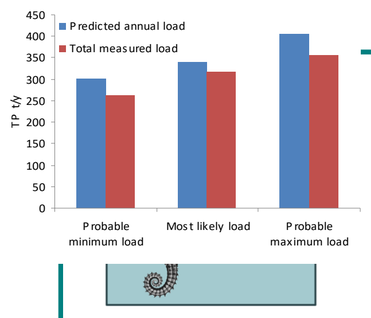


UNDP GEF Black Sea Ecosystem Recovery Project

Kamchiya Nutrient Export Model

The source apportionment approach used

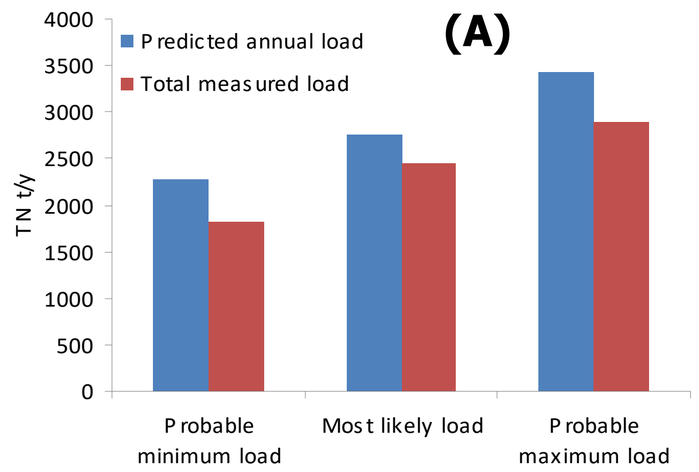
- A simplistic approach which uses data from a range of different sources. While this may contribute to greater spatial uncertainty in the results produced, it makes the model simple to use and greatly reduces the amount of input data required. The model is based in Excel spreadsheet format, with a GIS-based font end for result presentation
- Modelled loads are calibrated/validated against river loads calculated using monitoring data
- Because of the high level of uncertainty when calculating loads using generic export coefficients, for each source probable maximum, most likely and probable minimum loads are calculated from the sources shown below:

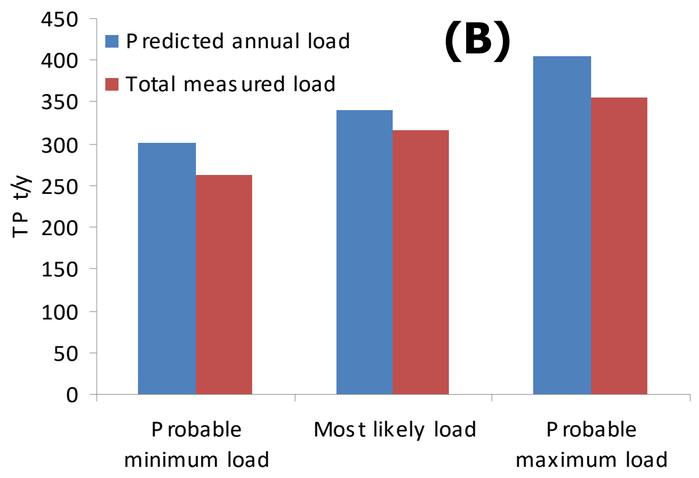
Nitrogen	Phosphorus	Approach
Sewage treatment works	Sewage treatment works	Per p.e. export coefficient, combined with sewage treatment process-specific coefficients and/or (where available) discharge monitoring data
Livestock farming	Livestock farming	Per head export coefficients, combined with generic soil retention coefficients
Land use-based diffuse sources	Land use-based diffuse sources	Land use-specific export coefficients
Industry	Industry	Discharge monitoring data
Unsewered population	Unsewered population	Per p.e. export coefficients and generic soil retention coefficients
Natural N export	Natural P export	Generic export coefficients derived from European studies
Atmospheric deposition	Generic deposition rate derived from Black Sea monitoring data	Not usually considered in export models, since this is considered to be such a minor source, but Bulgarian monitoring data were included

Nutrient sources considered in the model

Comparion of predicted and monitored results

- It is important to remember that loads calculated from measured flow and concentration data are themselves only 'most likely' estimates of real loads
- Upper and lower confidence limits are therefore applied to the measured loads to give probable minimum and probable maximum calculated loads





Comparison of predicted and measured nitrogen (A) and phosphorus (B) loads from the Poda sub-catchment

Notes

- The GIS front end of the model is for improved presentation of results. This is not necessary for 'internal use' and has no effect on the accuracy of results obtained
- The approach used requires only a spreadsheet for full operation
- For individual sub-catchments, calculated 'most likely' loads are used as input data to downstream sub-catchments
- More complex models do not necessarily produce more reliable results; they do, however, increase the data required and expense of obtaining results
- Calibration and validation of nutrient export models is exceptionally important. This requires robust surveillance monitoring data
- For unexpectedly high or low modelled results (see values in red in the figure to the right), an uncertainty analysis (in which a range of alternative export coefficients are used) often helps improve understanding for future models

Model results

KOCHOVO	N load	P load
Calculated upstream nutrient load	67,77	1,11
Livestock farming	52,19	4,54
Land-use diffuse sources	50,38	0,88
Industry	10,50	2,22
Unsewered population	84,87	19,24
Sewered population	120,27	43,79
Natural export	113,36	7,56
Atmospheric deposition	86,41	0,57
Predicted annual load	585,74	79,91
Total measured load	1417,68	52,61

