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Multi-year water allocation: an economic approach towards future planning and management of declining groundwater resources in the Texas Panhandle

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Abstract: Heavy withdrawals from the Ogallala Aquifer, the most dependable source of groundwater in the Texas Panhandle, create an impending need for implementing water conservation policies. This study evaluates the policy option of multi-year water allocation coupled with water-use restriction in Regional Water Planning Area-Region A of Texas, over a 60-year planning horizon for 4 study counties, namely Dallam, Sherman, Moore and Hartley. Dallam County is studied as a representative county and results compared with other study counties. For the unconstrained baseline scenario over 60 years, the counties of study show a decline in saturated thickness that recommends the incorporation of water-use restriction alternatives at different rates. Increasing restrictions rates led to decline in water use per acre as well as total annual water use. Such restrictions, if mandated by the water conservation districts, will result in individual irrigators bearing the cost of water savings in the form of reduction in net present value per acre. The decline in net present value may have implications to the regional economy, and therefore, it is crucial to analyze the socio-economic effects of implementing such a policy alternative and analyze the feasibility in the light of legislative and political scenarios.

Keywords: dynamic optimization, irrigation, multi-year allocation, Ogallala Aquifer

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Terms used in paper

Short name or acronym	Descriptive name
GAMS	General Algebraic Modeling Systems
LEPA	low energy precision application
NPV	net present value

INTRODUCTION

The economy of the Texas High Plains is driven by agriculture, and irrigation that utilizes groundwater resources plays a pivotal role in the development of cropping systems and sustaining the growth and productivity of the farming community in the area. The most important and dependable source of groundwater for irrigation purposes in this region is the Ogallala Aquifer, which overlies parts of 8 states: Texas, New Mexico, Oklahoma, Colorado, Kansas, Nebraska, South Dakota, and Wyoming (Alley et al. 1999). However, water table levels in the aquifer have been declining in certain locations over the years, more specifically in the southern and central region of the aquifer. This rate of decline is accelerated by the fact that recharge, when compared to the rate of depletion, is minuscule (Birkenfeld 2003). In 1990, the Ogallala Aquifer in the 8-state area of the Great Plains contained approximately 3½ billion acre-feet of water, of which Texas had about 12% of the water in storage or approximately 417 million acre-feet of water (Guru and Horne 2000). A recent estimate of the volume of water in the 8-state Great Plains area was less than 3 billion acre-feet (Tuholske 2008). Such changes in the groundwater resource supply will most likely have a significantly negative impact on the agricultural economy of the Texas High Plains in the near future.

The Texas law of water rights for groundwater has a complex structural framework that can be accounted for by inclusion of certain features of the Spanish law such as absolute ownership of groundwater by landowners (Wishart 2011), along with the incorporation of the traditional English common law (Handbook of Texas Online 2009). The rule of capture is the guiding principle behind percolating groundwater (percolating below the surface of the earth (Tex. Water Code §36.001(5) (Texas Constitution and Statues 2011)), and is sometimes referred to as the "law of the biggest pump." This principle has been derived from the English common law that was adopted in the year 1904 by the Texas Supreme Court in a historical ruling, which has been recorded as Houston and Central Texas Railway vs. East (East Ruling) (TWDB 2004). Under this rule the owner of the overlying land can pump and use the water with few restrictions, whatever the impact on adjacent landowners or more distant water users. The rule of capture has been maintained as the case law for groundwater in the State of Texas, ever since the East ruling and has been modified with regard to groundwater management in different regions. Therefore, it is crucial to understand various policy options that could be incorporated in the current water rights system for a particular area with an objective of conserving water for future use. Several studies have been undertaken in this regard. Wheeler et al. (2008) evaluated the impacts of short-term and long-term water-rights buyout policies. The results of the study suggested that the long-term buyouts were more economically efficient than short-term buyouts. Johnson et al. (2009) studied the impacts and economic effects of implementing groundwater policies on the Ogallala Aquifer in the Southern High Plains of Texas and concluded that a policy that restricts the quantity of groundwater pumped conserved more water over the 50-year planning horizon than implementation of a water-use fee, but at a higher cost. These studies provide an insight into scope of further research regarding water policy implementation in the study area with a long-term objective of water conservation in the aquifer.

Water allocation over multiple years may be of interest to policy-makers and the state legislature with an objective of extending the economic life of the Ogallala Aquifer in the High Plains of Texas and maintaining the viability of a regional economy that critically depends on agriculture. The North Plains Groundwater Conservation District, in its groundwater management plan for the years 2008–2018, set a maximum allowable production limit of 2 acre-feet per acre, per annum on water-rights tracts not to exceed 1,600 acres. This was done with an objective to limit groundwater withdrawal amounts based on an allowable production limitation and a contiguous water-right acre limitation (NPGCD 2008). Although the rule of capture remains in effect, local groundwater conservation district rules supersede. Therefore, any allocation system advocated in the State of Texas will need to be adjusted accordingly by the groundwater districts in their respective areas. In the above context, a "district" is defined as an authority formulated to regulate the spacing of water wells, the production from water wells, or both, as defined in the Texas Water Code §36.001(1) (Texas Constitution and Statues 2011).

A water allocation system over multiple years will potentially reduce inefficient use of water during the allocated period by allowing for water stock (allocation) to accumulate for the judicious users, which could be rolled over into the next allocation period at an appropriate rate of the unused stock. This system will also pave the way for producers to manage irrigation needs of their crops in a planned manner with better utilization of available water than previously used. The goal of the multi-year allocation policy is to allow an equitable distribution of a limited resource like water and ensure its availability in the future, given the excessive groundwater mining and associated decline in water levels from a limited water source for the area.

The objective of this study is to analyze and evaluate the impacts of multi-year water allocation as a policy alternative for optimizing groundwater use from the Ogallala Aquifer in the Northern High Plains of Texas. In this study, county-specific models were developed with an objective of maximizing net returns from the existing agricultural systems over a planning horizon of 60 years. A comparative analysis was conducted to evaluate the impacts of allocating the use of groundwater resources over a 5-year period under 3 different scenarios (15%, 30%, and 45% water-use restriction from baseline year-1 water use) when compared to a hypothetical baseline scenario, which assumes current water use with no restriction. The results of the study were evaluated for parameters such as change in saturated thickness, pump lift, water application per acre and also for changes in crop mix, over the planning horizon under the restriction scenarios. In addition, net present value per acre was estimated for the baseline as well as the alternative scenarios to compare the feasibility and economic effects of policy implementation along with the restriction scenarios.

