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Perspective

An Improved 21st Century Judicial System with Environmental Science Expertise is Needed for Resolving Interstate Water Conflicts

Nimisha Wasankar, Heather Elliott, and T. Prabhakar Clement*

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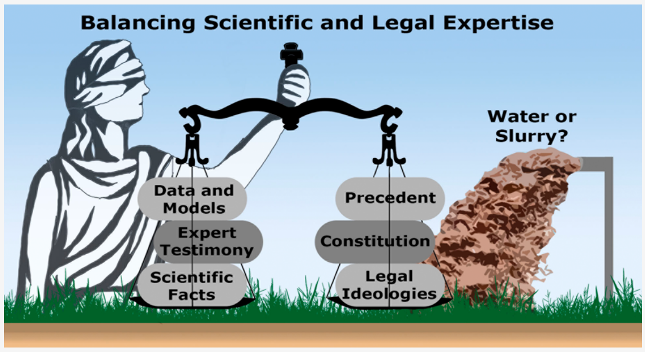
ABSTRACT: As stresses on groundwater resources increase due to growing population and climate change, water litigation, such as the recently decided Mississippi (MS) vs Tennessee (TN) lawsuit, will become more common. In the United States, lawsuits between states can be heard only by the Supreme Court of the United States (SCOTUS). These lawsuits are expensive and lengthy, often requiring highly specialized technical expertise. In the MS vs TN case, the Court unanimously held that an interstate aquifer is subject to equitable apportionment. Although this appears to be a sound resolution, a careful examination of the SCOTUS hearing transcript revealed that the Justices had several egregious misconceptions about the groundwater system. These misconceptions arose in part due to the failure of technical experts to communicate groundwater concepts in understandable terms and in part due to the Justices' lack of expertise in groundwater science. To address these issues, we first explore methods for improving scientific communication in courtrooms. Second, we propose ideas for reforming the legal system and provide compelling arguments for using the lower courts to hear such cases. We also explore the possibility of creating specialized federal water courts to resolve water disputes.



1. INTRODUCTION

In the US, interstate water conflicts can be resolved by using one of three methods: negotiating an interstate compact, seeking legislative action from the US Congress, or suing at the Supreme Court of the United States (SCOTUS).[1,2] Although having states voluntarily develop compacts is preferable, this approach has several limitations: parties may fail to arrive at sufficiently concrete terms, may ignore important scientific information, or may allow politics to prevail over common sense. Furthermore, if compacts are not properly structured, they can be difficult to manage or amend.[2] For example, the Pecos River Compact between Texas and New Mexico has no third-party tiebreaker vote, which prompted a lawsuit in SCOTUS when the states could not reach an agreement on revising the compact.[1] Federal legislation, if not well drafted, can also lead to extensive litigation, as with the Boulder Canyon Project Act of 1928.[1] Even though the US Congress has the authority to apportion water under its power to regulate interstate commerce, it has only utilized this power three times.[2] This is because elected officials are reluctant to impose solutions on regional conflicts fearing similar impositions when they face water conflicts. Given the issues with compacts and congressional actions, litigation in SCOTUS invariably becomes the most viable option for resolving interstate water disputes in the US.

In the US, the Supreme Court is not only the highest appeals court on issues related to federal law but also the trial court for states wishing to sue other states. The US Constitution allocates this jurisdiction exclusively to the Supreme Court.[3] Since the Justices view their work as primarily hearing appeals rather than holding trials,[4] they typically appoint a special master to perform fact-finding tasks in these cases.[4−6] This approach makes the litigation process fragmented and prolonged, which can lead to the miscommunication of complex scientific facts.

A recent interstate groundwater litigation exemplifies this problem. In 2014, Mississippi (MS) sued Tennessee (TN) for draining groundwater from the Middle Claiborne Aquifer (MCA), water that MS claimed it owned. SCOTUS had never directly addressed the law governing groundwater stored in interstate aquifers. SCOTUS ultimately held in 2021 that the water in interstate aquifers is subject to equitable apportionment.[7] Equitable apportionment, a doctrine employed by SCOTUS for resolving surface water conflicts since the early 20th century, involves the consideration of a variety of factors to equitably allocate water between or among states.[5,6,8] By

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holding that interstate groundwater is subject to equitable apportionment, SCOTUS has provided a legal basis for many future interstate groundwater lawsuits, which can put a significant burden on the Court's time.[9]

In the MS v. TN case, most of the trial proceedings were managed by the special master. In these proceedings, both sides provided comprehensive sets of competing scientific evidence, including United States Geological Survey (USGS) reports, expert assessment reports, published articles, and copies of old studies and testimony that had been presented in various other proceedings. This evidence was supplemented by new testimony from scientific experts at the trial hearings. The special master subsequently prepared a report to SCOTUS that summarized his findings and recommendations.