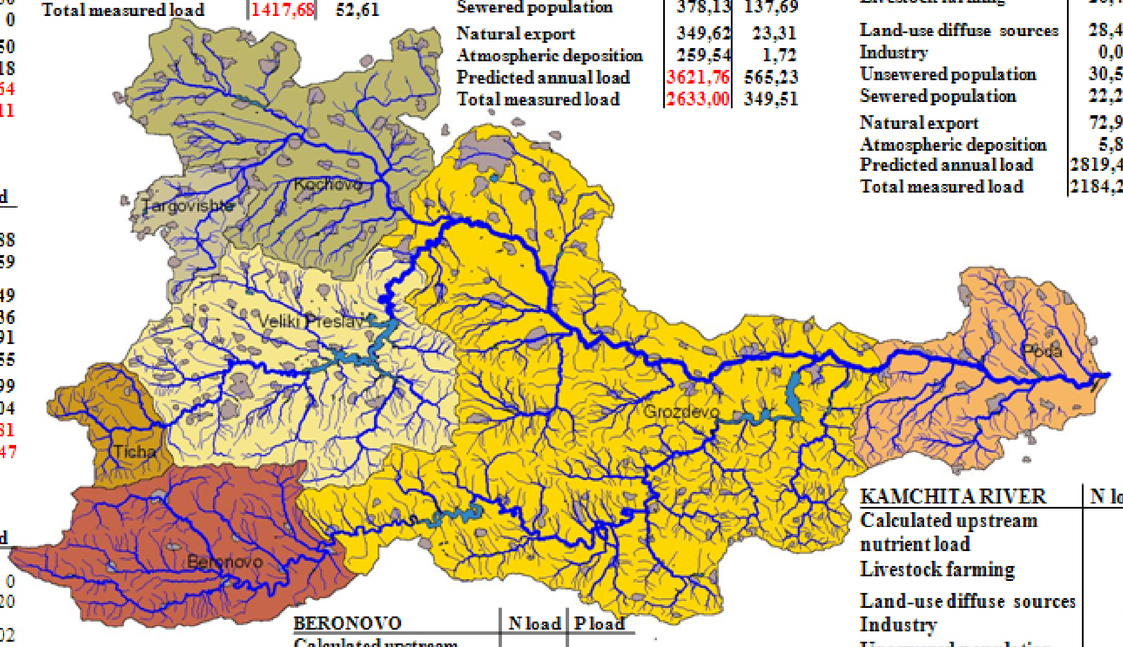
TARGOVISHTE	N load	P load
Calculated upstream nutrient load	0	0
Livestock farming	6,44	0,58
Land-use diffuse sources	4,69	0,08
Industry	0	0
Unsewered population	10,16	2,30
Sewered population	0	0
Natural export	22,46	1,50
Atmospheric deposition	26,74	0,18
Predicted annual load	70,49	4,64
Total measured load	67,77	1,11

PRESLAV	N load	P load
Calculated upstream nutrient load	128,94	5,88
Livestock farming	7,37	0,59
Land-use diffuse sources	28,16	0,49
Industry	1,12	0,36
Unsewered population	74,61	16,91
Sewered population	39,96	14,55
Natural export	134,84	8,99
Atmospheric deposition	156,42	1,04
Predicted annual load	571,42	48,81
Total measured load	608,00	271,47

TICHA	N load	P load
Calculated upstream nutrient load	0	0
Livestock farming	2,28	0,20
Land-use diffuse sources	1,39	0,02
Industry	0	0
Unsewered population	0,07	0,02
Sewered population	4,26	1,55
Natural export	21,26	1,42
Atmospheric deposition	9,19	0,06
Predicted annual load	38,45	3,27
Total measured load	66,82	4,43

GROZDEVO	N load	P load
Calculated upstream nutrient load	2199,26	345,27
Livestock farming	167,85	14,66
Land-use diffuse sources	103,20	1,80
Industry	21,63	8,48
Unsewered population	142,53	32,31
Sewered population	378,13	137,69
Natural export	349,62	23,31
Atmospheric deposition	259,54	1,72
Predicted annual load	3621,76	565,23
Total measured load	2633,00	349,51

PODA	N load	P load
Calculated upstream nutrient load	2633,00	349,51
Livestock farming	26,46	2,31
Land-use diffuse sources	28,44	0,50
Industry	0,00	0,00
Unsewered population	30,51	6,91
Sewered population	22,26	8,10
Natural export	72,91	4,86
Atmospheric deposition	5,86	0,04
Predicted annual load	2819,44	372,23
Total measured load	2184,24	300,89



BERONOVO	N load	P load
Calculated upstream nutrient load	0	0
Livestock farming	12,68	1,10
Land-use diffuse sources	8,16	0,14
Industry	0	0
Unsewered population	17,76	4,03
Sewered population	18,76	6,83
Natural export	89,15	5,94
Atmospheric deposition	51,36	0,34
Predicted annual load	197,87	18,39
Total measured load	173,58	21,20

KAMCHITA RIVER	N load	P load
Calculated upstream nutrient load	0	0
Livestock farming	254	22
Land-use diffuse sources	204	4
Industry	33	11
Unsewered population	360	82
Sewered population	584	213
Natural export	804	54
Atmospheric deposition	844	6
Predicted annual load	3083	390
Total measured load	2184	301

Modelled most probable nitrogen and phosphorus loads from Kamchiya sub-catchments