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Charting the Course of Riparianism: An Instrumentalist Theory of Change

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CHARTING THE COURSE OF RIPARIANISM: AN INSTRUMENTALIST THEORY OF CHANGE

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Riparianism[1] has governed surface water use in the humid regions of the United States since the arrival of English settlers.[2] Despite cogent attacks on its wisdom and ability to be administered,[3] riparianism's reign in the Eastern United States has been constant in both temporal and substantive terms.[4] Today, there are indications that riparianism is no longer a sufficiently reliable surface water management regime.[5]

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1. For a discussion of the basic rules of riparianism, see *infra* text accompanying notes 20-24.

2. *See* J. SAX & R. ABRAMS, LEGAL CONTROL OF WATER RESOURCES 158-82 (1986). The governing law of riparianism has experienced a degree of change over the centuries. Particularly in the 19th century, American water use needs exceeded those that could be met by employing English "natural flow" riparianism, and a more flexible American "reasonable use" doctrine emerged. *See infra* notes 32-46 and accompanying text.

3. *See, e.g.*, Lauer, *Reflections on Riparianism*, 35 MO. L. REV. 1, 12-15 (1970).

4. There is a move away from common-law riparianism toward administrative systems that have continuing ties to the region's riparian heritage. One thoughtful analysis terms these systems "regulated riparianism." *See* Dellapenna, *Owning Surface Water in the Eastern United States*, in PROC. OF THE SIXTH ANN. INST. E. MIN. L. FOUND. § 1.03[3] (1985). The need for a move away from riparianism toward administrative systems is nowhere more thoroughly considered than by the drafters of the Model Water Code. *See* F. MALONEY, R. AUSNESS & J. MORRIS, A MODEL WATER CODE WITH COMMENTARY (1972). These developments are discussed in Abrams, *Water Allocation by Comprehensive Permit Systems in the East: Considering a Move Away from Orthodoxy*, 9 VA. ENVTL. L. REV. (*forthcoming* 1990).

5. Throughout the Eastern United States there is also an increased concern with groundwater quality, and a growing number of instances in which groundwater supplies are being overtaxed by the demands of a growing population. This Article will concentrate on legal issues relating to the surface water doctrine of riparianism, discussing groundwater only as a potential source of water supply that could be used to augment shrinking surface supplies.

This Article is the first in a trilogy probing the future of Eastern water law.[6] Taken as a whole, the trilogy asserts that the problems of endemic water shortage are inescapable and are emphatically not ones well addressed by riparianism alone. Rather, these problems are best solved through government intervention and management of the water resources at issue. Government action will most likely take the form of direct regulation of competing users, but in all events, Eastern water law will be different as a result.[7]

Major changes in Eastern water law can be predicted. Specifically, in the core area of surface water law, the mediation of conflicting user claims to a limited supply of water, a managerial allocation system will bypass riparianism.[8] Rather than judicial common-law determinations about the reasonableness of a riparian's use of water,[9] a hierarchy of uses will emerge, with municipal water supply dominant over other uses. Other important collateral developments can be expected. Groundwater and surface water will merge into a universal concept of water supply, requiring the integrated governance of these two previously separate systems of water rights.[10] Traditional doctrinal obstacles to certain forms of water use, such as interbasin diversions and off-tract irrigation, will fall.[11] Riparianism will be greatly altered.

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6. The second article in the trilogy questions the value of existing permit systems as alternatives to riparianism. Abrams, *Water Allocation by Comprehensive Permit Systems in the East: Considering a Move Away from Orthodoxy*, 9 VA. ENVTL. L. REV. (*forthcoming* 1990). The final article focuses on the detailed characteristics and operating features of future permit systems and other regulatory mechanisms. Abrams, *Replacing Riparianism in the Twenty-First Century*, 36 WAYNE L. REV. (*forthcoming* 1990).

7. Even in the face of sustained shortages, it is possible that the East might respond as did the West. In addition to adopting the doctrine of prior appropriation, the West also relied on increasing physical supply through the construction of water storage and importation projects that redistribute the resource from areas of relative abundance to areas of immediate need. Riparianism can be made to support these projects, but their feasibility on fiscal, environmental, and political grounds is sufficiently doubtful to believe that riparianism will be saved in this manner. *See infra* notes 169-83 and accompanying text.

8. The allocation system is discussed in the third article of the trilogy. *See supra* note 6.

9. *See* RESTATEMENT (SECOND) OF TORTS § 850A (1977); *infra* notes 65-71 and accompanying text.

10. This development is discussed in the third article of the trilogy. *See supra* note 6.

11. Increasing pressure on water resources in the Great Plains led those states, initially settled under the law of riparianism, to repudiate on-tract and in-basin limitations. *Compare* Osterman v. Central Nebraska Pub. Power & Irri-

Data showing that Eastern water demands may surpass Eastern water supplies[12] suggest that the predicted eclipse of riparianism is far less radical than would otherwise be the case. One frequently cited reason for the longevity of riparianism is that the Eastern United States has never faced serious water supply problems.[13] Absent difficult cases, any legal doctrine, let alone one as venerable as riparianism, is likely to go unchallenged and largely unaltered.

Grief at the passing of riparianism may also be somewhat premature. It remains possible that riparianism will be unaffected in those areas of the Eastern United States not plagued by sub-regional shortages.[14] Additionally, in the recreational use setting, riparian principles of shared reasonable use should survive as the doctrinal measure of the legal rights of recreational water users. Finally, the spirit of riparianism will survive, especially in the effort to alleviate conflicts by altering otherwise antagonistic patterns of use.

Despite the inherently speculative nature of prediction and the theoretical cast of the discussion of natural resource law, the inquiry of this trilogy intends to have an applied value. To whatever degree that future events can be foretold, it will be that much easier to plan for those changes and minimize the disruption they engender.[15]

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gation Dist., 131 Neb. 356, 268 N.W. 334 (1936) (upholding limitation prohibiting transbasin diversion of waters from Platte River) *with* Little Blue Natural Resources Dist. v. Lower Platte N. Natural Resources Dist., 206 Neb. 535, 294 N.W.2d 598 (1980) (in hybrid riparian-prior appropriation jurisdiction, unappropriated waters may be diverted from one stream to another).

12. *See infra* notes 96-168 and accompanying text.

13. *See, e.g.*, W. Farnham, Modernization and Improvement of New York's Riparian Law 1-2 (1974). *But cf.* Dimmock v. City of New London, 157 Conn. 9, 245 A.2d 569 (1968) (municipal water use limited to protect amenities); Collens v. New Canaan Water Co., 155 Conn. 477, 234 A.2d 825 (1967); text accompanying notes 79-95, *infra*.

14. The dichotomy suggested between areas where riparianism is superceded by managerial systems and areas in which riparianism is unaffected is similar to the "critical management areas" concept being employed by an increasing number of Western states in their groundwater law. Under this dual regulation system, water use in groundwater short areas is stringently regulated; in groundwater sufficient areas, water regulation is more relaxed. *See, e.g.*, Ariz. Rev. Stat. Ann. §§ 45-411 to -637 (1987); Neb. Rev. Stat. §§ 46-656 to -674.20 (1986).

15. Changes in law frequently are disruptive of justifiable expectations that have grown up in reliance on the continued application of then current legal rules. Thus, to "know" in advance forthcoming changes in governing law is potentially to minimize the dislocations caused by the change. *Cf.* 6 R. Powell & P. Rohan, Powell on Real Property ¶ 871[4], at 79C-210.35 to -210.38 (1968) (amortization of nonconforming uses); Martinez, *Taking Time Seriously:*

But now for the note of leavening: prediction is an inherently risky business. Philosophical doubts akin to those expressed by both Hume and Berkeley appropriately caution all who would make predictions by reminding them that even the simple forecast that the sun will rise tomorrow remains uncertain until it actually happens and can be observed or otherwise empirically verified.[16]

Beyond a healthy skepticism born of doubts about supply/demand projections and legal responses to them, the history of American riparianism provides a final cautionary note about embracing predictions of radical doctrinal change. Somewhat like the persistent arrival of every tomorrow's sunrise, riparianism has shown a remarkable historic resiliency. In seemingly every era of American history, detractors have criticized riparianism and called for its abandonment in favor of different governing systems.[17] Time and again riparianism, though changed in some of its particulars, has survived as the controlling doctrine in Eastern States' water law. I believe this time will be different.

I. The First Stirrings of Change

This Article proposes a theory of when water law changes and shows that riparianism is at such a juncture. Riparianism's allocative

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The Federal Constitutional Right to be Free From "Startling" State Court Overrulings, 11 HARV. J.L. & PUB. POL'Y 297, 300-05 (1988) (mitigation of impact of changes in state common law).

16. *See* D. HUME, AN INQUIRY CONCERNING HUMAN UNDERSTANDING 86 (1955); G. BERKELEY, *The Principles of Human Knowledge*, in BERKELEY'S PHILOSOPHICAL WRITINGS 84-85 (D. Armstrong ed. 1965). Predictions regarding the course of legal development enjoy inherently less persuasiveness than do predictions about the physical universe in which law operates. This is because legal development is at least twice removed from the relative "certainty" of physical events. First, unlike predicting the coming of the morning sun, the underlying data upon which the prediction of riparianism's future must lie is neither as accurate nor as well defined. The variables that assuredly affect water supply and demand (e.g., matters such as climate and patterns of water use) are not easily calculated matters of mass and gravitational attraction. Moreover, unlike the precise sense of knowing what is relevant to undertake scientific calculations about the earth's rotation and orbit around the sun, the set of factors that contribute to the water supply/demand equation is almost as broad as the imagination is fertile. The second removal from Berkeley's hypothetical is that predicting changes in law involves predicting human responses to physical conditions. This too lacks the precision of scientific calculation.

17. *See, e.g.*, D. Haber, *Introductory Essay*, in THE LAW OF WATER ALLOCATION IN THE EASTERN UNITED STATES xxv, xxvii-xxxii (D. Haber & S. Bergen eds. 1957); Lauer, *supra* note 3.

regime works well in times of abundant water; however, the water news of the 1980s from the Eastern United States warns that the absence of significant water supply shortfalls is a thing of the past. The decade has witnessed several prolonged droughts, capped by the devastating drought in 1988 that led to multi-billion dollar losses in the agricultural sector in large portions of the Southeast and Midwest.[18] Local cases in which the inadequate quality of municipal supplies required expensive cleanup measures or importation of replacement supplies dotted the region. Pronounced groundwater overdraft in populous surface-water-poor coastal regions lowered water tables, caused subsidence, accelerated saline intrusion, and threatened the meteoric growth of those regions. Coupled with these specific episodes of overtaxed supplies were general increased demands for water due to population growth, with a concomitant increase in per capita water consumption rates, and the expanded use of agricultural irrigation. Under current legal and economic conditions, the adequacy of supply, particularly in peak load periods, is doubtful.

The question remains whether the mounting episodic evidence of local supply and demand imbalances heralds riparianism's demise. If water supply shortages are aberrational, the problems associated with the shortages will not be replicated with frequency. Thus, any need for revision in either water law or water supply mechanisms will fade as public memory of the past crisis dims. A central premise of this Article is that the recent sub-regional water shortages are produced by systemic factors, such as an increased likelihood of summer heatwave/drought situations, changes in agricultural practices, and increased municipal demand. Thus, the spate of recent Eastern water shortages, far from being aberrational, is symptomatic of greater, more widespread shortages to come.

The Article first acquaints the reader in a summary fashion with the way in which riparianism allocates water to water users. This discussion is followed by a somewhat didactic review of the development of modern riparianism. The historical material of Part II has two purposes. First, it supports an "instrumentalist" theory about natural resource law generally, and American water law in particular.[19] Under this theory, water law is crafted in a manner that permits society to make an effective use of the resource, i.e.,

18. Sidey, *The Big Dry*, TIME, July 14, 1988, at 2.

19. WEBSTER'S UNABRIDGED DICTIONARY 952 (2d ed. 1983) defines "instrumentalism" as "the pragmatic doctrine that ideas are plans for action which serve as instruments for adjusting the organism to its environment."

in a manner in which water serves as an instrument for the improvement of man's physical and economic welfare. Thus, legal rules governing water resources are derived not as a part of a more general jurisprudence, but as a matter of social and economic convenience and/or necessity. The theory is important because it has a predictive capacity: water law will remain essentially unchanged when it adequately supports a society's self-perceived needs; water law will change when those needs can no longer be met by the existing legal rules.

The second purpose of the historical account is to illustrate the strengths and weaknesses of riparianism as a resource allocative legal regime. In particular, the historical discussion demonstrates the singular deficiency of riparianism in responding to certain forms of water shortage.

The Article then changes character and examines the data regarding predicted water supply and demand in the Eastern United States. This factual discussion supports the assertion that Eastern water demand will exceed supply, thus setting the stage for a move away from riparianism's nonfunctional allocative rules. The material canvassed in Parts III and IV comes primarily from nonlegal disciplines, including studies of water flows and uses, and prospective changes in these parameters that can be predicted as a function of climate and other factors. The water supply discussion of Part III reviews the effects of human activity on water supplies in the Eastern United States, focusing primarily on the impact of the greenhouse effect and pollution. This segment reviews the vital questions of both long- and short-term climatic changes on surface water supplies, including whether the recent heatwaves and droughts are the product of the greenhouse effect. The discussion concludes with an analysis of the potential of various water supply strategies to mitigate the effects of predicted Eastern water shortages. Part IV surveys the diverse demands placed upon the Eastern water supply and examines the factors causing a growth in the demand for water. The discussion outlines methods of forecasting future increases and also attempts to ascertain whether increasing water conservation efforts can avoid an Eastern United States water future that portends recurrent water shortages. The findings are not hopeful.

II. Modern Riparianism's Water Allocation Rules: Their Forging and Survivability

A. *Water Entitlements Under Riparianism*

Providing a description of the series of entitlements created by the riparian system should be elementary. After all, riparianism is a form of water law, which is in turn a form of property law, whose *raison d'etre* is to establish entitlements governing the permissible use of property. Superficially, riparian rights enjoy clear definition in regard to both content and the class of holders of those rights.

Water rights in the riparian system are appurtenant to the ownership of land. The name of the system, riparianism, describes those lands that benefit by the attribution of water rights. Riparian lands are those which abut a watercourse.[20] Thus, as a matter of initial distribution of rights, the system functions with great efficacy—in most cases it is obvious which tracts are riparian and therefore enjoy water rights.

Over time, the distribution of riparian rights is complicated by two types of events, one initiated by physical changes, the other by human activity. Physically, waters change their courses and levels; these changes in turn pose questions of whether riparian rights are affected by the destruction or creation of a parcel's contact with the watercourse. Human actions that affect the distribution of riparian rights are primarily those involving transfers of something less than the entire parcel by the riparian owner. For example, the owner of a large riparian tract might sell a portion that does not abut the watercourse. The severed portion was riparian before the sale; the question raised after the sale is whether the severed tract retains any right of water use.

Legal rules of relatively certain application have emerged that respond to both physical and human actions affecting the riparian character of lands. The physical cases are divided into different governing rules dependent on whether the change was gradual (accretion and reliction) or sudden (avulsion). When the land's contact with the water changes gradually, the boundary of the property moves with the changing course of the stream, thereby insuring that riparian lands remain riparian. When the change is sudden, the property line remains unchanged and parcels no longer touching the water lose their riparian rights.[21] The general rule

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20. There is, within the class of lands abutting a watercourse, a distinction between lands along flowing waters, such as streams and rivers, and lands abutting standing water, such as lakes. Technically, the precise term for the latter is littoral rather than riparian. Practically, there are only the slightest differences in the governing legal rules; for example, the rules differ in defining the boundaries of a parcel to include some portion of the beds underlying the watercourse. These situations are not relevant to the water allocation rules under discussion here and the distinction between riparianism and littoralism will be ignored.

21. *See, e.g.*, Nebraska v. Iowa, 143 U.S. 359 (1892) (avulsion); Arizona v. Bonelli Cattle Co., 107 Ariz. 465, 489 P.2d 699 (1971) (accretion).

governing human actions is that a formerly riparian parcel, no longer contiguous with the water, is no longer riparian.[22] These rules ensure that the class of those who hold riparian rights remains well defined. This clear definition is an important condition for achieving full utilization of the water resource.

Specific water use entitlements are governed by a central allocative principle: each riparian proprietor has the right to make a reasonable use of the water consistent with the correlative usufructuary rights of coriparians.[23] One exception to the general rule of correlative water use rights is the right to withdraw as much water as is needed for domestic use (defined primarily as drinking and bathing) without regard to whether that use would exhaust the supply to the detriment of coriparians. Beyond the basic shared reasonable use entitlement, there are a number of additional incidents of riparian privilege that are quite certain, such as the right to wharf out to deeper water and the right to make use of the entire water surface for boating and recreation.[24] The rules of riparian rights can be succinctly stated, but, as will be explored later,[25] their application to water allocation disputes among riparian users is another matter.

B. *An Instrumentalist Theory[26] of Riparianism's Evolution*

Riparianism has endured as the dominant water law for humid eastern regions for two centuries because it has been able to adapt

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22. There is a split of jurisdictions regarding the case of a single owner who unites contiguous riparian and nonriparian tracts. In states that follow the "source of title" rule, the off-stream tract, even if reunited with the riparian tract, can never regain riparian rights; in states that follow the "unity of title" rule, all contiguous lands within the watershed owned by a single owner enjoy riparian rights as long as some part of the parcel is riparian. *See* D. GETCHES, WATER LAW IN A NUTSHELL 26-27 (1984).

A more difficult type of rights transfer case arises when a riparian owner attempts to transfer in gross all or a portion of the usufructuary right, such as by selling irrigation water to a nonriparian. *See infra* text accompanying notes 60-64. A similar, but somewhat less difficult, problem arises when a riparian proprietor seeks to make use of water on her own nonriparian tract. This situation is analytically one of determining whether the riparian's right of reasonable use of the water is spatially limited to the confines of the riparian tract.

23. *See generally* 78 AM. JUR. 2D *Waters* § 263 (1975).

24. *See, e.g.*, Joyce v. Templeton, 57 Md. App. 101, 468 A.2d 1369 (1984) (upholding riparian's right to have pier); McCardel v. Smolen, 71 Mich. App. 560, 250 N.W.2d 496 (1976) (recognizing riparian owners' right to build docks); Farnes v. Lane, 281 Minn. 222, 161 N.W.2d 297 (1968) (riparian rights include right of water access, wharfing out, other valuable rights.).

25. *See infra* text accompanying notes 65-75.

