Comprehensive Coverage of the Topics on the Civil PE Exam's Water Resources and Environmental Depth Section

Water Resources and Environmental Depth Reference Manual

for the Civil PE Exam

Jonathan A. Brant, PhD, PE, and
Gerald J. Kauffman, PhD, PE

Professional Publications, Inc.
The Choice of Over 3 Million Professionals
Since 1975

Benefit by Registering This Book with PPI

- Get book updates and corrections.
- Hear the latest exam news.
- Obtain exclusive exam tips and strategies.
- Receive special discounts.

Register your book at **ppi2pass.com/register**.

Report Errors and View Corrections for This Book

PPI is grateful to every reader who notifies us of a possible error. Your feedback allows us to improve the quality and accuracy of our products. You can report errata and view corrections at **ppi2pass.com/errata**.

WATER RESOURCES AND ENVIRONMENTAL DEPTH REFERENCE MANUAL FOR THE CIVIL PE EXAM

Current printing of this edition: 4

Printing History

date	edition number	printing number	update
Feb 2013	1	2	Minor corrections.
Nov 2014	1	3	Minor corrections.
Oct 2015	1	4	Minor corrections. Minor cover updates.

Printed in the United States of America.

PPI
1250 Fifth Avenue
Belmont, CA 94002
(650) 593-9119
ppi2pass.com

ISBN: 978-1-59126-095-0

Library of Congress Control Number: 2011929567

F E D C B A

Table of Contents

Preface

The *Water Resources and Environmental Depth Reference Manual* is intended to provide comprehensive coverage of the civil PE water resources and environmental depth exam specifications as presented by the National Council of Examiners for Engineering and Surveying (NCEES). It should be used in conjunction with the *Civil Engineering Reference Manual* (CERM), which covers the wide range of topics on the civil PE breadth exam.

Water resources and environmental engineering is different from many other disciplines of civil engineering. It requires an understanding of naturally occurring processes that respond to unpredictable forces of nature. As nature is unpredictable, calculations are usually based on conservative estimations and frequently rely on the professional judgment of the engineer. Yet, because professional judgment must often be exercised, reported design values will vary from one engineer to the next. The PE exam cannot allow for such variability. Therefore, we've written this book so that the methodologies you'll need to solve problems on the exam are the methodologies presented in each chapter and used in the examples and practice problems.

This book is meant to be a resource for your exam preparation. Therefore, we've done our best to ensure that we've presented the material in this book clearly and accurately. However, if you find a mistake, please let us know. PPI has an errata page on its website, at **ppi2pass.com/errata**, where you can submit suspected errors and view errors already submitted. Valid submitted errors will be posted and incorporated into future printings of this book.

Jonathan A. Brant, PhD, PE
Gerald J. Kauffman, PhD, PE

Acknowledgments

Thanks to Michael Bateman, PE; Steve C. Chiesa, PhD, PE; Tim O. Moore II, PhD, PE; and Thomas W. Schreffler, QEP, PE, for performing the technical review of this book, and to Ken Li, Patrick Albrecht, and Todd Fisher for checking the calculations. Thanks also goes to the PPI Product Development and Implementation staff, including Sarah Hubbard, director of product development and implementation; Cathy Schrott, production services manager; Megan Synnestvedt and Jenny Lindeburg King, editorial project managers; Tyler Hayes, Chelsea Logan, Scott Marley, Magnolia Molcan, and Julia White, copy editors; Kate Hayes, production associate; Tom Bergstrom, technical illustrator; and Amy Schwertman, cover designer. Thank you to Michael R. Lindeburg, PE, for the gracious use of material from the *Civil Engineering Reference Manual*.

Gerald would like to thank the students in the CIEG 440, Water Resources Engineering course, at the University of Delaware, Department of Civil and Environmental Engineering. Their enthusiasm and yearning for learning provided the inspiration for assembling this book. Gerald also wishes to express gratitude to his wife DeEtte, who gave her unconditional support during the writing of this book.

Jon would like to express sincerest gratitude to all the people who have supported his contributions to this book. Without their assistance and personal encouragement, this work would not have been possible. Jon would like to thank his loving wife Beth and daughter Olivia. Without their unyielding support, nothing would be possible. He would also like to thank Dr. Wane Schneiter and Dr. Amy Childress for serving as sources of inspiration throughout his career. Finally, Jon thanks both of his parents for all their untold sacrifices, which have provided him with all of the opportunities he has been blessed with in life.

Jonathan A. Brant, PhD, PE
Gerald J. Kauffman, PhD, PE

References

CODES AND REFERENCES USED ON THE EXAM

The water resources and environmental depth section of the civil PE exam is not based on specific codes or references. However, the minimum recommended library for the exam consists of the *Civil Engineering Reference Manual* (CERM) and the *Water Resources and Environmental Depth Reference Manual* (for the breadth and depth sections of the exam, respectively).

In addition to CERM and this book, it is recommended you bring *Urban Hydrology for Small Watersheds* (*TR-55*) and the *Precipitation-Frequency Atlas of the United States* with you to the exam. Though this book presents many worksheets from *TR-55*, *TR-55* contains additional data on rainfall and soils that you may need for the exam but that is too voluminous to include in this book. (For uniformity, *TR-55* worksheets reproduced in this book have been modified to reflect this book's nomenclature.) The *Precipitation-Frequency Atlas of the United States* is published by the National Oceanic and Atmospheric Administration (NOAA). In particular, you should bring with you to the exam NOAA Atlas 2 and Atlas 14, which contain precipitation depth maps for 6 hr and 24 hr storms. Links to the *TR-55*, the NOAA atlases, and other resources are available online at **ppi2pass.com/CEwebrefs**.

REFERENCES USED IN THIS BOOK

The following references were used to prepare this book. You may also find them useful references to bring with you to the exam.

Hydrologic Unit Maps. WPS 2294. Paul R. Seaber, F. Paul Kapinos, and George L. Knapp. U.S. Geological Survey.

Open Channel Hydraulics. V. T. Chow. The Blackburn Press.

Precipitation-Frequency Atlas of the United States. NOAA Atlas 14, Vol. 1 and Vol. 2. National Oceanic and Atmospheric Administration (NOAA).[1]

Precipitation-Frequency Atlas of the Western United States. NOAA Atlas 2. National Oceanic and Atmospheric Administration (NOAA).[1]

Recommended Standards for Wastewater Facilities. Ten States Standards. Great Lakes—Upper Mississippi River Board.[1]

Recommended Standards for Water Works. Ten States Standards. Great Lakes—Upper Mississippi River Board.[1]

Technical Manual for Stream Encroachment in New Jersey. New Jersey Dept. of Environmental Protection.

