THE PERFECT STORM FOR ALGAL BLOOMS IN ARIZONA

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I. INTRODUCTION

The necessity for clean, usable freshwater has led to countless battles, both physical[1] and legal.[2] Water serves religious purposes, can be aesthetically beautiful, and is the foundational resource behind all life, economic development and the environment. As Leonardo da Vinci so rightly put it: "[w]ater is the driving force of all nature."[3] Freshwater, however, is a finite, limited resource: 97.3 percent of the earth's water is saline; freshwater, a mere 2.7 percent.[4]

Despite water's paramountcy to all life, pollution and human-induced changes to ecosystems and the environment threaten to cloud and ruin much of the natural resource that is essential to our species' very existence. For example, the Great Pacific Garbage Patch,[5] is directly linked to certain unregulated water pollution practices. Similarly, the recent increase in algal blooms,[6] particularly cyanobacteria harmful algal blooms (CHABs), is a

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1. Wendy Barnaby, *Do Nations Go To War Over Water?*, 458 NATURE 282, 282–83 (2009); PETER H. GLEICK ET AL., *Water Conflict Chronology*, *in* THE WORLD'S WATER, 175–214 (Island Press, vol. 7, 2012).

2. This fact is particularly striking in the West. Mark Twain is believed to have remarked: "In the West, whiskey is for drinking and water is for fighting." It is also important to note that legal struggles over water do not quickly end. For example, the Little Colorado River Stream Adjudication is still ongoing, nearly 40 years after it started. *See* TRIBAL WATER RIGHTS 133 (John E. Thorson et al. eds., 2006).

3. L. PFISTER ET AL., LEONARDO DA VINCI'S WATER THEORY: ON THE ORIGIN AND FATE OF WATER, at vii (Int'l Ass'n of Hydrological Sci. 2009).

4. Suseela MR, *Bloom and Toxin Occurrence*, *in* 619 CYANOBACTERIAL HARMFUL ALGAL BLOOMS: STATE OF THE SCIENCE AND RESEARCH NEEDS 178, 178 (H. Kenneth Hudnell ed., 2008).

5. *Great Pacific Garbage Patch*, NAT'L GEOGRAPHIC http://education.nationalgeographic.com/education/encyclopedia/great-pacific-garbage-patch/?ar_a=1 (last visited Jan. 15, 2016).

6. Harmful Algal Blooms and Hypnoxia Research and Control, 33 U.S.C. §§ 4001–4009 (2014) [hereinafter the Amendments]; Kenneth Kilbert et al., *Legal Tools for Reducing Harmful Algal Blooms in Lake Erie*, 44 U. TOL. L. REV. 69, 69 (2012).

devastating result of humanity's often callous indifference towards the environment coupled with its failure to understand and accurately predict the cumulative impact of individual choices.

Algal blooms[7] are a menace to municipalities, states, provinces, and countries around the world and can occur in marine, estuarine, and freshwater ecosystems.[8] The unsightly, foul nuisance damages the ecosystem, kills animals, and can cause severe adverse effects on the human body.[9] In fact, scientists have called harmful algal blooms (HABs) "one of the most serious risks to human health in the 21st century."[10] It is therefore no secret that if certain practices are not limited or stopped altogether, the problem will only worsen.

For larger lakes suffering from the effects of HABs, such as Lake Erie and Lake Winnipeg, enacting proactive legislation to limit pollution can often be easier to accomplish than for smaller lakes. In these situations, widespread activism, deep pockets, broad health-impacts, and national pride overcome any local pressure against stringent regulations. For smaller lakes, however, state and local politicians must grab the legislative clean-up mop by the handle—something local lobbying and resident pressure can make tedious to accomplish. Because algal blooms have the potential to cause devastating damage to nearly any body of water, this paper will focus on applying larger lake's HAB regulatory regimes to the current situation in Arizona.

Arizona should implement procedures to efficiently prevent HABs from blooming and enact comprehensive management and monitoring guidelines in the event HABs do invade the state's waters. The policies, regulations and legislation protecting Lake Erie and Lake Winnipeg provide helpful guidance. This article will review these policies and suggest best practice methods and practical solutions that Arizona should implement before algal blooms harm the state's limited, yet essential surface water supply.

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7. In this paper, a distinction is drawn between "algal blooms," "HABs," and "CHABs." When referring to an algal bloom, the paper is referencing a bloom of non-toxic algae. When referencing an HAB, the paper is referring to a toxic algal bloom. Finally, when referring to a CHAB, the paper is referencing a specific form of HAB, that of cyanobacteria.

8. H. Kenneth Hudnell et al., *An Overview of the Interagency, International Symposium on Cyanobacterial Harmful Algal Blooms (ISOC-HAB): Advancing the Scientific Understanding of Freshwater Harmful Algal Blooms*, *in* 619 CYANOBACTERIAL HARMFUL ALGAL BLOOMS: STATE OF THE SCIENCE AND RESEARCH NEEDS, *supra* note 4, at 1, 1.

9. Kilbert et al., *supra* note 6, at 69.

10. Illona Gągała & Joanna Mankiewicz-Boczek, *The Natural Degradation of Microcystins (Cyanobacterial Hepatoxins) in Fresh Water—the Future of Modern Treatment Systems and Water Quality Improvement*, 21(5) POLISH J. ENVTL. STUD. 1125, 1125 (2012), http://www.pjoes.com/pdf/21.5/Pol.J.Environ.Stud.Vol.21.No.5.1125-1139.pdf.

II. HARMFUL ALGAL BLOOMS

HABs can cause millions of dollars of damage to a lake's local economy.[11] By foreclosing recreational activities such as swimming, boating and fishing; requiring exorbitant monitoring and clean-up expenses; negatively affecting aquaculture operations; increasing public health costs of illness; and limiting future uses with lingering impacts, HABs result in substantial financial losses.[12] But HABs are not just a by-product of human-induced environmental changes: these nuisance plants have bloomed for thousands of years.[13] Indeed, certain forms of algae are some of the oldest forms of plant life.[14] Yet, algal blooms and HABs have become an ever-increasing problem. This section provides an examination of HAB's causes, occurrences, routes of exposure, and effects.

A. The D.N.A. of an Algal Bloom

As a general matter, scientists categorize the various forms of algae into about a dozen groups, including green algae, golden-brown algae, and blue-green algae.[15] Alga is widely dispersed throughout the world and is likely present in every river, stream, and lake in the world.[16] In freshwater, blue-green blooms are the most common.[17] Each genre of algae is formed by different nutrients and has varying qualities,[18] the specifics of which go beyond the bounds of this paper. Suffice it to say, however, that several forms

11. *See* Brett Grosko, *Dead Zones and Harmful Algal Blooms*, 12 A.B.A. AGRIC. MGMT. COMMITTEE NEWSL., Jan. 2008, at 16, 17. ("While [HABs] do occur naturally, and have done so for millennia, it is thought humans are contributing to their increasing frequency.").

12. *Id.*

13. *Id.*; G.M. Hallegraeff, *A Review of Harmful Algal Blooms and Their Apparent Global Increase*, 32 PSYCHOL. REVS., no. 2, 1993, at 79, 81, http://www.researchgate.net/publication/243776284_A_Review_of_Harmful_Algal_Blooms_and_Their_Apparent_Global_Increase ("[H]armful algal blooms, in a strict sense, are completely natural phenomena which have occurred throughout recorded history . . . .").

14. *Blue-Green Algae (Cyanobacteria) and Water Quality Fact Sheet*, AUSTL. GOV'T DEP'T OF SUSTAINABILITY, ENV'T, WATER, POPULATION & CMTYS. 1, 1 (Nov. 2012), http://www.environment.gov.au/system/files/resources/5a8c0861-1d4c-424a-9bcd-ae9c4304fb5e/files/blue-green-algae-cyanobacteria-and-water-quality-fs.pdf (noting that blue-green algae is the oldest and simplest form of plant life).

15. *Id.*; *see* H. Kenneth Hudnell, *The State of U.S. Freshwater Harmful Algal Bloom Assessments, Policy and Legislation*, 55 TOXICON 1024, 1026 (2010), http://www.hablegislation.com/system/files/ToxiconPrint.pdf.

16. *Blue-Green Algae*, *supra* note 14, at 1.

17. Hudnell et al., *supra* note 8, at 1.

18. Gągała & Mankiewicz-Boczek, *supra* note 10, at 1130.

of algae, such as green algae, are generally not harmful to humans.[19] It is only certain other forms, such as golden-brown and blue-green algae, that produce toxic HABs which have adverse impacts on humans.[20] Blooms of blue-green algae, i.e., cyanobacteria, cause the most destructive HABs.[21]

HABs are defined by the Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2014 as "freshwater *phytoplankton* that proliferate to high concentrations, resulting in nuisance conditions or harmful impacts on marine or aquatic ecosystems, coastal communities, and human health through the production of toxic compounds or other biological, chemical, and physical impacts of the algae outbreak."[22] In other words, HABs are high growth episodes of poisonous or toxic algae in water bodies that can produce toxins, e.g., *microcystin*, that cause illness or death in humans, pets, or wildlife as a result of ingestion or contact.[23]

HABs often vary in appearance and can appear as foam, scum, or mats on a water's surface.[24] The frequency and severity of HABs has increased considerably across the United States in recent years, causing a nationwide problem.[25] HABs have also formed with increasing regularity on an international basis, including in India,[26] the Baltic Sea,[27] South Korea,[28] Switzerland,[29] Hong Kong,[30] and China.[31] In fact, a massive algal bloom threatened the boating sports at the 2008 Summer Olympic Games in Beijing,

19. *Photo Gallery of Green and Blue-green Algae*, N.Y. ST. DEP'T OF ENVTL. CONSERVATION, http://www.dec.ny.gov/chemical/81962.html (last visted Jan. 15, 2016) ("Green algae . . . do not produce harmful toxins.").

20. Hudnell, *supra* note 15, at 1026.

21. *Id.*

22. The Amendments, *supra* note 6, § 4008 (emphasis added).

23. *Id.*; *see also* Kilbert, et al., *supra* note 6, at 69–70.

24. *Blue-green Algae Blooms*, NATIONAL PARK SERVICE, http://www.nps.gov/sacn/naturescience/blue-green-algae-blooms.htm (last visited Jan. 16, 2016).

25. The Amendments, *supra* note 6, § 4002; Kilbert et al., *supra* note 6, at 69.

26. *Algal Blooms Hit the Poor of India Hard*, SCIENCE DAILY (May 31, 2010), http://www.sciencedaily.com/releases/2010/05/100531082607.htm.

27. *The Plague of Toxic Algae*, COPERNICUS 1, 2 (Sept. 2013), http://www.copernicus.eu/sites/default/files/documents/Copernicus_Briefs/Copernicus_Brief_Issue8_AlgalBloom_Sep2013.pdf.

28. Grosko, *supra* note 11, at 17.

29. Erica Rex, *Harmful Algae Blooms Increase as Water Warms in the World's Major Lakes*, E&E PUBLISHING LLC (Jan. 8, 2013), http://www.eenews.net/stories/1059974425.

30. Grosko, *supra* note 11, at 17.

31. Zunxuan "Digger" Chen, *Tackling China's Water Pollution Problem: A Legal and Institutional Perspective From Taihu Lake Water Pollution Control*, 24 TEMP. J. SCI. TECH. & ENVTL. L. 325, 325–26 (2005).

China.[32] Though naturally occurring in the environment, human-induced changes have spurred algal bloom growth.