26. A far more elaborate instrumentalist theory of law has been espoused

its rules to meet changing conditions without sacrificing its underlying coherence. The prospect of recurrent "hard cases," which riparianism had failed to resolve, prompted the only major doctrinal revisions to or rejection of riparianism. All other situations were met by making minor doctrinal adjustments that left the basic structure of riparianism unchanged.

The description of how and when riparianism has changed can be recast as a variant of the old adage, "if it ain't broke don't fix it." To say that when there is no pressing need for change the law should remain intact commends itself as a normative proposition on grounds of both common sense and efficiency.[27] More tellingly, the adage and its obverse (things that are broken should be fixed) describe the historic pattern in the development of water law. In that history, significant changes in the law occurred when and only when that law was "broken," that is, when water law was unresponsive to the social and economic realities of the society in which it operated.

The Western states' repudiation of riparianism and adoption of prior appropriation is the most dramatic example of "fixing" "broken" water law. Riparianism was perceived as an obstacle to Western development for two principal reasons. First, the traditional requirement that the water be used on the riparian tract would have consigned vast inter-stream expanses to nondevelopment. Second, riparianism's rules of sharing in times of shortage would have deterred entrepreneurs from investing in water dependent activities because they could not obtain sufficient security that their water supply would remain theirs to use. Relief from the on-tract limitation was possible without the abandonment of riparian doctrine, but the amorphous contour of the usufructuary water right, mutable in the event that new entrants located on an already heavily burdened stream, appeared intolerable. In comparison, the hallmark of prior appropriation is a quantified set of annual rights to water use that

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by Professor Summers. *See* R. SUMMERS, INSTRUMENTALISM AND AMERICAN LEGAL THEORY (1982). The theory of this Article and Summers' theory share a pragmatic orientation:

> A theory of this type is instrumentalist in its view that legal rules and other forms of law are most essentially tools devised to serve practical ends, rather than general norms laid down by officials in power, secular embodiments of natural law, or social phenomena with a distinctive kind of past.

Id. at 20.

27. This might even be considered an incarnation of the law of parsimony, a corollary of Ocham's Razor.

grants far more precise rights than those available under riparianism.[28] The prospect of water demands in excess of foreseeable supplies forced the West to adopt a governing doctrine that would prove a better instrument than riparianism for allowing the water resource to meet regional needs.

The instrumentalist theory is neither radical[29] nor overly aggressive. Other examples of change in law to meet society's particular resource utilization needs abound. For example, oil fields were unitized early in the twentieth century to combat the waste and gross overproduction encouraged by the pre-existing "race to capture" rule.[30] Similarly, administrative creation of licensed "monopolies" in the use of broadcast frequencies was a necessary change that enabled a thriving broadcast industry to develop. Not surprisingly, both of these examples, oil fields and air waves, are, like

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28. In Coffin v. Left Hand Ditch Co., 6 Colo. 443 (1882), an early absolute shortage case featuring competing claims based on riparianism and prior appropriation respectively, the Colorado Supreme Court stated:

> We think the latter doctrine [prior appropriation] has existed from the date of the earliest appropriations of water within the boundaries of the state. The climate is dry and the soil, when moistened only by the usual rainfall, is arid and unproductive; except in a few favored sections, artificial irrigation for agriculture is an absolute necessity. Water in the various streams thus acquires a value unknown in moister climates. Instead of being incident to the soil, it rises when appropriated, to the dignity of a distinct usufructuary estate, or right of property. It has always been the policy of the national, as well as the territorial and state governments, to encourage the diversion and use of water in this country for agriculture; and vast expenditures of time and money have been made in reclaiming and fertilizing by irrigation portions of our unproductive territory. Houses have been built, and permanent improvements made; the soil has been cultivated, and thousands of acres have been rendered immensely valuable, with the understanding that appropriations of water would be protected. Deny the doctrine of priority or superiority of right by priority of appropriation, and a great part of the value of all this property is at once destroyed.

Id. at 446.

29. Karl Wittfogel espouses a radical theory founded on the parallel premise that water utilization needs control legal arrangements. Wittfogel asserts that not only law, but the entire social and political structure of a pre-industrial agriculture-based society located in an arid climate, are determined by the demands of water utilization. *See* K. WITTFOGEL, ORIENTAL DESPOTISM (1957); *cf.* F. HERBERT, DUNE (1965) (laws and customs in fictional society on desert planet determined by water needs of society).

30. Unitization is the practice of treating each pool of the resource as a unit and assigning shares to the overlying owners based on the amount of the pool under their property. *See generally* W.L. SUMMERS, THE LAW OF OIL AND GAS § 951 (1966).

water, common pool resources requiring a somewhat more active role for legal institutions than traditional property forms.[31]

The instrumentalist theory is optimistic about the change of law in relation to social and economic imperatives. If confined solely to the field of American water law,[32] the thesis enjoys verisimilitude. Major Eastern United States water law revisions have materialized only as needed, and a notable degree of fine tuning has permitted the doctrine to meet local exigencies without losing its character as a distinct and coherent body of general law. Throughout the early periods of United States history, national policy favored economic development through the exploitation of natural resources. From colonial times up through the post-Civil War period, the wealth of the nation rested in its physical resources. The country was both cash poor and technologically backward in comparison to the European powers and could not tolerate property rules that impeded opportunities for economic development through natural resource exploitation.

In the early years of American nationhood, water was seldom valuable in its own right but it was a key instrumentality in economic development. Water provided both transportation for all manner of trade and power for the early mills and later for electric generation. The law supported all of these societal imperatives. Special doctrines of government ownership of beds beneath "navigable"[33] waters underpinned a right of public navigation. Without regard to docu-

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31. *Cf.* Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1268 (1968) (need to regulate common resources to avoid destruction by overuse).

32. The thesis can be defended equally for Western water law as for Eastern water law. In the West, the mere specter of numerous shortage-induced hard cases as well as other deficiencies of riparianism, such as the on-tract limitation, led to the prospective abandonment of riparianism in several states even before the user conflicts arose. This pragmatic repudiation of riparianism, yet another example of the instrumentalist theory at work, is bottomed on the well-founded belief that under different topographic and climatic conditions riparianism could not provide an efficient resource utilization pattern for either the water or the lands on which its use was needed. *See supra* note 28.

Some commentators reject the instrumentalist thesis in other settings. For example, one scholar, discussing aspects of European property law, makes a strong case that the law was deliberately manipulated to prevent efficient resource utilization as a means of propagating the privileged status of the landed classes. *See* J. Rosenthal, Drainage in the Pays d'Auge 1700-1848: The Weight of Uncertain Property Rights (1987) (unpublished paper on file at *The Wayne Law Review*).

33. This federal navigability test is called "navigability for title." For a more thorough discussion of this and other tests of navigability, see J. SAX & R. ABRAMS, *supra* note 2, at 33-36, 73-77.

ments of title or the private interests of riparian owners, these early doctrines established that the several states were the owners of the beds underlying all waters that were "navigable in fact . . . susceptible of being used, in their ordinary condition, as highways for commerce, over which trade and travel are or may be conducted,"[34] and that the public would enjoy a right of passage over those waters. In terms of legal doctrine, assuring this usufructuary right was a simple matter of adapting the inherited English public trust concept and applying it to a slightly broader class of waters.[35]

Aspects of English water law supporting navigation were easily imported into American legal doctrine. In contrast, the manor house aspects of English natural flow riparianism had to be rejected because they prevented the full utilization of the resource. Natural flow riparianism required that water be left to flow down to each lower owner, "undiminished as to quantity and quality."[36] This rule reflected the traditional English view of flowing water as an amenity and not as an instrument of national development. However, the economic growth of New England and the mid-Atlantic states required a different legal rule. Many mill dams changed the flow of the stream to a new course; some dams impounded large quantities of water, at times interdicting the entire flow of the stream to fill the pond. Other dams inundated streambeds, transforming them into ponds and lakes, and some streamside operations deposited wastes into the stream. To afford these uses of water meant

34. The Daniel Ball, 77 U.S. (10 Wall.) 557, 563 (1870); *see also* Utah v. United States, 403 U.S. 9 (1971). The navigation right was held sacrosanct even to the extent that government licensure of structures or alienation of lands that would compromise the public right were invalid. *See* Shively v. Bowlby, 152 U.S. 1 (1893); Illinois Central R.R. v. Illinois, 146 U.S. 387 (1892).

35. Owing to differences in topography, the waters described as navigable under the United States navigable for title test and the tidal waters covered by the English trust doctrine included almost all of the major arteries of waterborne trade in both nations. In those waters, the English people have always held public rights of navigation, fishery, and bathing. Royal stewardship protected these rights against privatization. *See, e.g.*, The Propeller Genesee Chief v. Fitzhugh, 53 U.S. (12 How.) 443 (1851).

36. The classic judicial statement of the natural flow doctrine appears in the early New Jersey case of Merritt v. Parker, 1 N.J.L. 460 (1795):

> In general it may be observed, when a man purchases a piece of land through which a natural water-course flows, he has a right to make use of it in its natural state, but not to stop or divert it to the prejudice of another. . . . It cannot legally be diverted from its course without the consent of all who have an interest in it.

Id. at 530. *See also* J. SAX & R. ABRAMS, *supra* note 2, at 158-62.

renouncing natural flow riparianism; no longer could the law permit a single owner to require the nonuse of the stream to vindicate the traditional riparian right of undiminished natural flow.

The courts of the several states were the crucibles in which the change in the legal rule occurred. The doctrinal vehicle that changed the law was the judicial rejection of a right to undiminished natural flow within the scope of riparian usufructuary rights. Beginning early in the nineteenth century, courts of the New England and mid-Atlantic states paved the way for water mills to operate by limiting the potential veto provided by the insistence on natural flow. The first cases challenging the old doctrine, however, seldom involved a riparian seeking total nonuse of the stream to vindicate the right to natural flow.[37] Instead, the early cases most often pitted active water users against one another.[38] For example, natural flow favored downstream millers claiming that an upstream mill was diverting or diminishing the flow or depositing debris into the water that damaged the downstream miller's apparatus.[39]

The natural flow doctrine could also serve upstream proprietors injured by inundation caused by a downstream mill.[40] However, some state courts were reluctant to alter the legal right of an upstream landowner to be free of flooding by the pond of a downstream dam.[41] In a number of these states legislative interven-

37. There is no certain explanation for this fact. Some possibilities include the fecklessness of lawsuits that seek to enjoin behavior that is causing no material harm to the suitor, the relative expense and inconvenience of litigation, and the scarcity of trained attorneys available to bring such cases.

38. In these cases, if the complainant's use was established first, a claim of right based on priority of use would substitute for a claimed right of natural flow. These cases reflect an early judicial attempt to define an alternative to natural flow riparianism. The courts were initially attracted to priority of use rules that measured the first use as being that which began to tap the economic potential of the water. In the end, recognizing that one entrant's priority of use is another's barrier to entry, the courts rebuffed not only natural flow, but also any general legal rule of water allocation based on priority of use. *See, e.g.*, Snow v. Parsons, 28 Vt. 457 (1858).

Professor Horwitz, in his celebrated work, *The Transformation in the Conception of Property in American Law 1780-1860*, 40 U. CHI. L. REV. 248, 251-61 (1973), traces in detail the antidevelopment aspects of both natural flow riparianism and priority of use rules, and notes that the rejection of priority of use is tempered by recognition of prescriptive rights. These are obtained only by long, uninterrupted use. In a new country, successful claimants were few indeed.

39. *See, e.g.*, Martin v. Bigelow, 2 Aik. 184 (Vt. 1827).

40. *See, e.g.*, Johns v. Stevens, 3 Vt. 308 (1830).

41. In *Johns*, the state supreme court reversed a trial court ruling permitting inundation without payment. The high court also declined to limit repetitive damage actions that might inhibit the establishment of mills. *Id.* at 316.

tion in the form of flowage statutes provided the equivalent of private condemnation favoring mill seat operators.[42] These statutes typically offered a limited, rental-like payment for lands inundated by millponds and had several significant prodevelopment consequences. First, the elimination of traditional damage actions based upon trespass theories, in which injury was presumed upon proof of inundation, precluded potential monetary impediments to the establishment of new mills. The statutes also removed all threat of punitive damages. Second, flowage statutes extinguished the possibility of physical interference with new dams by legally insulating them from self-help remedies of aggrieved coriparians, and by removing any threat of injunction, on either a continuing trespass or nuisance theory.[43] Third, the flowage statutes minimized the capital expenses of the mill proprietor[44] by limiting the amount of damages to a judicially fixed and seldom reconsidered sum,[45] payable on a year-to-year basis. Some of the flowage statutes had the practical result of requiring no compensation because of provisions permitting the inundating dam operator to obtain a set-off for any benefit that accrued to the inundated parcel as a result of the change in water level.[46]

In the end, the repudiation of natural flow riparianism had done far more than change the results in a series of water use conflicts. The new doctrine championed a de facto change in the distribution of wealth. The judicial elimination of the natural flow doctrine's veto power over development, a traditional privilege of the landed gentry, greatly benefitted a growing entrepreneurial middle class. Access to water power was no longer confined to the rich who could harness the stream and return it unchanged all within the boundaries of their land as required by the legal confines of natural flow riparianism. Water power was now available at a competitive price to all who could afford a small tract suited for a mill seat.

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42. *See, e.g.*, 1794-96 Mass. Acts 443, (Act of Feb. 27, 1795) ch. 74.

43. Horwitz, *supra* note 38, at 272.

44. Purchase of an easement or payment of lump sum damages would require the mill seat operator to make a capital investment in the inundated land, rather than a rental payment for its use.

45. The annual payment would be recomputed only upon a showing of changed circumstances by one of the parties. The cost of litigation and inertia tended to lock in the earlier computed price term. With land values generally rising in this era, older values were lower than present values in most cases.

46. For example, land that had previously been swampy and valueless might now be valuable as a pond for livestock watering, a potential set-off against damage done to arable lands that also were inundated.

The wider use of the resource provided the means to attain maximum economic and social development. Strangulation of water utilization, by the ill-fitting legal doctrines of natural flow riparianism and the brief adherence to rules of priority,[47] was at an end. One commentator chronicled the progression of legal doctrine:

> As property rights came to be justified by their efficacy in promoting economic growth, they also became increasingly vulnerable to the efficiency claims of newer competing forms of property. Thus, the rule of priority, wearing the mantle of economic development, at first triumphed over natural use. In turn, those property rights acquired on the basis of priority were soon challenged under a balancing test or "reasonable use" doctrine that sought to define the extent to which newer forms of property might injure the old with impunity. Priority then claimed the status of natural right, but only rarely did it check the march of efficiency. Nor could a doctrine of reasonable use long protect those who advanced under its banner since its function was to clear the path for the new and the efficient. Some of its beneficiaries eventually reclaimed the doctrine of priority, this time asserting the efficiency of "natural monopoly" and the inevitability of a standard of priority.
>
> Viewed retrospectively, one is tempted to see a Machiavellian hand in this process. How better to develop an economy than initially to provide the first developers with guarantees against future competitive injury? And once development has reached a certain level, can the claims of still greater efficiency through competition be denied? By changing the rules, and disguising the changes in the complexities of technical legal doctrine, the facade of economic security can be maintained even as the new property is allowed to sweep away the old.[48]

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47. *See supra* note 38.

48. Horwitz, *supra* note 38, at 251. The passage continues:

> The plan that the historian sees in retrospect, however, was not what the participants in this process saw. They were simply guided by the conception of efficiency prevailing at the moment. Practical men, they may never have stopped to reflect on the changes they were bringing about, nor on the vast differences between their own assumptions and those of their predecessors.

Id. This Article partakes of that tradition insofar as it seeks a practical legal

Machiavellian or not, the changes created a new water law doctrine that flourished. Reasonable use riparianism permitted the resource utilization upon which so much economic growth depended. In these times of water abundance, even "hard cases" could be resolved by reference to riparianism in ways that continued the social benefits of maximum water utilization. In *Mason v. Hoyle*,[49] a case that may be the apex of nineteenth century reasonable use riparianism, the Connecticut Supreme Court resolved a water allocation dispute among several mill operators all dependent on a small river for power. An upper mill seat operator who had been forced to augment the power of his mill with steam power raised the height of his dam, which raised the head and increased the amount of water that could be stored behind the dam. To improve efficiency, that owner operated the plant wholly by water when the millpond was draining from full to empty, and wholly by steam when the millpond was refilling. This change in operations wrought havoc with the operations of the lower proprietors, who now found the river's flow either completely restrained or so great that it overflowed their dams. The court, cognizant of the limited amount of water available, cited the correlative right of coriparians to use the stream and the principle that foreseeable shortages in water supply should be apportioned to permit all of the riparians to secure a fair proportion of the water's benefit. The court ruled that the upper proprietor must revert to the prior practice of permitting the flow to pass through his mill.[50] This practice was a reasonable use of the water and maximized utilization of the stream by providing power to the upper mill operator, while leaving the lower owners in the position they had enjoyed in the past.

The *Mason v. Hoyle* decision was Solomonic, permitting all of the uses to be harmonized and continued, sacrificing only the marginal efficiency gains of alternating power sources that would have accrued to the upper owner. This flexible, utility-seeking, fact-specific adjudication represents riparianism at its allocative best, imposing legal constraints on individual riparian owners only when their self-interested actions threaten the larger community's beneficial use of a common pool resource.

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response to a perceived failure of riparianism to promote "efficiency" under the changed circumstances of the coming decades. In contrast to the work of those practical men of old, however, this attempt to promote legal change is pursued consciously.

49. 56 Conn. 255, 14 A. 786 (1888).

50. *Id.* at 272, 14 A. at 790.

The navigability rules[51] associated with riparianism also proved amenable to the promotion of special local economic concerns by permitting the erosion of private claims of right. In Michigan, for example, to promote timbering, the supreme court adopted a log floating state law test of navigability to supplement the federal commercial navigability test.[52] The change provided the timber industry, the state's largest nineteenth century industry, with cost-free use of the state's abundant water network, much of which would have been nonnavigable under the federal standard. The modification of the legal doctrine reflected a conscious desire to promote the utilization of the water resource:

> We have a large territory yet undeveloped, rich in forest and in mineral wealth—washed by vast bodies of water upon three sides, and threaded by innumerable streams which are capable of navigation, . . . and with a commerce already established, rivaling in extent, that of some of the Atlantic States, and rapidly growing under the influence of increasing population, settlements, and wealth, it is of the first importance that the rights of the public be recognized, to the free use of all streams susceptible of any valuable floatage. . . . Although in some of the States usage and custom has been regarded as the foundation of this public right in fresh rivers, yet, in others the application of this doctrine has

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51. State law navigability rules arguably are not a part of riparianism per se. State law navigability rules determine which waters are open to navigation (very broadly defined) by the general public. Thus, a finding of state law navigability does not alter the rights of coriparians *inter sese*, it only increases the rights of nonriparians to make use of the water surface. The state law navigability doctrine affects the utilization of the water resource, allocating some part of the benefits to a broader beneficiary class. For that reason, changes in navigability doctrine based on changing perceptions about social welfare are the functional equivalent to changes in the core of riparian doctrine, and equally demonstrate the adaptability of the governing doctrines that establish property rights in water resources.

