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Steven W. Effler  
Editor

# Limnological and Engineering Analysis of a Polluted Urban Lake

Prelude to Environmental  
Management of Onondaga Lake,  
New York

With 557 Illustrations



Springer

Steven W. Effler  
Upstate Freshwater Institute, Inc.  
Syracuse, NY 13214, USA

Series Editor:  
David E. Alexander  
University of Massachusetts  
Department of Geology and  
Geography  
Amherst, MA 01003, USA

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# Series Preface

This series is concerned with humanity's stewardship of the environment, our use of natural resources, and the ways in which we can mitigate environmental hazards and reduce risks. Thus it is concerned with applied ecology in the widest sense of the term, in theory and in practice, and above all in the marriage of sound principles with pragmatic innovation. It focuses on the definition and monitoring of environmental problems and the search for solutions to them at scales that vary from the global to the local according to the scope of analysis. No particular academic discipline dominates the series, for environmental problems are interdisciplinary almost by definition. Hence a wide variety of specialties are represented, from oceanography to economics, sociology to silviculture, toxicology to policy studies.

In the modern world, increasing rates of resource use, population growth and armed conflict have tended to magnify and complicate environmental problems that were already difficult to solve a century ago. Moreover, attempts to modify nature for the benefit of humankind have often had unintended consequences, especially in the disruption of natural equilibria. Yet at the same time human ingenuity has been brought to bear in developing a new range of sophisticated and powerful techniques for solving environmental problems – for example, pollution monitoring, restoration ecology, landscape planning, risk management, and impact assessment. Books in this series will shed light on the problems of the modern environment and contribute to the further development of the solutions. They will contribute to the immense effort by scholars and professionals of all persuasions and in all countries to nurture an environment that is both stable and productive.

David E. Alexander  
Amherst, Massachusetts

# Preface

This book is a case study of the scientific and engineering analysis of a single ecosystem, Onondaga Lake, located in metropolitan Syracuse, New York. The single-system focus of this book allows greater attention to details and more effective integration of findings from various disciplines into a holistic comparative studies perspective, as compared to texts that draw on observations from a number of examples. The contributors to this volume believe that the reader will find this case study rich in lessons for a range of disciplines involved in water quality issues.

Onondaga Lake is a particularly appropriate subject for a detailed case study. The lake is replete with environmental problems as a result of the input of large quantities of municipal and industrial waste for more than a century. Many readers will be surprised, if not shocked, that there is a lake in the United States that remains as profoundly degraded as Onondaga Lake. Despite mandated reductions in pollutant loading and reductions brought about by the closure of a major industrial polluter, Onondaga Lake is arguably the most polluted lake in the United States. For example, effluent from the adjoining municipal wastewater treatment plant (METRO) represents nearly 20% of the total annual inflow to the lake. The myriad of environmental problems that prevail and the strong signatures of degradation observed in Onondaga Lake offer a unique opportunity for research and education and many challenges for scientists, engineers, and lake managers.

This analysis builds from basic disciplinary studies of Onondaga Lake in the early chapters (Chapters 2–8) to an interdisciplinary synthesis in the last two chapters (Chapters 9 and 10). The book includes historical (Chapter 1) and hydrogeologic (Chapter 2) descriptions of the area, an analysis of hydrologic and pollutant loadings to the lake (Chapter 3) and treatments of hydrodynamics (Chapter 4), chemistry (Chapter 5), biology (Chapter 6), optics (Chapter 7), and sediments (Chapter 8) of the lake. Chapter 9

presents the development, testing, and application of mechanistic water quality models for the system. The models are in fact a synthesis of our scientific and engineering understanding of the lake. Chapter 10 summarizes the foregoing material and places it in a management perspective.

Research continues on this fascinating lake. Two recent findings, not treated in the text, are noteworthy from a management perspective. First, during the late summer and early fall of 1995, Onondaga Lake suffered a severe lakewide oxygen depletion event in the upper waters. The New York State minimum oxygen concentration standard ( $4\text{mg}\cdot\text{L}^{-1}$ ) was violated for more than a month. The oxidation of large quantities of ammonia (nitrification) received from METRO contributed greatly to this event. Second, recent research from the laboratory of Martin T. Auer at Michigan Technological University has established that such violations of the oxygen standard would be eliminated by the diversion of the METRO effluent around the lake.