STUDY AREA

Declining levels of water in the aquifer have led to significant discussions among regulating authorities and water-law governing bodies, creating an impending need to realize the importance of the complexity of water laws affecting usage of groundwater in the Texas High Plains. The concept of estimated usable life in terms of aquifer yield, and the basin yield, can be instrumental in realizing the importance of the study area. Freeze and Cherry (1979) define aquifer yield as the maximum rate of withdrawal that can be sustained by an aquifer without causing an unacceptable decline in the hydraulic head in the aquifer. This indicates that the usable lifetime of an aquifer pumped at the aquifer yield is eternity, given acceptable consequences. However, due to continued withdrawals and the unconfined nature of an aquifer like the Ogallala, the estimated usable lifetime is better represented by the basin yield, which is the quantity of water available from a stream at a given point over a specified duration of time (Reddy 2004). The primary focus of this research concentrates on the northwest region of the Texas High Plains, more specifically the counties of Dallam, Sherman, Moore, and Hartley. In a study conducted by the Center for Geospatial Technology at Texas Tech University, the counties of study showed substantial change in amount of water storage underlying the county over a study period of 15 years from 1990 to 2004 (Barbato and Mulligan 2009). The percent change for individual counties was: Dallam, -22.7; Sherman, -14.2; Moore, -11.5; and Hartley, -8.1 (Barbato and Mulligan 2009). Wheeler et al. (2006) studied the impacts of water conservation policies that limit drawdown of the Ogallala Aquifer and concluded that in the High Plains of Texas, water conservation policies that focus on counties that deplete the aquifer to less than 30 feet of saturated thickness with respect to the usable lifetime over a 60-year period were most likely to benefit from the focus of water conservation. This emphasizes the fact that counties with lower estimated usable life and high water use should be studied extensively for measures of water conservation. Dallam County has a substantial area that falls in the estimated usable life of less than 15 years. Sherman and Moore counties follow the trend with an estimated usable life ranging from 31 to 100 years. Hartley County, however, shows a mixed scenario where certain locations of the county experienced high depletion and, on the other hand, other locations experienced a rise in water table. Figure 1 outlines the counties of study in the Texas High Plains, which are located in the Regional Water Planning Area–Region A.

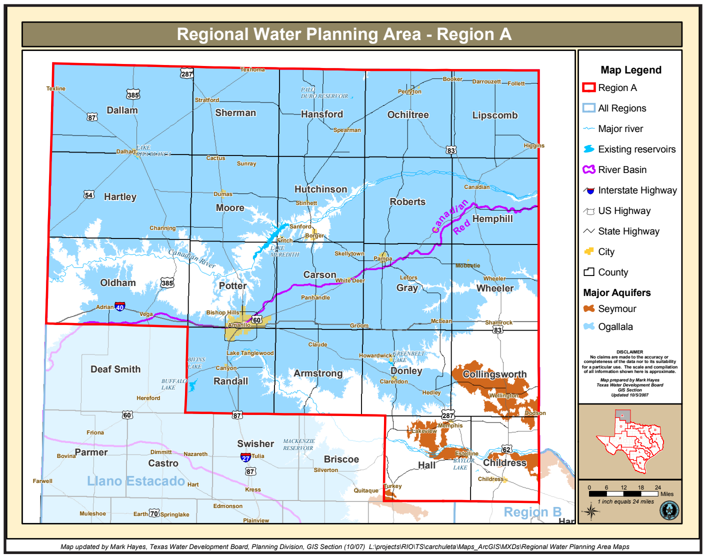

Figure 1. Counties of study in Region A – Regional Water Planning Area. Source: Texas Water Development Board 2007.

DATA SOURCES AND METHODOLOGY

Several steps were necessary to analyze the economic impacts of the multi-year water allocation policy coupled with restriction scenarios when compared to the baseline scenario of no restriction on water use. The study utilized the General Algebraic Modeling Systems (GAMS), which is a mathematical programming and optimization modeling software. For the purpose of this research, GAMS was specifically employed for developing non-linear optimization models for each county using specific parameters. The model for this specific study is a non-linear dynamic model with the incorporation of crop production functions for individual crops in the study area. These crops are corn, grain sorghum, cotton, and wheat. An approach that utilized non-linear dynamic programming in combination with GAMS (Brooke et al. 1998) was used in this research study to facilitate multiple runs of the model. First, hydrologic data were collected for the study counties for saturated thickness, pumping lift, hydraulic conductivity, and recharge rate, which were needed to calculate the water withdrawal on an annual basis for irrigation. Specific data were collected for 5-year average planted acreages of cotton, corn, grain sorghum, wheat, and fallow land from the Farm Service Agency for the years 2005 to 2009 (FSA 2009). Crop acreages under conventional furrow, low energy precision application (LEPA), and dryland were calculated utilizing the ratio of acreages under different irrigation systems from the Texas Water Development Board Survey of Irrigation (TWDB 2001). Operating costs were collected for specific crops of study, including fertilizer, herbicide, seed, insecticide, fuel, irrigation technology maintenance, irrigation, labor, and harvesting costs for the year 2009 (Amosson et al. 2009).

The developed models estimated the optimal water requirements for irrigation and the resulting net returns from crop production for major crops in the 4 counties of study over a 60-year planning horizon. A 3% discount rate was used to calculate the net present value for the 60-year period for each of the 4 counties.

Hydrologic data

Saturated thickness and pump lift by county calculations were based on data for the year 2008 from the Texas Tech University Center for Geospatial Technology website (TTU CGT 2010). Saturated thickness was calculated by subtracting the depth to water from the depth of the well. Pump lift was calculated as the depth from the ground surface to the water level. Recharge rate used in the model on a county-wide basis was obtained from the Panhandle Water Planning Group report on adjustments of parameters to improve calibration of models of the Ogallala Aquifer (Dutton 2004). An average estimated specific yield of 0.155 was used for the entire study area (Ryder 1996). Initial acres served per well and maximum allowable withdrawal were calculated from the Texas Water Development Board Survey of Irrigation (TWDB 2001). It was assumed that, as saturated thickness values for counties decrease, the well yield in gallons per minute also declined. As an example, for counties with saturated thickness above 80 feet, a well yield of 1,000 gallons per minute was assumed for modeling purpose. The well yield values assumed for modeling purpose were guided by the assumption that the maximum allowable annual withdrawal for each county in acre-feet would require a minimum average well yield for satisfying the water demand. The average hydraulic conductivity used in the model for Ogallala Aquifer in Texas is estimated to be 65 feet per day (Ryder 1996). Initial acres served per well were calculated by dividing the groundwater irrigated acres by the approximate number of wells in each county. All estimated and calculated hydrologic parameters are summarized in Table 1.

Production functions

The production function parameters by crop for each county were calculated by using field data obtained through personal communication with farmers in the counties of study (Personal communication from Leon New, Extension Agricultural Engineer, Texas AgriLife Extension Service, Amarillo, Texas. 2010). The production techniques and timing of cultural practices were held constant for irrigated crops with only the irrigation water amounts changing. Maximum and minimum water applications for each crop were also incorporated in the model. The minimum water application levels

Table 1. Hydrologic parameters for counties of the study area.

County	Pump lift (feet)	Saturated thickness (feet)	Well yield (gallons per minute)	Acres per well
Dallam	371	128	1,000	134
Sherman	340	182	1,000	114
Moore	260	162	1,000	107
Hartley	420	153	1.000	148

used in the model were 14, 7, 7, and 6 inches per acre for corn, cotton, sorghum, and wheat, respectively, while the maximum water application level for the above crops was capped at 36 inches per acre. Application efficiency for the LEPA and furrow irrigation systems were established as constants and the production functions were allowed to adjust with the application efficiencies in the functional form specifications for equations in the model.

Response functions were estimated from the field data using the quadratic functional form with yield per acre as the dependent variable and irrigation water applied as the independent variable. The coefficients (β_1, β_2) were estimated setting the intercept to zero or the respective dryland yield of the crop, achieved without irrigation as reported for the county. The crop-water production function thus developed established the relationship between crop yield and applied irrigation. With this function, producers and policy-makers can understand and evaluate irrigation water requirements in order to achieve targeted production or, conversely, estimate the most feasible and best-fit crop production functions for fixed or limited volumes of irrigation water. The established equation was represented as follows:

(1) $$Y = \beta_0 + \beta_1 X - \beta_2 X^2$$

where Y represents the yield and X represents water application rate.