52. Moore v. Sanborne, 2 Mich. 519 (1853). The Michigan Supreme Court acknowledged that customary public use as a highway of commerce would support a recognition of a public usufruct. It is not clear from the opinion whether the court considered that test to be a state law test of navigability or a refinement of the federal law test. *See supra* notes 33-34 and accompanying text. The opinion clearly illustrated that such a test was inadequate to meet Michigan's economic needs, for much of Michigan's stream network would remain nonnavigable under a test that based public rights on custom. In a newly settled terrritory there is little, if any, customary use. *Id.* at 523-24.

> been denied. In the new States, from necessity, and the very nature of things, such cannot be the foundation of the public right.[53]

Even well into the twentieth century, the malleable nature of both riparianism and the related navigability doctrine have continued to serve the riparian states well in promoting the full utilization of the water resource. As recreation became an important water use, both in terms of public benefits and economies built on providing recreational opportunities, facets of riparian water law doctrine that limited recreational use came under attack. States seeking to promote recreation adopted recreational suitability as their state law test of navigability.[54]

In *State v. McIlroy*,[55] the Arkansas Supreme Court explained how the recognition of recreationally valuable waters as state-law-navigable, although a novel holding, was nevertheless an inherent part of the state's longstanding water jurisprudence. Arkansas had long employed commercial navigability as its navigability standard.[56] As early as 1915, however, the Arkansas Supreme Court foreshadowed later changes, including the possible recognition of a recreational use test of navigability, by noting the mutability of results that attended the doctrine.[57] In an unusually candid statement of the instrumentalist nature of its water law, that court stated:

> It is the policy of this state to encourage the use of its water courses for any useful or beneficial purpose. There may be other public uses than the carrying on of commerce of pecuniary value. The culture of rice is being developed in this state, and the waters of the lake could be used for the purpose of flooding the rice fields and for other agricultural purposes. As the population of the state increases, the banks of the lake may become more thickly populated, and the water could be used for domestic purposes. Pleasure

53. *Id.* at 524.

54. *See, e.g.*, People v. Sweetser, 72 Cal. App. 3d 278, 140 Cal. Rptr. 82 (1977); Southern Idaho Fish & Game Ass'n v. Picabo Livestock, Inc., 96 Idaho 360, 528 P.2d 1295 (1974); Mentor Harbor Yachting Club v. Mentor Lagoons, Inc., 170 Ohio 193, 163 N.E.2d 373 (1959). For a more complete list, see J. SAX & R. ABRAMS, *supra* note 2, at 53.

55. 268 Ark. 227, 595 S.W.2d 659 (1980).

56. *See, e.g.*, Lutesville Sand & Gravel Co. v. McLaughlin, 181 Ark. 574, 576-77, 26 S.W.2d 892, 893 (1930).

57. Barboro v. Boyle, 119 Ark. 377, 382-83, 178 S.W. 378, 380 (1915).

> resorts might even be built upon the banks of the lake, and the water might be needed for municipal purposes. Moreover, the waters of the lake might be used to a much greater extent for boating for pleasure, for bathing, fishing, and hunting, than they are now used.[58]

In 1980, when the *McIlroy* court finally ruled that recreationally valuable waters were navigable under Arkansas law, it noted that the preexisting precedents were "a remnant of the steamboat era" that were no longer attuned to the modern concept of the public welfare.[59] The court's adoption of recreational suitability as the state law test of navigability created a new usufructuary right favoring recreational users, just as the adoption of log floating as the test of navigability in Michigan created a de facto use right favoring the timber industry.

A final example of the fine-tuning of reasonable use riparianism that has permitted it to endure is the doctrine's treatment of off-tract water use. Traditional riparian common law doctrine wed the water right to the riparian tract. Not only did the riparian character of the tract give rise to the usufructuary water right, the water use was required to be consummated on the riparian tract itself.[60] To effectuate this limitation, the legal doctrine deemed off-tract use per se unreasonable. Courts uncomfortable with the anti-development consequences of this rule began to ameliorate its effects by permitting off-tract uses to continue in the absence of material injury.[61] A few courts and other legal institutions[62] advocated elimination of the on-tract rule in favor of a determination of whether the use was a reasonable riparian use without regard to where it was consummated.

In the Eastern United States, the vindication of the on-tract rule caused few inefficiencies before the last half of the twentieth cen-

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58. *Id.* (citation omitted).

59. 268 Ark. at 236, 595 S.W.2d at 664. Riparianism's ability to maximize use of the water resource also fits well in cases in which recreational use is attacked as excessive or as an overuse of watercourses. *See, e.g.*, Thompson v. Enz, 379 Mich. 667, 154 N.W.2d 473 (1967) (finding of reasonableness must attend intensive funnel development for recreational use).

60. *See, e.g.*, RESTATEMENT (FIRST) OF TORTS § 41 topic note 3 (1939).

61. *See, e.g.*, Davis, *The Right to Use Water in the Eastern States*, in 7 WATERS AND WATER RIGHTS 614.1 n.57 (R. Clark ed. 1976).

62. The RESTATEMENT (SECOND) OF TORTS § 855B (1977) dropped the on-tract limitation, adopting the then minority view. This position did not take the next half step and, like the prior appropriation states, eliminate the need for the ownership of some riparian land by the party making the nonriparian use.

tury.[63] Small volume off-tract uses seldom had sufficient impact on a watercourse to prompt the need for legal proceedings. Large volume off-tract uses, such as those required by agriculture or industry, were rare. Most arable lands could be farmed without need of irrigation and the plentiful supply of watercourses accommodated the water withdrawal needs of industry, while simultaneously offering transport, power, and waste disposal opportunities. The reported cases of off-tract use involved cities and private water utilities providing water for municipal use. Here, in the event the municipal use on a nonriparian tract was held to constitute an unreasonable interference with riparian rights, the defendants were clothed with the power of eminent domain and could condemn that portion of the riparian estate that had been infringed.[64] Thus, riparianism continued to adapt as necessary, either abandoning the on-tract limitation by shifting doctrinal emphasis to the reasonableness of the use alone, or by finding that the only recurrent problem cases were obviated by the eminent domain powers of the vitally important water supply organization.

This evolutionary view of riparianism illustrates the doctrine's adaptability, which enabled it to survive the diverse pressures of a changing society. The doctrine changed radically, i.e., from natural flow to reasonable use, only when continued adherence to natural flow would have prevented full utilization of the resource. Modern riparianism's failure to solve the increasing number of absolute shortage cases also prevents maximum societal use of the resource, and will require a similar radical change.

C. *Riparianism's "Hard Cases"*

Riparianism's past performance in resolving absolute shortage cases is at best mediocre, and its future application in such cases portends unsatisfactory results on an increasingly large scale. In cases of absolute shortage, riparianism's mechanism of adjusting competing interests fails because it is impossible to salvage all of the competing uses. In deciding what use will prevail over the other, the doctrine does not provide a hierarchy of uses to guide the court.

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63. In the arid Western United States, where watercourses were few and far between, this traditional riparian rule denied vast tracts of any means of obtaining surface water rights. This was anathema to orderly development and was one of the two central factors in the rapid demise of riparianism in that region. *See supra* note 28 and accompanying text.

64. *See, e.g.*, Town of Purcellville v. Potts, 179 Va. 514, 19 S.E.2d 700 (1942).

Absent guidance, decisions become ad hoc (in the bad sense) and unpredictable. The future cases that will challenge reasonable use riparianism involve this type of absolute shortage, usually triggered by the water requirements of large volume off-stream uses such as irrigation or municipal supply.

One paradigm of irreconcilable competing interests arises between uses such as boating or driving a water mill, which require the water to be left in the watercourse, and uses such as irrigation, which require the water to be withdrawn.[65] If there is an absolute shortage of water forcing the courts to decide whether the boats will be left high and dry, the mill will not turn, or the crops will fail—then riparianism's guidance is unsatisfactory.

In cases approximating these scenarios,[66] courts founder. In *Taylor v. Tampa Coal*, a boating-irrigation conflict, the Florida Supreme Court, despite stating that reasonable riparian uses are equal in the eyes of the law,[67] upheld an injunction against the irrigator on the theory that a riparian may insist on the maintenance of the natural water level.[68] Given the claimed adherence to the reasonable use doctrine, predicating the result on a protection of "natural levels" is nothing more than a *non sequitur* advanced in support of an outcome. Such an opinion breeds only greater uncertainty about what result will arise in the future, thereby inhibiting the entrepreneurial activity that the instrumentalist theory of water law should encourage.

In *Pyle v. Gilbert*, a mill seat-irrigation conflict, the Georgia Supreme Court ruled that despite prior uncertainty in Georgia law, irrigation (including off-tract irrigation) is a reasonable riparian use of water.[69] Having reversed the summary judgment in favor of the

65. Another paradigmatic case involves competition among off-stream users, such as multiple irrigators on a small stream lacking sufficient water to serve them all.

66. *See* Taylor v. Tampa Coal, 46 So. 2d 392 (Fla. 1950) (boating-irrigation conflict); Pyle v. Gilbert, 245 Ga. 403, 265 S.E.2d 584 (1980) (mill seat-irrigation conflict). *Pyle*, discussed *infra* notes 69-71 and accompanying text, may not squarely present the stark dilemma of absolute shortage posed by the text; *Taylor* does. In *Taylor*, the trial court stated: "Obviously, if the defendant were allowed to continue to irrigate his grove bi-weekly as he contends is necessary, it would not take a greatly extended dry spell to very materially lower the waters to such a point that plaintiffs' fishing and swimming rights would be very materially damaged." 46 So. 2d at 393.

67. 46 So. 2d at 394.

68. *Id.*

69. 245 Ga. at 410, 265 S.E.2d at 588. In *Pyle*, at least one of the off-

mill operator on that ground, the court remanded the case in the hope that "all the uses of the creek and pond can be accommodated."[70] In the event that the uses could not be accommodated, the Georgia Supreme Court offered ambiguous guidance for the lower court, directing it to look to section 850A of the Restatement (Second) of Torts, while noting that "we cannot and do not here approve all that is said therein, we refer to it for whatever help it may be."[71]

Applying the Restatement in a case of absolute shortage offers little help indeed. Section 850A requires a consideration of the interests of the competing riparians and that of society as a whole. Each use is to be tested by reference to a series of factors, including the following:

> (a) the purpose of the use,
> (b) the suitability of the use to the watershed or lake,
> (c) the economic value of the use,
> (d) the social value of the use,
> (e) the extent and amount of harm it causes,
> (f) the practicality of avoiding the harm by adjusting the use or method of use of one proprietor or the other,
> (g) the practicality of adjusting the quantity of water used by each proprietor,
> (h) the protection of existing values of water uses, land, investments and enterprises, and
> (i) the justice of requiring the user causing harm to bear the loss.[72]

In a case in which the two uses are both reasonable per se but absolutely incompatible, the Restatment leaves a court with little more than factors (c), (d), (h) and (i) as guidance. Factors (a) and (b) drop out because the uses are both sufficiently meritorious and

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tract users was not a riparian and there was no reference to any grant or transfer of water rights from a riparian proprietor to the nonriparian user. Presumably, there must be at least acquiesence by the riparian proprietor on whose land the water is withdrawn for transport to the nonriparian tract.

70. 245 Ga. at 411, 265 S.E.2d at 589 (footnote omitted here but discussed in text accompanying note 71, *infra*).

71. *Id.* at 411 n.10, 265 S.E.2d at 589 n.10.

72. RESTATEMENT (SECOND) OF TORTS § 850A (1977).

adapted to their setting to be deemed reasonable.[73] Factors (f) and (g) are inoperative by definition—this is the core of the "absolute shortage" problem. Factor (e) is useless because it requires the court to decide which activity is causing the harm to the other when in fact both activities, as uses of a single resource complex, harm the other.[74]

The remaining factors amount to a comparison of the utility of the possible outcomes, with the possible addition of cash as compensation to the "loser" forced to forego the use of the water. The Restatement analysis measures utility by comparing economic and social values of the competing uses. The value associated with protecting justifiable investment-backed expectations is factored into the analysis, supporting the entrepreneurial activity on which the American economic system depends.[75] The result obtained by applying these factors seems to be a *tour de force* of the law permitting water resources to serve as an instrument of development. In real cases, however, the Restatement fails to achieve this effect, not because the test promotes the wrong values, but because comparative utility is so difficult to assess.

Consider the case of a nonriparian city, located at a considerable distance from a watercourse, seeking to supply its residents and industries with large quantities of water.[76] This water would otherwise support existing in-stream uses, including commercial navigation, recreation-based economies, hydro-electric power generation

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73. If factor (a) is intended to permit fashioning a hierarchy of uses, then the relative parity of uses that is a tenet of reasonable use riparianism is destroyed. The creation of a hierarchy of uses is one of the changes advocated in the final article of the trilogy. *See supra* note 6. But the introduction of such a hierarchy is as much a break with reasonable use riparianism as was reasonable use from its natural flow predecessor. *See supra* notes 36-48 and accompanying text.

74. *See* Sax, *Taking, Private Property and Public Rights*, 81 YALE L.J. 149, 151-55 (1971).

75. *Cf., e.g.*, Kaiser Aetna v. United States, 444 U.S. 164, 179-80 (1979) (importance of protection of justifiable investment backed expectations); Michelman, *Property, Utility and Fairness: Comments on the Ethical Foundations of "Just Compensation" Law*, 80 HARV. L. REV. 1165, 1214-24 (1967) (conditions under which compensation ought to be required for destruction of property rights by government regulation).

76. The choice of such a city is intended to posit high capital costs in transporting the water, thereby militating for a large volume project that can offer lower unit costs by achieving economies of scale. Diversion projects frequently face major costs for items, such as rights-of-way, that are unaffected by the size of the project. Many construction costs, such as for canals and conduits, increase only slightly as project size increases. In consideration of these types of cost curves, the unit cost of water is often lower if larger volumes are transported.

and baseflow necessary to maintain fisheries, wetland habitats, and aquifer recharge. All of these uses are in themselves reasonable, and riparianism has no hierarchy of preferred uses to guide the court's decision of whether to prefer the municipal water supply over the in-stream uses. The potential array of relevant data that the court must consider is staggering, due both to its magnitude and its imprecision. Quantitative measures of the economic and social value of the water to the nonriparian city must necessarily look to projections of the city's future economic growth, with and without the water. The values of the in-stream uses are likewise difficult to quantify. The court must evaluate foregone regional economic development in the area of origin that the loss of the water portends; it must assign values to loss of ecosystem integrity, as well as more conventionally measured losses that will inure to existing water dependent economies. Courts simply must do the best they can, but this offers neither solace to those whose uses are destroyed or limited, nor confidence to entrepreneurs whose plans require a secure supply of water.

It is this last aspect of the problem, the unpredictability of outcomes in times of shortage, that has always daunted defenders of riparianism. A recent water law text levelled an often repeated criticism:

> The riparian system favors flexibility over security. By and large it has worked well in the humid, water-rich eastern states . . . . Allocation decisions in pure riparian states are made by the courts, an institution lacking the expertise and administrative continuity to assure a predictable diversion rights system. Case-by-case judicial decisionmaking results in inconsistent and impermanent results. Any allocation may be altered by the entry of new users, changes in patterns of use, or changes in the characteristics of the watercourse. This absence of definite, quantifiable diversion rights inhibits investment. . . . [C]ourt decisions on water allocations are ad hoc [and] . . . [c]omprehensive record-keeping and water supply planning are impossible in a pure riparian state.[77]

While the criticism has always been valid, reasonable use riparianism endured with only modest modification because neither the number of "hard cases" nor the competing interests in those cases were

77. W. GOLDFARB, WATER LAW 24-25 (2d ed. 1988) (footnotes omitted).

very large. However, recurrent Eastern water shortages resulting from decreasing water supplies and increasing demands will trigger many water use conflicts in which the competing interests are large. As *Taylor* and *Pyle* demonstrate, continued adherence to reasonable use riparianism fails to resolve absolute shortage cases with any degree of certainty or consistency, and impedes the full utilization of the water resource. Absolute shortage cases, or their prospect, will be the driving force that will change the law of riparianism.

III. Water Supply in the Eastern United States

The supply/demand materials demonstrate that the need for large volume off-stream water uses in the Eastern United States is growing, and the supplies necessary to meet those needs are, in some parts of the region, already inadequate and appear likely to shrink in the future. Application of the instrumentalist theory to this factual background provides the inescapable conclusion that riparianism will change because it can no longer support society's water needs.

A. Measures of Current Water Supply[78]

Due to the historic adequacy[79] of water supply in the Eastern United States, it has seldom been the focus of detailed scrutiny in

78. The most accessible and comprehensive set of United States water supply data was compiled by the United States Water Resources Council as part of its Second National Water Assessment. The data was published in 1978 in four volumes entitled THE NATION'S WATER RESOURCES 1975-2000 [hereinafter SECOND ASSESSMENT]. These materials will serve as the principal quantitative source in this Article; more recent data will be discussed when available. The Second Assessment used 1975 as its baseline year. The data given for 1975 are not actually measurements, but instead "represent assumed average conditions" that were derived from actual data about the years preceding 1975. 2 SECOND ASSESSMENT, Glossary and Conversion Tables, at iv. Unless otherwise noted the 1975 figures will be used rather than the Second Assessment's projections about flows and conditions in 1985 and 2000, except when the projections themselves are discussed.

Methodologically, the Second Assessment divides the nation into 21 water regions and analyzes data on a regional and subregional level. The area covered by regions one through eight encompasses almost all of the Eastern United States in which riparianism is the governing law of water allocation. These regions are: Region 1—New England; Region 2—Mid-Atlantic; Region 3—South Atlantic-projections of the area's water future. Most water planning studies seeking to determine the appropriate capacity for expanded distribution systems, or to determine methods for meeting additional peak load water demands, review water demand trends and tacitly assume sufficient sources of supply. The inquiries do not probe, as do many Western studies, how much water is available and at what point water use will have to be curtailed due to lack of supply. Because this Article proposes that Eastern water law will not change absent a chronic undersupply problem, basic questions of existing and future water supply require review.