Urban Hydrology for Small Watersheds. TR-55. Natural Resources Conservation Service.[1]

Water Resources Engineering. Ray K. Linsley, Joseph B. Franzini, David L. Freyberg, and George Tchobanoglous. McGraw-Hill.

Water Surface Profiles. Vol. 6. U.S. Army Corps of Engineers.

Water Supply and Pollution Control. John W. Clark, Warren Viessman, Jr., and Mark J. Hammer. Harper & Row.

[1]A link to a downloadable version is provided at **ppi2pass.com/CEwebrefs**.

Introduction

ABOUT THIS BOOK

The *Water Resources and Environmental Depth Reference Manual* covers the water resources and environmental depth section of the civil PE exam administered by the National Council of Examiners for Engineering and Surveying (NCEES). This section of the exam is intended to assess your knowledge of design procedures and field practice.

This book is written with the exam in mind. Major topics, equations, and example problems are presented, and practice problems are given at the end of each chapter. Common resources, such as *TR-55* and the NOAA atlases, are used in examples and practice problems to increase your familiarity with these resources before you need them on the exam.

This book's eleven chapters are organized into three topics covering the following exam specifications.

- Hydraulics—Closed Conduit

  Energy and/or continuity equation (e.g., Bernoulli), pressure conduit (e.g., single pipe, force mains), closed pipe flow equations (Hazen-Williams, Darcy-Weisbach), friction and/or minor losses, pipe network analysis (e.g., pipeline design, branch networks, loop networks), pump application and analysis, cavitation, transient analysis (e.g., water hammer), closed conduit flow measurement, momentum equation (e.g., thrust blocks, pipeline restraints)

- Hydraulics—Open Channel

  Open-channel flow (e.g., Manning's equation), culvert design, spillway capacity, energy dissipation (e.g., hydraulic jump, velocity control), stormwater collection (stormwater inlets, gutter flow, street flow, storm sewer pipes), floodplain/floodway, subcritical and supercritical flow, open channel flow measurement, gradually varied flow

- Hydrology

  Storm characterization (rainfall measurement and distribution), storm frequency, hydrograph application and development, synthetic hydrographs, rainfall intensity-duration-frequency (IDF) curves, time of concentration, runoff analysis (rational method, NRCS method), gauging stations (runoff frequency analysis, flow calculations), depletions (e.g., transpiration, evaporation, infiltration), sedimentation, erosion, detention/retention ponds

- Groundwater and Well Fields

  Aquifers (e.g., characterization), groundwater flow (Darcy's Law, seepage analysis), well analysis (steady flow only), groundwater control (drainage, construction dewatering), water quality analysis, groundwater contamination

- Wastewater Treatment

  Wastewater flow rates (e.g., municipal, industrial, commercial), unit operations and processes, primary treatment (e.g., bar screens, clarification), secondary clarification, chemical treatment, collection systems (e.g., lift stations, sewer network, infiltration, inflow), National Pollutant Discharge Elimination System (NPDES) permitting, effluent limits, biological treatment, physical treatment, solids handling (e.g., thickening, drying processes), digesters, disinfection, nitrification and/or denitrification, operations (e.g., odor control, corrosion control, compliance), advanced treatment (e.g., nutrient removal, filtration, wetlands), beneficial reuse (e.g., liquids, biosolids, gas)

- Water Quality

  Stream degradation (e.g., thermal, base flow, TDS, TSS, BOD, COD), oxygen dynamics (e.g., oxygenation, deoxygenation, oxygen sag curve), risk assessment and management, toxicity, biological contaminants (e.g., algae, mussels), chemical contaminants (e.g., organics, heavy metals), bioaccumulation, eutrophication, indicator organisms and testing, sampling and monitoring (e.g., QA/QC, laboratory procedures)

- Water Treatment

  Demands, hydraulic loading, storage (raw and treated water), sedimentation, taste and odor control, rapid mixing, coagulation and flocculation, filtration, disinfection, softening, advanced treatment (e.g., membranes, activated carbon, desalination), distribution systems

ABOUT THIS BOOK'S UNIT CONVERSIONS

Unit conversion is one of the most error-prone components of the water resources and environmental depth section of the civil PE exam, so we've included all unit conversions throughout the solutions. The situations in which conversions are needed are numerous. For example, the United States Geological Survey stream gauge network provides records of stream flow in cubic feet per second, while a water distribution network engineer requires flow in million gallons per day and gallons per minute. Precipitation is measured by the United States National Weather Service in inches, yet engineers typically estimate stormwater runoff in units of cubic feet per second. Therefore, you should pay special attention to which units are specified in a problem and for the final answer. Make sure you convert appropriately. It would be a shame to get a problem wrong because you converted to cubic feet per minute instead of cubic feet per second.

As long as U.S. government agencies continue to provide water resources data in customary U.S. units, it is likely that most hydrology and hydraulics problems on the PE exam will be in customary U.S. units. However, NCEES specifies that SI units will also appear on the exam. Therefore, correct unit conversion is essential to mastering the water resources and environmental depth exam. Common unit conversions are provided in App. 1.B and App. 1.C as an aid.

HOW TO USE THIS BOOK

This book provides a comprehensive, targeted review of the material on the water resources and environmental depth section of the civil PE exam, and is designed to be used in conjunction with the *Civil Engineering Reference Manual* as your primary breadth exam review resource. Start by reviewing the exam topics (listed in this introduction) and familiarizing yourself with the content and format of this book by looking at the table of contents, the index, and scanning the chapters. Each chapter begins with a nomenclature list of the chapter's major variables and their units and ends with practice problems related to the presented concepts. Significant terms and concepts have been indexed to provide a method of easily finding information and data. Common acronyms and their definitions are listed in App. 1.A for quick reference. Unit conversions, national drinking water standards, and selected Ten States Standards are also given in the appendices.

The chapters are grouped into three topics. While any concept can be reviewed and referenced individually, successive chapters within each topic build on concepts previously presented. Decide on a study schedule, assess your strengths and weaknesses, and determine how much time to spend reviewing each chapter. Read the chapter, solving the example problems and reviewing the presented solutions as you go. Then solve the end-of-chapter practice problems: Restrain yourself from looking at the solutions until you've tried solving each problem on your own. The practice problems are designed to give you experience applying relevant equations, data, and theories to a given problem. Compare your solving approach against that provided in the solution. With practice, you will be able to quickly decide which data and equations are applicable to the problem at hand.

