Appendix D

Additional References to Models and Modeling Studies

Surface Water Flow and Supply References

Table of Model Types (with reference numbers)

General (50, 54, 66, 75, 82, 86, 112)

1. Watershed Soil/Water Process Models (5, 7, 9, 16, 18, 19, 23, 40, 41, 43, 53, 57, 59, 61, 88, 91, 95, 97, 98, 104, 108, 116, 117, 118, 119)
2. Snow Accumulation and Melt Models (1, 2, 3, 9, 16, 23, 40, 41, 43, 53, 59, 61, 98, 106, 118, 119)
3. Baseflow Models (5, 7, 9, 16, 19, 23, 34, 40, 41, 43, 52, 53, 57, 59, 61, 88, 98, 117, 118, 119)
4. Channel Routing Models (5, 9, 16, 18, 19, 28, 40, 41, 43, 47, 74, 91, 95, 97, 98, 104, 108, 119)
5. Lake and Reservoir Routing Models (19, 43, 47, 57, 97, 98)
6. Flood Formulae (24, 32, 37, 39,62, 73,80,93, 108)
7. Regional Flood Equations (24, 26, 48, 62, 64, 73, 87, 92, 115)
8. Regional Flood Simulation Models (24, 45, 62, 65, 125)
9. Flow Frequency Models (73, 78, 85)
10. Evapotranspiration Models (5, 9, 16, 18, 19, 23, 31, 40, 41, 43, 53, 57, 58, 59, 60, 61, 76, 77, 83, 91, 96, 97, 98, 107, 116, 117, 118, 119)
11. Unit Hydrography Models (22, 24, 39, 62, 94, 108)
12. Dam Failure Models (5, 10, 44)
13. Reservoir Water Accounting Models (9, 57, 98)
14. Annual Data Generation Models (27, 67,68,69, 79)
15. Regional Data Generation Models (20, 26, 36, 51, 64, 70, 79, 87, 111)
16. Reservoir Sedimentation Models (8, 15, 57, 98)
17. Ice Formation and Breakup Models (21, 25, 33, 71, 72, 81, 89, 102, 103, 120)
18. Freezing and Breakup Formulae (12, 21, 25, 33, 72, 81, 89, 102, 103, 120)
19. Plot Size Soil/Water Process Models (29, 31, 53, 57, 58, 59, 60, 61, 88, 95, 96, 108)
20. Plot Snow Accumulation and Melt Models (31, 53, 59, 60, 61, 96)
21. Bank Sloughing Models (109)
22. Flood Inundation Models (46)
23. Channel Erosion and Deposition Models (4, 84, 90, 101, 105)
24. Channel Geometry Equations (63, 99)
25. Irrigation Water Demand Models (57, 100)
26. Land Drainage Models (49, 57, 110, 114)
27. Conduit Capacity Models (11)
28. Pipe Network Models (56, 113)
29. Regional Water Use Relationships (30, 42)
30. Annual Use Generation Models (17)
31. Plant Water Use Models (6, 13, 14, 35, 38, 55, 76, 77, 83, 107)
32. System Water Need Models (56)

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Figure D-1 displays 14 of the most widely used surface water runoff models, and the types of problems each model is capable of analyzing. The following table (table D-1) lists and identifies the originator of over 40 surface water runoff models, including the 14 from figure D-1. Table D-1 is organized by the following categories: screening procedures, simplified computer models, continuous simulation models, and single event simulation models. The table includes those models that have received most extensive use (both private and governmental models) and less widely used models developed by governmental agencies.

Figure D-2 displays 27 of the most widely used receiving water quality models and the types of water bodies and problems they address. Again, table D-2 follows with a more extensive list of models, concentrating on those most widely used and/or developed by a Government agency.