Commodity prices and harvest costs

Prices and harvest costs for corn, cotton, sorghum, and wheat were obtained from the budgets available for District 1 from Texas AgriLife Extension Service (Amosson et al. 2009) for the year 2009 and are presented in Table 2. It is important to mention that a surge in prices of commodities like corn with considerable acreage in the study area may have significant impacts on future production and expansion, as long as it is economically viable to pump water for irrigated production.

Model specification

This study was conducted with an objective of finding the optimal combination on individual county basis, using models to maximize net returns from production of crops over a time horizon of 60 years.

The objective function is defined as:

(2) $$\text{Max NPV} = \sum_{t=1}^{60} NR_t (1 + r)^{-t}$$

where NPV represents the net present value of net returns; r represents the discount rate; and NR_t represents net revenue at time t. The bounds of summation for the net revenue are from 1 to 60 years. NR_t is defined as:

(3) $$NR_t = \Sigma_i \Sigma_k \Omega_{ikt} \{ P_i Y_{ikt} [WA_{ikt}, (WP_{ikt})] - C_{ik} (WP_{ikt}, X_t, ST_t) \}$$

where i represents crops grown; k represents irrigation systems used; Ω_{ikt} represents the percentage of crop i produced using irrigation system k in time t, P_i represents the output price of crop i, WA_{ikt} and WP_{ikt} represent irrigation water application per acre and water pumped per acre, respectively. Y_{ikt} represents the per acre yield production function, C_{ikt} represents the costs per acre, X_t represents pump lift at time t, ST_t represents the saturated thickness of the aquifer at time t. The bounds of summation are 1 to 5 and 1 to 3 for i and k respectively.

Table 2. Harvest cost and commodity prices in the study area for the year 2009.

	Units	Cotton	Corn	Sorghum	Wheat
Yield unit		pounds/acre	bushels/acre	cwt/ac	bushels/acre
Harvest cost	dollar/unit	0.1	0.42	0.88	0.67
Commodity price	dollar/unit	0.56	4.75	8.1	5.78

The main constraints of the model are:

(4) $ST_{t+1} = ST_t - [(\Sigma_i \Sigma_k \Omega_{ikt} * WP_{ikt}) - ARR]\ PIA/SY$,

(5) $X_{t+1} = X_t + [(\Sigma_i \Sigma_k \Omega_{ikt} * WP_{ikt}) - ARR]\ PIA/\ SY$,

(6) $GPC_t = (ST_t/IST)^2 * (4.42*WY/AW)$,

(7) $WT_t = \Sigma_i \Sigma_k \Omega_{ikt} * WP_{ikt}$,

(8) $WT_t \leq GPC_t$

(9) $PC_{ikt} = \{[EF(X_t + 2.31*PSI)EP]/EFF\}*WP_{ikt}$,

(10) $C_{ikt} = VPC_{ik} + PC_{ikt} + HC_{ikt} + MC_k + DP_k + LC_k$

(11) $\Sigma_i \Sigma_k \Omega_{ikt} \leq 1$ for all t,

(12) $\Omega_{ikt} \geq (2/3)\ \Omega_{ik\,(t-1)}$,

(13) $\Omega_{ikt} \geq 0$

Equations (4) and (5) update the 2 state variables, saturated thickness and pumping lift, ST_t and X_t respectively where *ARR* represents the annual recharge rate in feet, *PIA* represents the percentage of irrigated acres expressed as the initial number of irrigated acres in the county divided by the area of the county overlying the aquifer, and *SY* represents the specific yield of the aquifer. In equation (6), *GPC* represents gross pumping capacity, *IST* represents the initial saturated thickness of the aquifer in year one of the planning horizon, i.e. 2010, and *WY* represents the average initial well yield for the county in year one. Constraints (7) and (8) are the water application and water pumping capacity constraints, respectively. Equation (7) represents the total amount of water pumped per acre, WT_t, as the sum of water pumped on each crop. Constraint (8) requires WT_t to be less than or equal to *GPC*. Equations (9) and (10) represent the cost functions in the model. In Equation (9), PC_{ikt} represents the cost of pumping, *EF* represents the energy use factor for electricity, *EP* is the price of energy, *EFF* represents pump efficiency, and 2.31 feet is the height of a column of water that will exert a pressure of 1 pound per square inch.

Equation (10) expresses the cost of production, C_{ikt}, in terms of VPC_{ik}, the variable cost of production per acre; HC_{ikt}, the harvest cost per acre; MC_k, the irrigation system maintenance cost per acre; DP_k, the per acre depreciation of the irrigation system per year; and LC_k, the cost of labor per acre for the irrigation system. Equation (11) limits the fractional sum of all acres of crops *i* produced by irrigation systems *k* for time period *t* to be less than or equal to one. Equation (12) is a constraint placed in the model to limit the annual shift to a 33.3% change from the previous year's acreage. This was done with an objective of constraining the model from predicting rapid shifts towards dryland cropping. Equation (13) is a non-negativity constraint to assure all decision variables in the model take on positive values. The model works on the objective of profit maximization and finds the optimal by maximizing the 60-year NPV typically called the social planners solution.

RESULTS

Results were analyzed for the optimal levels of saturated thickness, annual net revenue per acre, pump lift, water applied per cropland acre, cost of pumping, and net present value of net returns per acre by county. These were derived using the non-linear dynamic optimization model for the baseline scenario of a 5-year water allocation policy with no restriction on water use and the 3 alternative scenarios of a 5-year water allocation policy coupled with water-use restriction rates of 15%, 30%, and 45% respectively.

Results for Dallam County

The results for the baseline model and 3 water-use restriction scenarios for a multi-year allocation over 5 years will be discussed and analyzed in this section for Dallam County. Dallam County was selected as the representative county because the entire county overlies the aquifer, has a diverse crop mix, and has crop acreages in both irrigated and dryland. The total irrigated acreage within this county is 220,695 acres, of which 1,858 acres utilize furrow irrigation systems and 218,837 acres utilize sprinkler irrigation, with LEPA as the major irrigation system. The dryland crop acreage for this county is 60,621 acres. The Ogallala Aquifer underlies the total county area of 963,004 acres. Corn is the predominant crop grown in this county, with 100% of the acreage under sprinkler system, which is 126,330 acres. Winter wheat is another important crop of this county, with 1,696 acres under furrow irrigation system and 83,122 acres using LEPA systems. There is substantial dryland acreage of winter wheat in this area, which is 42,777 acres. Sorghum is also grown in both irrigated and dryland conditions and the irrigated furrow, LEPA and dry acreages are 162 acres, 7,939 acres, and 10,509 acres, respectively. Cotton is a minor crop in the area, grown only under LEPA irrigation systems and has acreage of 1,446 acres. The fallow land within this county is 22,005 acres.

In the baseline scenario, which assumes current water use and absence of a water-use constraint, saturated thickness declined from 128 feet to 42 feet during the 60-year period. The net revenue per acre for the county decreased from $213.6 in year 1 to $48.7 by year 60. The net present value per acre of cultivated land for the county is $4,404.70 for 60 years. Average water applied per cropland acre decreased from 16.62 inches to 3.51 inches over 60 years and the nominal pump cost increased from $8.40 per acre inch to $10.20 per acre inch during the planning horizon of 60 years.

Comparison of water-use restriction scenarios for Dallam County

In this section, results of specific water-use restriction rates for the allocation policy are compared to the baseline.