Topic I: Water Resources

APPENDIX 1.A
Acronyms and Abbreviations

abbreviation	acronym
ABS	acrylonitrile-butadiene-styrene plastic
AQI	Air Quality Index
ASP	activated sludge process
BAT	best available technology
BTEX	compounds composed of benzene, toluene, ethylbenzene, and xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	chlorofluorocarbons
CSTR	completely stirred tank reactor
DAF	dissolved air floatation
DCE	dichloroethylene
DDT	insecticide dichlorodiphenyltrichloroethane
DNAPL	dense nonaqueous phase liquid
DRE	destruction and removal efficiency
EIR	environmental impact report
EPA	United States Environmental Protection Agency
FC	fecal coliform
FEMA	Federal Emergency Management Agency
FS	fecal streptococcus
GBT	gravity belt thickener
gpcd	gallons per capita per day
HDPE	high density polyethylene
HSWA	Hazardous and Solid Waste Amendments
LD_{50}	lethal dose; concentration from which 50% of exposed population will die
LNAPL	light nonaqueous phase liquid
MF	microfiltration
msl	mean sea level
MSW	municipal solid waste
MTBE	methyl tertiary-butyl ether
MVOC	methane-based volatile organic compound
NAPL	nonaqueous phase liquid
NF	nanofiltration
NFPA	National Fire Protection Association
NMVOC	nonmethane-based volatile organic compound
NO_X	nitrogen oxide gases
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NSDWR	National Secondary Drinking Water Regulations
NTU	nephelometric turbidity units
NTU	number of transfer units
PAH	polycyclic aromatic hydrocarbons or polyaromatic hydrocarbons
Pb	lead
PCB	polychlorinated biphenyls
PCDD	polychlorinated dibenzodioxin
PCDF	polychlorinated dibenzofuran
PCE	perchloroethylene
PFR	plug flow reactor
PM	particulate matter
PM_{10}	particulate matter with a size between 2.5 μm and 10 μm
$PM_{2.5}$	particulate matter with a size less than 2.5 μm
PRP	potentially responsible parties
PSI	Pollutants Standards Index
PT	primary treatment
PVC	polyvinyl chloride
RBC	rotating biological contactor
RCRA	Resource Conservation and Recovery Act

(continued)

Appendices

APPENDIX 1.A *(continued)*
Acronyms and Abbreviations

abbreviation	acronym
RDF	refuse derived fuel
RO	reverse osmosis
SARA	Superfund Amendments and Reauthorization Act
SCR	selective catalytic reduction
SRF	solid recovered fuel
SVE	soil vapor extraction
SVOC	semi-volatile organic chemicals
TC	total coliform
TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
TCE	trichloroethylene
TEF	toxic equivalence factors
TEQ	2,3,7,8-TCDD toxic equivalent
TF	trickling filter
THMs	trihalomethanes
TKN	total Kjehldahl nitrogen
TOC	total organic carbon
TSP	total suspended particulates
UF	ultrafiltration
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDC	United States Department of Commerce
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USNWS	United States National Weather Service
UV	ultraviolet
VOC	volatile organic compound
WAS	waste-activated sludge
WHPA	wellhead protection areas
WL	working level
WWTP	wastewater treatment plant

APPENDIX 1.B
Flow Rate and Velocity Unit Conversions

multiply	by	to obtain
gallon/minute	0.06309	liter/second
	0.004419	acre-foot/day
	0.002228	cubic foot/second
	0.001440	million gallon/day
	63.09×10^{-6}	cubic meter/second
liter/second	15.85	gallon/minute
	0.07005	acre-foot/day
	0.03531	cubic foot/second
	0.02282	million gallon/day
	0.0001	cubic meter/second
acre-foot/day	226.3	gallon/minute
	14.28	liter/second
	0.5042	cubic foot/second
	0.3259	million gallon/day
	0.01428	cubic meter/second
cubic foot/second	448.8	gallon/minute
	28.32	liter/second
	1.983	acre-foot/day
	0.6463	million gallon/day
	0.02832	cubic meter/second
million gallon/day	694.4	gallon/minute
	43.81	liter/second
	3.068	acre-foot/day
	1.547	cubic foot/second
	0.04382	cubic meter/second
cubic meter/second	15,850	gallon/minute
	1000	liter/second
	70.04	acre-foot/day
	35.31	cubic foot/second
	22.83	million gallon/day

Appendices

APPENDIX 1.C
Volumetric Unit Conversions

multiply	by	to obtain
cubic inch	0.01639	liter
	0.004329	U.S. gallon
	5.787×10^{-4}	cubic foot
	2.143×10^{-4}	cubic yard
	0.1639×10^{-4}	cubic meter
	0.0013×10^{-5}	acre-foot
liter	61.02	cubic inch
	0.2642	U.S. gallon
	0.03531	cubic foot
	0.001308	cubic yard
	0.001	cubic meter
	810.6×10^{-9}	acre-foot
U.S. gallon	231.0	cubic inch
	3.785	liter
	0.1337	cubic foot
	0.004951	cubic yard
	0.003785	cubic meter
	3.068×10^{-6}	acre-foot
cubic foot	1728	cubic inch
	28.32	liter
	7.481	U.S. gallon
	0.03704	cubic yard
	0.02832	cubic meter
	22.96×10^{-6}	acre-foot
cubic yard	46,660	cubic inch
	764.6	liter
	202.0	U.S. gallon
	27	cubic foot
	0.7466	cubic meter
	619.8×10^{-6}	acre-foot
cubic meter	61,020	cubic inch
	1000	liter
	264.2	U.S. gallon
	35.31	cubic foot
	1.308	cubic yard
	810.6×10^{-6}	acre-foot
acre-foot	75.27×10^{6}	cubic inch
	1,233,000	liter
	325,900	U.S. gallon
	43,560	cubic foot
	1.613	cubic yard
	1233	cubic meter

APPENDIX 2.A
Physical Properties of Water at Atmospheric Pressure
(U.S. customary units)

temperature	density	specific weight	absolute (dynamic) viscosity	kinematic viscosity	vapor pressure
(°F)	(slug/ft^3)	(lbf/ft^3)	(lbm-sec/ft^2)	(ft^2/sec)	(lbf/in^2)
32	1.940	62.416	0.374×10^{-4}	1.93×10^{-5}	0.09
40	1.940	62.423	0.323×10^{-4}	1.67×10^{-5}	0.12
50	1.940	62.408	0.273×10^{-4}	1.41×10^{-5}	0.18
60	1.939	62.366	0.235×10^{-4}	1.21×10^{-5}	0.26
70	1.936	62.300	0.205×10^{-4}	1.06×10^{-5}	0.36
80	1.934	62.217	0.180×10^{-4}	0.929×10^{-5}	0.51
90	1.931	62.118	0.160×10^{-4}	0.828×10^{-5}	0.70
100	1.927	61.998	0.143×10^{-4}	0.741×10^{-5}	0.95
120	1.918	61.719	0.117×10^{-4}	0.610×10^{-5}	1.69
140	1.908	61.386	0.0979×10^{-4}	0.513×10^{-5}	2.89
160	1.896	61.006	0.0835×10^{-4}	0.440×10^{-5}	4.74
180	1.883	60.586	0.0726×10^{-4}	0.385×10^{-5}	7.51
200	1.869	60.135	0.0637×10^{-4}	0.341×10^{-5}	11.52
212	1.847	59.843	0.0593×10^{-4}	0.319×10^{-5}	14.70

Adapted from *Design of Roadside Channels with Flexible Linings*, Hydraulic Engineering Circular No. 15, 3rd ed., Table A.7, 2005, U.S. Federal Highway Administration.

