

Analysis of the Numeric Water Quality Criteria Adopted by the Ten States That Border Directly on the Mississippi River

Mississippi

November 2009



**Analysis of the Numeric Water Quality Criteria
Adopted by the Ten States
That Border Directly on the
Mississippi River**

**MISSISSIPPI
Overview**

**Environmental Law Institute
September 2009**

Acknowledgements

This publication is a project of the Environmental Law Institute (ELI). Funding for this project was provided by a grant from the Mississippi River Water Quality Collaborative, a group of state, regional, and national non-profit organizations working together to improve water quality in the Mississippi River basin. The findings and conclusions of this report do not, however, necessarily represent the views of the Mississippi River Water Quality Collaborative or its individual members.

The findings presented in this document are based only on what was found in final, state WQS regulations as of September 1, 2008. Hence, though the existence of proposed changes to state water quality standards may be acknowledged, typically in footnotes, the contents of such potential modifications are not reflected in the various analyses contained in the report. Likewise, associated guidance documents, policy memoranda, and other state publications related to the state's WQS are not reflected in this report. As such, one limitation of this report is that it does not fully describe a given state's water quality standards program or how WQS are applied in other water quality programs.

This report was written by Bill Painter and Yen Hoang, with oversight by John Pendergrass, of ELI. Mr. Painter was at the time of the research and writing of this report a Visiting Government Scholar at ELI under the Inter-governmental Personnel Act Mobility Program from the U.S. Environmental Protection Agency where he has since returned. This report has not been reviewed by the U.S. Environmental Protection Agency and does not represent the views of the Agency and no official endorsement should be inferred. The authors gratefully acknowledge the review and guidance provided by Judith Petersen, Albert Ettinger, Dana Wright, Jill Witkowski, Jon Devine, Jeff Grimes, Susan Heathcote, and Betsy Lawton. Drafts of the state Overviews were sent to the water quality standards staff of the respective state environmental agencies for comment. ELI received responses from Illinois, Kentucky, Louisiana, and Missouri and sought to correct all errors that were identified, but neither the Overviews nor the report represent the views of any of the states and no official endorsement by any state should be inferred. The Environmental Law Institute is responsible for the views and information contained in this publication.

About ELI Publications

ELI publishes Research Reports that present the analysis and conclusions of the policy studies ELI undertakes to improve environmental law and policy. In addition, ELI publishes several journals and reporters—including the *Environmental Law Reporter*, *The Environmental Forum*, and the *National Wetlands Newsletter*—and books, which contribute to education of the profession and disseminate diverse points of view and opinions to stimulate a robust and creative exchange of ideas. Those publications, which express opinions of the authors and not necessarily those of the Institute, its Board of Directors, or funding organizations, exemplify ELI's commitment to dialogue with all sectors. ELI welcomes suggestions for article and book topics and encourages the submission of draft manuscripts and book proposals.

Analysis of the Numeric Water Quality Criteria Adopted by the Ten States That Border Directly on the Mississippi River

Copyright © 2009 The Environmental Law Institute.[®]

ELI Project No. 063101

(Environmental Law Institute[®], *The Environmental Forum*[®], and *ELR*[®]—*The Environmental Law Reporter*[®] are registered trademarks of the Environmental Law Institute.)

TABLE OF CONTENTS

List of Acryonyms	7
A. Introduction	8
B. Summary of Findings	8
C. “Traditional Pollutants” / Parameters	14
1. Coverage	15
a) Aquatic Life/“Fish and Wildlife”	15
b) Human Health: Shellfish Harvesting/“Shellfish Consumption”	15
c) Human Health: Drinking Water Supply/“Public Water Supply”	15
d) Human Health: Water-based Recreation/“Recreation” and “Secondary Contact Recreation”	16
e) Agricultural Water Supply	16
f) Industrial Water Supply	17
2. Criterion-Concentrations, Compared to EPA’s	17
a) Aquatic Life / “Fish and Wildlife”	17
b) Human Health: Shellfish Harvesting/“Shellfish Consumption”	17
c) Human Health: Drinking Water Supply/“Public Water Supply”	18
d) Human Health: Water-based Recreation/“Recreation” and “Secondary Contact Recreation”	18
e) Agricultural Water Supply	18
f) Industrial Water Supply	18
3. Articulation of Criterion-Duration	18
a) Freshwater Aquatic Life/“Fish and Wildlife”	19
b) Human Health: Shellfish Harvesting/“Shellfish Consumption”	20
c) Human Health: Drinking Water Supply/“Public Water Supply”	20
d) Human Health: Water-based Recreation/“Recreation” and “Secondary Contact Recreation”	20
e) Agricultural Water Supply	20
f) Industrial Water Supply	21
4. Articulation of Criterion-Frequency	21
5. Discussion: Traditional Parameters	21
D. Toxic Chemicals	28
1. Coverage	28
a) Aquatic Life-Freshwater/“Fish and Wildlife” Acute Toxicity	28

	Chronic Toxicity	29
b)	Aquatic Life – Salt Water/“Fish and Wildlife”	29
	Acute Toxicity	29
	Chronic Toxicity	30
c)	Human Health: Consumption of Fish and Other Aquatic Organisms/“Human Health: Organisms Only (HHO)”	30
d)	Human Health: Consumption of Water plus Fish and Other Aquatic Organisms/“Human Health: Water and Organisms”	31
e)	Human Health: Drinking Water Supply/“Public Water Supply”	31
f)	Human Health: Water-based Recreation/“Recreation” and “Secondary Contact Recreation”	32
g)	Industrial Water Supply	32
h)	Agricultural Water Supply	32
2.	Criterion-Concentrations, Compared to EPA’s	32
a)	Aquatic Life – Freshwater/“Fish and Wildlife”	32
	Acute Toxicity	32
	Chronic Toxicity	33
b)	Aquatic Life – Salt Water/“Fish and Wildlife”	33
	Acute Toxicity	33
	Chronic Toxicity	33
c)	Human Health: Consumption of Fish and Other Aquatic Organisms/“Human Health: Organisms Only (HHO)”	33
d)	Human Health: Consumption of Water plus Fish and Other Aquatic Organisms/“Human Health: Water & Organisms”	33
e)	Human Health: Drinking Water Supply/“Public Water Supply”	34
f)	Human Health: Water-based Recreation/“Recreation” and “Secondary Contact Recreation”	34
g)	Industrial Water Supply	34
h)	Agricultural Water Supply	34
3.	Articulation of Criterion-Durations	34
a)	Aquatic Life/“Fish and Wildlife” – Freshwater and Marine	35
	Acute Criteria	35
	Chronic Criteria	35
b)	Human Health: Consumption of Fish and Other Aquatic Organisms/“Human Health: Organisms Only (HHO)”	36
c)	Human Health: Consumption of Water plus Fish and Other Aquatic Organisms/“Human Health: Water & Organisms”	36
d)	Human Health: Drinking Water Supply/“Public Water Supply”	37
e)	Human Health: Water-based Recreation/“Recreation” and “Secondary Contact Recreation”	37
f)	Industrial Water Supply	37
g)	Agricultural Water Supply	37
4.	Articulation of Criterion-Frequencies	37
a)	Aquatic Life (Fish and Wildlife) – freshwater and marine	37

b)	Human Health: Various uses	38
5.	Discussion: Criteria for Toxic Chemicals	38
Appendix A: Missing and Extra Criteria for Conventional Pollutants: MISSISSPPI		
	Table 1 – Aquatic Life	44
	Table 2 – Drinking Water Supply	45
	Table 3 – Water-Based Recreation	45
Appendix B		
	Table 1: Aquatic Life Protection – Freshwater	46
	Table 2: Aquatic Life Protection	47
	Table 3: Aquatic Life Protection	49
	Table 4: Human Health: Aquatic Life Protection	50
	Table 5: Human Health: Aquatic Life Protection	50
Appendix C		
	Situations in Which State WQC are Clearly Less Protective Than Equivalent EPA WQC	51
	Situations in which State WQC are Clearly More Protective Than Equivalent EPA WQC	51
	Situations in Which Comparative Level of Protection Cannot be Determined by Simply Looking at the Two Criteria	51

List of Acronyms

AWS	Agricultural Water Supply
BATEA (or BAT)	Best Available Treatment Economically Achievable
BOD	Biochemical Oxygen Demand
CAFO	Concentrated Animal Feeding Operation
CALM	Consolidated Assessment and Listing Methodology
CSO	Combined Sewer Overflows
CWA	Clean Water Act
DDT	Dichloro-dephenyl-trichloroethane
DO	Dissolved Oxygen
DU	Designated Use
DW	Drinking Water Standards
DWS	Drinking Water Supply
FC	Fish Consumption
GLI	Great Lakes Initiative
HHO	Human Health Organism
HHWO	Human Health: Water and Organism
IWS	Industrial Water Supply
LA	Load Allocation
MCL	Maximum Contaminant Level
MS4	Separate Sewage System
NPDES	National Pollution Discharge Elimination System
NTU	Nephelometric Turbidity Unit
PAH	Polycyclic Aromatic Hydrocarbons
PBT	Persistent, Bioaccumulative and Toxic (EPA Program)
PCB	Polychlorinated biphenyl
PWS	Public Water System
SDWA	Safe Drinking Water Act
SRF	State Revolving Fund
SSM	Single Sample Maximum
STP	Sewage Treatment Plant
TBA	Technology-Based Approach
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TRI	Toxics Release Inventory
TSS	Total Suspended Solids
WLA	Wasteload Allocation
WQ	Water Quality
WQBA	Water Quality Based Approach
WQBEL	Water Quality Based Effluent Limits
WQC	Water Quality Criteria
WQS	Water Quality Standards

A. Introduction

This document is one of a number of state-specific reports resulting from an Environmental Law Institute (ELI) analysis of the numeric water quality criteria (WQC)¹ component of the water quality standards (WQS) of the ten states that border directly on the Mississippi River. In this report ELI compares the state numeric water quality criteria to recommended criteria and related standards² issued by the US Environmental Protection Agency. The findings presented in the documents produced for this report are based on the most recent version of the state's WQS regulations as of September 1, 2008. Hence, only water quality criteria contained in final state regulations were examined. Associated guidance documents, policy memoranda and other state publications related to the state's WQS are not reflected in this report. As such, one limitation of this report is that it does not fully describe a given state's water quality standards program or how WQS are applied in other water quality programs.

This work was funded by a grant from the Mississippi River Water Quality Collaborative, a group of state, regional and national non-profit organizations working together to improve water quality in the Mississippi River basin.

B. Summary of Findings

The water quality criteria (WQC) specified in Mississippi's water quality standards (WQS) regulations³ present a mixed picture when compared to the criteria published⁴ by EPA, in terms of: 1) pollutant /use combinations⁵ covered, 2) the degree to which all key elements of criteria are clearly articulated, and 3) level of protection likely afforded to applicable designated uses,

¹ The terms "water quality criteria," "WQC," and "criteria" are used interchangeably in this document. Water quality criteria are closely associated with "designated uses," another key element of all water quality standards established under state law and the federal Clean Water Act. Criteria describe waterbody conditions, primarily pollutant levels, associated with full support of one or more of the designated uses (e.g., aquatic life, fish consumption, water contact recreation and drinking water supply) assigned to specific waters by a state's water quality standards.

² The recommended EPA criteria are water quality criteria (WQC) issued by that agency under authority of the federal Clean Water Act. The related standards are regulatory requirements applicable to finished (post treatment) drinking water that is delivered to homes and businesses by a public drinking water system.

³ Mississippi Commission on Environmental Quality Regulation WPC-2: State of Mississippi – Draft – Water Quality Criteria for Intrastate, Interstate, and Coastal Waters. (*Modified for Public Review and Comment: October 6, 2006*).

⁴ Throughout this report, the criteria recommended by EPA will be referred to as the EPA's "issued" or "published" criteria, interchangeably. Terms like "established," "promulgated," and "set" are not used because EPA criteria are guidance, issued to help the states adopt their own water quality criteria in their water quality standards (WQS) regulations.

⁵ As used in this report, "pollutant/use combination" refers to designated use and a particular pollutant or other water quality parameter. Often states have just one WQC for a given pollutant and use; however, in the case of aquatic life criteria, more than one WQC per pollutant/use combination is common. This is usually due to: 1) having both acute and chronic criteria; 2) breaking aquatic life down into a number of sub-categories (e.g., cold and warm water habitat); 3) establishment of different criteria for different ecoregions within the state; and/or 4) setting waterbody-specific WQC.

With regard to “traditional”⁶ pollutants, Mississippi has adopted aquatic life WQC for relatively few of the parameters examined in this study. Among the missing⁷ are indicators of excess nutrients and sediments. The state has Public (Drinking) Water Supply WQC for half of the traditional pollutants for which EPA has published related standards.⁸ In August 2007, Mississippi adopted into its WQS regulations criteria for Enterococci bacteria for its coastal and marine waters. Mississippi continues to rely on a three-decade-old indicator (fecal coliform bacteria) of the potential presence of human pathogens in fresh waters designated for water contact recreation.

With regard to toxic pollutants,⁹ Mississippi has adopted numeric criteria to protect freshwater and salt water Fish and Wildlife for a few more pollutants than has EPA. While having specified some “extra”¹⁰ criteria applicable to aquatic life, the state has not established criteria for many of the toxic pollutants for which EPA has issued WQC to address risks associated with human consumption of drinking water and/or aquatic organisms. Among the pollutants for which Mississippi has no human health criteria are a number of carcinogens and highly bioaccumulative substances. Also missing are aquatic life and human health criteria for pollutants that fall into categories that are frequently mentioned as possible endocrine disruptors.

None of the state’s numeric Fish and Wildlife WQC for either traditional or toxic pollutants applies to ephemeral streams; protection of these waters is provided only via narrative criteria.

As for criterion-concentrations,¹¹ for traditional pollutants/parameters, those for Mississippi water quality criteria pertaining to fish and aquatic life are identical, or very similar to, the criterion-concentrations of corresponding EPA-issued, as those of nearby states covered by this report. Most of the state WQC for traditional pollutants related to human health have

⁶ For purposes of this ELI report, “traditional pollutant/parameter” refers to a number of pollutants and water quality parameters that were recognized as significant contributors to and indicators of degradation of the condition of surface water well before passage of the Clean Water Act in 1972. As used in this study, “traditional pollutant” includes those pollutants/parameters referred to as “conventional” in the CWA and EPA regulations and guidance, which includes: biochemical oxygen demand (BOD), dissolved oxygen (DO), pH, total suspended solids (TSS), bacteria and other pathogens, and temperature. Also considered “traditional” in this document are several other non-toxic pollutants and parameters including alkalinity, chloride, chlorophyll a, color, dissolved solids, hydrogen sulfide, (total) nitrogen, oil and grease, total phosphorus, and turbidity, which are sometimes called “non-conventional” or “non-priority” in the EPA literature. Also, one “non-priority” toxic chemical, ammonia, is discussed under the heading “traditional pollutants/parameters.”

⁷ For the purposes of this review, “missing” criteria are those pollutant/use combinations for which the state has not officially adopted WQC, whereas EPA has published recommended WQC of the type specified.

⁸ *Id.* at 2.

⁹ In this report, “toxic pollutant” includes not only EPA’s “priority toxic pollutants” but also all those toxics called, for CWA purposes “non-priority pollutant,” as well as all other toxic chemicals. The one exception is ammonia, which is covered as a traditional pollutant in this study.

¹⁰ For the purposes of this report, “extra” criteria are those pollutant/use pairs for which the state has officially adopted criteria, but for which EPA has not issued corresponding criteria.