I began research on Onondaga Lake in the mid-1970s as part of my doctoral studies. My research of the lake through the mid-1980s was largely unfunded. Since 1981, Onondaga Lake research has been conducted under the auspices of the Upstate Freshwater Institute, a not-for-profit corporation. Only with time did I understand the connection between the lack of funding and the extreme degree of the lake's polluted state. Partly in response to political and regulatory pressure, research funding became available between 1987 and 1994. This brought an extremely talented array of investigators into the Onondaga Lake research arena; they greatly accelerated and broadened the investigation of the lake and contributed greatly to this book. Unfortunately, there has been an unmistakable resistance to the technical findings and management implications that emerged from this research; advocacy consultants and lawyers now abound. Funding for independent research on the lake dried up in 1995.

The Onondaga Lake story, however, is far from over. Regulators and polluters are negotiating, a ruling from a federal judge is forthcoming, and management decisions may be made in the near future. The lake has many more lessons to give. The Institute, and the contributors to this book, will continue to study this unique system.

Several of the water quality models developed and tested for the lake in Chapter 9 are being used by environmental managers to evaluate a range of remediation alternatives related to the METRO discharge. A number of these alternatives are quite expensive. It is necessary for me to state, on behalf of all the authors of the book, that we are not as a group, nor individually, advocates for a specific management plan for the lake. We are, however, strong advocates for these decisions being made within the context of all the available technical information. The Clean Water Act represents another important constraint on these management deliberations.



This book would not have been possible without the input of many people. I thank the many students who gave their time and effort to study Onondaga Lake, often without pay. I thank the board of directors of the Upstate Freshwater Institute, who have continued to support work on the lake. Several of the contributing authors of this book are members of the board. I thank all of the authors, not only for the quality of their work, but for their patience during this long process. The authors will receive no royalties from the sale of this book, instead all royalties will be donated to the Water Foundation of Central New York, Inc. (a not-for-profit organization). Four research scientists have made very special contributions to the work of the Upstate Freshwater Institute and this book: Mary Gail Perkins, Carol Brooks, Susan Doerr, and Bruce Wagner. We thank Elizabeth Miller, who typed the original manuscript and the endless revisions.

Three people have been particularly instrumental in guiding me professionally, for which I am grateful; Myrton C. Rand, J. Charles Jennett, and Robert D. Hennigan. I am especially grateful to two collaborating researchers on the Onondaga Lake work, Stephen D. Field and Martin T. Auer. Steve helped start the research program and usually found ways to keep it going in the 1970s. He made lasting contributions to the spirit of this on-going work. Marty, more than any other individual, is responsible for raising the level of research at the Institute. I look forward to our continuing collaboration for the next twenty years of the Onondaga Lake story.

Steven W. Effler

# Contents

Series Preface .....	vii
Preface .....	ix
Contributors .....	xix
<b>1. Background .....</b>	<b>1</b>
STEVEN W. EFFLER AND GENA HARNETT	
1.1 Location and Morphometry .....	1
1.2 Tributaries and Subbasins .....	3
1.3 Climate .....	5
1.4 Historic Account .....	5
1.5 Specific Waste Sources .....	10
1.6 Technical Studies of Onondaga Lake and Its Tributaries .....	18
1.7 Demography and Land Use .....	21
1.8 Government Involvement and a Community's Vision .....	22
1.9 Summary .....	26
References .....	29
<b>2. Hydrogeologic Setting .....</b>	<b>32</b>
MARY GAIL PERKINS AND EDWIN A. ROMANOWICZ	
2.1 Background Geology .....	32
2.2 Geology and Hydrogeology of the Major Tributaries to Onondaga Lake .....	41
2.3 Special Topics Related to the Hydrogeology of Onondaga Lake .....	58
2.4 Onondaga Lake .....	79
2.5 Basic Concepts in Hydrogeology .....	83
2.6 Summary .....	89
References .....	93