While the SCOTUS Justices had access to this summary and an exhaustive number of original reports, many of the Justices' statements at the oral argument revealed their ignorance regarding the fundamental nature of the groundwater flow system. The first objective of this article is to review some of the egregious scientific misconceptions that occurred during the SCOTUS hearing in MS v. TN. We identify two key reasons for these misconceptions: (i) the poor scientific communication strategies employed by the plaintiff, the defendant, and various scientific experts and (ii) the lack of expertise in groundwater science among the legal professionals (lawyers, judges, and Justices). Now-retired Justice Breyer, who sat on the MS v. TN case, has openly acknowledged that judges face challenges in evaluating different types of scientific claims and expert testimony because most judges lack scientific expertise.[10] In the past, judges' ignorance of science has caused criminal verdicts to be overturned, dubious expert testimony to be admitted, and court judgments to go against established science.[11−13] In the MS v. TN case, the Justices' misunderstandings were exacerbated by the delegation of fact-finding to the special master. This meant the Justices did not directly hear the evidence but instead had to mine data from lengthy scientific reports.

Future interstate water lawsuits will likely suffer from similar problems unless steps are taken to remedy the situation. These problems raise the following fundamental question: is the Supreme Court the right place to adjudicate complex interstate water conflicts? In this study, we propose a two-step solution to address this question. The first step is to develop better strategies for communicating scientific concepts (groundwater concepts, in this case) to legal professionals. The second step is to develop an alternate judicial process by moving these cases to the federal trial courts or by creating specialized courts to handle complicated fact-finding missions.

The remainder of the article is structured as follows. In the next section, we present an analysis of two key scientific misconceptions that were apparent during the MS v. TN case. This section also explores why these misconceptions arose and proposes some methods to improve science communication strategies in the courtroom. Thereafter, we suggest alternate judicial strategies for resolving interstate water management problems that involve complex scientific evidence. We argue that these problems reveal the folly of relying on SCOTUS to resolve such cases and suggest more efficient legal alternatives. Finally, we summarize our key recommendations in the Discussion section.

2. IDENTIFYING SCIENTIFIC MISCONCEPTIONS THAT OCCURRED DURING THE MS V. TN TRIAL AND POSSIBLE SOLUTIONS TO AVOID SUCH PROBLEMS

A careful review of the SCOTUS hearing transcript reveals multiple scientific misconceptions related to groundwater transport processes. The SCOTUS Justices had to resolve the groundwater allocation dispute before them but appeared to lack the scientific understanding necessary to do so. In this section, we will use excerpts from the published SCOTUS hearing transcript to highlight the Justices' misconceptions in two key areas. We detail how the Justices' views depart from well-established groundwater science. We then attempt to identify the root cause of the problem and suggest possible solutions that could help avoid such misconceptions.

2.1. Misconception 1: Inaccurate Perception of Groundwater Storage and Well Design. During the oral argument in MS v. TN, Chief Justice Roberts appeared to misunderstand how groundwater is stored in aquifers and how pumping wells are used to extract silt-free groundwater. He seemed to assume that groundwater and soil are stored as a fully mixed silt-water slurry. This incorrect conceptualization led to a further misconception that a specialized "unnatural pumping operation" must be utilized to pump and process this slurry.

Justice Barrett shared this misunderstanding, expressing concerns that TN wells could potentially be used to pump MS-owned silt, which could then be processed to extract useful minerals. This concern reveals her mistaken belief that groundwater wells pump silt-water slurry, which can be subsequently processed to extract silts and minerals. These misconceptions are evident from the Justices' statements documented in the oral argument hearing transcript available on the SCOTUS Web site.[14] We have also provided the relevant sections of the transcript in the Supporting Information, S1. Some extracts from the transcript are given below, and the key mis-statements are highlighted in italics.

Chief Justice Roberts: "Mr. Frederick, thank you. I've had a little *trouble following the science* here. *Is this really water we're talking about?* I mean— it's complete --well, it's *mixed up with silt and small particles* and all. If you --you can put it in your hand, right, and it would be silt? It would be wet, but, *until you pump it, it's really not the water*, right?"

Chief Justice Roberts: "I mean, it is an *unnatural operation of the pumping, separates out the water*, and at that point, it's --it's usable."

Chief Justice Roberts: "But, *before that (implying before pumping), you would just call it silt*, and if somebody showed you, you know, a handful of silt, they wouldn't say, oh, that's water."

Justice Barrett: "I do have one question following up on the Chief's question to you about separating the water from the silt. *What if you could separate out some other thing from the silt, like some sort of mineral, and find some sort of way to pump it and pull it into Tennessee?*"

The scientific truth is vastly different from the conceptual ideas held by the two Justices. Groundwater and porous media (soil, silt, or fractured rock) always remain as two separate phases (in the form of immobile solid and mobile liquid phases). In this two-phase system, groundwater always resides as a clean liquid, not in the form of a silt-water slurry as the Justices assumed. Even if there is some migration of fine

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sediments during pumping, they are prevented from entering the well by the screen and gravel pack that are deployed in situ. Therefore, a fully developed groundwater well does not pump slurry; instead, it pumps highly filtered, clean water that is devoid of any suspended sediment or silt material. There is no need to treat the pumped groundwater to separate silts or sediment particles. Therefore, it would be technologically challenging for a state to steal another state's minerals by pumping groundwater from an interstate aquifer.