Under any supply standard, water is a plentiful resource in the Eastern United States. Qualitatively, rivers and streams are extensive and most watercourses have water flowing in them throughout the year.[80] Groundwater aquifers capable of producing significant recoverable quantities of fresh water are numerous.[81] Precipitation is sufficient to sustain most farming without irrigation, and the entire region is classified by geographers as "humid."[82]

These hydrologic characteristics result in an average natural freshwater flow (outflow) from the region of 351,600 million gallons per day (mgd).[83] To put those amounts of water into physical perspective, the equivalent outflow figure for the entire Colorado River basin is 13,400 mgd.[84] The regional outflow measure is the

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Gulf; Region 4—Great Lakes; Region 5—Ohio; Region 6—Tennessee; Region 7—Upper Mississippi; Region 8—Lower Mississippi. *Id.* pt. I, at 2.

79. Among the riparian states, only the narrow strip of highly urbanized land around the southern tip of Lake Michigan is considered an area of surface water supply shortage, in which 70% of the available streamflow would be depleted in a dry year. *See* 1 SECOND ASSESSMENT, *supra* note 78, at 57. However, more recent data indicates that 12 of northern New Jersey's largest cities cannot meet current surface water demands in years of average precipitation. *Water Supply Issues in the Middle Atlantic States: Hearings Before the Senate Subcomm. on Water and Power of the Senate Energy and Natural Resources Comm.*, 99th Cong., 1st Sess. 6 (1985) [hereinafter *Mid-Atlantic States Hearings*] (testimony of Dr. Dallas Peck, Director, U. S. Geological Survey (USGS)).

80. *See* 2 SECOND ASSESSMENT, *supra* note 78, pt. IV, at 7-10.

81. *Id.* at 18. *See also infra* note 94 and accompanying text.

82. *See, e.g.*, LIFE PICTORIAL ATLAS OF THE WORLD 26-27 (1961). The entire Eastern region receives an average of 44 inches in annual precipitation. 2 SECOND ASSESSMENT, *supra* note 78, pt. IV, at 5.

83. 1 SECOND ASSESSMENT, *supra* note 78, at 54. Coupled with these surface flows are groundwater deposits that are estimated to dwarf that amount. *See id.* at 20; *Mid-Atlantic States Hearings*, *supra* note 79, at 26-27 (testimony of Philip Cohen, Chief Hydrologist, USGS) [hereinafter *Cohen testimony*].

84. *See* 1 SECOND ASSESSMENT, *supra* note 78, at 55. The Colorado River basin begins in southwestern Wyoming and ends at the Arizona-Mexico border.

preliminary step in calculating regional water supply. Flow measures are a gauge of regional "water balance," an accounting of water inputs and water outputs. For example, the United States Water Resources Council, in its Second National Water Assessment (Second Assessment),[85] began its water supply analysis by calculating natural outflow on a watershed-by-watershed basis.[86] This analysis combines surface water flow inputs, including runoff, precipitation into lakes and rivers and water imports, with surface water outputs, such as evaporation, transpiration, water exports, and human consumption.[87] The consumptive uses of surface water are off-stream uses, often of high value, that require the withdrawal of water from the watercourse. A catalogue of those uses would include domestic, commercial, manufacturing, agriculture, power generation, minerals extraction, and others.[88] The water balance accounts for groundwater uses in a somewhat indirect way, netting out groundwater withdrawals as equal to groundwater recharge.[89]

Once the flow measure is determined, a second calculation measures what fraction of that flow must be left in the region's watercourses to support the broad spectrum of in-stream uses so vital to the general welfare. In-stream uses include "fish and wildlife population maintenance, outdoor recreation activities, navigation, hydroelectric generation, waste assimilation (sometimes termed water quality), conveyance to downstream points of diversion, and ecosystem maintenance that includes freshwater recruitment to the estuaries and riparian vegetation and flood-plain wetlands."[90]

The apparent region-wide superfluity of Eastern water supplies vanishes when water demands to support in-stream uses are incorporated into the water supply equation.[91] Using support of fish and

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The basin encompasses all of Arizona, the western half of Colorado, the eastern half of Utah, and portions of New Mexico, Nevada, and California. *See* J. SAX & R. ABRAMS, *supra* note 2, at 631.

85. *See supra* note 78.

86. 2 SECOND ASSESSMENT, *supra* note 78, pt. IV, at 5-11 and tables therein.

87. *Id.* at 39. In downstream regions, such as the Lower Mississippi Region, stream inflow from upstream regions is also treated as a water supply input. *Id.* at 42. Consumption refers to the difference between withdrawals and return flow.

88. *Id.* at 43.

89. *Id.* at 39. Groundwater overdraft (withdrawal of groundwater in excess of recharge) is counted as an input, but is treated as a temporary input that cannot be relied upon in the longer term. *Id.* at 40.

90. 1 SECOND ASSESSMENT, *supra* note 78, at 42.

91. This is not to say that there are no parts of the East having "surplus" surface water available to satisfy increases in consumption. It is only to caution that generalizations regarding Eastern surface water supplies must give way to watershed-by-watershed analysis.

wildlife populations as the primary indicator of the necessary in-stream flow levels, the Second Assessment calculated in-stream flow approximations (IFAs) as a percentage of total streamflow for all of the major river basins in the nation.[92] IFAs from 76% to 100% were necessary throughout the riparian East, except for portions of the central Ohio Valley, eastern North Carolina, and southern Florida; there the required IFAs ranged from 60% to 75%.[93] These figures demonstrate that the major proportion of surface water is unavailable for off-stream uses, the uses that are most closely associated with population centers and economic activity.

Groundwater supplements, and in some parts of the Eastern states supercedes, the surface water resource.[94] Water balance methods of determining water supply that emphasize regional outflows tend to obscure the important role groundwater plays in regional water supply equations. As with surface water, the groundwater resource in the Eastern states is substantial; as with the surface water resource, generalizations about its availability to supply increased water demands cannot substitute for site specific analysis.

Despite the high IFA requirements, and based solely on physical measures of current water availability, the overall Eastern water supply picture is hardly one that heralds crisis. The data make no attempt to survey local conditions, some of which reveal current water supply shortfalls.[95] Even when local shortages and the region's in-stream needs are taken into account, the most ominous portrait that emerges is a region that is reaching the limits of continuous growth in water use. If, as this Article contends, only a sustained series of water shortages will change the face of riparianism, the data illustrating present water supply support riparianism's survival.

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92. 1 SECOND ASSESSMENT, *supra* note 78, at 43.

93. *Id.*

94. One study notes that "[e]stimates of water in storage within 2,500 feet of the land surface within the conterminous United States range from 33 quadrillion gallons to 100 quadrillion gallons which varies in quality." V. PYE, R. PATRICK & J. QUARLES, GROUNDWATER CONTAMINATION IN THE UNITED STATES 2 (1983). The amount of water stored in the Atlantic Coastal Plain aquifer along the New Jersey coast contains "[a]t least thousands, and perhaps tens of thousands times more [water] than the amount of surface water in storage [in surface reservoirs]. . . . You're talking about cubic miles of fresh water." *Mid-Atlantic States Hearings*, *supra* note 79, at 26-27 (*Cohen testimony*). Of course, the presence of the water is but one condition that must be met before the water can serve as a source of supply. Location, depth (due to the cost of recovery), water quality, and the possibility of damage to overlying lands upon withdrawal must also be considered. *See infra* text accompanying notes 153-67.

95. *See infra* note 156 and accompanying text.

However, before future water supplies can be predicted, changing climatic conditions and increasing water contamination must also be factored into the supply equation.

B. *The Impact of Changing Climatic Conditions*

The heretofore ample surface water supply of the East derives from favorable topography, which has provided Eastern states with an extensive drainage system of rivers and lakes, and a hydrologic cycle that has provided relatively abundant precipitation. Both geologic change and climatic change have been so gradual that the water supply characteristics of the Eastern states would appear to be a constant over periods of study as short as the thirty to fifty years here attempted. To say that the annual average surface water supply is unchanging is not to say that annual water supply is a constant.[96] For example, in both Ann Arbor and East Lansing, Michigan, over the first half of the twentieth century, the wettest year was roughly forty percent wetter than an average year, and the driest was roughly forty percent drier than an average year.[97] Nevertheless, the East has managed variations from the norm with what, in the longer view, appears to be minimal economic and social dislocation.

To view the water supply of the Eastern United States as constant over the next few decades is very likely a serious miscalculation. Although the rate of climatic change in past centuries has been glacial, the impacts of modern technology on the environment have triggered accelerated climatic changes capable of significantly altering the water supply calculus. In particular, the impact of increased atmospheric concentrations of carbon dioxide (CO2), methane, nitrous oxides, and chlorofluorocarbons on ambient temperature levels, popularly referred to as the greenhouse effect,[98] and its potential to change the world's climate, cannot be ignored without peril. As one expert predicts:

> The resulting global temperatures will exceed any in human history and the rates of global warming could far surpass any climatic changes which have occurred in the past, cer-

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96. *See* C. Wisler & E. Brater, Hydrology 77-81 (2d ed. 1959).

97. *Id.* at 80, fig. 27.

98. For a thorough description of the physical processes causing the greenhouse effect, see Encyclopedia of Physical Science and Technology 303 (1987).

> tainly since the end of the last Ice Age. . . . The sea will rise at a rate which is five to ten times faster than over the last century. Neither human societies nor nature itself can keep pace with such changes. It is no exaggeration to say that climate change will remake the weather and the new weather will remake the face of the earth.[99]

Intensive investigation of how the greenhouse effect will influence water supply has begun only recently.[100] The most dramatic scientific statements on the subject to date indicate that the greenhouse effect is already operating. Reliable estimates attribute a 0.4 degree Celsius increase in global temperature in excess of the previous thirty year mean temperature to the greenhouse effect.[101] The warmer temperatures are causing increased summer dryness of soils[102] and may already be causing or exacerbating heatwave/

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99. *Global Climate Changes: Greenhouse Effect: Hearings Before the House Subcomm. on Human Rights and Int'l Orgs. of the Comm. on Foreign Affairs*, 100th Cong., 2d Sess. 57 (1988) [hereinafter *Global Climate Hearings*] (testimony of Dr. Michael Oppenheimer).

100. The Secretary of Interior has convened, under the auspices of the USGS, an Advisory Committee on Water Data for Public Use. This committee met in April 1988 to discuss the impacts of climatic change on water resources. *See* Freshwater Foundation, Facets of Freshwater, Spring 1988 Newsletter. The committee discussed a USGS draft report (Nov. 2, 1987) entitled Potential Hydrologic Impacts of Climate Change (on file at *The Wayne Law Review*). This report expressed the determination of the USGS "to become a focal point for hydrology in the climate-change arena." *Id.* at 2. The goal of the USGS program was "[t]o develop knowledge and information concerning the potential impacts on the water resources of the United States of America of changes in precipitation and evapotranspiration that may result from anthropogenic modification of the Earth's atmosphere." *Id.* at 3.

In an allied vein, under the National Climate Program Act, 15 U.S.C. § 2901 (1982), the National Climate Program Office of the National Oceanic and Atmospheric Administration presented its 1988-1992 Five Year Plan, which among other items called for improvements in data collection and modelling pertaining to the impact of emissions on climate and water resources. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, 1988-1992 FIVE YEAR PLAN 9-10 (Jan. 1988).

101. *Greenhouse Effect and Global Climate Change: Hearings Before the Senate Comm. on Energy and Natural Resources*, 100th Cong., 1st Sess. 51 (1987) [hereinafter *Greenhouse Hearings*] (prepared statement of Dr. James E. Hansen, NASA Goddard Institute for Space Studies). Despite the small numerical value of the observed change, the magnitude is three times greater than the standard deviation of annual mean temperatures for that period, which gives rise to "about 99% confidence that current temperatures represent a real warming trend rather than a chance fluctuation . . . ." *Id.*

102. *Id.* at 84 (statement of Dr. Syukuro Manabe, Geophysical Fluid Dynamics Laboratory of the National Oceanic and Atmospheric Administration).

drought conditions like those experienced in the American Midwest and Southeast during the summer of 1988.[103]

These recent revelations strongly suggest that the extraordinary weather patterns of the 1980s are among the first observable impacts of the greenhouse effect on water supply—recurrent summer droughts triggered by a change in mid-latitude weather patterns.[104] One prominent scientist described the most recent results generated by the Goddard Institute of Space Studies (GISS) of the National Aeronautic and Space Administration climate model in the following terms:

> We find a tendency in our simulations of the late 1980's and the 1990's for greater than average warming in the Southeast and Midwest United States. These areas of high temperature are usually accompanied by below normal precipitation. . . . It is not possible to blame a particular heatwave/drought on the greenhouse effect. However, there is evidence that the greenhouse effect increases the likelihood of such events.[105]

Even before these alarming reports on the present and short-term effects were made, other researchers were beginning to plumb the long-term impacts of the greenhouse effect. A study focusing on the Great Lakes basin is of particular interest because it attempts to forecast impacts of the greenhouse effect on two aspects of water supply: the hydrologic cycle and human demands.[106] In measuring the physical impacts of the greenhouse effect, the study, relying on the GISS climate model and another well-known global climate model created by the Princeton University Geophysical Fluid Dynamics Laboratory (GFDL),[107] forecasts that a pollution-induced doubling in atmospheric CO2 levels will cause a three to five degree

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103. *Id.* at 52. (statement of Dr. James E. Hansen). For a vivid description of the effects of the 1988 drought, see Sidey, *supra* note 18, at 12.

104. *Greenhouse Hearings*, *supra* note 101, at 85 (statement of Dr. Syukuro Manabe).

105. *Id.* at 58 (statement of Dr. James E. Hansen).

106. Cohen, *Impacts of CO2-Induced Climatic Change on Water Resources in the Great Lakes Basin*, in 8 CLIMATIC CHANGE 135 (1986) [hereinafter *Cohen Study*]. The temperature change data is generated from two different global climate models. Interpolation and additional data collection was done to utilize the models on a regional scale. *See id.* at 140.

107. *Id.* at 138.

Celsius rise in the Great Lakes region ambient temperature.[108] This heightened ambient temperature in turn affects the amount of surface water that is available to serve as a source of supply.[109]

Increased regional temperature has two major predicted impacts on water supply. First, higher temperatures will increase average annual rainfall by seven percent according to the GISS model and by just under one percent according to the GFDL model.[110] Increased rainfall plainly has positive impacts on the net basin supply (NBS),[111] putting more water into the system by increasing run-off from the land and by direct precipitation into the lakes. However, this positive increase in water supply is outweighed by the second major effect of increased ambient temperature, increased evapotranspiration.[112] Higher temperatures increase the transmission of groundwater and surface water into the atmosphere; the increase in evapotranspiration rates will outstrip any gains to the NBS caused by increased precipitation.

The net effect of these changes in the hydrologic cycle portends no more nor less than a significant decrease in surface water

108. *Id.* at 140.

109. *Id.* at 151.

110. *Id.* at 140. There is no contradiction in the GISS' long-term prediction of increased annual rainfall and Dr. Hansen's previously noted finding that in the short term the greenhouse effect makes summer heatwave/drought conditions more likely. *See supra* note 101. The lack of convergence of predicted short- and long-term phenomena around a single increased temperature scenario may be attributable in part to the immense difficulty in modelling future climates, but it may be more readily explained by seasonal variations in precipitation patterns, including milder, wetter winters and hotter, drier summers. *See Greenhouse Hearings*, *supra* note 101, at 88-89 (statement of Dr. Syukuro Manabe); *Cohen Study*, *supra* note 106, at 145 (noting two and threefold increases in summer deficits in southern portions of Great Lakes region).

111. The Cohen study notes: "Net basin supply (NBS) represents the quantity of water leaving the basin. . . . NBS can also be estimated as the difference between inputs (land based run-off, precipitation over the lakes) and 'losses' (lake evaporation, consumptive uses of water). . . . The effect of groundwater flow, believed to be negligible, is not considered." *Cohen Study*, *supra* note 106, at 143. The NBS measure is almost identical to the natural outflow measure used by the Second Assessment. *See supra* text accompanying notes 85-88.

112. The Cohen study employed the Canadian Climate Center's Thornthwaite model for calculating Great Lakes evapotranspiration. The predictions of this model have proven very accurate when compared to actual measured values. *Cohen Study*, *supra* note 106, at 143. For this reason, the extent of the predicted rainfall increase brought on by increased temperatures may be less certain than the predicted extent of increased evapotranspiration.

reservoir supplies.[113] Under the GISS, which predicts a smaller increase in temperature and rainfall, the NBS was predicted to decrease by eighteen percent; under the GFDL, which predicts greater temperature and rainfall increases, the predicted decline in the NBS was twenty-one percent.[114] These figures are little short of catastrophic.[115] Thus, the principal conclusion to be drawn from the Great Lakes study is that the greenhouse effect-driven increase in regional temperature will increase regional precipitation, but simultaneously will increase evapotranspiration by a far greater amount.

Human water demands are the second facet of the Great Lakes study. The study concludes that water demand will escalate as a function of increased ambient temperature.[116] Owing to the increased summer temperatures and concomitant dryness, water use

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113. For water supply purposes, it is appropriate to think of surface waters, whether contained or flowing, as "reservoirs" from which water is taken for human use. This is apt for lakes or rivers from which water is pumped for use by cities or farms. It is also acceptable for in-stream uses such as recreation, fishery, and waste assimilation. In all events, water lost to evaporation is no longer part of the supply upon which the uses can depend.

114. *Cohen Study*, *supra* note 106, at 149.

115. The predicted effects on NBS are tempered only by the fact that they do not account for possible changes in prevailing winds. Wind speed, like ambient temperature, is an important factor in evapotranspiration: higher winds increase the amount of water transferred into the air. If average world temperatures are higher, a lessening of wind is also possible. Factoring in wind prediction, which was a part of the GFDL but not the GISS, the Cohen study still predicted a 15.5% decrease in NBS. The table below summarizes a series of water supply scenarios projected for the Great Lakes region by the Cohen study.

TABLE 1

PRELIMINARY ESTIMATES OF NET BASIN SUPPLY (in CMS)

Scenario	Land run-off	precip.	Lake evapor.	NBS	Change from normal
NORMAL	5845	6224	4657	7412	
CO2 DOUBLED SCENARIOS:					
Winds as at present:					
GFDL	5200	6168	5321	6047	-18.4%
GISS	5368	6701	6199	5870	-20.8%
Winds as predicted by their model:					
GFDL	5200	6168	5105	6264	-15.5%
GISS	(no prediction of wind was made by the model)				

Id. at 150.