B. Natural and Human-Induced Causes of Algal Blooms

Algal blooms, including HABs, thrive in shallow, stagnant bodies of water.[33] High levels of nutrients, particularly nitrogen and phosphorus from agricultural, residential and industrial sources; warm water temperatures (>20˚ C); high light levels for photosynthesis; and calm or stagnant waters—or a combination of all four—help stimulate the overpopulation and reproduction of algae in the local ecosystem, forming an algal bloom.[34] The two essential nutrients for growth, phosphorus and nitrogen, are often a direct result of organic materials loading into a body of water from the surrounding watershed.[35] These two nutrients occur naturally in limited amounts, and this natural limitation acts to constrain the amount of plant and algal growth possible.[36] Nonetheless, human-induced loading coupled with external sources, such as pollen, terrestrial vegetation and non-native or invasive species, increase the levels of these nutrients in the water, stimulating rapid HAB growth.

As one of the primary nutrient drivers for algal growth, phosphorus is common in agricultural fertilizers, manure and organic wastes in sewage and industrial effluent.[37] The nutrient can enter water in urban and agricultural settings by attaching to soil particles and entering the water body via storm water runoff and soil erosion.[38] Phosphorus is an essential element for all plant life, but when too much is in the water, eutrophication accelerates.[39] Eutrophication is the reduction of dissolved oxygen in water bodies caused

32. Jim Yardley, *To Save Olympic Sailing Races, China Fights Algae*, N.Y. TIMES (July 1, 2008), http://www.nytimes.com/2008/07/01/world/asia/01algae.html?_r=0 (noting that more than 100,000 tons of algae had to be removed).

33. Hudnell, *supra* note 15, at 1028.

34. *See id.*

35. Gail Osherenko, *Understanding the Failure to Reduce Phosphorus Loading in Lake Champlain: Lessons for Governance*, 15 VT. J. ENVTL. L. 97, 101 (2014).

36. Daniel J. Conley et al., *Controlling Eutrophication: Nitrogen and Phosphorus*, SCIENCE, Feb. 20, 2009, at 1014, 1014, https://www.sciencemag.org/content/323/5917/1014.full.pdf.

37. Kilbert et al., *supra* note 6, at 69–71.

38. *See Testing the Waters: Sources of Beach Water Pollution*, NAT. RES. DEF. COUNCIL (2014), http://www.nrdc.org/water/oceans/ttw/2014/ttw2014_Sources_of_Beach_Pollution.pdf (last visited Jan. 16, 2016); *see also* Kilbert et al., *supra* note 6, at 70.

39. COMM. ON ENV'T AND NAT. RES., SCIENTIFIC ASSESSMENT OF HYPOXIA IN U.S. COASTAL WATERS 1 (Sept. 2010), https://www.whitehouse.gov/sites/default/files/microsites/ostp/hypoxia-report.pdf.

by an increase of mineral and organic nutrients.[40] Although the process occurs naturally over time, it usually requires centuries to have a significant effect on a body of water.[41] Unfortunately, human activities have amplified eutrophication's occurrence and rate,[42] hustling its process to culminate in less than a decade.[43]

Nitrogen is the other primary nutrient driver for algae growth. The element is naturally abundant in the environment but can also be introduced through sewage and fertilizers.[44] As a widely-practiced farming technique, chemical fertilizer or traditional animal manure is applied to crops to add nutrients to the soil.[45] In turn, the nitrogen in the fertilizer or manure finds its way into surface water through storm water runoff. Unfortunately, it can be unduly expensive to retain on site all nitrogen used by farms for feed or fertilizer and generated by animal manure.[46] Unless specialized structures are built, heavy rains will generate runoff, transporting these nutrients directly into nearby water bodies.[47] As an additional problem, wastewater-treatment facilities that do not specifically remove nitrogen can also result in retention of high levels of nitrogen in surface water.[48] Moreover, nitrogen can enter surface water through the atmosphere, which carries nitrogen-containing compounds, and through the oxidation of other forms of nitrogen, including nitrite, ammonia, and organic nitrogen compounds, such as amino acids.[49]

Agricultural activities are not the only land use that loads additional nutrients into a watershed. Other types of land use activities influence the watershed of a particular lake such as residential, industrial, water supply and wastewater treatment.[50] Residential land use activities vary widely and can include using lawn fertilizers, constructing hard surfaces on lands within the watershed (resulting in increased run-off into the surface water), burning leaves near a lakeshore, dumping leaves or other pollutants into storm drains,

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40. *Id.*

41. Edward Carney, *Relative Influence of Lake Age and Watershed Land Use on Trophic State and Water Quality of Artificial Lakes in Kansas*, 25 LAKE & RESERVOIR MGMT. 199, 199 (2008).

42. *See* COMM. ON ENV'T AND NAT. RES., *supra* note 39, at 1.

43. Carney, *supra* note 41, at 199.

44. *Nitrogen and Water*, U.S. GEOLOGICAL SURVEY (Aug. 7, 2015 1:58 PM), http://water.usgs.gov/edu/nitrogen.html.

45. *Id.*; *see also* Alyse Zadalis, *Kansas Growers and the Environmental Protection Agency: On the Same Side? A Look at Kansas' Implementation of the Surface Water Nutrient Reduction Plan*, 23 KAN. J.L. & PUB. POL'Y 381, 384 (2014).

46. U.S. GEOLOGICAL SURVEY, *supra* note 43.

47. *Id.*

48. *Id.*

49. *Id.*

50. *See generally* Sarah J. Meyland, *Land Use & the Protection of Drinking Water Supplies*, 10 PACE ENVTL. L. REV. 563, 592–600 (1993).

and removing vegetation from the land and near the water.[51] Industrial land use activities may include possible contamination of groundwater through discharges of chemical or thermal pollution.[52] Accordingly, a comprehensive approach is necessary for Arizona to effectively manage pollution as nutrients can be loaded into a watershed through several land uses.

C. Consequences and Effects

As can be seen, the proliferation of HAB's shares several characteristics with climate change. Like climate change, the main drivers of algal blooms, nitrogen and phosphorus, are naturally-occurring ones that are present in any normal ecosystem. The problem is that anthropogenic sources increase the concentration of the constituent to an unhealthy level—making something that is good for the environment ultimately hazardous. Moreover, as will be developed further,[53] much like climate change, there is no "one size fits all" solution that will effectively prevent algal blooms. Rather, several watershed-based factors must be considered in order to obstruct algal bloom formation.

As mentioned, certain forms of algae, such as green algae, are generally considered safe for human contact. Ancient cultures even consumed algae as a delicacy.[54] However, the physical effects that blue-green HABs, i.e., CHABs, can have on humans are daunting. CHABs produce neurotoxins, which affect the nervous system; hepatotoxins, which affect the liver; lipopolysaccharides, which affect the gastrointestinal system; and some even promote tumor development.[55] CHAB toxins have been linked to increases in liver cancer, chronic fatigue illness, skin rashes, abdominal cramps, nausea, diarrhea and vomiting.[56] Alarmingly, CHABs enter the body not only through direct contact with a bloom, but also through unknown exposure.[57] For example, CHAB toxins can pass through normal drinking water treatment processes, posing a hidden threat to humans and animals.[58] Moreover, water drawn from a source experiencing a CHAB could be sprayed on crops,

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51. *Id.* at 570 n.38.

52. *Id.* at 567–68.

53. *See infra* Part VII.

54. ANDREW NYAKUPFUKA, GLOBAL DELICACIES: DIVERSITY, EXOTIC, STRANGE, WEIRD, RELATIVISM 271(2013) (noting that in ancient China, eating algae was considered a delicacy).

55. Hallegraeff, *supra* note 13, at 81–82.

56. *Cyanobacteria and Algae Blooms*, CDC, http://www.cdc.gov/nceh/hsb/hab/default.htm (last visited Jan. 16, 2016); *see* Ian R. Falconer & Andrew R. Humpage, *Health Risk Assessment of Cyanobacterial (Blue-Green Algal) Toxins in Drinking Water*, 2 INT'L J. RES. & PUB. HEALTH, May 2005, at 43, 43, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3814695/.

57. Water Quality Standards for the State of Florida's Lakes and Flowing Waters, 75 Fed. Reg. 75762 (proposed Dec. 6, 2010) (to be codified at 40 C.F.R. pt. 131).

58. *Id.*

producing cyanotoxin-containing aerosols that could be inhaled by humans and animals.[59]

The effect of HABs on American's pocketbooks is equally alarming.[60] Over the past few decades, the total cost from fish kills, human illness and loss of tourism and fisheries revenue in the United States alone has been estimated at over one billion dollars annually,[61] with some estimates as high as $2.2 billion annually.[62] Additional financial harms include amplified drinking water treatment costs and losses sustained from diminished recreational water activities and depressed property values.[63]

HABs also impact the environment in which they develop. Specifically, HABs adversely impact aquatic life by out-competing other water-living organisms and depleting oxygen in the water, a process called hypoxia.[64] Notably, HABs can also cause serious harms to species' native habitats. At particular risk are habitats that are "biogenetically structured," such as coral reefs or seagrass beds.[65] While there are few reported cases of permanent species loss, this remains a possibility in smaller, localized ecosystems.[66]

Another effect HABs have on the environment is a substantial decrease in the water transparency.[67] Crystal clear waters are not only beautiful to behold, but necessary for underwater plant life: sunlight provides the energy for photosynthesis.[68] The penetration of sunlight into a body of water is determined by the water's transparency, which is inversely related to the amount of elements in the water.[69] Transparency correspondingly decreases as the amount of elements in the water increases.[70] Specifically, algal blooms reduce water clarity by absorbing sunlight that otherwise would pass through water. Alarmingly, water clarity in HAB infected water can often be less than one foot.[71]

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59. ADVANCING THE SCIENTIFIC UNDERSTANDING, *supra* note 8, at 6.

60. Zadalis, *supra* note 45, at 387.

61. The Amendments, *supra* note 6.

62. Walter K. Dodds et al., *Eutrophication of U.S. Freshwaters: Analysis of Potential Economic Damages*, 43 ENVTL. SCI. TECH. 12, 12 (2009), http://pubs.acs.org/doi/pdf/10.1021/es801217q.

63. *Id.*

64. Kilbert et al., *supra* note 6, at 69–72.

65. Id.

66. Id.

67. PowerPoint Presentation from Richard Sandford et al., Impacts of Eutrophication (on file with author).

68. *Id.*

69. Id.

70. *Id.*

71. *Blue-green Algae and Harmful Algal Blooms*, MINNESOTA POLLUTION CONTROL AGENCY (last updated Sept. 4, 2015), http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/lakes/blue-green-algae-and-harmful-algal-blooms.html.

D. Will Algal Blooms Continue to Bloom?

One might question whether algal bloom formation is just a natural environmental tendency that will biologically cease with time. Unfortunately, with a warming climate, rising carbon dioxide levels, dams on many rivers and overloading of nutrients into waterways, the magnitude and duration of HABs will only get worse.[72] The United States Federal Environmental Protection Agency (EPA) warns that "[t]he number of waters recognized as impaired is likely to increase, even if pollution levels [remain] stable."[73] That is because warmer atmospheric temperatures will lead to warmer water which holds less oxygen, thereby fostering HAB growth.[74] Warmer atmospheric temperatures will also increase the toxicity of some pollutants already in the water.[75] Several studies echo the EPA's ominous analysis, suggesting a relationship between climate and the magnitude, frequency, and duration of HABs.[76] In short, the quantity and duration of HABs does not appear to be decreasing anytime soon.

E. Role of the Federal Government

A national plan specifically targeting HABs and their toxins in marine and estuarine waters was developed by HARRNESS' *Harmful Algal Research and Response*.[77] Unfortunately, an analogous plan for freshwater HABs has

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72. Hallegraeff, *supra* note 13, at 89–91.

