

**LAND DEVELOPMENT  
FOR CIVIL ENGINEERS**



# LAND DEVELOPMENT FOR CIVIL ENGINEERS

---

SECOND EDITION

**T. R. Dion, P.E. & L.S., LLC**

**Thomas R. Dion, Member**

*Professor of Civil Engineering, The Citadel*



JOHN WILEY & SONS, INC.

This book is printed on acid-free paper.Ⓢ

Copyright © 2002 by John Wiley & Sons, Inc., New York. All rights reserved.

Published simultaneously in Canada.

No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning or otherwise, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 750-4744. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012, (212) 850-6011, fax (212) 850-6008, E-Mail: PERMREQ @ WILEY.COM.

This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold with the understanding that the publisher is not engaged in rendering professional services. If professional advice or other expert assistance is required, the services of a competent professional person should be sought.

*Library of Congress Cataloging-in-Publication Data*

Dion, Thomas R., 1946–

Land development for civil engineers / by Thomas R.

Dion.—2nd ed.

p. cm.

ISBN 0-471-43500-7 (cloth : alk. paper)

1. Civil engineering—Handbooks, manuals, etc. 2. Building sites—Handbooks, manuals, etc. I. Title.

TA151 .D56 2002

624—dc21

2001026918

Printed in the United States of America.

10 9 8 7 6 5 4 3 2 1

*To my wife, Susan, my sons, Tommy and Richard, and my family*



# CONTENTS

<b>Preface to the Second Edition</b>	<b>xiii</b>
<b>Preface to the First Edition</b>	<b>xv</b>
<b>Acknowledgments to the Second Edition</b>	<b>xvii</b>
<b>Acknowledgments to the First Edition</b>	<b>xix</b>
<b>PART I OVERVIEW OF ACTIVITIES</b>	<b>1</b>
<b>1 Introduction</b>	<b>3</b>
1.1 Defining Land Development	3
1.2 Areawide Development Planning	5
1.3 The Developer's Role	14
1.4 Land Development Measurement Conventions	17
References	18
<b>2 Developer's Constraints</b>	<b>19</b>
2.1 Market Analysis	19
2.2 Site Location	22
2.3 Site Geometry	23
2.4 Site Conditions	24
2.5 Site Layout	39
2.6 Regulatory Requirements	69
2.7 Economic Considerations	76
References	81
Suggested Readings	83
<b>3 Engineering Administration</b>	<b>86</b>
3.1 Organization	86
3.2 Marketability of Professional Services	87
3.3 Conditions of Employment	88
3.4 Conduct of Affairs	92
3.5 Engineering Communication	95
3.6 Types of Engineering Services	95
3.7 Selection of a Design Professional	96
3.8 Engineering Services Contract	97
3.9 Computing Facilities	101
3.10 Mobilization Plan	105
3.11 Remuneration for Engineering Services	105
3.12 Engineer's Role	107

References	107
Suggested Readings	108
<b>PART II PRELIMINARY ENGINEERING ACTIVITIES</b>	<b>111</b>
<b>4 Inventory, Analysis, and Reporting</b>	<b>113</b>
4.1 Geographic Information Systems	113
4.2 Desktop Study and Site Inspection	122
4.3 Floodplain Analysis	128
4.4 Wetlands Determination Study	129
4.5 Endangered Species Evaluation	133
4.6 Environmental Evaluation	135
4.7 Historical and Natural Resource Survey	142
4.8 Land Survey Controls	144
4.9 Conventional Surveying	161
4.10 Global Positioning Systems	166
4.11 Cadastral Surveys	186
4.12 Topographic Surveys	199
4.13 Utility Extension Surveys	208
4.14 Photogrammetric Surveys	208
4.15 Geotechnical Surveys	221
4.16 Traffic Studies	233
4.17 Materials Evaluation	236
4.18 Analysis and Report on Prospective Sites	236
References	239
Suggested Readings	241
<b>5 Preliminary Design and Costs</b>	<b>243</b>
5.1 Determination of Additional Auxiliary Service	243
5.2 Conceptual Plan Approval	243
5.3 Preparation of Preliminary Documents	244
5.4 Preliminary Project Submittals	248
5.5 Preliminary Project Approval	249
<b>PART III FINAL DESIGN-RELATED ACTIVITIES</b>	<b>251</b>
<b>6 Transportation System Design</b>	<b>253</b>
6.1 Traffic-related Site Impact Studies and Access	253
6.2 Street and Road Design Criteria	263
6.3 Parking Considerations	281
6.4 Street Alignment	283
6.5 Pavement Design	302
6.6 Pedestrian Facility Design	315
6.7 Bicycle Facility Design	315
References	319
Suggested Readings	322