APPENDIX 2.B
Physical Properties of Water at Atmospheric Pressure
(SI units)

temperature	density	specific weight	absolute (dynamic) viscosity	kinematic viscosity	absolute vapor pressure
(°C)	(kg/m^3)	(N/m^3)	(Pa·s)	(m^2/s)	(Pa)
0	1000	9810	1.79×10^{-3}	1.79×10^{-6}	611
5	1000	9810	1.51×10^{-3}	1.51×10^{-6}	872
10	1000	9810	1.31×10^{-3}	1.31×10^{-6}	1230
15	999	9800	1.14×10^{-3}	1.14×10^{-6}	1700
20	998	9790	1.00×10^{-3}	1.00×10^{-6}	2340
25	997	9781	8.91×10^{-4}	8.94×10^{-7}	3170
30	996	9771	7.97×10^{-4}	8.00×10^{-7}	4250
35	994	9751	7.20×10^{-4}	7.24×10^{-7}	5630
40	992	9732	6.53×10^{-4}	6.58×10^{-7}	7380
50	988	9693	5.47×10^{-4}	5.53×10^{-7}	12 300
60	983	9643	4.66×10^{-4}	4.74×10^{-7}	20 000
70	978	9594	4.04×10^{-4}	4.13×10^{-7}	31 200
80	972	9535	3.54×10^{-4}	3.64×10^{-7}	47 400
90	965	9467	3.15×10^{-4}	3.26×10^{-7}	70 100
100	958	9398	2.82×10^{-4}	2.94×10^{-7}	101 300

Adapted from *Design of Roadside Channels with Flexible Linings*, Hydraulic Engineering Circular No. 15, 3rd ed., Table A.6, 2005, U.S. Federal Highway Administration.

APPENDIX 5.A

Selected Ten States Standards

3.1. Surface Water

A surface water source includes all tributary streams and drainage basins, natural lakes, and artificial reservoirs or impoundments above the point of water supply intake. A source water protection plan enacted for continued protection of the watershed from potential sources of contamination shall be provided as determined by the reviewing authority.

3.1.1. Quantity

The quantity of water at the source shall be adequate to meet the maximum projected water demand of the service area as shown by calculations based on a one in 50 year drought or the extreme drought of record, and should include consideration of multiple year droughts.

4.1. Clarification

Clarification is generally considered to consist of any process, or combination of processes, which reduces the concentration of suspended matter in drinking water prior to filtration.

4.1.1. Presedimentation

Detention time: Three hours detention is the minimum period recommended; greater detention may be required.

4.1.2. Coagulation

Coagulation shall mean a process using coagulant chemicals and mixing by which colloidal and suspended material are destabilized and agglomerated into settleable or filterable flocs, or both. The engineer shall submit the design basis for the velocity gradient (*G* value) selected, considering the chemicals to be added and water temperature, color, and other related water quality parameters. For surface water plants using direct or conventional filtration, the use of a primary coagulant is required at all times.

4.1.2.a. Mixing: The detention period should not be more than 30 seconds with mixing equipment capable of imparting a minimum velocity gradient (*G*) of at least 750 ft/sec-ft. The design engineer should determine the appropriate *G* value and detention time through jar testing.

4.1.3. Flocculation

Flocculation shall mean a process to enhance agglomeration or collection of smaller floc particles into larger, more easily settleable or filterable particles through gentle stirring by hydraulic or mechanical means.

4.1.3.b. Detention: The detention time for floc formation should be at least 30 minutes with consideration to using tapered (i.e., diminishing velocity gradient) flocculation. The flow-through velocity should be not less than 0.5 ft/min nor greater than 1.5 ft/min.

4.1.3.c. Equipment: Agitators shall be driven by variable speed drives with the peripheral speed of paddles ranging from 0.5 ft/sec to 3.0 ft/sec. External, non-submerged motors are preferred.

4.1.3.d. Piping: Flocculation and sedimentation basins shall be as close together as possible. The velocity of flocculated water through pipes or conduits to settling basins shall be neither less than 0.5 ft/sec nor greater than 1.5 ft/sec. Allowances must be made to minimize turbulence at bends and changes in direction.

4.1.4. Sedimentation

Sedimentation shall follow flocculation. The detention time for effective clarification is dependent upon a number of factors related to basin design and the nature of the raw water. The following criteria apply to conventional sedimentation units.

4.1.4.a. Detention time: Detention time shall provide a minimum of four hours of settling time. This may be reduced to two hours for lime-soda softening facilities treating only groundwater. Reduced sedimentation time may also be approved when equivalent effective settling is demonstrated or when overflow rate is not more than 0.5 gal/min-ft^2 (1.2 m/h).

4.1.4.c. Outlet weirs and submerged orifices shall be designed as follows.

4.1.4.c.1. The rate of flow over the outlet weirs or through the submerged orifices shall not exceed 20,000 gal/day-ft (250 m^3/d·m) of the outlet launder.

4.1.4.c.2. Submerged orifices should not be located lower than 3 ft below the flow line.

4.1.4.c.3. The entrance velocity through the submerged orifices shall not exceed 0.5 ft/sec.

4.1.4.d. Velocity: The velocity through settling basins should not exceed 0.5 ft/min. The basins must be designed to minimize short-circuiting. Fixed or adjustable baffles must be provided as necessary to achieve the maximum potential for clarification.

4.1.5 Solids Contact Unit

Units are generally acceptable for combined softening and clarification where water characteristics, especially temperature, do not fluctuate rapidly, flow rates are uniform, and operation is continuous. Before such units are considered as clarifiers without softening, specific approval of the reviewing authority shall be obtained. Clarifiers should be designed for the maximum uniform rate and should be adjustable to changes in flow which are less than the design rate and for changes in water characteristics. A minimum of two units are required for surface water treatment.