116. *Cohen Study*, *supra* note 106, at 136-37, 150.

would increase primarily in the agricultural sector for irrigation, and the municipal sector for lawn watering, both large volume, highly consumptive uses. Secondary effects would include increased water demands for all industrial systems employing water for cooling, especially electric power generation, which will be increased due to greater use of air conditioning.

Another region-wide generalization seems fair: water users dependent on surface water reservoirs will face an especially grave risk of supply shortfalls as increased evaporation decreases the size of the reservoirs. Cities like New York and Boston, which satisfy their large volume water demands from reservoirs having relatively large surface areas, will be particularly hard hit. Smaller cities and rural communities, which depend more heavily on groundwater, are likely to be less affected.

As if decreased supply and increased demand were not bad enough, the greenhouse effect will have other less spectacular impacts that will further aggravate the strain on supplies.[117] Warming global temperatures are expected to cause some melting of polar ice, which will raise ocean levels.[118] Freshwater "floats" on top of salt water because it is less dense.[119] A rise in ocean levels will therefore cause an upstream advance along tidal rivers of the "salt front," the point at which the out-flowing freshwater and the ocean's saline water meet. This change, without reference to any absolute decline in freshwater flows, creates new problems regarding location of supplies. Water intakes on tidal rivers will need to be relocated further upstream, thus increasing the competition for upstream supplies.

The higher temperatures and increased evaporation caused by the greenhouse effect will significantly reduce the traditionally

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117. These "less spectacular" effects are only less spectacular in water supply terms. A significant rise in ocean levels, for example, will displace wetlands. In addition to filtering impurities in surface water, wetlands form a vital link in the food chain for innumerable species. 2 SECOND ASSESSMENT, *supra* note 78, pt. III, at 134. New wetlands will be formed at a higher elevation, but ecological communities will be unable to migrate as fast as the changing ocean levels, resulting in the devastation of many estuarine populations.

118. *See, e.g.* Brown & Postel, *Thresholds of Change*, in WORLD WATCH INSTITUTE, STATE OF THE WORLD 14-15 (1987).

119. 2 SECOND ASSESSMENT, *supra* note 78, pt. II, at 13. This characteristic has been used by the world's best-known water engineers, the Dutch, as a key element in their state-of-the-art Phillipsdam Project, which includes a lock and dam system in which the difference in the density of fresh water and salt water segregates those waters within a single cell of the lock.

available surface water supplies in the Eastern United States, although the precise impact of increased average temperature will be difficult to quantify with precision. What is clear is that water lost literally "into thin air" reduces the remaining stock of surface water supplies.

The skeptic's first refrain is "nonsense, nonsense on stilts!" The predictions of the global climatic models do not correspond very well to actual historic data (the nonsense),[120] and the disagreement among global climate models is so great that interpolation from them to predicting climate changes for a smaller region like the Eastern United States is inherently unreliable (the nonsense on stilts).[121] The skeptic's refrain can be conceded without ceasing to heed the alarm. Although the confidence level in the specifics of the Great Lakes study may be low, the general scientific underpinnings of its conclusions are beyond dispute. The correlation of evapotranspiration rates as a function of temperature is well known and empirically demonstrated.[122] So too, the greenhouse effect, the triggering event for the anticipated rise in temperature, is indisputably an active force that is already causing measurable changes in the global climate.

The skeptic's second refrain is "Let's wait and see." One facet of this position views efforts to plan for an uncertain future as

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120. Interview with Jerome Nemyous of the Scripps Institute, La Jolla, California, aired on National Public Radio's "All Things Considered" program (Aug. 16, 1988).

121. *See generally* S. GROTCH, REGIONAL INTERCOMPARISONS OF GENERAL CIRCULATION MODEL PREDICTIONS AND HISTORICAL CLIMATE DATA, monograph prepared for United States Department of Energy, Office of Basic Energy Sciences, Carbon Dioxide Research Division (DOE/NBB-0084, Dist. Category UC-11) (Apr., 1988). This report compares the two climate models used by the Great Lakes study, as well as two additional global climate models (GCM), and concludes:

> Although the results of the GCMs often agree well with each other and with historical surface air temperature data over large scales (global/hemispheric/zonal), when the model results are examined on successively smaller and smaller scales, eventually focusing on sub-continental regions containing only relatively few (5-20) gridpoints, significant differences arise. This result . . . has particularly profound implications for those who plan to use these GCM results for regional impact analyses. It seems apparent, if these sets of GCM results are representative of the current "state-of-the-art," that this art is simply not yet ready to be used for quantitative prediction at anything approaching even a multistate region, let alone a single surrogate gridpoint representing a particular state, county, or city.

Id. at 253.

122. *See supra* note 112.

premature and wasteful if that future does not materialize. A second facet of that attitude is that human adaptability and ingenuity will conquer the problem when it arises.[123] The plain fact of the matter is that past emissions of greenhouse gases have already committed the world to a warming trend that will continue for decades, even if emissions of these gases are reduced immediately:

> Because the oceans are slow to heat, there is a lag between emissions and full manifestation of corresponding warming—a lag of perhaps 40 years. The world is now 1 degree F warmer than a century ago and may become another one or more degrees warmer EVEN IF EMISSIONS ARE ENDED TODAY. These changes are effectively irreversible because greenhouse gases are long lived. WE CAN'T GO BACK IF WE DON'T LIKE THE NEW CLIMATE. So action to slow the warming must be undertaken before full consequences are manifest.[124]

It is currently impossible to ascertain the precise rise in temperature in the Eastern United States and whether the increased evapotranspiration rates will outstrip possible rainfall increases. However, the frequently dry, hot summer weather of the 1980s, and the coincidence of the models in predicting a massive decline in NBS, is reason enough to take the prediction seriously and begin preparations for meeting the challenges of changed water supply conditions.

The threat of reduced water supplies traceable to CO2 emissions and other greenhouse gases is not likely to be averted by attempts to control those emissions. First, as noted above, many of the effects of the increased concentrations are delayed, so that the conditions causing them have already matured and are effectively irreversible. Second, the single most significant cause of the greenhouse effect, air pollution from the burning of fossil fuels, is not readily cured.[125] In the United States, two decades of increasingly

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123. *Cf.* Einhorn & Charo, *Carbon Dioxide and the Greenhouse Effect: Possibilities for Legislative Action*, 11 COLUM. J. ENVTL. L. 495, 505-06 (1986) (cataloguing possible attitudes to general problem of greenhouse effect).

124. *Greenhouse Hearings*, *supra* note 101, at 95 (statement of Dr. Michael Oppenheimer (emphasis in original)).

125. The emission of carbon dioxide (CO2) from the burning of fossil fuels is a major cause of the increase in CO2 levels, with roughly half of those emissions accumulating in the atmosphere. *See* THE WEATHER ALMANAC 311 (1987).

stringent air pollution control legislation targeting reductions in fossil fuel emissions from both stationary and vehicular sources has at best only halted a significant increase in total greenhouse gas emissions, not reduced it. Legislation regulating fossil fuels has alternatively promoted fuels that are high in CO2 emissions[126] and fuels that are not,[127] but neither these legislative initiatives nor the Clean Air Act have significantly altered the trend of increasing atmospheric CO2 levels. Pending congressional action promises more of the same modest improvement in this area,[128] but the unresolved safety and disposal issues surrounding nuclear power render more sweeping moves away from fossil fuels unlikely.[129]

The global nature of the problem presents a third major obstacle to avoiding the crisis through reduction in greenhouse gas emissions.[130] The sources of emissions are many and diverse, including motor vehicles and coal burning power plants, as well as less well-known sources such as slash and burn agriculture.[131] For example,

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126. *See, e.g.*, United States Synthetic Fuels Corporation Act of 1980, 42 U.S.C. §§ 8701-8795 (1982).

127. *See, e.g.*, Geothermal Energy Research, Development, and Demonstration Act of 1974, 30 U.S.C. §§ 1101-1164 (1982).

128. Amendments were proposed to the Clean Air Act in 1989. These changes would decrease the production of ozone by: (1) requiring auto manufacturers to tighten tailpipe hydrocarbon emission standards; (2) increasing fuel volatility limits to control volatile organic compound emissions and requiring the installation of vapor recovery controls on fuel pumps; and (3) mandating that auto manufacturers make available by 1995 vehicles that run on alternative fuels, such as methanol or natural gas, in nine cities that are the areas of greatest nonattainment for ozone. *See generally* 20 Env't Rep. 427 (BNA) (June 16, 1989).

129. Other techniques, such as using price incentives to reduce the combustion of fossil fuels, also appear unlikely to significantly change the situation. A study commissioned by the United States Environmental Protection Agency (USEPA) concluded that even a tax system that severely escalated world prices of the fuels associated with CO2 emissions would only delay the temperature increase by a few years. *See* Einhorn & Charo, *supra* note 123, at 512 (citing S. SEIDAL & D. KEYENES, CAN WE DELAY A GREENHOUSE EFFECT? 4-27 to 4-31 (1983)).

130. As if to underscore the difficulty of obtaining widespread international cooperation to control atmospheric emissions, a recent international conference calling for the creation of an international "Law of the Air" adjourned without any progress toward producing a framework to address the world's air quality concerns, far less any concrete avenues by which to reduce the emissions causing the greenhouse effect. *See* N.Y. Times, June 28, 1988 (Environment), at 24, col. 2.

131. *See generally Global Climate Hearings*, *supra* note 99, at 30-32 (testimony of Linda Fisher, Assistant Administrator for Policy Planning and Evaluation, USEPA). Deforestation is a major contributing cause of increased CO2 levels. Woodwell, *Global Deforestation: Contribution to Atmospheric Carbon Dioxide*, 222 SCIENCE 1081 (1983).

no significant reduction in emissions from coal burning power plants can be realized without cooperation among the United States, the Soviet Union, and the People's Republic of China. The Soviet Union and China are heavily dependent on their massive coal reserves as an energy source, and lag far behind the United States in implementing effective emission control technologies. For the many developing nations that contribute to the greenhouse effect through deforestation and by increasing their use of fossil fuels, the cost of changing practices would be prohibitive.[132]

C. *Water Quality as a Determinant of Supply*

Along with accelerating climatic changes that will affect surface water supplies, modern man's activities have also affected water quality. Water quality has a significant impact on water supply. The Ancient Mariner's Rime, "Water, water, everywhere and nary a drop to drink," reminds that poor water quality can render a source of supply unavailable for a particular human use.[133]

In the 1950s and 1960s, rampant pollution of surface waters imperiled many watercourses, rendering them unfit for drinking, bathing, boating, fishing, wildlife habitat, and other quality dependent uses. In 1972, faced with the prospect of dead and dying

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132. *See generally Global Climate Hearings, supra* note 99, at 13-18 (prepared statement of Dennis Brennan, Deputy Assistant Administrator, Bureau of Science and Technology, U.S. Agency for International Development (USAID)). Developing nations often view environmental protection measures that will increase their development costs with suspicion. *See id.* at 88-89 (prepared statement of Gordon MacDonald, Vice President, MITRE Corp.)

133. In a symbolic overreaction to the Ancient Mariner's lament, the national policy of zero discharge announced in the Water Pollution Prevention and Control Act of 1972, 33 U.S.C. §§ 1251-1376 (1976), commonly known as the Clean Water Act, would result in virtually all surface water being available for all water supply needs. The Clean Water Act states that "it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985." 33 U.S.C. § 1251(a)(1) (1982). The term "pollution" is broadly defined as "man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water." *Id.* § 1362(19). In the pragmatic world of water law, the rhetorical flourish of a call for zero discharge is countermanded by laws that plainly acknowledge that water need not be perfectly clean to be useful. The common law of nuisance has always tolerated a degree of water pollution while refusing to permit unreasonable interference with others' uses of the water. Even the Clean Water Act explicitly contemplates differing quality levels in its ambient receiving body quality program. The Act allows states to designate the intended uses of their watercourses and concomitant standards of quality necessary to support the designated uses. *Id.* § 1313.

watercourses, Congress amended the Federal Water Pollution Control Act.[134] The Act, commonly known as the Clean Water Act (CWA), attacked the immense water pollution problem on two fronts. First, it provided federal funds to enable municipalities across the country to build primary wastewater treatment plants. Second, in the 1970s the CWA established uniform discharge standards for all point source discharges. Two decades of serious efforts to reduce the stream of pollutants under this technology-based program have resulted in the achievement of locally improved water quality levels with regard to many common parameters.[135] While this is encouraging, levels of other water pollutants, particularly toxics, have not been improved significantly.[136]

Although the CWA was mostly successful in halting the unchecked discharge of pollutants by point sources, it has failed to address the significant problem of nonpoint source pollution (NSP). The USEPA estimated that, in 1984, more than half of the surface water pollutants came from nonpoint sources, such as irrigation return flows or runoff from streets.[137] Pesticides entering water supplies from agricultural applications are especially troublesome.[138] Organic pesticides, which are toxic to humans and other organisms,

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134. Federal Water Pollution Control Act of 1972, 33 U.S.C. §§ 1251-1376 (1976).

135. The so-called "conventional" measures of water quality include dissolved oxygen, biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, and nitrogen. One commentator argues that "the Clean Water Act has not led to perceptible improvement in many individual bodies of water . . . ." Pedersen, *Turning the Tide on Water Quality*, 15 ECOLOGY L.Q. 69, 70 (1988). However, Pedersen does acknowledge that the "lack of improvement . . . starts from a base containing a relatively large share of clean water." *Id.* at 69 n.4.

136. For the expansive definition given to the term toxic pollutants by the Clean Water Act, see 33 U.S.C. § 1362(13) (1982). Pedersen notes that the amount of pollution attributable to toxics, such as pesticides and heavy metals, is currently unknown. Pedersen, *supra* note 135, at 69 n.4.

137. OFFICE OF WATER PROGRAM OPERATIONS, WATER PLANNING DIVISION, USEPA, REPORT TO CONGRESS: NONPOINT SOURCE POLLUTION IN THE UNITED STATES 1-14 (1984). Another report notes that "NPS . . . is responsible for 73% of the oxygen demanding loadings, 84% of nutrients, 98% of bacteria counts, and 99% of suspended solids in the nation's waters." Rogers & Rosenthal, *The Imperatives of Nonpoint Source Pollution Policies*, 60 J. WATER POLL. CONTROL FED. 1912 (1988).

138. One study estimates that less than 0.1% of applied pesticides actually do their intended job. Young, *Minimizing the Risk Associated with Pesticide Use: An Overview*, in AMER. CHEM. SOC., PESTICIDES—MINIMIZING THE RISKS, ACS Symp. Serv. 336 (1987).

can persist in aquatic environments for long periods of time and bio-accumulate in aquatic animals and plants.[139] Additionally, pesticides can move through the soil and contaminate groundwater supplies. Pesticide runoff from agricultural applications looms large as a potential limit on local surface water supplies.[140] These substances persist in the environment and threaten the viability of surface waters that drain areas of large scale agriculture. This imperils not only the surface watercourse as an irrigation source in the polluting region, downstream cities and other water uses are also put at risk.

At present, there is no unified federal legislative scheme to control NPS pollution. The CWA focuses on "end of the pipe" discharges; irrigation return flows are exempted from the Act's definition of point source.[141] The 1987 amendments to the CWA delegate NPS pollution control to the states to enact control programs on a voluntary basis.[142]

In determining the effect of poor water quality on groundwater supplies, contamination appears to have reached crisis proportions.[143] Newspaper accounts detail many hazardous waste dumping sites that have contaminated groundwater. The severity of the crisis dissipates only somewhat when both the proportion of supplies affected and the effect of a longer, thirty- to fifty-year timeline are analyzed.

Groundwater contamination is usually a localized event, with contaminant plumes affecting relatively small volumes of stored

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139. Younos & Weigmann, *Pesticides: A Continuing Dilemma*, 60 J. WATER POLL. CONTROL FED. 1199, 1202 (1988).

140. Clean Water Act of 1977, 33 U.S.C. § 1342(*l*) (1982).

141. Water Quality Act of 1987, Pub. L. No. 100-4, § 316, 1987 U.S. CODE CONG. & ADMIN. NEWS (101 Stat.) 7, 52 (to be codified at 33 U.S.C. § 1329). The amendments provide grants to the states for the study of regional water quality problems, but the USEPA can neither undertake the studies if the state fails to act, nor enforce the plans submitted by the states. Pedersen, *supra* note 135, at 82 n.64. The amendments also exempt agricultural stormwater runoff from permit requirements. Water Quality Act, *supra*, § 503 (to be codified at 33 U.S.C. § 1302(14)).

142. Currently, over one million kilograms of pesticides are used daily in American agriculture. Younos & Weigmann, *supra* note 139, at 1204.

143. In estimating the amount of groundwater in the United States presently contaminated, Philip Cohen, USGS Chief Hydrologist, stated:

> The numbers that one hears nationwide are on the order of 1 to 2 percent. In New Jersey it might be somewhat higher. But again you're dealing with a vast volume of water and very narrow, little plumes of contaminated water. . . . As you get shallower and shallower, you can rest assured that a larger percentage of the water is contaminated.

Mid-Atlantic States Hearings, *supra* note 79, at 28.

water supplies.[144] Recalling that the groundwater resource is truly immense,[145] the limited nature of most contamination episodes means that as a quantitative matter the contamination will affect only a tiny fraction of the recoverable resource.[146]

Even so, two effects of contaminated groundwater significantly affect water supplies in the Eastern United States. First, contamination requires alternate sources to replace the unusable supplies.[147]

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144. It is possible to compare a typical groundwater contamination episode to adding drops of food coloring to the top of a damp transparent sponge and watching the coloring (contamination) disperse. The rate of dispersion will depend on a host of factors, the two most critical of which are the permeability of the aquifer and the characteristics of the contaminant itself. Aquifers that are composed of highly compacted fine particles tend to have large volumes of pore space and tend to contain the contamination, permitting it to migrate only slowly. Unfortunately, these aquifers do not readily produce large volumes of water when pumped. Aquifers composed of sandier materials that have larger pore spaces permit faster and more extensive dispersion of contamination. Even in more permeable aquifers, some contaminants, like mercury, tend to become bound up with the sediments in the aquifer, and are therefore less likely to travel. Other contaminants, most notably organic compounds associated with petroleum products, disperse very quickly when introduced into an aquifer.

There are five principal types of groundwater contamination, four attributable to human activity, one to natural forces. The five types are: (1) contamination by percolation of spilled or leached hazardous materials; (2) contamination due to salt water intrusion prompted by a reduction in hydrostatic pressure that results from over-pumping of the aquifer; (3) intentional deep well injection of wastes; (4) unavoidable contamination of aquifers associated with mining and energy production and (5) natural brine formations. 2 SECOND ASSESSMENT, *supra* note 78, pt. II, at 29. Of these, only the first and the fourth are discussed here.

