The Memphis Sand Aquifer and the Uncertain Jurisprudence Over Groundwater

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I. INTRODUCTION

Aquifers are geological features in which water saturates cracks, pores, and fissures in the Earth's subsurface areas,[1] forming a critical source of freshwater resources. At any given point, freshwater accounts for only 2.5% of all water on the planet, of which only 1% is readily accessible, even as groundwater, while the remainder is locked away in glaciers and snowfields.[2] This translates to approximately 21,830 cubic miles of freshwater held in lakes, 509 cubic miles of freshwater held in rivers, and 2,526,000 cubic miles of freshwater held in the ground across the planet.[3] So, while groundwater represents 30% of all freshwater on the planet,[4] it represents approximately 99% of all freshwater that is *not* locked away in ice.

Groundwater extraction provides approximately 33% of the public supply for municipal and urban needs and 97% of the supply for

1. The United States Geological Survey ("USGS") defines an aquifer as: "[a] formation, group of formations, or part of a formation that contains sufficient saturated, permeable material to yield significant quantities of water to wells and springs." U.S. Geological Survey, *USGS Groundwater Information, Aquifer Basics*, USGS, https://water.usgs.gov/ogw/aquiferbasics/index.html (last modified Nov. 14, 2019). These features often consist of unsaturated or partially saturated soil, known as vadose zones. U.S. Geological Survey, *Unsaturated Flow Processes*, USGS, https://wwwrcamnl.wr.usgs.gov/uzf/ (last modified Feb. 2016).

2. *Freshwater Crisis*, NAT'L GEOGRAPHIC, https://www.nationalgeographic.com/environment/freshwater/freshwater-crisis/ (last visited Feb. 8, 2019).

3. U.S. Geological Survey, *Where is Earth's Water?*, USGS, https://water.usgs.gov/edu/earthwherewater.html (last visited Mar. 13, 2020) [hereinafter *Where is Earth's Water?*] (referencing Igor A. Shiklomanov, *World Fresh Water Resources*, *in* WATER IN CRISIS: A GUIDE TO THE WORLD'S FRESH WATER RESOURCES 13, 13 (Peter H. Gleick (ed., 1993)).

4. *Where is Earth's Water?*, *supra* note 3.

the rural population.[5] Withdrawals in the United States increased from 34 billion gallons per day in 1950 to 76 billion gallons per day by 2010.[6] Agriculture utilizes a particularly large percentage (roughly 70%)[7] of available freshwater. The balance of the public's freshwater needs necessarily comes from natural surface water supplies, including lakes and rivers,[8] and depending on needs, captured and stored in municipal dams. While water sources are varied, the sheer volume of water held in underground aquifers makes groundwater a vital natural resource. Groundwater presents the greatest available *freshwater* resource on the planet. The importance of maintaining freshwater supplies is difficult to overstate. Although freshwater is a renewable resource—as it recharges naturally via rainfall and snowmelt, its supply is not infinite. Consequently, lawsuits over access to freshwater are inevitable.

A lawsuit currently before the Supreme Court between the states of Mississippi and Tennessee over groundwater in the Memphis Sand aquifer[9] presents a watershed moment in groundwater allocation principles. Existing jurisprudence highlights the tension between the interests of property owners and proponents of sustainable development over how to allocate one of the most important natural resources on the planet, namely, fresh water. This case is but one of many examples of litigation working its way through the judicial system,[10] the results of

5. U.S. Geological Survey, *Drought and Groundwater Levels*, USGS, https://water.usgs.gov/edu/droughtandgw.html (last visited Feb. 19, 2020).

6. Noah D. Hall & Joseph Regalia, *Lines in the Sand: Interstate Groundwater Disputes in the Supreme Court*, 31 NAT. RESOURCES & ENV'T 8, 8 (2016).

7. U.S. Geological Survey, *Irrigation Water Use*, USGS, https://water.usgs.gov/edu/wuir.html (last visited Feb. 19, 2020).

8. *See Where is Earth's Water?*, *supra* note 3.

9. Complaint, Mississippi v. Tennessee, No. 22O143 (June 10, 2014).

10. The range of issues in these cases goes beyond the interstate/intrastate allocation issue raised in the Memphis Sand dispute. *See, e.g.*, *Upstate Forever v. Kinder Morgan Energy Partners, L.P.,* 887 F.3d 637 (4th Cir. 2018) (concerning an oil pipeline's contamination of groundwater); *Litigation*, *The Ventura SWP Interconnection Project*, CAL. WATER IMPACT NETWORK, https://www.c-win.org/ventura-interconnection (concerning the "State Water Interconnection" pipeline connecting the water systems of Calleguas and the City of Ventura, and whether the Environmental Impact Report meets standards set forth in state laws,

which could have potentially harmful and irreversible consequences on vulnerable freshwater aquifers.

This Article focuses on the developing jurisprudence concerning transboundary groundwater allocation in the United States through the lens of the ongoing dispute over the Memphis Sand aquifer.[11] The Article begins with an introduction to hydrogeology, which was not available when Memphis first tapped into the Memphis Sand. The purpose of the introduction is to dispel old notions of groundwater uncertainty, which has haunted groundwater jurisprudence to date. This Article also highlights many of the interconnected characteristics of a natural system. What results is an argument in favor of sustainable water management principles through applications of equitable apportionment to aquifers.

Part II begins with some background of the Memphis Sand and the ongoing dispute over the Memphis Sand's waters. Part III describes some of the key characteristics of aquifers, what those characteristics mean in a hydrogeological context, and what that might mean in a legal-geopolitical analysis that moves away from traditional groundwater exceptionalism.[12] Finally, Part IV applies those principles to two Memoranda of Decision issued by the Special Master[13] assigned to this dispute by the Supreme Court. Each of these Memoranda illustrate the uncertainty that still pervades discussions concerning aquifers while also highlighting the need for equitable apportionment to ensure sustainable water management.

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including whether the proposed pipeline meets municipal needs); *infra* Section III.B.5 (discussing the litigation over the environmental impact of the Cadiz Water Project).

11. Complaint, *supra* note 9.

12. "Groundwater exceptionalism" is a term coined by Prof. Christine A. Klein to describe how "[o]ften, the law treats groundwater differently than surface water," and is appropriate for the discussion here. Christine A. Klein, *Owning Groundwater: The Example of Mississippi v. Tennessee*, 35 VA. ENVTL. L.J. 474, 476 (2017).

13. The Supreme Court appointed Hon. Eugene E. Siler as Special Master on November 10, 2015. Order Appointing the Special Master, 136 S. Ct. 499, 2015 U.S. Lexis 7161, at *1 (2015). The Special Master in this matter is proceeding with a limited evidentiary hearing on whether the Memphis Sand is an interstate resource. Mississippi v. Tennessee at 36, No. 22O143 (Aug. 12, 2016) [hereinafter 2016 Memorandum] (order denying defendants' motions to dismiss and plaintiff's motion to exclude).

II. THE MEMPHIS SAND AQUIFER AND THE DISPUTE OVER ITS WATERS

The lawsuit discussed throughout this Article involves the contours of state ownership over natural resources. Mississippi claims sole ownership over waters that would remain in Mississippi for potentially thousands of years. The determinative issue is whether the Memphis Sand is categorized as an *interstate* or an *intrastate* resource. If the Memphis Sand is an *interstate* resource, then principles of Equitable Apportionment would apply and the waters in the Memphis Sand would be allocated accordingly to the respective states. If the Memphis Sand is an *intrastate* resource, however, then Mississippi would have an argument for asserting sole ownership, subject to limits on absolute control over natural resources carved out by common law principles. The resolution to the interstate versus intrastate question turns on the interconnectivity, or lack thereof, between the Memphis Sand and other natural systems. "Other natural systems" includes not just a disputed connection to other aquifer(s), but to other surface waters as well.

A. Geography and History of the Memphis Sand

The Memphis Sand aquifer consists of nearly 1,000 meters in depth of unconsolidated sand, silt, and clay.[14] It occupies approximately 26,000 km² in the south-central region of the United States—an expanse of land stretching across Arkansas, Mississippi, Tennessee, and Kentucky.[15] The Memphis Sand aquifer lies within the Mississippi Embayment Aquifer System,[16] an even larger basin which stretches southward from Missouri, Illinois, and Kentucky towards the Gulf of

14. W.S. PARKS & J. K. CARMICHAEL, U.S. GEOLOGICAL SURVEY, GEOLOGY AND GROUND-WATER RESOURCES OF THE MEMPHIS SAND IN WESTERN TENNESSEE, WATER-RESOURCES INVESTIGATIONS REPORT 88-4182, at 22 (1990), https://pubs.usgs.gov/wri/wrir88-4182/pdf/wrir_88-4182_a.pdf.

15. Michael E. Campana, *Mississippi v. Memphis: The Curious Case of the Memphis Sand Aquifer*, *in* TRANSBOUNDARY GROUNDWATER RESOURCES: SUSTAINABLE MANAGEMENT AND CONFLICT RESOLUTION 117, 117 (Jean Fried & Jacques Ganoulis eds., 2016)

16. *See* Campana, *supra* note 15, at 121 ("The Memphis Sand is part of the Claiborne Group of Tertiary Age and is within the Mississippi Embayment aquifer system.").

Mexico.[17] The Mississippi Embayment is a sort of "parent system" in which lies six aquifers and two confining units:[18] the Upper Claiborne, the Middle Claiborne, the lower Claiborne-upper Wilcox, the middle Wilcox, the lower Wilcox, the McNairy-Nacatoch.[19]

Meanwhile, the Sparta Sand is a sort of "sister" aquifer to the Memphis Sand, as it is another underground sandstone formation lying within the middle Claiborne,[20] primarily under Mississippi. The two aquifers are separated by "multiple thin clay-rich confining units[,]"[21] features which form physical barriers between aquifers. Whether the aquifers are deemed to be separate or part of one interconnected aquifer system is a key inquiry in the Memphis Sand litigation.

In the 1800s, Memphis, Tennessee, drew its municipal water from the Wolf River, a local surface water source that was both "muddy and polluted."[22] As a result, the population struggled with disease.[23] Yellow fever killed thousands of residents.[24] All of this changed when

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17. The City of Memphis hosts approximately 650,000 people. *Memphis city, Tennessee*, U.S. CENSUS BUREAU, https://data.census.gov/cedsci/profile?q=Memphis%20city,%20Tennessee&g=1600000US4748000. The greater Memphis metropolitan area hosts approximately 1.3 million people in Tennessee, Arkansas, and Mississippi. Campana, *supra* note 15, at 118.

18. Confining units are physical barriers between aquifers consisting of "[g]eologic material with little or no permeability or hydraulic conductivity such as clay or dense rock. Water does not pass through this layer or the rate of movement is extremely slow." *The Basics*, *Groundwater Glossary*, GROUNDWATER FOUND., https://www.groundwater.org/get-informed/basics/glossary.html (last visited Feb. 20, 2020).

19. Orville B. Lloyd, Jr. & William L. Lyke, U.S. Geological Survey, *Groundwater Atlas of the United States: Illinois, Indiana, Kentucky, Ohio, Tennessee*, *HA-730K*, *Mississippi Embayment Aquifer System* (1995), USGS, https://pubs.usgs.gov/ha/ha730/ch_k/K-text6.html.

20. *Id.* The Sparta Sand is situated primarily in the middle Claiborne, while the Memphis Sand extends across both the middle Claiborne and the lower Claiborne-upper Wilcox aquifers. *Id.*

21. Brian Waldron & Daniel Larsen, *Pre-Development Groundwater Conditions Surrounding Memphis, Tennessee: Controversy and Unexpected Outcomes*, 51 J. AM. WATER RESOURCES ASS'N 133, 135 (2015).

22. Boyce Upholt, *An Interstate Battle for Groundwater*, THE ATLANTIC (Dec. 4, 2015), https://www.theatlantic.com/science/archive/2015/12/mississippi-memphis-tennesee-groundwater-aquifer/418809/.

23. *Id.*

24. *Id.*

Memphis first tapped into the groundwater using the Bohlen-Huse well drilled by R.C. Graves in 1886.[25] This well was the starting point for Memphis's withdrawals from the Memphis Sand and a turning point for the city's development.[26] The city has benefited from the Memphis Sand's freshwater ever since.

Presently, Memphis Light, Gas and Water (MLGW) pumps 600,000 to 760,000 m^3—roughly 159 million gallons—from the aquifer daily[27] for public use in the Memphis metropolitan area.[28] Despite this massive quantity of water pumped daily, Shari Meghreblian, commissioner of the Tennessee Department of Environment and Conservation, notes that "[t]here are trillions upon trillions of gallons of water in the Memphis aquifer, so it has plenty of water[.]"[29] Even though the Memphis Sand is flush with water, this does not mean pumping operations do not affect how the groundwater is distributed in the region and among other aquifers, specifically, the Sparta Sand. And when the pumping in fact altered water allocations underground, it then became the focal point of the Memphis Sand lawsuit.

B. Mississippi and Tennessee at Odds Over Groundwater

MLGW's pumping forms the basis for Mississippi's complaint because groundwater extraction in Memphis lowers the water table in the whole region by forming a "cone of depression" that alters how the aquifer distributes water in Mississippi.[30] While MLGW's pumping

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25. Waldron & Larsen, *supra* note 21, at 134–135; *see also* Upholt, *supra* note 22.

26. *See* Waldron & Larsen, *supra* note 21, at 135 (noting that current withdrawals regularly exceed 710,000 m^3 per day).

27. Campana, s*upra*, note 15; *see also* Sam Stockard, *State Water Plan Seeks to Protect Memphis Sands Aquifer*, DAILY MEMPHIAN (Dec. 9, 2018, 11:00 PM), https://dailymemphian.com/article/1705/State-water-plan-seeks-to-protect-Memphis-Sands-Aquifer#.

28. *See* Stockard, *supra* note 27.

29. *Id.*

30. "Drainage! Drainage, Eli, you boy. Drained dry. I'm so sorry. Here, if you have a milkshake, and I have a milkshake, and I have a straw. There it is, that's a straw, you see? Watch it. Now, my straw reaches across the room and starts to drink your milkshake. I—drink—your—milkshake! I drink it up!" THERE WILL BE BLOOD (Ghoulardi Film Company 2007); *see also Agriculture Beware: Groundwater Future Belongs to SCOTUS*, WAYNE STATE UNIVERSITY: TODAY@WAYNE (May 31, 2017),

takes place entirely within Tennessee,[31] it is pumping water that, according to Mississippi, rightly belongs in the Sparta Sand, an allegedly independent aquifer that lies beneath Mississippi. So, Mississippi asserts that MLGW's pumping amounts to an unnatural operation as, but for MLGW's operations, the water would have remained in Mississippi—for 22,000 years, according to Mississippi's geologists.[32]

If Mississippi's arguments prevail, the potential cost of this litigation to the greater Memphis area is substantial in terms of both damages and the costs of compliance. Damages sought would result in a payout of $615 million dollars to Mississippi for converting Mississippi's water,[33] plus the costs of any necessary development of alternative infrastructure in the Memphis area to provide fresh water. The latter would also potentially result in a decrease in Memphis's water quality, as a portion of that water would not benefit from the naturally purifying effects of the Memphis Sand Aquifer.[34]

This lawsuit encapsulates two competing aspects to groundwater jurisprudence: (1) the developing scientific understanding of hydrology and sustainable ecosystem management and (2) varied water rights represented by common law and administrative regimes. Each of these aspects compete for attention and priority as they fight for greater weight in the administrative, legislative, and judicial decision-making process. An accurate understanding of the former necessarily affects how groundwater is treated in the latter. Indeed, the scientific understanding of hydrology is the focus of the Special Master's evi-

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https://today.wayne.edu/news/2017/05/31/agriculture-beware-groundwater-future-belongs-to-scotus-6519.

31. *But cf.* Tarrant Reg'l Water Dist. v. Herrmann, 569 U.S. 614 (2013) (concerning cross-border water rights and interstate compacts). MLGW does not run afoul of the precedent set forth in this case, as MLGW does not engage in cross-border pumping, which might be an intrusion on Mississippi's sovereign powers.

32. Mississippi v. Tennessee at 14–19, No. 22O143 (Nov. 29, 2018) [hereinafter 2018 Memorandum] (order denying defendants' motion for summary judgment).

33. Brett Walton, *Mississippi's Claim That Tennessee Is Stealing Groundwater Is a Supreme Court First*, CIRCLE OF BLUE (Oct. 3, 2016), https://www.circleofblue.org/2016/groundwater/states-lag-management-interstate-groundwater.

34. For a discussion of the natural purifying properties of the Memphis Sand, see MEMPHIS LIGHT, GAS & WATER, MEMPHIS WATER: A COMMUNITY TREASURE, WATER QUALITY REPORT (2015), http://www.mlgw.com/images/content/files/pdf/WQR%202015_final.pdf.

dentiary hearings on the matter which included testimony from geologists, civil engineers, and water and environment consultants.[35] This testimony will affect whether common law principles based on nonexistent science will continue to control water rights, and, in doing so, impact water management standards throughout the country.

The Memphis Sand litigation addresses both competing aspects and raises fundamental legal questions about groundwater. More specifically, the litigation poses the question of whether groundwater is viewed as property and, therefore, is a resource to be mined both privately and by the state. Or, alternatively, whether groundwater could be viewed with a more egalitarian approach, making it a public resource to be managed sustainably by all. The standards set forth in the Memphis Sand dispute foreseeably transcend the Memphis Sand Aquifer, affecting not just the natural resource, but also the stakeholders involved.

Different standards will affect different stakeholders, and different stakeholders will approach natural resources with different objectives.[36] These include: 1) government agencies such as the Environmental Protection Agency or the Department of the Interior with an interest in the proper management of those resources; 2) utilities, both private and public, such as Cadiz or MLGW with an interest in accessing and delivering those resources; 3) non-governmental organizations and advocacy groups such as Earthjustice or the World Wildlife Fund with an interest in ensuring fair, non-destructive access to those resources; 4) research institutions with interests in an accurate representation of scientific data; and 5) landowners such as those with agricultural interests or simply those who rely on clean water to live. Within the context of these competing interests, courts must establish standards based on scientific progress, to protect this vital natural resource.

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35. *See generally* Transcripts of Evidentiary Hearing, Mississippi v. Tennessee, No. 22O143 (May 30, 2019).

36. A system of over inclusion can give access to pro-risk parties. Meanwhile, a system of exclusion can drive away risk-averse parties from other productive uses. Any one system isn't necessarily destructive in isolation. The systems must work in conjunction with different stakeholders and different objectives. Systems of exclusion are those which pit private and state interests over property rights. Systems of inclusion enable interstate public resources to be apportioned to *all* stakeholders, even those who may seek to consume a resource beyond its limits.

Legal jurisprudence concerning transboundary groundwater should transition in kind with progress in hydrogeological science.[37] This transition means shifting away from the early system that made allowances for past uncertainty and toward a contemporary standard based on knowledge and sustainability. In other words, the science surrounding groundwater has advanced; so too should the legal analysis. While not a seamless process, the ongoing dispute over the Memphis Sand Aquifer, evidenced by the Special Master's evidentiary hearings, is proof positive this transition is happening.