73. *National Water Program Strategy: Response to Climate Change*, EPA ii (Sept. 2008), http://www.allianceforwaterefficiency.org/uploadedFiles/Resource_Center/Library/water_resources/National-Water-Program-Strategy-Response-to-Climate%20Change.pdf.

74. *Id.* at 7–8.

75. *Id.* at ii.

76. Stephanie K. Moore et al., *Impacts of Climate Variability and Future Climate Change on Harmful Algal Blooms and Human Health*, 7 ENVTL. HEALTH 1, 2 (2008), http://www.ehjournal.net/content/7/S2/S4/. As explained by another resource, evidence indicates that climate warming may benefit some species of harmful cyanobactera by providing more optimal conditions for their growth. *Coastal Ecosystem Effects of Climate Change*, NAT'L CTRS. FOR COASTAL OCEAN SCI., http://coastalscience.noaa.gov/about/centers/cscor (last updated Apr. 28, 2015). The report explains that increasing temperature and CO2, either alone or in combination with nutrient availability, may determine the growth and relative abundance of HAB species. *Id.*; *see* Erik Jeppesen et al., *Climate Change Effects on Runoff, Catchment Phosphorus Loading and Lake Ecological State, and Potential Adaptations*, 38 J. ENVTL. QUAL. 1930, 1930 (2009), http://www.researchgate.net/publication/26764293_Climate_Change_Effects_on_Runoff_Phosphorus_Loading_and_Lake_Ecological_State_and_Potential_Adaptations (explaining that climate change impacts increase phosphorus loading in freshwater lakes).

77. *National Plan for Harmful Toxins and Harmful Algal Blooms*, ECOLOGICAL SOC'Y OF AM., http://www.esa.org/HARRNESS/ (last updated Oct. 4, 2005).

not yet been created.[78] The federal government has instead chosen to regulate certain types of freshwater pollution in a general manner, rather than implement customized policies targeted on HAB growth.

Before analyzing the federal government's role in regulating pollution, it is important to note the distinction between "point source" pollution and "nonpoint source" (NPS) pollution. Point source pollution is broadly defined to include pollution via "any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel [or] conduit. . . from which pollutants are or may be discharged."[79] Point sources include end-of-pipe discharges of effluent from publicly owned treatment works and industrial wastewater treatment plants,[80] in addition to discharges from home sewage treatment systems.[81]

In contrast to the relative certainty of point source pollution, the pollution origin of nonpoint sources is difficult to identify because the pollution cannot be traced back to one particular location. Rather, NPS pollution includes sediment, fertilizer, chemicals and animal wastes that have indirectly been loaded into the water from lawns, roads, highways, farms, fields, pastures, forests, construction sites, landfills, and mines.[82] Properly distinguishing point source and NPS pollution is critical to appreciating the federal government's regulatory role. While the federal government strongly regulates point source pollution, it has left NPS largely unregulated. Consequently, each state must develop its own requirements—legislative or otherwise—to fill the void.

F. The Clean Water Act

The Clean Water Act (CWA) is a broad, fundamental piece of legislation governing water quality in the United States.[83] The CWA rigorously regulates point source pollution, but provides only a cursory approach to regulate NPS pollution. In fact, "[c]ongress consciously distinguished between point source and NPS discharges, giving [the] EPA authority under the [CWA] to regulate only the former."[84] As one commentator noted, "[t]he CWA, despite its partial success in regulating pollution point sources, has done little to

78. Hudnell et al., *supra* note 8, at 2.
79. 33 U.S.C. § 1362(14) (2014).
80. *Id.* § 1342(4)(l)(2).
81. 40 C.F.R. § 122.1(b)(2) (2007).
82. *What is Nonpoint Source Pollution?*, EPA (last updated Jan. 5, 2016), http://water.epa.gov/polwaste/nps/whatis.cfm.
83. 33 U.S.C. § 1311 (2015).
84. Appalachian Power Co. v. Train, 545 F.2d 1351, 1373 (4th Cir. 1976).

control the non-point runoff of oil, fertilizers, and other substances that now poses 'the greatest pollution threat to our [nation's waters].'"[85]

As a general matter, the CWA broadly prohibits discharges of pollutants from point sources into waters of the United States, i.e., all *navigable waters*, without a permit.[86] The permitting system under the CWA is relatively straightforward. The CWA grants authority to the EPA—the agency charged with enforcing the CWA—to delegate to each state the authority to develop and enforce the National Pollutant Discharge Elimination System (NPDES).[87] The NPDES is a permit program that "controls water pollution by regulating point sources that discharge pollutants into waters of the United States."[88] The NPDES requires that an entity desiring to discharge a pollutant into the waters of the United States apply for and receive a permit specifying the amount that the entity is allowed to discharge.[89] Unpermitted discharges of pollutants from a point source or discharges of pollutants from a point source in excess of the limits set forth in a permit violate the CWA, subjecting the violator to penalties and a possible injunction.[90]

In regards to NPS pollution, a limited few CWA sections evidence a Congressional attempt to regulate NPS pollution.[91] Unfortunately, these provisions have fallen to systematic failure.[92] For example, in addition to the absence of provisions actually regulating NPS pollution, Sections 208 and 319 of the CWA fail to provide a citizen remedy from NPS pollution.[93] Consequently, when compared to the law governing point source pollution, the CWA's regime for NPS is far less "compulsory."[94] In fact, no federal law specifically regulates NPS pollution.[95] As a result, regulation of NPS pollutants on the federal level has been less effective than regulation of point

85. Brooke Glass O'Shea, *Watery Grave: Why International and Domestic Lawmakers Need to Do More to Protect Oceanic Species from Extinction*, 17 HASTINGS W.-N.W. J. ENVTL. L. & POL'Y 191, 227 (2011).

86. 33 U.S.C. § 1311(a) (2015).

87. *Id.* § 1314(a).

88. *NPDES Home*, EPA (last updated Jan. 16, 2016), http://water.epa.gov/polwaste/npdes/.

89. *Water Permitting 101*, OFF. OF WASTEWATER MGMT.-WATER PERMITTING 2, http://www.epa.gov/npdes/pubs/101pape.pdf (last visited Jan. 17, 2016).

90. 33 U.S.C. § 1319(a)(6)(b)–(c); Kilbert et al., *supra* note 6, at 71.

91. Endre Szalay, *Breathing Life into the Dead Zone: Can the Federal Common Law of Nuisance Be Used to Control Nonpoint Source Water Pollution*, 85 TUL. L. REV. 215, 238 (2010) (explaining that the CWA provisions are weak and do not do enough to regulate nonpoint source pollution).

92. *Id.*

93. *Id.*

94. Kilbert et al., *supra* note 6, at 72.

95. Hudnell et al., *supra* note 8, at 1 ("Currently there are no US Federal guidelines, Water Quality Criteria and Standards, or regulations concerning the management of harmful algal blooms").

source pollution, and the amount of pollutants entering lakes through nonpoint sources is far greater than the amount discharged from point sources.[96]

G. Nonpoint Source Management Program

Contrary to its approach to point source pollution, the CWA does not provide a permitting system or even a regulatory schema to control NPS pollution.[97] The CWA instead requires states to identify all waters for which point source limitations are insufficient to attain applicable quality standards under the total maximum daily load (TMDL) program.[98] States must establish a TMDL for pollutants identified by the EPA as suitable for TMDL calculation.[99] Under the CWA, states have the option to create TMDLs for specific nutrients, including phosphorus and nitrogen.[100] Section 1313(d)(2) requires each state to submit the waters identified and the loads established under paragraphs (d)(1)(A), (1)(B), (1)(C), and (1)(D) of this subsection to the EPA for its approval or disapproval.[101] If the EPA approves the list and TMDLs, the state must incorporate the list and TMDLs into its "continuing planning process."[102] The state then incorporates any EPA-approved list or TMDL into the state's continuing planning process.[103]

Through regulation drafting, the EPA has partially solidified the CWA's requirements. The regulations define "water quality limited segment[s]"—those waters that must be included on the Section 303(d)(1) list—as "[a]ny segment where it is known that water quality does not meet applicable water quality standards, and/or is not expected to meet applicable water quality standards, even after the application of the technology-based effluent limitations required by Sections 301(b) and 306."[104] The regulations then divide TMDLs into two types: "load allocations," for NPS pollution, and "wasteload allocations," for point source pollution.[105] Under the regulations, states must identify those waters on the Section 303(d)(1) lists as "still

96. *See e.g.*, Kilbert et al., *supra* note 6, at 72.

97. Hudnell et al., *supra* note 8, at 1; *supra* note 95 and accompanying text.

98. 33 U.S.C. § 1313(d) (2000).

99. *Id.* § 1313(d)(1)(D).

100. Dioxin/Organochlorine Ctr. v. Clarke, 57 F.3d 1517, 1520 (9th Cir. 1995) ("A TMDL defines the specified maximum amount of a pollutant which can be discharged or loaded into the waters at issue from all combined sources" (internal quotation marks omitted)).

101. 33 U.S.C. § 1313(d)(2).

102. *Id.* § 1313(e)(1)–(3).

103. *Id.*

104. 40 C.F.R. § 130.2(j) (2015).

105. *Id.* § 130.2(g)–(i).

requiring TMDLs" if any required effluent limitation or other pollution control requirement (including those for NPS pollution) will not bring the water into compliance with water quality standards.[106]

Under Section 319, funds and grants to control NPS pollution may be supplied to a state provided the state submits a report outlining: (1) which navigable waters have NPS pollution problems; (2) what the nonpoint sources are; (3) best management practices and measures to control the NPS pollution; and (4) state and local programs for controlling NPS pollution.[107] Pursuant to Section 319, Arizona received a total of $2,573,000 from the federal government in fiscal year 2013.[108] States also have the ability to receive technical assistance in creating, drafting, and implementing their NPS management program.[109]

The EPA recently issued new guidelines for state NPS management programs under Section 319 of the CWA.[110] The guidelines replaced the 2004 guidelines and took effect beginning fiscal year 2014.[111] The guidelines emphasize watershed project implementation in watersheds with impaired waters, provide increased accountability measures, and emphasize the importance of states updating their NPS management programs to ensure that Section 319 funds are used by the highest priority needs.[112]

One section of the new guidelines discusses watershed pilot projects.[113] Under the pertinent provisions, municipal entities or municipalities themselves can obtain "technical assistance" or "grants" for their efforts in preventing NPS pollution.[114] Specifically, the statute states that "[t]he Administrator, in coordination with the States, may provide technical assistance and grants to a municipality or municipal entity to carry out pilot projects relating to . . . Watershed partnerships: Efforts of municipalities and property owners to demonstrate cooperative ways to address nonpoint sources of pollution to reduce adverse impacts on water quality."[115]

Notably, Title VI of the CWA provides another means of funding for pollution control.[116] The Clean Water State Revolving Fund ("CWSRF") has

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106. *Id.* § 130.7(b).

107. 33 U.S.C. § 1329(a)–(b) (2015).

108. ARIZ. DEP'T ENVTL. QUALITY, NONPOINT SOURCE ANNUAL REPORT 6 (2013) https://www.azdeq.gov/environ/water/watershed/download/nonpoint2013.pdf.

109. 33 U.S.C. § 1329(f) (2015).

110. EPA, NONPOINT SOURCE PROGRAM AND GRANTS GUIDELINES FOR STATES AND TERRITORIES 1 (2013), http://water.epa.gov/polwaste/nps/upload/319-guidelines-fy14.pdf.

111. *Id.*

112. *Id.*

113. *Id.* at 37.

114. *Id.*

115. 33 U.S.C. § 1274 (2014).