2.2. Examining the Cause of Misconception-1 and Exploring Communication Methods to Avoid Such Misconceptions. An analysis of the SCOTUS hearing transcript revealed that unnecessary scientific jargon was repeatedly used while communicating basic groundwater concepts. For example, the counsel for TN made this statement: "the definition of an aquifer is a fully saturated formation, hydrogeological formation, in which there are usable quantities of water".[14] This definition is vague and holds very little meaning to people outside the field of hydrogeology.

Similarly, the compiled evidence in the MS v. TN case, which included many scientific illustrations, such as conceptual drawings, maps, cross sections, and graphs, was difficult to understand. For example, the MS technical expert and the special master relied on the classic illustration developed by Heath[15] (see Figure 1) to explain aquifer systems.[16,17] This is a good graphic for hydrogeology students or experts but not for legal professionals: the MS expert witness had to provide detailed explanations to make the illustration understandable to them. Unsurprisingly, experts use such illustrations because they often assume that everyone can interpret scientific illustrations as well as they can.[18] However, cognitive theories suggest that new and difficult materials presented in quick succession can overwhelm a learner's cognitive ability, especially if they are novice learners.[19,20] Even the best-designed graphics can prove confusing if the learner is not trained to perceive them properly.[19]

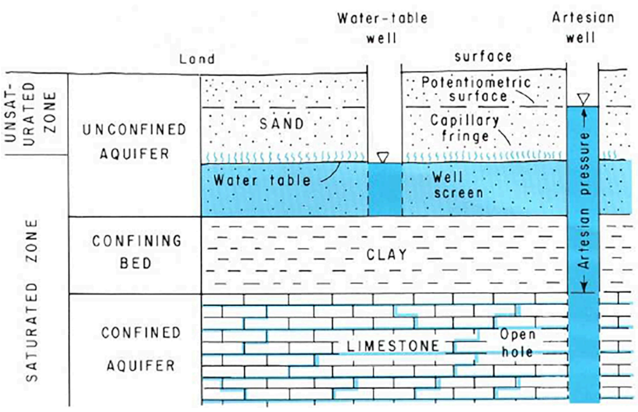

Figure 1. Highly technical illustration used in the MS v. TN case to describe the aquifer system in the courtroom.[17] Credit: U.S. Geological Survey report by Heath.[15]

Moreover, the figures presented in the MS v. TN case (see Figure 1) used a great deal of jargon, mentioning porosity, capillary fringe, water table, potentiometric surface, confined and unconfined aquifers, saturated and unsaturated zones, outcrop, residence time, drawdown, and cones of depression. Understanding specialized vocabulary like this requires long-term experience or rigorous technical education. The Justices, however, only had a short amount of time to review the written reports. Although the Justices have adjudicated water-law disputes involving surface water in the past, they are essentially novices in the field of groundwater science. Moreover, as is widely known, legal professionals generally lack scientific training.[10,11,13,21,22] Therefore, handling large volumes of technical information within a short time frame very likely overwhelmed the Justices' cognitive abilities, leading to the misconceptions described above.

Delving into new scientific concepts can be daunting to people without appropriate training.[23] In a past case involving beef adulteration with the hormone diethylstilbestrol, judges lamented that some exhibits were of no assistance to the court since they were too complex and difficult to comprehend.[24] The challenge is thus to develop graphics, animations, and perhaps some experiments that are simple enough to avoid information overload, yet interesting and engaging enough to allow for quick learning. Researchers have shown that real-world analogies increase the speed of comprehension and reduce learner frustration. Duit[25] found that analogies make new information easier to imagine, highlighting that new learning requires building ideas on a base of previous knowledge. Researchers have also found that combining scientific concepts with intuitive metaphors can help convey even the most complex information and abstract concepts by placing them in a familiar context.[23] Most experts tend to draw inferences from pre-existing schemas to rapidly process the core information presented by a graphic.[19,20] Therefore, utilizing real-world analogies can help legal professionals develop more realistic conceptual schemata that could be useful for communicating complex scientific concepts.