FIGURE D-1

Characteristics of Selected Surface Water Runoff Models

PROBLEM CHARACTERISTICS

MODEL NAME	Urban	Agriculture	Forests	Wetlands	Single Storm Events	Continuous Simulation	Annual or Seasonal Average	Single Catchment	Multiple Catchments	Surface/Total Hydrograph Generation	Subsurface Processes	Snowmelt	Dry-weather/Base Flow	Flow Routing in Channels/Pipes	Backwater, Surcharging, Pressure Flow	Flow Controls and Diversions	Storage / Reservoir Routing	Surface Generation	Routing in Channels/Pipes	Sediment / Erosion	Scour / Deposition in Channels/Pipes	Parameter Interaction	Soil/Sediment-Parameter Interaction	Routing through Storages	Treatment/Removal in Storages	Treatment Processes	Organics / BOD / COD	Nitrogen Species	Phosphorus	Suspended Solids	Coliforms	Pesticides	Arbitrary or other Conservative	Arbitrary or other Non-Conservative	Economic Analysis
	Applicable Land Area				Temporal Properties			Spatial Properties		Hydrology				Hydraulics				Quality Processes									Residuals								
Hydroscience	●						●	●		m								●						●		●	●	●	●	●	●		●		
HRI	●	●	●				●	●										●		●			●				●	●	●	0	●	●	●	●	
SWMM-Level I	●						●	●		●			●					●									●	●	●	0					●
EPARRB	●	●	●	●	●		●	●										●		●							●	●	●				●		
Simpl. SWMM	●					●			●	●							●									●	●	●	●		●				
ACTMO		●				●			o	m	●	●						●		●	●		●					●	●			●	●	●	
ARM		●			●	●			e	o	●	o								●		●	O					●	●	●		●	●	●	
HSP	●	●	●		0	●			e	a	●	e	●	●		●	●	●	●	●			●	●			●	●	●	a			●		
NPS	●	●	●	9	●	●			e	e	●	a						●		●					"		●						●		
QQS	●					●			o	o			●	●	●	●	●	●	●					●	0	●							●		
STORM	●					●		●		e		●	0				●	●		●				0	0	●	●	●	●	●	●				
AGRUN		●			●				●	e	●		●	●				●	●	●				●			●			,	●		●		
CAREDAS	●				0				0	e				●	●	●	●		●											●			●	●	
SWMM	●				0	●			0	a		●	0	●	●	●	●	●	●	●	●			0	●	●	●	●	●		●		●		●

TABLE D-1
Commonly Used Surface Water Runoff Models

Model Name	Commonly Used Acronym	Originator
SCREENING PROCEDURES		
Hydroscience Simplified Model	---	Hydroscience, Inc., Westwood, N.J.
Storm Water Management Model, Level I	SWMM-Level I	Dept. of Environmental Engineering Science, University of Florida, Gainesville, Florida
Midwest Research Institute Loading Functions	MRI	Midwest Research Institute, Kansas City, Missouri
SIMPLIFIED COMPUTER		
Rational Method	---	---
Los Angeles Hydrography Method	---	City of Los Angeles, Los Angeles, California
Santa Barbara Urban Hydrography Method	SBUH	Santa Barbara County Flood Control and Water Conservation District, Santa Barbara, California
Environmental Pollution Assessment-Erosion, Sedimentation and Rural Runoff Model	EPARRB	National Environmental Research Center, Environmental ProtectIon Agency, Athens, Georgia
TVA Stormwater Model		Division of Water Control Planning, Tennessee Valley Authority, Knoxville, Tennessee
Simplified Storm Water Management Model	Simplified SWMM	Metcalf and Eddy, Inc., Palo Alto, California
CONTINUOUS SIMULATION		
Stanford Watershed Model Variants		
Stanford Watershed Model IV	SUM-IV	Department of Civil Engineering, Stanford University, Palo Alto, California

TABLE D-1 (Continued)
Commonly Used Surface Water Runoff Models

Model Name	Commonly Used Acronym	Originator
Kentucky Watershed Model	KWM	University of Kentucky, Lexington, Kentucky
Self-Optimizing, Continuous Hydrologic Simulation Model	OPSET	University of Kentucky, Lexington, Kentucky
National Weather Service River Forecast System	NWSRFS	Office of Hydrology, National Weather Service, Silver Spring, Maryland
Sacramento Model	---	National Weather Service River Forecast Center and State of California Dept. of Water Resources, Sacramento, California
TVA Daily Flow Model	TVA	Division of Water Control Planning, Tennessee Valley Authority, Knoxville, Tennessee
Hydrocomp Simulation Program	HSP	Hydrocomp, Inc., Palo Alto, California
Pesticide Transport and Runoff Model	PTR	Hydrocomp, Inc., Palo Alto, California
Agricultural Runoff Management Model	ARM	Hydrocomp, Inc., Palo Alto, California
Nonpoint Source Model	NPS	Hydrocomp, Inc., Palo Alto, California
Terrestrial Ecosystem Hydrology Model	TEHM	Oak Ridge National Laboratory, Oak Ridge, Tennessee
Other Continuous Simulation Models		
Agricultural Chemical Transport Model	ACTMO	Agricultural Research Service, USDA, Beltsville, Maryland
Streamflow Synthesis and Reservoir Regulation	SSARR	North Pacific Division, Corps of Engineers, Portland, Oregon