<b>7</b>	<b>Drainage System Design</b>	<b>324</b>
7.1	Precipitation and Duration	325
7.2	Rainfall Abstractions	329
7.3	Time of Concentration	336
7.4	Runoff	338
7.5	Factors Affecting Site Drainage	355
7.6	Best Management Practices	366
7.7	Mitigating Floodplain Hazards	374
7.8	Drainage System Design	376
7.9	Pipe Bedding and Protection	397
7.10	Subsurface Water	408
	References	410
	Suggested Readings	412
<b>8</b>	<b>Sedimentation and Erosion Control</b>	<b>413</b>
8.1	General Considerations	413
8.2	Predicting Rainfall Erosion Loss	417
8.3	Construction Sites	455
8.4	Erosion Control Using Soil Bioengineering	465
8.5	Considerations for Permanent Ponds or Lakes	466
	References	468
	Suggested Readings	469
<b>9</b>	<b>Site Grading and Appurtenance Design</b>	<b>470</b>
9.1	Improved Land Developments	470
9.2	Total Development Activities	471
9.3	Earthwork Calculations	472
9.4	Elements of the Grading Plan	479
9.5	Stairs, Ramps, and Handrails	481
9.6	Slope Stability	483
9.7	Retaining Walls	485
	References	497
	Suggested Readings	497
<b>10</b>	<b>Sanitary Sewer System Design</b>	<b>498</b>
10.1	Engineer's Report	498
10.2	Wastewater Flows	501
10.3	Individual On-Site Wastewater Disposal Systems	503
10.4	Collection Methods for Off-Site Wastewater Treatment	510
10.5	Centralized Gravity Flow Wastewater Collection Systems	515
10.6	Wastewater Pressure Transport System	524
10.7	Pumping Station Discharge	542
10.8	Special Forcemain Considerations	547
10.9	Centralized Wastewater Treatment Plant Considerations	549
10.10	Wastewater System Appurtenances	554
	References	555
	Suggested Readings	556

<b>11</b>	<b>Potable Water System Design</b>	<b>557</b>
11.1	Engineer's Report	557
11.2	Water System Demands	558
11.3	Ways to Provide Water to a Development	567
11.4	Treatment Considerations	577
11.5	Treated Water Storage Facilities	584
11.6	Water Distribution Systems	593
11.7	Computer Modeling of Water Systems	605
11.8	Water System Components	605
11.9	Water System Protection	610
	References	612
	Suggested Readings	613
<b>12</b>	<b>Miscellaneous Design Considerations</b>	<b>614</b>
12.1	Recreational Playing Courts	614
12.2	Swimming Pool Facilities	615
12.3	Fencing	627
12.4	Pipe Jacking and Boring	628
	References	632
	Suggested Readings	632
<b>13</b>	<b>Project Manual Including Specifications</b>	<b>633</b>
13.1	Construction and Contract Documents	633
13.2	Specifications	636
13.3	An Example of a Project Manual	638
	References	697
	Suggested Readings	698
<b>14</b>	<b>Project Costs and Scheduling</b>	<b>702</b>
14.1	Establishing a Database	702
14.2	Cost Analysis	702
14.3	Project Scheduling	703
	References	718
	Suggested Readings	718
<b>15</b>	<b>Development Guidelines</b>	<b>719</b>
15.1	Purpose of Guidelines	719
15.2	Controlling Elements	719
15.3	Additional Controls	721
	Reference	722
	Suggested Reading	722
<b>16</b>	<b>Completion of Design Activities</b>	<b>723</b>
16.1	Final Plans Format	723
16.2	Completed Project Manual	728
16.3	Permit Applications to Construct	728