145. The following colloquy, between Philip Cohen, USGS Chief Hydrologist, and Senator Bill Bradley indicates the magnitude of the groundwater resource:

Sen. Bradley: Again, can you give us any comparative number that would help us understand the quantity of ground versus surface water?

Mr. Cohen: At least thousands, and perhaps tens of thousands times more than the amount of surface water in storage at this area.

Mid-Atlantic States Hearings, supra note 79, at 26; *see also supra* note 94 and accompanying text.

146. A 1982 study estimated that at least two percent of the nation's groundwater resource is polluted. Lehr, *How Much Ground Water Have We Really Polluted*? GROUND WATER MONITORING REVIEW, Winter 1982, at 4-5. The study assumes a worst case scenario, and uses a large number of point sources, a fast rate of travel of plumes of pollution, and a long distance of plume travel. *See generally* V. PYE, R. PATRICK & J. QUARLES, *supra* note 94, at 81, 82.

147. The following example illustrates the high cost of replacing groundwater supplies. In 1983, 10 wells in central Oahu, Hawaii were closed because of pesticide contamination of groundwater, removing 13 mgd of water from human use. Replacement costs totaled nine million dollars. Lav & Mink, *Organic Contamination of Groundwater: A Learning Experience*, J. AM. WATER WORKS A., Aug. 1987, at 37, 39.

These short-term dislocations can pressure already overburdened water supplies. Second, the bulk of groundwater pollution occurs near the earth's surface, affecting shallow aquifers that are often the lowest cost sources of groundwater. Contamination of shallow aquifers requires groundwater to be extracted from greater and greater depths, increasing the energy cost of recovery. This latter effect, the substitution of higher cost supplies for contaminated lower cost supplies,[148] alters the supply function. The change in the price of water can result in serious social and economic consequences as some users are "priced out" of the market. The exact effect, however, remains difficult to assess.

Taking a longer view, using a thirty- to fifty-year timeline supports discounting groundwater contamination as a serious constraint on water supply to some degree. The recent legislative programs of both prevention and cure offer promise that, one or two decades into the next century, contamination threats to groundwater quality, like the pollution threat to surface water encountered three decades ago, will recede. In the area of prevention, federal statutes have greatly improved the regulation of handling, storage, and disposal of most hazardous materials.[149] Industry compliance with these statutes substantially reduces the circumstances under which those materials will escape into the environment. Legislation that requires the siting of facilities having the potential to release dangerous pollutants away from important aquifers will also help to limit future groundwater contamination.[150] In the area of cure, many present sites of contamination will be identified for cleanups paid for by the responsible parties or the government.[151] Similarly,

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148. If cleanup is performed a similar substitution of high cost (cleaned water) for low cost (the original uncontaminated supply water) takes place.

149. *See generally* Resource Conservation and Recovery Act (RCRA), 42 U.S.C. §§ 6901-6991 (1982 & Supp. III 1985).

150. *See id.* § 6924(4) and implementing regulations at 40 C.F.R. §§ 264.1-.600 (1988). The importance of proper siting of sources of pollution is illustrated by the contamination of the Biscayne Aquifer in southeast Florida. The Biscayne Aquifer is the only source of portable water for approximately three million people. The surface of the aquifer lies two to five feet below the ground surface. Nine EPA National Priority List hazardous waste sites are located over the aquifer, including municipal landfills, drum recycling facilities, and the Miami airport. Investigation of wells in an 80 square mile area revealed widespread levels of moderate toxic contaminants, mostly volatile organic compounds. Cleaning the contaminated groundwater was estimated to require a capital investment of 14 million dollars. *See generally* Singh & Orban, *The Biscayne Aquifer Contamination: Cleanup and Prevention*, 23 WATER RES. BULL. 879 (1987).

151. The cleanups will be instituted under §§ 9606-9607 of the Comprehensive

more rigorous standards for drinking water treatment may spur innovative methods for treatment, thereby increasing the proportion of water that can be treated on a cost-effective basis to serve users who demand high quality.[152]

The conclusion for groundwater quality concerns is similar to that tentatively reached in regard to surface water quality concerns. The supply function will be affected by contamination of the resource, but optimistically, the impact will be of limited importance. Especially in the groundwater area, the small scale of contamination relative to the quantity of groundwater reserves, the manifest improvements in the management of hazardous materials, and the amount of cleanup that will be undertaken in the next three decades all support that conclusion. Therefore, for present purposes only, both the short-term dislocations associated with groundwater contamination and the long-term possibility that supplies will be affected will be assumed to have no major effect on water supply in the Eastern United States. The assumption may be unwarranted, however, and pollution could have a large impact on water supplies. That would support the larger conclusion of this Article, to wit, that total water supplies in the Eastern United States will decline significantly in the next thirty to fifty years.

D. *The Supply Potential of the Groundwater Resource*

As noted previously, there is a vast quantity of freshwater stored in aquifers in the Eastern United States.[153] In some regions, increased utilization of groundwater could serve as a supply strategy to mitigate the effects of dwindling surface water supplies caused by changing climatic conditions. Increased use of groundwater can succeed in areas having uncontaminated aquifers (1) that can support high capacity wells, (2) that enjoy a sufficiently high water table to allow extraction of groundwater at a reasonable cost, and (3) from which large volume withdrawals are possible without damaging overlying surface areas, the aquifer itself, or other hydrologically interconnected uses of the water. This propitious com-

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Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. § 9601-9675 (Supp. V 1987). *See also* N.J. STAT. ANN. § 58:10-23.11g(c) (West 1982).

152. *See generally* Safety of Public Water Systems Act, 42 U.S.C. §§ 300f to 300j-11 (1982). The 1986 amendments to the Act require the USEPA to regulate 83 drinking water contaminants by June 1989. *Id.* §§ 300f to 300j-11 (Supp. V 1987). In the past, only 23 chemical contaminants were regulated.

153. *See supra* note 94.

bination of attributes is not widely available. More significantly, in those parts of the region already showing the greatest evidence of present water supply shortages, these three conditions simply do not exist.

Looking first at the distribution of the groundwater resource, potential productive aquifers capable of supplying water at rates in excess of fifty gallons per minute (gpm) are located in a large U-shaped area, beginning south of New York City, running along the Atlantic Coast, encompassing all of the region from mid-Georgia to the Gulf of Mexico and extending northward along the Mississippi River Valley into the central and western portions of the Great Lakes region.[154] Similar aquifers can be found along the ridge line of the Appalachians.[155] Thus, in some of the more heavily populated areas of the East, such as the Ohio River Valley and New England, aquifers capable of providing large quantities of water are absent.

Second, it is difficult to estimate how much of the East's groundwater is found at a depth at which pumping costs are prohibitive, making recovery economically unfeasible. Assuming, *arguendo*, that present water table levels throughout the East are sufficiently close to the surface to permit recovery does not prevent a finding that groundwater recovery will become uneconomic, because significant groundwater overdraft is already, or soon will be, occurring.[156] Overdraft occurs whenever more water is extracted from an aquifer (withdrawal) than is deposited in the aquifer (recharge).[157] When withdrawal exceeds recharge, the water table

154. *See* 2 SECOND ASSESSMENT, *supra* note 78, pt. IV, at 17, table IV-7.

155. *Id.*

156. Three areas in the Eastern United States were already experiencing substantial overdrafting of groundwater in 1975. These were the coastal regions in Virginia and the Carolinas, east-central Indiana, and a strip of land that runs along the entire western shore of Lake Michigan and about 100 miles south beyond that. 2 SECOND ASSESSMENT, *supra* note 78, pt. IV, at 17, table IV-7. The recent rapid population growth and recreational development of the Virginia and Carolina coasts have made that overdraft condition a particularly ominous signal of accelerating water supply shortfalls. More recently, densely populated regions in New Jersey have begun to experience significant water table declines, indicative of substantial overdrafting in that region. *Mid-Atlantic States Hearings*, *supra* note 79, at 6-7. The water table, formerly near sea level throughout the region, had fallen to 250 feet below sea level in Lakewood, New Jersey, 100 feet below sea level in Camden, and 70 feet below sea level in Atlantic City.

157. For a layman's description of the geohydrology of groundwater aquifers generally, and of overdraft in particular, see J. SAX & R. ABRAMS, *supra* note 2, at 796-802, 822-24.

falls and the water must be lifted farther in order to bring it to the surface. Continuing overdraft causes ever-increasing pumplifts, a consequence that eventually puts the remaining water beyond economic reach.[158]

Problems of inadequate groundwater supply (either absence of suitable aquifers or aquifers from which recovery is, or will become, too expensive) are not the only problems that prevent increased reliance on groundwater supplies. Under certain conditions, extraction of groundwater causes physical damage either to overlying lands, to the aquifer itself, or to hydrologically interconnected streams.[159]

Land subsidence is the most dramatic example of damage caused by groundwater extraction. In extreme cases, the movement of groundwater toward the bottom hole of a high capacity well can erode the subsurface materials, causing the collapse of the overlying land.[160] Florida's highly publicized sinkholes are a manifestation of this type of process. More commonly, and less spectacularly, groundwater extraction causes land subsidence through the dewatering of the aquifer.[161] Dewatering endangers land development, and more significantly, the compaction of the particles in the aquifer reduces the ability of the aquifer to recharge.

A greater physical problem encountered in groundwater utilization is the introduction of contamination, most often saline water, into the aquifer.[162] This problem is most acute in coastal regions where fresh water and saline water are commonly adjacent to one another in an aquifer. Fresh and saline water tend not to mix under those conditions because salt water is denser than fresh water. Small scale pumping of these aquifers, particularly if they are recharged by freshwater (as from percolation of rainfall or inflow from surface fresh water streams), can frequently take place without

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158. This discussion presents aquifers as being bottomless repositories of groundwater, with recovery of the stored water limited only by cost. This treatment, of course, is a false picture because there are some aquifers that can be pumped dry. In those aquifers, water supply is subject to physical, rather than economic, limits. In cases of overdraft, and of physically limited groundwater reserves, the recoverable supply can be depleted by choice. Mining the aquifer treats the water as a nonrenewable resource. *See* J. SAX & R. ABRAMS, *supra* note 2, at 831-32.

159. 2 SECOND ASSESSMENT, *supra* note 78, pt. II, at 11.

160. *See generally* J. SAX & R. ABRAMS, *supra* note 2, at 862-63.

161. *Id.*

162. *Id.* at 160. *See also* 2 SECOND ASSESSMENT, *supra* note 78, pt. II, at 13.

causing the saline water to migrate into the fresh water areas of the aquifer. Large scale pumping reduces the barrier between freshwater and salt water to such an extent that saline intrusion occurs. Aquifers damaged by saltwater intrusion already dot the Atlantic Coast from Maine to Florida and include many of those same Virginia and Carolina aquifers that are being taxed by over-drafting.[163]

A final type of physical problem created by large volume groundwater withdrawals is the impact those withdrawals may have on other users of the same water source. Large volume groundwater withdrawals can have two adverse effects on other users. Well interference, a familiar and often litigated problem, can result from large withdrawals from an aquifer that supports several users.[164] A second, and more legally intractable problem, occurs when the withdrawal of groundwater causes the level or flow of a surface watercourse to decline.[165] The level of surface water would most commonly be at risk from increased pumping when the watercourse is "effluent" in nature, i.e., when the groundwater discharge contributes to the baseflow of the stream.[166] In water supply terms, resort to groundwater in these situations does not augment water supply. Increased groundwater withdrawals by one pumper are offset in whole or in part by decreases in surface water supply or groundwater available to competing water users. In water supply

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163. 2 SECOND ASSESSMENT, *supra* note 78, pt. II, at 12, fig. II-2. The Rarritan-Megothy aquifer, a major source of drinking water in urban New Jersey, is threatened by saline intrusion. In part, the threat is a textbook example of saline intrusion. However, the threat is also related to the salt front advance that will be triggered by the melting of the polar ice caps caused by the forthcoming increases in atmospheric temperatures. *See supra* notes 118-19 and accompanying text. The Delaware River "loses" its water to the hydrologically interconnected aquifer, thereby recharging it. *See generally* Davis, *Wells and Streams: Relationship at Law*, 37 Mo. L. REV. 189, 196-97 (1972) (explanation of interconnection between surface and groundwater movements). If, by the year 2015, for example, the level of the Atlantic Ocean rises by four feet, the point at which the water along the bottom of the Delaware is salt water rather than fresh water will be several miles further upstream. From the point of the salt front to the sea, the water at the bottom of the Delaware river recharging the Rarritan Megothy aquifer will be saline rather than fresh. This salt water advance compounds the dangers to the aquifer of continued high volume groundwater withdrawals.

164. *See* J. SAX & R. ABRAMS, *supra* note 2, at 796-822.

165. *See generally* Davis, *supra* note 163.

166. *Id.* at 196. Influent streams lose water to a hydrologically connected aquifer. These streams are also at risk if increased withdrawals from the aquifer accelerate the rate at which the streams lose water to the aquifer. *See, e.g.*, Wiggins v. Brazil Coal & Clay Corp., 452 N.E.2d 958 (Ind. 1983).

planning terms, the gains of one user are netted out with the losses of the other. The legal thicket takes on added importance in crafting a legal regime for the management of hydrologically related waters.[167]

This discussion of groundwater began as an attempt to ascertain whether the large groundwater supplies available in the Eastern states could fill supply needs not met from surface water sources. An answer is now in order: "In places, yes; in places, no." The areas where the groundwater resource will not provide significant relief in the event of surface water supply shortfalls are too numerous and too obviously areas of major water supply difficulty to optimistically posit groundwater as a savior. The densely populated Eastern seaboard corridor from Boston to Washington, D.C. lacks the groundwater resource at its northern end and imperils it elsewhere by large volume pumping. In the areas of most rapid growth and development that stretch down the remainder of the Atlantic coast, saltwater intrusion, serious overdraft and subsidence are already occurring. Even without touching on the several other areas where groundwater will be unavailing, the best that can be said is that increased reliance on groundwater will alleviate some subregional water supply shortages, but not enough to free riparianism's allocative weakness from repeated embarrassment if surface waters are generally in short supply.[168] Continued adherence to the doctrine will result in inefficient use of the water resource and create uncertainty regarding water rights that will inhibit entrepreneurial activities.

E. Reallocation of Supplies by Large-Scale Water Transfers

Another possible response to climate-induced surface water shortages is the redistribution of supplies. An aura of truth attaches to the bromide that there are no true water supply shortages, only maldistributions. Large-scale water importation is common in the Western states and is the water supply pedestal upon which vital cities, such as Los Angeles, stand. Yet while Los Angeles still

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167. The legal requirements for an integrated management scheme for hydrologically connected surface and groundwaters are discussed in the third article in the trilogy. *See supra* note 6.

168. This leaves to one side the ecological issues posed by groundwater withdrawals. One significant example of a major ecological impact of increased groundwater withdrawals can be found in the Florida Everglades. *See* B. WALKER, EFFECTS OF LAND USE ON GROUND-WATER QUALITY IN THE EAST EVERGLADES, DADE COUNTY, FLORIDA (1983).

clamors for water despite a long tradition of massive long-distance water imports, including water transfers from the northern part of the state, large quantities of Northern California water not needed for ecosystem maintenance flow unused into the Pacific Ocean. In this there is a lesson for the East. Three reasons prevent the transfer of additional northern supplies to relieve southern demands: engineering limitations, cost, and lack of political consensus. There is little in the conditions surrounding major water transfers in the Eastern United States that renders them exempt from these same three impediments.

At a rather literal level, few projects lie beyond the limits of existing water transfer engineering.[169] Some massive water transfers, such as a project designed to lift in a single closed conduit 10,000 cfs of water over an obstacle (such as a mountain), are impossible using presently available pumps and materials.[170] The same large project might become physically possible if several smaller closed conduits are used, but the use of such multiple facilities increases the project's cost to such an extent that the needed economies of scale are lost and the project becomes economically unfeasible.

Cost is the second major impediment to modern water projects. In the West, the rate of major water project initiation has slowed to a near halt because major projects are simply too expensive relative to their benefits to justify the fiscal commitments necessary to fund them.[171] Large-scale projects are fantastically expensive due to the costs of land acquisition, physical impoundment, and conveyance structures.[172] Additionally, these projects frequently impose costs for the construction and operation of power generating facilities if the water must be transported out of one watershed into another.

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169. For example, there is at present no proven method for building a coastal undersea freshwater pipeline to capture water flowing out of northern California rivers into the Pacific Ocean and transport it south to Los Angeles. However, the present lack of such engineering capability can be overcome if sufficient resources are devoted to the project. This perhaps fanciful idea has long been proposed. *See* J. SAX, WATER LAW, PLANNING AND POLICY 19-20 (1968).

170. *See* Bulkley, Wright & Wright, *Preliminary Study of the Diversion of 283 m3s-l (10,000 cfs) from Lake Superior to the Missouri River Basin*, 68 J. HYDROLOGY 461, 464-65 (1984).

171. Without the massive federal subsidies that fueled Bureau of Reclamation projects in the first half of the century, many or all of those projects would not have been built.

172. One recent proposal to deliver 10,000 cfs of Great Lakes water to replenish overtaxed groundwater supplies in the Ogalalla aquifer carried a price tag of $26 billion. Bulkley, Wright & Wright, *supra* note 170, at 469.

To the extent that water is extraordinarily valuable for municipal and industrial uses, and these uses are dominant in riparian regions, there is a potential distinction between the value of Eastern water transfers and those Western projects that primarily support irrigated agriculture. To continue these high-value uses it should be possible to generate sufficiently large sums of money to fund Eastern water transfer projects. The recent water news out of the Denver region, for example, is replete with stories of water transfer projects reflecting water values of as much as $1,000 per acre-foot of water.[173] Assuming similar water values for Eastern municipal use, a project bringing a city 100 cfs of water, or 64 million gallons per day, could be cost effective if the price could be held to around $70 million.[174] That amount of water is non-trivial by municipal use standards,[175] amounting to about twelve percent of Washington, D.C.'s projected increase in water demand in the next forty years.[176]

Political opposition is the final hurdle for those water redistribution projects serving municipal and industrial users that are not prohibitively expensive.[177] Despite what, under the "one person, one vote" standard of state legislative apportionment, appears to be a political imbalance favoring heavily populated regions, and the generally greater political power associated with more economically developed areas,[178] political opposition to interbasin water transfers has frequently been successful.[179] Inhabitants of areas of

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173. This value is the present value of a continuing right to receive the water on an annual basis.