<b>3. Tributaries and Discharges</b> .....	97
STEVEN W. EFFLER AND KEITH A. WHITEHEAD	
3.1 Hydrology of Onondaga Lake .....	97
3.2 Material Loading .....	110
3.3 Summary .....	189
References .....	196
<b>4. Hydrodynamics and Transport</b> .....	200
EMMET M. OWENS AND STEVEN W. EFFLER	
4.1 Introduction .....	200
4.2 Lake Inflows and Outflow .....	201
4.3 Lake Temperature, Salinity, and Density Stratification .....	213
4.4 Lake Circulation .....	227
4.5 Modeling Stratification and Vertical Transport ..	238
4.6 Horizontal Mass Transport Model .....	252
4.7 Summary .....	257
References .....	261
<b>5. Chemistry</b> .....	263
5.1 Salinity .....	263
STEVEN W. EFFLER	
5.2 Dissolved Oxygen .....	272
STEVEN W. EFFLER	
5.3 Inorganic Carbon, $\text{Ca}^{2+}$ , $\text{CaCO}_{3(s)}$ , and pH .....	283
CHARLES T. DRISCOLL, STEVEN W. EFFLER, AND SUSAN M. DOERR	
5.4 Nitrogen Species .....	294
CAROL M. BROOKS AND STEVEN W. EFFLER	
5.5 Phosphorus .....	307
STEVEN W. EFFLER, CHARLES T. DRISCOLL, SUSAN M. DOERR, MARTIN T. AUER, AND BRUCE A. WAGNER	
5.6 Anoxic Organic Carbon Decomposition and the Distribution of Related Chemical Species .....	324
CHARLES T. DRISCOLL, STEVEN W. EFFLER, SUSAN M. DOERR, JEFFREY ADDESS, AND CAROL M. BROOKS	
5.7 Mercury .....	352
CHARLES T. DRISCOLL AND WEI WANG	
5.8 Particle Chemistry .....	359
DAVID L. JOHNSON, J. JIAO, SAUL G. DOS SANTOS, AND STEVEN W. EFFLER	
5.9 Summary .....	368
References .....	374

<b>6. Biology</b> .....	<b>384</b>
6.1 Phytoplankton .....	384
MARTIN T. AUER, STEVEN W. EFFLER, MICHELLE L. STOREY, SUSAN D. CONNORS, AND PHILIP SZE	
6.2 Zooplankton .....	421
CLIFFORD A. SIEGFRIED, NANCY A. AUER, AND STEVEN W. EFFLER	
6.3 Aquatic Macrophytes .....	436
JOHN D. MADSEN, R. MICHAEL SMART, LAWRENCE W. EICHLER, CHARLES W. BOYLEN, JEFFREY W. SUTHERLAND, AND JAY A. BLOOMFIELD	
6.4 Benthic Macroinvertebrates .....	446
BRUCE A. WAGNER, ROBERT DANEHY, NEIL A. RINGLER, AND STEVEN W. EFFLER	
6.5 Fish Communities and Habitats in Onondaga Lake, Adjoining Portions of the Seneca River, and Lake Tributaries .....	453
NEIL A. RINGLER, CHRISTOPHER GANDINO, PRADEEP HIRETHOTA, ROBERT DANEHY, PETER TANGO, CHARLES MORGAN, CHRISTOPHER MILLARD, MARGARET MURPHY, MARK A. ARRIGO, RONALD J. SLOAN, AND STEVEN W. EFFLER	
6.6 Indicator Bacteria .....	494
MARTIN T. AUER, STEVEN W. EFFLER, STEPHEN L. NIEHAUS, AND KEITH A. WHITEHEAD	
6.7 Summary .....	515
References .....	522
<b>7. Optics</b> .....	<b>535</b>
STEVEN W. EFFLER AND MARY GAIL PERKINS	
7.1 Introduction .....	535
7.2 Optical Measurements .....	536
7.3 Optical Properties of Water .....	539
7.4 Historic Changes in Apparent Optical Properties	542
7.5 Components of Attenuation/Evaluation of Empirical Relationships .....	549
7.6 Regional Comparison .....	556
7.7 Angular Distribution of Underwater Irradiance ..	562
7.8 Checks on Optical Measurements and Estimates	564
7.9 Estimates of <i>a</i> and <i>b</i> .....	565
7.10 Spectroradiometer Measurements .....	569
7.11 Partitioning <i>a</i> .....	574
7.12 Partitioning <i>b</i> .....	579
7.13 Components of Attenuation, Models, and Analysis of Scenarios .....	584
7.14 Summary .....	592
References .....	597