III. AQUIFERS: A SCIENCE AND JURISPRUDENCE OF UNCERTAINTY

Hydrology, or hydrogeology, is a subset of geological research that looks at "water as it occurs in the atmosphere, on the surface of the ground, and underground."[38] Like any other science, the field has its inherent uncertainties. This itself is not so unusual. However, these uncertainties should neither preclude the application of equitable apportionment, nor should they provide a basis for continued proliferation of a skewed perception over groundwater's perceived unknowable character. Courts have historically resolved disputes by relying on property law principles to allocate water rights.[39] As the knowledge base increases, the need for a property rights-based solution to water disputes dissipates, and the need for sustainable groundwater management principles increases. But the question remains: will property law principles rooted in the belief that this is a mysterious and unknowable

37. Whether or not equitable apportionment applies to this dispute will affect how research in this field propagates throughout the United States, enabling systems which are risk averse (precautionary principle, sustainability), or those which are not (pumping in excess of groundwater recharge rates).

38. U.S. Geological Survey, *Water Resources of the United States*, *Water Basics Glossary*, USGS, https://water.usgs.gov/water-basics_glossary.html (last modified June 17, 2013).

39. But in using the same property-based language, courts did not necessarily confer ownership rights. Rather, the courts used property-based language to confer rights and responsibilities upon the States, more akin to that of a trustee, not an outright owner. *See* Brief of Amici Curiae Law Professors at 9, Mississippi v. Tennessee, No. 22O143 (Oct. 16, 2019). *See also* Nat'l Audubon Soc'y v. Superior Court, 658 P.2d 709 (Cal. 1983) (concerning water held in public trust).

natural resource continue to govern water rights or will scientific advances be acknowledged and taken into account to allow the shift toward sustainable groundwater management principles to take place?

A. Past Problems of Uncertainty Led to a Jurisprudence of Groundwater Exceptionalism

Many 19th century courts acknowledged a type of groundwater exceptionalism, a "historic view that groundwater is too mysterious to allow for its regulation,"[40] unlike surface waters. In the United States, these uncertainties led courts to focus on the exceptional and mysterious nature of groundwater, creating a body of jurisprudence that characterized groundwater as beyond the reach of regulation. For example, in 1861, the Ohio Supreme Court stated:

> [b]ecause the existence, origin, movement and course of [underground] waters, and the causes which govern and direct their movements, are so secret, occult and concealed, that an attempt to administer any set of legal rules in respect to them would be involved in hopeless uncertainty, and would be, therefore, practically impossible.[41]

Similarly, a Pennsylvania court noted that a "surface stream cannot be diverted without knowledge that the diversion will affect a lower proprietor. Not so with an unknown subterraneous percolation or stream. One can hardly have rights upon another's land which are imperceptible, of which neither himself or that other can have any knowledge."[42] A Connecticut court expressed similar views on groundwater:

> The laws of its existence and progress . . . cannot be known or regulated. It rises to great heights, and moves collaterally, by influences beyond our apprehension. These influences are so secret, changeable and uncontrollable, we cannot subject them to the regulations of law,

40. Klein, *supra* note 12, at 520.

41. Frazier v. Brown, 12 Ohio St. 294, 311 (1861).

42. State v. Michels Pipeline Constr., Inc., 217 N.W.2d 339, 345 (Wis. 1974) (quoting Haldeman v. Bruckhart, 45 Pa. 514, 519 (1863)).

> nor build upon them a system of rules, as has been done, with streams upon the surface.[43]

The Supreme Court of the United States itself remarked that "[t]he underground movement of water will always be 'a problem of uncertainty.'"[44]

This early uncertainty in hydrological science led to a perception that "groundwater does not follow the same physical patterns as surface water and, therefore should not be subject to the same legal constraints."[45] Despite increased scientific knowledge of hydrology from subsequent decades of research, groundwater exceptionalism is deeply embedded in statutory and common law. And yet, the ancient mythos surrounding groundwater—that groundwater is a "problem of uncertainty"—no longer exists. Hydrology is still an area of science in transition, with many inherent uncertainties; however, groundwater can no longer be considered mysterious and unknown for the purposes of groundwater management.

With historical uncertainty in mind, the following section discusses what the hydrogeology of aquifers might mean in a legal-geopolitical analysis. Showing that ground and surface waters are interconnected will point to the interstate character of many groundwater systems, the Memphis Sand included. Establishing that point shows how equitable apportionment, and sustainable water management, should be applied to groundwater just as it has to surface water.

Where historical groundwater uncertainty emphasized the unknown, magical, and mysterious, contemporary groundwater uncertainty looks more towards quantifiable error in geological research. These are not the same types of uncertainty. Groundwater management, and judicial opinions, should reflect the difference. Groundwater exceptionalism will continue to ripple through the judiciary so long as this notion of groundwater mysticism persists. Failing to leave ground-

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43. *Michels Pipeline Constr.*, 217 N.W.2d at 344 (quoting Roath v. Driscoll, 20 Conn. 533, 541 (1850)).

44. Kansas v. Colorado, 206 U.S. 46, 107 (1907).

45. Klein, *supra* note 12, at 476. "Today, each state follows one of three different legal systems for the allocation of surface water rights, and one of five different regimes for the allocation of groundwater rights." *Id.* at 485.

water exceptionalism in the past and progress to a sustainable management model will promote an untenable situation of haves and have-nots in the country's drier lands.

B. Moving Towards a Jurisprudence of Sustainable Water Management

As noted above, hydrological science has progressed substantially since the time when the first wells tapped into the Memphis Sand. While some scientific uncertainties inevitably remain, they are not unworkable.[46] Indeed, there are many aspects of groundwater and aquifers which are quite settled and point to a need for the sustainable administration of groundwater.

Aquifers play a role in the larger hydrologic cycle and understanding that cycle requires some understanding of how aquifers function. The substantial increase in scientific knowledge since the early days of groundwater uncertainty allows a closer look at some key aquifer properties, which will show the interconnected relationship between groundwater and surface water. Specifically, a discussion of aquifer borders, recharge rates, withdrawal rates, and flow rates, along with ecological dependence on aquifers, will illustrate how surface waters are connected to groundwater systems, which in turn illustrates a growing need for sustainable water management.

While there are obvious differences between surface water and groundwater, research has shown that they are not completely independent systems, because a surface water system is often *hydrologically connected* to an underground aquifer.[47] The two systems can be

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46. *See* Baruch Fischhoff & Alex L. Davis, *Communicating Scientific Uncertainty*, 111 PROC. NAT'L ACAD. SCI. U.S. 13664, 13664 (2014) ("Taking full advantage of scientific research requires knowing how much uncertainty surrounds it.").

47. *See, e.g.*, Gregg Eckhardt, *Frequently Asked Questions*, THE EDWARDS AQUIFER WEBSITE, https://www.edwardsaquifer.net/faqs.html (last visited Feb. 22, 2020). The Edwards Aquifer situation highlights the interconnected nature of surface and groundwater in drought prone territories. *Id.* During periods of drought, the upper layers of the Edwards Aquifer formation run dry, reducing the flow of freshwater to surface springs. *Id.* The Edwards Aquifer provides drinking water for approximately 2 million people, over half of whom reside in San Antonio. THE EDWARDS AQUIFER WEBSITE, https://www.edwardsaquifer.net/index.html (last visited Feb. 22, 2020). In 1950, the San Antonio population was approximately 400,000. By 1980, that number was approximately 785,000. *Texas Almanac: City Population History from 1850–*

closely intertwined, which warrants closer scrutiny to determine whether the system is intrastate or interstate in nature. However, despite the connection between the two, surface water is frequently treated differently from groundwater, a viewpoint that could be dispositive in the Memphis Sand dispute.

To be sure, various aspects of aquifers continue to present "problems of uncertainty." Freshwater is a renewable but not unlimited resource. Aquifer borders are indefinite. Strata depths are often undetermined. Flow patterns are hotly debated, as they are in the Memphis Sand dispute. Recharge rates are shifting and are often the focal point over how to sustainably manage and develop a region. But these uncertainties must be incorporated into a common-sense solution, not preclude one.

Disagreements over fundamental definitions can lead to schisms in legal applications, perpetuating notions of "groundwater exceptionalism" and inhibiting the development of cohesive and sustainable water management plans. For example, Tennessee and Mississippi apply different standards for defining water, and these standards are reflected in their respective positions in the Memphis Sand dispute.[48] Tennessee Law incorporates language that includes surface and groundwater in one definition, referring to water that is "on or beneath the surface of the ground."[49] Meanwhile, Mississippi Law distinguishes between surface and groundwater, defining surface water as "water occurring on

2000, TEX. ALMANAC, https://texasalmanac.com/sites/default/files/images/CityPopHist%20web.pdf (last visited Feb. 22, 2020). By 2018, the numbers for greater San Antonio reached 1,532,233 people. *Quick Facts*, *San Antonio city, Texas*, U.S. CENSUS BUREAU, https://www.census.gov/quickfacts/sanantoniocitytexas (last visited Feb. 22, 2020). This is a heavily stressed hydrogeological system.

48. Mississippi distinguishes between groundwater and surface waters, to allege that the Memphis Sand is an intrastate resource. *See* Complaint, *supra* note 9, at 14–15. To the contrary, Tennessee and the other defendants emphasize that the two are interconnected, allowing them to argue that the Memphis Sand is interstate in nature. *See* Answer of Defendants The State of Tennessee at 14, Mississippi v. Tennessee, No. 22O143 (Sept. 14, 2015); Answer of Defendants The City of Memphis, Tennessee, and Memphis Light, Gas and Water Division at 11, Mississippi v. Tennessee, No. 22O143 (Sept. 11, 2015).

49. Water Quality Control Act, TENN. CODE ANN. § 69-3-103(45) (2019).

the surface of the ground," and groundwater as "water occurring beneath the surface of the ground."[50] These separate definitions are themselves relics of an earlier common law and an example of groundwater exceptionalism.

A simple overview of aquifer and groundwater characteristics shows 1) how past notions of groundwater uncertainty should be inapplicable to modern jurisprudence; 2) how scientific uncertainty is not the same thing as legal uncertainty; and 3) how the intertwined nature of surface and groundwater warrants application of sustainable water management principles.

1. Aquifer Borders

For the purposes of this discussion, two types of "borders" are worth mentioning. The first is an aquifer's outer border, or perimeter. The second is an aquifer's subterranean layers, where an aquifer might extend below other aquifers or other material. Like sedimentary rock, they exist like layers in a cake separated by confining units to form an area's vertical profile. Both types of borders contribute to the debate over whether the Memphis Sand is an interstate or intrastate resource.

Aquifer perimeters are amorphous and do not conveniently coincide with geopolitical borders. They can exist in more than one geopolitical space despite the borders provided by their surface waters. In the United States alone, a map of the aquifers reveals a picture that is highly complicated, with little connection to state borders or physical features.[51] Interstate, or transboundary, aquifers underlay shared boundaries between two or more states.[52] There are 366 identified transboundary aquifers and 226 transboundary "groundwater bodies"[53]

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50. MISS. CODE ANN. § 51-3-3(b), (n) (2019).

51. U.S. Geological Survey, *USGS Groundwater Information*, *Aquifers: Map of the Principal Aquifers of the United States*, USGS, https://water.usgs.gov/ogw/aquifer/map.html (last modified Dec. 18, 2017).

52. INT'L LAW COMM'N, UNITED NATIONS, REPORT OF THE INTERNATIONAL LAW COMMISSION, SIXTIETH SESSION 20 (2008) [hereinafter Draft Articles], https://legal.un.org/ilc/documentation/english/reports/a_63_10.pdf. Article 2(c) of the Draft Articles on the Law of Transboundary Aquifers defines a "transboundary aquifer" as one with "parts . . . situated in different States." *Id.*

53. Int'l Groundwater Resources Assessment Ctr., *Transboundary Groundwaters*, UN-IGRAC, https://www.un-igrac.org/areas-expertise/transboundary-groundwaters (last visited Feb. 22, 2020). This calculation doesn't consider intra-national

on the planet. In North America, some aquifers exist in multiple American states and multiple nations at the same time.[54]

Aquifers are like surface waters in that they have outer edges. But unlike aquifers, surface water bodies, typically lakes and rivers, often serve as geo-political borders due to their visible edges and pathways.[55] Although these edges may shift over time, and surface waters may disappear entirely, surface waters have served as geo-political borders for millennia.[56] For example, several rivers in North America provide natural borders between States as well as the United States and Mexico or Canada.[57]

As noted, beneath their perimeters, aquifers also have depth, as they are three-dimensional geological formations with layers of varying depths separated by confining units. Their depth, however, is distinguishable from that of lakes and oceans, as an aquifer has depth for the purpose of defining its separation from another aquifer. The qualities of this separation have important legal consequences when an aquifer's intra- or interstate nature is in question.

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aquifers with overlapping boundaries—those aquifers contained within a single country, but which cross over into different territories within that country.

54. *See, e.g.*, U.S. Geological Survey, *Transboundary Aquifer Assessment Program (TAAP)*, USGS, https://www.usgs.gov/centers/nm-water/science/transboundary-aquifer-assessment-program-taap?qt-science_center_objects=0#qt-science_center_objects (last visited Feb. 22, 2020). For example, per the USGS, the Hueco Bolson and Mesilla aquifers underlie parts of Texas, New Mexico, and Mexico.

55. *See* Sam Grainger & Declan Conway, *Climate Change and International River Boundaries: Fixed Points in Shifting Sands*, 5 WIREs CLIMATE CHANGE 835, 836 (2014). ("The International River Boundaries Database (IRBD) calculates that well over one third of the total length of international borders follow watercourses.").

56. *See generally* Christof Mauch & Thomas Zeller, *Rivers in History and Historiography: An Introduction*, *in* RIVERS IN HISTORY: PERSPECTIVES ON WATERWAYS IN EUROPE AND NORTH AMERICA 1, 1–10 (Christof Mauch & Thomas Zeller, eds., Univ. of Pittsburgh Press 2008).

57. The Mississippi River provides an expansive border for Louisiana, Arkansas, Tennessee, Missouri, Kentucky, Illinois, Iowa, Wisconsin, Minnesota and, of course, Mississippi. The Colorado River provides a natural border for sections of California, Arizona and Nevada before extending further South into Mexico. The Rio Grande defines a section of the United States-Mexico border (the entirety of the approximately 1,000-mile Texas-Mexico border stretching from El Paso, Texas, to the Gulf of Mexico). The St. Lawrence River provides a natural border between the United States and Canada between New York State and Ontario, Canada.

Aquifers are typically separated by confining units, which serve as approximate geological borders between aquifers. A confining unit is a "relatively low permeability geologic unit that impedes the vertical movement of water."[58] They function as barriers that not only define the edges of theoretically separate aquifers but also limit lateral movement of water,[59] thereby protecting an aquifer system from contaminants. Because of their semi-permeability, it is an open question whether confining units that divide aquifers effectively form two separate aquifers or whether they are still part of the same aquifer system.

To further complicate the issue, the water contained within each is not equally distributed.[60] It is not enough to simply state that an aquifer lies under certain land without consideration of depth—a function which affects volume. Accessibility for pumping across an aquifer is not uniform. In some areas, an aquifer may be near the surface. In others, the same aquifer may be functionally inaccessible, lying beneath layers of other geological formations—aquifers, confining units, and other deposits.[61] Furthermore, an aquifer's thickness can vary considerably over its expanse, as in the case of the Memphis Sand, which "ranges from 0 to about 900 feet in thickness but, where the original

58. J.M. CARTER ET AL, U.S. GEOLOGICAL SURVEY, HYDROLOGIC ATLAS, HA-747, ATLAS OF WATER RESOURCES IN THE BLACK HILLS AREA, SOUTH DAKOTA 118 (2002), https://pubs.usgs.gov/ha/ha747/pdf/definition.pdf.

59. RALPH C. HEATH. U.S. GEOLOGICAL SURVEY, BASIC GROUND-WATER HYDROLOGY, U.S. GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2220, at 6 (1983) ("A *confining bed* is a rock unit having very low hydraulic conductivity that restricts the movement of ground water either into or out of adjacent aquifers.").

60. See Anouck Ferroud, Silvain Rafini & Romain Chesnaux, *Using Flow Dimension Sequences to Interpret Non-uniform Aquifers with Constant-rate Pumping-tests: A Review*, 2 J. OF HYDROLOGY X, at 1 (2019) for a discussion of the pumping in aquifers with non-uniform geometry.

61. U.S. Geological Survey, *Aquifers and Groundwater*, USGS, https://www.usgs.gov/special-topic/water-science-school/science/aquifers-and-groundwater?qt-science_center_objects=0#qt-science_center_objects (last visited Mar. 14, 2020) ("A relationship does not necessarily exist between the water-bearing capacity of rocks and the depth at which they are found. . . . Rocks that yield freshwater have been found at depths of more than 6,000 feet, and salty water has come from oil wells at depths of more than 30,000 feet. On the average, however, the porosity and permeability of rocks decrease as their depth below land surface increases; the pores and cracks in rocks at great depths are closed or greatly reduced in size because of the weight of overlying rocks.").

thickness is preserved, it is about 400 to 900 feet thick."[62] The formation dips below other strata and, incidentally, appears to reach its thickest points directly below the City of Memphis.[63] In other words, a larger area of land doesn't necessarily equate to a greater volume of water below.

Determining the borders of aquifers has legal consequences. Confining units are found in the Mississippi Embayment, a fact which provides part of Mississippi's justification for asserting that the Memphis Sand is a separate aquifer system from the Sparta Sand.[64] The question arises as to whether each subordinate aquifer is a separate geologic formation or whether it comprises part of a greater interstate network of aquifers. Mississippi asserts the confining units do, in fact, establish separate aquifers.[65] In doing so, Mississippi considers the Mississippi Embayment a multi-segmented but unified aquifer system,[66] while Tennessee and its co-defendants assert the groundwater in the Memphis Sand is an interstate resource.[67] Whether the Memphis Sand is part of an interstate aquifer network or its own system with its own outer edges is a key inquiry, the answer to which will determine whether equitable apportionment applies to its waters.[68] This, in turn, will affect whether sustainable water management principles will apply, giving due consideration to factors such as the recharge rate, withdrawal rate, flow rate, and ecology.

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62. PARKS & CARMICHAEL, *supra* note 14.

63. *Id.* at 4 tbl.1.

64. *See* Plaintiff's Response to Defendants' Joint Motion in Limine to Preclude Mississippi from Arguing That There Are Two Aquifers at Issue at 6, Mississippi v. Tennessee, No. 22O143 (Nov. 20, 2018).

65. *See* State of Mississippi's Proposed Findings of Fact and Conclusions of Law at ¶ 86, Mississippi v. Tennessee, No. 22O143 (Sept. 19, 2019) ("A hydrogeologic unit can either be a 'hydrogeologic aquifer unit,' or a 'hydrogeologic confining unit,' and a hydrogeologic aquifer unit may have multiple, separate aquifers within the unit." (citations omitted)).

66. *See* 2018 Memoranda, *supra* note 32, at 12. Mississippi refers to the aquifers in question as "a *group* of distinct formations, which includes the Memphis Sand and Sparta Sand," a system where one aquifer "disappears" into the other. *Id.*

67. *See id.* at 11–12.

68. *See id.* at 14.

