Station H371000D
5. Holocen Station 27
6. Holocen Station 23
7. Holocen Station 22
8. Estimated based on land use export coefficients

Table 8. Concentrations for Nitrogen Species Used in Model Calibration

Description	Reach/ element	Ammonia -N		Nitrate -N		Nitrite -N		Organic Nitrogen	
		mg/L	Reference	mg/L	Reference	mg/L	Reference	mg/L	Reference
Hornád KM 48	Headwater	0.148	1	1.988	1	0.0150	1	0.619	8
Hornád KM 39	1/9	0.241	2	2.245	2	0.0165	2	0.619	8
Hornád KM 27	2/11	0.124	3	2.573	3	0.0143	3	0.619	8
Hornád KM 18	4/4	0.582	4	2.388	4	0.0774	4	0.619	8
Hernad KM 65	11/10	0.300	5	5.500	5	0.1500	5	0.619	8
Hernad KM 55	12/10	0.200	6	5.500	6	0.1500	6	0.619	8
Hernad KM 23	16/3	0.000	7	4.400	7	0.1500	7	0.619	8

References:
1. Slovak Hydrometeorological Institute Station H165000D
2. Slovak Hydrometeorological Institute Station H171000D
3. Slovak Hydrometeorological Institute Station H372000D
4. Slovak Hydrometeorological Institute Station H371000D
5. Holocen Station 27
6. Holocen Station 23
7. Holocen Station 22
8. Estimated based on land use export coefficients

Table 9. Concentrations for Phosphorus Species Used in Model Calibration

Description	**Reach/ element**	**Organic P**		**Dissolved P**	
		mg/L	Reference	mg/L	Reference
Hornád KM 48	Headwater	0.133	4	0.153	4
Hornád KM 39	1/9	0.133	4	0.153	4
Hornád KM 27	2/11	0.133	4	0.153	4
Hornád KM 18	4/4	0.133	4	0.153	4
Hernad KM 65	11/10	0.133	4	0.412	1
Hernad KM 55	12/10	0.133	4	0.330	2
Hernad KM 23	16/3	0.133	4	0.250	3

References:

1. Holocen Station 27
2. Holocen Station 23
3. Holocen Station 22
4. Estimated based on land use export coefficients

Table 10. Concentrations for Parameters Used in Model Validation

Description	**Reach/ element**	**Temperature**		**DO**		**BOD**	
		C	Reference	mg/L	Reference	mg/L	Reference
Hornád KM 48	Headwater	17	1	9.1	1	5.3	1
Hornád KM 39	1/9	17	2	9.5	2	6.4	2
Hornád KM 27	2/11	17	3	7.8	3	3.2	3
Hornád KM 18	4/4	17	4	6.2	4	5.2	4
Hernad KM 65	11/10	21	5	7.9	5	4.7	8
Hernad KM 55	12/10	22	6	8.9	6	4.7	8
Hernad KM 23	16/3	23	7	7.0	7	4.7	8

References:

9. Slovak Hydrometeorological Institute Station H165000D
10. Slovak Hydrometeorological Institute Station H171000D
11. Slovak Hydrometeorological Institute Station H372000D
12. Slovak Hydrometeorological Institute Station H371000D
13. Holocen Station 27
14. Holocen Station 23
15. Holocen Station 22
16. Estimated based on land use export coefficients

Table 11. Concentrations for Nitrogen Species Used in Model Validation

Description	**Reach/ element**	**Ammonia -N**		**Nitrate -N**		**Nitrite -N**		**Organic Nitrogen**	
		mg/L	Reference	mg/L	Reference	mg/L	Reference	mg/L	Reference
Hornád KM 48	Headwater	0.396	1	2.282	1	0.0045	1	0.619	8
Hornád KM 39	1/9	0.280	2	2.282	2	0.0043	2	0.619	8
Hornád KM 27	2/11	0.179	3	1.807	3	0.0060	3	0.619	8
Hornád KM 18	4/4	1.281	4	2.711	4	0.1068	4	0.619	8
Hernad KM 65	11/10	0.500	5	6.600	5	0.0900	5	0.619	8
Hernad KM 55	12/10	0.100	6	3.300	6	0.0900	6	0.619	8
Hernad KM 23	16/3	0.000	7	5.500	7	0.0450	7	0.619	8