Scenario A (15% reduction in water use from Baseline Year-1)

This scenario placed a constraint on the annual water use, with a 15% reduction from Baseline Year-1 water use and the allocation period assumed was 5 years, as in the baseline scenario. The results indicated that saturated thickness declined from 128 feet to 43.05 feet during the 60-year period, which is 1% less than the baseline scenario. The net revenue per acre for the county decreased from $174.20 in year 1 to $54.90 by year 60. The net present value of productivity per acre of cultivated land for the county is $4,209.20 for 60 years, which is 4% less than the baseline. Average water applied per cropland acre decreased from 14.13 inches to 3.73 inches in the 60th year, which was 15% less than that applied in the 60th year of the baseline scenario. The nominal pump cost increased from $8.40 per acre inch to $10.20 per acre inch during the planning horizon of 60 years. The total annual water use for the entire county decreased from 348,532 acre-feet in year 1 to 92,035 acre-feet by year 60, when compared to the baseline scenario of annual water use from 410,038 acre-feet in year 1 to 86,584 acre-feet by year 60.

Scenario B (30% reduction in water use from Baseline Year-1)

This scenario placed a constraint on the annual water use, with a 30% reduction from Baseline Year-1 water use and the allocation period assumed was 5 years, as in the baseline scenario. The results indicated that saturated thickness declined from 128 feet to 54 feet during the 60-year period, which is 14% less than the baseline scenario. The net revenue per acre for the county decreased from $120.80 in year 1 to $14.40 by year 60. The net present value per acre of cultivated land for the county is $2,318.50, which is 47% less than the baseline. Average water applied per cropland acre decreased from 11.64 inches to 5.86 inches in the 60th year, which was 30% less than that applied in the 60th year of the baseline scenario. The nominal pump cost increased from $8.40 per acre inch to $10.00 per acre inch during the planning horizon of 60 years. The total annual water use for the entire county decreased from 287,027 acre-feet in year 1 to 144,645 acre-feet by year 60, when compared to the baseline scenario of annual water use from 410,038 acre-feet in year 1 to 86,584 acre-feet by year 60.

Scenario C (45% reduction in water use from Baseline Year-1)

This scenario placed a constraint on the annual water use, with a 45% reduction from Baseline Year-1 water use and the allocation period assumed was 5 years, as in the baseline scenario. The results indicated that saturated thickness declined from 128 feet to 57 feet during the 60-year period, which is 17% less than the baseline scenario. The net revenue per acre for the county decreased from $53.40 in year 1 to $9.40 by year 60. The net present value per acre of cultivated land for the county is $1,083.50, which is 75% less than the baseline. It is observed that both net present value and water applied per cropland acre decrease successively with increasing water-use restriction rates. Therefore, individual irrigators will bear the cost of water savings in the form of reduction in net present value per acre, if such a restriction is mandated by the water conservation district. It is also important to realize the depreciation in the value of land when converted from irrigated to dryland production. Irrigated cropland in the study area with good water has a value of $2,200 to $2,800 per acre and dry cropland values range from $350 to $500 per acre in 2009 dollars (TAMU REC 2009). Therefore, the irrigator is faced with various options and has to decide on the most profitable alternative accompanying the cost of water conservation. Average water applied per cropland acre decreased from 9.14 inches to 6.41 inches in the 60th year, which was 61% less than that applied in the 60th year of the baseline scenario and the nominal pump cost increased from $8.40 per acre inch to $9.90 per acre inch during the planning horizon of 60 years. The total annual water use for the entire county decreased from 225,521 acre-feet in year 1 to 158,090 acre-feet by year 60, when compared to the baseline scenario of annual water use from 410,038 acre-feet in year 1 to 86,584 acre-feet by year 60. The comparisons for parameters of saturated thickness, average water applied per cropland acre, and net returns per acre, under the 3 restriction scenarios, and baseline for Dallam county are provided in Figure 2.

General observations about regional results

As discussed previously in the unconstrained baseline scenario, all the 4 counties in the region (Dallam, Sherman, Moore, and Hartley) showed a decrease in the saturated thickness over the planning horizon in addition to reduction in net revenue per acre and also in water applied per cropland acre. These counties are among the highest water-use counties of the Panhandle region with low estimated usable life for the Ogallala Aquifer, with the exception of Hartley, which shows a rise in water table in certain parts (Barbato and Mulligan 2009).

Results of the baseline scenario and policy alternatives with

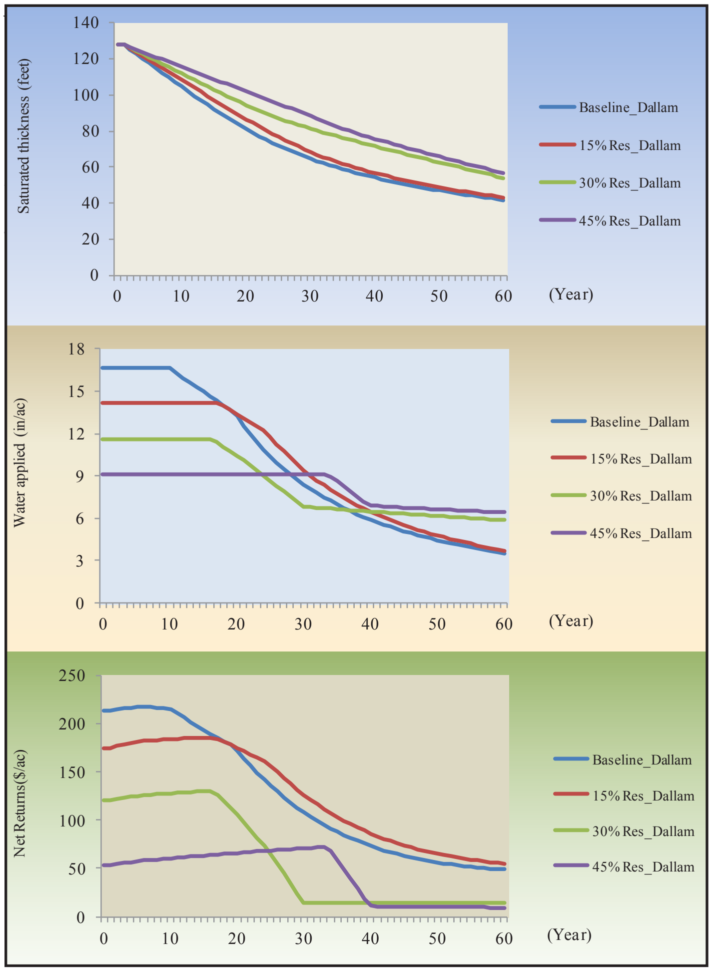

Figure 2. Changes in saturated thickness, water applied per acre, and net returns per acre for Dallam County under different scenarios.

of the counties over the planning horizon was comparatively less in the restriction scenarios when compared to the baseline. The water applied per cropland acre decreased in the baseline scenario within a range of 76.02% to 78.90% decrease in the counties from year 1 to year 60. This decrease was more significant with increasing water-use restriction rates and led to a change in cropping patterns in the study area.

Dryland acreage of sorghum increased substantially and irrigated sorghum, wheat and cotton acreages witnessed a decline during the planning horizon. The acreage for sprinkler irrigated corn shows a very slow decline rate in all the scenarios for each county, due to the high acreage of corn and its importance as the major livestock feed in the area. Irrigated acreage for all the major crops under furrow irrigation systems went out of production by the 20th year and showed a shift towards the more efficient sprinkler irrigation systems. A graphical description to understand the movement in crop-mix over the planning horizon is provided in Figure 3. Dallam County's baseline scenario is used as an illustration to depict these changes.