4.1.5.9. Detention Period

The detention time shall be established on the basis of the raw water characteristics and other local conditions that affect the operation of the unit. Based on design flow rates, the detention time should be

4.1.5.9.a. two to four hours for suspended solids contact clarifiers and softeners treating surface water, and

(continued)

Appendices

APPENDIX 5.A *(continued)*
Selected Ten States Standards

4.1.5.9.b. one to two hours for the suspended solids contact softeners treating only groundwater.

4.1.5.12. Weirs or Orifices

The units should be equipped with either overflow weirs or orifices constructed so that water at the surface of the unit does not travel over 10 ft horizontally to the collection trough.

4.1.5.12.a. Weirs shall be adjustable, and at least equivalent in length to the perimeter of the tank.

4.1.5.12.b. Weir loading shall not exceed

4.1.5.12.b.1. 10 gal/min-ft of weir length (120 L/min·m) for units used for clarifiers, and

4.1.5.12.b.2. 20 gal/min-ft of weir length (240 L/min·m) for units used for softeners.

4.2 Filtration

Acceptable filters shall include, upon the discretion of the reviewing authority, the following types.

4.2.a. rapid rate gravity filters (4.2.1),

4.2.b. rapid rate pressure filters (4.2.2),

4.2.c. diatomaceous earth filtration (4.2.3),

4.2.d. slow sand filtration (4.2.4),

4.2.e. direct filtration (4.2.5),

4.2.f. deep bed rapid rate gravity filters (4.2.6),

4.2.g. biologically active filters (4.2.7),

4.2.h. membrane filtration (see Interim Standard on Membrane Technologies), and

4.2.i. bag and cartridge filters (see policy statement on Bag and Cartridge Filters for Public Water Systems).

4.2.1. Rapid Rate Gravity Filters

4.2.1.6. Filter material: The media shall be clean silica sand or other natural or synthetic media free from detrimental chemical or bacterial contaminants, approved by the reviewing authority, and having the following characteristics.

4.2.1.6.a. a total depth of not less than 24 in and generally not more than 30 in,

4.2.1.6.b. a uniformity coefficient of the smallest material not greater than 1.65, and

4.2.1.6.c. a minimum of 12 in of media with an effective size range no greater than 0.45 mm to 0.55 mm.

4.2.1.6.d. Types of filter media

4.2.1.6.d.1. Anthracite: Filter anthracite shall consist of hard, durable anthracite coal particles of various sizes. Blending of non-anthracite material is not acceptable. Anthracite shall have an

4.2.1.6.d.1.a. effective size of 0.45 mm to 0.55 mm with uniformity coefficient not greater than 1.65 when used alone,

4.2.1.6.d.1.b. effective size of 0.8 mm to 1.2 mm with a uniformity coefficient not greater than 1.7 when used as a cap,

4.2.1.6.d.1.c. effective maximum size of 0.8 mm when used as a single media on potable groundwater for iron and manganese removal only (effective sizes greater than 0.8 mm may be approved based upon onsite pilot plant studies or other demonstration acceptable to the reviewing authority).

4.2.1.6.d.1.d. a specific gravity greater than 1.4,

4.2.1.6.d.1.e. an acid solubility less than 5%, and

4.2.1.6.d.1.f. a Mho's scale of hardness greater than 2.7.

4.2.1.6.d.2. Sand: Sand shall have

4.2.1.6.d.2.a. an effective size of 0.45 mm to 0.55 mm,

4.2.1.6.d.2.b. a uniformity coefficient not greater than 1.65,

4.2.1.6.d.2.c. a specific gravity greater than 1.4, and

4.2.1.6.d.2.d. an acid solubility less than 5%.

4.2.1.6.d.4. Granular activated carbon (GAC): Granular activated carbon as a single media may be considered for filtration only after pilot or full scale testing and with prior approval of the reviewing authority.

4.2.1.6.e. Support media

4.2.1.6.e.2. Gravel: Gravel, when used as the supporting medium, shall consist of cleaned and washed, hard, durable, rounded silica particles and shall not include flat or elongated particles. The coarsest gravel shall be $2^1/_2$ in in size when the gravel rests directly on a lateral system, and must extend above the top of the perforated laterals. Not less than four layers of gravel shall be provided in accordance with the following size and depth distribution.

size	depth
2½ in to 1½ in	5 in to 8 in
1½ in to ¾ in	3 in to 5 in
¾ in to ½ in	3 in to 5 in
½ in to 3/16 in	2 in to 3 in
3/16 in to 3/32 in	2 in to 3 in

(continued)

APPENDIX 5.A *(continued)*
Selected Ten States Standards

4.2.3.8. Filtration

4.2.3.8.a. Rate of filtration: The recommended nominal rate is 1.0 gal/min-ft^2 of filter area (2.4 m/h) with a recommended maximum of 1.5 gal/min-ft^2 (3.7 m/h). The filtration rate shall be controlled by a positive means.

4.3. Disinfection

Chlorine is historically the preferred disinfecting agent. Disinfection may be accomplished with gas and liquid chlorine, calcium or sodium hypochlorites, chlorine dioxide, ozone, or ultraviolet light. Disinfection is required for all surface water supplies, groundwater under the direct influence of surface water, and for any groundwater supply of questionable sanitary quality or where other treatment is provided. Disinfection with chloramines is not recommended for primary disinfection. The required amount of primary disinfection needed shall be specified by the reviewing authority. Continuous disinfection is recommended for all water supplies. Consideration must be given to the formation of disinfection by-products (DBP) when selecting the disinfectant.

4.3.1. Chlorination Equipment

4.3.1.2. Capacity: The chlorinator capacity shall be such that a free chlorine residual of at least 2 mg/L can be maintained in the water once all demands are met after contact time of at least 30 minutes when maximum flow rate coincides with anticipated maximum chlorine demand. The equipment shall be of such design that it will operate accurately over the desired feeding range.

4.3.3. Residual Chlorine

4.3.3.a. Minimum free chlorine residual in a water distribution system should be 0.2 mg/L. Minimum chloramine residuals, where chloramination is practiced, should be 1.0 mg/L at distant points in the distribution system.

7.3 Distribution System Storage

7.3.1. Pressures

The maximum variation between high and low levels in storage structures providing pressure to a distribution system should not exceed 30 ft. The minimum working pressure in the distribution system should be 35 psi (240 kPa) and the normal working pressure should be approximately 60 psi to 80 psi (410 kPa to 550 kPa). When static pressures exceed 100 psi (690 kPa), pressure reducing devices should be provided on mains or as part of the meter survey on individual service lines in the distribution system.