2. Aquifer Recharge Rate

An aquifer's recharge rate is a critical consideration in the an aquifer's sustainability because when water is pumped from an aquifer in excess of the recharge rate, the aquifer will eventually run out of water. Recharge is "the process of addition of water to the saturated zone,"[69] or how an aquifer replenishes its stores. This characteristic is typically measured indirectly with a great deal of uncertainty built into the property's measurements.[70] Usually multiple methods are employed,[71] each with their own advantages and disadvantages,[72] to obtain an accurate estimate of this property. To further complicate matters, recharge rates are not static,[73] as they are dependent on other geological and atmospheric features such as the year's precipitation in the form of rain and snowfall.[74] Recharge rates are also dependent on certain

69. U.S. Geological Survey, *Methods for Estimating Groundwater Recharge in Humid Regions*, USGS, https://water.usgs.gov/ogw/gwrp/methods/ (last modified Jan. 3, 2017) [hereinafter USGS, *Methods for Estimating*]. The "saturated zone" is the layer of rock below the water table where groundwater is stored. U.S. Geological Survey, *Aquifers and Groundwater*, USGS, https://www.usgs.gov/special-topic/water-science-school/science/aquifers-and-groundwater?qt-science_center_objects=0#qt-science_center_objects (last visited Mar. 14, 2020).

70. USGS, *Methods for Estimating*, *supra* note 69.

71. U.S. Geological Survey, *Selected Methods for Estimating Groundwater Recharge in Humid Regions*, USGS, https://water.usgs.gov/ogw/gwrp/methods/methods.html (last modified Jan. 3, 2017).

72. *See* U.S. Geological Survey, *Comparison of Selected Methods for Estimating Groundwater Recharge in Humid Regions*, USGS, https://water.usgs.gov/ogw/gwrp/methods/compare/ (last modified Jan. 3, 2017) (showing each method with different advantages and disadvantages, with variations in the time scale required, the ease of use, the level of data required for accurate calculations, and the cost burdens).

73. *See* U.S. Geological Survey, *Available Groundwater Recharge Data*, USGS, https://water.usgs.gov/ogw/gwrp/activities/HydCompData.html (last visited Mar. 14, 2020).

74. U.S. Geological Survey, *Drought and Groundwater Levels*, USGS, https://www.usgs.gov/special-topic/water-science-school/science/drought-and-groundwater-levels?qt-science_center_objects=0#qt-science_center_objects (last visited Mar. 14, 2020) ("Groundwater levels first are dependent on recharge from *infiltration of precipitation* . . . ." (emphasis added)).

manmade variables[75] such as groundcover from pavement and concrete. So, prior years' rates are not necessarily a reliable predictor of future recharge, and thus conservative estimates of likely recharge rates, taking many factors into account, are the usual practice for those who have sustainability in mind.

To illustrate, the Snake Valley Aquifer is historically fed by snowmelt.[76] The Snake Valley Aquifer is a narrow depression across multiple western states, bound by the Snake Range to the west; the Conger and Confusion ranges to the east; Modena, Utah to the south; and the Great Salt Lake Desert in the north.[77] Beneath this expanse lies approximately 132,000 acre-feet of water.[78] Historical recharge rates for the Snake Valley Aquifer amounted to 160,000 acre-feet per year, from precipitation and unconsumed irrigation[79] with "60% of [the Snake Valley aquifer's] recharge com[ing] from snowpack in the Snake Range Mountains on the Nevada side of the border."[80] However, increased warming in the American West has resulted in a decrease in the quantity of snowpack, thus reducing what would otherwise be a predictable recharge level.[81] Despite this reduction, there are calls to

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75. *See* THOMAS C. WINTER ET AL., U.S. GEOLOGICAL SURVEY, GROUND WATER AND SURFACE WATER: A SINGLE RESOURCE, U.S. GEOLOGICAL SURVEY CIRCULAR 1139, at 54 (1998), https://pubs.usgs.gov/circ/circ1139/pdf/circ1139.pdf.

76. Philip M. Gardner & Victor M. Heilweil, *A Multiple-Tracer Approach to Understanding Regional Groundwater Flow in the Snake Valley Area of the Eastern Great Basin, U.S.A.*, 45 APPLIED GEOCHEMISTRY 33, 33–34 (2014).

77. Noah D. Hall & Benjamin L. Cavataro, *Interstate Groundwater Law in the Snake Valley: Equitable Apportionment and a New Model for Transboundary Aquifer Management*, 2013 UTAH L. REV. 1553, 1558 (2013).

78. LEWIS YOUNG ROBERTSON & BURNINGHAM, INC., SOCIO-ECONOMIC ANALYSIS: SNAKE VALLEY – JUAB AND MILLARD COUNTIES 3 (2010), http://www.greatbasinwater.net/doc/snake_valley_economic_study_2010.pdf [hereinafter LEWIS YOUNG].

79. MELISSA D. MASBRUCH, PHILIP M. GARDNER, & LYNETTE E. BROOKS, U.S. GEOLOGICAL SURVEY, HYDROLOGY AND NUMERICAL SIMULATION OF GROUNDWATER MOVEMENT AND HEAT TRANSPORT IN SNAKE VALLEY AND SURROUNDING AREAS, JUAB, MILLARD, AND BEAVER COUNTIES, UTAH, AND WHITE PINE AND LINCOLN COUNTIES, NEVADA, SCIENTIFIC INVESTIGATIONS REPORT 2014-5103, at 1 (2014), https://pubs.usgs.gov/sir/2014/5103/pdf/sir2014-5103.pdf.

80. Hall & Cavataro, *supra* note 77, at 1592–93.

81. *See* Gardner & Heilweil, *supra* note 76 ("Most groundwater in the valleys is derived from snowmelt and rainfall above altitudes of 1800 m where precipitation amounts generally exceed losses from evapotranspiration. There is also the potential

tap into the aquifer to support the growing needs of metropolitan Las Vegas.[82] This is a classic scenario where increases in withdrawals are not in accord with decreases in recharge.

Sources of recharge generally include areas where rainwater or surface water seeps into the ground. As the Memphis Sands situation will reveal, groundwater does not behave like surface water: "[G]roundwater recharge may be dependent upon upstream river flow and downstream river flow may be dependent upon aquifer discharge."[83] In other words, water extracted from an aquifer upstream will reduce the flow of surface water downstream. This process will, in turn, reduce the recharge rate of a downstream aquifer. Thus, supply is not dependent on precipitation alone. Depleted supplies may be a

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threat that warmer winter temperatures associated with future climate change will result in *less snow and a reduction in groundwater recharge*." (emphasis added) (citations omitted)).

82. The States of Nevada and Utah proposed a draft agreement to allocate this water, but eventually then-sitting Utah State Governor Gary Herbert declined to sign the agreement into law. *See* Hall & Regalia, *supra* note 6, at 11; *see also* Christopher Smart et al., *Herbert Rejects Snake Valley Water Pact with Nevada*, SALT LAKE TRIB. (Apr. 4, 2013, 10:35 AM), http://archive.sltrib.com/article.php?id=56090274&itype=CMSID. The draft agreement would have allocated the aquifer's supply as follows: "55,000 af of allocated water rights to Utah, 12,000 af of allocated water rights to Nevada, 5,000 af of unallocated water rights to Utah, and 36,000 af of unallocated water rights to Nevada. Assuming 24,000 af still reside in the aquifer after allocating the water in the above manner, 18,000 af will be allocated to Nevada and 6,000 af to Utah." LEWIS YOUNG, *supra* note 78.

83. AFRICA GROUNDWATER NETWORK, INTEGRATION OF GROUNDWATER MANAGEMENT INTO TRANSBOUNDARY BASIN ORGANIZATIONS IN AFRICA: TRAINING MANUAL 17 tbl.2.4 (Richard Owen, ed., 2105), https://www.gwp.org/globalassets/global/toolbox/references/trainingsmanual.pdf. Table 2.4 provides a list of factors that will affect the approach to groundwater management at any given moment, including the following:

> The depth, size and complexity of the groundwater resource, [t]he climate and the rate of aquifer recharge and resource renewal, [t]he scale of groundwater abstraction and the number and types of groundwater users, [t]he ecosystems and environmental services dependent upon groundwater . . . , [t]he susceptibility and vulnerability of the aquifer system to degradation . . . , [n]atural groundwater quality concerns, [p]resent degradation of the groundwater resource (from depletion or pollution), [and] other available water resources[.]

Id. at 17.

result of both decreased recharge rates and excess consumption upstream. This relationship highlights the importance of cooperative and coordinated efforts to manage resources as one region's withdrawals may have considerable impacts on downstream stakeholders' supplies.

3. Aquifer Withdrawal Rate

An aquifer's withdrawal rate, or pumping rate, is a corollary to its recharge rate. Humans cannot withdraw water at volumes which exceed the rate of recharge without eventually depleting the resource entirely. Historically, human activity ignored this reality, or at least lacked the knowledge required to recognize the tipping point, until the global understanding of climate change and the limits of the earth's resources[84] codified ideas related to sustainable development concepts.[85] When an aquifer reaches that threshold and transitions from a healthy resource to one marked by scarcity, sustainable water management becomes a necessity.

The withdrawal rate looks at both the aggregate draw from the aquifer and the specific yield from single wells. Again, aquifers are not simple shapes, and they can extend for hundreds of miles.[86] Yields can vary wildly within individual aquifers.[87] For example, individual "wells completed in the middle Claiborne and the lower Wilcox aquifers (where the Memphis Sand is located) commonly yield from 200 to

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84. *See* Dennis Dimick, *As World's Population Booms, Will Its Resources Be Enough for Us?*, NAT'L GEOGRAPHIC (Sept. 21, 2014), https://www.nationalgeographic.com/news/2014/9/140920-population-11billion-demographics-anthropocene/.

85. *See* REPORT OF THE WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT: OUR COMMON FUTURE 41 (United Nations World Comm'n on Env't and Dev., ed. 1987), http://www.un-documents.net/our-common-future.pdf ("Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.").

86. As seen by looking at a map of aquifers in the United States. *See, e.g.*, U.S. Geological Survey, *Aquifers: Map of the Principal Aquifers of the United States*, USGS, https://water.usgs.gov/ogw/aquifer/map.html (last modified Dec. 18, 2017).

87. *See* R.W. Buddemeier & J.A. Schloss, *Groundwater Storage and Flow*, KAN. GEOLOGICAL SURV., http://www.kgs.ku.edu/HighPlains/atlas/apgengw.htm (last modified Nov. 21, 2000) ("At any given location, the porosity of the formation remains essentially constant, but the volume of water in storage, the average local porosity, and the specific yield all vary with changes in saturated thickness . . . .").

1,000 gallons per minute, but yields might locally exceed 2,000 gallons per minute."[88]

Measurements from the Memphis Sand show the relationship over time among yields, withdrawals, and water levels. This relationship shows that long-term increases in withdrawals contribute to broad declines in water yields. From 1886 to 1975, the rate of withdrawal from the Memphis Sand increased from below 38,000 m^3/day to an excess of 681,000 m^3/day[89]—a 1,700% increase in withdrawals from the aquifer *per day*. With this increase in consumption, 48.6% of wells sampled in the Memphis Sand showed declines.[90]

Unlimited pumping is not in accord with limited, and sometimes decreasing yields. This disconnect represents a conflict between a regime of plenty and a regime of scarcity: "[G]roundwater use routinely activates the tension between a widely shared desire to protect private property rights from regulation and an equally widely recognized need to use regulation to curb problematic uses of property."[91] The "traditional" regime—the regime of plenty—"purports to allow unlimited pumping so long as water remains physically available."[92] Unlimited pumping only makes sense with unlimited yields. As "scarcity" becomes the norm, we will necessarily see a transition away from a regime of plenty to governance which relies largely on sustainable management.

Propert*y* rights regimes do have limits that have been imposed by the judiciary. For example, *Sporhase v. Nebraska ex rel. Douglas*

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88. *See* Lloyd, Jr. & Lyke, *supra* note 19.

89. Waldron & Larsen, *supra* note 21, at 136. Current withdrawals regularly exceed 710,000 m^3. *Id.*

90. LEE HOLT, K.J. HUNT & J. FAUSTINI, U.S. DEP'T OF THE INTERIOR, FISH AND WILDLIFE SERV., WATER RESOURCE INVENTORY AND ASSESSMENT: CACHE RIVER NATIONAL WILDLIFE REFUGE 80 (2015), https://ecos.fws.gov/ServCat/DownloadFile/53133?Reference=52218 ("The average change over the entire aquifer during the 2013-2014 monitoring period was +0.64 feet. During the monitoring period from 2009 to 2014 [by the U.S. Fish and Wildlife Service], 229 wells were monitored for water-level change, with 95 of these wells (41.5%) showing a decline in static water levels. During the 10-year monitoring period, 187 wells were monitored with 82 (43.9%) of these wells showing declines. . . . The average ten-year decline in the Grand Prairie study area was -1.70 feet; in the Cache River study area, the average decline was -3.90 feet[.]").

91. Dave Owen, *Taking Groundwater*, 91 WASH. U. L. REV. 253, 257 (2013).

92. *Id.* at 260.

illustrated the limits of property rights by applying a Reasonable and Beneficial Use standard.[93] That case concerned a Nebraska statutory restriction seeking to restrain groundwater withdrawals for use in neighboring Colorado by Sporhase, a farmer whose property lay within both states.[94] The Nebraska Supreme Court upheld the restraint based on the supposition that private citizens *cannot* trade in groundwater for profit.[95] As the Nebraska Supreme Court saw the matter,

> the owner of land is entitled to appropriate subterranean waters found under his land, but he c*annot extract and appropriate them in excess of a reasonable and beneficial use* upon the land which he owns, especially if such use is injurious to others who have substantial rights to the waters, and if the natural underground supply is insufficient for all owners, each is entitled to a reasonable proportion of the whole . . . .[96]

The States may still "regulate" natural resources, but those States may not hoard or overconsume those resources, to the detriment of all.[97] Nonetheless, a restraint on hoarding is not necessarily sufficient to ensure sustainable and equitable groundwater management.

Though private property rights are not unlimited under *Sporhase*, the "reasonable and beneficial use" restraint is still keyed to notions of ownership and property rights, not availability of the specific resource, and does not address issues related to safe yields[98] and overdraft which are critical for sustainable allocation and management of

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93. Sporhase v. Nebraska *ex rel.* Douglas, 458 U.S. 941 (1982).

94. *Id.* at 944.

95. State *ex rel.* Douglas v. Sporhase, 305 N.W.2d 614, 616 (1981) (finding that groundwater is *not* "a market item freely transferable for value among private parties, and therefore [is] not an article of commerce.").

96. *Id.* at 617 (emphasis added) (quoting Olson v. City of Wahoo, 248 N.W. 304, 308 (1933)).

97. *See* Sporhase v. Nebraska, 458 U.S. at 952–54 (1982). Justice Stevens notes that state ownership of groundwater is a "legal fiction" and that there is a "significant federal interest in conservation as well as in fair allocation of this diminishing resource." *Id.* at 952–53; *see also* Reeves, Inc. v. Stake, 447 U.S. 429 (1980) (rejecting arguments against protectionism and hoarding of resources only two years prior to the *Sporhase* case in response to a cement shortage in South Dakota).

98. *See* WILLIAM M. ALLEY, THOMAS E. REILLY & O. LEHN FRANKE, U.S. GEOLOGICAL SURVEY, SUSTAINABILITY OF GROUND-WATER RESOURCES, U.S.

groundwater. Limited use does not automatically equate to sustainable use. Unsustainable uses persist: "Ground water overdraft is a national problem and Congress has the power to deal with it on that scale."[99] Water management is a pressing concern locally, nationally, and internationally. This is a matter of line drawing. As has been stressed in the Memphis Sand dispute, "[s]tates have an important interest in, and may regulate and control natural resources, but they do not own those resources."[100] In the United States, the accident of a political border does not equate to unrestricted use of a natural resource.

4. Aquifer Flow Rate and Residence Time

Limits on consumption of a natural resource pertain not just to extraction, but to injection as well. Unfettered pollution and contaminated groundwater[101] can be just as damaging as unlimited extraction, to the extent both result in an un-usable value. As surface water flows in a river, groundwater flows through the ground. Natural groundwater flow rate is generally much lower than surface waters, occurring as seepage through pores and fractures, a natural process dubbed the "groundwater residence time" factor.[102] Without human intervention,

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GEOLOGICAL SURVEY CIRCULAR 1186, at 4 (1999), https://pubs.usgs.gov/circ/circ1186/pdf/circ1186.pdf ("The term 'safe yield' commonly is used in efforts to quantify sustainable groundwater development. The term should be used with respect to specific effects of pumping, such as water-level declines, reduced streamflow, and degradation of water quality."); *see also* William M. Alley & Stanley A. Leake, *The Journey from Safe Yield to Sustainability*, 42 GROUND WATER 12 (2004), https://ngwa-onlinelibrary-wiley-com.ezproxy.memphis.edu/doi/pdfdirect/10.1111/j.1745-6584.2004.tb02446.x.

99. Sporhase v. Nebraska, 458 U.S. at 954.

100. 2018 Memorandum, *supra* note 32, at 23.

101. *See, e.g.*, ENVTL. PROT. AGENCY, GETTING UP TO SPEED: GROUND WATER CONTAMINATION, https://www.epa.gov/sites/production/files/2015-08/documents/mgwc-gwc1.pdf.

102. *See* JAMES A. KINGSBURY ET AL., U. S. GEOLOGICAL SURVEY, WATER QUALITY IN THE MISSISSIPPI EMBAYMENT—TEXAS COASTAL UPLANDS AQUIFER SYSTEM AND MISSISSIPPI RIVER VALLEY ALLUVIAL AQUIFER, SOUTH-CENTRAL UNITED STATES, 1994–2008, CIRCULAR 1356, at 22 fig.4.1 (2014), https://pubs.usgs.gov/circ/1356/pdf/circ1356.pdf ("The amount of time groundwater is in an aquifer (groundwater residence time) depends on the flow path along which the water moves. Groundwater can take from days to millennia to flow from points of

this flow occurs at rates on the order of feet per day, or even feet per decade.[103] The Memphis Sand is no exception, but not without some dispute as to flow rate.[104]

Water is, and no one can stress this enough, an essential resource for life. The focus of this conversation is necessarily on extraction—pumping water from the Memphis Sand. However, groundwater residence time deals with time scales that are beyond the human experience, and it means aquifers can become a potential long-term store for contaminants.[105]

Pressing issues concerning water contamination and access to water are becoming increasingly important in the United States and abroad. Aquifer systems interact with other natural systems, humans included.[106] Human interaction includes not just extraction of groundwater for irrigation and drinking, but the introduction of waste into the system.[107] An ever-present risk of contamination, combined with low

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recharge at land surface to points of discharge at, for example, a pumping well or a stream.").

103. *See* ALLEY, REILLY & FRANKE, *supra* note 98, at 8 ("The movement of ground water normally occurs as slow seepage through the pore spaces between particles of unconsolidated earth materials or through networks of fractures and solution openings in consolidated rocks. A velocity of 1 foot per day or greater is a high rate of movement for ground water, and ground-water velocities can be as low as 1 foot per year or 1 foot per decade."). A consideration of groundwater residence time in relation to groundwater flow rates would essentially transform all groundwater into intrastate resources, as groundwater would never leave a given state on human time scales.