The results also showed a decrease in the net present value and net revenue per acre under all the scenarios for each county of study during the planning horizon. The net revenue per acre showed a decline in the range of 71.20% to 89.02% in the study counties under the baseline scenario. This decline became more evident with progressive rates of water-use restriction. Detailed results for the counties of study for the above parameters are presented in Table 3.

In order to validate the results of the model, a trend in actual crop acreages over the years 2005–2008 were studied utilizing the most recent data for the study area. It was observed that in the years of observation, the total irrigated corn acreage for the 4 counties, continuously increased from 37% in year 2005 to 41% in year 2008, which is also depicted by the results of the model for all the 4 counties of study until water became limiting at a point in time in the planning horizon. Again, from the observations, it was found that the total irrigated sorghum acreage for the 4 counties increased from the year 2005 to the year 2006 but slightly decreased in the years 2007 and 2008. Dryland sorghum showed an increase in the same trend as irrigated sorghum, and again decreased slightly during the years 2007 and 2008. Irrigated wheat increased continuously throughout the years of observation from 25% to 30% and dryland wheat decreased in the year 2006 but again rose in the year 2007. Irrigated cotton saw a moderate decline throughout the years of observation. It should be noted that the results of the model showed an increase in the dryland acreage of sorghum throughout the planning horizon, and this increase in the actual observations of the crop acreages for the study area was interrupted by an increase in irrigated wheat acreage, due to the high commodity prices for wheat crop in the year 2008.

The results of the model show a consistent trend with the actual crop acreages; however, it is important to realize that the

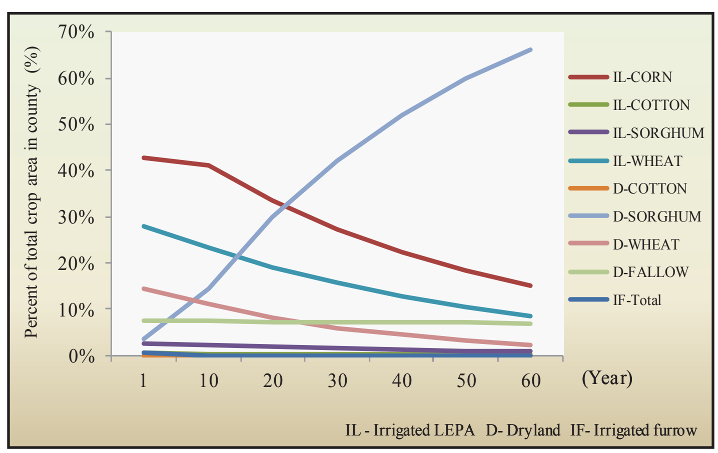

Figure 3. Shift in crop mix for Dallam County under the baseline scenario.

Table 3. Results for the counties of study — Baseline and 3 alternative scenarios.

Dallam	Baseline		15% Redc.		30% Redc.		45% Redc.	
	Year 1	Year 60	Year 1	Year 60	Year 1	Year 60	Year 1	Year 60
Saturated thickness (feet)	128	41.76	128	43.05	128	53.97	128	56.42
Change from baseline				3%		29%		35%
Water applied (inch/acre)	16.62	3.51	14.13	3.73	11.64	5.86	9.14	6.41
Change from baseline			-15%	6%	-30%	67%	-45%	83%
Net returns (dollar/acre)	213.67	48.74	174.25	54.98	120.84	14.47	53.45	9.48
Change from baseline			-18%	13%	-43%	-70%	-75%	-81%
Sherman	**Baseline**		**15% Redc.**		**30% Redc.**		**45% Redc.**	
	Year 1	Year 60	Year 1	Year 60	Year 1	Year 60	Year 1	Year 60
Saturated thickness (feet)	182	51.69	182	53.86	182	58.69	182	70.59
Change from baseline				4%		14%		37%
Water applied (inch/acre)	13.89	3.13	12.83	3.4	10.56	4.03	8.3	5.83
Change from baseline			-8%	9%	-24%	29%	-40%	86%
Net returns (dollar/acre)	173.12	40.09	162.31	47.35	125.12	60.68	72.82	14.61
Change from baseline			-6%	18%	-28%	51%	-58%	-64%
Moore	**Baseline**		**15% Redc.**		**30% Redc.**		**45% Redc.**	
	Year 1	Year 60	Year 1	Year 60	Year 1	Year 60	Year 1	Year 60
Saturated thickness (feet)	162	42.65	162	48.94	162	51.93	162	56.24
Change from baseline				15%		22%		32%
Water applied (inch/acre)	11.93	2.86	11.28	3.77	9.29	4.24	7.3	4.98
Change from baseline			-5%	32%	-22%	48%	-39%	74%
Net returns (dollar/acre)	170.15	18.65	162.77	14.51	128.03	12.65	79.42	9.84
Change from baseline			-4%	-22%	-25%	-32%	-53%	-47%
Hartley	**Baseline**		**15% Redc.**		**30% Redc.**		**45% Redc.**	
	Year 1	Year 60	Year 1	Year 60	Year 1	Year 60	Year 1	Year 60
Saturated thickness (feet)	153	60.55	153	62.11	153	70.56	153	77.11
Change from baseline				3%		17%		27%
Water applied (inch/acre)	18.69	4.68	15.89	4.93	13.08	6.35	10.28	7.59
Change from baseline			-15%	5%	-30%	36%	-45%	62%
Net returns (dollar/acre)	226.34	65.35	186.69	70.54	131.26	7.28	60.05	3.14
Change from baseline			-18%	8%	-42%	-89%	-73%	-95%

models are dynamic optimization models, which are guided by the profitability and production costs of commodities in the base year. In this study, crop budgets for the year 2009 were utilized in the models for calculating the net revenue and the net present value for each county on a per acre basis and did not consider changes in commodity prices or input costs over time (in 2009 dollars). Therefore, the most optimal and profitable combinations of crop mix for a given county are depicted by the model, given the current water use and its future availability over the planning horizon.

CONCLUSIONS

The results from this study indicate that in all 4 counties, there was a greater reduction in net present value per acre with increasing rates of restriction scenarios when compared to the baseline. Under the unconstrained baseline scenario, the counties of study show a decline in saturated thickness over a 60-year planning horizon that recommends the incorporation of water-use restriction alternatives at different rates. As shown by the results, the reduction in net present value per acre becomes higher with increase in water-use restriction rates for all the counties in the study area, and therefore it is important to analyze the socio-economic effects of the same. This study faced limitations with regard to the availability of data sets for several parameters across similar time frames. Therefore, it is important to mention that although these were the most recent datasets pertaining to individual parameters, the economic results obtained through the model may be impacted by the input parameters, if used across different years. While considering water conservation policy alternatives for the Ogallala Aquifer, it is crucial to realize the set of legislative norms that govern groundwater use in a particular region or state. The rule of capture, still being the primary law governing underground water use in the State of Texas, limits the incorporation of water policy alternatives unless suitable relaxations or changes are made as deemed necessary by groundwater conservation districts in the region. Therefore, it is of vital importance that studies be carried out that address these issues and analyze the suitability and feasibility of a policy like multi-year allocation in the light of legislative and political scenarios.

Another interesting possibility in the research direction of this policy could be the incorporation of a moving 5-year constraint in the model that will permit 'carry-over' of unused water and also take into consideration stochastic weather conditions and change in recharge rate. This will allow the researchers to achieve the possibility of finding suitable optimization scenarios to overcome production risk in a multi-year allocation model.