16.4	Final Document Scan by Engineer	728
16.5	Developer's Review	730
16.6	Financial Institution's Review	730
16.7	Regulatory Reviews	730
	References	731
	Suggested Reading	731
<b>PART IV CONSTRUCTION-RELATED ACTIVITIES</b>		<b>735</b>
<b>17</b>	<b>Contracts and Award</b>	<b>735</b>
17.1	Types of Construction Contracts	737
17.2	Engineer's Duties	737
17.3	Job Bidding and/or Negotiation	737
17.4	Bid Review and Analysis	739
17.5	Contract Award	740
	References	741
	Suggested Readings	742
<b>18</b>	<b>Layout, Observation, and Monitoring</b>	<b>743</b>
18.1	Scope of Engineering Activities	743
18.2	Construction Layout	744
18.3	Administrative Duties	747
18.4	Construction Conflicts and Extra Work	749
18.5	Work Directives	751
18.6	Delays	751
18.7	Construction Progress	753
	References	755
	Suggested Readings	755
<b>19</b>	<b>Completion and Start-Up</b>	<b>756</b>
19.1	System Testing and Start-Up	756
19.2	Final Inspection	758
19.3	Approval of Improvements	759
19.4	Operational Needs	759
19.5	Final Stake-Out of Parcels	762
19.6	Release of Retainage	762
19.7	Engineer's Administrative Closeout	762
19.8	Warranty Period	763
	Reference	763
<b>APPENDIX</b>		<b>764</b>
<b>Conversion Tables</b>		<b>765</b>
<b>INDEX</b>		<b>768</b>



# PREFACE TO THE SECOND EDITION

During the seven-year period following the publication of the premier edition of *Land Development for Civil Engineers*, many changes affecting the development of land have taken place. The areas where most of these changes occurred are in the fields of technology, regulation, and land planning. In most cases, these changes have been brought about where better utilization of land, resources, and effort (time and money) result. The focus of this second edition is to place emphasis on defining some of these changes that are most significant and then to provide the reader an opportunity to learn how they apply to land development.

In the technology area many new tools previously under development or locked in the domain of the government are now available to the general public and are commonly used today. For example, the explosive growth in use and reliance on the electronic “information highway” offered by the World Wide Web (WEB) has outstripped the capabilities of the early 1990s vintage computers where both hardware and software improvements have gone through several cycles. Computer networking has expanded user access and capability where electronic data today commonly flows in venues such as e-mail, drawing or document files, electronic spreadsheet files, and even files having multimedia formats including those supporting graphics, sound, and animation.

Another area where technology has driven change is in computer software offerings. With increased storage and computing capability being made available in desktop PC computers, software vendors have increased their offerings since the early 1990s in land development-related fields such as geographic information systems (GISs), surveying and design packages, and improved graphical data-handling capabilities such as the emergence of the triangulated irregular network (TIN).

Because information sharing saves time, eliminates confusion, and provides ready access, there is a trend being followed by software vendors to produce and offer integrated packages or “suites” of software modules (e.g., mapping, surveying, and civil design) that share common databases and conventions. This approach allows multiple users on networked systems to work as a multidisciplinary team, and even allows connected access through the WEB with some enterprise package offerings.

Other technological changes have occurred in instrumentation and application techniques pertaining to land surveying, photogrammetry, and mapping. The biggest boon has occurred in the giant increase of global positioning system (GPS) usage. Improvements in receiver technology have made GPS affordable to most surveyors. To this end, the federal government is in the process of upgrading its geodetic control network and has placed into operation a series of continuously operating reference stations (CORSs) that allow users the opportunity to have access to positional data at no cost just by downloading it over the Internet.

Changes in regulatory requirements have also been seen throughout the 1990s. Some of these changes have resulted from evolving technology changes. For example, the emergence of GIS applications has in some cases precipitated the requirement for design professionals to submit electronic drawing files as part of the review process. These files are then imported into the GIS database to update the system. Other changes that have evolved are the increased usage of GIS and on-line format applications for regulatory construction permit reviews, review status, and issuance.

One area of regulatory growth has occurred in the formation of stormwater utilities. Traditionally, most drainage systems were operated, maintained, and controlled by the municipal public works department until the early 1990s. Since that time, municipalities have formed separate stormwater utilities that raise operation and maintenance revenues from monthly fees specifically targeting storm runoff from properties.