116. EPA, *supra* note 110, at 12; *see* 33 U.S.C. § 1381(a)–(b) (2014).

provided nearly $275 million annually to control pollution, including NPS pollution.[117] The guidelines observe that while some states are using this source of funding effectively, most states do not.[118] Specifically, the EPA noted it "believes that the CWSRF is particularly well-suited to assisting in the implementation of NPS projects requiring capital investment. [Therefore, s]tates are encouraged to increase their use of these financial resources to help implement WBPs and other NPS projects."[119]

H. EPA Goes Rogue

When the EPA recognized the CWA did not go far enough to effectively combat NPS pollution, it decided to act. In 1998, the EPA developed the Clean Water Action Plan (CWAP),[120] which was signed by President William Clinton on February 19, 1998.[121] CWAP's primary objective was to manage the newest water pollution challenge facing the United States: NPS pollution.[122]

In order to meet this goal, the CWAP called on all levels of government to strengthen existing water quality measures and to formulate numeric nutrient criteria for nutrient discharges by the year 2000.[123] While this objective ultimately failed,[124] the EPA did formulate the National Strategy for the Development of Regional Nutrient Criteria (National Strategy), which describes EPA's approach to implementing CWAP's mandate.[125]

The National Strategy outlined a non-binding scheme that the EPA strongly urged states to follow when adopting numeric nutrient criteria.[126] The scheme consisted of a two-phase process: first, the EPA would develop guidance in the form of numerical nutrient ranges for various types of water regions and second, the states would adopt and incorporate into their water

117. EPA, *supra* note 110, at 12.

118. *Id.*

119. *Id.*

120. EPA, CLEAN WATER ACTION PLAN: RESTORING AND PROTECTING AMERICA'S WATERS (1998).

121. *President Clinton Announces the Clean Water Action Plan*, EPA (Feb. 19, 1998) http://www2.epa.gov/aboutepa/clean-water-action-plan.

122. *Id.*

123. *Id.*

124. For a detailed analysis discussing the reasons for the CWA's failure in this area, see Szalay, *supra* note 91, at 238–40.

125. EPA, NATIONAL STRATEGY FOR THE DEVELOPMENT OF REGIONAL NUTRIENT CRITERIA 5–15 (1998) http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/planningtmdls/amendments/estuarineNNE/EPA%201998%20National%20Strategy%20Document.pdf.

126. *Id.* at 1.

quality criteria the new numeric criteria.[127] These criteria therefore provided pollution thresholds with the goal of reducing nutrient levels in the water body. In 2008, the EPA published a ten-year report detailing the status of state water guidelines.[128] According to the report, Arizona's existing quality standards for nitrogen and phosphorus discharges into selected lakes/reservoirs and rivers/streams were already in-effect prior to the issuance of the National Strategy.[129]

I. Harmful Algal Blooms and Hypoxia Research and Control Amendments Act of 2014

The primary federal legislation specifically addressing HABs is the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA).[130] Originally passed in 1998 and reauthorized several times thereafter, HABHRCA was developed by Congress to tackle the growing threat of HABs in United States waters through research and study.[131] The main goal of HABHRCA is to increase scientific understanding of HABs and the ability to detect, monitor, assess and predict HABs.[132] Using this research, HABHRCA was designed to develop programs to prevent, control, and mitigate the environmental consequences of HABs.[133]

On June 30, 2014, President Obama signed the 2014 Amendments to the HABHRCA (the Amendments).[134] Among other things, the Amendments added Section 603A, establishing a "national harmful algal bloom and hypoxia program" to be formed during year 2014 and tasked with creating a statement of objectives for detecting, predicting, controlling, mitigating, and responding to HABs.[135] Furthermore, the Amendments require the EPA Administrator to: (1) research the ecology and impacts of freshwater harmful algal blooms; (2) forecast and monitor event response to freshwater harmful algal blooms in lakes, rivers, estuaries, and reservoirs; and (3) ensure that HABHRCA activities focus on new approaches to addressing freshwater

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127. *Id.* at 5–6.

128. *See generally* EPA, STATE ADOPTION OF NUMERIC NUTRIENT STANDARDS (1998–2008) 3 (2008), https://www.owrb.ok.gov/quality/standards/pdf_standards/scenicrivers/EPA%202008c.pdf.

129. *Id.* at A-6.

130. The Amendments, *supra* note 6, § 4002 .

131. *Id.* § 4003.

132. *Id.*

133. *Id.*

134. Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2014, S. 1254, 113th Cong. (2014) (enacted), https://www.govtrack.us/congress/bills/113/s1254/text.

135. *Id.* § 603A.

HABs and are not duplicative of existing research and development programs authorized by the HABHRCA or any other law.[136] While the Amendments focus primarily on research-based initiatives, they provide the first means of federal support specifically aimed at freshwater HABs.

Newly added Section 603B creates a "Comprehensive Research Plan and Action Strategy" (Action Strategy) which serves several purposes. First, the Action Strategy will streamline and coordinate existing HAB-prevention activities and develop an action strategy to help communities predict, control and mitigate freshwater HAB events.[137] Secondly, the Action Strategy intends to identify regional, state and local needs in prioritizing research and developing products and tools to aid decision making.[138] Finally, the Action Strategy will promote the transition of research products into implementable actions for regional, state, and local governments to prevent, monitor, and mitigate HAB events and to minimize any resulting economic, ecologic, and health impacts in their communities.[139]

In summary, HABHRCA will increase research and awareness of HABs. Like Section 319 of the CWA, however, it does not provide specific limits for NPS pollution. Nor does it provide enforcement mechanisms or even a private cause of action for citizens. Instead, the states are left to create, regulate, and enforce NPS pollution on their own.

J. Lake Erie

Lake Erie is one of the five Great Lakes and is the eleventh largest freshwater lake in the world by surface area.[140] Bordering Lake Erie's United States shores are Michigan, New York, Pennsylvania, and Ohio, while Ontario shapes Lake Erie's Canadian border. Lake Erie's port cities are some of the largest in the United States, including Detroit, Michigan; Cleveland, Ohio; Toledo, Ohio; and Buffalo, New York.

Lake Erie was plagued by HABs in the early 1970s.[141] Effective regulatory measures were soon implemented to resolve the problem.[142] Unfortunately, increased phosphorus loading from fertilizer applied to no-till soybean and

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136. *Id.*

137. *Id.* § 603B.

138. *Id.*

139. *Id.*

140. *Lake Erie Facts and Figures*, GREAT LAKES INFORMATION NETWORK, http://www.great-lakes.net/lakes/ref/eriefact.html (last updated Jan. 16, 2016).

141. Timothy T. Wynne et al., *NOAA Forecasts and Montiors Blooms of Toxic Cyanobacteria in Lake Erie*, CLEAR WATERS, Summer 2015, at 21, 21, http://www.glerl.noaa.gov/pubs/fulltext/2015/20150041.pdf.

142. *Id.*

corn fields, washed into streams and rivers by heavy rains, has caused HABs on Lake Erie to rage in recent years.[143] In 2013 and 2014, HABs on Lake Erie were especially treacherous: in 2014, nearly 500,000 people went without safe drinking water for several days due to the lake's toxicity.[144]

K. Regulatory and Statutory Approaches

There are four sources of water quality measures governing Lake Erie water: federal law, state law, international treaties, and compacts. Federal law relies substantially on the water quality measures incorporated in CWA[145] and a program called the Coastal Zone Management Act (CZMA). CZMA's objective is to control NPS pollution sources that effect coastal water quality.[146] Specifically, Section 6217(g) of CZMA calls upon states and tribes with federally approved coastal zone management programs to develop and implement coastal nonpoint pollution control programs.[147] The remainder of this section will outline various treaties, state laws and compacts that serve to protect Lake Erie's waters.

The 1978 U.S.-Canada Great Lakes Water Quality Agreement (the Agreement) was first signed in 1972, renewed in 1978, updated in 1987, and amended in 2012.[148] The Agreement was developed to express the United States and Canada's commitment "to restore and maintain the chemical, physical and biological integrity of the Waters of the Great Lakes."[149] The Agreement emphasized the policy that "coordinated planning processes and best management practices be developed and implemented by the respective

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143. *Researchers Track Lake Erie Algae Blooms*, USA TODAY (Sept. 13, 2007, 6:02 PM), http://usatoday30.usatoday.com/tech/science/2007-09-13-14954030_x.htm; The Windsor Star, *Lake Erie Undergoing 'Huge' Ecological Changes*, CANADA.COM (April 28, 2008), http://www.canada.com/windsorstar/story.html?id=c93bc013-1130-45fd-bd28-976a43b6374c&k=3267. According to the Ohio Lake Erie Phosphorus Task Force, the most significant Ohio contributor to phosphorus loading to Lake Erie today is storm-water runoff from agricultural activities. Kilbert et al., *supra* note 6, at 71–72.

144. George Tanber, *Toxin Leaves 500,000 in Northwest Ohio Without Drinking Water*, REUTERS (Aug. 2, 2014, 7:35 PM), http://www.reuters.com/article/2014/08/02/us-usa-water-ohio-idUSKBN0G20L120140802; *see also* D'Arcy Egan, *Lake Erie's Algal Blooms Intensively Studied on the Water, and from Space*, CLEVELAND.COM (Sept. 5, 2014, 4:37 PM) http://www.cleveland.com/outdoors/index.ssf/2014/09/lake_eries_algal_blooms_intens.html.

145. *See infra* Section III.

146. *Coastal Zone Management Act*, OFFICE OF COASTAL MGMT., https://coast.noaa.gov/czm/act/ (last visited Dec. 14, 2015).

147. 16 U.S.C. § 1455(g) (1990).

148. Great Lakes Water Quality Agreement, Can.-U.S., Sept. 7, 2012, http://binational.net/wp-content/uploads/2014/05/1094_Canada-USA-GLWQA-_e.pdf. [hereinafter Great Lakes Water Quality Agreement].

149. *Id.* at art. II.

jurisdictions to ensure adequate control of all sources of pollutants."[150] As a general objective regarding algal bloom growth, the countries agreed that the waters would be "[f]ree from materials and heat directly or indirectly entering the water as a result of human activity that alone, or in combination with other materials, will produce conditions that are toxic or harmful to human, animal, or aquatic life" and "free from nutrients directly or indirectly entering the waters as a result of human activity in amounts that create growths of aquatic life that interfere with beneficial uses."[151] Moreover, the Agreement created various standards for pollution from municipal sources, industrial sources, and agricultural, forestry and all other land use activities.[152] Importantly, the Agreement specifically required the creation of "[p]rograms and measures for the reduction and control of inputs of phosphorus and other nutrients."[153]

The Great Lakes-St. Lawrence River Basin Sustainable Water Resources Compact (the Compact) is composed of eight states and two Canadian provinces and was created to research and study the Great Lakes' ecosystems and waterways.[154] The goals of the Compact are to (1) promote development and conservation of the water resources of the Great Lakes Basin; (2) plan for the Basin states to derive the max benefit of the water; (3) plan for the welfare and development of the water; (4) advise in securing and maintaining a proper balance among uses of the water; and (5) establish an intergovernmental agency to effectuate these purposes.[155] Unfortunately, the Compact does not endow any authority to implement binding policies or statutes.[156] Rather, the parties' roles are merely advisory in nature.[157]

State efforts to prevent HABs in Lake Erie have varied across the lake's bordering states. For example, in Ohio, the Ohio EPA, Ohio Department of Natural Resources (ODNR), Ohio Department of Agriculture (ODA), and Ohio Department of Health (ODH) all play roles in regulating NPS pollution of phosphorus into Lake Erie and its tributaries under state statutory law.[158] Notably, due to increased concerns about HABs, the Ohio EPA created the Ohio Lake Erie Phosphorus Task Force in 2007 to identify and evaluate

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150. *Id.* at art. II, c.