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Documentation of a recharge-discharge water budget and main streambed recharge volumes, and fundamental evaluation of groundwater tracer studies for the Barton Springs segment of the Edwards Aquifer

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Abstract: Data and information reveal that the Edwards Aquifer between Lady Bird Lake (the Colorado River) in Austin, Texas and the "groundwater divide" near Kyle, Texas discharges to 2 major springs: Barton Springs and Cold and Deep Eddy Springs. The long-term mean discharges for the springs are 51 cubic feet per second and 5.5 cubic feet per second, respectively. The source for Cold and Deep Eddy Springs probably represents Dry Creek in the Rollingwood, Texas area and a small amount of recharge water from Barton Creek.

Additional springflow, which periodically discharges from the lower reach of Barton Creek immediately upstream from Barton Springs, varies from zero when Barton Springs is flowing about 50 cubic feet per second to about 5 cubic feet per second during extreme high-flow conditions at Barton Springs. Two streamflow gain-loss studies on the Colorado River document any other discharges from the Edwards Aquifer to the Colorado River to be nonexistent or minor.

A recharge-discharge water budget for a 32-month period reveals that the total discharge from Barton Springs, Cold and Deep Eddy Springs, the lower reach of Barton Creek, and groundwater pumpage is about 3% less than the surface recharge—a value within the potential error of the measurements. Additionally, for the budget period, recharge within the main channels of the 6 major streams crossing the recharge area account for a minimum of 75% of total recharge. Therefore, long-term recharge within the recharge area from overland flow or tributaries to the main channels represents a maximum of 25% of total recharge, a value equivalent to a mean depth of 2.1 inches per year over the 90-square-mile recharge area, or no more than 6.6% of the long-term mean precipitation of 32 inches per year over the recharge area.

Keywords: Edwards Aquifer, Barton Springs, water budget

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Terms used in paper

Short name or acronym	Descriptive name
BSEACD	Barton Springs/Edwards Aquifer Conservation District
TBWE	Texas Board of Water Engineers
USGS	U.S. Geological Survey

INTRODUCTION

Barton Springs discharges a relatively hydrologically distinct part of the Edwards Aquifer, commonly referred to as the Barton Springs segment of the Edwards Aquifer. The boundaries for this part of the aquifer are presented in Figure 1. The recharge area for the aquifer is composed mostly of the outcrop of rocks that form the aquifer. The western boundary for the aquifer coincides with the western boundary of the recharge area.

All of the 6 major creeks that cross the recharge area have basins that extend upstream (west) of the aquifer. Figure 1 identifies the contributing area, which covers 264 square miles—about 3 times larger than the 90-square-mile recharge area.

By 1979, streamflow gaging stations were installed and operated by the U.S. Geological Survey (USGS) near the upstream and downstream boundaries of the recharge area on 5 of the 6 streams, so that runoff and recharge volumes could be calculated. Because of the relatively small contributing area for Little Bear Creek, a streamflow station was not installed at the upstream boundary of its recharge area. Recharge volumes are calculated as explained by Slade et al. (1986). Although the recharge calculations account for total recharge within the recharge area, they cannot distinguish among the individual components of recharge that occur in each of the 3 source areas of recharge: the main channels of the 6 major streams; the channels of tributaries to the main streambeds; and the overland flow area within the recharge area. Except during extreme dry conditions, subsurface recharge and discharge to the aquifer are believed to be minimal (Slade et al. 1986).

By 1979, 12 precipitation gages were installed within the 6 basins. The distribution of precipitation measured with these gages has been used to construct a water budget that documents the fate of precipitation on the recharge and contributing areas: in other words, the amounts of recharge, runoff, and evapotranspiration (Woodruff 1984; Slade et al. 1986). The budget indicates that recharge represented 6% of precipitation; runoff represented 9% of precipitation; and evapotranspiration represented 85% of precipitation.

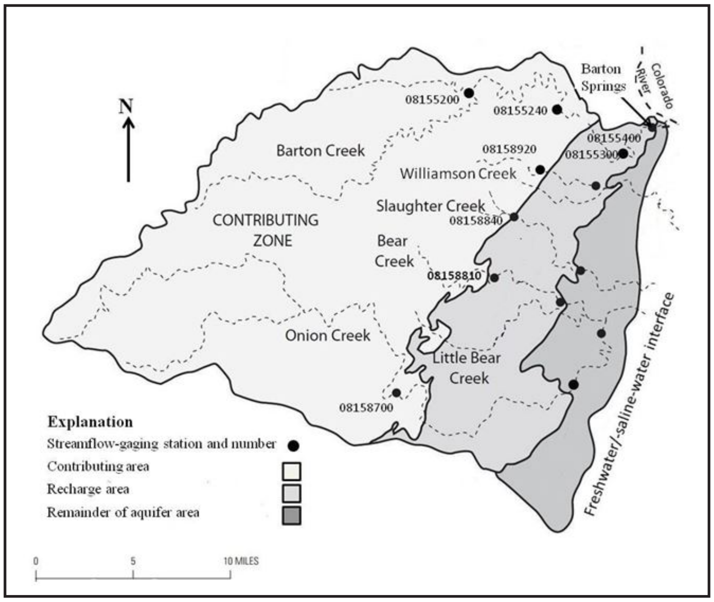

Figure 1. Boundaries for the aquifer, recharge area, and contributing area and locations of streamflow gaging stations.

PURPOSE OF REPORT

The purpose of this report is to refine the components of a recharge-discharge water budget for the Barton Spring segment of the Edwards Aquifer reported by Slade (1986) and to quantify the recharge that occurs in the main channels of the 6 major streams that cross the recharge area, as well as the recharge that occurs within the recharge area but outside the main channels. A secondary purpose is to provide a fundamental analysis of groundwater tracer studies that have been conducted in the aquifer.

LONG-TERM MEAN DISCHARGE FROM BARTON SPRINGS

The USGS has measured the discharge of Barton Springs since 1894. Beginning in 1917, more frequent measurements of springflow have been made. In 1978, a springflow gaging station was installed at the springs, providing daily-mean springflow values since then. The measurements and gaged springflow for Barton Springs include 3 major springs, 1 of which discharges into the swimming pool. The other 2 springs, locally named Concession (Eliza) Springs and Old Mill Springs, discharge into Barton Creek immediately downstream from the pool.

The monthly-mean and annual-mean discharge values for Barton Springs for 1917–1982 were estimated based on 725 discharge measurements made during 1917–1978, and daily-mean discharge gaged during 1979–1982 (Slade et al. 1986). Precipitation records for the city of Austin, published by the National Weather Service, were used to estimate springflow values for the intervals of missing measurements between 1917 and 82. Considering the reconstructed record of monthly-mean springflow during 1917–82, the mean and median values of Barton Springs discharge is 50 cubic feet per second and 46 cubic feet per second, respectively. The maximum and minimum measured discharges are 166 cubic feet per second and 10 cubic feet per second, respectively. Pumpage from the aquifer has been inventoried by the Texas Water Development Board and the Barton Springs/Edwards Aquifer Conservation District (BSEACD). For the 1917–1982 period, the mean rate of pumpage from the aquifer was about 0.8 cubic feet per second (Kent Butler, University of Texas School of Architecture, written communications 2010), thus the long-term mean discharge (springflow and pumpage) for Barton Springs is about 51 cubic feet per second. Additionally, the author and BSEACD (written communications 2013) believe that all pumpage from the aquifer represents an equal rate of reduced springflow because no evidence exists that pumpage volumes are returned to the aquifer. Additionally, other than the lowest reach of Barton Creek, the unsaturated zone of the aquifer exceeds 100 feet, and no evidence exists that reduced groundwater levels due to pumpage have caused increased recharge to the aquifer.