TABLE D-1 (Continued)
Commonly Used Surface Water Runoff Models

Model Name	Commonly Used Acronym	Originator
Conversational Streamflow Synthesis and Reservoir Regulation Program	COSSARR	North Pacific Division, Corps of Engineers, Portland, Oregon
Storage, Treatment, Overflow, and Runoff Model	STORM	Hydrologic Engineering Center, Corps of Engineers, Davis, California
Quantity-Quality-Simulation Model	QQS	Dorsch Consult, Munich, Germany and Toronto, Ontario
MIT Catchment Model	MITCAT	Dept. of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts and Resource Analysis, Inc., Waltham, Massachusetts
SINGLE EVENT SIMULATION		
U.S. Dept. of Agriculture Hydrological Laboratory Model	USDAHL-74	Agricultural Research Service, USDA, Beltsville, Maryland
Problem Oriented Computer Language for Hydrologic Modeling	HYMO	Agricultural Research Service, USDA, Soil and Water Conservation Research Division, Riesel, Texas
Computer Program for Project Formulation Hydrology	TR-20	C-E-I-R, Inc., for Soil Conservation Service, USDA, Washington, D. C.
Urban Hydrology for Small Watersheds	TR-55	Soil Conservation Service, USDA, Washington, D. C.
Agricultural Runoff Model	AGRUN	Water Resources Engineers, Inc. Walnut Creek, California
U.S. Geological Survey Rainfall Runoff Model for Peak Flow Synthesis	USGS	U.S. Geological Survey, Reston, Virginia
Calcul des Reseaux D'assainissement (Calculation of Sewage Networks)	CAREDAS	SOGREAH, Grenoble, France (also New York, New York)

TABLE D-1 (Continued)
Commonly Used Surf ace Water Runoff Models

Model Name	Commonly Used Acronym	Originator
Chicago Hydrography Method	CHM (also NERO)	City of Chicago Bureau of Engineering, Chicago, Illinois
Chicago Flow Simulation Program	FSP	Metropolitan Sanitary District of Greater Chicago, Chicago, Illinois
HEC-1 Flood Hydrography Package	HEC-1	Hydrologic Engineering Center, Corps of Engineers, Davis California
Hydrography Volume Method	HVM	Dorsch Consult, Munich, Germany and Toronto, Ontario
Illinois Urban Drainage Area Simulator	ILLUDAS	Illinois State Water Survey, Urbana, Illinois
Road Research Laboratory Model	RRL	Transport and Road Research Laboratory, London, United Kingdom
Storm Water Management Model	SWMM	Metcalf and Eddy, Palo Alto, California; University of Florida, Gainesville, Florida; Water Resources Engineers, Walnut Creek, California
University of Cincinnati Urban Runoff Model	UCUR	Dept. of Civil Engineering, University of Cincinnati, Cincinnati, Ohio

FIGURE D-2

Characteristics of Selected Receiving Water Quality Models

WATER BODY CHARACTERISTICS

MODEL	Streams	Rivers	Lakes	Estuaries	Offshore Waters	Constant Streamflow	Variable Streamflow	Tidal Action	Steady State Lake Levels	Variable Lake Levels
SSM	●	●	●			●				
SEM		⊙		●		⊙				
DOSAG-1	●	⊙				⊙				
DOSAG-3	●	⊙				⊙				
DOSCI	●	⊙				⊙				
ES001				●		⊙		●		
QUAL-I	●	●				⊙				
DEM	⊙	⊙		●		⊙	●	●		
TTM	⊙	⊙		⊙		⊙	⊙	⊙		
RECEIV	⊙	⊙	●	⊙		⊙	⊙	⊙	●	●
RIVSCI	⊙	⊙		⊙			⊙	⊙		
WRECEV	⊙	⊙		⊙		●	⊙	⊙		
DRM			●			⊙	⊙		●	●
LAKSCI			⊙			⊙			⊙	
EPARES			⊙			⊙	●		⊙	●
HSP	●	●	⊙			⊙	⊙		⊙	⊙
CAFE/DISPER		⊙	⊙	●	●		⊙	●		
EXPLORE-I		⊙		⊙		●		⊙		
PLUME			●	⊙	●					
HYD/SAL				⊙	⊙	●	●	●		
QUAL-II	●	●				⊙				
LAKECO			●			⊙	●		●	●
ECOMOD				●		⊙	⊙	●		
ESTECO				⊙	●	⊙	⊙	⊙		
LAKE-I			●						●	
WORKS	●	●	⊙			●	●		⊙	●
Narragansett Bay				●	●	⊙	⊙	●		