104. *See* Waldron & Larsen, *supra* note 21, at 151 ("The estimated average quantity of flow from Mississippi into Shelby County around the time of pre-development was approximately 220,000 m^3/day as compared to zero or no flow according to Criner and Parks (1976). Accounting for uncertainty in the data, the volumetric flow crossing from Mississippi into Shelby County, Tennessee is still much greater than zero where the range is approximately 139,000 and 331,000 m^3/day with an average rate of 221,000 m^3/day.").

105. *See* ENVTL. PROT. AGENCY, *supra* note 101, at C2 ("[B]ecause ground water usually moves slowly, contaminants generally undergo less dilution than when in surface water.").

106. *See* WINTER, *supra* note 75.

107. *See* ENVTL. PROT. AGENCY, *supra* note 101, at C1 ("Groundwater contamination is nearly always the result of human activity. In areas where population density is high and human use of the land is intensive, ground water is especially vulnerable.").

volume flow rates, translates to contaminant residence time on the order of thousands of years.[108] Thus, sound sustainable management of all aquifers is necessary, not just from a standpoint of consumption and allocation, but also for protection and conservation purposes.

As with any other aquifer, the Memphis Sand's groundwater characteristics do not exist in a vacuum. The Memphis Sand produces some of the most pristine water in North America from a layer in the geological strata called the Middle Claiborne Aquifer.[109] This layer is largely protected by layers of "less permeable clay."[110] Despite these natural geological shields, the Memphis Sand is not invincible and remains vulnerable to human industry.[111]

To illustrate, groundwater monitoring conducted by the Tennessee Valley Authority ("TVA") identified an "area between the shallow aquifer and the Memphis Sand aquifer without a protective clay barrier."[112] Subsequent excavation revealed "[s]ixteen breaches in the clay layer protecting the Memphis Sand aquifer . . . in Shelby County,"[113] a discovery which prompted the Shelby County Health Department to limit well use."[114] In 2017, "investigators found 300 times

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108. COMM. ON GROUND WATER CLEANUP ALTERNATIVES, ALTERNATIVES FOR GROUND WATER CLEANUP 55 (Nat'l Academies Press 1994) ("Natural ground water flow rates, however, are slow in most formations (1 to thousands of meters per year), so this migration will take place over large time scales—months to hundreds or thousands of years, compared to days or weeks in most rivers and streams.").

109. *See* Upholt, *supra* note 22.

110. *Id.*

111. *See* Micaela A. Watts, *TVA Report: Clay Barrier Absent Above Memphis Aquifer at Site Near Coal Ash Landfill*, COMMERCIAL APPEAL (Mar. 1, 2019, 3:15 PM), https://www.commercialappeal.com/story/news/breaking/2019/03/01/memphis-aquifer-not-protected-arsenic-some-parts-tva-says-coal-ash-contamination-ground-water/3034179002/.

112. *Id.*

113. Jamie Munks, *Sixteen Known Breaches Pose Threats to Memphis's Drinking Water Supply, Study Seeks to ID More*, COMMERCIAL APPEAL, (Apr. 8, 2019, 10:27 PM) https://www.commercialappeal.com/story/news/2019/04/08/memphis-sand-aquifer-contamination-drinking-water-safety-study/3401419002/.

114. *Shelby County Health Department Puts Strict Limits on TVA Water Wells at Allen Power Plant*, S. ENVTL L. CTR. (Feb. 21, 2019), https://www.southernenvironment.org/news-and-press/press-releases/shelby-county-health-department-puts-strict-limits-on-tva-water-wells-at-al. Indeed, the Shelby County Health Department modified existing well permits held by the Tennessee Valley Authority to curb the risk

the legal limit of arsenic in an alluvial aquifer that sits above the Memphis Sand Aquifer"[115] near the TVA's Allen Fossil Plant. The TVA is expected to remediate the water of its arsenic content, but what that process entails, or its likelihood of success, is still to be determined.[116]

This example shows that even an aquifer as relatively large and flush as the Memphis Sand is not immune to contamination by human activities. As the next Section will show, the decision reached in the Memphis Sand dispute will affect not just the flush aquifers, but the vulnerable ones in fragile and often arid lands, and the life that relies on those waters.

5. Ecological Dependence

Precedent set by the Memphis Sand dispute will impact management principles governing vulnerable aquifers, with potentially harmful and irreversible consequences to both the human population and to the region's flora and fauna. Ecological vulnerability must be considered in any discussion about aquifer consumption, and it informs the potentially wide-reaching nature of the Memphis Sand dispute's

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of contamination by limiting well use to three circumstances: "(1) to sample for contaminants or further study the connection of the coal ash-contaminated shallow aquifer to the Memphis Sand Aquifer, the county's drinking water source; (2) to operate the gas plant when water from [MLGW] is not available and there is a risk of catastrophic failure of the gas plant or serious damage or disruption to the regional power grid; and (3) for very limited, periodic maintenance." *Id.*

115. Toby Sells, *TVA to Remove Arsenic from Aquifer*, MEMPHIS FLYER: NEWS BLOG (Nov. 30, 2018, 3:04 PM), https://www.memphisflyer.com/NewsBlog/archives/2018/11/30/tva-to-remove-arsenic-from-aquifer.

116. *Id.* TVA invited public comments on their "Environmental Impact Statement" plan, to which Protect Our Aquifer, The Tennessee Chapter of the Sierra Club, and the Southern Environmental Law Center filed a joint comment on the matter, stating that the TVA was not doing enough to remediate the problem:

> [Data from the investigations] indicated that there is a current risk of ongoing coal ash contamination in the Memphis Sand Aquifer and McKellar Lake due to TVA storage of coal ash in the leaking, unlined East Ash Pond and the consequent coal ash contamination of the alluvial aquifer. . . . Neither the (remedial investigation) itself nor the EIP acknowledge this current and ongoing risk, and therefore, do not outline an appropriate next step in the ongoing investigation of coal ash contamination at the Allen Plant site.

Id.

outcome. While the Memphis Sand is relatively flush with freshwater—questions over the aquifer's flow and recharge rate aside—many aquifers are not so rich. Many are situated in dry, arid regions and are prone to periods of drought, a source of substantial stress on a region's flora and fauna.[117]

The Cadiz Watershed resides in a dry, arid region and so the proposed Cadiz Valley Water Conservation, Recovery, and Storage Project ("Cadiz Project") highlights the concerns with ecological vulnerability.[118] It is not flush with water like the Memphis Sand. For the sake of comparison, where the Cadiz Watershed supports withdrawals based on a recharge rate of a few tens of thousands of acre feet

117. *See, e.g.*, Nicholas R. Bond et al., *The Impacts of Drought on Freshwater Ecosystems: An Australian Perspective*, 600 HYDROBIOLOGIA 3 (2008), https://doi.org/10.1007/s10750-008-9326-z. For further related research, see generally *Drought Stress*, SCI. DIRECT, https://www.sciencedirect.com/topics/earth-and-planetary-sciences/drought-stress.

118. This controversial project is moving forward regardless of the risks. On October 13, 2017, the Trump Administration, by way of the Bureau of Land Management, determined the project could move forward *without* approvals or permits otherwise required by the Bureau of Land Management. Such approvals would have been required under Obama Administration decisions. *Compare* U.S. Dep't of the Interior, Bureau of Land Mgmt., Opinion Letter Superseding the October 2015 Administrative Determination for the Cadiz Project (Oct. 13, 2017), *with* U.S. Dep't of the Interior, Bureau of Land Mgmt., Cal. State Office, Opinion Letter Finding that the Cadiz Project Does Not Comply with 43 CFR Section 2800 Rights of Way under the Federal Land Policy and Management Act (Oct. 2, 2015). The project piggy-backs off an existing easement granted to the Arizona California Railroad under the 1875 General Railroad Right-of-Way Act (1875 Act), ignoring and essentially reversing an earlier determination that any activities related to the easement must "derive from or further a railroad purpose." *See* 6 FINAL ENVIRONMENTAL IMPACT REPORT, SCH# 2011031002, MASTER RESPONSE ON RAILROAD RIGHT-OF-WAY AND NEPA ANALYSIS 3.13-1–13-3 (2012), http://www.cadizwaterproject.com/wp-content/uploads/2015/07/V6_3-13_MR-Railroad-ROW-and-NEPA.pdf. The Center for Biological Diversity opposes the project in a lawsuit which is unrelated to the Memphis Sand litigation. Complaint for Declaratory & Injunctive Relief at ¶¶ 13–14, Ctr. for Biological Diversity & Ctr. for Food Safety v. U.S. Bureau of Land Mgmt., No. 2:17-cv-08587 (C.D. Cal. Nov. 28, 2017). The Complaint seeks an injunction against proceeding with the project and a decision which would determine that the Cadiz Project "falls outside the scope of the 1875 Act right-of-way at issue, vacate BLM's determination to the contrary, and enjoin BLM from allowing the pipeline to proceed . . . ." *Id.* at ¶ 6.

per year,[119] or approximately 10 million gallons *per year*, withdrawals from the Memphis Sand are on the order of hundreds of millions of gallons *per day*.[120] The Cadiz Project seeks to "create a new water supply that can serve up to 400,000 people a year by reducing a recurrent loss of groundwater to evaporation in California's Mojave Desert"[121] by building a 43-mile pipeline through the Mojave Trail National Monument (the "Monument"),[122] founded under the Obama Administration.[123] The Monument is a 1.6 million-acre expanse that stretches across three different watersheds: the Fenner, Bristol, and the Cadiz Watersheds, within which Cadiz owns a 34,000 acre "donut hole."[124]

There is a disconnect in the reported data over the project's environmental impact. The Cadiz Project would potentially pump up to 16.3 billion gallons from the Monument to sell to Southern California's[125] urban water districts.[126] In doing so, Cadiz would leverage the

119. *Project Hydrology*, CADIZ, https://www.cadizinc.com/project-hydrology/ (last visited Feb. 23, 2020) (basing this comparison on Cadiz's assessment of the watershed (32,000 acre-feet equals 10.432 million gallons)).

120. *See* TN H2O, TENNESSEE'S ROADMAP TO SECURING THE FUTURE OF OUR WATER RESOURCES: GROUNDWATER WORKING GROUP EXECUTIVE SUMMARY 4 (2018) ("Groundwater use in Middle Tennessee is about 60 mgd (14% of the State total) and in East Tennessee about 86 mgd (20%)."); s*ee also* PARKS & CARMICHAEL, *supra* note 14, at 1; JOHN A. ROBINSON, U.S. GEOLOGICAL SURVEY, PUBLIC-SUPPLY WATER USE AND SELF-SUPPLIED INDUSTRIAL WATER USE IN TENNESSEE, 2010, SCIENTIFIC INVESTIGATIONS REPORT 2018–5009, at 1 (2018), https://pubs.usgs.gov/sir/2018/5009/sir20185009.pdf.

121. *The Cadiz Water Project*, CADIZ WATER PROJECT, https://www.cadizwaterproject.com/ (last visited Feb. 23, 2020).

122. Complaint for Declaratory & Injunctive Relief, *supra* note 118, at ¶ 32.

123. Proclamation No. 9395, 81 Fed. Reg. 8371 (Feb. 18, 2016).

124. *See* Complaint for Declaratory & Injunctive Relief, *supra* note 118, at ¶¶ 23, 27, 30. Cadiz is a self-described "publicly-held natural resources company that owns 70 square miles of property and water resources in Southern California." *Welcome to Cadiz, Inc.*, CADIZ, https://www.cadizinc.com/ (last visited Feb. 23, 2020). The extent to which a company or government agency can own or access "water resources" is the very question raised by the Memphis Sand Dispute.

125. Sam Metz, *Lawmakers Advance Bill to Increase Oversight on Cadiz's Mojave Desert Water Project*, DESERT SUN (May 18, 2019, 9:34 AM), https://www.desertsun.com/story/news/politics/2019/05/17/california-lawmakers-advance-bill-increase-oversight-cadiz-mojave-desert-water-project/3694988002/.

126. Complaint for Declaratory & Injunctive Relief, *supra* note 85, at 1.

generally unrestricted access provided by property-based water management principles. Cadiz contends that "[a]pplication of the latest 2008 USGS computer model (INFIL3.0) results in water recharge rate estimates of approximately 32,000 acre-feet per year."[127] Meanwhile, the USGS reported the water pipeline would withdraw water from the region in excess of the aquifer's recharge rate.[128] Specifically, Cadiz reports that the "total quantity of groundwater to be recovered and conveyed to Project participants will not exceed a long-term annual average of 50,000 acre-feet per year,"[129] which confirms the findings of the USGS.

By withdrawing groundwater in excess of its recharge rate, the Cadiz project is a potential threat to the region's wildlife, "stealing habitat from threatened and endangered species."[130] These lands are "extremely fragile, easily scarred, and slowly healed."[131] The lakebed systems in the Monument are highly sensitive to changes in the aquifers, and even though "desert lakebeds, or 'playas,' are dry for most of the year, evaporation from underground aquifers keeps the lakebeds moist year-round and prevents lakebed sediment from becoming airborne particulate pollution."[132] The Cadiz Project would upset this sensitive

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127. Project Hydrology, *supra* note 119.

128. The Times Editorial Board, *Editorial: The Cadiz Project to Drain the Desert is a Bad Idea*, L.A. TIMES (May 15, 2019, 3:05 AM), https://www.latimes.com/opinion/editorials/la-ed-cadiz-water-california-bill-20190515-story.html ("The U.S. Geological Survey studied the land and the water and, in 2002, found otherwise. Its scientists concluded that the proposed pumping would far exceed the rate of natural refill. The National Park Service submitted comments in 2012 stating that Cadiz's estimates are '3 to 16 times too high.' The Geological Survey, in 2017, reported that there was no information to lead it to change its 2002 conclusions.").

129. *Cadiz Valley Water Conservation, Recovery and Storage Project*, CADIZ, https://www.cadizinc.com/cadiz-water-project/ (last visited Feb. 23, 2020) (stating in effect that withdrawals of 50,000 acre-feet per year would exceed their previously estimated recharge rate of 32,000 acre-fee per year).

130. *The Cadiz Water Project: [Mojave] Water Grab Déjà Vu*, CTR. FOR BIOLOGICAL DIVERSITY, https://www.biologicaldiversity.org/campaigns/Cadiz/index.html (last visited Feb. 23, 2020).

131. 43 U.S.C. § 1781(a)(2) (2020).

132. Complaint for Declaratory & Injunctive Relief, *supra* note 118, at 7. The plaintiffs explain in the Complaint that a disruption of this balance "could take up to 390 years after the cessation of pumping for the aquifer to return to its natural equilibrium." *Id.* at 8.

relationship by lowering groundwater levels by approximately eighty feet.[133] The excessive withdrawals would therefore threaten vegetation and wildlife, including desert tortoises, bighorn sheep, Mojave fringe-toed lizards and kit foxes.[134] Furthermore, the Cadiz Pipeline will also contribute to "toxic air pollution from windswept sediments . . . [and] produce water laced with toxins that could pose a serious risk to consumers[,]" due to the presence of hexavalent chromium, arsenic and mercury.[135]

Whether or not the project is, in fact, a threat turns on differing opinions on the Cadiz Watershed's recharge rate. The complaint against Cadiz's hydraulic modeling indicates that Cadiz "overestimated the natural recharge rate by 5 to 25 times."[136] Not surprisingly, proponents of the pipeline suggest the Cadiz Project will pump water at a level well below the recharge rate, while opponents paint a much more fragile picture, one where the Cadiz Project will drain the region dry.[137]

Overconsumption of freshwater for agriculture and other human needs and increasing pollution of available surface water stress hydrogeological systems. Such human interaction contributes to a definite trend towards the desolation of surface waters, whether by desiccation

133. ANTHONY BROWN ET. AL., AQUILOGIC, INC., REPORT OF THE INDEPENDENT PEER REVIEW PANEL FOR THE GROUNDWATER MANAGEMENT, MONITORING, AND MITIGATION PLAN (GMMMP) FOR THE CADIZ VALLEY GROUNDWATER CONSERVATION, RECOVERY AND STORAGE PROJECT 3 (2019), https://www.fvwa.org/wp-content/uploads/2019/03/Aquilogic-Report-Cadiz-Project-Overview-2-19.pdf\ ("A groundwater level drawdown threshold (80 feet) is proposed in the GMMMP for a distance of two miles from the center of the Cadiz Project well-field. This threshold is intended to provide a management 'floor' below which mitigation actions would be triggered. Such a floor was selected as it lessens the need for resource-specific mitigation actions at individual Critical Resources, and it provides a proactive Corrective Measure that would prevent significant impact.").

134. *See Lawsuit Challenges Trump Administration's OK of Corporation's Plan to Drain California Desert Aquifer*, CTR. FOR BIOLOGICAL DIVERSITY (Nov. 28, 2017), https://www.biologicaldiversity.org/news/press_releases/2017/cadiz-11-28-2017.php.

135. Complaint for Declaratory & Injunctive Relief, *supra* note 118, at 2.

136. *Id.* at 8; *see* discussion on Recharge Rates, *supra* Section III.B.2)

137. *Id.* at 2.

through drought and overconsumption, or by spoilage through pollution and waste.[138] Such threats call for applying risk-averse, groundwater management principles based on caution and restraint, such as those proposed by the Precautionary Principle, for example.[139]

Under the Precautionary Principle, groundwater management would avoid even a hypothetically deleterious course of action,[140] such as the construction of a water pipeline through arid land.[141] The Pre-

138. *See* WINTER, *supra* note 75.

139. *See* KIRSTIN I. CONTI & JOYEETA GUPTA, GLOBAL GOVERNANCE PRINCIPLES FOR THE SUSTAINABLE DEVELOPMENT OF GROUNDWATER RESOURCES, INT'L ENVTL. AGREEMENTS 10 (2015) https://www.un-igrac.org/sites/default/files/resources/files/Global%20governance%20principles%20for%20the%20sustainable%20development%20of%20groundwater%20resources.pdf, (defining the Precautionary Principle as to " [t]ake precautionary action to prevent irreversible harm even when there is inconclusive scientific evidence on cause and effect."); *see also* UNITED NATIONS, RIO DECLARATION ON ENVIRONMENT AND DEVELOPMENT 3–4 (1992), https://www.jus.uio.no/lm/environmental.development.rio.declaration.1992/portrait.a4.pdf ("In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.").

140. *See* Andrew Jordan & Timothy O'Riordan, *The Precautionary Principle: A Legal and Policy History*, *in* THE PRECAUTIONARY PRINCIPLE: PROTECTING PUBLIC HEALTH, THE ENVIRONMENT AND THE FUTURE OF OUR CHILDREN 31, 32–33 (Marco Martuzzi & Joel A Tickner, eds., 2004), http://www.euro.who.int/__data/assets/pdf_file/0003/91173/E83079.pdf ("In the context of sustainable development, although the principle of precaution does not state how various environmental and economic factors should be traded off, it strongly suggests that a strenuous search be conducted for alternative modes of development that minimize discharges and waste products, regardless of whether they are known to have harmful effects, on the basis that prevention is often, though not always, more cost-effective than cure.").

