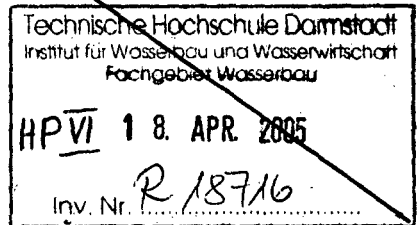


Heft 133 Development of a 2-D Numerical
Module for Particulate
Contaminant Transport in Flood
Retention Reservoirs and
Impounded Rivers

von
Dr.-Ing.
George Jacoub



Contents

Vorwort	I
Preface	III
Abstract	IV
Zusammenfassung (Extended abstract in German)	VII
Notation	XXIII
1 Introduction	1
1.1 Problems classification	1
1.1.1 Sediment related issues in rivers	2
1.1.2 Impact of suspended sediment on river morphology	5
1.1.3 Management of sediment and contaminant in rivers	6
1.1.4 Suggestions for the problems addressed	7
1.2 Physical aspects of flow and transport models	8
1.2.1 Motivation	8
1.2.2 Approaches to flow, sediment and contaminant transport	8
1.2.2.1 Suspended sediment behavior	8
1.2.2.2 Contaminants and suspended sediment interaction	9
1.3 Numerical modeling aspects	11

1.3.1	Transport and morphology modeling concept	11
1.3.2	Development of contaminant transport numerical codes	12
1.3.3	Commercial numerical programs	16
1.4	Aim of the work and its structure	17
2	Theory behind the developed module CTM-SUBIEF-2D	20
2.1	Flow characteristics in two horizontal dimensions	20
2.2	Depth averaged suspended sediment transport	27
2.3	Erosion and deposition	31
2.3.1	Critical shear stress for deposition and erosion	31
2.3.2	Erosion and deposition rates	34
2.3.3	Sediment mixing layer concept	37
2.4	Sorption and degradation processes	39
2.4.1	Sorption processes	39
2.4.2	Degradation processes	40
2.5	Contaminant transport module CTM-SUBIEF-2D	42
2.5.1	Physical concept	42
2.5.2	Module parameters	49
2.6	An overview of the numerical program used	50
3	Implementation of the developed module CTM-SUBIEF-2D	52
3.1	Introduction	52
3.2	Solution algorithms	54
3.2.1	Operator Splitting Method	54
3.2.1.1	First step: advection step	55
3.2.1.2	Second step: propagation-diffusion-source step	55
3.2.2	Method of Streamline Upwind/Petrov-Galerkin "SUPG"	63

3.2.3	Method of Positive Streamwise Invariance "PSI"	65
3.2.4	Boundary conditions	65
3.3	Solvers	66
3.3.1	Nonlinearity	66
3.3.2	Solvers used	68
3.4	Mass conservation	68
4	Testing the developed module CTM-SUBIEF-2D	69
4.1	Introduction	69
4.2	Domain description	71
4.2.1	Hydraulic and physical conditions	71
4.2.2	Numerical conditions	71
4.3	Results of the reference case	73
4.3.1	Hydrodynamic flow field	73
4.3.2	Suspended sediment and contaminant behavior	75
4.4	Results of parameter sensitivity	85
4.5	Conclusion of the chapter	87
5	Application to flood retention reservoir	89
5.1	Introduction	89
5.2	Field measurements	92
5.3	Physical model	95
5.4	Numerical simulations	98
5.4.1	Parameters used	100
5.4.2	Hydrodynamic flow field	102
5.4.3	Suspended sediment transport	108
5.4.4	Contaminant transport	114

5.4.5	Sedimentation of contaminants	117
5.5	Conclusion of the chapter	128
6	Application to the River Rhine	129
6.1	Introduction	129
6.2	Field data	131
6.3	Numerical simulations	134
6.3.1	Weir and hydropower plant conditions	134
6.3.2	Numerical initial and boundary conditions	137
6.3.3	Flow field computation	138
6.3.4	Sediment and contaminant transport dynamics	140
6.4	Conclusion of the chapter	155
7	Summary and conclusion	157
7.1	Summary	157
7.2	Future work	160
	References	161
	Appendix	174
A.1	Input file of the hydrodynamic simulation for test case	174
A.2	Input file of the transport simulation for test case	176
A.3	Results of test cases	179
A.4	Input file of the hydrodynamic simulation for the flood retention reservoir	186
A.5	Input file of the transport simulation for the flood retention reservoir	188
A.6	Input file of the hydrodynamic simulation for the River Rhine	191
A.7	Input file of the transport simulation for the River Rhine	193