151. *Id.* at art. III, d–e.

152. *Id.* at art. VI, a, b, e.

153. *Id.* at art. VI, d.

154. Great Lakes Basin Compact, Pub. L. No. 90-419, 82 Stat. 414 (1968).

155. *Id.* at art. II.

156. David B. Stouffer, *Toxic Waters: How Regional Businesses Can Respond to the Algal Bloom Crisis in the Great Lakes*, 9 OHIO ST. ENTREPRENEURIAL BUS. L.J. 233, 242 (2014).

157. *Id.*

158. OHIO EPA, OHIO NUTRIENT REDUCTION STRATEGY 2 (2013), http://epa.ohio.gov/Portals/35/wqs/ONRS_final_jun13.pdf (last visted Dec. 14, 2015).

sources of phosphorus loading into Lake Erie.[159] The Task Force issued its final report in April 2010, which discussed several point and nonpoint sources of phosphorus that likely contribute to HAB events in Lake Erie.[160]

L. "Canada's Sickest Lake": Lake Winnipeg, Manitoba[161]

1. Background

The United States' northern neighbor has also suffered negative consequences from algal blooms. In fact, Lake Winnipeg, located in the south-central region of Manitoba, Canada, has been deemed "Canada's Sickest Lake."[162] Lake Winnipeg covers 9,465 square miles making it the sixth largest freshwater lake in Canada, the third largest of which is entirely contained within Canada, and the world's 10th largest freshwater lake.[163] The lake's watershed measures 380,000 square miles and covers much of Alberta, Saskatchewan, Manitoba, Ontario, Minnesota, and North Dakota.[164] In comparison to other lakes its size, Lake Winnipeg is relatively shallow with a mean depth of only 39 feet.[165] Consequently, given the lake's large watershed and relatively small volume of water, events in the watershed can quickly change the lake's dynamic.[166] Thus, when nutrients overload the lake's watershed, the lake's ecosystem could change rapidly.

Between 1997 and 2007, the number of livestock in Manitoba increased by nearly 65 percent,[167] leading to a large increase in organic waste and use of that waste as fertilizer.[168] Due to climatic conditions and soil properties, Manitoban farmers historically applied fertilizers to their lands during winter

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159. Kilbert et al., *supra* note 6, at 71 (citing OHIO EPA, OHIO LAKE ERIE PHOSPHORUS TASK FORCE FINAL REPORT 11 (2010), http://www.epa.ohio.gov/portals/35/lakeerie/ptaskforce/Task_Force_Final_Executive_Summary_April_2010.pdf).

160. *Id.*

161. Nancy Macdonald, *Canada's Sickest Lake*, MACLEAN'S (Aug. 20, 2009), http://www.macleans.ca/society/life/canadas-sickest-lake/.

162. *Id.*

163. *Lake Winnipeg Quick Facts*, MANITOBA, http://www.gov.mb.ca/waterstewardship/water_quality/lake_winnipeg/facts.html (last visited Jan. 14, 2016).

164. *Id.*

165. *Id.*

166. *Id.*

167. SAFE DRINKING WATER FOUND., WATER POLLUTION 4, http://www.safewater.org/PDFS/resourcesknowthefacts/WaterPollution.pdf (last visited Jan. 14, 2016).

168. *Id.*

seasons.[169] Regrettably, this practice caused devastating impacts to Lake Winnipeg's watershed as seasonal runoff combined with torrential runoff events in the spring carried away winter fertilizer, loading nutrients in the streams and rivers that feed the lake.[170] In fact, Manitoba estimates that nearly two-thirds of the nitrogen and phosphorus loading of Lake Winnipeg from within Manitoba is contributed by runoff from the surrounding land.[171] In an effort to prevent such overloading, thousands of hectares of farmland in the Winnipeg area have been designed for efficient runoff to minimize flooding.[172]

Lake Winnipeg is no stranger to algal blooms. Reports from the 1930s described algal blooms in the lake, indicating that the lake produced blooms long before it received the sizable increase in phosphorus and nitrogen loading during the 1990s and 2000s.[173] Nonetheless, satellite pictures reveal that the size and frequency of the blooms have increased in recent years.[174] According to local reports, nearly 8,000 tons of phosphorus are loaded into Lake Winnipeg each year, but only a small fraction of that amount actually flows through and leaves the lake.[175] Due in large part to this phosphorus loading, the Global Nature Fund termed Lake Winnipeg its "Threatened Lake of the Year" in 2013.[176] Further, according to Conservation and Water Stewardship Minister, Gord Mackintosh and Infrastructure and Transportation Minister, Steve Ashton: "Manitoba faces three water woes: excessive nutrient loading of waterways that is harming Lake Winnipeg, damage from flooding and the risk of drought."[177] Mr. Ashton continued,

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169. *Id.*

170. *Id.*

171. PROVINCE OF MANITOBA, MANITOBA'S SURFACE WATER MANAGEMENT STRATEGY 9 http://gov.mb.ca/waterstewardship/questionnaires/surface_water_management/pdf/surface_water_strategy_final.pdf (last visited Jan. 14, 2016).

172. *Id.*

173. *State of Lake Winnipeg: 1999 to 2007*, ENV'T CAN. MANITOBA WATER STEWARDSHIP 129 (June 2011), http://www.manitoba.ca/waterstewardship/water_quality/state_lk_winnipeg_report/pdf/state_of_lake_winnipeg_rpt_technical_low_resolution.pdf.

174. Vicki Burns, *Satellite Pictures Show Reality of Algal Blooms on Lake Winnipeg*, H2O: IDEAS & ACTIONS FOR CANADA'S WATER (July 26, 2012), http://savelakewinnipeg.org/2012/07/26/satellite-pictures-show-reality-of-algal-blooms-on-lake-winnipeg/.

175. *Lake Facts*, LAKE WINNIPEG FOUND., http://www.lakewinnipegfoundation.org/lake-facts (last visited Jan. 16, 2016).

176. Randy Turner, *Lake Winnipeg Declared Threatened Lake of Year*, WINNIPEG FREE PRESS (Feb. 5, 2013), http://www.winnipegfreepress.com/local/lake-winnipeg-declared-threatened-lake-of-year-189778541.html.

177. Press Release, Province of Manitoba, Province Announces Manitoba's First Comprehensive Surface Water Management Strategy (June 11, 2014), http://news.gov.mb.ca/news/index.html?item=31346.

however, by noting that "[a]ll three can be mitigated with a new, sustainable approach to managing drainage and investing in flood control infrastructure."[178]

2. Regulatory Approaches

Responding to increased nutrient loading, Manitoba passed several pieces of legislation to regulate and minimize pollution into Lake Winnipeg. The Water Protection Act, C.C.S.M. c W65, promotes protection and conservation of watersheds.[179] Specifically, the Water Protection Act requires that a watershed management plan include objectives and policies respecting the prevention, control and abatement of water pollution, including wastewater and other point source discharges, and NPS pollution.[180] However, the Water Protection Act is similar to the United States' CWA in that it promotes best practices to contain NPS pollution, but it does not go far enough to actually create specific, enforceable water quality measures or pollution requirements.

A potentially landmark piece of Manitoban legislation regarding NPS pollution is its recent Surface Water Management Strategy (SWMS), which is currently open to public comment.[181] SWMS is part of Manitoba's Green Plan for the future, "TomorrowNow."[182] SWMS was designed as a multi-year, $320 million plan to specifically protect Lake Winnipeg from algal blooms.[183] The SWMS recognizes that significant reductions in nutrient loading and improvements in water quality can only manifest by adopting comprehensive management practices, not only for surface water, but also for the surrounding agricultural, industrial, and urban landscapes.[184] SWMS focuses on Manitoba's wetlands, reasoning that if the wetlands are properly maintained and preserved, Lake Winnipeg will, in turn, become healthier and less prone to HABs.[185] Wetlands act as a natural absorbent for many nutrients that cause HABs to flourish, such as phosphorus and nitrogen[186]—proper maintenance of wetlands is therefore crucial for a healthy ecosystem.

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178. *Id.*

179. Water Protection Act, C.C.S.M. c. W65 (Can.) (assented to June 16, 2005).

180. *Id.* § 16(1)(b)(ii).

181. PROVINCE OF MANITOBA, MANITOBA'S SURFACE WATER MANAGEMENT STRATEGY, http://www.manitoba.ca/conservation/waterstewardship/questionnaires/surface_water_management/pdf/surface_water_strategy_final.pdf (last visited Jan. 16, 2016).

182. *Id.*

183. Province of Manitoba, *supra* note 177.

184. PROVINCE OF MANITOBA, *supra* note 181, at 9–10.

185. *Id.* at 11.

186. *Id.* at 9.

To that end, SWMS suggests planting ecological biomass, such as cattails, which can absorb large amounts of phosphorus from the watershed (up to 20 kg/hectare).[187] "Processing the biomass for nutrient extraction, bioenergy, carbon offsets and/or biomaterial end-uses creates a very low-cost and potentially profitable method for nutrient management."[188] Secondly, SWMS also creates procedures for drainage.[189] Specifically, Manitoba is actively working with stakeholders regarding agricultural drainage to develop a new regulatory approach for drainage policies.[190] This new approach is designed to incorporate "an integrated watershed-based approach that will be implemented to better coordinate maintenance, consider the cumulative impacts of all types of existing drainage, and reduce downstream impacts such as erosion and degradation of water quality."[191]

In summary, SWMS will reduce nutrient loss from all sources by "strengthening existing regulatory, incentive and educational programs."[192] SWMS will provide a coordinated approach between the watershed and basin by using a holistic approach to land and water management. This approach will consider the impacts that land use decisions have on water and vice versa.

III. THE STATE OF THE SYSTEM: ARIZONA SURFACE WATER POLLUTION REGULATIONS

Arizona water law is extraordinarily complex and consists of statutes, compacts, treaties, administrative codes, and countless agency regulations. This section consequently provides only a brief background on water law in Arizona, the state's statutory law regarding NPS pollution, and a historical overview of algal blooms in Arizonan rivers, lakes, and waterways.

A. Background: Surface Water in Arizona

Arizona has over 120 lakes, yet only two are natural: Stoneman Lake, located about 30 miles south of Flagstaff, Arizona, and Mormon Lake, located within Coconino National Forest in northern Arizona.[193] The

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187. *Id.*
188. *Id.*
189. *Id.*
190. *Id.* at 10.
191. *Id.*
192. *Id.* at 12.
193. Clay Thompson, *Watery Truth: Arizona Has Lots of Lakes, but Only 2 Are Natural*, AZ CENT. (Sept. 13, 2007), http://www.azcentral.com/news/columns/articles/0913clay0913.html. Although it is considered a "natural lake," Stoneman Lake is not filled with water much of the year. *Id.*

remaining lakes are man-made reservoirs.[194] The largest reservoirs, lakes Mead, Powell, Mohave, and Havasu, are filled with Colorado River water,[195] while the others are filled by the Salt, Verde, and Gila rivers.

Several key points need to be underscored when addressing Arizona water's susceptibility to algal blooms. First, water levels in several of the largest Arizona lakes and reservoirs are plummeting, some, such as Lake Mead[196] and Lake Powell,[197] to all-time lows. Lower lake levels lead to warmer water temperatures and less water circulation: factors that promote algae growth.[198] Second, Arizona is located in a dry, arid climate and global warming will increase the state's notoriously warm temperatures, increasing water temperatures in turn.[199] Unfortunately, warm water is more apt to produce and maintain algae than colder water; this means that Arizona's HAB problem will continue to grow if left unchecked.[200] Third, Arizona is the eighth fastest growing state by population in the nation.[201] Population growth inevitably leads to more construction, and if not disposed of properly, construction materials and residue, especially near watersheds, lead to more nutrients entering the water,[202] spurring algae growth.[203] This problem is exacerbated if the areas surrounding the watershed are covered with hard

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194. *Id.*

195. *Park History*, LAKE POWELL, http://www.lakepowell.com/glen-canyon-history.aspx (last visited Dec. 18, 2015); *Colorado River and Lake Destinations*, DESERTUSA, http://www.desertusa.com/riverinfo/lake-and-river-destinations.html (last visted Jan. 16, 2016).