References:

9. Slovak Hydrometeorological Institute Station H165000D
10. Slovak Hydrometeorological Institute Station H171000D
11. Slovak Hydrometeorological Institute Station H372000D
12. Slovak Hydrometeorological Institute Station H371000D
13. Holocen Station 27
14. Holocen Station 23
15. Holocen Station 22
16. Estimated based on land use export coefficients

Table 12. Concentrations for Phosphorus Species Used in Model Validation

Description	Reach/ element	Organic P		Dissolved P	
		mg/L	Reference	mg/L	Reference
Hornád KM 48	Headwater	0.133	4	0.153	4
Hornád KM 39	1/9	0.133	4	0.153	4
Hornád KM 27	2/11	0.133	4	0.153	4
Hornád KM 18	4/4	0.133	4	0.153	4
Hernad KM 65	11/10	0.133	4	0.500	1
Hernad KM 55	12/10	0.133	4	0.560	2
Hernad KM 23	16/3	0.133	4	0.500	3

References:

5. Holocen Station 27
6. Holocen Station 23
7. Holocen Station 22
8. Estimated based on land use export coefficients

Table 13. Performance of the Upper Hornád and Hernad River Model in Predicting Dissolved Oxygen Concentrations

Location	**Calibration for June 1996**		**Validation for August 1996**	
	Measured	**Predicted**	**Measured**	**Predicted**
Hornád KM 39	8.6	9.3	9.5	9.6
Hornád KM 27	9.0	9.5	7.8	9.4
Hornád KM 18	7.4	7.4	6.2	7.3
Hernad KM 65	6.2	7.2	7.9	7.3
Hernad KM 55	7.2	7.0	8.9	7.0
Hernad KM 23	8.2	7.1	7.0	7.2
Statistics				
Median Absolute Deviation (mg/L)	0.6		0.9	
Median Scaled Residual (%)	3%		2%	
Root Mean Square Error (mg/L)	0.3		0.2	
Relative Error (%)	4%		3%	

Table 14. Performance of the Upper Hornád and Hernad River Model in Predicting Ammonia Nitrogen Concentrations

Location	**Calibration for June 1996**		**Validation for August 1996**	
	Measured	**Predicted**	**Measured**	**Predicted**
Hornád KM 39	0.241	0.270	0.280	0.280
Hornád KM 27	0.124	0.220	0.179	0.220
Hornád KM 18	0.582	1.110	1.281	1.110
Hernad KM 65	0.300	0.290	0.500	0.290
Hernad KM 55	0.200	0.160	0.100	0.160
Hernad KM 23	0.000	0.010	0.000	0.010
Statistics				
Median Absolute Deviation (mg/L)	0.035		0.051	
Median Scaled Residual (%)	8%		1%	
Root Mean Square Error (mg/L)	0.250		0.110	
Relative Error (%)	103%		28%	

Table 15. The Effect on the Hornád and Hernad Rivers from Different Options for Košice Wastewater Treatment

Treatment Description	**Highest River Ammonia Concentration Downstream (mg N/L)**	**Kilometers Downstream Not Meeting the Clean Water Standard for Ammonia**
Current Level of Treatment	3.57	47
Chemical Precipitation	3.23	42
Bacterial Assimilation	2.33	31
Electrodialysis	2.17	27
Gas-phase Separation	1.48	16
Oxidation with Chlorine	1.31	12
Air Stripping of Ammonia	0.41	0
Ion Exchange	0.41	0
Reverse Osmosis	0.35	0