RECHARGE-DISCHARGE WATER BUDGET

Explanations for a 32-month recharge-discharge budget (December 1979–July 1982) were presented by Slade et al. (1986). The assumptions and qualifications for the calculation of the budget are presented on pages 43-73 in that report. Because the springflow and groundwater levels were comparable for the beginning and end of the December 1979 to July 1982 period, overall changes in aquifer storage are assumed insignificant. Whereas the budget's elements of discharge represent Barton Springs discharge, pumpage, and an estimate of the discharge for Cold and Deep Eddy Springs, recharge represents that calculated from the 6 major streams discussed above.

Of note is the fact that the water budget is characterized by 12% more surface recharge than surface discharge (Slade et al. 1986). Several explanations are presented for the discharge deficit, including the possibility that part of the recharge in Barton Creek could discharge to Cold and Deep Eddy Springs. Subsequent groundwater dye studies, explained later in this report, verify that part of the water that recharges in Barton Creek discharges from Cold and Deep Eddy Springs (Figure 2). Additionally, when groundwater levels are sufficiently high, several intermittent springs discharge from the streambed in the lower reach of Barton Creek immediately upstream from Barton Springs.

The following information and data are analyzed and used as basis for a revision in the original water budget.

Cold and Deep Eddy Springs

The location of Cold and Deep Eddy Springs is presented in Figure 2. A search of historical data for these springs reveals only 11 discharge measurements. However, part of the springflow now discharges below the level of Town Lake (now known as Lady Bird Lake), built in 1960 (Brune 1975). The measured springflow ranges from zero (during a severe drought in 1955) to a maximum of 8.2 cubic feet per second, and the mean discharge is 4.8 cubic feet per second (Table 1). The mean value is based on all but 2 measurements made before 1960, and the 1997 and 2008 measurements.

The 1914 measurement was excluded from the calculation of mean discharge because the discharge for Barton Springs was unknown for that date, and the 1955 springflow measurement of zero was excluded because it was made during a severe drought. The 1997 and 2008 measurements were included in the calculation of the mean discharge because the lake was lowered during the measurements, thus these measurements represent total springflow. It is believed that the 1972, 1979, and 1999 measurements were made when at least some of the springflow was below the lake level, thus not included in the measured discharges.

The discharge was estimated at Barton Springs for the same dates as the measurements of discharge from Cold and Deep Eddy Springs (Table 1). The mean discharge of Barton Springs for the 6 measurements used to calculate the mean discharge for Cold and Deep Eddy Springs is 45 cubic feet per second, which is 88% of Barton Springs' long-term mean springflow of 51 cubic feet per second. The assumption was made that the mean discharge for the 6 measurements of Cold and Deep Eddy Springs (4.8 cubic feet per second) also is 88% of its long-term mean discharge. Based on this assumption, the long-term mean discharge for Cold and Deep Eddy Springs is estimated to be 5.5 cubic feet per second.

Evidence that recharge in Barton Creek is conveyed to Cold and Deep Eddy Springs is presented by Slade et al. (1986). Periodically, Barton Springs pool was partially drained so that the pool walls could be cleaned. A roughly 4-foot drop

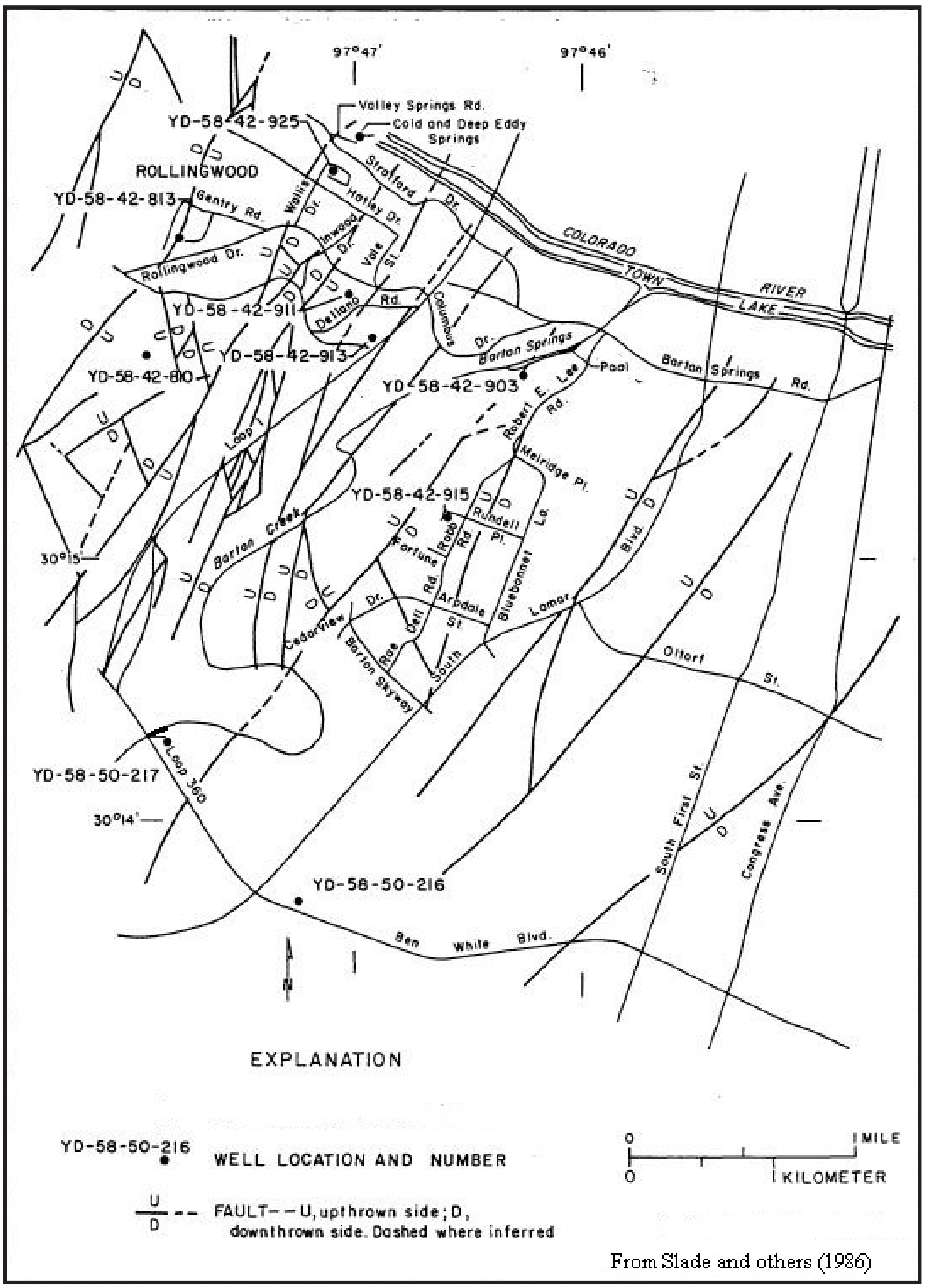

Figure 2. Mapped fault traces proximate to Barton Springs and Cold and Deep Eddy Springs.

Table 1. Discharge measurements for Cold and Deep Eddy Springs.