141. The Precautionary Principle is reflected in other United Nations articles with specific reference to groundwater. Specifically, Equitable and Reasonable Utilization is an outgrowth of Equitable Apportionment considered and applied by international organizations. *See* INT'L LAW COMM'N, *supra* note 45, at 40–43. The Draft Articles on the Law of Transboundary Aquifers of the United Nations propose a method of Equitable and Reasonable Utilization for allocating water in transboundary aquifers in Article 4:

> Aquifer States shall utilize transboundary aquifers or aquifer systems according to the principle of equitable and reasonable utilization, as

cautionary Principle is not a call for an outright ban on a course of action, but rather it promotes moderation with a view towards preservation.[142] Stakeholders may use the available water but should not harm the stakeholders' neighbors.[143] The wealth of freshwater held in aquifers paired with human consumption inevitably leads to an increase in actions to tap the water, to develop appropriate infrastructure to distribute that water to human population centers, and then litigate the complications which will arise.[144] Indeed, this is precisely the trend we are

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> follows: (a) they shall utilize transboundary aquifers or aquifer systems in a manner that is consistent with the equitable and reasonable accrual of benefits therefrom to the aquifer States concerned; (b) they shall aim at maximizing the long-term benefits derived from the use of water contained therein; (c) they shall establish individually or jointly a comprehensive utilization plan, taking into account present and future needs of, and alternative water sources for, the aquifer States; and (d) they shall not utilize a recharging transboundary aquifer or aquifer system at a level that would prevent continuance of its effective functioning.

Id.

Additionally, Article 6 proposes an obligation to "prevent the causing of significant harm to other aquifer States or other States in whose territory a discharge zone is located." *Id.* at 22.

142. *See* Ted Schettler & Carolyn Raffensperger, *Why is a Precautionary Approach Needed?*, *in* THE PRECAUTIONARY PRINCIPLE: PROTECTING PUBLIC HEALTH, THE ENVIRONMENT AND THE FUTURE OF OUR CHILDREN, 63, 66 (Marco Martuzzi & Joel A Tickner, eds., 2004), http://www.euro.who.int/__data/assets/pdf_file/0003/91173/E83079.pdf (stating that the Precautionary Principle "is based on recognizing that people have a responsibility to prevent harm and to preserve the natural foundations of life, now and into the future.").

143. *Executive Summary* of THE PRECAUTIONARY PRINCIPLE: PROTECTING PUBLIC HEALTH, THE ENVIRONMENT AND THE FUTURE OF OUR CHILDREN, 1, 5 (Marco Martuzzi & Joel A Tickner, eds., 2004), http://www.euro.who.int/__data/assets/pdf_file/0003/91173/E83079.pdf (commenting that the "preventive precautionary actions ultimately aim at continuously reducing and if possible removing exposures to potentially harmful substances, activities and other conditions," not prohibiting those actions outright); *see also* CONTI & GUPTA, *supra* note 139, at 10 (providing a list of "Simple explanations of principles/rights from groundwater governance texts," which defines "No Significant Harm" as: "Not cause harm to other states; this limits the sovereign rights of a state.").

144. *See, e.g.*, *Freshwater Crisis*, *supra* note 2.

seeing play out in the United States courts. The outcome of the Memphis Sand dispute has the potential to greatly impact the future of groundwater and the sustainable management of this precious resource.

6. Summary

The above discussion of certain aquifer characteristics showed a definite trend away from treating groundwater as a problem of uncertainty and towards a view favoring sustainable water management with an understanding that groundwater is part of an interconnected hydrologic system. Aquifer borders exist as both two-dimensional perimeters and as three-dimensional shapes with variable depths separated by confining units. Groundwater is a renewable resource, but aquifers recharge at different rates and under different circumstances depending on precipitation, snow melt, and interchange from surface waters. Sustainable management must consider these limits. Furthermore, aquifer withdrawal rates are not constant. Humans have been withdrawing water from the ground at ever increasing levels with little regard to the recharge rate. This practice is not sustainable, particularly with vulnerable aquifers such as those in arid regions. Aquifer flow rates also vary considerably compared to surface waters, and are typically much, much slower. This characteristic affects both groundwater residence time—an important aspect of Mississippi's claims in the Memphis Sand dispute—and contaminant residence time. These characteristics affect not only the health of the aquifer, but the viability of life that depends on aquifers' waters. Furthermore, the Special Master and the Supreme Court will consider all of these characteristics to determine whether the Memphis Sand is, indeed, an interstate natural resource.

IV. THE MATTER BEFORE THE SUPREME COURT

The previous section set forth the terms for engaging in this discussion and for understanding the sensitivity of the dispute's outcome. The Memphis Sand's future, indeed the future of many domestic aquifers, hinges on whether the Court deems the aquifer to be an interstate resource. The answer to this question is a potentially dispositive issue in the Memphis Sand dispute. With this case, the Supreme Court is

called on to address how groundwater fits into the Court's interstate water jurisprudence.[145]

Should the Special Master find the Memphis Sand to be an intrastate resource, both groundwater jurisprudence and management will remain the status quo. Such a result would ease the way for anti-regulation, pro-property policies to enable the exploitation of groundwater resources for profit, and it will do so to the exclusion of sustainable alternatives. On the other hand, should the Special Master find the Memphis Sand to be an interstate resource, it will lay a foundation for a broader application of sustainable groundwater management and equitable apportionment. Equitable apportionment is premised on cooperative efforts for fair and sustainable use for "all stakeholders,"[146] not just those who happen to own the land over which the water temporarily lies. To gain some insight into the Memphis Sand's interstate versus intrastate character, this Part will examine some key issues raised in the Special Master's two Memoranda.

A. The Dispute's Procedural and Substantive History

The state of Mississippi started this dispute as a claim against Memphis Light, Gas and Water ("MLGW") for compensation for "the alleged conversion of groundwater in the Memphis Sands Aquifer."[147] Mississippi did not seek an application of equitable apportionment of water in the Memphis Sand because it did not consider the water allegedly converted by MLGW to be part of an interstate resource.[148] So,

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145. *See also* United States v. New Mexico, 438 U.S. 696 (1978); Kansas v. Colorado, 206 U.S. 46 (1907); Montana v. Wyoming, 563 U.S. 368 (2011); Wyoming v. Colorado, 259 U.S. 419 (1922).

146. *See* HÉCTOR GARDUÑO, FRANK VAN STEENBERGEN & STEPHEN FOSTER, THE WORLD BANK WATER PARTNERSHIP PROGRAM, STAKEHOLDER PARTICIPATION IN GROUNDWATER MANAGEMENT 4, http://siteresources.worldbank.org/EXTWAT/Resources/4602122-1210186362590/GWM_Briefing_6new.pdf. ("*All* stakeholders for a given groundwater body need to be identified, and provision made to ensure their fair representation in the institutional mechanism defined for aquifer management . . . ." (emphasis added)).

147. Hood *ex rel.* Miss. v. City of Memphis, 570 F.3d 625, 627 (5th Cir. 2009).

148. *Id.* at 629 ("Mississippi argues that its suit does not require an equitable apportionment of the Aquifer because the state owns the groundwater resources of the

Mississippi brought the lawsuit before the United States District Court for the Northern District of Mississippi, Delta Division ("USDC"), against the City of Memphis and MLGW in February 2005 *without* naming the State of Tennessee as a party.[149] Memphis moved to dismiss for several reasons, including the failure to include the State of Tennessee as a party.[150] Although Mississippi was bringing the action against a municipality in another state, it argued that because the aquifer from which MLGW pulls its water was *not* an interstate system, it was proper to exclude the State of Tennessee from the lawsuit.[151] In other words, the State argued that since the aquifer's waters would functionally reside in Mississippi for millennia, but for MLGW's pumping operations, the Memphis Sand's "interstate" character only exists by artificial operation of the City of Memphis and MLGW.[152]

Judge Davidson from the USDC, determined Tennessee was a "necessary and indispensable"[153] party under Rule 19 of the Federal Rules of Civil Procedure ("FRCP").[154] To the extent the Memphis

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state as a self-evident attribute of statehood, and thus there is no interstate water to be equitably apportioned.").

149. Hood *ex rel.* Miss. v. City of Memphis, 533 F. Supp. 2d 646 (N.D. Miss. 2008), *aff'd*, 570 F.3d 625 (5th Cir. 2009).

150. *See* Defendants' Memorandum of Law in Support of Their Motion (I) to Dismiss for Lack of Ripeness/Lack of Standing, (II) to Dismiss for Failure to Join an Indispensable Party, and (III) to Dismiss the Tort Claims for Lack of Subject Matter Jurisdiction/Improper Venue at 1, Hood *ex rel.* Miss. v. City of Memphis, 533 F. Supp. 2d 646 (N.D. Miss. 2008) (No. 2:05-CV-32-D-B), 2005 WL 1183346.

151. *Hood*, 533 F. Supp. 2d at 649 ("Plaintiff contends on the one hand that only Mississippi water is involved in this suit . . . .").

152. *See Hood*, 570 F.3d at 627.

153. *Id.* at 648; *see also Hood*, 570 F.3d at 630 ("The Aquifer is an interstate water source, and the amount of water to which each state is entitled from a disputed interstate water source must be allocated before one state may sue an entity for invading its share." (citing Hinterlander v. La Plata River & Cherry Creek Ditch Co., 304 U.S. 92, 104–05 (1938))).

154. *Hood* 533 F. Supp. 2d at 648; *see* FED. R. CIV. P. 19 ("(a) Persons Required to Be Joined if Feasible. (1) *Required Party.* A person who is subject to service of process and whose joinder will not deprive the court of subject-matter jurisdiction must be joined as a party if: (A) in that person's absence, the court cannot accord complete relief among existing parties; or (B) that person claims an interest relating to the subject of the action and is so situated that disposing of the action in the person's absence may: (i) as a practical matter impair or impede the person's ability to protect the interest; or (ii) leave an existing party subject to a substantial risk of incurring

Sand is, indeed, an interstate resource, the FRCP require that Tennessee be afforded an opportunity to defend its interest in the Memphis Sand.[155] Therefore, because the District Court, in Tennessee's absence, could not accord complete relief among existing parties, it dismissed the suit.[156] The Fifth Circuit upheld the holding.[157]

Mississippi then initiated its *second* dispute against MLGW, this time before the Supreme Court.[158] The Supreme Court appointed Hon. Eugene E. Siler as Special Master for the purpose of reviewing evidentiary material[159] under FRCP 53.[160]

The Defendants then moved to dismiss the case again, this time claiming that Mississippi is barred from relitigating whether the Memphis Sand is an intrastate or interstate resource, claiming that the Fifth Circuit essentially did just that.[161] After all, the USDC ostensibly found

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double, multiple, or otherwise inconsistent obligations because of the interest. (2) *Joinder by Court Order.* If a person has not been joined as required, the court must order that the person be made a party. A person who refuses to join as a plaintiff may be made either a defendant or, in a proper case, an involuntary plaintiff. (3) *Venue.* If a joined party objects to venue and the joinder would make venue improper, the court must dismiss that party.").

155. *Hood*, 533 F. Supp. 2d at 649–50; *see* FED. R. CIV. P. 19(a)(1)(B)(i).

156. *Hood*, 533 F. Supp. 2d at 651.

157. *Hood*, 570 F.3d at 633.

158. *See* Motion for Leave to File bill of Complaint in Original Action at 1, Mississippi v. Tennessee, No. 22O143 (June 6, 2014).

159. *See* Order Appointing the Special Master, *supra* note 13.

160. *See* FED. R. CIV. P. 53(c) (stating that "a master may . . . if conducting an evidentiary hearing, exercise the appointing court's power to compel, take, and record evidence."); THOMAS E. WILLGING ET AL., FED. JUDICIAL CTR., SPECIAL MASTERS' INCIDENCE AND ACTIVITY: REPORT TO THE JUDICIAL CONFERENCE'S ADVISORY COMMITTEE ON CIVIL RULES AND ITS SUBCOMMITTEE ON SPECIAL MASTERS 1 (2000) ("Rule 53(c) appears to contemplate the traditional activity of a special master in holding evidentiary hearings and issuing reports with factual findings to facilitate a trial."). Matters where the Supreme Court is the Court of original jurisdiction are particularly prone to Special Master appointments as the matter would, by its very nature, lack the filings of a lower court. *See, e.g.*, *Hood*, 533 F. Supp. 2d at 650 ("[E]xclusive and original jurisdiction over disputes of this type are vested in the United States Supreme Court, which has typically in the past assigned these disputes to a Special Master, who then makes proposed findings of fact and conclusions of law to the Supreme Court, which subsequently renders a decision in the case.").

161. Defendants' Motion for Judgment on the Pleadings & Memorandum of Law in Support at 26–28, Mississippi v. Tennessee, No. 22O143 (Feb. 24, 2016). The

the Memphis Sand was, in fact, an interstate resource.[162] Indeed, once the Fifth Circuit affirmed the USDC's decision,[163] this conclusion could be considered central to including the State of Tennessee in the current iteration of the dispute.[164]

However, in a 2016 Memorandum, the Special Master found the Fifth Circuit was inconclusive on the point and found that Mississippi was not barred from litigating the Memphis Sand's intrastate versus interstate character.[165] The Memphis Sand's "potential" interstate character was, indeed, central to the Fifth Circuit's dismissal of the case for failure to include Tennessee.[166] The Fifth Circuit even said so explicitly: "The Aquifer is an interstate water source, and the amount of water to which each state is entitled from a disputed interstate water source must be allocated before one state may sue an entity for invading its share."[167] However, the Special Master determined that the Fifth

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alternative reading is a classic example of circular logic. By the Defendants' contention, the Fifth Circuit concluded that the Memphis Sand was an interstate resource, and then found that Tennessee was a necessary party to a dispute designed to determine whether the Memphis Sand was an interstate resource. *Id.* "The thought behind the phrase *proclaims itself misread when the outcome of the reading is injustice or absurdity*." Surace v. Danna, 161 N.E. 315, 316 (N.Y. 1928). This approach would decrease the scope of the Supreme Court's original jurisdiction as much as Mississippi's proposed "pre-development standard" for determining whether a resource is interstate or intrastate.

162. *Hood*, 533 F. Supp. 2d at 649 ("The Court . . . notes that while the Plaintiff contends on the one hand that only Mississippi water is involved in this suit, it also contends that the sole basis for the court's jurisdiction is the existence of a federal question because interstate water is the subject of the suit."). The court ultimately found that "the State of Tennessee is a necessary and indispensable party to this action pursuant to Rule 19 of the Federal Rules of Civil Procedure" and dismissed the action without prejudice. *Id.* at 650.

163. Hood *ex rel.* Miss. v. City of Memphis, 570 F.3d 625, 627 (5th Cir. 2009).

164. *See* 2016 Memorandum, *supra* note 13, at 26.

165. *See id.* at 26–28.

166. *See id.* at 26 ("On the face of the matter, the Fifth Circuit indeed appears to have determined that the [Memphis Sand] Aquifer is an interstate resource and that an equitable apportionment is necessary to grant relief, and the parties appear to have actually litigated these issues.").

167. *Hood*, 570 F.3d at 630.

Circuit's decision was not that the Memphis Sand was interstate in nature, but rather that Tennessee needed to join the dispute to litigate that exact question.[168]

Furthermore, the Special Master stresses that this subject matter is "central" to the Supreme Court's exclusive jurisdiction.[169] The Supreme Court of the United States has original jurisdiction over disputes between two or more states under Article 3 Section 2 of the Constitution,[170] a category which necessarily includes any dispute between states over interstate resources.[171] With the inclusion of Tennessee, it follows that the Supreme Court has original jurisdiction over this dispute.[172]

This case is somewhat unique from typical cases where the Supreme Court is the court of original jurisdiction because an extensive record exists from the USDC, and yet, the Supreme Court appointed a Special Master anyway. Special Masters serve primarily as fact finders and "have only the authority to provide recommendations for findings of fact and law that the Court must then adopt or reject. Accordingly, they have been advised to err on the side of over-inclusiveness . . . ."[173] Free of any jurisdictional barriers concerning the Supreme Court's original jurisdiction, the Special Master was free to proceed with a

168. *See* 2016 Memorandum, *supra* note 13, at 26–28.

169. *Id.* at 28 ("[I]n the absence of a clear indication from the Court that issue preclusion attaches to determinations made by other courts on matters central to its exclusive jurisdiction, the [Special Master] declines to recommend that the Court dismiss the matter on these grounds.").

170. U.S. CONST. art. III, § 2, cls. 1–2 ("The judicial Power shall extend to all Cases, in Law and Equity, arising under this Constitution, the Laws of the United States, and Treaties made, or which shall be made, under their Authority;—to all Cases affecting Ambassadors, other public Ministers and Consuls;—to all Cases of admiralty and maritime Jurisdiction;—to Controversies to which the United States shall be Party;—to Controversies between two or more States . . . . *In all Cases . . . in which a State shall be Party, the supreme Court shall have original Jurisdiction*. In all the other Cases before mentioned, the supreme Court shall have appellate Jurisdiction, both as to Law and Fact, with such Exceptions, and under such Regulations as the Congress shall make." (emphasis added)).

171. For example, in *Louisiana v. Mississippi*, 516 U.S. 22, 23–24 (1995), the Supreme Court exercised jurisdiction over the Mississippi River in a dispute between the two states.

172. U.S. CONST. art. III, § 2, cls. 1–2; *see* 2016 Memorandum, *supra* note 13, at 28.

173. 2016 Memorandum, *supra* note 13, at 35.

"limited" evidentiary hearing on whether the Memphis Sand is an interstate resource.[174] This then provides an opportunity for the Special Master to consider geological research in his opinion, which means he may consider what is known about the specific region's geology, as opposed to merely applying blanket rules concerning aquifers which may reflect outdated standards.

The Special Master has, to date, issued two Memoranda of Decision on the matter: the first Memorandum of Decision on Tennessee's Motion to Dismiss, Memphis and Memphis Light, Gas & Water Division's Motion to Dismiss, and Mississippi's Motion to Exclude, dated August 12, 2016,[175] and the second Memorandum of Decision on Defendants' Motion for Summary Judgment, dated November 29, 2018.[176] The following sections address each of these Memoranda in turn, with emphasis on those points of uncertainty which still pervade discussions concerning aquifers and reveal a trend towards concluding the Memphis Sand is an interstate resource.

B. The 2016 Memorandum

With this 2016 Memorandum, the Special Master addressed competing motions from both the plaintiffs and the defendants, considering certain foundational questions before the Supreme Court, specifically, over what point(s) the Special Master will take evidence and whether there is a basis for issue preclusion in light of the previous proceedings in the USDC. Mississippi moved to "exclude materials outside the complaint from consideration."[177] The defendants' motion for judgment on the pleadings claims: 1) Mississippi has no right to "unapportioned groundwater,"[178] and 2) Mississippi's arguments before the USDC and the Fifth Circuit are subject to issue preclusion, which bars the State's claims before the Supreme Court.[179] In other words, the defendants' second claim alleges that the Fifth Circuit rejected Mississippi's arguments in favor of determining the Memphis

174. *Id.* at 1.
175. *Id.*
176. 2018 Memorandum, *supra* note 32.
177. 2016 Memorandum, *supra* note 13, at 1.
178. *Id.* at 7.
179. *Id.* at 8.

Sand was an intrastate resource by the courts' inclusion of Tennessee under the Federal Rules.

The Special Master deemed necessary an evidentiary hearing in this matter on the "limited—and potentially dispositive—issue of whether the [Memphis Sand] Aquifer is, indeed, an interstate resource."[180] The Special Master notes that whether a body of water is intrastate or interstate in nature is a legal conclusion.[181] While the basis for that conclusion may be grounded in hard science, the designation itself is bestowed by historical and cultural circumstance and the accident of geopolitical borders.[182] The intrastate versus interstate question itself is one which requires scrutiny by the Court, and any designation of water in the Memphis Sand as either type, by Mississippi or any other party, is "not entitled to [an] assumption of truth"[183] by the Court. The Court will make that designation.