Appendix

Calibrated Model Qual2E Code

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TITLE01              Hernad Calibration
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       =        17          NUMBER OF JUNCTIONS     =         0
NUM OF HEADWATERS       =         1          NUMBER OF POINT LOADS   =         9
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=       Hornád 38   FROM         163.    TO          153.
STREAM REACH      2.RCH=       Hornád 27   FROM         153.    TO          142.
STREAM REACH      3.RCH=       Hornád 22   FROM         142.    TO          137.
STREAM REACH      4.RCH=       Hornád 17   FROM         137.    TO          132.
STREAM REACH      5.RCH=       Hornád 10   FROM         132.    TO          125.
STREAM REACH      6.RCH= Hornád @ Border   FROM         125.    TO          115.
STREAM REACH      7.RCH=      Hernad 105   FROM         115.    TO          105.
STREAM REACH      8.RCH=       Hernad 95   FROM         105.    TO           95.
STREAM REACH      9.RCH=       Hernad 85   FROM          95.    TO           85.
STREAM REACH     10.RCH=       Hernad 75   FROM          85.    TO           75.
STREAM REACH     11.RCH=       Hernad 65   FROM          75.    TO           65.
STREAM REACH     12.RCH=       Hernad 55   FROM          65.    TO           55.
STREAM REACH     13.RCH=       Hernad 45   FROM          55.    TO           45.
STREAM REACH     14.RCH=       Hernad 35   FROM          45.    TO           35.
STREAM REACH     15.RCH=       Hernad 25   FROM          35.    TO           25.
STREAM REACH     16.RCH=       Hernad 15   FROM          25.    TO           15.
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STREAM REACH     17.RCH=  Hernad at Sajo   FROM          15.    TO             0
ENDATA2
ENDATA3
FLAG FIELD RCH=   1.       10.         1.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=   2.       11.         2.6.6.6.6.6.6.2.2.2.2.
FLAG FIELD RCH=   3.        5.         2.2.6.6.2.
FLAG FIELD RCH=   4.        5.         2.2.2.6.2.
FLAG FIELD RCH=   5.        7.         2.2.2.2.2.2.2.
FLAG FIELD RCH=   6.       10.         2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=   7.       10.         2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=   8.       10.         2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=   9.       10.         2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  10.       10.         2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  11.       10.         2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  12.       10.         2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  13.       10.         2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  14.       10.         2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  15.       10.         2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  16.       10.         2.2.2.2.2.2.2.2.2.2.
FLAG FIELD RCH=  17.       15.         2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.
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
ENDATA5
REACT COEF RCH=   1.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=   2.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=   3.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=   4.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=   5.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=   6.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=   7.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=   8.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=   9.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=  10.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=  11.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=  12.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=  13.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=  14.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=  15.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=  16.     0.1      0     0.1  4.       0       0       0
REACT COEF RCH=  17.     0.1      0     0.1  4.       0       0       0
ENDATA6
N AND P COEF   RCH=   1.   0.03     0     1.   200.   1.00   0.01     0      0
N AND P COEF   RCH=   2.   0.03     0     1.      0   1.00   0.01     0      0