¹¹ According to EPA guidance, numeric water quality criteria (WQC) consist of 3 components: 1) a criterion-magnitude, 2) a criterion-duration, and 3) a criterion-frequency. The first of these—criterion-magnitude—is usually expressed as a concentration; hence, the frequent use of the term “criterion-concentration” in this report. For some key water quality parameters, such as temperature and pH, quantity is not expressed as a concentration, so EPA employs the broader term “criterion-magnitude.”

criterion-concentrations identical to EPA's, for the same pollutant/use combinations,¹² with the exception of Mississippi's Public Water Supply WQC for indicator bacteria. In that case, the state's criterion-concentrations are higher than that of the roughly corresponding EPA standard established under authority of the Safe Drinking Water Act (SDWA).¹³ The state's Recreation (primary contact) WQC have criterion-concentrations equal to that of the corresponding ("bathing") EPA criteria. The state's Public Water Supply criteria that apply from November 1 to April 30, which also address secondary contact recreation, have criterion-concentrations ten times higher than those of its Recreation WQC. EPA has not issued WQC related to secondary contact recreation.

Most of the state's Fish and Wildlife WQC for toxic chemicals have criterion-concentrations that are equal to, or slightly less than, the criterion-concentrations in the corresponding EPA criteria. As for the state's Human Health: Organisms and Human Health: Water and Organisms WQC, there are approximately twice as many toxic pollutants with human health-related criterion-concentrations that are higher than their corresponding EPA values than there are pollutants with criterion-concentrations that are lower than EPA's. Four of the five toxic pollutants for which the state has Public Water Supply Criteria have criterion-concentrations equal to the somewhat corresponding EPA criteria.

In August 2007, Mississippi formally adopted a set of modifications to its WQS regulations, among which are additions of new criteria and revision of criterion-concentrations in the criteria of two toxic metals. The state revised acute and chronic criterion-concentrations in the freshwater and saltwater Fish and Wildlife criteria for cadmium, as well as a revised acute criterion concentration in the freshwater Fish and Wildlife criteria for silver. All of the revised toxic metal criterion-concentrations are either lower than or equal to those in the corresponding EPA criteria.

Mississippi has also recently added two new pollutants to its WQS regulations, alpha and beta endosulfan. For these two pollutants, the state has adopted acute and chronic freshwater and saltwater Fish and Wildlife criteria, "Human Health: Organisms Only" criteria, and Human Health: Water and Organisms criteria. The revised acute and chronic criterion-concentrations in the Fish and Wildlife criteria for these two pollutants are equal to those in EPA's corresponding aquatic life criteria, while the newly adopted criterion-concentrations in the Human Health: Organisms Only and Human Health: Fish and Organisms criteria are higher than those in EPA's corresponding criteria.

¹² Id. at 5.

¹³ The term "somewhat corresponding" has been used because water quality criteria and drinking water standards apply to different endpoints. WQC apply to surface waters within the jurisdiction of the Clean Water Act (CWA). Some of these waters are, or might be, used as a source of "raw" water by public and private drinking water systems. Hence, when a waterbody in Mississippi is designated "Public Water Supply" then a certain set of WQC applies to said river or lake, per the CWA. There also is another set of standards that apply to the "finished" water that results from "raw" water from a river or lake being run through treatment processes aimed at removing contaminants. These are called Drinking Water Standards, and are established as national regulations under authority of the SDWA. They are often referred to as "maximum contaminant levels" (MCLs). Another difference between Mississippi's Public Water Supply water quality criteria and EPA's SDWA standards pertaining to waterborne pathogens is that the former are expressed in terms of fecal coliform bacteria, while the latter employ the more encompassing grouping total_coliform bacteria as the indicator parameter.

As for the specificity of criterion-durations,¹⁴ for traditional pollutants, the picture is mixed. The acute Fish and Wildlife criteria for several parameters are clearly expressed as instantaneous levels (i.e., duration of just a fraction of a second). On the other hand, all the other acute WQC for traditionals for Fish and Wildlife, as well as all WQC for traditionals pertaining to Public Water Supply use, appear to have a criterion-duration of just an instant, but this is not entirely clear. The chronic Fish and Wildlife criteria for traditional parameters do have all clearly articulated.

With the exception of Public Water Supply WQC for a few toxic pollutants, for which a criterion-duration of an instant is clear, Mississippi's WQC for toxic chemicals (for both aquatic life and human health) do not directly specify a criterion-duration. However, language in the state's regulations, including direct reference to EPA's aquatic life criteria development methodology for toxic chemicals, could be taken to strongly imply a criterion-duration of one hour for Mississippi's acute Fish and Wildlife WQC for toxics and a criterion-duration of 96 hours (four day) for its chronic criteria for this use and type of chemical. Unfortunately, EPA guidance documents regarding its Human Health WQC are not clear as to a criterion-duration; so, a default to a duration of an instant is employed in this report with regard to the states Human Health: Water and Organisms and Human Health: Organisms criteria.

Turning to the matter of criterion-frequency, most of the state's criteria for traditionals do have a clearly articulated frequency (either zero, or 10%), while others appear to have a criterion-frequency of zero, but the language of the regulations is not clear. As for toxic chemicals, none of the state's criteria make direct or indirect mention of a criterion-frequency. However, since language in the regulations links the state's WQC for toxics to EPA's, use of EPA's recommended frequency of no more than one excursion¹⁵ in any three year period is assumed in this report, with regard to Mississippi's Fish and Wildlife criteria for toxics. On the other hand, because EPA makes no mention of a criterion-frequency for its human health WQC for toxics, a criterion-frequency of zero is assumed for Mississippi's human health-related criteria for toxic substances. Also, the state's WQC for toxics applicable to Public Water Supply are presented as "concentrations...shall not be exceeded at any time"—a clear criterion-frequency of zero.

As for the level of protection provided by a state WQC for a given pollutant/use combination in comparison to that of EPA (or another state), this cannot be done with any degree of confidence unless all three elements of both WQC are clearly articulated. And, even when the criterion-concentration, criterion-magnitude, and criterion-frequency of each of the two WQC

¹⁴ According to terminology employed in some EPA guidance, the criterion-duration portion of a numeric WQC specifies the length of an "excursion"—the time period over which waterbody concentration of a pollutant is higher (or in the case of dissolved oxygen, lower) than the criterion-magnitude. For instance, EPA's chronic aquatic life WQC for toxic chemicals have a criterion-duration of 4 days, which results in their being expressed as 4 day average concentrations. The occurrence of one or more excursion (e.g., a four-day period in which the instream concentration, for example, of cyanide was higher than the criterion-concentration of 5.2 µg/L) would not necessarily represent failure to meet WQC. Only when the rate at which excursions occur is higher than that specified by the criterion-frequency has an actual exceedence of a water quality criterion occurred

¹⁵ As used in this report, and in some EPA guidance documents, an "excursion" is any period equal in length to the criterion-duration of a WQC when the average waterbody concentration is higher than the criterion-concentration.

being compared are precisely stated, their comparative degree of protectivity can only be determined, simply by looking at the two WQC and nothing else, with certain combinations of relative criterion-concentration, concentration-duration, and combination-frequency. For instance, if a state and a comparable (same pollutant and same designated use) EPA criterion both have the same criterion-concentration, same criterion-duration, and the same criterion-frequency, they would provide equal levels of protection. If, however, the criterion-concentration of one of the two WQC were lower than the other, and the criterion-duration and criterion-frequency remained identical, then that WQC would provide the higher degree of protection. Likewise, if the criterion-concentrations are the same, the criterion-durations are identical, but one of the WQC has a lower acceptable criterion-frequency, then that criterion with the lower frequency would provide more protection. Also providing a higher level of protection would be a WQC with a shorter criterion-duration than a comparable WQC that had the same criterion-concentration and criterion-frequency. (Appendix C provides a set of tables that list all possible combinations--in relative terms—of criterion-concentrations, criterion-durations, and criterion-frequencies, indicating which represent higher, lower, and identical levels of protection.)

Unfortunately, the relevance of the tables in Appendix C to Mississippi's WQC is significantly limited by the fact that, though a majority of the state's criteria have a specified criterion-duration, the state's WQS regulations make no mention of a criterion-frequency for any of its water quality criteria. Further complicating comparison of the level of protection afforded to applicable designated uses by a state WQC is the fact that most of EPA's criteria for traditional pollutants lack a clearly-articulated criterion-duration and criterion-frequency.

As to the degree of protection provided by Mississippi's WQC in relation to corresponding EPA criteria, a simple comparison of the criterion-concentration in a given state criterion to that of EPA's is not necessarily a reliable indicator of relative protectiveness. Attention also must be paid to the criterion-duration and criterion-frequency in each of criteria being compared. If the criterion-duration and criterion-frequencies of the state and EPA are identical, then the WQC with the lower criterion-concentration will indeed provide more protection to the use to which the criteria apply, while a higher concentration would be indicative of less protection. For instance, if one assumes, as is done in this report, that Mississippi's Fish and Wildlife WQC for toxics have the same criterion-duration¹⁶ (acute is one hour; chronic is 96 hours) and criterion-frequency (maximum of one excursion¹⁷ in 3 years) as do EPA's criteria for toxics for aquatic life, then, for example, the state's recently revised Fish and Wildlife WQC for cadmium and silver, having criterion-concentrations lower than that in the corresponding EPA WQC, would provide a greater level of protection than would adoption of EPA's values. And, the new Fish and Wildlife criteria for alpha- and beta- endosulfan would provide the same level of protection as EPA's corresponding WQC, since the criterion-concentrations are identical. Likewise, Mississippi's Fish and Wildlife WQC for ammonia should provide the same level of protection as the EPA's aquatic life criteria, because the state has adopted the EPA criteria verbatim. In fact it seems that most of the state's aquatic life criteria for toxic substances are be equally, or slightly more, protective than EPA's criteria.

¹⁶ Id. at 14

¹⁷ Id.

Other combinations of criterion-durations and criterion-frequencies in the WQC under consideration can also be taken as grounds to believe that one criterion is more protective than another. For example, if a state criterion had a shorter criterion-duration and lower criterion-frequency than that of the corresponding EPA criterion, then if the state's criterion-concentration were equal to or lower than that of the EPA criterion, it would clearly provide a higher level of protection than EPA's. However, if the state's criterion-concentration were higher than EPA's, and the criterion-duration were an instant and the criterion-frequency were zero, it would be difficult to know ascertain the relative protection provided by the two criteria, based just on looking at the two WQC. Without obtaining or collecting additional toxicity data, there would be no way to know whether the less protective effect of the state's higher criterion-concentration would be outweighed by the state's shorter criterion-duration and lower criterion-frequency. Several other combinations of relative concentrations, durations, and frequencies between WQC also present a complex situation. (See Appendix C for a chart listing all the possible combinations of the three components of a properly-articulated numeric WQC, and what they mean in terms of comparative levels of protection.)

Needless to say, ascertaining the relative degree of protection provided by one WQC versus another based solely on the two criteria themselves is rendered more difficult if the concentration, duration, and/or frequency of either of the WQC are not well articulated. For example, Mississippi has a dissolved oxygen (D.O.) criterion with the same criterion-concentration as EPA's only criterion for this parameter applicable to freshwater aquatic life—5.0 mg/L. The state's WQC has a criterion-duration of one hour, while EPA's WQC simply describes 5.0 mg/L as a minimum concentration. In this report, when criteria are worded like this EPA criterion, then a criterion-duration of an instant is assumed. Given that neither Mississippi's or EPA's criteria make mention of a criterion-frequency, this report assumes they both have a criterion-frequency of zero. Based on these assumptions, then Mississippi's criterion would be less protective than EPA's, because it has a longer duration (one hour versus one second or less), while the criterion-concentration and criterion-frequencies for the two WQC are identical. But, what if one assumed that EPA's WQC for DO had a criterion-duration of a day (24 hours), then the state's WQC would be the more protective of the two.

Further complicating this picture, with regard to aquatic life WQC, there could be state-specific, watershed-specific, or even waterbody-specific reasons (differences in water column chemistry, temperature, stream flow patterns, resident species of aquatic life) that a state criterion can have a criterion-concentration higher or lower than that for the corresponding EPA criterion and still provide aquatic life protection equal to that for which the EPA WQC was designed. This would not, however, mean that the two criteria would provide equal levels of protection to the relevant use. For example, eight of Mississippi's acute Fish and Wildlife WQC for toxics have a criterion-concentration lower than EPA's, while the duration and frequency for the two WQC are (we presume) identical. In this case, the state's criteria would provide a higher degree of protection relative to that which would be provided by adoption of EPA's criterion as a state WQS for the waterbody in question. Nevertheless, site-specific conditions could have resulted in EPA's WQC providing a lower level of protection than that for which EPA designed it. The effect of the state's lower criterion-concentration would, then, be to bring the level of protection back up to that intended by EPA.

Turning from aquatic life to human health, safe levels of pollutants tend to vary less from waterbody to waterbody. The most obvious reason is that, unlike aquatic life WQC, human health criteria address impacts on just one species, regardless of the location of the waterbody to which the WQC apply. The most common reason for need for variation in human health criteria from one locale to another is differences in patterns of human use. For example, regarding drinking water use, persons in hotter climates tend to consume more water, on average, than those in cooler areas. Also, the amount of fish and other aquatic life from local waters that are caught and eaten by people can differ by an order of magnitude from place to place and/or within subpopulations of humans. And, of course, patterns of swimming and other water contact recreation can change considerably depending on difference in the climate in which one waterbody versus another is located, along with the type of waterbody (river, lake, ocean beach).

Mississippi's WQS regulations give no indication of modification of criterion-concentrations for WQC related to fish consumption to account for higher rates of human fish consumption from some waterbodies to another. Perhaps there are no such differences within Mississippi. If there are some areas where subsistence-fishing is more common than others, then persons in the former areas would be getting a lower level of protection than the latter areas, if other factors are the same. Conversely, persons taking fish from a given waterbody at a rate *lower* than that assumed by the state would be provided a higher level of protection than that for which the state WQC was designed.

Returning briefly to the effects of un-addressed or imprecisely-articulated criterion-durations and criterion-frequencies, in addition to making comparison of levels of protection afforded relevant uses difficult, if not impossible, such ambiguities can pose challenges to the implementation of CWA programs driven by WQS—303(d) and 305(b) reporting on the condition of a state's waters, total maximum daily loads (TMDLs), and water-quality based effluent limits in NPDES permits. For instance, if a TMDL were being developed because of exceedences of one of Mississippi's Human Health: Organisms Only criteria WQC, the absence of a clearly-articulated criterion-duration for this category of WQC would create a quandary. What should the time-interval for the maximum loading set forth in the TMDL be? If one assumes, as has been done in this report, a default criterion-duration of an instant in such circumstances, then it would seem logical to express the TMDL as a maximum load over a very short interval, even just a second. On the other hand, if the criterion-duration for the state's Human Health: Organisms WQC were 12 months, then setting a maximum 12 month total load would seem appropriate.¹⁸

C. "Traditional" Pollutants/Parameters¹⁹

¹⁸ In *Friends of the Earth v EPA*, 446 F.3d.145 (2006) the federal D.C. Circuit Court ruled that because of the specific reference to "daily" in the portion of Section 303(d) of the CWA that established the Total Maximum Daily Load program, all TMDLs should include, at least, a maximum daily load. Despite this ruling, maximum loads over other time spans would also be needed, in order for the TMDL to consistent with relevant WQC, when such criteria have criterion-durations other than 24 hours.