174. On a proportional basis, the Lake Superior-Ogalalla transfer would cost $260 million for each 100 cfs of water transferred. *See supra* note 172.

175. The amount is small by Western agricultural standards. It would provide enough water annually to irrigate about 40 square miles applying three acre-feet of water per acre. This is an average to low water duty in Arizona or Colorado.

176. *See infra* note 211 and accompanying text.

177. Fiscal objections can also be masked as political hurdles. If a project can find funding only through public mechanisms (i.e., the project beneficiaries are unwilling to pay the entire costs), and for fiscal reasons political decision-makers are unwilling to supply the remaining funds, the true basis for project failure is fiscal rather than political.

178. *See* Abrams, *Interbasin Transfer in a Riparian Jurisdiction*, 24 WM. & MARY L. REV. 591, 597 (1983).

179. *See generally* Robie & Kletzing, *Area of Origin Statutes—The California Experience*, 15 IDAHO L. REV. 419 (1979). Another scholar puts the matter of area of origin opposition more emphatically. Writing in the interstate interbasin context, Professor Johnson states that "a major consideration in the planning for any major interbasin transfer will be the treatment accorded to the area of origin. The political structure of the nation virtually requires the affirmative

origin view the water as their own by virtue of a natural right conferred by its physical presence. Whether justifiable or not, this view is ardently held and receives political support from residents of present nontarget areas who see their waters as future targets of opportunity. Additional impediments to water transfers stem from their frequently high environmental costs. These environmental considerations find protection in the legislative process, at times in wild and scenic rivers statutes that directly prevent transfers, or by an unwillingness of legislators to support specific transfer proposals. Occasionally, the political consent of the area of origin can be "purchased" by providing that area with benefits, such as current construction of development projects.[180]

Interbasin transfers cannot, because of the limits of engineering, cost, and political will, eradicate the maldistribution of water sufficiently to avoid the onset of recurrent and widespread regional water supply shortages. However, as the magnitude of the East's water crisis grows, the political opposition to water transfers will decline, and the number of interbasin water transfers will increase to insure sufficient water supplies to meet the demands of high-value municipal and industrial uses.[181] To the extent that common-law riparianism stands as a significant impediment to transfers,[182] that is, to an efficient use of the resource, it will not survive the crisis.[183]

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assent of such an area before a project can go forward." LAW OF INTERBASIN TRANSFERS, National Water Commission Report NWC-L-71-008, Legal Study No. 7 (1971). Even in water abundant areas, some states limit interbasin water transfers. Massachusetts requires approval by state regulatory agencies before water can be transferred from one basin to another.

180. *See* L. MACDONNELL, C. HOWE, J. CORBRIDGE & W. AHERNS, GUIDELINES FOR DEVELOPING AREA-OF-ORIGIN COMPENSATION, Occasional Papers Series, Nat. Resources L. Center, University of Colorado School of Law (1985); Weatherford, *Legal Aspects of Interregional Water Diversion*, 15 UCLA L. REV. 1299 (1968).

181. In cases of regional shortages, interstate transfers may be difficult to initiate. For example, the city of Virginia Beach, Virginia attempted to secure water from Lake Gaston. The lake is 85 miles away from the city on the border of Virginia and North Carolina, and North Carolina has sought judicial intervention to force Virginia to find another source. Fisher, *Water Supplies Evaporating?* AM. CITY & COUNTRY, June 1987, at 26, 28; *see also* North Carolina v. Hudson, 665 F. Supp. 428 (E.D.N.C. 1987).

182. *See generally* Abrams, *supra* note 178.

183. The administrative system described in the third article of the trilogy would have authority to grant permits for the interbasin diversion transfer of water. *See supra* note 6.

IV. Water Demand in the Eastern United States

At different times in American history, the Eastern United States has placed diverse demands on its abundant water resource. These demands have grown throughout the region's history, and continue to increase. Initial settlement of the region required use of the in-stream flows to channel people and goods inland. The use of watercourses as vital transportation avenues has continued throughout the region's history. In the nineteenth century the watercourses were used for log floating. Now, late in the twentieth century, the inland waterways support barges, lake steamers, and ocean-going vessels. Water has also been a historic provider of power, first driving the mills of the industrial revolution, then the turbines of the hydropower dams, and now cooling conventional fossil fuel and nuclear power plants. Water demands have increased for other needs as well. Cities require large volumes of water for domestic and industrial users. The network of rivers and lakes dilutes, assimilates, and carries away sewage and other effluents. Manufacturing industries requiring large volumes of water for processing have long found Eastern water supplies a major consideration in plant location. Finally, the waters themselves are in demand to provide further benefits, including commercial and sport fisheries, recreational boating, and scenic beauty.

A. Types and Measures of Water Demand

1. In-stream and Off-stream Uses

The myriad water dependent activities create an overall level of demand that has two distinct facets: demands for in situ uses and demands for off-stream uses. In-stream uses include recreation activities, hydropower generation, navigation requirements, and maintenance of both fish and wildlife habitats and natural areas.[184] Off-stream uses include domestic, commercial and manufacturing needs, and uses for production of food, fiber, energy, and minerals.[185]

It is difficult to quantify precisely in-stream water use demand because in-stream uses are inherently nonconsumptive, and in most

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184. 2 Second Assessment, *supra* note 78, pt. III, at 1.

185. *Id.* The Second Assessment also has a third general category relating to flow management for flood control and erosion and sedimentation management. These latter categories, however, reflect land management initiatives rather than classic demands for the use of water. *Id.* at 151-73.

instances do not measure the water as a part of the use. Nevertheless, in-stream demands plainly compete with off-stream consumptive water uses, and at times with nonconsumptive water withdrawals. For example, any consumption of a hydro-electric generating plant's source water deprives that plant of "fuel" to drive its turbines. A barge cannot carry a full load in a channel made shallower by municipal water supply withdrawals that return the bulk of the water to the channel downstream as treated effluent. Fish habitat requirements and recreational water use prevent an irrigator from draining the watercourse, but it is very difficult to determine precisely how much water must be left in place to fully protect the ecosystem that supports the commercial or sport fishery industry.

Serious efforts to quantify in-stream flow requirements on a broad scale are relatively new. The First National Water Assessment completed in 1968 did not even attempt to quantify in-stream flow requirements due to a lack of data.[186] The Second Assessment heroically attempted to fill that void by creating a methodology for measuring the water demands of each of the four constituent categories of in-stream use.[187] Data was compiled in relation to these newly erected methodologies.

The results of the Second Assessment's effort are a promising start, but do not provide sufficient data on which to rely in measuring either current or future in-stream water demands. The requirements of both natural areas preservation and navigation were viewed in most instances as being insignificant to the overall level of required in-stream flows.[188] The Second Assessment did not attempt to quantify how much water must be left in place to support recreational water uses. Instead, the methodology first tried to pinpoint the areas in which there was a deficit of suitable water surface acreage necessary to meet the demands for recreational water use.[189] Second, the methodology stressed an identification process that would alert water planners to areas where developments

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186. *Id.* at 130.

187. *Id.*

188. The natural and historic area preservation requirements were, in all but the most unusual cases, adequately protected by the broad fish and wildlife requirements. The commercial navigational interests were likewise "[i]n most water resource regions . . . less than that needed for other in-stream purposes such as fish and wildlife habitats." *Id.* at 117. Additionally, there are surprisingly few major channels for commercial navigation in the United States, although these are almost all located in the East. *Id.* at 118.

189. *Id.* at 104-05.

related to agricultural and energy production would be likely to conflict with recreational uses.[190]

Fish and wildlife habitat, the fourth category of in-stream use, was the focus of the most significant quantitative effort. Here, the methodology fixed gross stream system estimates that base the requirements for the entire stream system on the requirements at its outflow. These "in-stream flow approximations" (IFAs) measure the percentage of the flow required to "support aquatic life and outdoor recreation."[191] Additionally, the IFAs are coordinated with a host of other factors that attempt to account for the specific characteristics of the stream system under study and the historic patterns of use that have prevailed in that system. The relatively high IFAs throughout the Eastern United States mean that water demands for in-stream use are equal to the greater part of regional water supplies.[192]

Quantitative measures of the demand for off-stream water use in the Eastern states can be determined with relative certainty. This data can be developed by analyzing the actual use of water. In 1975, the region's fresh water withdrawals totalled 160,000 million gallons per day (mgd), and consumption totalled 17,000 mgd.[193] The withdrawals are about forty-six percent and the consumption is near five percent of regional supply as measured by the outflow method.[194]

In the East, the needs of large, concentrated urban and suburban populations provide the driving force in the off-stream water demand equation. The data reveal that domestic, commercial, manufacturing, and energy uses for steam generation dwarf all other uses.[195] This is in marked contrast to the nation as a whole,

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190. *Id.* at 115-16.

191. *Id.* at 115. For a complete description of the IFA process, see *id.* at 130.

192. *See supra* text accompanying notes 91-93.

193. *See* 2 SECOND ASSESSMENT, *supra* note 78, pt. III, at 5, table III-3. Water withdrawal measures the amount of water taken out of the watercourse. Water consumption is the difference between the amount withdrawn and the amount returned. Many uses require large volume withdrawals, but consume little of the water. Two prime examples are power plant cooling and water distributed to meet domestic needs. Over 90% of this water will be returned after use, although it will be somewhat hotter and less pure than at the time of intake.

194. *See supra* notes 83-89 and accompanying text for an explanation of measuring supply by the outflow method.

195. These four categories taken together are almost entirely a measure of urban usage. The Second Assessment uses the domestic and commercial category

where irrigation accounts for almost fifty percent of all fresh water withdrawals, and over eighty percent of all water consumption.[196] These quantitative measures comport with expectations that a generally humid region would demand little water for agricultural activities that can be sustained by rainfall.[197]

The number of perceived water shortages in the Eastern states has been limited by the combination of water supply comfortably in excess of off-stream water demands, and limited awareness of the extent of in-stream water demands. Until recent decades these shortages were virtually nonexistent. However, beginning in the 1950s, it became apparent that the toll of pollution (a form of demand) had outstripped the assimilative capacity (a form of supply) of many receiving bodies. In the 1960s, drought conditions imperiled the water supply of major cities such as New York and Philadelphia. In the 1970s, numerous coastal areas heavily dependent on groundwater[198] found that their over-pumping of groundwater had drawn down aquifers to such an extent that water tables were lowered or saltwater intrusion occurred.[199] That same pumping had also led to compaction of the aquifers, retarding recharge and in some localities causing serious land subsidence.[200] Drought conditions returned in the 1980s. In the early years of the decade the drought punished agricultural areas in the Southeast. Later in the decade, the drought ravaged the central portions of the nation,

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to reflect centrally supplied water, the staple of municipal water supply systems. 2 SECOND ASSESSMENT, *supra* note 78, pt. III, at 23. Commercial water use, as distinguished from manufacturing, focuses on service industries, like offices, restaurants, and hotels, as well as municipal use for fire protection, parks, and public buildings. *Id.* at 19. The Second Assessment noted that the manufacturing water demands arose primarily in urban areas, and were at times supplied by central systems. *Id.* To avoid double counting, to the extent that the data permitted, the water supplied by central systems to manufacturing concerns was reported as part of the manufacturing totals. *Id.* Electric generating plants, although clustered around major metropolitan areas, are somewhat more physically dispersed. Nevertheless, the largest driving forces in electric energy consumption are again urban living and manufacturing.

196. *Id.* at 57.

197. *See, e.g.*, D. GIBBONS, THE ECONOMIC VALUE OF WATER 7 (1986) (consumptive municipal use of water is more than half of consumptive water use in densely populated states like New York and New Jersey and less than 1% of consumptive water use in sparsely populated states like Nebraska).

198. In coastal areas many surface streams are influenced by tidal action and are a mix of fresh and salt water that is unsuitable for purposes other than in situ uses.

199. 2 SECOND ASSESSMENT, pt. II, at 16-17.

200. *Id.*

parching crops and lowering in-stream flows to such an extent that barge traffic on the Mississippi and Ohio Rivers was near a standstill.[201]

Except for the fundamental improvement in water pollution control that substantially reduced the amount of water required to assimilate and dilute wastes (i.e., reduced demand), all of the other water crises in the Eastern states have produced no more than sporadic, limited efforts at water demand reduction.[202] These minimal restrictions belie serious effort at reducing demand for water in the East. The response to all of the past Eastern "water crises" recounted above, except for that of surface water pollution, was an increased effort to enhance supply. For example, New York and other cities moved to increase reservoir capacity, and Atlantic coastal areas are studying interbasin water transfers and aquifer storage to augment supply.[203] In 1988, the "drought relief" water caravans from the Midwest bringing water for parched livestock in the Southeast received far greater notice than did the modest conservation efforts. Likewise, Mississippi Valley representatives sought tripled diversions of Great Lakes water through the Illinois waterway to lift their stalled barges. Stated differently, no matter whether the "crisis" was precipitated by an increase in demand (population growth) or a short-term decease in supply (drought), the remedy of choice was to increase supply, not to curtail demand.

2. Water Demand Forecasting

These recent episodes of pollution, drought, and over-pumping graphically illustrate that the long-term growth of water use in the East has brought the aggregate demand for water in the region within close proximity of, and at times beyond, its copious water supply. The growth in aggregate demand to the point where it regularly challenges supply also raises the question of whether the

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201. By mid-July, 1988, the drought had reduced flows in the Mississippi River to one-quarter of normal, around 64,000 cfs at St. Louis and 119,000 cfs at New Orleans. *See, e.g.*, *Engineers Reject Lake Diversion*, Ann Arbor News, July 15, 1988, at A1, col. 5; Sidey, *supra* note 18.

202. It is hard to forget the publicity given to the water conservation gimmick in which New York City restaurants served water to patrons only on request. In response to the 1980s droughts, some temporary restrictions were placed on manufacturing firms using water intensive practices, and some limited urban conservation measures were announced.

203. The Washington, D.C. Suburban Sanitary Commission has recently completed a dam and reservoir designed to meet "emergency water supply needs for . . . 3 million residents." Fisher, *supra* note 181, at 30.

heretofore episodic instances of subregional shortfall will become a chronic problem.[204] Chronic shortages will increase the number of allocative disputes, a challenge that riparianism in its present form will be unable to meet.

To adequately determine the scope of regional water shortages it is necessary to forecast Eastern water demand. Water demand forecasting is primarily the province of water supply utilities and government planners. An array of methodologies are used in making water demand forecasts. The three principal methods are judgmental forecasting, causal forecasting, and extrapolative forecasting.[205] However, even those trained in the field acknowledge that good demand forecasting is as much art as it is science, and that one method does not consistently yield more accurate results than the others.[206]

Despite the dissimilarity of the judgmental, causal, and extrapolative methodologies in predicting future events, the process by which most forecasting evolves is fairly similar.[207] The first step is to assess past records of water deliveries. Actual consumption of the water delivered is irrelevant to the analysis.[208]

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204. If demand and supply have reached rough parity, continued growth in demand would pose difficulties for riparianism without regard to the major supply decrease forecast by the earlier segment of this Article. *See supra* notes 92-132 and accompanying text.

205. Gardiner & Herrington, *The Basis and Practice of Water Demand Forecasting*, in WATER DEMAND FORECASTING 9-11 (1986). To describe the three types of forecasting briefly:

> Judgmental approaches rely upon the experience of an individual and may be either entirely subjective in nature or a modification of more objective results. . . . [T]he greatest challenge . . . is in successfully combining the elegance of sophisticated statistical techniques with judgmental adjustments made necessary because future trends may be different from past patterns. . . . Causal, explanatory or analytical forecasts are those in which an attempt is made to predict the variable of concern by reference to other variables which, it is assumed, control or influence it. . . . Extrapolative forecasts derived from time series involve consideration of only the variable of concern and the prediction of future values from the projection of past trends.

Id. at 9-10.

206. *Id.* at 12.

207. *See generally* D. PRASIFKA, CURRENT TRENDS IN WATER SUPPLY PLANNING 62-142 (1988).

208. *See, e.g.*, D. STEAD, J. FAN, R. BRAZEE & J. BULKLEY, PUBLIC WATER WITHDRAWAL FORECASTING IN SOUTHEST MICHIGAN, FINAL REPORT TO THE GREAT LAKES AND WATER RESOURCES PLANNING COMMISSION 22, School of Natural Resources, University of Michigan (1987) [hereinafter PUBLIC WATER]. This work contains an extensive and informative literature survey at pages 61-75.

The data set may be very sparse, but can often be enriched by referencing climatic and socio-economic data about the water service area under consideration. The next step identifies the best historic predictors of water usage, often employing sophisticated multiple regression analyses.[209] Reflecting the interests of the water utilities, the results of most water demand forecasting are expressed as a daily water "consumption"[210] requirement for a particular water service area.[211]

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209. *See id.* at 18-21.

210. There is a chameleon-like nature to the way this term is used in Eastern United States demand forecasting. The word "consumption" can describe the actual consumption of water; for example, the Second Assessment uses consumption in this sense and distinguishes withdrawals as a separate item. 2 SECOND ASSESSMENT, *supra* note 78, pt. III, at 2. However, "consumption" can also describe only the delivery of water; used in this sense, all water delivered is considered consumed. This latter use of the term is at odds with reality; most water users do not wholly consume the water they receive. Nevertheless, in the context of a water utility's demand forecasting, this odd use of the term is highly functional. Treating all water delivered as water consumed is, in essence, the water utility point of view. The utility needs to operate its system in order to deliver sufficient water to allow the uses, whether consumptive or not, to go forward. If water is available for later reuse, it can be considered an addition to supply.

Beware, however, that the United States Geological Survey (USGS), which played a pivotal role in preparing the Second Assessment, *supra* note 78, at times releases "consumption" figures that are in fact withdrawal figures. *Compare* D. PRASIFKA, *supra* note 207, at 2-3 (USGS data reporting United States per capita water consumption as 1,900 gpd) *with Mid-Atlantic States Hearings*, *supra* note 79, at 27 (statement of Philip Cohen, USGS Chief Hydrologist, stating that average per capita water consumption in United States is 100 gpd). Yet another estimate sets the current per capita United States consumption figure in the 180-200 gpd range. *See* 1987 STATISTICAL ABSTRACT OF THE UNITED STATES 188, table 327.

211. The local emphasis is warranted because "[d]ata on national aggregate water use have little relevance . . . because urban water-supply planning is a local phenomenon." D. PRASIFKA, *supra* note 207, at 2. Most national forecasts like the Second Assessment are summations of demand forecasts done on a smaller scale.