196. Lloyd Alter, *Will the Next War with Canada Be a Fight Over Water?*, TREEHUGGER (Aug. 25, 2014), http://www.treehugger.com/clean-water/will-next-war-canada-be-fight-over-water.html; Nathan Fey, *Lake Mead's Record Low Echoes in Colorado*, DENVER POST, http://www.denverpost.com/opinion/ci_26373402/lake-meads-record-low-echoes-colorado (last updated Aug. 21, 2014); *Water Level in Nevada's Lake Mead Drops to All-Time Lows*, USATODAY (July 10, 2014), http://www.usatoday.com/story/weather/2014/07/10/lake-mead-nevada-drought/12486313/.

197. *Water Summary*, LAKE POWELL WATER DATABASE, http://lakepowell.water-data.com/ (last visited Dec. 18, 2015).

198. James Murphy, *Factoring Climate Change into TMDLS: Pollution Budgets for a Warming World*, 25 NAT. RESOURCES & ENVTL. 53, 54 (2010) (citing NATIONAL WATER PROGRAM STRATEGY: RESPONSE TO CLIMATE CHANGE, EPA OFFICE OF WATER, EPA 800-R-08-001 (Sept. 2008)).

199. *Id.*

200. *Id.*

201. *The Ten Fastest-Growing U.S. States*, FORBES, http://www.forbes.com/pictures/mhj45mejl/8-arizona/ (last visited Dec. 18, 2015).

202. *Nonpoint Source Management Plan*, ARIZ. DEP'T OF ENVTL. QUALITY 1, http://www.azdeq.gov/environ/water/watershed/download/NPS_5yr_Plan_final.pdf (last visited Dec. 18, 2015).

203. *Prevention, Control and Mitigation of Harmful Algal Blooms: A Research Plan*, NAT'L SEA GRANT COLL. PROGRAM (Sept. 2001) http://www.whoi.edu/science/B/redtide/pertinentinfo/PCM_HAB_Research_Plan.

surfaces, such as cement or concrete.[204] Fourth, Arizona becomes littered with ash from raging summer wildfires, such as a fire in 2011 that burned over 733 square miles.[205] When this ash finds its way into streams, lakes and canals more nutrients are introduced into the surface water system. Finally, accompanying wildfires, Arizona summers are bookended by monsoons. A monsoon's heavy rains pick up and channel nutrients left behind on the land into the streams, rivers and canals that fill the reservoirs.

In summary, the environmental and human-induced factors in Arizona make its waters particularly susceptible to algal blooms. Nutrient loading is most prevalent in the summer season when wildfires and construction materials scatter large quantities of nutrients on the ground, only to be washed into warm streams and rivers by a monsoon's rains. Arizona's natural environment, therefore, makes regulation of nutrient loading even more critical.

B. Arizona Legislation

Mimicking the CWA's format, Arizona regulates point source and NPS pollution differently. Point source polluters in Arizona must be issued an Arizona Pollution Discharge Elimination System (AZDES) permit which is foundationally structured by the CWA.[206] In contrast, the Arizona administrative code does not require a permit for NPS pollution from an agricultural or silvicultural activity, such as storm water runoff from an orchard, cultivated crop, pasture, rangeland, or forest land.[207]

The Arizona Nonpoint Source Program is administered by the Arizona Department of Environmental Quality (ADEQ).[208] Among other tasks, ADEQ gathers information, monitors water quality trends, issues permits, and develops policy focusing on runoff from land use activities that impact surface water within Arizona.[209] ADEQ works with local stakeholder groups and land management agencies to develop complex plans in order to reduce

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204. *Id.* at 9.

205. *Arizona Wildfire May Be Biggest in State History*, USA TODAY (June 15, 2011), http://usatoday30.usatoday.com/weather/wildfires/2011-06-14-arizona-colorado-wildfires_n.htm.

206. ARIZ. REV. STAT. ANN. §§ 49-255.0 *et seq.* (2001); ARIZ. ADMIN. CODE § R18-9-A902 (2004).

207. ARIZ. ADMIN. CODE § R18-9-A902(G) (2004).

208. ARIZ. DEP'T OF ENVTL. QUALITY, *supra* note 202, at 1.

209. *What is ADEQ and What Do We Do for Arizona?*, ARIZ. DEP'T OF ENVTL. QUALITY, http://www.azdeq.gov/function/about/index.html (last visited Dec. 19, 2015).

sediment and nutrient loads from nonpoint sources and help impaired waters attain water quality standards.[210]

Currently, Arizona law remains silent on HABs. There are no enforceable state requirements to monitor for blue-green toxins or any regulatory limits on the quantity of toxins that are acceptable. Arizona has instead left the task of monitoring algal blooms, whether harmful or not, to local communities.[211] As noted by the water program coordinator for the Sierra Club Grand Canyon chapter, "the Clean Water Act is the only law that protects surface-water quality in Arizona."[212] And as discussed, the CWA does not regulate NPS pollution.[213]

Notably, Arizona statutes authorize the development of a regulatory program for NPS pollution discharges, which may incorporate, but does not require, enforceable mechanisms.[214] Enforcement mechanisms available under the statute include compliance orders, temporary restraining orders, preliminary injunctions, permanent injunctions, and court actions to recover civil penalties not to exceed $25,000 per day.[215]

Arizona recently embarked on a new "5-Year Nonpoint Source Management Plan" (NPS Management Plant) for fiscal years 2015 to 2019.[216] The NPS Management Plan integrates voluntary incentives with the state's Clean Water Act and Safe Drinking Water Act programs. To implement the plan, ADEQ uses a variety of tools, including surface and ground water monitoring, watershed inventories, watershed characterizations, TMDL studies, TMDL implementation plans, watershed-based plans, and water quality improvement projects.[217]

Interestingly, nuisance law also provides additional enforcement remedies in cases where a party can prove a specific health or environmental hazard. In Arizona, an environmental nuisance is the "creation or maintenance of a condition in the soil, air or water that causes or threatens to cause harm to the

210. *Id.*

211. ALGAE TASK FORCE, BLUE-GREEN ALGAL TOXINS MONITORING AND REPORTING PLAN 3 (2004), https://ndep.nv.gov/forum/docs/AlgaeReport/Algae_Task_Force_Blue_Green_Algal_Toxins_Monitoring_and_Reporting_Plan_July_2004.pdf.

212. Steve Pawlowski, *Clean Water Act is Remarkably Successful*, AZ CENT. (June 10, 2014), http://www.azcentral.com/story/opinion/op-ed/2014/06/10/clean-water-act-epa-arizona-pawlowski/10273883/.

213. *See infra* Section III, A.

214. *See* ARIZ. REV. STAT. ANN. § 49-203(A)(3) (2010).

215. *Id.* §§ 49-261 to -262.

216. *Water Quality Division: Watershed Management: Nonpoint Source Pollution Reduction*, ARIZ. DEP'T OF ENVTL. QUALITY, http://www.azdeq.gov/environ/water/watershed/nonpoint.html (last visited Dec. 19, 2015).

217. *Id.*

public health or the environment and that is not otherwise subject to regulation under this title."[218] Examples include "[t]he pollution or contamination of any domestic waters."[219] In these situations, the ADEQ Director can serve an abatement order, enforceable by the Superior Court.[220]

C. Historical Algae Problems in Arizona

Historically, the types of algal blooms seen in Arizona have been location-dependent: golden-brown in central Arizona and green in northern Arizona. In recent years, however, blue-green blooms have begun making appearances across the state. This section will provide a cursory overview of algal blooms impacting Arizonan lakes since 2000.

Lake Mead is the largest reservoir in the United States and is located on the northwestern corner of Arizona, forming the border between Arizona and Nevada. The lake is sustained by the Hoover Dam and is divided into several water bodies: Boulder Basin, the Narrows, Temple Basin, Gregg Basin, and Virgin Basin. The largest recent algal bloom in Lake Mead occurred in 2001, when the lake suffered an outbreak of the green-algae, *Pyramiclamys disecta*.[221] In response, Southern Nevada water authorities created the Algae Task Force (ATF) to study the bloom, determine the potential causes, and develop best practices to prevent further blooms.[222] ATF concluded that several elements contributed to the bloom, including (1) lower reservoir water levels, (2) heavy rains flushing the watershed causing nutrients to enter Lake Mead quickly and compactly, (3) increased construction activity, and (4) decreased water density resulting from a wide shallow area of the water body.[223]

Two other large Arizona lakes remain at risk of excessive algal bloom growth: Lake Havasu and Lake Powell. Lake Havasu is a large reservoir formed by Parker Dam on the Colorado River and serves as a portion of the

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218. ARIZ. REV. STAT. ANN. § 49-141 (1998).

219. *Id.* § 49-141(A)(6).

220. *Id.* § 49-142(C).

221. *Algae in Lake Mead*, S. NEV. WATER AUTH., http://www.snwa.com/wq/facts_algae.html (last visited Dec. 19, 2015); *The Lake Mead Algal Bloom of 2001*, NEV. DIV. OF ENVTL. PROT., http://ndep.nv.gov/forum/docs/AlgaeReport/LaBounty_2001_The_Lake_Mead_Algal_Bloom_of_2001.pdf (last visited Dec. 19, 2015).

222. *Toxic Algae Found in Small Amounts in Lake Mead*, LAS VEGAS SUN (Dec. 4, 2003, 9:40 AM), http://www.lasvegassun.com/news/2003/dec/04/toxic-algae-found-in-small-amounts-in-lake-mead/.

223. NEV. DIV. OF ENVTL. PROT., *supra* note 221; *see also* CLARK CTY. RECLAMATION DIST., LAKE MEAD WATER QUALITY FORUM ALGAE TASK FORCE UPDATE 18, https://ndep.nv.gov/forum/EcoMtg/LMWQF%20presentation%2010-22-2013.pdf ("Beware of warm spring rains.").

border between Arizona and California. According to Albert Graves, senior maintenance engineer of civil works for the Central Arizona Project (CAP), a serious problem for Lake Havasu in the near future will be the blue-green algae starting to appear on the lake.[224] Similarly, while not yet the victim of widespread algal blooms, Lake Powell, another reservoir forming the border between Arizona and Utah, could produce algal blooms in the near future due to the high levels of phosphorus and nitrogen in its waters.[225]

Other Arizonan lakes that have suffered from algal blooms in recent years include Lake Pleasant, where blue-green algae was identified in 2012;[226] Lake Watson;[227] Theodore Roosevelt Lake, where golden algae killed fish in 2012;[228] Saguaro Lake, where blue-green algae produced a fish die-off in 2004;[229] Apache Lake, where a fish die-off resulting from blue-green algae associated with wildfire ash washed into the lake's tributary, Gila River, occurred in 2004;[230] Canyon Lake, which has had several algae-related problems, including a fish die-off in 2004 caused by blue-green algae[231] and another blue-green algae outbreak in 2008 stimulated by dam maintenance and re-suspensions of subtrates that increased the nutrient load in the water;[232] and finally, a 20 mile stretch of the Salt River, which, in 2012, experienced a

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224. Colleen Svancara, *Invasive Quaggas 'Musseling' in on Arizona Territory*, UNIV. OF ARIZ. (May 10, 2011), http://swes.cals.arizona.edu/environmental_writing/stories/2011/svancara.html; Videotape: Colorado River Basin, http://100thmeridian.org/video/DMAM2011/DMAM2011_Videos/Interviews/Entries/2011/6/8_Al_Graves_-_Colorado_River_Basin.html.