¹⁹ For purposes of this ELI report, "traditional pollutant/parameter" refers to a number of pollutants and water quality parameters that were recognized as significant contributors to and indicators of degradation of the condition of surface water well before passage of the Clean Water Act in 1972. As used in this study, "traditional pollutant" includes those pollutants/parameters referred to as "conventional" in the CWA and EPA regulations and guidance, which includes: biochemical oxygen demand (BOD), dissolved oxygen (DO), pH, total suspended solids (TSS),

1) Coverage

a) Aquatic Life / “Fish and Wildlife”²⁰

Mississippi lacks acute and/or chronic WQC for a number of the traditional pollutants for which EPA has published criteria. Among the missing²¹ criteria are several that correspond to published EPA criteria related to hyper-eutrophication – chlorophyll a, total phosphorous (P), and total nitrogen (N). (Note: the excess algal growth resulting from an un-naturally high degree of eutrophication also can adversely impact water-based recreation and public water supply uses). In addition, Mississippi lacks “true numeric” chronic criteria for turbidity, whereas EPA has published numeric criteria as part of its set of criteria addressing excess nutrients.

However, Mississippi does have some “extra” criteria.²² The state has chronic dissolved oxygen (DO) criteria, while EPA does not. (Both have acute DO criteria). In addition, the state has acute and chronic criteria for total dissolved solids (TDS) and for temperature, in fresh waters, which EPA lacks. Unlike most states, Mississippi applies its criteria for human health pathogens to its fish and wildlife use (Appendix A, Table 1).

b) Human Health: Shellfish Harvesting / “Shellfish Consumption”

Like EPA, Mississippi has a chronic fecal coliform criterion applicable to designated shell fishing areas. The state also has an acute criterion for this pollutant/use, while EPA does not.

c) Human Health: Drinking Water Supply / “Public Water Supply”

Mississippi lacks criteria applicable to drinking water supply use for four of the eight (8) traditional pollutants/parameters for which EPA has somewhat related standards.²³ However,

bacteria and other pathogens, and temperature. Also considered “traditional” in this document are several other non-toxic pollutants and parameters including alkalinity, chloride, chlorophyll a, color, dissolved solids, hydrogen sulfide, (total) nitrogen, oil and grease, total phosphorus, and turbidity, which are sometimes called “non-conventional” or “non-priority” in the EPA literature. Also, one “non-priority” toxic chemical, ammonia, is discussed under the heading “traditional pollutants/parameters.”

²⁰ Throughout this document, generic names (e.g., “aquatic life,” “human health: drinking water supply” and “human health: water contact recreation”) are used in reference to certain categories of uses. When a state uses different wording to refer to the same use, the name that the state employs is listed in quotation marks, after the generic name.

²¹ For the purposes of this review, “missing ” criteria are those pollutant/use combinations for which the state has not officially adopted WQC, whereas EPA has published recommended WQC of the type specified.

²² For the purposes of this report, “extra” criteria are those pollutant/use pairs for which the state has officially adopted criteria, but for which EPA has not issued corresponding criteria.

²³ Unlike the water quality criteria that it issues for CWA purposes, the drinking water standards EPA promulgates, via formal rulemaking, under authority of the Safe Drinking Water Act are regulatory requirements, not just recommendations. EPA lacks actual drinking water supply criteria for traditional pollutants – specification of the levels of contaminants in surface waters being used as a raw water supply by public drinking water systems. The only EPA standards with regard to ensuring safe levels of contaminants in drinking water apply to “finished” water – that which results from raw water being passed through a treatment system aimed at removing contaminants to the degree practicable.

with the exception of fecal coliform bacteria, the EPA Safe Drinking Water Act standards for these eight pollutants/parameters are “secondary” standards (related to taste, odor, and appearance of drinking water), rather than “primary” drinking water standards (related to health).

For fecal coliform bacteria, Mississippi has both acute and chronic public water supply (PWS) criteria, whereas the somewhat corresponding²⁴ EPA Safe Drinking Water Act standard applies only to acute exposures. And, though the state lacks a chronic criterion for chlorides, odor, and total dissolved solids (TDS), it does have acute criteria for these pollutants. The state also has an acute criterion for specific conductance for PWS use – EPA has neither an acute nor a chronic criterion (Appendix A, Table 2).

Mississippi also lacks WQC for the nutrients phosphorous and nitrogen, excess levels of which can lead to un-natural blooms of aquatic algae. High levels of algae in the raw water supply used by a public drinking water system can result in unpleasant taste and odor in finished drinking water, unless special care is taken in the drinking water treatment process. Such extra treatment efforts can, in turn, lead to increased costs to a drinking water utility and its customers.

d) Human Health: Water-based Recreation / “Recreation” and “Secondary Contact Recreation”

Mississippi continues to rely on fecal coliform bacteria as indicators of the possible presence of pathogenic microorganisms in the state’s waters. Mississippi has adopted no criteria applicable to the bacterial indicators *E. coli* and Enterococci for fresh waters, though EPA issued recommended criteria for these two pathogen indicators in 1986. In 2004, EPA promulgated a chronic Enterococci criterion applicable to the state’s coastal and marine waters, under authority of the “BEACH Act,” which was passed by the US Congress in 2000. In August 2007, Mississippi formally incorporated this criterion into its WQS regulations.

Mississippi has recreational criteria for dissolved solids and specific conductance, for which there are no corresponding EPA criteria (Appendix A, Table 3).

The state also lacks WQC for the nutrients phosphorous and nitrogen—excess levels of which can lead to un-natural blooms of aquatic algae. Such blooms can form mats on the water surface which can interfere with a variety of water-based recreational activities.

e) Agricultural Water Supply

EPA has issued agricultural water supply criteria for boron/borates, while Mississippi has not. (Agricultural water supply is not among the specific designated uses that can be assigned to waterbodies in the state’s WQS regulations.)

²⁴ EPA’s Primary Drinking Water Standard, promulgated under the Safe Drinking Water Act addresses total coliform bacteria, while Mississippi’s Public Water Supply Criteria apply to the less inclusive category fecal coliform bacteria. Another difference is that the EPA drinking water standard applies to finished drinking water, whereas the Mississippi PWS criterion applies to the raw water supply from which finished drinking water is produced.

f) Industrial Water Supply

EPA has issued Industrial Water Supply criteria for calcium carbonate, while Mississippi has not. (Industrial water supply is not among the specific designated uses that can be assigned to waterbodies in the state's WQS regulations).

2) *Criterion-Concentrations,*²⁵ *Compared to EPA's*

a) Aquatic Life / "Fish and Wildlife"

Mississippi's criterion-concentrations for traditional pollutants appear comparable to those of corresponding EPA criteria, as well as other states' criteria.

EPA has published recommended ecoregion-specific and waterbody type-specific "nutrient"²⁶ WQC applicable to the two ecoregions present in Mississippi – Ecoregion IX (Southeastern Forested Plains and Hills) and Ecoregion X (Texas-Louisiana Coastal and Mississippi Alluvial Plains), but the state has not adopted nor proposed criteria for total N, total P, chlorophylla, or turbidity based on these EPA documents. Comparison of state and EPA criterion-concentrations for these pollutants is, therefore, not possible.

b) Human Health: Shellfish Harvesting / "Shellfish Consumption"

Mississippi's chronic criterion-concentration for fecal coliform bacteria in shellfish harvesting areas (14 MPN/100 ml) is identical to EPA's.

c) Human Health: Drinking Water Supply / "Public Water Supply"

The criterion-concentrations in Mississippi's Public Water Supply criteria for chlorides and total dissolved solids are identical to the concentrations specified in the secondary drinking water standards issued by EPA under authority of the Safe Drinking Water Act. The threshold odor number in the state's public water supply criterion is 24 (at 60 C°), whereas the threshold odor number in the EPA secondary drinking water standard is 3 (no temperature specified).

The state's Public Water Supply fecal coliform criterion-concentrations (400 CFU/100 ml (acute), and 200 CFU/100 ml (chronic) – applicable from May 1 to October 31) are identical to those of the EPA acute and chronic, respectively, criteria for primary contact recreation (bathing waters). These concentrations are, however, much higher than the criterion-concentration in the

²⁵ According to EPA guidance, numeric water quality criteria (WQC) consist of 3 components: 1) a criterion-magnitude, 2) a criterion-duration, and 3) a criterion-frequency. The first of these—criterion-magnitude is usually expressed as a concentration; hence, the frequent use of "criterion-concentration" in this report. For some key water quality parameters, such as temperature and pH, quantity is not expressed as a concentration, so EPA employs the broader term "criterion-magnitude."

²⁶ EPA's package of "nutrient criteria" includes WQC not only for nitrogen and phosphorous but also for turbidity and chlorophyll a.

only EPA primary drinking water standard for indicator bacteria – the level of detection, which applies to total coliform bacteria rather than fecal coliform bacteria.²⁷

Mississippi’s fecal coliform criterion-concentrations – 4000 CFU/100 ml (acute) and 2000 CFU/100 ml (chronic) – that apply to Public Water Supply use from November 1 to April 30 are an order of magnitude higher than those for the other 7 months of the calendar year.

d) Human Health: Water-based Recreation / “Recreation” and “Secondary Contact Recreation”

The state’s criteria for fecal coliform and Enterococci bacteria applicable to waters with the designated use “Recreation” are exactly identical in all relevant aspects, such as concentration, duration, and frequency, to EPA’s corresponding criteria for primary contact recreation (“bathing waters”). Unlike the state’s fecal coliform criteria for Public Water Supply and Fish and Wildlife (see above), the criterion-concentrations for the state’s fecal coliform Recreation criteria do not differ from warmer to colder periods of the year.

e) Agricultural Water Supply

Mississippi has no WQC for traditional pollutants for use of a given waterbody as an agricultural water supply. (Agricultural water supply is not among the specific designated uses that can be assigned to waterbodies).

f) Industrial Water Supply

Mississippi has no WQC for traditional pollutants for of a given waterbody as an industrial water supply. (Industrial water supply is not among the specific designated uses that can be assigned to waterbodies.)

3) *Articulation of Criterion-Duration*²⁸

²⁷ Though relative degree of protection will be covered in the Discussion: Traditionals portion of this report, brief mention of a key point is merited here. Mississippi’s Public Water Supply WQC apply to surface waters, which are, or might in the future be, used as a source of raw water by a drinking water utility; whereas EPA’s primary drinking water standards apply to water at the tap. Typically, utilities that obtain their raw water from a surface (rather than ground) water source treat said water before delivering it to their customers. Hence, for a given pollutant, a drinking water supply WQC with a concentration equal to that specified in a drinking water standard could actually provide greater protection to consumers of finished drinking water. For instance, if the drinking water treatment process to which the raw water is subjected removes 50% of a certain pollutant, then the level of the pollutant in the raw water could be two-times the concentration specified by the SDWA standard, and still meet that standard in the finished drinking water. .

²⁸ According terminology employed in some EPA guidance, the criterion-duration portion of a numeric WQC specifies the length of an “excursion”—the time period over which waterbody concentration of a pollutant is higher (or in the case of dissolved oxygen, lower) than the criterion-magnitude. For instance, EPA’s chronic aquatic life WQC for toxic chemicals have a criterion-duration of four days, which results in their being expressed as four day average concentrations. The occurrence of one or more excursion (e.g., a four-day period in which the instream concentration, for example, of cyanide was higher than the criterion-concentration of 5.2 µg/L) would not necessarily represent failure to meet WQC. Only when the rate at which *excursions* occur is higher than that specified by the criterion-frequency has an actual exceedence of a water quality criterion occurred.

Mississippi's WQC for traditional pollutants are roughly evenly split between those having a clearly articulated criterion-duration and those that are somewhat ambiguous in this regard.

a) Freshwater Aquatic Life / "Fish and Wildlife"

Mississippi's criterion-duration for its acute Fish and Wildlife criteria for ammonia and dissolved oxygen are clearly stated. The acute ammonia criterion is stated as a one hour average concentration. The acute criterion for dissolved oxygen reads "concentrations shall be maintained with an instantaneous minimum of not less than 4.0 mg/L." There also are WQC for several parameters (chloride, total dissolved solids, and sulfate) stated as "not to exceed ___ at any time"—a clear intent of an instantaneous level.

On the other hand, the acute criteria for some traditionals lack clearly articulated criterion-durations, in which case this report has defaulted to a duration of an instant. For example, "The normal pH of the waters shall be 6.0 to 9.0" and "The maximum temperature shall not exceed 90° F (32.2° C) in streams lakes and reservoirs..." In these cases, despite the fact that they are not stated as instantaneous levels not to be surpassed at any time, there is no indication that the cited values are anything other than levels not to be exceeded for any period, at any time; hence, a default "instantaneous" duration has been employed herein.

As for chronic Fish and Wildlife criteria, that for dissolved oxygen is expressed as a "daily" average. It is assumed herein that this means a calendar day (period from 12:00 midnight to 11:59 pm), but it could also be taken to mean any 24 hour period. The chronic criterion for total dissolved solids is stated a "monthly average value," which is assumed to mean calendar month, but perhaps could mean any 30 day period.²⁹ In contrast, Mississippi's chronic WQC for ammonia is expressed as a 30 day average. There is also a "semi-chronic" ammonia WQC with a criterion-duration of 4 days.³⁰

Mississippi has a criterion for pH that reads, "[pH] shall not be caused to vary more than 1.0 unit within this range." The following WQC for temperature is stated in a similar manner: "the discharge of any heated waters ... shall not raise temperatures ... more than 5° F (2.8° C) over natural background temperatures." These are examples of what this report calls "quasi-numeric" criteria – those expressed in terms of a certain change from background conditions. Unlike the case of typical numeric WQC, determination of whether such criteria have been exceeded requires knowledge of water quality at earlier times and/or at more than one location (e.g., above and below a discharge pipe). Also, there is no indication as to what duration(s) of time such "differential" or "change-based" condition is intended to apply. It would presumably apply to the overall natural background pattern of temperature, over time and space. In this case, not only instantaneous temperature levels, but also average temperatures over various periods of time (minutes, hours, days, etc.), would be relevant to determining whether this criterion was being met.

²⁹ Use of calendar months as the duration/averaging period means that the actual span of time would vary from 28 to 31 days, depending on the month of the year.

³⁰ The term "4 days" could be taken to mean 4 calendar days, but it also could be taken to mean any 96 hour period.

b) Human Health: Shellfish Harvesting / “Shellfish Consumption”

Like EPA’s, the state’s shellfish consumption criterion is expressed as a median value with no indication of the duration of time to which this “average” value would apply.

c) Human Health: Drinking Water Supply / “Public Water Supply”

Mississippi’s Public Water Supply criteria for chlorides, specific conductance, and dissolved solids are expressed as “no substances added which will cause the ... to exceed ____.” This wording is assumed to mean that the criterion-duration is an instant, even though it could be worded more clearly, such as “the instantaneous concentration shall not be above ____.” The criterion for threshold odor is stated as a daily average, which could mean the level over any calendar day (12.00 AM to 11:59 PM) or any 24 hour period.

The criterion-duration for the state’s Public Water Supply criteria for fecal coliform bacteria that are expressed as “nor shall the samples examined during a 30-day period exceed ____ per 100 ml more than 10% of the time” would appear to be a second or instant. This is because of the reference to a percentage of samples.³¹ Most ambient monitoring for bacteria takes the form of “grab” sampling—collecting a series of single aliquots of water, by manual or mechanical means. It takes only a second to reach into the water and grab each of these individual measurements. Hence, the assumption is that the duration of concern is an instant/second.

The chronic WQC for fecal coliform bacteria applicable to PWS use has a clearly-stated duration of 30 days.

d) Human Health: Water-based Recreation / “Recreation” and “Secondary Contact Recreation”

The criterion-duration for the criterion expressed as a percentage of samples is assumed to be “instantaneous,” for the same reason provided above with regard to similarly-stated bacterial WQC for public water supply.

The chronic criteria for fecal coliforms and Enterococci pertaining to recreational use have a criterion-duration of 30 days, clearly stated.

e) Agricultural Water Supply

³¹ Technically, this is not a water quality criterion, because it describes the characteristics of a set of samples taken from a waterbody, rather than the desired condition of the waterbody itself. A true WQC would read something like, “The density of __ bacteria in surface waters shall be higher than __ no more than 10% of the time.” What is presented as a WQC actually reads like a waterbody assessment methodology—a prescribed means of interpreting data collected from a waterbody in order to infer the true (but never completely knowable, with current technology) condition of the waterbody over time and space.