Changes have also occurred in the area of land planning. In many parts of the United States buildable land is scarce and renewed interest in improving the use of the land that is available is an effort defined as the “new urbanism.” This groundswell of activity is focused on limiting urban sprawl which resulted from land planning approaches that were practiced in the 1960s, 1970s, and 1980s. Neotraditional towns are being promoted as ways to make better use of available property, limit encroaching on areas more suited as conservation and natural areas, reduce vehicular dependence, promote pedestrian and bicycle activities, create a sense of neighborhood by providing a “central” open area, similar to a town park, and improve the streetscape by making use of back-lot access alleys.

What I have mentioned here are but a few of the many changes affecting the development of land that have evolved since I wrote the first edition. The text has been updated to reflect the most important changes that have occurred. Because this book is used in some colleges and universities as a course text, it is an important undertaking to prepare this second edition where students have access to current engineering practices and technologies. Likewise, it is anticipated that practicing engineers who use this book as a reference will find this refreshed presentation of value.

*February 2002*  
*Summerville, S.C.*

Thomas R. Dion

# PREFACE TO THE FIRST EDITION

I have had the distinct privilege over the past decade and a half of teaching a course on land development to various senior civil engineering students. This course, which builds on most basic civil engineering courses in the nonstructural area, includes the integrated design of roads, storm drainage systems, potable water systems, sanitary sewer systems, site layout, and regulatory agency conformance. The value of this classroom experience is that it allows students to be exposed to the design process prior to graduation and thus illustrates to them practical application of learned theory in an academic setting. Students interested in structural engineering also find this course helpful, because structures are located on improved sites with utilities, parking, and other types of infrastructure.

One major problem associated with teaching a course on land development has been the lack of an adequate textbook. As a result, I have attempted to set forth in a single volume information pertaining to land development that will not only introduce the prospective graduating engineer to practical integrated design applications but also enlighten the student that there is much to be learned after graduation.

It is emphasized that this book is not an end unto itself, and certainly it is not intended to be a substitute for the individual courses from which a foundation for the use of this book must be acquired. Therefore, application of the principles presented in this book can be applied only after adequate related course work has been completed in graphic science, land surveying, photogrammetry, transportation engineering, highway engineering, fluid mechanics, geotechnical engineering, environmental engineering, and engineering administration. Also, throughout the text numerous standards and procedures have been referenced. A prudent engineer should thoroughly review the complete source before making a determination of its applicability for a particular design application. The examples included in this book are provided only to illustrate a way to approach solving various problems. In many cases, other approaches can be used satisfactorily.

I feel that this book will be a valuable reference for practicing engineers because integrated design and analysis procedures are included. In addition, other persons involved professionally with various aspects of land development should find this book a useful reference.

*June 1993*  
*Summerville, S.C.*

T. R. Dion



# ACKNOWLEDGMENTS TO THE SECOND EDITION

Because the development of land includes many different topics, the author is fortunate to have been offered suggestions and advice from a number of diverse people who reviewed portions of the new edition. To each, I am indebted, especially my colleagues at The Citadel, who again helped me in a variety of ways. They include Thomas J. Anessi, Kenneth P. Brannan, William J. Davis, Dennis J. Fallon, John A. Murden, Russell H. Stout, Sam Tongtoe, and Michael H. Woo.