To illustrate this idea, we will use a simple cup of Coca-Cola with ice and a straw (see Figure 2a) as a visual analogy for explaining groundwater concepts. This everyday example can help explain water storage in an unconfined aquifer, how water is extracted using a well, and various aquifer properties like porosity. Since human minds can understand new knowledge easily when it is related to previously acquired knowledge, starting with a simple illustration like a cup of Coke can help better communicate groundwater concepts. In the figure, the ice cubes represent the solid phase or the soil matrix, and the beverage represents groundwater (to ensure that the ice cubes are a good representation of the soil matrix, we must assume that the ice cubes do not melt). The straw represents the "well" used for extracting the groundwater. Using this example, one can conceptually illustrate how the groundwater pumping process only moves the liquid phase, not a combination of liquid and solid phases in the form of an ice-coke or soil-water slurry as imagined by the two Justices. Just like the small aperture of the straw prevents ice from entering, the well screen and gravel pack installed in situ prevent any soil particles from entering the well. Furthermore, the voids between the ice cubes, occupied by the Coke, are a simple way to explain the concept of porosity. Comparing this real-world analogy to a conceptual diagram of an unconfined aquifer with a pumping well (see Figure 2b) can enhance learning and minimize misconceptions like Misconception-1. Using simple physical models of 2D groundwater systems can be another effective approach for explaining basic groundwater concepts.[26] Hydrologists should routinely employ appropriate analogies and/or physical models to communicate basic groundwater concepts in a courtroom setting. However, it is important to acknowledge that analogies (like Figure 2a),

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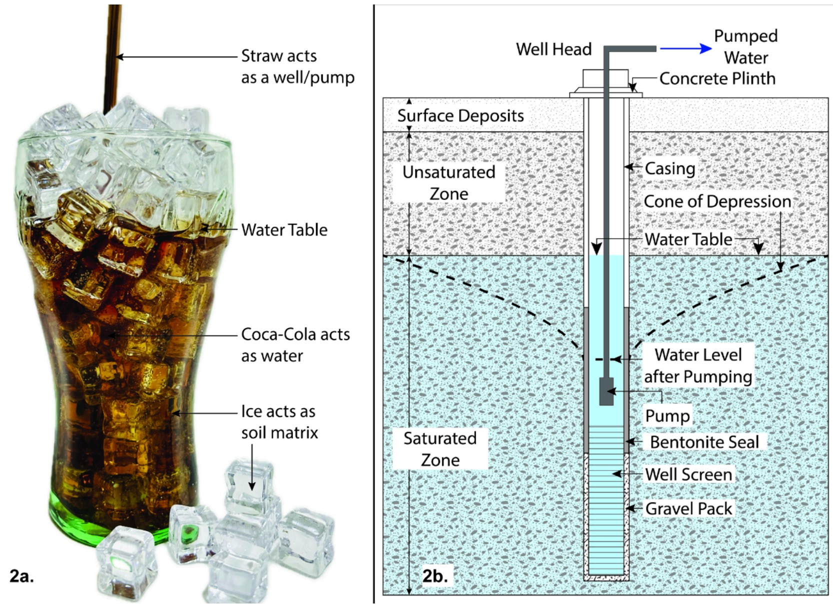

Figure 2. An example of employing an everyday experience as an analogy to explain groundwater storage and pumping wells in a surficial aquifer. (a) A cup of cold Coke is a good analogy for explaining aquifer storage changes in a surficial aquifer during pumping (ice is the soil matrix, Coke is water, and the straw is the well). (b) Conceptual illustration of groundwater being pumped from a well with a screen and gravel pack installed in the aquifer soil matrix.

which are indeed excellent tools for introducing new concepts, are not a replacement for detailed scientific illustrations. It is imperative to follow them with illustrations like Figure 1 and Figure 2b to explain complex real-world situations.

2.3. Misconception 2: Inaccurate Perception of Groundwater Flow Processes. Justice Breyer indicated his lack of understanding of the groundwater flow process when discussing interstate resource management issues. During this discussion, Chief Justice Roberts first used wild horses as an analogy for groundwater. He raised a concern that TN could capture all the horses when they wander across the border. He even questioned the permissibility of TN's actions in capturing these horses while they were in TN.

Justice Breyer agreed with the Chief Justice and commented that the comparison to wild horses was a fitting analogy since groundwater is going all over the place. He further added that capturing groundwater is perhaps similar to capturing San Francisco fog and physically taking it to some other state like Colorado or Massachusetts via airplane. These discussions illustrate Justice Breyer's conceptual misunderstanding that natural groundwater flow is similar to the movement of wild horses that drift in all directions. This implies groundwater will randomly flow in all directions, and hence could also flow back and forth across the state boundary. Some of the incorrect statements (key portions are highlighted in italics) made by the two Justices [full hearing transcript available on the SCOTUS Web site[14]] are given below, and the relevant sections of these exchanges are provided in the Supporting Information, S2:

Chief Justice Roberts: "You know, in the western states, they have these, I don't know, wild horses or wild burros, whatever they are, and they don't obey the state lines and *they're wandering around.* If they (horses) were in Mississippi and crossed into Tennessee and Tennessee seized them at that point, could Tennessee say, look, they're on our territory, they're under our physical control, we can exercise dominion over them?"

Chief Justice Roberts: "It's (implying wild horses) an interstate resource that *goes back and forth between two different states."*

Chief Justice Roberts: "Whoever --you know, *in the spring or whenever, they --they go to Mississippi, and then, in the fall, they go to Tennessee*, and can Tennessee, say, just grab --round them up and say they're ours?"