Not applicable. Mississippi has no WQC for traditional pollutants for this use; nor is agricultural water supply among the specific designated uses that can be assigned to waterbodies under Mississippi's WQS regulations.

f) Industrial Water Supply

Not applicable. Mississippi has no WQC for traditional pollutants for this use; nor is industrial water supply among the specific designated uses that can be assigned to waterbodies under Mississippi's WQS regulations.

4) Articulation of Criterion-Frequency³²

Several the WQC for "traditional" pollutants examined lack any statement regarding a criterion-frequency, which suggest an acceptable frequency of excursions (periods equal to the criterion-duration in which the ambient concentration averages higher than the criterion-concentration) of zero.³³

However, Mississippi does have several criteria for total dissolved solids (TDS), chloride, and sulfate for which a criterion-frequency of zero is clearly specified. For instance, the acute criterion for TDS for Fish and Wildlife and for recreational uses reads, "...nor exceed 1500 mg/L at any time."

Also, one of the criteria for fecal coliform bacteria (See subsection C(3)(d) of this report) strongly implies³⁴ a frequency of excursions in waterbodies of no more than 10% of the time.

5) Discussion: Traditional Parameters³⁵

³² In EPA water quality standard terminology, the criterion-frequency specifies the maximum rate at which "excursions" can occur and the waterbody of concern can still fully support the designated use to which the criterion applies. For instance, EPA guidance specifies a criterion-frequency of once in three (3) years for both its acute and chronic aquatic life WQC for toxic chemicals. This means that only if two or more excursions occur during any 3-year period has there actually been an exceedence of the WQC in question. For example, only if the 4 day average concentration of , for example, cyanide in a lake were higher than the chronic criterion-concentration of 5.2 µg/L more than once in three years would there have been failure to meet the EPA chronic aquatic life WQC.

³³ A frequency of once in 10 years could perhaps be inferred from the following text from Section I.10.6, "Applicable Flow: All criteria herein shall apply to all stages of stream flow greater than or equal to the 7-day, 10-year minimum flow in unregulated, natural streams ..." However, a frequency of zero seems more consistent with the manner in which the WQC themselves are expressed in the regulations.

³⁴ The term "strongly implies" rather than the term "specifies," is used with regard to the criterion-frequency because, as noted previously, these particular "criteria" are presented in the form of a water quality assessment methodology. That is, they indicate that no more than 10% of samples collected have a density of the indicator bacteria higher than the criterion-concentration. It seems reasonable to assume that a "10% of samples" data interpretation rule was chosen by the state because the intent was to determine whether or not the waterbody concentration of the indicator bacteria went above the criterion-concentration more than 10% of the time. Since a key purpose of CWA-related ambient monitoring is to determine whether or not water quality criteria have been exceeded, it seems reasonable to believe that the assessment methodology (no more than 10% of samples) infers a WQC of "bacterial densities in waterbodies shall not go above (criterion-concentration) more than 10% of the time." This, in turn, implies a criterion-frequency of ten percent.

³⁵ For purposes of this ELI report, "traditional pollutant/parameter" refers to a number of pollutants and water quality parameters that were recognized as significant contributors to and indicators of degradation of the condition of surface water well before passage of the Clean Water Act in 1972. As used in this study, "traditional pollutant" includes those pollutants/parameters referred to as "conventional" in the CWA and EPA regulations and guidance,

Mississippi has adopted numeric WQC for a relatively small portion of the combinations of “traditional” pollutants and uses for which EPA has published criteria.

With regard to aquatic life uses, the most significant gap in coverage is the lack of numeric criteria for nutrients (phosphorous and nitrogen) or chlorophyll a (a measure of the density of algae) relevant to eutrophication. The algal blooms resulting from excess loadings of nutrients can not only adversely affect aquatic life, but also the use of waterbodies for drinking water supply and water contact recreation.

Despite this omission, the state has included on its 303(d) list of impaired waters 135 assessment units for “nutrients.” These listings reflect the willingness of the state to put waters on the 303(d) list based on conditions considered inconsistent with one or more narrative WQC. Nevertheless, the adoption of numeric nutrient WQC would likely eventually result in the identification of additional nutrient-impaired waters. (“Nutrients” are among the five most frequently mentioned causes of impairment for waters on state 303(d) lists nationwide, along with “sediment/sedimentation,” pathogens, mercury, and metals other than mercury).³⁶

The state does have an aquatic life criterion for one aspect of sediment/sedimentation – turbidity. In contrast to EPA, however, Mississippi’s is a quasi-numeric criterion that applies to all waters: “turbidity outside the limits of a 750 foot mixing zone shall not exceed the background turbidity at the time of discharge by more than 50 Nephelometric Turbidity Units (NTU).” (See the discussion of “quasi-numeric” criteria in the Subsection C(3)(a), above). Though it lacks a full compliment of numeric criteria related to sediments/sedimentation, Mississippi has placed 131 waters on its 303(d) list because of unnaturally high levels of this pollutant group.

The state lacks Public Water Supply criteria for four of the eight traditional parameters for which EPA has somewhat relevant standards. However, given that EPA has not issued actual water quality criteria for public water supply use and that all public water supplies serving more than 25 connections are covered by Safe Drinking Water Act regulations applicable to finished (at the tap) drinking water, the lack of public water supply criteria probably has little effect on human health. (On the other hand, high levels of contaminants in raw water supplies can increase the cost of meeting federal drinking water standards.)

The criterion-concentrations in Mississippi’s Fish and Wildlife WQC for “traditional” pollutants are within the range that would be expected for waters in a state such as Mississippi – located in the southern part of the country and having relatively low elevations and gradients. An exception to this overall pattern is presented by an unusual feature of Mississippi’s bacterial

which includes: biochemical oxygen demand (BOD), dissolved oxygen (DO), pH, total suspended solids (TSS), bacteria and other pathogens, and temperature. Also considered “traditional” in this document are several other non-toxic pollutants and parameters including alkalinity, chloride, chlorophyll a, color, dissolved solids, hydrogen sulfide, (total) nitrogen, oil and grease, total phosphorus, and turbidity, which are sometimes called “non-conventional” or “non-priority” in the EPA literature. Also, one “non-priority” toxic chemical, ammonia, is discussed under the heading “traditional pollutants/parameters.”

³⁶ EPA National Section 303(d) List Fact Sheet: Causes of Impairment. Available at: (http://iaspub.epa.gov/waters/national_rept.control#TOP_IMP).

criteria for public water supply worth noting is that, from November through April, the applicable criterion-concentration for the acute and chronic criteria is ten times higher than the criterion-concentrations for the remainder of the year. No explanation is provided in the WQS regulations as to why considerably higher levels of indicator pathogens in raw water supplies for public drinking water systems during the colder months of the year than in the warmer months would be consistent with protecting the health of persons drinking water from such a system.

Approximately half of the criterion-durations in Mississippi's criteria for traditional pollutants are clearly stated instantaneous values—that for dissolved oxygen in all waters, as well as WQC for dissolved solids, chlorides, and sulfates that apply to the Mississippi River. The acute dissolved solids WQC for all Fish and Wildlife—designated waters also is clearly an instantaneous maximum (“nor exceed ... at any time”); then again, the specific conductance criterion for this just says “shall be no substances added to increase the conductivity above ___,” which implies, but does not clearly state, a duration of an instant. The state's WQC for specific conductance for Public Water Supply is also expressed in this manner, as are those for chlorides and dissolved solids for this use.

Mississippi's chronic criteria for various uses all have fairly clearly specified criterion-durations. The only ambiguity arises from the terms “daily average” and “monthly average,” which could literally mean “calendar day/month,” but also could mean “24 hour rolling average” or “30 day rolling average.” Though using time periods corresponding to ones used for human convenience might be easier to implement, from an administrative standpoint, the “rolling average” approach is more consistent with biological science.

As for criterion-frequencies, some of Mississippi's WQC for traditional pollutants/parameters are stated as levels not to be surpassed “at any time,” which indicates a criterion-frequency of zero. Also, the fecal coliform WQC applicable to Fish and Wildlife, Public Water Supply, and Recreation read “nor shall the samples examined during a 30 day period exceed _____ per 100 ml more than 10% of the time,” a clearly articulated criterion-frequency of 10 percent. On the other hand, there are a few WQC for traditionals that are essentially silent as to a criterion-frequency, in which case a frequency of zero is assumed for purposes of this study.

As noted previously, the degree of protection provided by any state's WQC in relation to corresponding EPA criteria, requires looking not only at the criterion-concentration, but also the criterion-duration and criterion-frequency in each of criteria being compared. If indeed the criterion-duration and criterion-frequencies of the state and EPA are identical, then the WQC with the lower criterion-concentration will indeed provide more protection to the use to which the criteria apply, while a higher concentration would be indicative of less protection. For instance, Mississippi has a chronic criterion applicable to Recreation for fecal coliform bacteria, with a criterion-concentration of 200/100 mL, a criterion-duration of 30 days, and (apparently) a criterion-frequency of zero. EPA has a WQC for bathing waters for the same category of indicator bacteria with an identical concentration, duration, and frequency. (Because both the state and EPA WQC make no mention of a criterion-frequency, a frequency of zero is assumed for both.) Obviously, these two WQC would seem to provide the same level of protection to swimmers. Now, for discussion's sake, assume the state's criterion-concentration were changed

from 200/ 100mL to 150/100 mL, while the durations and frequencies of the two WQC remained identical. Then, the state's fecal coliform WQC would provide a higher level of protection than U.S. EPA's WQC.

Another combination that would provide a higher level of protection is lower criterion-concentration, shorter criterion-duration, and identical criterion-frequency. Mississippi has a special sulfate criterion that applies to the Mississippi River, from the state border with Tennessee to Vicksburg. The criterion-concentration is 150 mg/L of sulfate. The criterion-duration is instantaneous ("not to exceed ... at any time") and the criterion-frequency is assumed to be zero, because the WQS regulations are silent regarding this component of the WQC. EPA has a Secondary Drinking Water Standard for sulfate of 250 mg/L, measured as a rolling four calendar quarter average. As with the Mississippi criterion, there is no mention of an acceptable rate of excursions, so the criterion-frequency is taken to be zero. If the EPA standard were applied as a WQC to the water in this stretch of the Mississippi, then it would provide less protection to relevant uses than does the state's criterion.

Of course, there are additional combinations of criterion-durations and criterion-frequencies that would clearly indicate criterion is more protective than another. For example, if a state criterion had a criterion-duration the same as that of EPA's corresponding WQC, but higher criterion-frequency than that of the corresponding EPA criterion, then if the state's criterion-concentration were equal to or higher than that of the EPA criterion, it would clearly provide a lower level of protection than EPA's. Though not a perfect comparison, a situation close to this is presented by Mississippi's Public Water Supply criterion for bacteria, which reads, "nor shall the samples examined...exceed 400 per 100 mL more than 10% of the time." EPA's Primary Drinking Water standard for indicator bacteria says that no more than 5% of samples shall contain detectable levels of the bacteria. At first glance, this would indicate that the state's WQC was less protective (higher concentration: 400 vs. level of detection, same duration: instantaneous, presumably, and higher frequency: 10% vs. 5%). However, with regard to drinking water-related uses, there are a number of confounding factors, which will be discussed below.

Harder to discern are situations where, for example, the state's criterion-concentration is higher than EPA's, while the criterion-duration is shorter and the criterion-frequency is lower. There are no Mississippi WQC for traditionals that fit this pattern. Without obtaining or collecting additional toxicity data, there would be no way to know whether the less protective effect of the state's higher criterion-concentration would be outweighed by the state's shorter criterion-duration and criterion-frequency. Several other combinations of relative concentrations, durations, and frequencies between WQC also present a complex situation. (See Appendix C for a chart listing all the possible combinations of the three components of a properly-articulated numeric WQC, and what they mean in terms of comparative levels of protection.)

Unfortunately, both Mississippi and EPA have WQC for traditional pollutants/parameters that lack a well articulated criterion-duration and/or criterion-frequency in a WQC, which renders any attempt to determine the absolute, or even just the relative, level of protection afforded to the applicable designated use(s) an exercise with a high degree of uncertainty. Obviously, any attempt to perform such comparisons would require making assumptions that

may or may not turn out to be consistent with the duration and/or frequency intended by the state. The results of attempts to compare the protection provided by a state vs. an EPA would, of course, be greatly affected by whatever assumptions were made. Assumption of some short-term duration (such as one hour), rather than a longer term (such as 30 days), would tend to make a criterion more protective. Likewise, assumption of a lower frequency (such as once in five years), rather than a higher frequency (such as once in two years) would have the same effect—more protective than if the alternative were used.

Further complicating this picture, with regard to aquatic life WQC, there could be state-specific, watershed-specific, or even waterbody-specific reasons (differences in water column chemistry, temperature, stream flow patterns, resident species of aquatic life) that a state criterion can have a criterion-concentration higher or lower than that for the corresponding U S EPA criterion and still provide aquatic life protection equal to that for which the EPA WQC was designed. With the exception of site-specific WQC for chlorides, sulfates, and total dissolved solids, Mississippi appears to not have developed site-specific Fish and Wildlife WQC for traditional pollutants.³⁷

The problems resulting from inadequately defined criterion-durations and/or criterion-frequencies can be illustrated by Mississippi's Shellfish Consumption and EPA's corresponding "shellfish harvesting" criteria for fecal coliform bacteria. Both are expressed as "The median fecal coliform MPN (most probable number) of the water shall not exceed 14 per 100 ml." Clearly, this is not intended as an instantaneous, never to surpass bacterial density; rather, it refers to a central tendency over some longer period of time. Unfortunately, neither the state nor the federal agency WQC specify the averaging period (i.e., criterion-duration). Assuming that the criterion-frequency for both the Mississippi and the EPA WQC are zero, then the relative degree of protection afforded to humans who eat shellfish taken from waters with this use designation will depend on the criterion-durations. If criterion-frequencies are identical (e.g., several days), then the level of protection resulting from attainment of the two WQC would be the same because the criterion-concentration, criterion-duration and criterion-frequency of the two WQC would be identical. But, if the state's criterion-duration are shorter (e.g., 24 hours), then its criterion would be the more protective (concentration and frequency identical, state duration shorter). On the other hand if Mississippi's criterion-duration were longer, e.g., 30 days, then its WQC would be less protective (concentration and frequency are identical, and the state duration is longer).

Additional complications arise when seeking to ascertain the comparative degree of protection afforded to humans by state and EPA criteria and standards related to drinking water. For example, Mississippi's Public Water Supply criteria applicable to chlorides and total dissolved solids apparently apply to acute (instantaneous) conditions, while EPA's Safe Drinking Water Act standards are applied to chronic scenarios (four rolling calendar quarters/365 days).³⁸ Given that the state's and EPA's criterion-concentrations for both of these contaminants are identical, the (apparently) much shorter duration for the state's WQC, compared to the implicit

³⁷ The state does have ammonia WQC that can be adjusted based on pH and temperature of specific waterbodies. However, these WQC, expressed as equations, were developed by EPA.

³⁸ Compliance with drinking water standards under SDWA is based on the average of samples collected over four "rolling" calendar quarters (12 months total).

criterion-duration for EPA's standard, would seem to make³⁹ the state's criterion considerably more protective. For instance, Mississippi's Public Water Supply criterion for chlorides would limit concentrations to 250 mg/100 ml or less at all times, whereas EPA's standards would allow numerous instances with concentrations above 250 mg/L, so long as the 365 day average concentration was 250 mg/L or less. This assumes that both the state and EPA criteria have a criterion-frequency of zero. If, however, it were assumed that the state's Public Water Supply criteria had a criterion-duration of 365 days (one year), then the state and EPA chloride WQC might appear provide the same level of protection.