8.2. System Design

8.2.1 Pressure

All water mains, including those not designed to provide fire protection, shall be sized after a hydraulic analysis based on flow demands and pressure requirements. The system shall be designed to maintain a minimum pressure of 20 psi (140 kPa) at ground level at all points in the distribution system under all conditions of flow. The normal working pressure in the distribution system should be approximately 60 psi to 80 psi (410 kPa to 550 kPa) and not less than 35 psi (240 kPa).

Selections from *Recommended Standards for Water Works, Policies for the Review and Approval of Plans and Specifications for Public Water Supplies*, 2007 ed.

APPENDIX 5.B

National Primary Drinking Water Regulations Code of Federal Regulations (CFR), Title 40, Ch. I, Part 141, October 2003

microorganisms	MCLG[a] (mg/L)[b]	MCL or TT[a] (mg/L)[b]	potential health effects from ingestion of water	sources of contaminant in drinking water
Cryptosporidium	0	TT[c]	gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	human and animal fecal waste
Giardia lamblia	0	TT[c]	gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	human and animal fecal waste
heterotrophic plate count	n/a	TT[c]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water is.	HPC measures a range of bacteria that are naturally present in the environment.
Legionella	0	TT[c]	Legionnaire's disease, a type of pneumonia	found naturally in water; multiplies in heating systems
total coliforms (including fecal coliform and *E. coli*)	0	5.0%[d]	Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present.[e]	Coliforms are naturally present in the environment as well as in feces; fecal coliforms and *E. coli* only come from human and animal fecal waste.
turbidity	n/a	TT[c]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease causing organisms are present). Higher turbidity levels are often associated with higher levels of disease causing microorganisms such as viruses, parasites, and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.	soil runoff
viruses (enteric)	0	TT[c]	gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	human and animal fecal waste

disinfection products	MCLG[a] (mg/L)[b]	MCL or TT[a] (mg/L)[b]	potential health effects from ingestion of water	sources of contaminant in drinking water
bromate	0	0.010	increased risk of cancer	by-product of drinking-water disinfection
chlorite	0.8	1.0	anemia in infants and young children; nervous system effects	by-product of drinking-water disinfection
haloacetic acids (HAA5)	n/a[f]	0.060	increased risk of cancer	by-product of drinking-water disinfection
total trihalomethanes (TTHMs)	n/a[f]	0.080	liver, kidney, or central nervous system problems; increased risk of cancer	by-product of drinking-water disinfection

(continued)

Appendices

APPENDIX 5.B *(continued)*
National Primary Drinking Water Regulations Code of Federal Regulations (CFR), Title 40, Ch. I, Part 141, October 2003

disinfectants	MCLG[a] (mg/L)[b]	MCL or TT[a] (mg/L)[b]	potential health effects from ingestion of water	sources of contaminant in drinking water
chloramines (as Cl_2)	4[a]	4.0[a]	eye/nose irritation, stomach discomfort, anemia	water additive used to control microbes
chlorine (as Cl_2)	4[a]	4.0[a]	eye/nose irritation, stomach discomfort	water additive used to control microbes
chlorine dioxide (as ClO_2)	0.8[a]	4.0[a]	anemia in infants and young children, nervous system effects	water additive used to control microbes

inorganic chemicals	MCLG[a] (mg/L)[b]	MCL or TT[a] (mg/L)[b]	potential health effects from ingestion of water	sources of contaminant in drinking water
antimony	0.006	0.006	increase in blood cholesterol; decrease in blood sugar	discharge from petroleum refineries; fire retardants; ceramics; electronics; solder
arsenic	0[g]	0.010 as of January 23, 2006	skin damage or problems with cirulatory systems; may increase cancer risk	erosion of natural deposits; runoff from orchards; runoff from glass and electronics production wastes
asbestos (fiber > 10 micrometers)	7 million fibers per liter	7 MFL	increased risk of developing benign intestinal polyps	decay of asbestos cement in water mains; erosion of natural deposits
barium	2	2	increase in blood pressure	discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
beryllium	0.004	0.004	intestinal lesions	discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries
cadmium	0.005	0.005	kidney damage	corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints
chromium (total)	0.1	0.1	allergic dermatitis	discharge from steel and pulp mills; erosion of natural deposits
copper	1.3	TT[h], action level = 1.3	short-term exposure: gastrointestinal distress long-term exposure: liver or kidney damage People with Wilson's disease should consult their personal doctor if the amount of copper in their water exceeds the action level.	corrosion of household plumbing systems; erosion of natural deposits
cyanide (as free cyanide)	0.2	0.2	nerve damage or thyroid problems	discharge from steel/metal factories; discharge from plastic and fertilizer factories

(continued)

Appendices

APPENDIX 5.B *(continued)*
National Primary Drinking Water Regulations Code of Federal Regulations (CFR), Title 40, Ch. I, Part 141, October 2003

inorganic chemicals	MCLG[a] (mg/L)[b]	MCL or TT[a] (mg/L)[b]	potential health effects from ingestion of water	sources of contaminant in drinking water
fluoride	4.0	4.0	bone disease (pain and tenderness of the bones); children may get mottled teeth	water additive that promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories
lead	0	TT[h], action level = 0.015	infants and children: delays in physical or mental development; children could show slight deficits in attention span and learning disabilities adults: kidney problems, high blood pressure	corrosion of household plumbing systems; erosion of natural deposits
mercury (inorganic)	0.002	0.002	kidney damage	erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands
nitrate (measured as nitrogen)	10	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue baby syndrome.	runoff from fertilizer use; leaching from septic tanks/sewage; erosion of natural deposits
nitrite (measured as nitrogen)	1	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue baby syndrome.	runoff from fertilizer use; leaching from septic tanks/sewage; erosion of natural deposits
selenium	0.05	0.05	hair and fingernail loss; numbness in fingers or toes; circulatory problems	discharge from petroleum refineries; erosion of natural deposits; discharge from mines
thalium	0.0005	0.002	hair loss; changes in blood; kidney, intestine, or liver problems	leaching from ore-processing sites; discharge from electronics, glass, and drug factories

organic chemicals	MCLG[a] (mg/L)[b]	MCL or TT[a] (mg/L)[b]	potential health effects from ingestion of water	sources of contaminant in drinking water
acrylamide	0	TT[i]	nervous system or blood problems; increased risk of cancer	added to water during sewage/wastewater treatment
alachlor	0	0.002	eye, liver, kidney, or spleen problems; anemia; increased risk of cancer	runoff from herbicide used on row crops
atrazine	0.003	0.003	cardiovascular system or reproductive problems	runoff from herbicide used on row crops
benzene	0	0.005	anemia; decrease in blood platelets; increased risk of cancer	discharge from factories; leaching from gas storage tanks and landfills
benzo(a)pyrene (PAHs)	0	0.0002	reproductive difficulties; increased risk of cancer	leaching from linings of water storage tanks and distribution lines