MAJOR PROBLEMS

MODEL	Ambient Variations	Waste Heat Inputs	Thermal Stratification	Natural Salt Sources	Irrigation Return Flows	Saltwater Intrusion	Salinity Stratification	Bedload Transport	Suspended Solids Transport	Absorbed Residuals Transport
SSM										
SEM						●				
DOSAG-1										
DOSAG-3				●	●					
DOSCI				●	●					
ES001						●				
QUAL-I										
DEM	●	●				●			●	●
TTM	⊙	⊙				⊙				
RECEIV						⊙				
RIVSCI	●	●				⊙				
WRECEV						⊙				
DRM	●		●							
LAKSCI	●		⊙			●				
EPARES		●	⊙	●	●	⊙	●			
HSP	⊙	⊙	⊙			⊙				
CAFE/DISPER									⊙	
EXPLORE-I						●			⊙	
PLUME										
HYD/SAL						●				
QUAL-II	●	●		●	●				●	
LAKECO	⊙	⊙	●							
ECOMOD						●			⊙	●
ESTECO						⊙				○
LAKE-I			●							
WORKS	●	●	⊙	●	●	●	●		●	
Narragansett Bay	*					⊙				

MODEL	Carbonaceous Oxygen Demand Nonpoint Sources	Carbonaceous Oxygen Demand Point Sources	Nitrogenous Oxygen Demand	Instream Oxygen Demand	Nitrogen Kinetics	Phosphorus Kinetics	Minor Nutrients	Heavy Metals
SSM	●	●						
SEM	⊙	⊙						
DOSAG-1	⊙	⊙	●					
DOSAG-3	⊙	⊙	⊙		●	●		●
DOSCI	⊙	⊙	⊙		●	●		●
ES001	⊙	⊙		●				
QUAL-I	⊙	⊙	●					
DEM	⊙	⊙	⊙		●	●	●	●
TTM								
RECEIV	●	●	●		●	●	●	●
RIVSCI	⊙	⊙	⊙		●	●	●	●
WRECEV	⊙	⊙	⊙		●	●	●	●
DRM								
LAKSCI	●	●	●					●
EPARES	⊙	⊙	⊙		●	●	●	⊙
HSP	⊙	⊙	⊙		⊙	⊙	●	⊙
CAFE/DISPER					⊙	⊙	○	⊙
EXPLORE-I	●	●	●	●	⊙	⊙		⊙
PLUME		⊙						
HYD/SAL								
QUAL-II	●	●	●		●	●		●
LAKECO	⊙	⊙	⊙	●	⊙	⊙	●	⊙
ECOMOD	⊙	⊙	⊙	●	⊙	⊙	●	
ESTECO		⊙	⊙	●	⊙	⊙	●	
LAKE-I					⊙	⊙		
WORKS	●	●	●	●	⊙	⊙	●	
Narragansett Bay	⊙	⊙	⊙		⊙	⊙		

MODEL	Pesticides	Refractory/Synthetic Organics	Radioactive Material	Decomposers Inc. Coliforms	Primary Producers	Zooplankton-Invertebrates	Fishes	Ecosystem-Level Indicators
SSM								
SEM								
DOSAG-1								
DOSAG-3				●	●			
DOSCI				⊙	⊙			
ES001				⊙	⊙			
QUAL-I				⊙				
DEM	●	*	*	⊙	●			
TTM								
RECEIV	⊙	●	●	●				
RIVSCI				⊙	●			
WRECEV	⊙	*	*	⊙				
DRM								
LAKSCI								
EPARES				●	●			
HSP	●	*	*	⊙	⊙	●		
CAFE/DISPER	⊙	○	○	⊙	⊙	○	○	
EXPLORE-I		●		⊙	⊙			
PLUME								
HYD/SAL								
QUAL-II	●	*	*	●	●			
LAKECO	⊙	●	●	⊙	⊙	●	●	
ECOMOD				⊙	⊙	●	●	
ESTECO				⊙	⊙	●	●	●
LAKE-I					⊙	●	●	
WORKS				●	⊙	●	●	
Narragansett Bay						●	●	

applicable ; ○ applicable if treated as discrete particles ; * [illegible] ; ⊙ [illegible] Abbreviations: Inc., including