The Memphis Sand either *is* an interstate resource, or it is not. As discussed in the 2016 Memorandum, there are three accepted methods for allocating interstate resources: interstate compacts, equitable apportionment, and congressional apportionment (a rarely used method which is not discussed in depth here).[184] The Special Master does not discuss these for the purpose of resolving the truth as a fact-finder, though that role would follow. Instead, the Special Master raises these subjects to analyze the defendants' motion for judgment on the pleadings based on issue preclusion, to determine whether the Fifth Circuit previously found the Memphis Sand to be an interstate resource and then what "avenue" might apply to the Memphis Sand's waters.[185] Indeed, since there is no applicable Interstate Compact, the crux of the discussion focuses on equitable apportionment. The Special Master's commentary on precedent and the facts before him provide valuable insight into the direction he seems to be sending this matter.

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180. *Id.* at 1.

181. *Id.* at 25.

182. *See id.* ("While legal conclusions can provide the framework of a complaint, they must be supported by factual allegations." (quoting Ashcroft v. Iqbal, 556 U.S. 662, 679 (2009)).

183. *Id.* at 25 (quoting *Iqbal*, 556 U.S. at 680).

184. *See id.* at 19–35.

185. *See id.* at 19.

1. Interstate Compacts

Interstate compacts are agreements between states governing allocation of natural resources.[186] While each of the several States may agree to join in an interstate compact, the United States Constitution states that the power to approve any such agreement lies with Congress.[187] The Compact Clause specifically provides that "[n]o State shall, without the Consent of Congress, . . . enter into any Agreement or Compact with another State . . . ."[188] However, despite the seemingly straightforward language in the Constitution, there is some understanding among scholars that nothing prevents several states from entering into an agreement, and not all agreements require congressional approval.[189]

Despite the number of known international transboundary aquifers (366 known bodies on the planet),[190] there is a dearth of transboundary aquifer agreements in existence.[191] Agreements between France and Switzerland,[192] between Jordan and Saudi Arabia,[193] one

186. *See* Justin Newell Hesser, Comment, *The Nature of Interstate Groundwater Resources and the Need for States to Effectively Manage the Resource Through Interstate Compacts*, 11 WYO. L. REV. 25, 34–35 (2011); *see also* John D. Leshy, *Interstate Groundwater Resources: The Federal Role*, 14 HASTINGS W.-NW. J. ENVTL. L. & POL'Y 1475 (2008).

187. U.S. CONST., art. I, § 10, cl. 3.

188. *Id.*

189. *See* Hesser, *supra* note 188, at 34.

190. *See Transboundary Groundwaters*, *supra* note 53. The lack of agreements persists even though the United Nations International Law Commission establishes a framework in its draft Articles on the Law of Transboundary Aquifers for nations to form agreements governing transboundary aquifers. *See* Draft Articles, *supra* note 52.

191. *See Agriculture Beware: Groundwater Future Belongs to SCOTUS*, *supra* note 30.

192. Arrangement on the Protection, Utilization, and Recharge of the Franko-Swiss Genevese Aquifer, Fr.-Switz., June 9, 1977, https://www.internationalwaterlaw.org/documents/regionaldocs/franko-swiss-aquifer.html.

193. Agreement between the Government of the Hashemite Kingdom of Jordan and the Government of the Kingdom of Saudi Arabia for the Management and Utilization of the Ground Waters in the Al-Sag/Al-Disi Layer, Jordan-Saudi Arabia, Apr. 30, 2015, https://www.internationalwaterlaw.org/documents/regionaldocs/Disi_Aquifer_Agreement-English2015.pdf.

over the Nile,[194] and another over the Orange-Senqu River Basin in Southern Africa[195] are among the few. No interstate compact exists between Tennessee and Mississippi over the Memphis Sand.[196]

To illustrate how interstate compacts would operate, look to the Rio Grande. The Rio Grande example serves as an ideal case study for bringing different governments together to implement a comprehensive water management plan because multiple compacts govern water allocation along the Rio Grande, specifically, the 1938 Rio Grande Compact[197] and the United States-Mexico Transboundary Aquifer Act.[198] The former governs allocation of Rio Grande waters within the United States[199] while the latter governs downstream obligations between the United States and Mexico.[200] Congress approved the 1938 Rio Grande

194. Agreement Between the Republic of the Sudan and the United Arab Republic for the Full Utilization of the Nile Waters, Sudan-U.A. Rep., Nov. 8, 1959, http://www.fao.org/3/w7414b/w7414b13.htm; *see also* Maha El Dahan, *FACTBOX: Nile River Agreements and Issues*, REUTERS (July 27, 2009, 11:50 AM), https://www.reuters.com/article/us-egypt-nile-factbox-sb/factbox-nile-river-agreements-and-issues-idUSTRE56Q3MD20090727.

195. Agreement Between the Governments of the Republic of Botswana, the Kingdom of Lesotho, the Republic of Namibia, and the Republic of South Africa on the Establishment of the Orange-Senqu River Commission, Bots.-Lesotho-Namib.-S. Afr., Nov. 3, 2000, https://iea.uoregon.edu/treaty-text/2000-orangesenqucommissionentxt.

196. Hood *ex rel.* Miss. v. City of Memphis, 570 F.3d 625, 627 (5th Cir. 2009) ("There is no interstate compact governing use of the Aquifer's water, and thus no specific volumes of groundwater from the Aquifer have been apportioned to Mississippi, Tennessee, or Arkansas.").

197. Rio Grande Compact, Pub. L. No. 76-96, 53 Stat. 785 (1939).

198. United States-Mexico Transboundary Aquifer Assessment Act, Pub. L. No. 109-448, 120 Stat. 3328 (2006).

199. Rio Grande Compact, 53 Stat. at 785 ("The State of Colorado, The State of New Mexico, and the State of Texas, desiring to remove all causes of present and future controversy among these States and between citizens of one of these States and citizens of another State with respect to the use of the waters of the Rio Grande above Fort Quitman, Texas, and being moved by considerations of interstate comity, and for the purposes of effecting an equitable apportionment of such waters, have resolved to conclude a Compact for the attainment of these purposes . . . .").

200. United States-Mexico Transboundary Aquifer Assessment Act, 120 Stat. at 3328 ("To authorize the Secretary of the Interior to cooperate with the States on the border with Mexico and other appropriate entities in conducting a hydrogeologic characterization, mapping, and modeling program for priority transboundary aquifers, and for other purposes.").

Compact in 1939 to allocate waters in Colorado, New Mexico and Texas, a region of the United States prone to periodic droughts.[201]

The Rio Grande flows from Colorado through New Mexico, Texas, and finally into the Gulf of Mexico, forming over 1,200 miles (1,900 kilometers) of the border between the United States and Mexico.[202] Pursuant to the Convention Between the United States and Mexico Providing for the Equitable Distribution of the Waters of the Rio Grande for Irrigation Purposes, the United States agreed to deliver to Mexico 60,000 acre-feet of water from the Elephant Butte Reservoir on an annual basis.[203] To meet this obligation, New Mexico employs a conjunctive water management approach to the Lower Rio Grande Basin.[204] This approach "looks at the hydrologic connection between surface water and groundwater and develops a system of timing by shifting when and where water is stored based on availability."[205]

Though separate agreements, these are all part of one water management regime over the Rio Grande. The two agreements, the 1938 Rio Grande Compact and the United States-Mexico Transboundary Aquifer Assessment Act, operate in conjunction with one another to ensure any upstream diversions of waters by Colorado, New Mexico,

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201. Rio Grande Compact, 53 Stat. 785.

202. Int'l Boundary & Water Comm'n, *About Us, The International Boundary and Water Commission – Its Mission, Organization and Procedures for Solution of Boundary and Water Problems*, https://www.ibwc.gov/About_Us/About_Us.html ("[T]he U.S. – Mexico continental boundary follows the centerline of the Rio Grande a distance of 1,255 miles from the Gulf to a point in El Paso, Texas and Ciudad Juárez, Chihuahua."). To ensure the United States and the several States meet their downstream obligations, waters from the Rio Grande are stored at the Elephant Butte Reservoir in Texas and the Caballo Reservoir in New Mexico. *See News & Multimedia, Bureau of Reclamation Expects Above Average Runoff on the Rio Grande Through New Mexico This Spring*, BUREAU OF RECLAMATION (Apr. 18, 2019), https://www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=65723.

203. Convention Between the United States and Mexico Providing for the Equitable Distribution of the Water of Rio Grande for Irrigation, Mex.-U.S., May 21, 1906, 34 Stat. 2953, 2954.

204. *See* Elizabeth Wheat, *Groundwater Challenges of the Lower Rio Grande: A Case Study of Legal Issues in Texas and New Mexico*, 4 RESOURCES 172, 177 (2015) ("New Mexico administers its water regime through a conjunctive water management approach established by the decision in *City of Albuquerque v. Reynolds* (1962).").

205. *Id.*

or Texas do not impair the ability of the United States to satisfy its treaty obligations to Mexico.[206]

With the Rio Grande, different governments developed a single comprehensive water management plan. However, and this cannot be stressed enough, there is *no* interstate compact[207] and *no* management plan[208] between Mississippi and Tennessee allocating the waters of the Memphis Sand. The Memphis Sand represents the other side of the spectrum. The absence of an interstate compact leaves but one recourse if the Memphis Sand is an interstate resource: equitable apportionment is the "appropriate" remedy.[209] On the other hand, if the Memphis Sand is not an interstate resource, then Mississippi may be entitled to relief.

2. Equitable Apportionment

Equitable apportionment is the mechanism through which the judicial system allocates interstate resources in the absence of an interstate compact.[210] To the extent the Federal Courts may hear disputes

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206. *See* Texas v. New Mexico, 138 S. Ct. 954, 959 (citing Sanitary Dist. of Chi. v. United States, 266 U.S. 405, 423–25 (1925)) (holding that the United States was an indispensable party to the dispute between the States because "a breach of the [Rio Grande] Compact could jeopardize the federal government's ability to satisfy its treaty obligations.").

207. Hood *ex rel.* Miss. v. City of Memphis, 570 F.3d 625, 627 (5th Cir. 2009).

208. *See* Klein, *supra* note 12, at 520 (citing Brett Walton, *Mississippi's Claim That Tennessee Is Stealing Groundwater Is a Supreme Court First*, CIRCLE OF BLUE, Oct. 3, 2016, http://www.circleofblue.org/2016/groundwater/stateslag-management-interstate-groundwater/).

209. 2016 Memorandum, *supra* note 13, at 19 (citations omitted) ("Where a compact exists, the Court's role is to declare rights under it and enforce its terms. But, in the absence of a compact, '[e]quitable apportionment is the doctrine of federal common law that governs disputes between states concerning their rights to use the water of an interstate stream.'").

210. *See* Hood *ex rel.* Miss. v. City of Memphis, 533 F. Supp. 2d 646, 648 ("[T]he doctrine of equitable apportionment has historically been the means by which disputes over interstate waters are resolved. The United States Supreme Court has held that it possesses a 'serious responsibility to adjudicate cases where there are actual existing controversies over how interstate streams should be apportioned among States.' Arizona v. California, 373 U.S. 546, 564 (1963); *see* Texas v. New Mexico, 462 U.S. 554, 567 (1983) (The Supreme Court held that '[t]here is no doubt that this court's jurisdiction to resolve controversies between two states . . . extends to a properly framed suit to apportion the waters of an interstate stream between States

concerning interstate waterways, rights concerning interstate streams "have been recognized as presenting federal questions."[211] To date, the groundwater shared between Tennessee and Mississippi has *not* been apportioned, by the judiciary or otherwise. Part of the difficulty here is that the circumstances necessitating allocation of interstate waters by the judiciary is not yet settled.[212]

As Justice Holmes explained equitable apportionment, "water is a 'necessity of life that must be rationed among those who have power over it,' and where two states 'have real and substantial interests' in interstate water, those interests 'must be reconciled as best they may be.'"[213] It is a test of justice with consideration of numerous factors.[214] Equitable apportionment is also consistent with precedent stating that States cannot claim absolute ownership over resources which are situated in their lands, suggesting the precise water source (of paramount concern in property law regimes) is "essentially irrelevant"[215] to the analysis when compared to other features of the natural resource, not least of which is the character of human consumption.

Equitable apportionment has broad application to interstate resources where those resources are the subject of "natural laws," and courts have implemented the doctrine in numerous instances.[216] None-

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through which it flows . . .')."); *see also* Colorado v. New Mexico, 459 U.S. 176, 183 ("Equitable apportionment is the doctrine of federal common law that governs disputes between States concerning their rights to use the water of an interstate stream.").

211. Hinderlider v. La Plata River & Cherry Creek Ditch Co., 304 U.S. 92, 110 (1938).

212. *Illinois* v. City of *Milwaukee*, 406 U.S. 91, 105 (*1972*) ("The question of apportionment of interstate waters is a question of 'federal common law' upon which state statutes or decisions are not conclusive.").

213. *See* Hall & Cavataro, *supra* note 77, at 1604 (quoting New Jersey v. New York, 283 U.S. 336, 342–43 (1931).)

214. *See* Colorado v. New Mexico, 467 U.S. 310, 323 (1984).

215. *Id.*

216. Hood *ex rel.* Miss. v. City of Memphis, 570 F.3d 625, 630 (quoting Kansas v. Colorado, 206 U.S. 46, 97–98 (1907)) ("[W]henever . . . the action of one state reaches, through the agency of natural laws, into the territory of another state, the question of the extent and the limitations of the rights of the two states becomes a matter of justiciable dispute between them, and this court is called upon to settle that dispute in such a way as will recognize the equal rights of both and at the same time establish justice between them.").

theless, the small body of interstate water case law is quite limited. Between the limited case law and the range of factors which may impact the analysis, "equitable apportionment cases are frequently unpredictable."[217]

The factors are not prescribed by statute, but rather are reviewed and determined on a case-by-case basis. For example, in *Colorado v. New Mexico*, the Supreme Court applied the doctrine to resolve "disputes between states concerning their rights to use the water of an interstate stream."[218] The Court determined that, while the doctrine of prior appropriation was a substantial consideration, conservation measures and the balance of harms were also a part of the analysis.[219] The Supreme Court also applied principles of equitable apportionment when assessing responsibility over sewage dumped into the interstate waters of Lake Michigan.[220] And in *Kansas v. Colorado*, the Supreme Court permitted a substantial increase in Colorado's consumption of waters from the Arkansas River, not due to the source of the water in the Arkansas River, but due to a high rate of conversion of Colorado into agricultural land.[221]

While the Supreme Court has applied equitable apportionment to transboundary surface waters (the Delaware River,[222] the Laramie

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217. *See* Hall & Cavataro, *supra* note 77, at 1606 (citing Douglas L. Grant, *Collaborative Solutions to Colorado River Water Shortages: The Basin States' Proposal and Beyond*, 8 NEV. L.J. 964, 991 (2008) ("Equitable apportionment requires the weighing of multiple factors that are incommensurable, and there is a dearth of precedent on how to weigh competing factors. For these reasons, unpredictability is the hallmark of equitable apportionment litigation.")).

218. Colorado v. New Mexico, 459 U.S. 176, 183 (1982).

219. *Id.* at 183–84.

220. *See* Illinois v. City of *Milwaukee*, 406 U.S. 91 (1972) (applying federal common law to review shared responsibility over pollution from four Wisconsin cities and two sewerage commissions in interstate waters). The same standards applied whether the user was extracting natural resources or injecting unwanted material, *see also supra* Section III.B.5.

221. 206 U.S. 46, 107 (1907) ("The underground movement of water will always be a problem of uncertainty. We know that when water is turned upon dry and barren soil the barrenness disappears, vegetation is developed, and that which was a desert becomes a garden. It is the magic of transformation; the wilderness budding and blossoming as the rose.").

222. *See* New Jersey v. New York, 347 U.S. 995 (1954) (superseding 1931 decree); New Jersey v. New York, 345 U.S. 369 (1953) (denying motion for leave to intervene pursuant to 1931 decree); New Jersey v. New York, 283 U.S. 336 (1931)

River,[223] and the North Platte River[224]), it has yet to apply equitable apportionment to transboundary groundwater, much less the water in the Mississippi Embayment. The closest the Supreme Court has come to addressing transboundary groundwater specifically was in *Texas v. New Mexico*, when the Court applied equitable apportionment to interstate surface water "with a groundwater component."[225] The ongoing dispute between Mississippi and Tennessee therefore represents the first instance where the Supreme Court would potentially consider whether equitable apportionment applies to transboundary aquifers.

Any State has "full jurisdiction over the lands within its borders, including the beds of streams and other waters."[226] The several States have held "the absolute right to all their navigable waters and the soils under them for their own common use, subject only to the rights since surrendered by the Constitution to the general government."[227] Waters, whether navigable or underground, within a State are subject to that State's authority.

A State may have equal footing, but that does not mean each State may regulate the natural resources within its borders with impunity, as noted by Special Master Siler: "[A] State may not preserve

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(applying equitable apportionment principles to allow the State of New York to divert water from the Delaware River).

223. *See* Wyoming v. Colorado, 353 U.S. 953 (1957); Wyoming v. Colorado, 309 U.S. 572 (1940); Wyoming v. Colorado, 298 U.S. 573 (1936); Wyoming v. Colorado, 286 U.S. 494 (1932); Wyoming v. Colorado, 260 U.S. 1 (1922) (correcting error in 1922 decree); and Wyoming v. Colorado, 259 U.S. 419 (1922).

224. *See* Nebraska v. Wyoming, 534 U.S. 40 (2001); Nebraska v. Wyoming, 515 U.S. 1 (1995); Nebraska v. Wyoming, 507 U.S. 584 (1993); Nebraska v. Wyoming, 345 U.S. 981 (1953); Nebraska v. Wyoming, 325 U.S. 589 (1945); Nebraska v. Wyoming, 295 U.S. 40 (1935).

225. *See* 462 U.S. 554, 557 n.2 (1983) ("The nonflood 'base' flow of the Pecos below Alamogordo Dam is supplied to a large part by groundwater aquifers that empty into the river in the reach between Acme and Artesia, N. M. The operation of these aquifers is little understood. They are depleted by pumping from wells in the Roswell area, and there is some suggestion that at times heavy groundwater pumping in the area around Roswell may actually reverse the direction of flow of the underground aquifer, so that water flows away from the river.").

226. Kansas v. Colorado, 206 U.S. 46, 93 (1907).

227. Martin v. Waddell, 41 U.S. 367, 410 (1842).

solely for its own inhabitants natural resources located within its borders."[228] It follows that equal footing with respect to intrastate resources does *not* equate to equal division of interstate waters. In his 2016 Memorandum, the Special Master flat out rejects the Equal Footing Doctrine as the State of Mississippi would apply it to the Memphis Sand dispute and the "depletion of interstate water."[229]

Returning to the Memphis Sand, the Special Master unsubtly hints at which direction this matter is proceeding, and it is one which rejects applying traditional property rights to groundwater and favoring equitable apportionment. As the Special Master notes, "[T]he Court has authorized only one avenue for States to pursue a claim that another State has depleted the availability of interstate waters within its borders: equitable apportionment."[230] But this statement does not resolve the matter. The Special Master resolved to fulfill his role as fact finder and hear evidence relevant to whether the Memphis Sand is an interstate or an intrastate natural resource.