N AND P COEF   RCH=   3.   0.03     0     1.      0   1.00   0.01     0      0
N AND P COEF   RCH=   4.   0.03     0     1.      0   1.00   0.01     0      0
N AND P COEF   RCH=   5.   0.03     0    1.2      0   1.00   0.01     0   100.
N AND P COEF   RCH=   6.   0.03     0    1.2      0   1.00   0.01     0   300.
N AND P COEF   RCH=   7.   0.03     0    1.2      0   1.00   0.01     0   500.
N AND P COEF   RCH=   8.   0.03     0    1.2      0   1.00   0.01     0   600.
N AND P COEF   RCH=   9.   0.03     0    1.2      0   1.00   0.01     0   700.
N AND P COEF   RCH=  10.   0.03     0    1.2      0   1.00   0.01     0   700.
N AND P COEF   RCH=  11.   0.03     0    1.2      0   1.00   0.01     0   600.
N AND P COEF   RCH=  12.   0.03     0     3.      0   1.00   0.01     0      0
N AND P COEF   RCH=  13.   0.03     0     5.      0   1.00   0.01     0      0
N AND P COEF   RCH=  14.   0.03     0     5.      0   1.00   0.01     0      0
N AND P COEF   RCH=  15.   0.03     0     5.      0   1.00   0.01     0      0
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N AND P COEF   RCH=  16.   0.03      0     5.      0   1.00   0.01      0      0
N AND P COEF   RCH=  17.   0.03      0     5.      0   1.00   0.01      0      0
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    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=   9.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=  10.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=  11.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=  12.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=  13.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=  14.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=  15.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=  16.  50.00    0.9  0.330      0      0      0      0
ALG/OTHER COEF RCH=  17.  50.00    0.9  0.330      0      0      0      0
ENDATA6B
INITIAL COND-1 RCH=   1.    18.    8.6    5.7   0.00   0.00   0.00   0.00   0.00
INITIAL COND-1 RCH=   2.    17.    9.0    3.6      0      0      0      0      0
INITIAL COND-1 RCH=   3.    17.    9.0    3.6      0      0      0      0      0
INITIAL COND-1 RCH=   4.    17.    7.4    5.6      0      0      0      0      0
INITIAL COND-1 RCH=   5.    17.    7.4    5.6      0      0      0      0      0
INITIAL COND-1 RCH=   6.    17.    7.4    5.6      0      0      0      0      0
INITIAL COND-1 RCH=   7.    17.    7.4    5.6      0      0      0      0      0
INITIAL COND-1 RCH=   8.    17.    7.4    5.6      0      0      0      0      0
INITIAL COND-1 RCH=   9.    17.    7.4    5.6      0      0      0      0      0
INITIAL COND-1 RCH=  10.    17.    7.4    5.6      0      0      0      0      0
INITIAL COND-1 RCH=  11.    22.    6.2    4.7      0      0      0      0      0
INITIAL COND-1 RCH=  12.    22.    7.2    4.7      0      0      0      0      0
INITIAL COND-1 RCH=  13.    22.    7.2    4.7      0      0      0      0      0
INITIAL COND-1 RCH=  14.    22.    7.2    4.7      0      0      0      0      0
INITIAL COND-1 RCH=  15.    22.    7.2    4.7      0      0      0      0      0
INITIAL COND-1 RCH=  16.    23.    8.2    4.7      0      0      0      0      0
INITIAL COND-1 RCH=  17.    23.    8.2    4.7      0      0      0      0      0
ENDATA7
INITIAL COND-2 RCH=   1.   0.01  0.619  0.241 0.0165  2.245  0.133  0.153
INITIAL COND-2 RCH=   2.   0.01  0.619  0.124 0.0143  2.573  0.133  0.153
INITIAL COND-2 RCH=   3.   0.01  0.619  0.124 0.0143  2.573  0.133  0.153
INITIAL COND-2 RCH=   4.   0.01  0.619  0.582 0.0774  2.388  0.133  0.153
INITIAL COND-2 RCH=   5.   0.01  0.619  0.582 0.0774  2.388  0.133  0.153
INITIAL COND-2 RCH=   6.   0.01  0.619  0.582 0.0774  2.388  0.133  0.153
INITIAL COND-2 RCH=   7.   0.01  0.619  0.582 0.0774  2.388  0.133  0.153
INITIAL COND-2 RCH=   8.   0.01  0.619  0.582 0.0774  2.388  0.133  0.153
INITIAL COND-2 RCH=   9.   0.01  0.619  0.582 0.0774  2.388  0.133  0.153
INITIAL COND-2 RCH=  10.   0.01  0.619  0.582 0.0774  2.388  0.133  0.153
INITIAL COND-2 RCH=  11.   0.01  0.619  0.300 0.1500  5.500  0.133  0.412
INITIAL COND-2 RCH=  12.   0.01  0.619  0.200 0.1500  5.500  0.133  0.330
INITIAL COND-2 RCH=  13.   0.01  0.619  0.200 0.1500  5.500  0.133  0.330
INITIAL COND-2 RCH=  14.   0.01  0.619  0.200 0.1500  5.500  0.133  0.330