Justice Breyer: "*My understanding --and you have to --it's very elementary*. I mean, I think water falls from the sky. Some of it's evaporated back. Others of it go into oceans or lakes or streams. A huge amount goes under water --underground. *It's groundwater, and it runs all over the place*. That's why I like the wild horses. *My idea of that groundwater is it's going all over the place."*

Justice Breyer: "What's the standard when one state takes some of that *running-around groundwater* that another state says, oh, no, it should stay here? It sounds to me --you know, San Francisco has beautiful fog. Suppose somebody came by in an airplane and took some of that beautiful fog and flew it to Colorado, which has its own beautiful water --air. And somebody took it and flew it to Massachusetts or some other place."

Similar to Misconception-1, the scientific reality is significantly different from the conceptual ideas held by the Justices. Contrary to their understanding, the direction of groundwater movement is not random. It is highly unlikely that groundwater stored in the MCA would ever randomly flow back and forth across the border like wild horses. The natural flow direction in any regional aquifer system is well-defined by the hydraulic head levels, which are, in turn, defined by aquifer properties, natural recharge rates, pumping rates, and boundary conditions. These variables can be measured or evaluated using various field methods. In the case of MCA, hydrologists had access to basic aquifer-property data and measured groundwater levels. They integrated these data within computer models to establish that the natural flow direction in this region is predominantly from MS to TN (see

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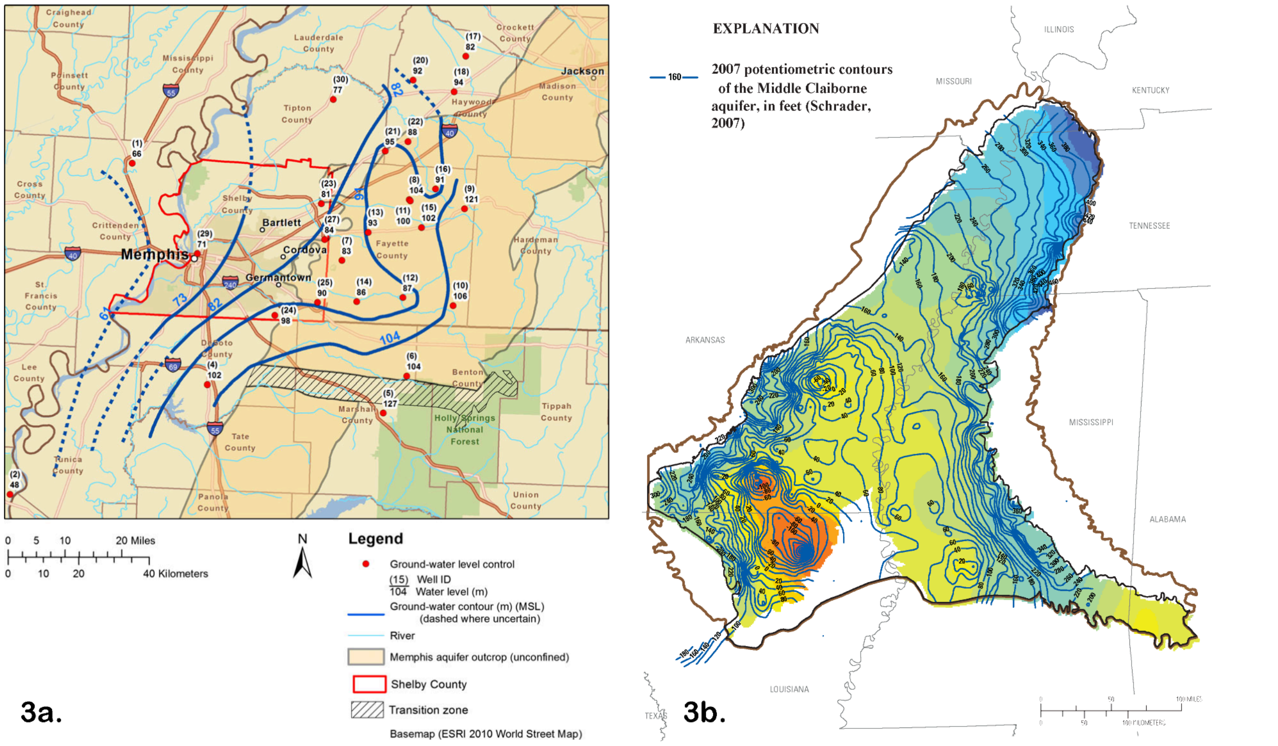

Figure 3. Spatial variations in groundwater head values presented at the MS v. TN trial. (a) Predevelopment potentiometric levels near the state border.[27] Reproduced with permission from ref 28. Copyright 2014 American Water Resources Association. (b) Regional scale postdevelopment potentiometric levels. Credit: modified from U.S. Geological Survey report by Clark and Hart.[29] The blue lines in both figures represent potentiometric contours.

Figure 3). Furthermore, the natural flow direction and rate of flow can be managed in an organized manner by lowering groundwater levels using pumping wells to form cones of depression. This capture process does not require any physical intrusion into the other state (like flying an aircraft into California to capture fog).