<b>8. Sediments</b> .....	600
8.1 Deposition .....	600
STEVEN W. EFFLER	
8.2 Surficial Sediments .....	611
MARTIN T. AUER, NED JOHNSON, MICHAEL PENN, AND STEVEN W. EFFLER	
8.3 Sediment Stratigraphy .....	622
H. CHANDLER ROWELL AND STEVEN W. EFFLER	
8.4 Summary .....	655
References .....	659
<b>9. Mechanistic Modeling of Water Quality in Onondaga Lake</b> .....	667
9.1 Background and Evolution of Model Frameworks .....	667
STEVEN W. EFFLER	
9.2 Chloride Model .....	672
SUSAN M. DOERR, STEVEN W. EFFLER, AND MARTIN T. AUER	
9.3 Total Phosphorus Model .....	679
SUSAN M. DOERR, RAYMOND P. CANALE, MARTIN T. AUER, AND STEVEN W. EFFLER	
9.4 Nitrogen Model .....	690
RAYMOND P. CANALE, RAKESH K. GELDA, AND STEVEN W. EFFLER	
9.5 Dissolved Oxygen Model .....	702
RAKESH K. GELDA, MARTIN T. AUER, RAYMOND P. CANALE, AND STEVEN W. EFFLER	
9.6 Fecal Coliform Bacteria Model .....	714
RAYMOND P. CANALE, EMMET M. OWENS, MARTIN T. AUER, THOMAS M. HEIDTKE, AND STEVEN W. EFFLER	
9.7 Water Quality Model for the Seneca and Oswego Rivers .....	723
RAYMOND P. CANALE, EMMET M. OWENS, MARTIN T. AUER, AND STEVEN W. EFFLER	
9.8 Application of Models .....	743
STEVEN W. EFFLER AND SUSAN M. DOERR	
9.9 Summary .....	776
References .....	782
<b>10. Synthesis and Perspectives</b> .....	789
STEVEN W. EFFLER	
10.1 Impact of the Soda Ash/Chlor-alkali Facility on Onondaga Lake and Adjoining Systems: Update .....	789
10.2 The Polluted State of Onondaga Lake: How Bad Is It? .....	798

10.3	But Has Not the Quality of Onondaga Lake Improved? .....	800
10.4	The METRO Discharge Is Too Much for a Small Lake .....	803
10.5	Diversion of METRO .....	805
10.6	Where Do We Go from Here? .....	808
	References .....	809
	Index .....	813

# Contributors

JEFFREY ADDESS  
General Chemical Corporation, Syracuse, NY 13202, USA

MARK A. ARRIGO  
College of Environmental Science and Forestry, State University of  
New York, Syracuse, NY 13210, USA

MARTIN T. AUER  
Michigan Technological University, Houghton, MI 49931, USA

NANCY A. AUER  
Michigan Technological University, Houghton, MI 49931, USA

JAY A. BLOOMFIELD  
New York State Department of Environmental Conservation,  
Albany, NY 12233-0001, USA

CHARLES W. BOYLEN  
Rensselaer Polytechnic Institute, Albany, NY 12180, USA

CAROL M. BROOKS  
Upstate Freshwater Institute, Inc., Syracuse, NY 13214, USA

RAYMOND P. CANALE  
University of Michigan, Ann Arbor, MI 48109, USA

SUSAN D. CONNORS  
CH2M Hill, Reston, VA 22090-1483, USA

ROBERT DANEHY  
College of Environmental Science and Forestry, State University of  
New York, Syracuse, NY 13210, USA