INITIAL COND-2 RCH=  15.   0.01  0.619  0.200 0.1500  5.500  0.133  0.330
INITIAL COND-2 RCH=  16.   0.01  0.619  0.000 0.1500  4.400  0.133  0.250
INITIAL COND-2 RCH=  17.   0.01  0.619  0.000 0.1500  4.400  0.133  0.250
ENDATA7A
INCR INFLOW-1  RCH=   1.  0.575    18.   8.6  4.69  0.00   0.00   0.00   0.00   0.00
INCR INFLOW-1  RCH=   2.  0.244    17.   9.0  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=   3.  0.029    17.   9.0  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=   4.  0.140    17.   7.4  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=   5.  0.066    17.   7.4  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=   6.  0.246    17.   7.4  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=   7.  0.411    17.   7.4  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=   8.  0.156    17.   7.4  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=   9.  0.118    17.   7.4  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=  10.  0.094    17.   7.4  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=  11.  0.244    22.   6.2  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=  12.  0.244    22.   7.2  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=  13.  0.534    22.   7.2  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=  14.  0.291    22.   7.2  4.69     0      0      0      0      0
INCR INFLOW-1  RCH=  15.  0.490    22.   7.2  4.69     0      0      0      0      0
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INCR INFLOW-1  RCH=  16.  0.160    23.   8.2  4.69     0     0     0     0     0
INCR INFLOW-1  RCH=  17.  0.330    23.   8.2  4.69     0     0     0     0     0
ENDATA8
INCR INFLOW-2  RCH=   1.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=   2.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=   3.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=   4.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=   5.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=   6.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=   7.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=   8.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=   9.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=  10.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=  11.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=  12.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=  13.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=  14.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=  15.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=  16.      0  0.619  0.094 0.0073  0.364  0.133  0.153
INCR INFLOW-2  RCH=  17.      0  0.619  0.094 0.0073  0.364  0.133  0.153
ENDATA8A
ENDATA9
HEADWTR-1 HDW=  1.0       Hornád 38    0.076   17.   8.5   5.3     0     0     0
ENDATA10
HEADWTR-2 HDW=  1.0     0     0  0.01 0.619 0.148 0.015 1.988 0.133 0.153
ENDATA10A
POINTLD-1 PTL=    1 Bana Bankov    0 0.00353   18.  6.00   1.7  0.00  0.00  0.00
POINTLD-1 PTL=    2     Agrokov    0 0.00001   18.  6.00  51.0     0     0     0
POINTLD-1 PTL=    3Obchod S Pal    0 0.00003   18.  6.00 150.0     0     0     0
POINTLD-1 PTL=    4         ZSR    0 0.00266   18.  6.00   6.5     0     0     0
POINTLD-1 PTL=    5VK Kosise #1    0 0.00239   18.  6.00   4.0     0     0     0
POINTLD-1 PTL=    6Cassoviamilk    0 0.00025   18.  6.00   4.9     0     0     0
POINTLD-1 PTL=    7VK Košice #2    0 1.24961   18.  6.00  30.0     0     0     0
POINTLD-1 PTL=    8Torysa River    0   4.834   17.   6.7   1.7     0     0     0
POINTLD-1 PTL=    9Olslava Rive    0   1.267   16.   9.4   6.4     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  39.2  80.0  0.08 30.80  1.00  3.30
POINTLD-2  PTL=    3     0     0   0.0  15.0  25.0  0.06  0.15  3.00 10.00
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   6.1   7.9  0.19  1.30  0.50  1.60
POINTLD-2  PTL=    6     0     0   0.0   6.1   7.9  0.19  1.30  0.50  1.60
POINTLD-2  PTL=    7     0     0   0.0   5.4   6.2  0.30  3.30  0.21  0.69
POINTLD-2  PTL=    8     0     0   0.0     0 0.4270.1236 3.185     0     0
POINTLD-2  PTL=    9     0     0   0.0     0 0.2250.0141 1.807     0     0
ENDATA11A
ENDATA12
ENDATA13
ENDATA13A
LOCAL CLIMATOLOGY06    96    0      140.    0.71    20.3    10.8  1000.0      8.
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