2.4. Examining the Cause of Misconception 2: Wild Horses and Fog Analogies. While better communication strategies can help reduce some ambiguities, they are insufficient to dispel all possible misconceptions. Misconception 2 is a good example where better communication strategies alone cannot solve the problem. Judges do have access to manuals and guidance documents that they can use to better understand scientific concepts and their admissibility in courtrooms.[30,31] These manuals have been touted as a promising approach to bolster the bond between science and law to improve scientific awareness in the age of misinformation.[10,32,33] However, many such manuals have failed to make a dent in the legal system even years after publication because the legal community is not aware of them, or other issues like inconsistent treatment of topics by different authors and insufficient scientific details.[11,34,35] The Justices in the MS v. TN case had access to numerous scientific reports that discussed groundwater flow patterns in this region. For example, the compiled evidence contained several useful illustrations to show predevelopment and postdevelopment potentiometric contours that clearly describe the groundwater flow patterns occurring within the aquifer system (see Figure 3). Technical experts who testified in this case also provided detailed explanations using these illustrations at various hearings. Using high-quality measured or model-predicted data sets in figures like these to supplement verbal testimony can be considered a good communication strategy, yet the Justices misunderstood the basic nature of the groundwater flow process. This is likely because the Justices did not have direct access to the experts, and instead had to read large volumes of expert testimony transcripts to absorb all the relevant information in a limited amount of time. In such scenarios, subject matter expertise could be essential to fully understand the problem. There is no question that the SCOTUS Justices' lack of technical expertise in the field of hydrology hindered their ability to comprehend the groundwater flow process described by the head contour data presented in Figure 3. Given that the root cause of this problem is the lack of technical expertise, perhaps the best way to remedy this issue is to ensure that water lawsuits are decided by legal professionals with adequate scientific knowledge. This could be accomplished using two different approaches: (a) by appointing judges or special masters who possess the necessary scientific expertise or (b) by reforming the current judicial process. We discuss the details of these two remedies in the following sections.

2.5. Approaches for Increasing Technical Expertise on the Judicial Bench. The first approach to address the Justices' lack of scientific expertise is to appoint a special master who has the necessary technical background. This would at least ensure that the final recommendation of the special master is based on sound science (though the Justices are not bound by the special master's recommendation). In the past, the Court has appointed special masters with strong backgrounds in water resources law and the underlying science.[36] However, in recent years, the special masters appointed by the Court were federal judges. It would be virtually impossible to find federal judges with relevant

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scientific training to serve as special masters. Currently, only about 18% of law professionals have some STEM training and most of these STEM-trained lawyers end up as corporate or intellectual property management lawyers.[37,38] A survey of more than 400 state court judges found more than 96% had not received any scientific training.[11] Therefore, this problem must be first addressed by our nation's higher education system. Law schools should make concerted efforts to recruit and train lawyers with backgrounds in environmental science and other scientific disciplines. Rapid technological advances and globalization have already made the US economy far more technocentric. Arguably, most of our society's problems will be resolved in the future using science and technology tools, likely increasing the demand for law professionals with a background in science. It is time for law schools to address our technocentric society's need for STEM-trained lawyers.

The Court could, of course, appoint special masters from the ranks of lawyers or technical experts who do have the requisite experience. Currently, the Court has no standards for appointing special masters and no regulations requiring the masters to be impartial.[39] Since the work of special masters is mostly part-time, those appointed will have a career outside of their work for the Court, which might create conflicts of interest.[39] Additionally, while the Court often defers to the recommendations given by the special master, it need not accept them.[2,5,6] The Court can choose to request additional investigation or even reject the recommendations entirely, as the Court did in a case involving the Chattahoochee, Flint, and Apalachicola Rivers.[40] Because the parties pay the masters' fees, special masters can also make the litigation process more expensive. Given the Court's failure to establish structures for the masters' work, the ambiguity surrounding the masters' exact duties could create additional issues.[39,41] Given these problems, it might be more prudent to reform the legal process to create an alternative system where a trial court can hear evidence directly and deliver verdicts.

2.6. Reforming the Current Judicial System for Efficiently Resolving Future Interstate Water Conflicts. A possible reform is to make SCOTUS's exclusive jurisdiction over interstate disputes concurrent with the lower federal courts. The US Constitution makes the Supreme Court the trial court for interstate lawsuits, and US Congress has never made this jurisdiction concurrent with the lower federal courts.[3,4] Congress is, however, free to do so, and it should. Giving states the freedom to file their suits in the federal district courts, which regularly hear cases involving complicated scientific facts and frequently evaluate the credentials and credibility of expert witnesses, would give the states a forum more suited to the task of resolving water disputes. Such a move could not remove the Court's jurisdiction over these cases, meaning that some state plaintiffs might file in the Court regardless. But concurrent jurisdiction gives the Court a solid basis for refusing to hear those cases, which it currently does in an *ad hoc* and unexplained way.[4]