A further confounding factor pertaining to criteria aimed at risks associated with consuming contaminants in drinking water is the fact that most states' water quality criteria for public water supply (Public Water Supply, in Mississippi's case) apply to the untreated water from a river or lake that is used as a "raw" water supply for a public drinking water system, while EPA's standards established under the Safe Drinking Water Act (SDWA) apply to "finished" drinking water at the tap, which usually has undergone some form of treatment to remove contaminants. Hence, for a given pollutant, a drinking water supply WQC with a concentration equal to that specified in a drinking water standard could actually provide greater protection to consumers of finished drinking water. For instance, if the drinking water treatment process to which the raw water is subjected removes 50% of a certain pollutant, then the level of the pollutant in the raw water could be two-times the concentration specified by the SDWA standard, and still meet that standard in the finished drinking water. For example, EPA's Secondary Drinking Water Standard for chloride is 250 mg/L, so a water quality criteria for raw drinking water supply with a criterion-concentration of 500 mg/L should result in finished drinking water with a concentration equal to that of the drinking water standard (250 mg/L). And, if the drinking water treatment system could remove more than 50% of the chloride, e.g., 80%, then a water supply criteria with a concentration of 500 mg/L would lead to finished drinking water with a chloride level of 100 mg/L.⁴⁰

Yet another confounding factor affecting efforts to ascertain the relative degree of protection afforded by a Mississippi Public Water Supply criterion and the somewhat corresponding EPA Safe Drinking Water Act standard arises in the case of bacteria. Mississippi's WQC for this use are for fecal coliform bacteria, while the federal drinking water standard is for total coliform bacteria.

In cases where both the state and EPA have well articulated criterion-durations and criterion-frequency, then it should be possible to draw reliable conclusions about the degree of protection associated with attainment of one criterion versus another. For example, if a state and corresponding EPA criteria have identical durations and frequencies (most likely the duration is instantaneous and frequency is zero, in the case of traditional parameters), then comparison of state and EPA criterion-concentrations would provide a relatively good indicator of comparative

³⁹ The phrase "seem to make" is used here, rather than a more definitive term such as "renders" because, as explained in the following paragraph, Mississippi's Public Water Supply criteria and EPA's drinking water standards apply to different points in the water supply process.

⁴⁰ Only if the drinking water treatment system had the very unusual effect of increasing levels of a given pollutant found in the raw water supply—rather than achieving the reductions for which the treatment is intended—would there be any chance that raw water meeting state water quality criteria would end up providing finished water that failed to meet EPA drinking water standards.

levels of protection provided. As noted earlier, Mississippi's and EPA's aquatic life criteria for ammonia exemplify such a situation. If, on the other hand, the state WQC had a shorter criterion-duration and a lower acceptable frequency of excursions, then any criterion with a criterion-concentration equal to or lower than that of the EPA WQC would definitely provide a higher level of protection to the relevant use(s). There are no examples of such, in Mississippi's case. As for a state WQC with a higher criterion-concentration, shorter criterion-duration, and lower criterion-frequency, it would be hard to determine, without performing additional laboratory studies, whether the state WQC was more or less protective than the EPA criterion. That is, to what degree would the less-protective effect of the higher concentration be offset by the more protective effects of a shorter duration and lower frequency?

Even in cases where both a state and the corresponding EPA WQC have clearly defined durations and frequencies, with regard to aquatic life WQC, there could be, state-specific, watershed-specific, or even waterbody-specific reasons that a state criterion can have a criterion-concentration higher or lower than that for the corresponding U S EPA criterion and still provide aquatic life protection equal to that for which the EPA WQC were designed.⁴¹ Of course, if the criterion-duration and criterion-frequency for a state and corresponding EPA criteria are the same (e.g., duration is 24 hours, frequency is zero) and the state's criterion-concentration were higher than EPA's, then the state's criterion would indeed provide less protection to aquatic organisms in the waterbody or set of waterbodies than would EPA's, in relative terms. Nonetheless, due to site-specific or watershed-specific conditions, the state's WQC could provide the same absolute level of protection as that for which the EPA WQC were designed, while use of the recommended EPA WQC in such waters would actually provide *greater* protection than that which EPA intended.

A possible example of such effects applicable to all the waters of Mississippi is the state's acute Fish and Wildlife criterion for dissolved oxygen—an instantaneous minimum of 4.0 mg/L. EPA has issued only one dissolved oxygen WQC for all the inland fresh waters in the country—an instantaneous (apparently) minimum of 5.0 mg/L. Though the state's criterion would clearly provide a lower level of protection than would EPA's, it could be that the state's criterion is sufficient to protect the forms of aquatic life that are native to the waters of Mississippi, because the state's WQC is reflective of the natural conditions in those waters, in which the native aquatic species have evolved. For any waterbody where this is indeed the case, application of EPA's absolute minimum of 5.0 mg/L dissolved oxygen could, in fact, be overly protective. There might, in fact, be some waterbodies in Mississippi (e.g., swamps) where a site-specific instantaneous minimum WQC somewhat lower than 4.0 would be consistent with full support of native communities of aquatic life; but, there could be other waterbodies (e.g., fast moving turbulent streams) for which an instantaneous minimum dissolved oxygen concentration higher than 4.0 mg/L would be needed to fully protect aquatic life.

Returning briefly to the effects of absence of clearly-stated criterion-durations and criterion-frequencies, they also can render considerably more challenging the implementation of CWA programs that are driven largely by WQC (Section 303(d) and 305(b) assessment and reporting, TMDLs, and water quality-based NPDES permitting programs). Clearly, it would be

⁴¹ Possible reasons include differences in waterbody chemistry and in species present in a given type of aquatic ecosystems, compared to what were used in studies on which EPA's criteria were based.

difficult for someone implementing one of these “downstream” CWA programs to deal with a WQC having a criterion-concentration reading, “not too high” or “levels no greater than approximately 40 µg/L - 60 µg/L.”⁴² Though perhaps less immediately obvious, imprecisely-stated criterion-durations and criterion-frequencies can pose similar challenges to those presented by missing or vaguely-stated criterion-magnitudes. For example, if over some 30 day period, four “grab” samples had been collected and analyzed for levels of a certain pollutant, and one of those samples had a concentration higher than a relevant criterion-concentration, the answer to the question “Was this pollutant exceeded this WQC?” would differ depending on the criterion-duration and criterion-frequency. If the duration were “instantaneous” and the frequency “zero,” the WQC would have been exceeded, without question.⁴³ But, if the duration were 30 days and the frequency remained at zero, the mere fact that one out of four instantaneous measurements surpassed the criterion concentration would not prove that an exceedence had occurred. Rather, only if the average of the concentrations in the four samples were higher than the criterion-concentration would there be strong evidence of an exceedence of WQC in the water from which said samples were collected. And, if the criterion-frequency were “two or more times per year,” then one might not conclude that WQC exceedence had occurred based on the above evidence.⁴⁴

D. Toxic Chemicals⁴⁵

1) Coverage

a) Aquatic Life-Freshwater / “Fish and Wildlife”⁴⁶

Acute Toxicity

Mississippi has adopted acute freshwater Fish and Wildlife criteria for 26 pollutants, including recently added acute freshwater aquatic life criteria for four (4) pollutants (alpha-endosulfan, beta-endosulfan, cadmium, and silver).

⁴² Mississippi has no WQC worded in this fashion. These are hypothetical.

⁴³ This statement assumes that all four of the samples passed the state’s quality assurance/quality control (QA/QC) tests.

⁴⁴ The phrase “might not conclude” was employed because it would be contrary to the laws of probability to conclude that no additional excursions (30 day periods with average bacterial concentrations about the criterion-concentration) had occurred during any 12 month period encompassing the 30 days in which the four grab samples had been collected, based on the information presented herein. In fact, if these four individual samples were the only ones gathered during a given 12 month period, then it is quite likely that additional excursion did occur. The reason for this inference is that, given that there are 336 thirty-day periods in any 12 month period, the odds of having randomly chosen to collect samples during the only 30-day period in which an excursion occurred are very low. (Several times lower than randomly selecting a card from a well-shuffled deck of 52, and having that card turn out to be one named in advance.)

⁴⁵ In this report, the term “toxic pollutant” includes not only EPA’s “priority” toxic pollutants but also all those toxics called – for CWA purposes – “non-priority” pollutants, as well as all toxic chemicals falling into neither of these two EPA classifications. (The one exception is ammonia, which is addressed under “traditional pollutants” in this report.)

⁴⁶ Throughout this document, generic names (e.g., “aquatic life,” and “human health: drinking water supply,” and “human health: water contact recreation”) are used in reference to certain categories of uses. When a state uses different wording to refer to one of the generic uses, the name the state employs is listed in quotation marks, following the generic title.

Out of the 31 toxic pollutants for which EPA has issued⁴⁷ acute criteria for freshwater aquatic life, Mississippi has not adopted corresponding criteria for nine pollutants (Appendix B, Table 1).⁴⁸ These pollutants are mostly a combination of organophosphate pesticides and herbicides and toxic metals.

On the other hand, the state has adopted *acute* freshwater aquatic life (Fish and Wildlife) criteria for four (4) “extra”⁴⁹ pollutants – pollutants for which the EPA has not issued corresponding Section 304(a) criteria (Appendix B, Table 3).⁵⁰

Chronic Toxicity

Mississippi has adopted chronic freshwater Fish and Wildlife criteria for 23 pollutants, including chronic freshwater aquatic life criteria for three pollutants (alpha-endosulfan, beta-endosulfan, and silver).

Out of the 35 toxic pollutants for which EPA has issued *chronic* criteria for freshwater aquatic life, Mississippi has not adopted corresponding criteria for 16 pollutants (Appendix B, Table 1).⁵¹ These pollutants are mostly a combination of organophosphate pesticides and herbicides and toxic metals, among which is methoxychlor, a substance that has been mentioned as possible endocrine disruptor.

On the other hand, the state has adopted chronic freshwater Fish and Wildlife criteria for four “extra”⁵² pollutants for which EPA has not published corresponding Section 304(a) criteria: arsenic (III), endosulfan sulfate,⁵³ gamma-BHC, and phenol (Appendix B, Table 3).

b) Aquatic Life – Salt Water / “Fish and Wildlife”

Acute Toxicity

Mississippi has adopted acute salt water Fish and Wildlife criteria for 25 pollutants, including recently added acute salt water aquatic life criteria for three (3) pollutants (alpha-endosulfan, beta-endosulfan, cadmium).

⁴⁷ Throughout this report, the criteria recommended by EPA under authority of the CWA are referred to as the EPA’s “issued” or “published” criteria, interchangeably. Terms such as “promulgated” and “established” are not used in reference to these EPA values because they are not regulatory requirements; rather they are guidance to the states.

⁴⁸ Arsenic (total) is listed as missing because Mississippi has no acute criterion for this form of the substance, while EPA does. On the other hand, the state has a criterion for arsenic (III), which is listed as “extra” because EPA does not have a corresponding criterion for this form of arsenic.

⁴⁹ Id. at 9

⁵⁰ Several of these are actually congeners or isomers of total PCBs. They are counted as individual pollutants for the purpose of this review. EPA, on the other hand, has just one WQC for this set of chemicals, expressed as total PCBs, which is counted herein as one pollutant/criterion.

⁵¹ Arsenic (total) is listed as missing because Mississippi has no acute criterion for this form of the substance, while EPA does. On the other hand, the state has a criterion for arsenic (III), which is listed as “extra” because EPA does not have a corresponding criterion for this form of arsenic.

⁵² Id. at 9

⁵³ While EPA does not have a criterion for “endosulfan sulfate” as does Mississippi, it has separate, though identical, acute and chronic freshwater aquatic life criteria for the alpha and beta forms of endosulfan.

Mississippi has not adopted acute salt water Fish and Wildlife criteria for seven (7) out of the 28 toxic pollutants for which EPA has issued criteria. Among those pollutants with missing acute salt water Fish and Wildlife criteria are several organophosphate pesticides (Appendix B, Table 1).

On the hand, the state has adopted salt water acute aquatic life criteria for four pollutants for which EPA has not issued Section 304(a) criteria: arsenic (III), endosulfan sulfate, PCBs,⁵⁴ and phenol.

Chronic Toxicity

Mississippi has adopted chronic salt water aquatic life criteria for 22 pollutants, including recently adopted chronic salt water aquatic life criteria for three pollutants (alpha-endosulfan, beta-endosulfan, and cadmium).

Mississippi has not adopted, nor proposed, chronic salt water aquatic life criteria for 14 of the 33 toxic pollutants for which EPA has issued corresponding criteria. Some of the pollutants with missing salt water aquatic life WQC are organophosphate pesticides (Appendix B, Table 1). Also, among the pollutant without a salt water aquatic life criterion is methoxychlor, which has been mentioned as possible endocrine disruptor.

On the other hand, the state has adopted chronic salt water aquatic life criteria for three (3) pollutants for which EPA has not published corresponding criteria: arsenic III, endosulfan sulfate,⁵⁵ and phenol.

c) Human Health: Consumption of Fish and Other Aquatic Organisms/ “Human Health: Organisms Only (HHO)”⁵⁶

Mississippi has adopted Human Health: Organisms Only criteria for 24 pollutants, including recently adopted Human Health: Organisms Only criteria for two pollutants (alpha-endosulfan and beta-endosulfan).

Mississippi has not adopted Human Health: Organisms Only criteria for 82%, or 87 pollutants, of the total 106 pollutants for which the EPA has issued corresponding criteria (Appendix B, Table 2).

On the other hand, the state has adopted Human Health: Organisms Only criteria for five pollutants for which the EPA has not issued corresponding criteria. They are: cadmium chromium (III), chromium (VI), copper, and mercury.⁵⁷

⁵⁴ The congeners PCB 1016, PCB 1221, PCB 1232, PCB 1242, PCB 1248, PCB 1254, PCB 1260 are counted as one pollutant for the purposes of this report.

⁵⁵ While EPA does not have a criterion for “endosulfan sulfate” as does Mississippi, it has separate, though identical, acute and chronic salt water aquatic life criteria for the alpha and beta forms of endosulfan.

⁵⁶ Like EPA, Mississippi has a set of criteria it calls “Human Health: Organisms Only (HHO).” These criteria are aimed at protecting people who consume fish and other aquatic organisms from surface waters. Such criteria are sometimes referred to as “fish consumption” criteria.

d) Human Health: Consumption of Water plus Fish and Other Aquatic Organisms / “Human Health: Water & Organisms”⁵⁸

Mississippi has adopted Human Health: Water and Organisms criteria for 27 pollutants, including recently adopted criteria for two pollutants (alpha-endosulfan and beta-endosulfan).

Mississippi has not adopted Human Health: Water and Organisms criteria for 81%, or 92 pollutants, of the total 113 pollutants for which the EPA has issued corresponding criteria (Appendix B, Table 2).

On the other hand, the state has adopted Human Health: Water and Organisms for six pollutants for which the EPA has not issued corresponding criteria (chromium III, chromium IV, cadmium, lead, mercury, and silver).

e) Human Health: Drinking Water Supply / “Public Water Supply”

Mississippi has WQC for four toxic substances specifically applicable to their Public Water Supply use alone. Also, section II.10(E)(1) of the state’s WQS regulations stipulate that waters with the "Public Water Supply" use designation must comply with the state's "Water and Organisms" criteria.

EPA has no Section 304(a) criteria for toxics for this use, though it has promulgated somewhat corresponding Primary Drinking Water Standards applicable to finished drinking water (as opposed to raw source water) for 77 toxic contaminants.⁵⁹

Both Mississippi and EPA have criteria for toxics for combined drinking water and fish consumption uses (see subsection D(1)(d) above).