225. *See* COMM. TO REVIEW THE GLEN CANYON ENVTL. STUDIES, RIVER RESOURCE MANAGEMENT IN THE GRAND CANYON 91 (1996), http://www.nap.edu/read/5148/chapter/8#91 ("[T]he total phosphorus load for Lake Powell is quite high.").

226. Water Control Dep't, *2012 Annual Water Quality Report*, CENT. ARIZ. PROJECT 33 (Aug. 2013) http://www.cap-az.com/documents/water-operations/quality-reports/2012_Annual_Water_Quality_Report.pdf.

227. Cindy Barks, *Algae Create Nuisance on Willow and Watson Lakes*, DAILY COURIER (July 5, 2010, 10:23 PM), http://www.dcourier.com/Main.asp?SectionID=1&SubSectionID=1&ArticleID=82919.

228. Darby Fitzgerald, *Algae Outbreak Killing Fish in Roosevelt Lake*, AZ CENT. (Sept. 26, 2012), http://www.azcentral.com/news/articles/20120926alga-outbreak-killing-fish-roosevelt-lake.html.

229. *Golden Alga Causes Fish Die-Off on Salt River*, AZ BASS ZONE (July 6, 2012), http://www.azbasszone.com/forums/showthread.php?t=127853&highlight=saguaro+lake+algae.

230. *Id.*; *Fish Kills in Arizona*, BIG FISH TACKLE, http://www.bigfishtackle.mobi/cgi-bin/bigfish.cgi?post=140913 (last visited Dec. 19, 2015); *New Data on Saguaro Fish Kill?*, AZ BASS ZONE (June 17, 2004, 5:29 PM), http://www.azbasszone.com/forums/archive/index.php/t-29485.html.

231. *Fish Kill Mystery at 3 Lakes Has Scientists Playing Detective*, AZ BASS ZONE (Feb. 10, 2005, 5:45 PM), http://www.azbasszone.com/forums/showthread.php?t=8188.

232. *Central Arizona*, ARIZ. GAME & FISH DEP'T (Aug. 6, 2008), http://www.azgfd.net/fish/central-arizona/central-arizona-37/2008/08/06/.

fish kill estimated in the thousands due to a golden algae outbreak that was stimulated by mountain storms washing wildfire ash and silt into the river system.[233]

There is no doubt that Arizonan lakes and river systems have experienced numerous algal bloom events and that they remain particularly susceptible to future blooms. According to Arizona State University researchers, cyanobacteria are well-adapted to live in central Arizona's lakes and canals due to the warm water and high nutrient load.[234] Consequently, central Arizona lakes and canals could be problematic areas particularly in late summer and early fall when the summer's warm, salty water allows cyanobacteria populations to accumulate.[235] Arizona should therefore implement systems to counteract these elements and prevent the formation of HABs.

IV. PROACTIVE METHODS ARIZONA SHOULD IMPLEMENT TO PREVENT ALGAL BLOOMS FROM FORMING

As outlined in Section II, *supra*, four primary factors spur algal bloom formation: (1) excessive nutrient loading, (2) warm water temperatures, (3) strong sunlight, and (4) stagnant water. Of these factors, only two present viable options for systematic intervention: nutrient loading and stagnant water. Outside of broad, global adjustments, water temperature is generally an impractical area in which a state could artificially intervene. Additionally, while water's access to sunlight is generally a foregone factor, some scientists suggest that by adding colorants to water bodies, the amount of light available for algal photosynthesis will decrease.[236] Nonetheless, the same scientists warn that colorants "indiscriminately inhibit beneficial and harmful algae, thereby adversely impacting aquatic ecosystems."[237] Accordingly, the two primary factors Arizona should actively regulate are nutrient loading and stagnant water.

The key for a state-based solution to succeed will be to effectively monitor and control NPS pollutants. As highlighted by the EPA, "NPS pollution continues to dominate water quality impairments throughout the United

233. Chelsey Davis, *Algae Outbreak Blamed for Dead Fish in Salt River*, AZ CENT. (July 7, 2012), http://www.azcentral.com/news/articles/2012/07/06/20120706arizona-dead-fish-found-salt-river-near-roosevelt-lake-abrk.html.

234. James Hathaway, *Ecology Study Makes Urban Water Cheaper, Taste Better*, ARIZ. ST. UNIV., http://www.asu.edu/news/research/urbanwater_042402.htm (last visited Dec. 19, 2015).

235. *Id.*

236. Hudnell, *supra* note 15, at 1028.

237. *Id.*

States."[238] The tenets of watershed management, e.g., focusing on the land area linked with the water body, utilizing progressive scientific information in the decision-making process, and stakeholder involvement throughout the process, are best-suited for the management and prevention of algal blooms.[239] Yet even with optimal watershed management, stagnant water will still compel algal growth. A fully integrated process is therefore required. To that end, Arizona should incorporate several components in a comprehensive watershed management plan to neutralize nutrient loading: (1) community involvement, (2) monetary incentives, (3) a statewide algae task force, and (4) modern technology.

A. Community Involvement

In order for Arizona to effectively control and monitor NPS pollutants, the communities located on and near watersheds must become educated on best practice methods and be willing to actively participate in the management plan. State agencies, such as the Arizona Department of Water Resources, the Arizona Game and Fish Department, and the Arizona Department of Agriculture, should work alongside local communities to reduce storm-water runoff. These agencies should encourage communities to incorporate agricultural practices that reduce soil erosion while maintaining high crop yields. To have clean waters, the architecture of agriculture must be consistent with that goal.

In order to reduce nutrient concentrations, Arizonans should implement several best practices, including: (1) applying lawn fertilizers only when and where truly needed; (2) preventing yard debris, e.g., leaves, animal waste, grass clippings and ash, from washing into storm drains by picking up the debris; (3) supporting local ordinances that require silt curtains for residential and commercial construction sites; (4) guiding roof runoff onto a grassed area or into a rain barrel; (5) using porous surfaces such as flagstone, gravel, stone and interlocking pavers rather than concrete or asphalt; (6) properly recycling engine oil; and (7) planting and maintaining vegetative buffer strips along shorelines of lakes, ponds, and streams. As explained by Manitoba's SWMS, ecological biomass, especially native plants, could be planted near streams

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238. EPA, *supra* note 110, at 16.

239. Michael F. Piehler, *Watershed Management Strategies to Prevent and Control Cyanobacterial Harmful Algal Blooms*, *in* CYANOBACTERIAL HARMFUL ALGAL BLOOMS: STATE OF THE SCIENCE AND RESEARCH NEEDS, *supra* note 4, at 259, 259.

and rivers to absorb nutrients, thereby preventing excessive nutrients from loading into the water.[240]

These proposals do have consequences, however. For example, by planting vegetative buffer strips around bodies of water, water will necessarily be lost to the vegetation's consumption—an issue that will assuredly be hotly contested in the Arizona desert. Because surface water in Arizona is governed by prior appropriation,[241] questions concerning how much water should be allocated to the planter of the vegetation, if any, could arise. Pursuant to Arizona law, a junior appropriator cannot change his use of surface water to a use that is injurious to a senior appropriator. Similarly, a senior appropriator cannot change his use of water to a use that is injurious to a junior appropriator. In fact, if a person wishes to change his use, he must file an application with ADWR, who will then issue a public notice whereby other water users will have the opportunity to object.[242] Thus, if a riparian owner, or the state of Arizona for that matter, decided to plant vegetative buffer strips along the state's streams and waterways, the new use of the water could be injurious to other appropriators and result in financial liability.

The issue of liability is speculative, however, as there are no reported cases on the issue.[243] Moreover, it would be difficult for an appropriator to argue, much less prove, that its water rights were injured because of the vegetative buffer strips. Because water flow is lessened in a myriad of ways, such as large losses to evaporation, providing sufficient evidence to withstand summary judgment would pose a formidable challenge for even the most *peritus* water lawyer. Accordingly, the benefits afforded by planting vegetative strips along waterways outweigh the costs of speculative losses.

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240. MANITOBA'S SURFACE WATER MANAGEMENT STRATEGY 9–10, http://gov.mb.ca/waterstewardship/questionnaires/surface_water_management/pdf/surface_water_strategy_final.pdf (last visited Dec. 19 , 2015).

241. ARIZ. REV. STAT. ANN. § 45-151(A) (2015); *see also* ARIZ. CONST. art. XVII, § 1 (stating that the doctrine of riparian water rights will not be of any force).

242. ARIZ. REV. STAT. ANN. § 45-156(B) (2015).

243. While not directly on point, *Southeastern Colorado Water Conservancy District v. Shelton Farms, Inc*. presented the Colorado Supreme Court with an issue of first impression: can a riparian owner *create additional* water rights in a prior appropriation system by *removing* vegetation on the banks of a river, resulting in increased water flows. Se. Colo. Water Conservancy Dist. v. Shelton Farms, Inc., 529 P.2d 1321, 1323–24 (Colo. 1974) (en banc). The court held that the water was "developed water" and thus outside of the prior appropriative system because the riparian owner was not adding any new water to the system: he was merely "salvaging" it. *Id.* at 1324–27.

B. Monetary Incentives

To spur community involvement, Arizona should offer tax breaks or financial assistance to landowners who implement certain best practice methods. To structure and implement such legislation, Arizona should review the federal government's Environmental Quality Incentives Program ("EQIP") and Virginia's Agricultural Best Management Practices Cost Share ("VACS") Program for guidance. EQIP provides financial assistance of up to $450,000 and technical assistance to agricultural producers to address natural resource concerns.[244] EQIP also creates individualized plans with each program participant using customized contracts of up to ten years in length.[245] Notably, each contract includes provisions allowing for adjustments to the contract, giving landowners the opportunity to work with the government to modify the contract due to changing circumstances.[246] EQIP's goals are to enable environmental benefits such as improved water and air quality, conserve ground and surface water, reduce soil erosion and sedimentation, and improve and create wildlife habitat.[247] EQIP is offered to Indian tribes, agricultural producers, and owners of non-industrial private forestland.[248] Eligible land includes cropland, rangeland, pastureland, non-industrial private forestland, and other farm or ranch lands.[249]

A similar incentive should be offered by the state of Arizona. Arizona should provide financial assistance for agricultural producers, owners of non-industrial private forestland, and Tribes to implement certain best practices. Of course, such assistance should mandate that the producer, owner or Tribe strictly follow the provisions of its individualized conservation plan. Like the EQIP programs, each contract and plan should be tailored to the specific entity, rather than incorporate generalized provisions. Arizona's landscape is diverse, and a "one-size-fits-all" conservation plan would not adequately address the state's conservation needs. That being said, several generic principles should be considered when developing each plan. Notably, the needs and capabilities of each acre within the plan; the individual's facilities and economic situation; the willingness of the individual to try new practices;

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244. *Environmental Quality Incentives Program*, USDA, http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/ (last visited Dec. 17, 2015).