Alternatively, a strong case can be made to create specialized water courts in the US, given two key characteristics of water conflicts: (1) the complexity and nonuniformity of water laws employed by various states and (2) the technical nature of water management cases.[41,42] The US legal system already has specialized environmental and water courts in states such as Vermont, Colorado, and Montana. The Vermont Environmental Court was established in 1990, and its appeals are heard directly by the Vermont Supreme Court.[43] The court issues all decisions in writing to maintain transparency and favors mediation between parties. Nearly 28% of the cases filed in 2009 were resolved without any judicial action, which increases litigation efficiency and enhances the chances of a fair outcome.[43] However, Vermont statutes do not require environmental judges to be experts, and the term for appointment is six years.[44] The Colorado and Montana water court systems divide the states into divisions, with water judges appointed for each division. Water judges are granted exclusive jurisdiction on any matter related to water, including groundwater.[45,46] However, like the Vermont environmental judges, these judges need not have any expertise in science or water law, serve limited terms, and appoint water referees or masters much like the Supreme Court.[45,46] It is tempting to expand these state-specific courts to create a national-level system, but these courts are not ideal models since they require no scientific expertise and have judges who serve limited terms (and thus have limited opportunity to gain expertise). Some environmental court systems used by other nations are better models.

Sweden's environmental court is a promising model to consider. The Swedish court comprises five regional environmental courts and one higher court, the Environmental Court of Appeal.[41] These courts handle issues regarding decisions made by about 20 regional boards and 250 environmental bodies.[47] The regional courts have a judge, an environmental technical advisor, and two law experts on the bench.[41] Since appeals are usually based on legal issues rather than technical ones, the appeals court has four judges, one of whom can be replaced with a technically trained judge if needed.[47] The hearings of the court are generally informal, and judges travel to the site of the dispute from their regional seats where other parties and people around the site are given leave to provide comments in person.[47] According to Bjällås,[47] the Swedish environmental court has high credibility because the court can adopt a holistic approach while solving cases, it imposes no filing fees, and it has the option to fast-track urgent cases. Furthermore, the court is open and user-friendly, which increases public confidence in the verdicts and provides a prime example of good environmental governance.[47]

Another great example of a well-structured specialized court is the Environmental Court of New Zealand. It has heard issues arising under the Resource Management Act (RMA) of 1991 since its establishment in 1996.[48] The court is national, with judges permanently located in Wellington, Auckland, and Christchurch.[48] The court commissioners are usually experts in the fields of ecology, engineering, planning, policy, or law. For example, an expert appointed in December 2016 for a three-year term had a Ph.D. in botany, specializing in ecology from the University of Guelph, Canada, and had extensive work experience providing ecological and resource management consulting.[48]

Following these international models, we suggest that the US could establish regional water courts. Case facts in water litigation can vary widely depending on the geographical location. Therefore, a decentralized structure is essential. These courts will not be affiliated with any one state; hence, they can be an impartial forum for bringing interstate lawsuits in the region. Appeals can be handled by nationally designated courts or can be heard by SCOTUS. Since appeals are usually based on legal issues rather than scientific issues, the Justices' lack of expertise poses less of a problem.

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Although these international court systems provide compelling models for creating specialized water courts in the US, implementing the system will be challenging. Establishing a new court system and training specialized judges is expensive and time-consuming; and the possibility remains that such a specialized court could be influenced by special interest groups.[41] However, the resources invested to establish the court might be recouped through the savings of shorter proceedings and fewer appeals. For example, the water courts could efficiently mediate mutually agreeable solutions for a significant percentage of its cases as Vermont's environmental court does. To avoid being influenced by special interests, the judges' serving terms should be sufficiently long, perhaps even a lifetime appointment like the current SCOTUS model.

3. DISCUSSION

The landmark MS v. TN case serves as a reminder that the current litigation process for resolving interstate water disputes is multistepped, arduous, and protracted. Information loss is common in such multistep processes, and this can introduce egregious scientific misconceptions, as in the MS v. TN case. These misconceptions could give rise to faulty judgments when aquifers are equitably apportioned in the future. Equitable apportionment essentially freezes a state's ability to utilize a groundwater resource at a certain level, and a faulty apportionment could adversely affect both existing and future uses, or overallocate an already stressed aquifer system.[9] States involved in these water lawsuits have a vested interest in minimizing scientific misconceptions to ensure that the resulting judgment is fair and accurate. Justices also understand the value of scientific accuracy in the decision-making process and regularly base their decisions on expert analyses. Some examples include the Maui v. Hawaii Wildlife Fund case (where groundwater hydrologists provided opinions regarding contaminant transport)[49] and the Massachusetts v. EPA case (where the Court cited IPCC reports and other climate change experts).[50,51]