A recent congressionally mandated Northeast Water Supply Study (NEWS) of that region's anticipated water needs examined the particular characteristics of several major metropolitan areas, and then expressed the water forecast for each service area. *See* Act of Oct. 27, 1965, Pub. L. No. 89-298, § 101, 79 Stat. 1073. The study predicted a 137% increase in metropolitan Washington, D.C. water demand, from an actual annual average "consumption" level of 390 million gallons per day (mgd) in 1970, to a predicted level of 925 mgd in the year 2020. The use of a daily figure based on an annual average (i.e., a figure calculated as the total used in the year divided by 365) puts to one side issues of peak load

Without regard to their type, individual forecasts differ most in the extent to which they attempt to disaggregate total demand.[212] One type of disaggregation separates out domestic and commercial, manufacturing, power generation, minerals production, and agriculture. This is the approach taken by the Second Assessment.[213] Other disaggregation methods further break down the domestic use figure into the number of households, or even the number of households at selected income levels, and link these finer differentiations with group specific (and historically validated) per capita use rates. Thus, rather than tracking population change in the aggregate, the forecast would track the changes in the smaller groupings.

In the end, the predictions of all types of water demand forecasts are inaccurate beyond the first few years.[214] One commentator notes the problems of forecasts that look ahead twenty to fifty years:

> Given such a long time frame, errors in water-use forecasting can occur for many reasons. Inappropriate or unintended assumptions may be made in determining the parameters of the forecast; for example, future population may be incorrectly projected, changes in the mix of household types may be omitted, or changes in the real level of water prices may be ignored. . . .
>
> As these examples illustrate, a water-use forecast is a conditional prediction of the level of water use at some future time. Forecasts are conditional because they contain assumptions regarding future levels of water-using activities, future relationships between water use and these activities, future economic conditions, and so on.[215]

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water use. H.R. Doc. No. 107, 98th Cong., 1st Sess. 37 (1983) [hereinafter NEWS]. The document is a report on the Northeastern United States Water Supply Study made by the Chief Engineer, Department of the Army.

212. *Compare* NEWS, *supra* note 211, at 24 (extrapolative forecast that does not disaggregate) *with* Public Water, *supra* note 208, at 2 (causal forecast of Southeastern Michigan water demand that considers several predictors, including population, median household income, and median household size).

213. 2 Second Assessment, *supra* note 78, pt. III, at 27-28, 41-42, 73-74, 93, 100-01.

214. *See, e.g.*, Archibald, *Demand Forecasting in the Water Industry*, in Water Demand Forecasting, *supra* note 205, at 17-19 (discussing proven inaccuracy of major forecasts done by English Water Resources Board).

215. D. Prasifka, *supra* note 207, at 62.

An illustrative example of the difficulty of forecasting can be found in the predictive portions of the Second Assessment. In 1975, the Second Assessment predicted that within ten years total freshwater withdrawals in the United States would decrease by two and one-half percent. In reality, during that ten-year period withdrawals increased by thirty-three percent.[216] This wild inaccuracy was primarily due to an erroneous forecast of a forty-six percent decrease in manufacturing water withdrawals,[217] which was premised on a mistaken assumption that manufacturers would recycle water to reduce the volume of treated effluent released.[218]

It is beyond the scope of this Article[219] to provide a long-term water demand forecast for the Eastern United States. Still, a very brief and generalized judgmental forecast suggests some reasons to expect a growth in aggregate Eastern water demand. First and most elementally, population will grow in most parts of the region, and rather rapidly in the south coastal areas. Second, more people in the United States are living an affluent life-style, which includes the increased use of water "consuming" appliances, and greater demands for in-stream uses of water for recreation. Third, industrial and commercial growth continue to be cornerstones of national economic policy, and it is likely that water use will increase to support that growth. Fourth, irrigation is already an important element of Eastern water demand and may be a growing practice, especially if summers become hotter and drier.[220] This increase in

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216. 2 SECOND ASSESSMENT, *supra* note 78, pt. III, at 3, table III-1. The Second Assessment predicted freshwater withdrawals would fall from 338,500 mgd in 1975 to 330,375 mgd in 1985. Recalling the 1985 USGS figure of 1900 gpd as the 1985 per capita use in the United States, and multiplying by a population of 238 million, reflects actual water withdrawals in excess of 452,200 mgd.

217. *Id.*

218. The authors of the Scond Assesement reasoned as follows:

> There has been a long-term trend toward using recycled water for an increasingly greater proportion of gross [manufacturing] water use. This trend has been accelerated by the Water Pollution Control Act Amendments of 1972, which were further amended in 1977. The major goal of the Act, as it currently exists, is zero discharge of industrial pollutants to water bodies by the year 2000. Thus, high rates of water reuse are projected for the year 2000, with discharges chiefly limited to the control of solids buildup in plant water systems.

Id. at 41-42.

219. Not to mention also being beyond the training and ken of the author.

220. In four riparian states, irrigation accounts for more than half of the water consumed. The states are Louisiana (55%), Florida (63%), Georgia (58%),

irrigation, coupled with the three factors listed above, portends further increases in both withdrawal and consumption.

3. *Water Demand Reduction*

Anticipating reductions in water use is a coequal part of making a judgmental water demand forecast. Water conservation efforts offer potential demand reductions that could temper the pace of the projected growth in demand. Conservation measures can reduce water demand for household and industrial use, and reduce distribution system losses. All of these conservation strategies have value, but with the possible exception of reducing demand in the industrial sector, these measures are unlikely to have a major effect on the overall pattern of growth in water demand.

At the household level, water conservation devices such as flow restricting shower heads and toilet efficiency kits are readily available at a modest one-time cost per household. Studies estimate that domestic water use in a conserving household can decline from seventy-seven gallons per capita per day (gpcd) to sixty gpcd.[221] In a presently nonconserving major city, such as Washington, D.C., this degree of demand reduction can offset roughly ten percent of the projected 535 mgd growth in water demand predicted to occur by the year 2000. What is necessary to obtain these reductions is the political will to require the installation of conservation hardware, and a credible threat of sanctions in the event that the hardware is not installed. As water shortages grow

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and Delaware (59%). Michigan at 46% is close. *See* USGS, NATIONAL WATER SUMMARY 1983—HYDROLOGIC EVENTS AND ISSUES, Water Supply Paper No. 2,250, at 11 n.34 (1984).

The Second Assessment, with the exception of the Lower Mississippi region, predicted a small but steady increase in both withdrawals and consumption for irrigation and livestock. 2 SECOND ASSESSMENT, *supra* note 78, pt. III, at 74, table III-39. More recent government studies have found that irrigation is rising rapidly in the East and Southeast. *See* CONGRESSIONAL RESEARCH SERVICE OF THE LIBRARY OF CONGRESS, STATE AND NATIONAL WATER USE TRENDS TO THE YEAR 2000, 96th Cong., 2d Sess. 244 (1984) (report prepared for Senate Comm. on Environment and Public Works). *See also* Tarlock, *Supplemental Groundwater Irrigation Law: From Capture to Sharing*, 73 KY. L. REV. 695, 695-97 (1985).

In making a judgmental forecast, the predicted repetition of summers dominated by heatwave/drought and reduced summer soil moisture is also central. Under these weather conditions, irrigation will increase greatly to sustain the vital agricultural sector.

221. D. PRASIFKA, *supra* note 207, at 27. Conservation measures in Virginia Beach, Virginia, have decreased per capita use to 100 gpcd; per capita use in other parts of Virginia is 200 gpcd. Fisher, *supra* note 181, at 34.

more common, it seems likely that politicians will embrace this simple, rather painless water saving strategy.[222]

Water distribution system loss is another area in which water demand can be reduced without any adverse impact on water users (and therefore without political repercussions), by the simple expedient of detecting and repairing the leaks.[223] A California study places leakage in that state at four percent of total water produced. A survey conducted by the American Water Works Association (AWWA) offers leakage figures from three percent to as high as six percent.[224] Leakage reductions are, like household water conservation, worthwhile, but realizing them seems far less likely because of the high costs of detection and repair.[225]

Distribution losses can also be reduced by moving away from piped delivery systems and surface reservoir storage to aquifer storage. Pumping surface water into "groundwater reservoirs" is an innovative strategy that lacks large-scale potential, but which may nevertheless have important local applications.[226] For example,

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222. The 1986 amendments to the Safe Drinking Water Act (SDWA) may indirectly force municipal and household conservation measures. Pub. L. No. 99-339, 100 Stat. 642 (1986) (codified at 42 U.S.C. §§ 300f to 300j-11). The amendments require the EPA to set maximum contaminant levels (MCLs) for 83 contaminants, including volatile organic compounds, inorganic chemicals, radionuclides, microbes, and turbidity. Regulation of these substances will make drinking water "safer;" however, it will also greatly increase the cost of water treatment. The amendments do not provide for federal funds to be used to upgrade municipal treatment plants, so this increased cost will be passed on to consumers. The USEPA has estimated that annual residential water bills could increase by as much as $275; currently the average water bill is less than $100. Norling, Stephens & Davis, *Safer Water at a Higher Price—Anticipating the Impact of the Safe Drinking Water Act*, PUB. UTIL. FORT., Dec. 12, 1988, at 11, 14. Such a significant increase in water rates would cause an increase in residential and municipal conservation practices.

223. Leaky distribution systems are the largest single component of what the water utilities refer to as "unaccounted for water" (UAW). UAW is calculated as the difference between what is pumped by the utility and what is paid for by the customers. Some UAW is authorized, such as fire fighting. Other UAW is unauthorized, such as theft or meter bypassing.

224. D. PRAFISKA, *supra* note 207, at 51. New York City's water consumption is increasing even though its population is decreasing. Leakage in the city's 200-year-old water system is the principal cause of the increase. Fisher, *supra* note 181, at 34.

225. An estimate of the American Consulting Engineers Council placed a $1 trillion figure on the cost of water infrastructure repair to meet basic maintenance needs by the year 2002. *See Systems Face Financial Crisis*, U.S. WATER NEWS, Aug. 1987, at 6.

226. *See generally* Lampe, *Recharge Saves Water for a Not-So-Rainy Day*, AM. CITY & COUNTY, June 1987, at 40.

the use of aquifer storage permits time-shifting of the surface water supply. At times of low demand the water is stored in the ground; when demand is high the water is recovered by pumping. Additionally, groundwater reservoirs reduce evaporation losses, a pure conservation measure. Depending on the characteristics of the aquifer, wells can be used to extract the water at the point of intended use, reducing transmission costs and transmission losses. Perhaps most important, that same stored water can protect the aquifer against overdrafting and all of its associated evils, including saline intrusion.[227]

The final area where conservation can reduce water demand is in the industrial sector. Industrial water use is the predominant regional water use in the Eastern states.[228] Manufacturing is the one area in which physical conservation measures could potentially result in impressive water savings. However, it is difficult to determine whether large-scale water reuse and recycling actually will occur.[229]

As discussed above, the Second Assessment predicted a significant net decrease in manufacturing water withdrawals for the

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227. These ideas are of particular interest along the southern Atlantic Coast. *See* Castro, *Aquifer Storage Recovery in Coastal Plain Sediments at Myrtle Beach, South Carolina*, South Carolina Water Resources Commission, Open File Report No. 22 (Aug., 1987) (on file at *The Wayne Law Review*). For the complexities that must be considered in evaluating the feasibility of such projects, see Castro & Hockensmith, *Preliminary Hydrogeologic Study of the Aquifer Storage Recovery Testing Site, Myrtle Beach, South Carolina*, South Carolina Water Resources Commission, Open File Report No. 21 (July, 1987) (on file at *The Wayne Law Review*).

228. *See supra* note 195 and accompanying text; *see also* D. GIBBONS, *supra* note 197, at 45-46 (15 leading states in industrial water withdrawals all located in Eastern United States).

229. Water reuse outside of the industrial sector has generally been resisted by the public. However, a paper presented at a recent symposium on water reuse predicts public attitudes towards water reuse will change and water reuse will become a standard practice. Westerhoff & Berkun, *Water Reuse 2000: Trends of Influencing Change*, in IMPLEMENTING WATER REUSE 17, Proc. Water Reuse Symp. (1987). The report notes that reclaimed waste water can be used for irrigation of lawns, golf courses and public parks, and in industry without any public resistance. However, the public demands relatively risk-free water for personal uses, vegetable crop irrigation, and groundwater recharge. *Id.* at 25. The report concludes that as water needs become more acute and water treatment technologies improve, public attitudes toward water reuse, driven by the increasing cost of "pure" water, will change. *Id.* at 31. *But cf.* text accompanying notes 234-35, *infra*.

years 1985 and 2000.[230] The prediction was based on the premise that industries would institute water conservation methods to comply with the Clean Water Act's industry-by-industry requirement of "best available technology economically achievable" (BAT)[231] to control surface water pollution. This assumption was consistent with the conclusions of an influential study that found compliance with BAT would radically alter water withdrawal practices.[232] The study concluded that new plants employing BAT would, without any other stimulus, find it less expensive to recycle large percentages of their process water rather than use water on a once through basis.[233]

Although the predicted water savings are very high,[234] it is important to remember that industrial reuse and recycling result only in declining water withdrawals, not in declining water con-

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230. 2 SECOND ASSESSMENT, *supra* note 78, pt. III, at 33. *See supra* text accompanying notes 220-22.

231. 2 SECOND ASSESSMENT, *supra* note 78, pt. III, at 41-42. For a definition of BAT, see 42 U.S.C. § 1857 (1982).

232. *See generally* G. BREWER & P. MCAULEY, AN ANALYSIS OF PRICE/COST SENSITIVITY OF WATER USE IN SELECTED MANUFACTURING INDUSTRIES (1976). This study considered four major industrial use processes: water for cooling; water for cotton textile manufacture; water for unbleached Kraft paper manufacture; and water for the conversion of iron to steel. The study based its results on hypothetical models, not actual industrial plants.

233. Table 3, taken from the Brewer & McAuley study, *supra* note 232, shows the cost of water use both with and without BAT pollution control equipment, and the percentage of water that each industry would opt to recycle in an effort to minimize the total water cost of the particular industrial process. The "no control" recycling already in practice occurs because reuse of process water would at times be less expensive than obtaining (pumping and piping costs) and treating (to meet processing quality requirements) additional intake water.

Table 3

Impact of Water Pollution Control Requirements on Water Costs and Recycling Rates

	Costs per 1000 gal gross water used		Recycled water as % of gross water used	
	No control	BAT	No Control	BAT
Non-contact cooling	$.045	$.070	0%	97.5%
Cotton Mill	$.034	$.979	0%	58.9%
Kraft Mill	$0.85	$.158	64.9%	93.0%
Oxygen steelmaking	$.117	$.405	10.5%	92.6%

Id. at iv.

234. *See supra* note 233 and table therein.

sumption. The authors of the study noted: "If the goal . . . is to allocate net demands on stream flow in a river basin, then recycling water within the plant does not further this objective, since its impact on consumption is negligible."[235] Reducing withdrawals without reducing consumption will occasionally help to resolve some water shortage problems, such as when an industrial user precipitates a conflict with in-stream uses by failing to return the withdrawn water to the watercourse at or near the point of withdrawal. This case would most likely occur if the water is withdrawn by a municipal water supplier with an upstream intake, and the discharge is into a municipal sewer system with a downstream outfall. This same set of circumstances gives rise to a second area in which water use conflicts could be minimized by industrial recycling. The water supplier, in designing and operating the supply system, must consider the intake water needs of the industrial users and, in the absence of water conservation by the industries, may be obliged to build larger reservoirs or import additional supplies to the detriment of other water users, particularly those in the exported water's area of origin.[236]

This brief survey of conservation measures indicates that there are spheres in which the projected growth of Eastern water demand can be tempered. Important water withdrawal and consumption savings can be made in the areas of household water use and distribution system leakage control. Water recycling by industries has a massive potential for water savings, but industrial conservation measures will play only a small role in solving "absolute" water shortage problems, such as those that arise between competing consumptive users.

The water supply/demand discussion illustrates that the era of supply consistently in excess of demand is at an end in the Eastern United States. Water supply in the East will decline between now and the middle of the twenty-first century. The most significant factor driving the supply decline is the large predicted increase in evapotranspiration associated with an air pollution-induced increase in regional average temperature. The predicted temperature increase will cause summer soil dryness that will further stress water supplies by forcing wider use of irrigation, a large volume, highly consumptive water use.

The absolute decrease in supply is also likely to be accompanied by cost increases for remaining available supplies. Some of this

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235. G. Brewer & P. McAuley, *supra* note 232, at v.
236. *See supra* notes 180-85 and accompanying text.

change in the cost of existing sources will be associated with redesigning the water supply infrastructure to offset decreased reservoir capacity, and to relocate freshwater intakes further upstream to avoid the upstream movement of saltwater tidal action. Expensive prophylactic and remedial measures necessary to maintain the quality of groundwater and surface water at levels suitable for most uses will also contribute to the forces driving up the cost of supply. These secondary developments will decrease the availability of water. The absolute decline in supplies threatens all water users with a problem of physical impossibility: that there is not enough water to go around. Absolute shortage cases, riparianism's "hard cases," will become more and more common as competing water users sue for their "share" of a dwindling resource. The increasing number of these cases will bring riparianism's allocative weakness to the fore and accelerate the search for ways to assure efficient distribution of the resource.

The demand side offers little or no relief from the unhappy supply predictions. Population growth and economic growth in many parts of the region assuredly will increase water demand. Large cities are the driving force of the water demand equation in most parts of the region. These cities are facing predictions that their water distribution requirements will more than double by the end of this century. Growth remains rapid in attractive coastal areas that are already short of water. Increased irrigation spurred by climatic change will also add to an already predicted slow growth of agricultural water demand. There is but one conclusion: in many critically important parts of the Eastern United States demand will catch and pass supply.

IV. Conclusion

This Article has traced an almost Odyssean path from Eastern United States water law history into a future fraught with increasing doubts about the adequacy of the region's water supply in relation to the growing need for water. The history of riparianism shows that the doctrine first changed substantially when water was needed for productive rather than amenity values. Increasing shortages in Eastern water supplies will drive a similar change in the venerable doctrine. Both the historical change and the predicted change are consistent with the instrumentalist theory of law, which requires rules that promote the most efficient distribution of resources.

Conditions for major changes in water law are present today. Increasingly common subregional water shortages in the Eastern

United States, coupled with a precipitous decline in surface water supplies caused by the greenhouse effect, suggest an increase in the number of absolute shortage cases that riparianism has historically been hard-pressed to resolve adequately. The doctrine's failure to manage water allocation conflicts results in unpredictable and uncertain outcomes. These hard cases of absolute shortage, evermore prevalent, demand a different water law for their management, one designed to function in times of shortage rather than abundance.

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