I am also thankful for the following persons who have reviewed various sections of this book and have offered many valuable comments and suggestions: John F. Adams, U.S. Army Corps of Engineers; Thomas O. Barnwell, U.S. Environmental Protection Agency; Ed Baruth, American Water Works Association; William B. Beauchene, East Coast Development Corporation; Ronald E. Benson, Hole Montes & Associates; John E. Bonkoski, U.S. Department of Housing and Urban Development; Benjamin Bunting, Summerville Fire and Rescue Department; James E. Chellis, Chellis & Frampton; Marc E. Cherry, Berenyi; Christopher M. Childs, S.C. Department of Health and Environmental Control; Joseph Christie, Town of Summerville, S.C.; Charles Crosby, U.S. Army Corps of Engineers; Robert P. Dean, Building Systems Design, Inc.; Lori A. Duncan, U.S. Fish and Wildlife Service; George R. Foster, USDA Agricultural Research Service; John G. Frampton, Chellis & Frampton; Matthew J. Halter, Town of Summerville, S.C.; David G. Hansen, Dalhousie University; Lloyd Herman, Ohio University; Robert D. Horan, The Asphalt Institute; Stephen F. Hutchinson, East Coast Development Corporation; Mark A. Isaak, Post Buckley Schuh and Jernigan; Danny Johnson, S.C. Department of Natural Resources; John E. Keen, Land Surveyor's Workshops; John Kwist, Newton Builders; John A. Laffin, Purdue University; Lewis A. Lapine, South Carolina Geodetic Survey; Dennis A. Leverett, Palmetto Environmental & Site Consultants; Susan McClendon, Building Systems Design; J. P. Mohsen, University of Louisville; Joseph R. Molinaro, National Association of Home Builders; Kenneth Myers, Federal Highway Administration; Fazil T. Najafi, University of Florida; J. Frank Newham, Town of Mount Pleasant, S.C.; Jon C. Noble, CBCL Limited; Donald F. Nye, Olde Towne Mortgage; James P. Reilly, New Mexico State University; Kenneth G. Renard, USDA Agricultural Research Service; Joseph L. Rucker, S.C. Department of Health and Environmental Control; Antony M. Sease, Duany Plater-Zyberk & Company; Stephen W. Skelton, S.C. Department of Archives and History; Edward F. Straw, Insurance Services Office; Brent A. Straka, Surveyors Module International; James H. Suddeth, Keenan Insurance Co.; C. A. Tiltrum, South Dakota State University; Mark A. Vieira, Federal Emergency Management Agency; Richard C. Walker, ROK; H. Fred Waller, The

Asphalt Institute; Glenn A. Weesies, USDA Natural Resources Conservation Service (NRCS); and James Wojcik, Environmental Systems Research Institute.

An expression of gratitude is also in order to William L. Walker, Jr., for his assistance in keeping the issues focused and Joel E. Stein for his encouragement and assistance as editor.

## ACKNOWLEDGMENTS TO THE FIRST EDITION

The author is indebted to many persons who have assisted in the preparation of this book. Unfortunately, space limitations preclude all names from being included here; however, thanks are given to my colleagues at The Citadel whose guidance has helped to shape the scope of this book. They include Thomas J. Anessi, Kenneth P. Brannan, Dennis J. Fallon, Loring K. Himelright, John A. Murden, Charles Lindbergh, Arnold B. Strauch, Russell H. Stout, and Michael S. Woo.

Special thanks are given to the following persons who have reviewed various portions of the book and have supplied the author with valuable comments and suggestions: William B. Beauchene, East Coast Development Corporation; Ronald E. Benson, Jr., Hole, Montes & Associates, Neale E. Bird, S. C. Coastal Council; James A. Broody, First Trident Savings and Loan Company; Robert D. Carr, U.S. Department of Housing and Urban Development; J. Edwin Clark, Clemson University; George L. Craft, American Water Works Association; Stephen P. Dix, National Small Flows Clearing House; Jack M. Ellis, C.R.S. Serrine; Craig K. Haney, Introspec; Gene E. Hardee, U.S. Department of Agriculture—SCS; Stephen F. Hutchinson, East Coast Development Corporation; Mark A. Isaak, Post, Buckley, Schuh & Jernigan; John Kwist, Newton Builders; Edward J. McKay, National Geodetic Survey; D. Sherwood Miler, III, Pine Forest Properties; Sidney C. Miller, S.C. Geodetic Survey; Joseph R. Molinaro, National Association of Home Builders; J. Herbert Moore, Virginia Polytechnic Institute; James K. Nelson, Clemson University; Joseph L. Rucker, S.C. Department of Health and Environmental Control; Harry C. Saxe, Norwich University; Edward F. Straw, ISO Commercial Risk Services; H. Fred Waller, Jr., the Asphalt Institute; Glenn A. Weesies, National Soil Erosion Laboratory; Donald E. Woodward, U.S. Department of Agriculture—SCS; and David B. Zilkoski, National Geodetic Survey.

Thanks are also given to Thomas S. Mc Canless for preparing most of the graphical displays used in this book and to William L. Walker, Jr., for his encouragement and guidance. Finally, appreciation is also given to Daniel R. Sayre for his continued support as editor throughout the preparation of this book.