245. *Id.*

246. *Id.*

247. *Id.*

248. *Id.*

249. *Id.*

and, most importantly, the land's relationship to the watershed, should all be discussed when creating the plan.[250]

Implementing such an incentive-based approach could be problematic for several reasons. First, by allowing individualized plans for each participant, the financial costs for creating, adjusting and monitoring hundreds if not thousands of plans will be high. Moreover, participants may be wary to enter into contracts that are ten years in length. Finally, such a program will be funded by taxpayer dollars, so actually creating the program may be difficult given politicians' vote-driven tendencies. Nonetheless, the long-term savings realized by Arizona, both monetarily and environmentally, will more than outweigh the short-term, up-front costs of creating the program. Plus, by allowing contracts to be amendable and adjustable based on changing economic and environmental situations, participants' contract-length fears can be abated. Finally, by showing the public the environmental need for such a program, the public demand for the program should increase.

In summary, each program participant would work with Arizona to create an individualized conservation plan which would incorporate best practices into the participant's land operations. By creating a state-based monetary incentive program functionally structured like EQIP, Arizona could drastically reduce the amounts of nutrient loading into the state's waterways.

In regards to tax incentives, Arizona would be wise to consider VACS. VACS is an innovative cost-share program in Virginia that "supports using various practices in conservation planning to treat animal waste, cropland, pastureland and forested land."[251] Specifically, VACS offers cost-share assistance as an incentive to carry out construction or implementation of selected Best Management Practices.[252] In some situations, a landowner's expense can be less than thirty percent of the total cost.[253]

Arizona should implement a VACS-like program to encourage the voluntary installation of agricultural best management practices. Cost-shared best management practices will not only maximize nutrient reductions but will also protect the taxpayer's interest by implementing the most cost-effective best management practices. By reducing the cost of implementing

250. HUGH HAMMOND BENNETT, ELEMENTS OF SOIL CONSERVATION 138–51 (1947).

251. *Virginia Agricultural BMP Cost Share and Tax Credit Programs*, VA. DEP'T OF CONSERVATION & RECREATION, http://www.dcr.virginia.gov/soil_and_water/costshar.shtml (last visited Dec. 17, 2015).

252. Virginia Soil and Water Conservation Board, *Policy and Procedures on Soil and Water Conservation District Cost-Share and Technical Assistance Funding Allocations (Fiscal Year 2015)*, VA. DEP'T OF CONSERVATION & RECREATION 1 (June 2014), http://www.dcr.virginia.gov/laws_and_regulations/documents/lr8b-swcd-cs-tafa-fy2015.pdf.pdf.

253. *Id.* at 13–14.

these practices, Arizona could drastically reduce the nutrient loading from the state's largest NPS polluter: agricultural producers.

Of course, such a program could be financially burdensome. To be sure, many agricultural producers would likely jump at the chance to implement these procedures for only thirty percent of the cost. Thus, Arizona should follow Virginia's guidance and cap the value covered at $50,000 per entity. Additionally, Arizona should ensure that the entity is a viable, productive entity. Specifically, in order to prevent small-scale farmers from asking for large amounts of cash, another eligibility requirement should be that the land must be a minimum of five contiguous acres with verifiable gross receipts in excess of $1,000 per year from the production or sale of agriculture products produced on the applicant's land for each of the past five years.[254]

By granting monetary incentives for the implementation of best management practices, Arizona could drastically reduce the amount of nutrient loading from agricultural activities.

C. State Algae Task Force Agency

Arizona simply cannot afford to leave HAB legislation to local communities. Instead, it should follow other states' leads and develop a state algae task force agency similar to Ohio's Lake Erie Phosphorus Task Force or Lake Mead's ATF. Like the Ohio Task Force and Lake Mead's ATF, the Arizona Algae Task Force should research specific areas in which phosphorus and nitrogen loading are most concentrated and determine best practices most suitable for Arizona's current infrastructure and environment.

The Arizona Algae Task Force should also be obligated to create and manage a coordinated system of notification and response. The 1978 U.S.-Canada Great Lakes Water Quality Agreement included such a provision.[255] Specifically, the Agreement recognized the "importance of anticipating, preventing and responding to threats to the Waters of the Great Lakes."[256] To further this interest, the Agreement obligated each party to notify the other country when it became "aware of a pollution incident, or the imminent threat of a pollution incident, that could be of joint concern to both of the parties."[257] Imminent threats included the storage of nuclear waste and radioactive materials, mining and mining related activities, oil and gas pipelines, oil and gas drilling, refineries, waste storage, and treatment and disposal facilities.[258]

254. *See id.* at 1.
255. Great Lakes Water Quality Agreement, *supra* note 148, at art. VI.
256. *Id.*
257. *Id.* at art. VI(a).
258. *Id.* at art. VI(c)(i)–(ix).

Arizona should implement a similar requirement between its communities so that state resources could best be used to mitigate and monitor a portentous situation if and when a threat arises.

The main difficulty with this strategy is the challenge inherent in drafting enforceable and objective notification procedures. Obligating one community to notify other communities when it becomes aware of an algal bloom creates questions of which communities must be notified, when the duty to notify arises, when the notification must occur and what the enforcement mechanisms are.

As to which communities must be notified and when, a provision including language requiring a community to notify other communities which "are reasonably in danger of severe economic or environmental harm" from a bloom event within "a reasonable time from the actual knowledge of the bloom's possible consequences" may be sufficient. Including reasonableness measures and an economic/environmental harm qualifier are essential to prevent unnecessary warnings. Such language also urges communities to work together to prevent harm. Of course, a community's "knowledge" is an issue that would likely be debated. Nonetheless, the importance of such a provision, for the purposes of this article, is simply that a program be developed that implores communities to cooperate and work with each other to monitor for and react to bloom events. The goal of the notification requirement is not litigation, but prevention and mitigation.

D. Modern Technology and Stagnant Water

Stagnant water is the second primary driver of algal bloom growth that Arizona should strive to prevent. Fortunately, circulation of the majority of Arizona's surface water is quite swift. Arizona is unique in that the majority of its population and water usage takes place in a desert. Thus, freshwater must move to the people, not vice versa. This movement facilitates high surface water circulation. Consequently, as the Salt, Verde, and Gila rivers fill and refill central Arizona's reservoirs and the Colorado River fills and refills the upper reservoirs, stagnant water is not a systematic water issue in Arizona. Moreover, prior appropriation, Arizona's water allocation system, is based on the fundamental tenant: "use it or lose it." In other words, if a water user has a right to use water but does not use it beneficially for a certain period of time, the water user's right could be lost.[259] This tenant encourages the speedy use of and, in turn, movement of water. Even so, blooms still do

259. San Carlos Apache Tribe v. Superior Court *ex rel.* Cty. of Maricopa, 972 P.2d 179, 189 (Ariz. 1999) (en banc) (citing Clough v. Wing, 17 P. 453, 455 (Ariz. 1888)).

strike in Arizona, indicating that the increase in nutrient loading, warm water temperatures, and high volume of sunlight overcome the current water flow rate. Thus, artificial circulation of water should at least be a consideration for any comprehensive management program.

Most ecological approaches use hydrological manipulations to target stagnant water for HAB prevention, suppression, and termination.[260] Indeed, such manipulations are necessary for any successful scheme as water flow rates are decreasing because of the increase in drought frequency and duration from global climate change and the increase in water withdrawals from rising usage.[261] For smaller ponds and water bodies, diffused air and simulated mixing systems could be used to artificially circulate the water. For larger bodies of water, the laminar flow aeration system has been used successfully on lakes suffering from algal blooms.[262] Laminar flow aeration systems are retrofitted to a specific site and account for variables such as water depth and volume, depth contours, water flow rates, and thickness and composition of lake sediment.[263] The systems are designed to completely mix the surrounding waters with currents and evenly distribute dissolved oxygen throughout the lake sediments for aerobic microbial utilization.[264] In other words, these systems artificially circulate the water to help distribute oxygen levels thereby preventing algal blooms formation.[265] These systems provide substantial benefits, including: enhanced clarity of the water and measurable declines in water temperature, sediment thickness, sediment organic matter, phosphorus, and toxic blue-green algae.[266] Moreover, a system like this is "affordable, typically declines in cost with time, is technologically simple, and usually requires little maintenance."[267]

The negative consequences of stimulating water movement can be significant. As noted by Hudnell, "[d]eployments that destratify the water

260. Hudnell, *supra* note 15, at 1029.

261. *Id.*; *see also* Brian K. Sullivan, *No Drought Relief in U.S. West Without Deep Mountain Snow*, BLOOMBERG (Sept. 24, 2014), http://www.bloomberg.com/news/2014-09-24/no-drought-relief-in-u-s-west-without-deep-mountain-snow.html (noting that portions of the Western United States, primarily California and western Arizona, are experiencing one of the worst droughts in recorded history).

262. *See* Jennifer L. Jermalowicz-Jones, *In Situ Effects of Laminar Flow Aeration on Water Quality in Indian Lake, Cass County, Michigan* 14–15 (Mar. 4, 2012), http://www.austinlakeportage.com/media//DIR_47201/2850a3d5c747e8cffff872effffe417.pdf.

263. *Id.*; *see also* Jennifer L. Jermalowicz-Jones, *Laminar Flow Aeration: A Sustainable Lake Improvement Option*, MICHIGAN RIPARIAN 6, 6 (2012), http://www.pawpawlakerestoration.com/laminarflowaeration.pdf.

264. Jermalowicz-Jones, *supra* note 262, at 14–15.

265. *Id.*

266. *Id.* at 6–7.

267. *Id.* at 8.

column, transport[] nutrients from the nutrient-rich hypolimnion to the epilimnion and photic zone where [HABs] occur [and] have the potential to stimulate blooms."[268] Reports nevertheless show that laminar flow aeration systems provide an excellent resource to purge carbon dioxide, hydrogen and nitrogen from lake sediments.[269] Furthermore, laminar flow aeration systems are tried and tested and have been used to successfully remove toxic algae in lakes in southern states.[270]

To lessen the costs of mixing systems, natural attenuation provides an excellent supplemental measure. Natural attenuation is an organic process that decreases concentrations of contaminants in a body of water. Monitored natural attenuation (MNA) involves collecting samples to analyze them for the presence of the contaminant and other site characteristics.[271] Dilution and evaporation lessen the amount of contaminants as they mix with clean water and change from liquids to gases.[272] MNA should be coupled with mixing systems to rapidly dilute any nutrients in the water and to regularly monitor the water's characteristics. Moreover, if natural attenuation reduces the nutrient levels of a water body by itself, a mixing system may not even be necessary.

V. CONCLUSION

Algal blooms are best managed at the local level due to the varying circumstances in each situation. Local councils and state water authorities are most able to investigate suspected outbreaks and alert the public of any unsafe waters. The most effective and plausible method of stymieing algal blooms is to incorporate a comprehensive watershed management plan to minimize the nutrient load entering waterways through nonpoint sources. This plan should be supported by planting and maintaining riparian vegetation around watersheds, conserving soil, and implementing appropriate treatment and disposal of storm water, agricultural, industrial, and sewage effluent. Flow and circulation manipulation systems should also be considered to block the accumulation of algae-triggering nutrients. To be sure, in order for Arizona to proactively prevent algal blooms requires a comprehensive approach wherein numerous actors are called upon to develop and integrate best

268. Hudnell, *supra* note 15, at 1029.

269. Jermalowicz-Jones, *supra* note 262, at 6–7.

270. *See id.* at 7 (noting that the use of an laminar flow aeration system resulted in a decline of *Microcystis* algae in Arbuckle Lake in Oklahoma).

271. EPA, A CITIZEN'S GUIDE TO MONITORED NATURAL ATTENUATION (Sept. 2012), https://clu-in.org/download/Citizens/a_citizens_guide_to_monitored_natural_attenuation.pdf.

272. *Id.*

practices for Arizona watersheds. Implementing such a broad system will be costly and will require a highly coordinated approach between numerous actors. Nevertheless, the numerous long-term benefits to the people of Arizona and the state's environment will more than outweigh the costs.