Groundwater aquifers are complex systems,[42] and therefore, misconceptions about groundwater systems in a courtroom setting are not new. In fact, in 1861, the Ohio Supreme Court concluded that groundwater systems are so "secret, occult, and concealed" that it would be simply impossible to regulate them.[52] As late as 1999, this statement about mystical groundwater systems was invoked by the Texas Supreme Court.[53] However, the US Supreme Court has always recognized the need to incorporate science in the courtroom. Justice Breyer once famously said: "A judge is not a scientist, and a courtroom is not a scientific laboratory. But the law must seek decisions that fall within the boundaries of scientifically sound knowledge".[10] Therefore, hydrologists and educators should make concerted efforts to understand the root cause of scientific misconceptions in the courtroom and devise solutions to minimize them. Our analysis of the MS v. TN case materials shows that scientific misconceptions arose due to inadequate communication and the lack of technical expertise. On the basis of preliminary analysis (using web-based data), we estimated that only about 9% of SCOTUS Justices appointed after 1900 had any scientific training. Interestingly, none of the Justices who presided over MS v. TN had a STEM education.

We propose the following solutions to minimize scientific misconceptions in the courtroom. First, scientific experts should use better communication strategies by utilizing widely recognized analogies and visuals to explain complicated scientific concepts. Second, the legal profession should reform law school admissions by recruiting more students with STEM training. Finally, the legal process itself could be fundamentally improved if the US Congress would permit interstate water disputes to be heard in the lower federal courts or special water courts.

The current system of allowing generalist judges to resolve technical issues has several limitations. First, it is unfair to expect generalist judges, especially SCOTUS Justices, to mine through a large volume of technical documents with a fine-tooth comb to find relevant information in a limited amount of time. SCOTUS' precious time is better spent on its primary role as the US's top appellate court. Furthermore, the current practice of relying on expert testimony during trials puts disproportionate emphasis on the credentials of each state's expert witnesses and introduces some inherent bias.[9] The state with greater resources is likely to hire experts with better credentials, potentially causing discrimination against the less affluent state. There are also concerns about the partisan nature of experts and the proliferation of "junk science" in the courtroom.[11,12,21,32] If, instead, legal professionals themselves had the requisite scientific expertise, the reliance on expert knowledge could be minimized.

An ideal solution to develop scientific expertise is to establish a decentralized specialized water court system with concurrent jurisdiction over interstate water lawsuits. This will eliminate the need for special masters and prolonged "battles of the experts", which in turn will reduce the average cost of these lawsuits, reduce scientific misconceptions, and increase public confidence in the outcomes. This solution will streamline the adjudication process for interstate water conflicts, thereby saving precious time and resources for SCOTUS.

We believe that implementing the strategies proposed in this study can help create a robust system for adjudicating future water conflicts. Our strategies have the added benefit of improving scientific communication in the courtroom. While most people understand the importance of safeguarding surface water systems, they tend to underestimate the impact of groundwater contamination on human and ecological health.[54] Groundwater systems are a part of everyday life, and public support is essential for protecting these highly vulnerable resources. Hydrologists should utilize more effective methods to explain fundamental groundwater concepts to the public, perhaps even at the high school level. Good communication strategies can aid in a better understanding of complex groundwater systems, resulting in informed citizens who are more likely to support sensible water management practices. For example, a Danish magazine published a well-written article explaining that their waterworks failed to comply with the government's Arsenic criterion; that informative article helped to raise public awareness and ultimately led to better enforcement of regulations.[55] We acknowledge that the decision to implement any changes in the judicial process would be a complex challenge that can only be achieved through public support. Water management is an important 21st-century issue, and we need citizens, legislators, legal experts, and scientific professionals to work together to develop "more perfect" water management strategies.

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■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acsestwater.4c00289.

Extracts from the SCOTUS hearing transcript with the full exchanges between SCOTUS Justices and the legal representatives of the plaintiff and the defendant (PDF)

■ AUTHOR INFORMATION

Corresponding Author

T. Prabhakar Clement − *Department of Civil, Construction and Environmental Engineering, University of Alabama, Tuscaloosa, Alabama 35487, United States;* orcid.org/0000-0002-7878-8139; Email: pclement@ua.edu

Authors

Nimisha Wasankar − *Department of Civil, Construction and Environmental Engineering, University of Alabama, Tuscaloosa, Alabama 35487, United States*

Heather Elliott − *The University of Alabama School of Law, Tuscaloosa, Alabama 35487, United States*

Complete contact information is available at:
https://pubs.acs.org/10.1021/acsestwater.4c00289

Author Contributions

N.W. formulated detailed strategies, created graphics, and led the manuscript writing efforts. H.E. refined legal strategies, offered valuable legal insights, and edited the manuscript. T.P.C. conceptualized the overarching idea, secured funding, provided input to manuscript developmental efforts, and contributed to writing. All authors have approved the final version of the manuscript. CRediT: **Nimisha Wasankar** conceptualization, data curation, formal analysis, investigation, methodology, software, validation, visualization, writing-original draft, writing-review & editing; **Heather Elliott** investigation, methodology, supervision, writing-review & editing; **T. Prabhakar Clement** conceptualization, funding acquisition, investigation, project administration, resources, supervision, validation, writing-original draft, writing-review & editing.

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