3. Summary

The 2016 Memorandum addressed first the legal theories governing groundwater in the United States, most notably, interstate compacts and equitable apportionment. In the Memorandum, the Special Master stressed that equitable apportionment was the appropriate remedy for resolving matters concerning interstate resources. Equitable apportionment is an analytical method considering numerous factors for allocating a natural resource. This discussion considered whether evidentiary hearings were appropriate in the matter to determine whether the Memphis Sand is an interstate resource subject to equitable apportionment, or if the case warranted dismissal due to decisions from the Fifth Circuit. The Special Master chose to proceed to an evidentiary hearing.

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228. 2016 Memorandum, *supra* note 13, at 31 (quoting Idaho *ex rel.* Evans v. Oregon, 462 U.S. 1017, 1025 (1983).

229. *Id.* at 24 (Mississippi asserting that, by virtue of its statehood, it is entitled to dominion over natural resources contained within its borders).

230. *Id.* at 35.

C. The 2018 Memorandum

MLGW and co-Defendants, the City of Memphis and the State of Tennessee, filed a Motion for Summary Judgment on four points, "arguing that no genuine dispute exists that (1) the water is interstate in nature, (2) equitable apportionment is the exclusive remedy for interstate water disputes when States have not entered into a compact, (3) no compact exists here, and (4) Mississippi has not sought equitable apportionment."[231] This 2018 Memorandum accordingly addresses in turn the co-Defendants' bases for summary judgment. Much of the 2018 Memorandum retreads hydrogeological and theoretical distinctions raised earlier in the case and discussed in the Special Master's 2016 Memorandum, but specifically addresses whether summary judgment is appropriate. That is, the Special Master reviewed these 4 points in turn to determine whether there is a triable issue of fact requiring evidentiary hearings, or whether the point is a basis for summary judgment.[232]

As previously noted, per the Federal Rules of Civil Procedure,[233] the Special Master's primary purpose is "holding evidentiary hearings and issuing reports with factual findings to facilitate a trial."[234] With that charge in mind, the Special Master chose to proceed to an evidentiary hearing on the matter, despite the apparent overlap between the Defendants' Motion for Summary Judgment and the issues raised in the Special Master's 2016 Memorandum[235] The scope of the evidentiary hearings are confined to the "limited issue identified by the Special Master: whether the case involves an interstate resource."[236]

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231. *Id.* at 2.

232. *See* 2018 Memorandum, *supra* note 32, at 8–10.

233. FED. R. CIV. P. 53(c), *supra* note 160.

234. WILLGING ET AL., *supra* note 162.

235. *See* 2018 Memorandum, *supra* note 32, at 26–27. To do otherwise would effectively sidestep the Special Master's appointment, and therefore the Supreme Court's discretion in appointing the Special Master. It would be nonsense for the Supreme Court to appoint a Special Master to take evidence, then have that same Special Master decline to hear that evidence by going directly to Summary Judgment. Whatever hoops the parties went through in the lower courts, this matter between Mississippi and Tennessee is a case of original jurisdiction for the Supreme Court and should be treated accordingly. That might require relitigating some issues, albeit with all necessary parties at hand per the Federal Rules.

236. *Id.* at 7.

This dispute is a contest of intertwined theories regarding the Memphis Sand and its connection to the greater hydrogeological system in the Southeastern United States. The issue is framed as a problem of scope: if on a spectrum, how interstate does a natural resource need to be before it becomes an interstate resource in the eyes of the Supreme Court?[237] To address this question, the Special Master discusses in turn several theories raised by the parties: (1) the Aquifer Theory; (2) the Pumping Effects Theory; (3) the Natural Flow Theory; (4) the Surface Connection Theory;[238] and (5) various alternative theories including Nuisance.[239]

1. Aquifer Theory

The Memphis Sand occupies land under eight different states,[240] which seems to suggest that it is an interstate resource. Mississippi asserts that the aquifer in question is "at least two distinct, but interconnected, Aquifers: the Sparta Sand and the Memphis Sand,"[241] both of which reside in the Mississippi Embayment, and that these are "separate geologic formations and aquifers."[242] The question is whether the Memphis Sand is one aquifer, or many. Here arises one of the points of uncertainty in hydrogeological science: where are the borders for underground aquifers?[243] At what point is a single aquifer independent and at what point is it part of a greater system?[244]

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237. *See id.* at 9 ("Mississippi's position hinges on whether the Special Master can limit this case only to water that would remain in Mississippi for thousands of years but for MLGW's pumping.")..

238. *See id.* at 10.

239. *See id.* at 20–26. This paper will not address this issue in detail as the Special Master concluded that equitable apportionment principles and an analysis of the Memphis Sand as an interstate resource would apply anyway. *See id.* at 26.

240. The USDC, in *Hood ex rel. Miss. v. City of Memphis*, ruled against the State of Mississippi by joining the State of Tennessee due to an interest in a potentially interstate resource, which would necessitate equitable apportionment. 533 F. Supp. 2d at 648. If the Memphis Sand does, indeed, lie under eight states, then should not the other six states join this dispute as necessary parties under the Federal Rules and the District Court's reasoning? *See supra* Section III.B.1.

241. *See* 2018 Memorandum, *supra* note 32, at 11.

242. *See id.* at 12.

243. *See supra* Section III.B.1.

244. *See supra* Section III.B.4.

Mississippi attempts to sidestep the definitional issue first by claiming that how geological sciences define the aquifer is beside the point,[245] and then asserting that the real pumping heart of the matter is that there is "a *portion* of the water that has resided in, and would remain in, Mississippi for thousands of years."[246] This is the *only* portion Mississippi is interested in insulating from MLGW's pumping. As the Special Master describes the plaintiff's position, "Other water is irrelevant to Mississippi."[247]

But the Special Master disagrees.[248] Mississippi cannot so simply carve out a piece of the aquifer. An interstate resource is an interstate resource. Mississippi cannot ignore a portion of that resource to suit its own purposes. As the Special Master remarks: "If the water Mississippi claims is part of a large interstate resource—such as an interstate Aquifer—then the water is likely interstate in nature."[249] Premised on the pleadings alone, there is a "lack of clarity"[250] on this issue, and so the Special Master did not grant summary judgment on this point. The Aquifer Theory is a broad sweeping standard, one which does not allow for self-serving interpretations of hydrological research, and it unifies scientific data with legal analysis.

2. Pumping Effects Theory

In the 1800s, Memphis drew its municipal water from the Wolf River, a local surface water source that was both "muddy and polluted."[251] All of this changed when Memphis first drew water from the Memphis Sand Aquifer.[252] No longer lying in the ground in its natural state, it was at this point in history when humans first took an unnatural action on the aquifer and where the water flowed through the Memphis Sand towards those wells.[253] The State of Mississippi alleges that MLGW has caused the Memphis Sand to reorient the flow from its pre-

245. *See* 2018 Memorandum, *supra* note 32, at 13.
246. *See id.*
247. *See id.*
248. *See id.* at 13–14.
249. *See id.* at 14.
250. *Id.*
251. *See* Upholt, *supra* note 22.
252. *See id.*; Waldron & Larsen, *supra* note 21.
253. *See* Upholt, *supra* note 22; Waldron & Larsen, *supra* note 21.

development (pre-1886) east-west orientation to the northwest orientation of the post-development era.[254]

Mississippi's argument posits that the interstate analysis is effects-focused, entailing an inquiry into the original state of the natural resource to counter what is an "*unnatural* action,"[255] namely, pumping. In this case, the inquiry would have to rely on historical data to determine the condition of the Memphis Sand Aquifer before MLGW's pumping activities began in the late 1800s. Should the interstate analysis look at how the water moves with or without the impacts of MLGW's pumping operations? Is this an effects-focused analysis or an inquiry into the natural resource's original state, which would be the aquifer's condition pre-pumping in the late 1800s, as determined by historical data? If the latter, defining the precise consequence of MLGW's alleged 'unnatural' action remains an issue, as obtaining accurate historical data isn't an easy task.[256]

To the extent the Memphis Sand's original state is significant, there is a corresponding need to obtain accurate data representing the aquifer's pre-development state to compare to the effects of contemporary pumping.[257] But accurate, historical data is limited. Ironically, Mississippi would be claiming ownership over the aquifer's waters based on estimates extrapolated from a time when aquifers presented a very real "problem of uncertainty." Much of the pre-development data in the region would have come from a time when underground aquifers were regarded as a mysterious subsection of geology.[258]

What place does the original state have in the analysis? The Special Master seemed to debunk Mississippi's argument calling for an

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254. *See* Waldron & Larsen, *supra* note 21, at 134.

255. *See* 2018 Memorandum, *supra* note 32, at 15–16.

256. *See generally* Waldron & Larsen, *supra* note 21 (discussing some of the attendant difficulties in determining pre-development conditions and comparing them with post-development changes regarding water transfer).

257. *See* Waldron & Larsen, *supra* note 21, at 151. The Waldron and Larsen study "demonstrates the utility of accurate reconstruction of early groundwater conditions in assessing the validity of transboundary water disputes. This research also amplifies the importance of retaining historic groundwater level records and the need for additional groundwater level control along political boundaries that may separate regional groundwater resources." *Id.*

258. *See supra* Section III.A.

analysis of the aquifer's original state in determining whether the resource is intra- or interstate, noting that "[i]f a body of water is such that the removal of water within a State's borders can have a direct effect on the availability of water in another State, the resource is likely interstate in nature."[259] Moreover, as the Special Master points out, since an "unnatural" action in Tennessee "affects the availability of water in Mississippi, the water is likely interstate in nature."[260] The Special Master leaves open whether a resource's original state is an appropriate consideration for final equitable apportionment, but seems settled that it does not speak to the interstate vs. intrastate question.[261] This principle is echoed in earlier Supreme Court opinions stating that when "the action of one State reaches through the agency of natural laws into the territory of another State, the question of the extent and the limitations of the rights of the two states becomes a matter of justiciable dispute between them."[262]

If there are hydrological and geological connections between two or more states, then those are the very same "natural laws" that evidence an interstate resource.[263] Increased flow rates as a direct result of pumping is itself proof of those geological connections.[264] That mankind needed to intervene, as it were, is incidental. As Tennessee argues, no natural condition *stops* the resource from flowing.[265] In a way, the flow of water in the aquifer is a natural response to MLGW's pumping operations.[266] An alternative view would point to Mississippi's hoarding and exclusion of the groundwater, actions which have both been rejected by the Supreme Court as violations of the Commerce Clause.[267]

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259. *See* 2018 Memorandum, *supra* note 32, at 14 (quoting a finding in his 2016 Memorandum, *supra* note 13, at 31).

260. *See id.* at 16.

261. *See id.* at 14–18.

262. *See id.* at 15 (quoting Kansas v. Colorado, 206 U.S. 46, 97–98 (1907).

263. *See id.* at 15–16.

264. *See id.* at 15–17.

265. *See id.* at 16.

266. *See id.* at 17 ("[MLGW] pumps in Tennessee, which causes the water, through a *natural* response to a cone of depression, to flow underground." (emphasis added)).

267. *See id.* at 15–17 (citing Idaho *ex rel.* Evans v. Oregon, 462 U.S. 1017 1983)).

While the natural resource's original state may not be a factor in determining whether equitable apportionment applies in the first place, it is an important consideration with respect to how equitable apportionment applies to the resource itself[268] to the extent a state may still regulate those resources.[269] Access to water has been a fundamental tenet of urban growth throughout history. Doctrines like equitable apportionment would potentially reallocate available resources, a prescient reality for regions that struggle with drought, salinity and pollution,[270] in turn affecting population growth, urban expansion and agricultural development across all areas above an aquifer.[271] The Mississippi Attorney General asserts that his state is not immune to this phenomenon.[272] So, if equitable apportionment allocates a greater proportion of water to one area due to current conditions, another area becomes necessarily limited in its own ability to develop.[273] The Special

268. *See* Waldron & Larsen, *supra* note 21, at 133 ("A common approach to water quantity or distribution disputes is to determine the water movement prior to water development, to use quantitative modeling to assess pre- and post-development groundwater budgets, and to apportion the resource according to sustainable yield.").

269. *See* Sporhase v. Nebraska *ex rel.* Douglas, 458 U.S. 941, 958–60 (1982).

270. *See, e.g.*, Derek Walter, *California Cities Struggle with Water Quality, and Poor Areas Suffer Most*, CAL. HEALTH REP., (July 3, 2016), https://www.calhealthreport.org/2016/07/03/california-cities-struggle-with-water-quality-and-poor-areas-suffer-most/ ("Each year over 1 million Californians are impacted by unsafe water, and it disproportionately impacts poor communities," [Strategic Communications Coordinator for the Community Water Center] said. "The drought has only worsened the existing crisis, as in addition to the prevalence of arsenic, nitrates and chemical byproducts, now we're seeing entire communities running out of water.").

271. *See* U.S. Geological Survey, *Urbanization and Water Quality*, USGS, https://www.usgs.gov/special-topic/water-science-school/science/urbanization-and-water-quality?qt-science_center_objects=0#qt-science_center_objects (last visited Mar. 1, 2020).

272. Candice Ludlow, *Supreme Court Considers Tennessee vs. Mississippi Water War*, WKNO 91.1, https://www.wknofm.org/post/supreme-court-considers-tennessee-vs-mississippi-water-war (last visited Mar. 15, 2020) ("'If the wells are along the state line and the city of Memphis are creating a depression and effecting the wells in DeSoto County,' Mississippi Attorney General Jim Hood said[,] '[w]e believe that Memphis should build some type of water treatment plant, get their water from a lake or the Mississippi River because it effects our development south of the state line.'").

273. *See* Daniel P. Bigelow et al., *How Does Urbanization Affect Water Withdrawals? Insights from an Econometric-Based Landscape Simulation*, 93 LAND ECONS. 413, 433 (2017) ("If groundwater-dependent farmers are unable to satisfy their

Master again declined to grant summary judgment, opting to hold evidentiary hearings to clarify the Memphis Sand's characteristics.

3. Natural Flow Theory

The natural flow theory recognizes that some of the water beneath Mississippi will flow into Tennessee naturally, and that this natural flow takes a very, very long time.[274] The Special Master's discussion of the natural flow theory focuses on whether water flows from Mississippi into Tennessee and the rate at which this occurs, with a view towards determining how important those two factors are to the analysis.[275] Is the original rate at which water flows between the two states relevant when that rate has been modified by MLGW's operations?

Under the Natural Flow Theory, Mississippi argues that a portion of the water in the Memphis Sand, the portion on which Mississippi makes its claims, would remain in Mississippi for thousands of years.[276] This argument presents the interstate question as one of timescales: will the water leave Mississippi on a time-scale meaningful to the human experience? Water beneath Mississippi is essentially "static" on human time scales, the argument goes, and thus the water is part of a functionally unmoving underground aquifer.[277] The question arises because the water is functionally static, if not literally so, which

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water needs due to increased pumping costs that come about from aquifer depletion, then the estimates of future withdrawals will be attenuated.").

274. *See* 2018 Memorandum, *supra* note 32, at 18. Groundwater will flow at a rate of "inches per day," and, as Mississippi argues, "would not leave the state for thousands of years if MLGW did not pump." *Id.*

275. *See id.*

276. *See id.* at 19 ("[T]he groundwater that Mississippi claims would remain in Mississippi for up to 22,000 years without MLGW's pumping.").

277. *See* Upholt, *supra* note 22. This is a difficult proposition for Mississippi to maintain since, *even if* the water would be static but for MGLW's operations, the mere fact that the Mississippi water can flow to Tennessee at all suggests the underground water is part of one interconnected system and there are other natural phenomena in play—gradient, porosity, rock and clay mixtures. *See* 2018 Memorandum, *supra* note 32, at 19. The emphasis on flow as the controlling factor is reductive to the extent it conflates underground aquifers with surface rivers, without regard to aquifers' many other characteristics. *See supra* Section III.B.

is a sympathetic argument. In other words, but for MLGW's operations, the water would not go anywhere anytime soon, and therefore its eventual flow into Tennessee is irrelevant.[278] Due to the waters' groundwater residence time, Mississippi argues in favor of treating the Memphis Sand and the Sparta Sand as separate geological features, and functionally intrastate in nature.[279] Essentially, Mississippi argues that if the water would remain in Mississippi for thousands of years, then it is absurd for the Courts to call that same water an interstate resource.[280]

Mississippi's argument suggests this low volume flow aspect of groundwater would essentially make all groundwater an intrastate resource, for better or worse.[281] Research supports different conclusions concerning the Memphis Sand's flow both in terms of total volume across the aquifer and rate at particular points, but that the water flows naturally from Mississippi to Tennessee at a rate of inches per year appears certain.[282] So, if water moves from Mississippi into Tennessee naturally, i.e., without human intervention, then "drilling in Mississippi

278. *See* 2018 Memorandum, *supra* note 32, at 19 ("[T]he water that naturally flows from Mississippi into Tennessee is a very small portion of the Aquifer and is not included in Mississippi's claims.").

279. *See id.* at 18. Equitable apportionment is a cross-section between law and geo-engineering. Imagine suggesting that all water is interstate in nature since, by process of evaporation, all water will end up somewhere else eventually. Evaporation is a natural process, and nothing stops the process from taking place. So, some areas will benefit from evaporation by other natural processes, such as prevailing winds, and others will contaminate the air by pollution, and then spread those contaminants as acid rain.

280. *See* 2018 Memorandum, *supra* note 32, at 9.

281. *See id.* at 17.

282. *See* Upholt, *supra* note 22 ("[R]esearchers at the University of Memphis concluded that water *naturally* moves from Mississippi to Tennessee." (emphasis added)). Meanwhile, Waldron and Larsen conclude pre-development flow from Mississippi into Tennessee was approximately 22,000 m^3/day, a volume which is far greater than the picture presented by Mississippi, which is one of near stagnation on human time scales. *See* Waldron & Larsen, *supra* note 21, at 151. Their model does not support the zero-gradient model propounded by the State of Mississippi. *Id.* Also, using pre-development values around Memphis as a baseline represents only part of the picture. Any useful analytical model would need to account for urban development within Mississippi near the Mississippi-Tennessee border. To do otherwise would seem to have Tennessee pay Mississippi for water consumed by Mississippi residents.

was actually capturing water that 'would be moving into Tennessee'"[283] and drilling in Tennessee was capturing water that would have been in Tennessee, albeit eventually.[284]

Despite Mississippi's viewpoint, there is no precedent for considering groundwater residence time on a graduated scale. That is, there is no judicial precedent which questions whether flow rate is valued differently at different time scales. The water either flows or it does not; it is an interstate resource, or it is not. As the Special Master in the ongoing Memphis Sand dispute remarked, "[*No*] Supreme Court decision appears to have endorsed one State suing another State, without equitable apportionment, for the depletion of water that is part of a larger interstate resource by limiting its claims to a specific portion of the water."[285]

Nonetheless, this is an interesting argument that, if accepted, would have a ripple effect beyond this dispute. If it were to provide the basis for the Court's decision, the argument would create a requirement of "original" or "predevelopment" conditions in analyzing whether a resource is interstate in character. Validating the argument would functionally remove the interstate character of many natural resources over precedent noting that many resources are interstate as a direct result of human intervention. With this in mind, the effects would be far-reaching, considering that "nearly every water dispute involves some type of 'unnatural' action by a state."[286] Such a decision would reduce the scope of the Supreme Court's original jurisdiction,[287] because fewer interstate resources would mean fewer disputes between several States.

