

Contents

Foreword	vii
Executive Summary	ix
Notices	xix
Acknowledgments	xxi
I. Introduction	1
National Criteria	2
Regional Nutrient Criteria	2
Chesapeake Bay Criteria	3
II. Chesapeake Bay Nutrient and Sediment Enrichment Criteria ...	5
III. Dissolved Oxygen Criteria	7
Background	7
Chesapeake Bay science	7
Natural dissolved oxygen processes	8
Chesapeake Bay oxygen dynamics	8
Low dissolved oxygen: historical and recent past	10
Approach to Deriving Dissolved Oxygen Criteria	12
Chesapeake Bay dissolved oxygen restoration goal framework	14
Regionalizing the EPA Virginian Province saltwater dissolved oxygen criteria	15
Applying the EPA freshwater dissolved oxygen criteria	25
Species listed as threatened or endangered	27
Scientific literature findings	33
Instantaneous minimum versus daily mean	33
Strengths and limitations of the criteria derivation procedures	34
Chesapeake Bay Dissolved Oxygen Criteria Derivation	40
Migratory fish spawning and nursery designated use criteria	42
Open-water fish and shellfish designated use criteria	46
Deep-water seasonal fish and shellfish designated use criteria	52
Deep-channel seasonal refuge designated use criteria	60

Chesapeake Bay Dissolved Oxygen Criteria	65
Literature Cited	67
IV. Water Clarity Criteria	81
Background	81
Approach	82
The relationships between water quality, light and underwater bay grasses	82
Determining light requirements	84
Strengths and limitations of the criteria derivation procedures	85
Water Clarity Criteria Derivation	90
Minimum light requirements	90
Light-through-water requirements	95
Chesapeake Bay Water Clarity Criteria	96
Literature Cited	97
V. Chlorophyll <i>a</i> Criteria	101
Background	101
Scope and magnitude of nutrient enrichment in Chesapeake Bay ..	101
Chlorophyll <i>a</i> : key indicator of phytoplankton biomass	102
Chesapeake Bay Chlorophyll <i>a</i> Criteria	104
Supporting Technical Information and Methodologies	105
Context for the narrative Chesapeake Bay chlorophyll <i>a</i> criteria ...	105
Chlorophyll <i>a</i> concentrations characteristic of various ecological conditions	107
Chlorophyll <i>a</i> concentrations characteristic of trophic-based conditions	129
Chlorophyll <i>a</i> concentrations protective against water quality impairments	132
Methodologies for deriving waterbody-specific chlorophyll <i>a</i> criteria	134
Literature Cited	137
VI. Recommended Implementation Procedures	143
Defining Criteria Attainment	144
Dissolved oxygen criteria	144
Water clarity criteria	144
Chlorophyll <i>a</i> criteria	147

Addressing Magnitude, Duration, Frequency, Space and Time	148
Developing the Cumulative Frequency Distribution	152
Step 1. Interpolation of water quality monitoring data	152
Step 2. Comparison of interpolated water quality monitoring data to the appropriate criterion value	155
Step 3. Identification of interpolator cells that exceed the criterion value`	156
Step 4. Calculation of the cumulative probability of each spatial extent of exceedance	156
Step 5. Plot of spatial exceedance vs. the cumulative frequency	159
Diagnosing the Magnitude of Criteria Exceedance	164
Defining the Reference Curve	166
Strengths and limitations	166
Approaches to defining reference curves	167
Reference curves for dissolved oxygen criteria	168
Reference curves for water clarity criteria	171
Reference curves for chlorophyll <i>a</i> criteria	174
Reference curve implementation	174
Monitoring to Support the Assessment of Criteria Attainment	176
Shallow-water monitoring	176
Dissolved oxygen criteria assessment	177
Water clarity criteria assessment	185
Chlorophyll <i>a</i> criteria assessment	191
Evaluation of Chesapeake Bay Water Quality Model Output	194
Chesapeake Bay Watershed Model	195
Chesapeake Bay Water Quality Model	196
Integration of Monitoring and Modeling for Criteria Assessment	196
Literature Cited	197
VII. Diagnostic Procedures for Natural Processes and Criteria Nonattainment	201
Addressing Natural Exceedance of the Chesapeake Bay Criteria	201
Natural excursions of low dissolved oxygen conditions	202
Natural reductions in water clarity levels	206
Natural elevated chlorophyll <i>a</i> concentrations	209

Diagnosing Causes of Criteria Nonattainment	210
Dissolved oxygen criteria	210
Water clarity criteria	211
Chlorophyll <i>a</i> criteria	218
Literature Cited	218
Glossary	221
Acronyms	229
Appendices	
A. Refined Designated Uses for the Chesapeake Bay and Tidal Tributaries	A-1
B. Sensitivity to Low Dissolved Oxygen Concentrations for Northern and Southern Atlantic Coast Populations of Selected Test Species	B-1
C. Summary of Literature on the Tolerance of Chesapeake Bay Macrobenthic Species to Low Dissolved Oxygen Conditions	C-1
D. Narrative, Numerical and Method-based Chlorophyll <i>a</i> Criteria Adopted as Water Quality Standards by States Across the U.S.	D-1
E. 1950s–1990s Chesapeake Bay and Tidal Tributary Chlorophyll <i>a</i> Concentrations by Chesapeake Bay Program Segment	E-1
F. Phytoplankton Reference Community Data Analyses	F-1
G. Data Supporting Determination of Adverse Affect Thresholds for Potentially Harmful Algal Bloom Species	G-1
H. Derivation of Cumulative Frequency Distribution Criteria Attainment Reference Curves	H-1
I. Analytical Approaches for Assessing Short-Duration Dissolved Oxygen Criteria	I-1
J. Development of Chesapeake Bay Percent Light-at-the-Leaf Diagnostic Requirements	J-1