(continued)

APPENDIX 5.B *(continued)*
National Primary Drinking Water Regulations Code of Federal Regulations (CFR), Title 40, Ch. I, Part 141, October 2003

organic chemicals	MCLG[a] (mg/L)[b]	MCL or TT[a] (mg/L)[b]	potential health effects from ingestion of water	sources of contaminant in drinking water
carbofuran	0.04	0.04	problems with blood, nervous system, or reproductive system	leaching of soil fumigant used on rice and alfalfa
carbon tetrachloride	0	0.005	liver problems; increased risk of cancer	discharge from chemical plants and other industrial activities
chlordane	0	0.002	liver or nervous system problems; increased risk of cancer	residue of banned termiticide
chlorobenzene	0.1	0.1	liver or kidney problems	discharge from chemical and agricultural chemical factories
2,4-D	0.07	0.07	kidney, liver, or adrenal gland problems	runoff from herbicide used on row crops
dalapon	0.2	0.2	minor kidney changes	runoff from herbicide used on rights of way
1,2-dibromo-3-chloropropane (DBCP)	0	0.0002	reproductive difficulties; increased risk of cancer	runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards
o-dichloro-benzene	0.6	0.6	liver, kidney, or circulatory system problems	discharge from industrial chemical factories
p-dichloro-benzene	0.007	0.075	anemia; liver, kidney, or spleen damage; changes in blood	discharge from industrial chemical factories
1,2-dichloroethane	0	0.005	increased risk of cancer	discharge from industrial chemical factories
1,1-dichloroethylene	0.007	0.007	liver problems	discharge from industrial chemical factories
cis-1,2-dichloroethylene	0.07	0.07	liver problems	discharge from industrial chemical factories
trans-1,2-dichloroethylene	0.1	0.1	liver problems	discharge from industrial chemical factories
dichloromethane	0	0.005	liver problems; increased risk of cancer	discharge from industrial chemical factories
1,2-dichloropropane	0	0.005	increased risk of cancer	discharge from industrial chemical factories
di(2-ethylhexyl) adipate	0.4	0.04	general toxic effects or reproductive difficulties	discharge from industrial chemical factories
di(2-ethylhexyl) phthalate	0	0.006	reproductive difficulties; liver problems; increased risk of cancer	discharge from industrial chemical factories
dinoseb	0.007	0.007	reproductive difficulties	runoff from herbicide used on soybeans and vegetables
dioxin (2,3,7,8-TCDD)	0	0.00000003	reproductive difficulties; increased risk of cancer	emissions from waste incineration and other combustion; discharge from chemical factories
diquat	0.02	0.02	cataracts	runoff from herbicide use
endothall	0.1	0.1	stomach and intestinal problems	runoff from herbicide use
endrin	0.002	0.002	liver problems	residue of banned insecticide
epichlorohydrin	0	TT[i]	increased cancer risk; over a long period of time, stomach problems	discharge from industrial chemical factories; an impurity of some water treatment chemicals

(continued)

Appendices

APPENDIX 5.B *(continued)*
National Primary Drinking Water Regulations Code of Federal Regulations (CFR), Title 40, Ch. I, Part 141, October 2003

organic chemicals	MCLG[a] (mg/L)[b]	MCL or TT[a] (mg/L)[b]	potential health effects from ingestion of water	sources of contaminant in drinking water
ethylbenzene	0.7	0.7	liver or kidney problems	discharge from petroleum refineries
ethylene dibromide	0	0.00005	problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	discharge from petroleum refineries
glyphosphate	0.7	0.7	kidney problems; reproductive difficulties	runoff from herbicide use
heptachlor	0	0.0004	liver damage; increased risk of cancer	residue of banned termiticide
heptachlor epoxide	0	0.0002	liver damage; increased risk of cancer	breakdown of heptachlor
hexachlorobenzene	0	0.001	liver or kidney problems; reproductive difficulties; increased risk of cancer	discharge from metal refineries and agricultural chemical factories
hexachloro-cyclopentadiene	0.05	0.05	kidney or stomach problems	discharge from chemical factories
lindane	0.0002	0.0002	liver or kidney problems	runoff/leaching from insecticide used on cattle, lumber, and gardens
methoxychlor	0.04	0.04	reproductive difficulties	runoff/leaching from insecticide used on fruits, vegetables, alfalfa, and livestock
oxamyl (vydate)	0.2	0.2	slight nervous system effects	runoff/leaching from insecticide used on apples, potatoes, and tomatoes
polychlorinated biphenyls (PCBs)	0	0.0005	skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	runoff from landfills; discharge of waste chemicals
pentachlorophenol	0	0.001	liver or kidney problems; increased cancer risk	discharge from wood preserving factories
picloram	0.5	0.5	liver problems	herbicide runoff
simazine	0.004	0.004	problems with blood	herbicide runoff
styrene	0.1	0.1	liver, kidney, or circulatory system problems	discharge from rubber and plastic factories; leaching from landfills
tetrachloroethylene	0	0.005	liver problems; increased risk of cancer	discharge from factories and dry cleaners
toluene	1	1	nervous system, kidney, or liver problems	discharge from petroleum factories
toxaphene	0	0.003	kidney, liver, or thyroid problems; increased risk of cancer	runoff/leaching from insecticide used on cotton and cattle
2,4,5-TP (silvex)	0.05	0.05	liver problems	residue of banned herbicide
1,2,4-trichlorobenzene	0.07	0.07	changes in adrenal glands	discharge from textile finishing factories
1,1,1-trichloroethane	0.20	0.2	liver, nervous system, or circulatory problems	discharge from metal degreasing sites and other factories

(continued)

Appendices

APPENDIX 5.B *(continued)*

National Primary Drinking Water Regulations Code of Federal Regulations (CFR), Title 40, Ch. I, Part 141, October 2003

organic chemicals	MCLG[a] (mg/L)[b]	MCL or TT[a] (mg/L)[b]	potential health effects from ingestion of water	sources of contaminant in drinking water
1,1,2-trichloroethane	0.003	0.005	liver, kidney, or immune system problems	discharge from industrial chemical factories
trichloroethylene	0	0.005	liver problems; increased risk of cancer	discharge from metal degreasing sites and other factories
vinyl chloride	0	0.002	increased risk of cancer	leaching from PVC pipes; discharge from plastic factories
xylenes (total)	10	10	nervous system damage	discharge from petroleum factories; discharge from chemical factories

radionuclides	MCLG[a] (mg/L)[b]	MCL or TT[a] (mg/L)[b]	potential health effects from ingestion of water	sources of contaminant in drinking water
alpha particles	none[g]	15 pCi/L	increased risk of cancer	erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation
beta particles and photon emitters	none[g]	4 mrem/yr	increased risk of cancer	decay of natural and artificial deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation
radium 226 and radium 228 (combined)	none[g]	5 pCi/L	increased risk of cancer	erosion of natural deposits
uranium	0	30 μg/L as of December 8, 2003	increased risk of cancer; kidney toxicity	erosion of natural deposits

[a]Definitions:

Maximum Contaminant Level (MCL): The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.