SUSAN M. DOERR  
Upstate Freshwater Institute, Inc., Syracuse, NY 13214, USA

SAUL G. DOS SANTOS  
College of Environmental Science and Forestry, State University of  
New York, Syracuse, NY 13210, USA

CHARLES T. DRISCOLL  
Syracuse University, Syracuse, NY 13210, USA

STEVEN W. EFFLER  
Upstate Freshwater Institute, Inc., Syracuse, NY 13214, USA

LAWRENCE W. EICHLER  
Rensselaer Polytechnic Institute, Albany, NY 12180, USA

CHRISTOPHER GANDINO  
College of Environmental Science and Forestry, State University of  
New York, Syracuse, NY 13210, USA

RAKESH K. GELDA  
Michigan Technological University, Houghton, MI 49931, USA

GENA HARNETT  
The Write Design Co., Albany, NY 12205, USA

THOMAS M. HEIDTKE  
Department of Civil Engineering, Wayne State University, Detroit,  
MI 48202, USA

PRADEEP HIRETHOTA  
College of Environmental Science and Forestry, State University of  
New York, Syracuse, NY 13210, USA

J. JIAO  
College of Environmental Science and Forestry, State University of  
New York, Syracuse, NY 13210, USA

DAVID L. JOHNSON  
College of Environmental Science and Forestry, State University of  
New York, Syracuse, NY 13210, USA

NED JOHNSON  
CH2M Hill, Reston, VA 22090, USA

JOHN D. MADSEN  
U.S. Army Corps of Engineers, Louisville, TX 75056, USA

CHRISTOPHER MILLARD  
College of Environmental Science and Forestry, State University of  
New York, Syracuse, NY 13210, USA



CHARLES MORGAN  
College of Environmental Science and Forestry, State University of  
New York, Syracuse, NY 13210, USA

MARGARET MURPHY  
College of Environmental Science and Forestry, State University of  
New York, Syracuse, NY 13210, USA

STEPHEN L. NIEHAUS  
Gosling Czubak Associates, P.C., Traverse City, MI 49684, USA

EMMET M. OWENS  
Syracuse University, Syracuse, NY 13210, USA

MICHAEL PENN  
Michigan Technological University, Houghton, MI 49931, USA

MARY GAIL PERKINS  
Upstate Freshwater Institute, Inc., Syracuse, NY 13214, USA

NEIL A. RINGLER  
College of Environmental Science and Forestry, State University of  
New York, Syracuse, NY 13210, USA

EDWIN A. ROMANOWICZ  
Upstate Freshwater Institute, Inc., Syracuse, NY 13214, USA

H. CHANDLER ROWELL  
Onondaga Lake Management Conference, Syracuse, NY 13261,  
USA

CLIFFORD A. SIEGFRIED  
Biological Survey, New York State Museum, Albany, NY 12230,  
USA

R. MICHAEL SMART  
U.S. Army Corps of Engineers, Louisville, TX 75056, USA

RONALD J. SLOAN  
New York State Department of Environmental Conservation,  
Albany, NY 12233, USA

MICHELLE L. STOREY  
Kieser and Associates, Kalamazoo, MI 49007, USA

JEFFREY W. SUTHERLAND  
New York State Department of Environmental Conservation,  
Albany, NY 12233, USA

PHILIP SZE  
Georgetown University, Washington, DC 20057, USA

PETER TANGO

College of Environmental Science and Forestry, State University of  
New York, Syracuse, NY 13210, USA

BRUCE A. WAGNER

Upstate Freshwater Institute, Inc., Syracuse, NY 13214, USA

WEI WANG

Syracuse University, Syracuse, NY 13210, USA

KEITH A. WHITEHEAD

Upstate Freshwater Institute, Inc., Syracuse, NY 13214, USA