In discounting human intervention, the distinction proposed by Mississippi misses the point of allocating a natural resource like water; there is no need to allocate a natural resource if humans do not interact with that resource. Equitable apportionment, by its nature, is designed to allocate natural resources that are the targets of often competing human interventions. Removing human intervention from the analysis means viewing consumption at a "predevelopment" state. However, a

283. *See* Upholt, *supra* note 22.

284. *See* 2018 Memorandum, *supra* note 32, at 20. This is a point of contention when the Special Master addresses the Defendants' Motion to Dismiss. *Id.*

285. 2016 Memorandum, *supra* note 13, at 32 (emphasis added).

286. 2018 Memorandum, *supra* note 32, at 16.

287. This potentially reduced scope would also mean fewer applications of Article 3, Section 2, of the Constitution.

"predevelopment conditions" requirement ignores hundreds of years of human economic activity. Such a standard does not accurately represent conditions found between aquifer borders, nor does it adequately account for hundreds of years of human infrastructure. It also skews towards a standard of absolute ownership by a State over resources contained within its borders by introducing a priority of right and interest to the state over which the natural resource originally resided.

4. Surface Connection Theory

The Surface Connection Theory posits that the Memphis Sand "is hydrologically connected to interstate surface waters[,]"[288] which the Defendants use to prove the interstate nature of the aquifer. This theory is distinct from other arguments addressing uncertainty over the Memphis Sand because there is legal precedent to support its premise. Specifically, *Texas v. New Mexico* held that "equitable-apportionment principles govern disputes between States over a body of interstate surface water with a groundwater component."[289] It logically follows that when groundwater has a hydrological connection to surface waters, this same principle applies. And so, the surface connection theory dispenses with some of the old groundwater exceptionalism.

In other words, in a manner consistent with *Barney v. Keokuk*, which dealt with property rights on the banks of the Mississippi,[290] the Court does not distinguish between navigable and non-navigable waters in its most literal sense. The emphasis is on the hydrological connection, not the human one. Although *Barney* did not address allocation of water in the Mississippi, its lessons are instructive. Surface waters interact with groundwater to form two interdependent natural systems.[291] In *Barney v. Keokuk*, Justice Bradley drew on precedent to

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288. 2018 Memorandum, *supra* note 32, at 19.

289. *Id.* (citing Texas v. New Mexico, 462 U.S. 554, 556–58, 557 n.2 (1983)).

290. Barney v. Keokuk, 94 U.S. 324, 338 (1876) (concerning an ejectment action by the plaintiff from lands adjacent to the Mississippi River).

291. *Id.* ("And since this court, in the case of *The Genesee Chief*, 12 [How.] 443, has declared that the Great Lakes and other navigable waters of the country, *above as well as below the flow of the tide*, are, in the strictest sense, entitled to the denomination of navigable waters, and amenable to the admiralty jurisdiction, there seems to be no sound reason for adhering to the old rule as to the proprietorship of the beds and shores of such waters.") (emphasis added).

recognize that "navigable waters of the country, above as well as below the flow of the tide, are, in the strictest sense, entitled to the denomination of navigable waters,"[292] and thus should be subject to the same laws.

From as recently as the October 2019 term and continuing in the tradition of *Barney v. Keokuk*, the Court took an expansive view of the 'navigable waters' designation in *County of Maui, Hawaii v. Hawaii Wildlife Fund et al*.[293] That case addressed wastewater discharges into Hawaii's navigable waters, specifically, partially treated sewage discharged from a wastewater reclamation facility (a 'point source') for the purposes of permitting requirements under the Clean Water Act.[294] The facility discharged the effluent into the ground which would then travel through Maui's groundwater before reaching the Pacific Ocean. Meanwhile, the Clean Water Act "forbids the "addition" of any pollutant from a "point source" to "navigable waters" without the appropriate permit from the Environmental Protection Agency (EPA),"[295] and that permit was not obtained. Different standards applied by the Courts of Appeals necessitated the Court's review.[296]

In *County of Maui*, the Court held that the Clean Water Act "requires a permit when there is a direct discharge from a point source into navigable waters or when there is the *functional equivalent of a direct*

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292. *Id.* The Federal Emergency Management Agency ("FEMA") defines the Navigable Waters of the United States as "all surface water bodies such as drainage ditches, intermittent streams, streams, lakes, and ponds, as well as vegetated wetlands adjacent to water bodies." *D-1: Determining If Your Project Will Affect "Waters of the U.S.,"* FEMA, https://www.fema.gov/d-1-determining-if-your-project-will-affect-waters-us (last updated Apr. 23, 2015, 5:11 PM). Navigation certainly provides an easy shorthand mechanism for describing interstate surface waters. "Navigation" is a term of conceptual convenience and it should not drown other pieces of the discussion. How can they be treated differently when surface and "below tide" waters are both "entitled to the denomination of navigable waters," per *Barney v. Keokuk*?

293. County of Maui, Hawaii v. Hawaii Wildlife Fund, 140 S. Ct. 1462 (2020).

294. Federal Water Pollution Control Act, §§ 301(a), 502(12)(A), as amended by the Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act) § 2, 86 Stat. 844, 886, 33 U. S. C. §§ 1311(a), 1362(12)(A).

295. *County of Maui* at 1468.

296. *See* Kentucky Waterways Alliance v. Kentucky Util. Co., 905 F. 3d 925, 932–938 (CA6 2018) (excluding groundwater from Clean Water Act permit requirements).

discharge."[297] This expansive view meant that a discharge into groundwater didn't 'cleanse' or create a legal 'filter' from the discharging act, in turn recognizing that groundwater and navigable water systems are very much connected. As Justice Breyer notes, a narrow view "is inconsistent with the statutory text and simultaneously creates a massive loophole"[298] to be exploited.

In this case, the surface water in question is the Wolf River, which flows from Mississippi to Tennessee and into the Mississippi River.[299] Water in the Wolf River flows at a far greater rate than a few feet per year, as every second, approximately 200 cubic feet of water flows through the Wolf River in Lagrange, Tennessee,[300] approximately seven miles from the Mississippi border, and hundreds of thousands of cubic feet discharge from the Wolf River into the Mississippi River.[301] This far exceeds what Mississippi proposes as a functionally static body of water.[302] Should the evidentiary hearings confirm this connection between underground and surface waters, it would establish the Memphis Sand as an interstate resource.[303]

The Defendants use the surface connection theory to provide an analytical framework for understanding and managing a natural system that has been historically treated as uncertain and thus beyond regulation. The theory recognizes that a "hidden" groundwater body—whether interstate or not—that connects to an interstate surface water body, such as a river, is an interstate resource, by virtue of the connection.

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297. *County of Maui* at 1476.

298. *Id.*

299. 2018 Memorandum, *supra* note 32, at 20.

300. U.S. Geological Survey, *Web Interface*, *USGS 07030392 Wolf River at Lagrange, TN*, USGS, https://waterdata.usgs.gov/tn/nwis/uv/?site_no=07030392&PARAmeter_cd=00065,00060 (last modified Mar. 1, 2020 6:09 PM).

301. U.S. Geological Survey, *Web Interface*, *USGS* 07032000 *Mississippi River at Memphis, TN*, USGS, https://waterdata.usgs.gov/tn/nwis/uv/?site_no=07032000&PARAmeter_cd=00065,00060 (last modified Mar. 1, 2020, 6:20 PM).

302. *See* 2018 Memorandum, *supra* note 32, at 18.

303. *See id.* at 20 ("Because the water in the Aquifer is hydrologically connected to interstate surface waters, the Aquifer is interstate in nature, according to Defendants.").

5. Summary

The 2018 Memorandum addressed different views proposed by the Plaintiffs and Defendants concerning the Memphis Sand and Sparta Sand aquifers, specifically, the aquifer theory, the pumping effects theory, the natural flow theory and the surface connection theory. All of these theories ask whether aquifers function as part of a larger system of natural resources and the extent to which geological features can be broken down into segments. A treatment of aquifers as part of an interconnected hydrologic system is in closer accord with a current and still expanding understanding of how aquifers function, a view which in turn favors sustainable water management. Meanwhile, a segmented view skews toward a property rights regime which considered aquifers to present problems of uncertainty.

V. CONCLUSION

This paper presents a narrative which envisions a departure from the country's history of groundwater exceptionalism and towards an administrative regime of sustainable water management that does not distinguish between surface and groundwater. The preceding discussion of certain key aquifer characteristics should dispel some of the ancient mystique surrounding groundwater and make clear that groundwater is not as uncertain as it once was. Therefore, current jurisprudence should not treat groundwater based on preconceptions that are more than 100 years old. Aquifers are part of an interconnected, and sometimes very delicate, hydrologic system that warrants considered sustainable water management.

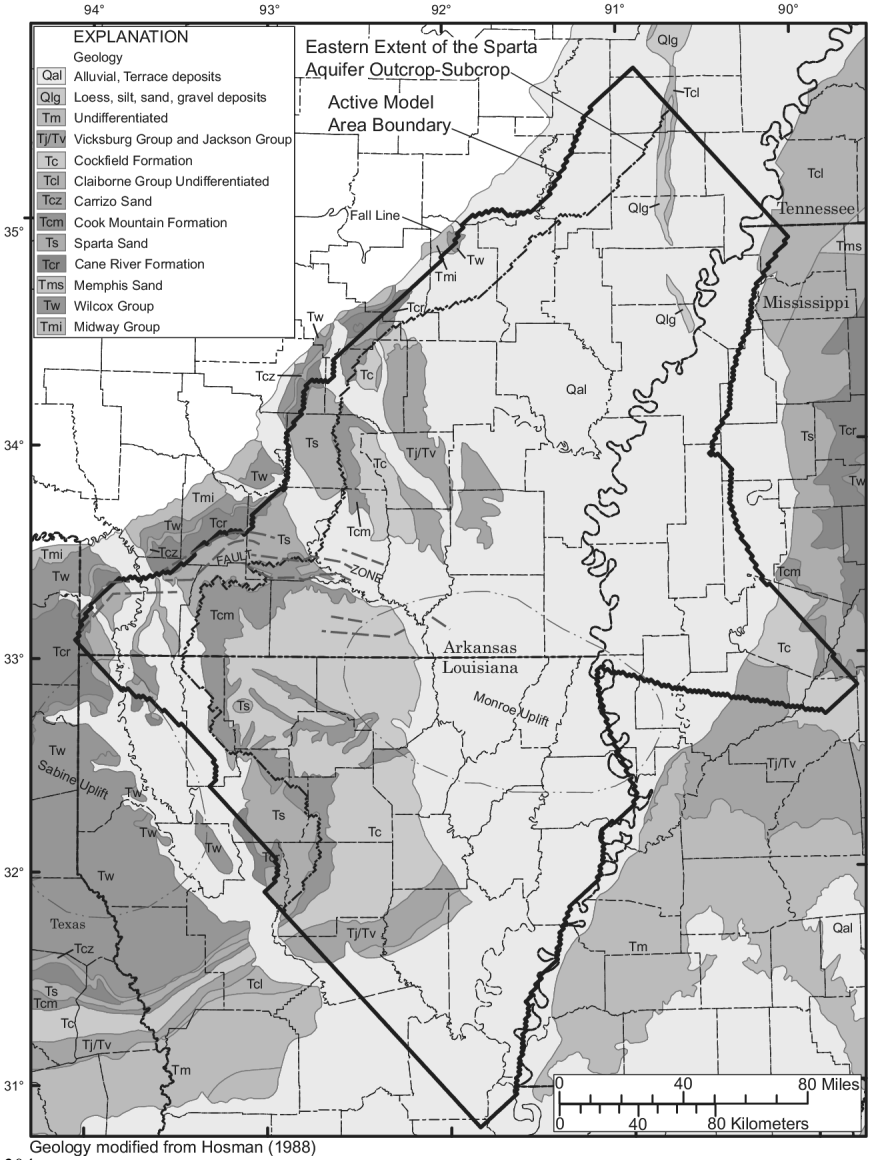
There is a difference between the judicial uncertainty baked into groundwater jurisprudence from the past century, and the scientific uncertainty represented in current hydrological research. The ongoing dispute in the Supreme Court of the United States over groundwater allocation in the Memphis Sand aquifer should capture that distinction. Free of outdated views, the Memphis Sand can and should lay the groundwork for implementing appropriate sustainable water management principles to groundwater in a manner akin to those governing surface water.

The Supreme Court should treat sustainability as a fundamental and guiding principle, take a holistic view of natural resources' rela-

tionship with the built environment, and in turn, apply principles of equitable apportionment to the Memphis Sand. More than merely setting proscriptive conditions for continued pumping from the Memphis Sand, this approach will establish a framework which will force all stakeholders, Tennessee, MLGW, the City of Memphis and Mississippi included, to remain cognizant of their obligations to the Memphis Sand's precious resources, and in turn, encourage sustainable resource management.

Think about it. Sit down. Have a glass of water. Straight from the source.

Mississippi Embayment Aquifer System



Geology modified from Hosman (1988)

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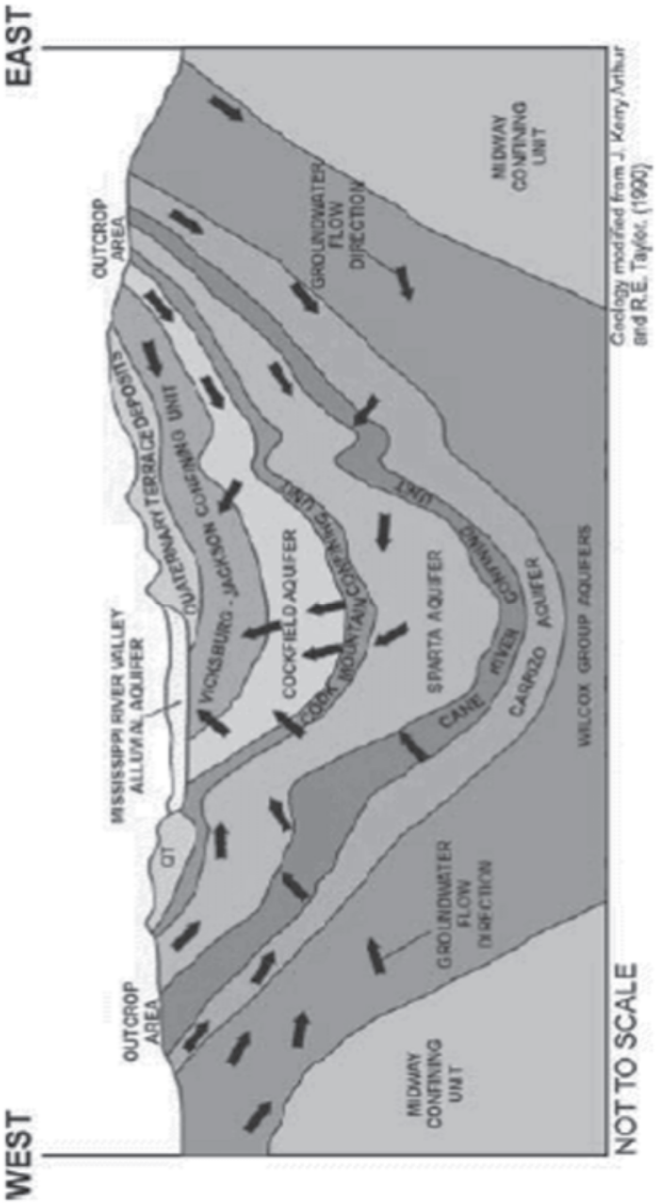
304. PAUL W. MCKEE & BRIAN R. CLARK, U.S. GEOLOGICAL SURVEY, DEVELOPMENT AND CALIBRATION OF A GROUND-WATER FLOW MODEL FOR THE SPARTA AQUIFER OF SOUTHEASTERN ARKANSAS AND NORTH-CENTRAL LOUISIANA AND SIMULATED RESPONSE TO WITHDRAWALS, 1998–2027, WATER-RESOURCES



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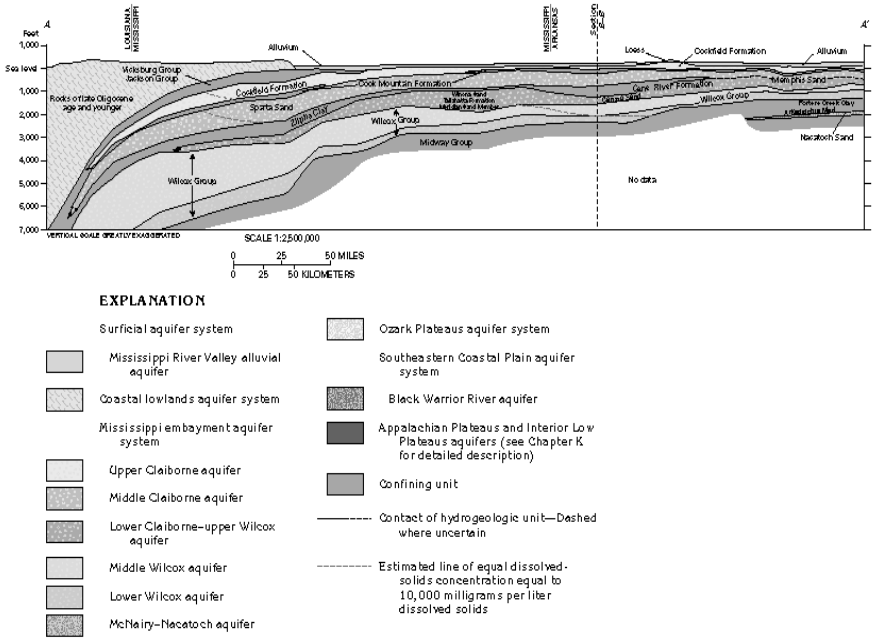
INVESTIGATIONS REPORT 13-4132, at 7 (2003), https://pdfs.semanticscholar.org/0c8b/4dd5ec7327a2aecb091f416285037ed5adcd.pdf?_ga=2.17519225.1113942520.1581893508-748081726.1581893508.

305. PAUL W. MCKEE & PHILLIP D. HAYS, U.S. GEOLOGICAL SURVEY, THE SPARTA AQUIFER: A SUSTAINABLE WATER RESOURCE?, FACT SHEET FS-111-02, at 1 (2002), https://pubs.usgs.gov/fs/fs-111-02/fs-111-02.pdf.



Modified from Hosman, R.L., and Weiss, J.S., 1991, Geohydrologic units of the Mississippi embayment and Texas coastal uplands aquifer systems, south-central United States: U.S. Geological Survey Professional Paper 1416–B, 19p.

Figure 68. A hydrogeologic section of the Mississippi embayment aquifer system shows that the Coastal Plain sedimentary rocks that compose the system dip southward beneath the rocks that compose the coastal lowlands aquifer system. The line of the section is shown in figure 66.

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306. Robert A. Renken, U.S. Geological Survey, *Ground Water Atlas of the United States: Arkansas, Louisiana, Mississippi, HA-730F, Mississippi Embayment Aquifer System* (1998), USGS, https://pubs.usgs.gov/ha/ha730/ch_f/F-miss_embay.html.

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