TABLE D-2
Commonly Used Receiving Water Quality Models

Model Name	Commonly Used Acronym	Originator
CHEMICAL REACT ION MODELS		
Analytically Integrated		
Streeter-Phelps Dissolved Oxygen Equation		Indiana State Board of Health, Bloomington, Indiana
Lumped Parameter Nutrient Budget Model	___	Center for Inland Waters, Canadian Fisheries Research Board, Burlington, Ontario
Long Term Phosphorus Balance Model	___	Battelle Pacific Northwest Labs, Richland, Washington
Steady-State Stream Network Model	SNSIM	U.S. Environmental Protection Agency-Region II, New York, New York
Simplified Stream Model	SSM	Hydroscience, Inc., Westwood, New Jersey
Simplified Estuary Model	SEM	Hydroscience, Inc., Westwood, New Jersey
Numerically Integrated		
Dissolved Oxygen Sag Model	DOSAG-I	Texas Water Development Board, Austin, Texas
Dissolved Oxygen Sag Model (revised version)	DOSAG-3	Water Resources Engineers, Austin, Texas
SCI DOSAG Modification	DOSCI	Systems Control Inc., Palo Alto, California
Estuary Model	ES001	U.S. Environmental Protection Agency-Region II, New York, New York
Automatic Quality Model	AUTO-QUAL	U.S. Environmental Protection Agency, Washington, D. C.

TABLE D-2 (Continued)
Commonly Used Receiving Water Quality Models

Model Name	Commonly Used Acronym	Originator
River Quality Model	QUAL-I	Texas Water Development Board, Austin, Texas
Dynamic Estuary Model	DEM	Water Resources Engineers, Walnut Creek, California
Tidal Temperature Model	TTM	U.S. Environmental Protection Agency, Pacific Northwest Laboratory, Corvallis, Oregon
Receiving Water Model Module of SWMM	RECEIV	Water Resources Engineers, Walnut Creek, California
Receiving Water Model (modification)	RIVSCI	Systems Control, Inc., Palo Alto, California
Receiving Water Model (modification)	WRECEV	Water Resources Engineers, Austin, Texas
Deep Reservoir Model	DRM	Water Resources Engineers, Walnut Creek, California
Lake Ecologic Model (modification of Deep Reservoir Model)	LAKSCI	Systems Control, Inc., Palo Alto, California
Reservoir Water Quality Model	EPARES	Water Resources Engineers, Austin, Texas
Hydrocomp Hydrologic Simulation Program	HSP	Hydrocomp, Inc., Palo Alto, California
Water Quality Feedback Model (HAR03 modification)	FEDBAK03	U.S. Environmental Protection Agency-Region II, New York, New York
Coastal Circulation and Dispersion Model	CAFE/DISPER	Ralph M. Parsons Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts
Estuary Water Quality Model	EXPLORE-I	Battelle Pacific Northwest Labs, Richland, Washington
Nutrient Accumulation Model	SPLOTCH	U.S. Environmental Protection Agency, Rochester, New York
Two-Dimensional Stream Mixing Model	---	Water Resources Division, U.S. Geological Survey, Washington, D. C.

TABLE D-2 (Continued)
Commonly Used Receiving Water Quality Models

Model Name	Commonly Used Acronym	Originator
Outfall Plume Model	PLUME	U.S. Environmental Protection Agency, Pacific Northwest Laboratory, Corvallis, Oregon
Willamette River Model	WIRQAS	Water Resources Division, U.S. Geological Survey, Washington, D. C.
Estuary Hydrodynamic/ Salinity Model	HYD/SAL	Texas Water Development Board, Austin, Texas
ECOLOGIC MODELS (All Numerically Integrated)		
River Quality Model (QUAL-I modification)	QUAL-II	Water Resources Engineers, Walnut Creek, California
Lake Ecologic Model (DRM modification)	LAKECO	Water Resources Engineers, Walnut Creek, California
Estuary Ecologic Model	ECOMOD	U.S. Environmental Protection Agency, Washington D. C.
Estuarine Aquatic Ecologic Model	ESTECO	Texas Water Development Board/ Water Resources Engineers, Austin, Texas
Lake Phytoplankton Model	LAKE-1	Department of Civil Engineering Manhattan College, New York, New York
Eutrophic Lake Quality Model	---	Battelle Pacific Northwest Labs, Richland, Washington
Lake Ecologic Model	CLEAN-CLEANER	International Biological Program, Rensselaer Polytechnic Institute, New York
Water Quality in River-Reservoir Systems	WQRRS	U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California
Narragansett Bay Hydrodynamic Model	---	Department of Ocean Engineering, University of Rhode Island, Narragansett, Rhode Island