⁵⁷ While EPA does not have a criterion for “mercury” as does Mississippi, it has issued a “Human Health: Organisms Only” WQC for methyl mercury. For purposes of this report, these are counted as different pollutants. Because of this, “methyl mercury” is included in the list of pollutants for which Mississippi does not have HHO criteria, while “mercury” is on the list of “extra” criteria.

⁵⁸ Both EPA and Mississippi have a set of criteria referred to as “Human Health: Water and Organisms (HHWO).” These criteria are aimed at protecting people who consume both water and aquatic organisms from designated surface waters.

⁵⁹ The term “somewhat corresponding” has been used because water quality criteria and drinking water standards apply to different endpoints. WQC apply to surface waters within the jurisdiction of the Clean Water Act (CWA). Some of these waters are, or might be, used as a source of “raw” water by public and private drinking water systems. Hence, when a waterbody in Mississippi is designated “Public Water Supply” then a certain set of WQC applies to said river or lake, per the CWA. There also is another set of standards that apply to the “finished” water that results from “raw” water from a river or lake being run through treatment processes aimed at removing contaminants. These are called Drinking Water Standards, and are established as national regulations under authority of the SDWA. They are often referred to as “maximum contaminant levels” (MCLs). Another difference between Mississippi’s Public Water Supply water quality criteria and EPA’s SDWA standards pertaining to waterborne pathogens is that the former are expressed in terms of fecal coliform bacteria, while the latter employ the more encompassing grouping total coliform bacteria as the indicator parameter.

f) Human Health: Water-based Recreation / “Recreation” and “Secondary Contact Recreation”

Mississippi’s water quality criteria for toxic substances are applicable to all waters in the state. There is no specific set of WQC for toxic substances for the either of the state’s “recreation” or “secondary contact recreation” designated use. EPA has no criteria for toxic chemicals applicable to this use.

g) Industrial Water Supply

Mississippi’s water quality criteria for toxic substances are applicable to all waters in the state. There are no specific WQC applicable to “industrial water supply,” nor is this among the uses for which a waterbody can be designated. EPA has no criteria for toxic chemicals applicable to this use.

h) Agricultural Water Supply

Mississippi’s water quality criteria for toxic substances are applicable to all waters in the state. There are no specific WQC applicable to “agricultural water supply,” nor is this among the uses for which a waterbody can be designated. EPA has no criteria for toxic chemicals applicable to this use.

2) Criterion-Concentrations, Compared to EPA’s

a) Aquatic Life – Freshwater / “Fish and Wildlife”

Acute Toxicity

Among the pollutants 26 pollutants for which Mississippi has adopted acute freshwater aquatic life criteria, 21 pollutants have criteria that correspond to a EPA recommended criterion.⁶⁰ Within this subset, thirteen pollutants have acute freshwater aquatic life criteria for which the criterion-concentrations are the same as the corresponding EPA values. There are eight pollutants for which the criterion-concentrations are lower than the corresponding EPA values (Appendix B, Table 4). And among these eight pollutants for which the criterion-concentrations are lower than the corresponding EPA values, the criterion-concentrations for two pollutants (cadmium and silver) are recently adopted values.

The newly adopted acute criterion-concentrations in the freshwater aquatic life criteria for alpha-endosulfan beta-endosulfan are both equal to those in EPA’s corresponding criteria.

⁶⁰ The other five pollutants are selenium and four other pollutants for which EPA has not issued acute freshwater aquatic life criteria. Because the EPA criterion for selenium is expressed in the form of an equation and because the Agency is in the process of developing a more stringent criterion for selenium, direct quantitative comparison of EPA’s selenium WQC to Mississippi’s selenium WQC was not undertaken in this review.

Chronic Toxicity

Among the 23 pollutants for which Mississippi has adopted chronic freshwater aquatic life criteria, 19 pollutants have criteria that correspond to a EPA recommended criterion.⁶¹ Within this subset, the chronic freshwater aquatic life criteria for eleven pollutants have the same criterion-concentrations as those of EPA. Eight pollutants have criteria for which the criterion-concentrations are lower than the corresponding EPA values (Appendix B, Table 4).

b) Aquatic Life – Salt Water / “Fish and Wildlife”

Acute Toxicity

Among the 25 pollutants for which Mississippi has adopted acute salt water aquatic life criteria, 21 pollutants have criteria that correspond to a EPA recommended criterion.⁶² Within this subset, twenty pollutants have criteria for which the criterion-concentrations are equal to the corresponding EPA values. The criterion-concentration for one pollutant, nickel, is higher than the corresponding EPA value (Appendix B, Table 5).

Chronic Toxicity

Among the 22 pollutants for which Mississippi has adopted chronic salt water aquatic life criteria, nineteen pollutants have criteria that correspond to a EPA recommended criterion.⁶³ Within this subset, 18 pollutants have criteria for which the criterion-concentrations are equal to the corresponding EPA values. The criterion-concentration for one pollutant, nickel, is higher than the corresponding EPA value (Appendix B, Table 5).

c) Human Health: Consumption of Fish and Other Aquatic Organisms/ “Human Health: Organisms Only (HHO)”

Among the 24 pollutants for which Mississippi has adopted Human Health: Organisms Only criteria, 19 pollutants⁶⁴ have criteria that correspond to a EPA recommended criterion. Within this subset, five pollutants have criteria for which the criterion-concentrations that are lower than EPA’s (Appendix B, Table 4) and fourteen pollutants have criteria for which the criterion-concentrations are higher than the EPA’s (Appendix B, Table 5). And among these 14 pollutants for which the criterion-concentrations are higher than the corresponding EPA values, the criterion-concentrations for 12 pollutants are EPA-sanctioned values and the criterion-concentrations for two pollutants (alpha-endosulfan and beta-endosulfan) are state-defined values.

d) Human Health: Consumption of Water plus Fish and Other Aquatic Organisms / “Human Health: Water & Organisms”

⁶¹ The other four pollutants are selenium and three pollutants for which EPA has not issued chronic freshwater aquatic life criteria.

⁶² The other four pollutants are those for which EPA has not issued acute saltwater aquatic life criteria.

⁶³ The other three pollutants are those for which EPA has not issued chronic saltwater aquatic life criteria.

⁶⁴ The other five pollutants are those for which EPA has not issued “human health: organisms only” criteria.

Among the 27 pollutants for which Mississippi has adopted “human health: organisms only” criteria, 21 pollutants⁶⁵ have numeric criteria that correspond to a EPA recommended criterion. Within this subset, one pollutant has a criterion-concentration that is equal to that in EPA’s corresponding criterion, six pollutants have criterion-concentrations that are lower than EPA’s (Appendix B, Table 4), and fourteen pollutants have higher criterion-concentrations than the EPA’s (Appendix B, Table 5). And among these fourteen pollutants for which the criterion-concentrations are higher than the corresponding EPA values, the criterion-concentrations for two pollutants (alpha-endosulfan and beta-endosulfan) are recently adopted values.

e) Human Health: Drinking Water Supply / “Public Water Supply”

Of the four toxic pollutants for which Mississippi has specifically applicable to Public Water Supply use, three have concentrations equal to the concentration in EPA’s Primary Drinking Water Standards, and one has a lower concentration than EPA’s.

f) Human Health: Water-based Recreation / “Recreation” and “Secondary Contact Recreation”

Not applicable. Mississippi does not have any WQC for toxic chemicals pertaining to water-based recreational use. Similarly, EPA has no WQC for toxic chemicals applicable to water-based recreation.

g) Industrial Water Supply

Not applicable. Mississippi does not have any WQC for toxic chemicals pertaining to use of waterbodies as a water supply for industrial operations. Similarly, EPA has no WQC for toxic chemicals applicable to this use.

h) Agricultural Water Supply

Not applicable. Mississippi does not have any WQC for toxic chemicals pertaining to use of waterbodies as a water supply for agricultural operations. Similarly, EPA has no WQC for toxic chemicals applicable to this use.

3) Articulation of Criterion-Durations

While some of Mississippi’s numeric WQC for toxic chemicals have a clearly stated criterion-duration, most do not. The criteria for barium, fluoride, and lead are clearly intended to have a duration of just an instant, as the Mississippi WQS regulations states, “the following concentrations shall not be exceeded at any time.” The remaining criteria for toxic substances, for both aquatic life and human health criteria, lack a clear indication of a criterion-duration; though a duration for the aquatic life criteria could be inferred from the linkage made in the Mississippi WQS regulations between the state’s Fish and Wildlife criteria for toxics and those published by EPA.

⁶⁵ The other six pollutants are those for which EPA has not issued Human Health: Water and Organisms criteria.

a) Aquatic Life / “Fish and Wildlife” – Freshwater and Marine

Acute criteria

No clear indication of a criterion-duration applicable to acute Fish and Wildlife criteria is provided in the relevant table (Table #1), footnotes to said table, or the definitions section of the Mississippi WQS regulations. The only language relevant to duration for the state’s existing acute toxic pollutant criteria appears in Section 1.10.A (1), which states, “The concentrations of toxics substances cannot exceed the ... acute values” Based on this text, a default to an “instantaneous” duration would be indicated.

However, Section I.10.B specifically refers to the criteria for toxic chemicals issued by EPA pursuant to Section 304(a) of the Clean Water Act, though it does not explicitly say that the state’s criteria are identical to, or based upon, EPA’s criteria. Also, there is reference to a one-hour duration in Section I.10.G of the Mississippi WQS regulations, which is titled “Toxic and Human Health Parameters for Which no Numeric Criteria Have Been Established.” This subsection addresses procedures by which “the Commission shall determine limitations,” which seems to be a reference to setting TMDLs and water quality-based limits for NPDES permits for chemicals for which the state has not yet adopted numeric water quality criteria. This subsection specifically mentions EPA’s Section 304(a) water quality criteria. Also, Subsection (2) of 1.10.G, titled “Definitions,” refers to “one-hour average value for criteria published in 1985” – which probably is meant to refer to the criteria contained in EPA’s 1986 “Gold Book” listing of criteria.

On balance, however, it seems reasonable to assume, for the purposes of this report, a duration equal to the criterion-duration for corresponding EPA criteria: 1 hour.

Chronic criteria

Section II.10.A (1) of the Mississippi WQS regulations states, “The concentrations of toxics substances shall not exceed the *chronic* or acute values” This suggests that the criterion-duration for both the acute and chronic criteria is “instantaneous,” but by definition, there is no such thing as a chronic criterion with a duration of only a fraction of a second.

There is in reference to a four-day duration in Section 1.10.G of the Mississippi WQS regulations, which could possibly be used to impute such a duration for the state’s chronic Fish and Wildlife criteria for toxics, though this text does not seem to apply to existing criteria.

Still another way in which a concentration-duration is implied for Mississippi’s chronic Fish and Wildlife criteria for toxics is the reference in Section II.10.E of the Mississippi WQS regulations (“Application of Numerical Criteria”) to stream flow of a low 7Q10 parameter – lowest seven-day average flow likely to occur once-in-ten years, on average. This language could suggest a criterion-duration of seven days, for existing chronic criteria for toxics; however, this notion is brought to question by the fact that the 7Q10 parameter is also listed as the design stream flow for application of the criteria addressing acute toxicity.

On balance, assumption of a four day (96 hour) duration – that applicable to EPA criterion-concentrations for chronic Fish and Wildlife criteria for toxics – seems reasonable.

b) Human Health: Consumption of Fish and Other Aquatic Organisms/ “Human Health: Organisms Only (HHO)”

The Mississippi WQS regulations do not clearly provided a criterion-duration for the Human Health: Organisms Only criteria applicable to toxic substances. Possible assumptions include: 1) instantaneous, 2) seven days, 3) one year (365 days), and 4) 70 years.

No clearly-stated duration for Mississippi’s human health criteria appears in Table (#1), footnotes to Table 1, or the definitions section of regulation. And, unlike the situation with aquatic life (Fish and Wildlife) criteria for toxics, no specific durations are mentioned anywhere in the regulations.

However, as with its Fish and Wildlife criteria for toxics, the state’s WQS regulations do make reference to WQC published by EPA, which could be taken as a rationale for using the same criterion-duration as that in EPA’s human health criteria. Unfortunately, inference from EPA human health WQC is more difficult than for aquatic life criteria, because EPA guidance per duration for human health criteria is ambiguous. Some guidance suggests instantaneous, other guidance language suggests annual, and still other EPA text implies a 70 year duration (average human lifetime).

A criterion-duration of seven days could perhaps be inferred from the following text from Section I.6 WQS regulation, “Applicable Flow: All criteria herein shall apply to all stages of stream flow greater than or equal to the 7-day, 10-year minimum flow in unregulated, natural streams” Still another criterion-duration is implied for Mississippi’s human health criteria for toxic chemicals by the reference in Section II.10.E (“Application of Numerical Criteria”) to “mean annual flow.” This could be taken to imply a criterion-duration of 365 days/1 year.

On balance, an assumed criterion-duration of an instant/second seems appropriate, for purposes of this report.

c) Human Health: Consumption of Water plus Fish and Other Aquatic Organisms / “Human Health: Water & Organisms”

The Mississippi WQS regulations has not clearly provided a criterion-duration for the “Human Health: Water & Organisms” criteria applicable to toxic substances. (See discussion of duration in Subsection D(3)(b).)

On balance, an assumed criterion-duration of an instant/second seems appropriate, for purposes of this report.

d) Human Health: Drinking Water Supply/ “Public Water Supply”

All of Mississippi’s WQC for toxic substances applicable to their Public Water Supply use have a criterion-duration of an instant.

e) Human Health: Water-Based Recreation/ “Recreation” and “Secondary Contact Recreation”

Not applicable. Mississippi has no WQC for toxic chemicals pertaining to risk to human health resulting from various types of water-based recreation.

f) Industrial Water Supply

Not applicable. Mississippi has no WQC for toxic substances for this use.

g) Agricultural Water Supply

Not applicable. Mississippi has no WQC for toxic substances for this use.

4) Articulation of Criterion-Frequencies

None of Mississippi’s numeric WQC for toxic chemicals have fully articulated or clearly stated criterion-frequencies.

a) Aquatic Life (Fish and Wildlife) – freshwater and marine

Given the lack of specificity in the state’s WQS regulation regarding criterion-frequencies, a default to a criterion-frequency of zero might be appropriate per the state’s Fish and Wildlife criteria.

However, since Mississippi’s WQS regulations do include explicit references to EPA’s 304(a) WQC, use of the same criterion-frequency as that in corresponding EPA aquatic life criteria could, for purposes of this study, be justified. Following this logic, a maximum frequency of excursions (conditions worse than those described by the combination of the criterion-concentration and criterion frequency) of one in three (years) would be in order – for both acute and chronic Fish and Wildlife criteria.

Another way in which a criterion-frequency could be inferred for Mississippi’s acute and chronic Fish and Wildlife criteria for toxic substances is the following text from Section I.6 of the Mississippi WQS regulations, “Applicable Flow: All criteria herein shall apply to all stages of stream flow greater than or equal to the seven-day, ten-year minimum flow in unregulated, natural streams” Also, Section II.10.E (2) (“Application of Numerical Criteria”) indicates that the 7Q10 stream flow parameter should be used when applying acute and chronic toxicity criteria. The 7Q10 parameter is defined in the regulations as “the seven day average low stream flow with a ten-year recurrence interval.” This suggests a lower acceptable frequency of excursions – no more than one in ten years.

On balance, an assumed criterion-frequency of once-in-three years appears most appropriate.

b) Human Health: Various Uses

The state's Public Water Supply criteria for toxics are expressed as concentrations "not to be exceeded at any time." This clearly establishes a criterion-frequency of zero. Since none of Mississippi's other WQC for toxics pertaining to human health nor EPA's water quality criteria guidance regarding its human health WQC mentions a criterion-frequency (allowed rate of excursions) for toxic chemical, there seems no basis for thinking that any excursions per human health criteria are acceptable.