Maximum Contaminant Level Goal (MCLG): The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

Maximum Residual Disinfectant Level (MRDL): The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.

Maximum Residual Disinfectant Level Goal (MRDLG): The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.

Treatment Technique: A required process intended to reduce the level of a contaminant in drinking water.

[b]Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million.

(continued)

Appendices

APPENDIX 5.B *(continued)*

National Primary Drinking Water Regulations Code of Federal Regulations (CFR), Title 40, Ch. I, Part 141, October 2003

[c]The EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels.

- Cryptosporidium (as of January 1, 2002, for systems serving >10,000 and January 14, 2005, for systems serving < 10,000): 99% removal
- *Giardia lamblia*: 99.9% removal/inactivation
- *Legionella*: No limit, but the EPA believes that if *Giardia* and viruses are removed/inactivated, *Legionella* will also be controlled.
- Turbidity: At no time can turbidity (cloudiness of water) go above 5 nephelolometric turbidity units (NTU); systems that filter must ensure that the turbidity go no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples in any month. As of January 1, 2002, turbidity may never exceed 1 NTU, and must not exceed 0.3 NTU in 95% of daily samples in any month.
- Heterotrophic plate count (HPC): No more than 500 bacterial colonies per milliliter.
- Long Term 1 Enhanced Surface Water Treatment (as of January 14, 2005): Surface water systems or ground water under direct influence (GWUDI) systems serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g., turbidity standards, individual filter monitoring, cryptosporidium removal requirements, updated watershed control requirements for unfiltered systems).
- Filter Backwash Recycling: The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the systems' existing conventional or direct filtration system or at an alternate location approved by the state.

[d]More than 5.0% of samples are total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or *E. coli*: If two consecutive samples are TC-positive, and one is also positive for *E. coli* or fecal coliforms, the system has an acute MCL violation.

[e]Fecal coliform and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems.

[f]Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants.

- Haloacetic acids: dichloroacetic acid (0); trichloroacetic acid (0.3 mg/L). Monochloroacetic acid, bromoacetic acid, and dibromoacetic acid are regulated with this group but have no MCLGs.
- Trihalomethanes: bromodichloromethane (0); bromoform (0); dibromochloromethane (0.06 mg/L). Chloroform is regulated with this group but has no MCLG.

[g]MCLGs were not established before the 1986 Amendments to the Safe Drinking Water Act. Therefore, there is no MCLG for this contaminant.

[h]Lead and copper are regulated by a treatment technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead it is 0.015 mg/L.

[i]Each water system agency must certify, in writing, to the state (using third party or manufacturers' certification) that, when acrylamide and epichlorohydrin are used in drinking water systems, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows.

- acrylamide = 0.05% dosed at 1 mg/L (or equivalent)
- epichlorohydrin = 0.01% dosed at 20 mg/L (or equivalent)

Appendices

APPENDIX 5.C

National Secondary Drinking Water Regulations
Code of Federal Regulations (CFR),
Title 40, Ch. I, Part 143, July 2010

contaminant	secondary standard
aluminum	0.05–0.2 mg/L
chloride	250 mg/L
color	15 (color units)
copper	1.0 mg/L
corrosivity	noncorrosive
fluoride	2.0 mg/L
foaming agents	0.5 mg/L
iron	0.3 mg/L
manganese	0.05 mg/L
odor	3 threshold odor number
pH	6.5–8.5
silver	0.10 mg/L
sulfate	250 mg/L
total dissolved solids	500 mg/L
zinc	5 mg/L

Index

D

E

F

INDEX - S

T

U

V

W

Y

Z

Water Resources and Environmental Depth Reference Manual
for the Civil PE Exam

Comprehensive Coverage of the Topics on the Civil PE Exam's Water Resources and Environmental Depth Section

To succeed on the Civil PE exam's water resources and environmental depth section, you'll need to know the exam subject matter and how to efficiently solve related problems. The *Water Resources and Environmental Depth Reference Manual* provides a concise but thorough review of the exam topics and associated equations. Its 115 example problems show how to apply concepts and equations to solve exam-like problems. Also included are valuable *TR-55 Manual* worksheets and instructions for using them to efficiently calculate runoff manually during the exam. More than 100 end-of-chapter problems provide ample opportunity to practice solving exam-like problems, and step-by-step solutions allow you to check your solution approach.

Just as important as exam topic knowledge and an efficient solving method is quick access to the information you'll need during the exam. This book's thorough index will direct you to the concepts you are looking for. Throughout the book, references to the 226 equations, 67 tables, 102 figures, and 8 appendices point you to additional support material when you need it.

Topics Covered

- Hydrology
- Hydraulics—Closed Conduit
- Hydraulics—Open Channel
- Groundwater Engineering
- Water Treatment
- Water and Wastewater Composition and Chemistry
- Wastewater
- Wastewater Treatment
- Activated Sludge
- Hazardous Waste and Pollutants
- Environmental Remediation

About the Authors

Jonathan A. Brant, PhD, PE, is an assistant professor in the Department of Civil and Architectural Engineering at the University of Wyoming. His research focuses on the development and implementation of advanced technologies and techniques for treating drinking water, wastewater, and water for industrial purposes. Dr. Brant holds a bachelor of science degree in civil engineering from the Virginia Military Institute and master of science and doctorate degrees in civil engineering from the University of Nevada, Reno.

Gerald J. Kauffman, PhD, PE, is an experienced water resources and watershed management engineer. He is the director of the University of Delaware's Water Resources Center and was appointed as Delaware's first water coordinator in 1999. He holds faculty appointments in the University of Delaware's Department of Civil and Environmental Engineering and School of Public Policy and Administration. Dr. Kauffman holds a bachelor of science degree in civil and environmental engineering from Rutgers University and a master of public administration degree in watershed policy and a doctorate degree in marine policy, both from the University of Delaware.

ISBN 978-1-59126-095-0
90000>
9 781591 260950
CEWE