A concentration-frequency of once in ten years could be inferred for Mississippi's human health criteria for toxics the following text from Section I.10.6, "Applicable Flow: All criteria herein shall apply to all stages of stream flow greater than or equal to the seven-day, ten-year minimum flow in unregulated, natural streams" However, Section II.10.E (2), "Application of Numerical Criteria," indicates that a different design flow should be used with human health criteria – the mean annual stream flow. No mention of an occurrence period is provided in the Mississippi WQS regulations' definition for mean annual flow (Section II.10 (D)).

On balance, a criterion-frequency of zero appears most consistent with the wording of the Mississippi WQS regulations.

5) Discussion: Criteria for Toxic Chemicals

Mississippi's WQS regulations specify aquatic life (Fish and Wildlife) protection criteria for most of the toxic substances for which the EPA has issued corresponding Section 304(a) criteria. The group of toxic substances lacking criteria state equivalent to EPA's aquatic life WQC is mostly made up of organophosphate pesticides, herbicides, and toxic metals.

However, the state's WQS regulations lack human health-related criteria for a large number of pollutants. Indeed, Mississippi has not adopted Human Health: Organisms Only and "Human Health: Water & Organism" WQC for over 80% of the total number of pollutants for which the EPA has issued corresponding human health WQC. The majority of these pollutants are synthetic organic chemicals, including over two dozen known or suspected carcinogens and/or persistent bioaccumulators. Among the pollutants lacking state equivalents to EPA's Human Health: Organisms Only and "Human Health: Water & Organism" are benzo-a-pyrene and several other polycyclic aromatic hydrocarbons (PAHs), which are not only carcinogenic and bioaccumulative, but are also commonly found in urban stormwater. And, like phthalate esters, for which Mississippi also lacks human health-related criteria, PAHs are among those types of chemicals cited by numerous sources as likely endocrine disruptors. The state also lacks

human health criteria for heptachlor epoxide, hexachlorobenzene and methoxychlor – contaminants reported to be associated with suspended material in the Mississippi River.⁶⁶

In theory, the absence of a human health criterion for a pollutant might not be important in ensuring that people are protected from exposure (via ingestion of drinking water and/or aquatic organisms) to levels of that pollutant which would pose a significant risk. In particular, if the state has an acute and/or a chronic Fish and Wildlife criterion for the pollutant that has a lower criterion-concentration than the criterion of the EPA human health criteria for the pollutant of concern, attainment of the Fish and Wildlife criterion should ensure that waterbody levels of the pollutant would remain below those specified in EPA's human health criteria. However, this is not relevant to Mississippi because there are no pollutants for which the state is missing human health criteria but does have aquatic life (Fish and Wildlife) criteria.

Where state has adopted numeric criteria comparable to EPA's freshwater Fish and Wildlife WQC, the criterion-concentrations for two-thirds of these criteria are equal to the concentrations in the corresponding EPA criteria. The criterion-concentrations for the remaining WQC are lower than those in EPA's corresponding criteria. For the numeric salt water Fish and Wildlife criteria that Mississippi has adopted, the criterion-concentrations for the criteria of all but one pollutant, nickel, are the equal to concentrations of the corresponding EPA criteria.

Where they have been adopted, criteria involving human consumption of fish (or shellfish) tissue, labeled as Human Health: Organisms Only and Human Health: Water & Organisms, have the largest number of criterion-concentrations that are either higher or lower than EPA's corresponding values. Of these, there are more criteria with higher criterion-concentrations than EPA's than those with criterion-concentrations that are lower than EPA's.

As for the other two basic elements of numeric WQC – criterion-duration and criterion-frequency—Mississippi's regulations are essentially silent as to these factors regarding both its Fresh Water and Saltwater (Fish and Wildlife) criteria⁶⁷ and two categories of human health criteria (Human Health: Organisms and Human Health: Water and Organisms) presented in Table I of the WQS regulation. The state's four Public Water Supply criteria for toxics, to the contrary, have a clearly stated criterion-duration of just one second, as they are expressed as concentrations “not to be exceeded at any time.” As for majority of the state's human health criteria for toxics, the absence of any reference to a specific duration or any mention of a frequency could be read to indicate a criterion-duration of an instant, and a criterion-frequency of zero. The exception is Mississippi's four WQC for toxic substances applicable to Public Water Supply use, which have an explicit criterion-frequency of zero.

However, language in the state's regulations, including direct reference to EPA's aquatic life criteria development methodology for toxic chemicals, could be taken to imply a criterion-duration of 1 hour for Mississippi's acute Fish and Wildlife WQC for toxics and a criterion-duration of 96 hours (four day) for its chronic criteria for this use and type of chemical—the

⁶⁶ “Polychlorinated Biphenyls and other Synthetic Organic Contaminants Associated with Sediments and Fish in the Mississippi River” Colleen E. Rostad, et. al. Contained in U.S. Geological Survey Circular 1133, “Contaminants in the Mississippi River” (1995).

⁶⁷ Actually, Table 2 of the Mississippi WQS regulations presents only a set of criterion-concentrations. Lacking any reference to a criterion-duration and criterion-frequency, these are not complete WQC.

same criterion-durations EPA indicates for its acute and chronic aquatic life criteria, respectively. Further supporting this assumption is the fact that the procedure for developing new WQC for toxics related to aquatic life laid out in Section II.10.G specifies, in subsections (2)(a) and (2)(b), the one hour average concentration for acute criteria and the four-day average for chronic criteria. As for human health criteria, Section II.10.G also clearly bases the method for deriving its Human Health: Organisms and Human Health: Fish and Organisms WQC on EPA's methodology. Unfortunately, unlike its aquatic life WQC for toxics, EPA guidance is not consistent as to a criterion-duration for its human health criteria; hence, in the absence of mention of a criterion-duration for the human health WQC appearing in Table 2 of the Mississippi WQS regulations, a criterion-duration of an instant is assumed, in this report.

As to criterion-frequency for the WQC⁶⁸ in Table 2, the regulations are silent. However, the clear reference to EPA's aquatic life criteria as the basis for the state's Fish and Aquatic Life (Fresh Water and Salt Water) WQC for toxics could be taken to suggest application of EPA's criterion-frequency for its toxics aquatic life criteria—maximum of one excursion in any 3 year period—to Mississippi's Fish and Wildlife WQC for toxics. Unfortunately, unlike its aquatic life WQC for toxics, EPA guidance is silent as to an explicit criterion-frequency; hence, in the absence of mention of a criterion-frequency for the human health WQC appearing in Table 2 of the Mississippi WQS regulations, a criterion-frequency of zero is assumed, in this report.

As regards the degree of protection provided by a given EPA WQC for toxics pertaining to protection of aquatic life, assuming, as indicated above, that the criterion-durations and criterion-frequency for Mississippi's (Fresh Water and Salt Water) Fish and Wildlife criteria are the same as those for the corresponding EPA criteria (acute is one hour, once in three years; chronic is 96 hours, once in three years),⁶⁹ it is reasonable to conclude that the Mississippi acute and chronic Fish and Wildlife criteria for nickel, having higher criterion-concentrations than those of corresponding EPA WQC, are less protective than EPA's. And, those 20 acute criteria and 18 chronic criteria with criterion-concentrations identical to those of corresponding EPA WQC are equally protective as their EPA counterparts.

If, however, one took the absence of any mention of a criterion-duration with regard to the state's Fish and Wildlife WQC to imply a criterion-duration of an instant, but continued to assume the criterion-frequency were the same as EPA's (maximum of one in three years) then any of the state's criteria for this use that had a criterion-concentration equal to or lower than that of the corresponding EPA criterion would definitely provide a higher level of protection to communities of aquatic life than would the EPA criterion. If also, one changed the assumed state criterion-frequency from once in three years to zero, this would render the Mississippi Fish and Wildlife criteria with criterion-concentrations equal to or lower than those in EPA's WQC even more protective, in relation to those of the federal agency.

If, on the other hand, the criterion-duration for the state's acute Fish and Wildlife criteria for toxics were assumed to be longer than the one hour for EPA's, but the criterion-frequency were assumed to be the same, this would tend to make the state's criteria less protective in general than if the duration were either an instant, or one hour. Assumption of a longer criterion-

⁶⁸ Id.

⁶⁹ See discussion of duration and frequency for toxics in Section D(3) and D(4) above.

duration, e.g., 12 hours, would also make it difficult to know, by just looking at the WQC themselves, whether a state acute Fish and Wildlife WQC for a toxic substance with a criterion-concentration lower than that of the corresponding EPA WQC would be more or less protective than EPA's aquatic life criterion. It would be hard to know whether the more-protective effect of the lower criterion-concentration would be offset by the longer criterion-duration, without having data on the toxic effects of a given pollutant at the concentration equal to that specified by Mississippi's WQC, for an exposure period equal to 12 hours. On the other hand, state WQC with a criterion-concentration equal to, or greater than that of the corresponding EPA WQC would definitely provide less protection than the EPA criterion. (See Appendix C for a listing of various combinations of higher and lower concentrations, shorter and longer durations, and lower and higher frequencies as to their relative degree of protection.)

Another consideration with regard to aquatic life WQC is that there could be state-specific, watershed-specific, or even waterbody-specific reasons (differences in water column chemistry, temperature, stream flow patterns, resident species of aquatic life) that a state criterion can have a criterion-concentration higher or lower than that for the corresponding U S EPA criterion and still provide aquatic life protection equal to that for which the EPA WQC was designed. This would not, however, mean that the two criteria would provide equal levels of protection to the relevant use. If, for example, a state's criterion-concentration were higher than EPA's, while the duration and frequency for the two WQC were identical, then the state's criteria would provide a lower degree of protection relative to that which would be provided by adoption of EPA's criterion as a state WQC for the waterbody in question. Nevertheless, site-specific conditions could have resulted in EPA's WQC providing an even higher level of protection than that for which EPA designed it. The effect of the state's higher criterion-concentration would be to bring the level of protection back down to that intended by EPA.

As to the degree of protection provided by Mississippi's WQC for toxics pertaining to human health protection (Human Health: Organisms; Human Health, Water and Organisms, and Public Water Supply), as previously noted, lack of clarity regarding any of the three elements of a numeric water quality criteria makes judgments about the relative level of protection provided by one criterion versus another impossible. This is doubly true with regard to Mississippi's and EPA's criteria for: a) consumption of fish and other aquatic organisms—Human Health: Organisms Only, and b) consumption of fish/other aquatic organisms and drinking water, because neither Mississippi nor the federal agency have clearly specified criterion-durations or criterion-frequencies. Since any attempt to discern the relative protectiveness of a state versus EPA WQC would require making assumptions about the criterion-durations and criterion-frequencies for each of the two WQC, whatever would be said about level of protection would inherently be burdened by uncertainty.

An exception to this situation is presented by the four WQC for toxic chemicals for Mississippi's Public Water Supply designated use, which are expressed as pollutant levels "not to be exceeded at any time." This wording indicates a criterion-duration of an instant and a criterion-frequency of zero. Since the standards established by the federal Safe Drinking Water Act are implemented in such a way as to create a de facto duration of 12 months, the state's instantaneous criterion-duration is much shorter than EPA's. Both the state's WQC and EPA's drinking water standards make no mention of a frequency, which implies a zero frequency. This

combination--same frequency, and an apparently much shorter state duration, means that the Mississippi Public Water Supply WQC for barium, lead, and nitrate would seem to provide a higher level of protection from than the somewhat corresponding EPA standard. And, since the state's WQC for fluoride has a lower criterion-concentration than the EPA drinking water standard, it too would appear, based just on looking at the concentration, duration, and frequency of the state's WQC versus the EPA standard, to be more protective. Finally, the fact that the state's WQC applies to the raw water drawn from a river or lake, while EPA's drinking water standards apply to the "finished" drinking that a drinking water supply sends to its customers would provide yet another degree of protection for those who consume water from a public water supply system, assuming the treatment to which the raw water would remove at least some of the pollutant in the raw water.

Going back to the remainder of the state's human health WQC (Human Health: Organisms; Human Health: Water and Organisms), if one assumes that the state and EPA for a given pollutant have identical criterion-durations and identical criterion-frequency—whatever each of those might be, then comparison of the state and EPA criterion-concentrations would be indicative of the relative degree of protection provided. Hence, the five pollutants for which the Mississippi Human Health: Organisms criteria have criterion-concentrations lower than that of the EPA criteria would provide more protection to people who consume fish and other aquatic life taken from a waterbody in the state than would the EPA criterion; while the 14 state WQC with a criterion-concentrations higher than the concentration of the corresponding EPA WQC would provide less protection than the EPA criterion. Turning to Human Health: Water and Organisms criteria, the six criteria with state WQC having criterion-concentrations than the EPA WQC would provide a higher level of protection than the federal agency's criterion; the one WQC with identical state and EPA criterion-concentrations would provide the same level of protection; and the 14 state WQC with a higher criterion-concentration than EPA's WQC would offer a lower degree of protection.

Among the toxic pollutants with higher state criterion-concentrations than the EPA's, several are highly bioaccumulative (e.g., aldrin, DDT, dieldrin, dioxin, endrin, heptachlor, and toxaphene). One possible explanation for this pattern is that, according to Section II .10.G. (2)(e)(i) of the Mississippi WQS regulations, when calculating fish consumption-related criteria (HHO and HHWO), the state assumed a fish consumption rate of 6.5 grams/person-day – a rate considerably lower than the 17.5 grams per day rate utilized by EPA. Use of a fish consumption rate lower than that employed by EPA would lead to higher criterion-concentrations.

The Mississippi WQS regulations do include the following caveat, "alternative FCR (fish consumption rate) values may be used when it is considered necessary to protect localized populations which may be consuming fish at a higher rate." However, nothing indicating application of this provision appears in the WQS regulations – that is, there seem to be no site-specific HHO or HHWO criteria for any bioaccumulative pollutants. Criterion-concentrations lower than EPA's would be needed to protect persons engaging in subsistence fishing on a given waterbody, given that such persons typically consume locally-caught aquatic organisms at a considerably higher rate than the national average of 17.5 grams/day employed by EPA.

Finally, returning to the problem of the lack of clearly-stated criterion-durations and criterion-frequencies, this not only complicates efforts to determine relative degree of protection provided by one WQC as compared to another, but also can result in lack of consistency in the application of Clean Water Act programs that are “driven by” water quality criteria. For instance, if one assumes that the criterion-duration for Mississippi’s Human Health: Organisms criteria is an instant and the criterion-frequency is zero, then any waterbody from which just one valid (meets QA/QC requirements/guidelines) grab sample, out of several such samples, with a concentration of a pollutant higher than the criterion-concentration should be included in the state’s Section 303(d) list. On the other hand, if the criterion-duration the criteria were 365 days, then exceedence of WQC would *not* be indicated by having just one sample out of a number collected over any 365 day period with a concentration above the criterion-concentration. In this latter case, the appropriate determinant of criterion exceedence would be having a set of samples collected over some 365-day periods with an *average* concentration higher than the criterion-concentration (assuming the criterion-frequency is zero).

Other possible ways in which different outcomes could result from different assumptions regarding the criterion-duration for the state’s human health criteria could be manifested in the TMDL and NPDES programs. For instance, it would seem that meeting TMDL wasteload allocation or an NPDES permit limit of “no higher than 10 µg/L for an instant, at any time” would be considerably more difficult, and presumably more expensive, than keeping the 365 day average concentration at or below 10 µg/L.

Appendix A

Missing and Extra Criteria for Conventional Pollutants: MISSISSIPPI

Table 1 - Aquatic Life

i) MISSING⁷⁰ POLLUTANTS

	ACUTE	CHRONIC
fresh water	calcium carbonate chloride	chlorophyll a chloride dissolved gases hydrogen sulfide nitrogen (total) phosphorous (total). turbidity (NTU) ⁷¹ turbidity (Secchi)

ii) EXTRA⁷² POLLUTANTS

	ACUTE	CHRONIC
fresh water	fecal coliform (total dissolved) solids temperature	dissolved oxygen fecal coliform (total dissolved) solids temperature ⁷³
coastal/marine	---	---

⁷⁰ For the purposes of this review, “missing pollutants” are, for a given designated use, those pollutants for which the state has not formally proposed – nor officially adopted – WQC, whereas EPA has published recommended WQC of the type specified.

⁷¹ EPA’s criterion for this pollutant is numeric, whereas Mississippi’s criterion is “quasi-numeric.” (For the purposes of this study, WQC expressed in terms of a certain change from background conditions, rather than a specified single value).

⁷² For the purposes of this review, “extra pollutants” are those pollutants for which the state has formally proposed or officially adopted WQC while EPA has not published recommended WQC of the type specified.

⁷³ EPA has neither numeric nor quasi-numeric criteria – only narrative criteria. Mississippi has “quasi-numeric” criteria.

Table 2 - Drinking Water Supply⁷⁴

MISSING POLLUTANTS

ACUTE

CHRONIC

chloride
color
foaming agents
odor
pH
(total dissolved) solids
sulfate

ii) EXTRA POLLUTANTS

ACUTE

CHRONIC

chloride
odor
(total dissolved) solids
specific conductance

fecal coliform

Table 3 - Water-Based Recreation

i) MISSING POLLUTANTS

ACUTE

CHRONIC

fresh water

E. coli
Enterococci

coastal/marine

ii) EXTRA POLLUTANTS

ACUTE

CHRONIC

fresh/coastal/marine

(dissolved) solids
specific conductance

(dissolved) solids

⁷⁴ EPA lacks actual drinking water supply criteria for conventional pollutants – specification of the levels of contaminants in surface waters being used as a raw water supply by public drinking water systems. The only EPA standards with regard to ensuring safe levels of contaminants in drinking water apply to “finished” water – that which results from raw water being passed through a treatment system aimed at removing contaminants to the degree practicable.

Appendix B

Table 1

	Aquatic Life Protection - Freshwater		Aquatic Life Protection - Salt Water	
	<i>Acute</i>	<i>Chronic</i>	<i>Acute</i>	<i>Chronic</i>
MISSING POLLUTANTS – Pollutants for which EPA Has Adopted WQC where Mississippi Has Not	Aluminum Arsenic ⁷⁵ Chlorpyrifos Diazinon Heptachlor Epoxide Mercury Nonylphenol Parathion Tributyltin	4,4'-DDT Aluminum Arsenic Chlorpyrifos Demeton Diazinon Guthion Heptachlor Epoxide Iron Malathion Mercury Methoxychlor Mirex Nonylphenol Parathion Tributyltin	Arsenic Chlorpyrifos Diazinon Heptachlor Epoxide Mercury Nonylphenol Tributyltin	Arsenic Chlorpyrifos Demeton Diazinon Di-n-Butyl Phthalate Guthion Heptachlor Epoxide Malathion Manganese Mercury Methoxychlor Mirex Nonylphenol Tributyltin

⁷⁵ Arsenic is listed as missing because Mississippi has no acute criterion for this form of the substance, while EPA does. On the other hand, the state has a criterion for arsenic (III), which is listed as “extra” because EPA does not have a corresponding criterion for this form of arsenic.

Table 2

	Human Health	
	<i>Water and Organism</i>	<i>Organism Only</i>
MISSING POLLUTANTS – Pollutants for which EPA Has Adopted WQC where Mississippi Has Not	1,1,2,2-Tetrachloroethane 1,1,2-Trichloroethane 1,1-Dichloroethylene 1,2,4-Trichlorobenzene 1,2-Dichlorobenzene 1,2-Dichloroethane 1,2-Dichloropropane 1,2-Diphenylhydrazine 1,2-Trans-Dichloroethylene 1,3-Dichlorobenzene 1,3-Dichloropropene 1,4-Dichlorobenzene 2,3,7,8-TCDD (Dioxin) 2,4,6-Trichlorophenol 2,4-Dichlorophenol 2,4-Dimethylphenol 2,4-Dinitrophenol 2,4-Dinitrotoluene 2-Chloronaphthalene 2-Chlorophenol 2-Methyl-4,6-Dinitrophenol 3,3'-Dichlorobenzidine 4,4'-DDD 4,4'-DDE Acenaphthene Acrolein Acrylonitrile alpha-BHC Anthracene Antimony Asbestos Barium Benzene Benzidine Benzo(a)Anthracene Benzo(a)Pyrene Benzo(b)Fluoranthene Benzo(k)Fluoranthene beta-BHC Bis(2-Chloroethyl)Ether Bis(2-Chloroisopropyl)Ether Bis(2-Ethylhexyl)Phthalate Bromoform Butylbenzyl Phthalate Carbon Tetrachloride	1,1,2,2-Tetrachloroethane 1,1,2-Trichloroethane 1,1-Dichloroethylene 1,2,4-Trichlorobenzene 1,2-Dichlorobenzene 1,2-Dichloroethane 1,2-Dichloropropane 1,2-Diphenylhydrazine 1,2-Trans-Dichloroethylene 1,3-Dichlorobenzene 1,3-Dichloropropene 1,4-Dichlorobenzene 2,3,7,8-TCDD (Dioxin) 2,4,6-Trichlorophenol 2,4-Dichlorophenol 2,4-Dimethylphenol 2,4-Dinitrophenol 2,4-Dinitrotoluene 2-Chloronaphthalene 2-Chlorophenol 2-Methyl-4,6-Dinitrophenol 3,3'-Dichlorobenzidine 4,4'-DDD 4,4'-DDE Acenaphthene Acrolein Acrylonitrile alpha-BHC Anthracene Antimony Benzene Benzidine Benzo(a)Anthracene Benzo(a)Pyrene Benzo(b)Fluoranthene Benzo(k)Fluoranthene beta-BHC Bis(2-Chloroethyl)Ether Bis(2-Chloroisopropyl)Ether Bis(2-Ethylhexyl)Phthalate Bromoform Butylbenzyl Phthalate Carbon Tetrachloride Chlorobenzene Chlorodibromomethane

Table 2 (cont. on next page)

	Human Health		
	<i>Water and Organism</i>	<i>Organism Only</i>	
MISSING POLLUTANTS – Pollutants for which EPA Has Adopted WQC where Mississippi Has Not	Chlorobenzene	Chloroform	
	Chlorodibromomethane	Chrysene	
	Chloroform	Dibenzo(a,h)Anthracene	
	Chlorophenoxy Herbicide (2,4,5,-TP)	Dichlorobromomethane	
	Chlorophenoxy Herbicide (2,4-D)	Diethyl Phthalate	
	Chrysene	Dimethyl Phthalate	
	Dibenzo(a,h)Anthracene	Di-n-Butyl Phthalate	
	Dichlorobromomethane	Dinitrophenols	
	Diethyl Phthalate	Endrin Aldehyde	
	Dimethyl Phthalate	Ether, Bis(Chloromethyl)	
	Di-n-Butyl Phthalate	Ethylbenzene	
	Dinitrophenols	Fluoranthene	
	Endrin Aldehyde	Fluorene	
	Ether, Bis(Chloromethyl)	Heptachlor Epoxide	
	Ethylbenzene	Hexachlorobenzene	
	Fluoranthene	Hexachlorobutadiene	
	Fluorene	Hexachlorocyclo-hexane-Technical	
	Heptachlor Epoxide	Hexachlorocyclopentadiene	
	Hexachlorobenzene	Hexachloroethane	
	Hexachlorobutadiene	Ideno(1,2,3-cd)Pyrene	
	Hexachlorocyclo-hexane-Technical	Isophorone	
	Hexachlorocyclopentadiene	Manganese	
	Hexachloroethane	Methyl Bromide	
	Ideno(1,2,3-cd)Pyrene	Methylene Chloride	
	Iron	Methylmercury ⁷⁶	
	Isophorone	Nitrobenzene	
	Manganese	Nitrosamines	
	Methoxychlor	Nitrosodibutylamine,N	
	Methyl Bromide	Nitrosodiethylamine,N	
	Methylene Chloride	Nitrosopyrrolidine,N	
	Nitrobenzene	N-Nitrosodimethylamine	
	Nitrosamines	N-Nitrosodi-n-Propylamine	
	Nitrosodibutylamine,N	N-Nitrosodiphenylamine	
	Nitrosodiethylamine,N	Pentachlorobenzene	
	Nitrosopyrrolidine,N	Pyrene	
	N-Nitrosodimethylamine	Tetrachlorobenzene,1,2,4,5-	
	N-Nitrosodi-n-Propylamine	Tetrachloroethylene	
	Pyrene	Trichloroethylene	
	Tetrachlorobenzene,1,2,4,5-	Trichlorophenol,2,4,5-	
	Tetrachloroethylene	Vinyl Chloride	
	Thallium		
	Toluene		
	Trichloroethylene		
	Trichlorophenol,2,4,5-		
	Vinyl Chloride		
	Total # of Pollutants	92	87

⁷⁶ While EPA does not have a criterion for “mercury” as does Mississippi, it has issued a “Human Health: Organisms Only” WQC for methyl mercury. For purposes of this report, these are counted as different pollutants. Because of this, “methyl mercury” is included in the list of pollutants for which Mississippi does not have HHO criteria, while “mercury” is on the list of “extra” criteria.

Note: Several of the PCBs listed in this table are actually congeners or isomers of total PCBs. They are counted as individual pollutants for the purpose of this review. EPA, on the other hand, has just one WQC for this set of chemicals, expressed as total PCBs, which is counted herein as one pollutant/criterion.

Table 3

	Aquatic Life Protection - Freshwater		Aquatic Life Protection - Salt Water		Human Health	
	<i>Acute</i>	<i>Chronic</i>	<i>Acute</i>	<i>Chronic</i>	<i>Water and Organism</i>	<i>Organism Only</i>
EXTRA POLLUTANTS – Pollutants for which Mississippi Has Adopted WQC where EPA Has Not	Arsenic (III) Endosulfan Sulfate ⁷⁷ PCB 1016 PCB 1221 PCB 1232 PCB 1242 PCB 1248 PCB 1254 PCB 1260 Phenol	Arsenic (III) Endosulfan Sulfate ⁷⁸ gamma-BHC Phenol	Arsenic (III) Endosulfan Sulfate ⁷⁹ PCB 1016 PCB 1221 PCB 1232 PCB 1242 PCB 1248 PCB 1254 PCB 1260 Phenol	Arsenic (III) Endosulfan Sulfate ⁸⁰ Phenol	Cadmium Lead Mercury Silver	Cadmium Chromium (III) Chromium (VI) Copper Mercury ⁸¹

⁷⁷ While EPA does not have a criterion for “endosulfan sulfate” as does Mississippi, it has separate, though identical, *acute* and *chronic* freshwater aquatic life criteria for the alpha and beta forms of endosulfan.

⁷⁸ Id. at 9

⁷⁹ While EPA does not have a criterion for “endosulfan sulfate” as does Mississippi, it has separate, though identical, *acute* and *chronic* salt water aquatic life criteria for the alpha and beta forms of endosulfan.

⁸⁰ Id. at 11

⁸¹ While EPA does not have a criterion for “mercury” as does Mississippi, it has issued a “Human Health: Organisms Only” WQC for methyl mercury. For purposes of this report, these are counted as different pollutants. Because of this, “methyl mercury” is included in the list of pollutants for which Mississippi does not have HHO criteria, while “mercury” is on the list of “extra” criteria.

Table 4

	Human Health		Aquatic Life Protection - Fresh Water		Aquatic Life Protection – Salt Water	
	<i>Water and Organism</i>	<i>Organism Only</i>	<i>Acute</i>	<i>Chronic</i>	<i>Acute</i>	<i>Chronic</i>
Pollutants with a state criterion-concentration lower than that of EPA's	Copper gamma-BHC Nickel Phenol Selenium Zinc	gamma-BHC Nickel Phenol Selenium Zinc	Cadmium Chromium (III) Copper Lead Nickel Pentachlorophenol Silver Zinc	Cadmium Chromium (III) Copper Lead Nickel Pentachlorophenol Selenium Zinc	---	---

Table 5

	Human Health		Aquatic Life Protection - Fresh Water		Aquatic Life Protection – Salt Water	
	<i>Water and Organism</i>	<i>Organism Only</i>	<i>Acute</i>	<i>Chronic</i>	<i>Acute</i>	<i>Chronic</i>
Pollutants with a state criterion-concentration higher than that of EPA's	4,4'-DDT Aldrin alpha-Endosulfan Arsenic beta-Endosulfan Chlordane Cyanide Dieldrin Endosulfan Sulfate Endrin Heptachlor Pentachlorophenol PCBs (total) Toxaphene	4,4'-DDT Aldrin alpha-Endosulfan Arsenic beta-Endosulfan Chlordane Cyanide Dieldrin Endosulfan Sulfate Endrin Heptachlor Pentachlorophenol PCBs (total) Toxaphene	---	---	Cadmium Nickel	Nickel

Appendix C

SITUATIONS IN WHICH STATE WQC ARE CLEARLY LESS PROTECTIVE THAN EQUIVALENT EPA WQC

	Concentration	Duration	Frequency
State vs. EPAⁱ	higher	longer	higher
“ “ “	equal	longer	higher
“ “ “	higher	equal	higher
“ “ “	higher	longer	equal
“ “ “	higher	equal	equal
“ “ “	equal	equal	higher
“ “ “	equal	longer	equal

SITUATIONS IN WHICH STATE WQC ARE CLEARLY MORE PROTECTIVE THAN EQUIVALENT EPA WQC

	Concentration	Duration	Frequency
State vs. EPA	lower	shorter	lower
“ “ “	equal	shorter	lower
“ “ “	lower	equal	lower
“ “ “	lower	shorter	equal
“ “ “	lower	equal	equal
“ “ “	equal	equal	lower
“ “ “	equal	shorter	equal

SITUATIONS IN WHICH A COMPARATIVE LEVEL OF PROTECTION CANNOT BE DETERMINED BY SIMPLY LOOKING AT THE TWO CRITERIA

	Concentration	Duration	Frequency
State vs. EPA	lower	shorter	higher
“ “ “	equal	shorter	higher
“ “ “	lower	equal	higher
“ “ “	lower	longer	equal
“ “ “	higher	equal	lower
“ “ “	higher	shorter	equal
“ “ “	equal	longer	lower

ⁱ The state WQC's component (e.g., duration) compared to the component for corresponding EPA WQC.

The Environmental Law Institute (ELI) makes law work for people, places, and the planet. For nearly four decades, ELI has played a pivotal role in shaping the fields of environmental law, policy, and management, domestically and abroad. Today, ELI is an internationally recognized independent research and education center known for solving

problems and designing fair, creative, and sustainable approaches to implementation.

The Institute delivers timely, insightful, impartial analysis to opinion makers, including government officials, environmental and business leaders, academics, members of the environmental bar, and journalists. ELI serves as a clearinghouse and a town hall, providing common

ground for debate on important environmental issues.

The Institute's board of directors represents a balanced mix of leaders within the environmental profession. Support for ELI comes from individuals, foundations, government, corporations, law firms, and other sources.

Environmental Law Institute

2000 L Street, N.W., Suite 620

Washington, D.C. 20036

Telephone: (202) 939-3868

Fax: (202) 939-3868

www.eli.org



**ENVIRONMENTAL
LAW • INSTITUTE®**