Date	Cold and Deep Eddy	Barton Springs
	Discharge	Discharge
	(cubic feet per second)	(cubic feet per second)
Aug. ?, 1914 [1]	4.2	unknown
Aug. ?, 1916 [2]	**3 to 4**	**31**
Aug. ?, 1917 [3]	**4.2**	**15**
Aug. 10, 1918 [4]	**3.7**	**14.3**
Feb. 8, 1941 [3,5]	**3.0**	**61**
1955 [3,6]	0	17
May ?, 1972 [3]	2.9	84
Dec. 19, 1979 [6]	2.6	46
Nov. 4, 1997 [7,8]	**6.4**	**84**
Oct. 18, 1999 [7]	4.8	33
Jan. 29, 2008 [7]	**8.2**	**66**
Mean value	**4.8**	**45**

Note: Only measurements in bold used for calculation of mean value. Part of flow for other measurements likely below lake level and thus not included in mean value.

[1] Brune and Duffin 1983.

[2] Source unknown

[3] Brune 1975.

[4] TBWE 1960.

[5] TBWE 1959.

[6] Mike Dorsey, U.S. Geological Survey, personal communications.

[7] David Johns, Watershed Management Dept., City of Austin, personal communications.

[8] 4.5 cubic feet per second directly measured and 1.9 cubic feet per second estimated.

in the pool water level generally occurred during such times. Measurements confirm that water levels in each of the 3 wells south of the pool also decline during such times, thus indicating hydrologic communication among these wells and Barton Springs. However, none of the 4 wells west of Barton Creek (Figure 2) displayed a decline in water levels during such periods. Considering the likelihood that dissolution cavities have developed along the fault traces from Barton Creek to Cold and Deep Eddy Springs, the permeability associated with such cavities likely conveys water from Barton Creek to Cold and Deep Eddy Springs. In contrast, vertical displacement along these same faults probably create barriers to groundwater flow perpendicular to the faults: in other words, groundwater that might otherwise move to Barton Springs from areas immediately west likely is routed to Cold and Deep Eddy Springs.

The February 8, 1941 measurement of 3.0 cubic feet per second at Cold and Deep Eddy Springs (Table 1) was made during relatively high-flow conditions for Barton Creek immediately upstream from Barton Springs—probably about 100 cubic feet per second (TBWE 1959). The limited discharge from Cold and Deep Eddy Springs even during high-flow conditions for its source (Barton Creek), likely indicates that the discharge from Cold and Deep Eddy Springs is limited for most if not all flow conditions.

Groundwater dye tracing studies as indicators of flow to Cold and Deep Eddy Springs

The BSEACD and city of Austin (Hauwert et al. 2004) have conducted dye tracer studies to identify flow paths and travel times within the aquifer. A summary of the results are presented in Table 2, on pages 43-45 in the report. They report that dye was detected at Cold and Deep Eddy Springs after dye injections at Barton Creek at Loop 360 (Figure 2; Hauwert et al. 2004), and at Mopac bridge (Hauwert et al. 2004), about 2,000 feet west of the Loop 360 bridge. The same report indicates that an unknown volume of dye was detected at Cold and Deep Eddy Springs following a dye injection in a well in the Williamson Creek Basin (site F). However, during that injection Barton Springs was discharging 110 cubic feet per second (Hauwert et al. 2004), representing extreme high-flow conditions. Therefore, it is possible that the dye was routed during this injection to Cold and Deep Eddy rather than to Barton Springs because the groundwater conduits between Barton Creek and Barton Springs were at or near full capacity. Also, during this injection, groundwater levels were extremely high adjacent to Barton Springs, which might have caused the dye to move to Cold and Deep Eddy Springs rather than to Barton Springs.

Additionally, the path and travel time for off-stream sites might not be the same as the path and travel time in the streambeds where most recharge occurs. For example, Hauwert et al. (2004) report that dye injections at 2 other sites in the Williamson Creek Basin (both in streambeds) were detected at Barton Springs rather than Cold and Deep Eddy Springs (sites C and D). One of the stream channel injection sites (site D) is only about three-quarters of a mile from the well that transmitted dye to Cold and Deep Eddy Springs (Hauwert et al. 2004). Finally, review of mapped faults in the area reveal that a major fault extending south from Cold and Deep Eddy Springs passes through the area along Barton Creek between Loop 360 and Mopac bridge and is proximate to the well in the Williamson Creek Basin (Slade et al. 1986). However, the well is not a recharge source for the Williamson Creek Basin, and no evidence was found that recharge in the Williamson Creek Basin discharges to Cold and Deep Eddy Springs.

Regardless, the long-term mean discharge for Cold and Deep Eddy Springs is limited to only about 5.5 cubic feet per second, thus the source recharge area for these springs likely is confined to Dry Creek, a watershed of about 4 square miles in the Rollingwood area (Figure 2), and a limited reach of Barton Creek under at least most flow conditions.

Discharge from intermittent springs in the lower reach of Barton Creek

When groundwater levels are sufficiently high, the top of the saturated zone is at or above the bottom of the creek bed for a reach of Barton Creek immediately upstream from Barton Springs. Under such relatively high-flow conditions, the stream reach discharges water from the aquifer. These discharges are believed to be limited to the stream reach between Loop 360 and Barton Springs (Figure 2). Additionally, a streamflow gain-loss study conducted during high-flow conditions by the USGS in 1980 indicate that the upstream end of the streamflow gain-reach in Barton Creek is immediately downstream from Loop 360 (Slade et al. 1986).

The streamflow gaging station on Barton Creek at Loop 360 (station number 08155300) was installed in 1977. Beginning about October 1, 1998, a streamflow station was installed on Barton Creek immediately upstream from Barton Springs (station number 08155400) at the downstream end of the recharge reach for the creek and immediately upstream from Barton Springs (Figure 1). For selected periods, streamflow values for the upstream station were subtracted from same-date streamflow values for the downstream station, to calculate the contribution of springflow from the intervening length of streambed. The selected periods represent relatively steady-flow conditions and represent extended durations after runoff-producing precipitation. Such periods were selected with the expectation that additional inflow due to the effects of local runoff, bank storage, and perched groundwater would be nonexistent or minimal. Additionally, to minimize the potential error in the calculated springflow values, only periods representing no flow or very low flow at the Loop 360 station were used in the analyses.

The discharge from Barton Springs is highly and directly correlated with adjacent groundwater levels, especially for wells proximate to the springs (Slade et al. 1986). The data for the 628 days that were selected for analyses within the common 14-year period for the 2 stations represent many periods and long durations.

Figure 3 presents the relation between the springflow from the Barton Creek main channel for the selected dates and the same-date discharge from Barton Springs. The linear equation for the best-fit line from the graph was used to calculate, based on Barton Springs discharge, the contribution of springflow discharging from the Barton Creek main channel for each day in the 32-month water budget.

Other springflow from the aquifer

It has been reported that discharge from the aquifer might occur as springflow along the southern bank of the Colorado River. The Colorado River Valley cuts through much of the Edwards Aquifer, thus it is possible that discharge from the aquifer could discharge to the river in this area.

Such discharge would be difficult if not impossible to ascertain since 1960, when Longhorn Dam was built, which created Lady Bird Lake that inundates much of the river bank. The city of Austin reported that dye from some of its dye studies have been visible in the lake from sources other than Cold and Deep Eddy and Barton Springs, thus indicating that other springs likely discharge from the Edwards Aquifer south of the lake (David Johns, city of Austin, written communications 2013).

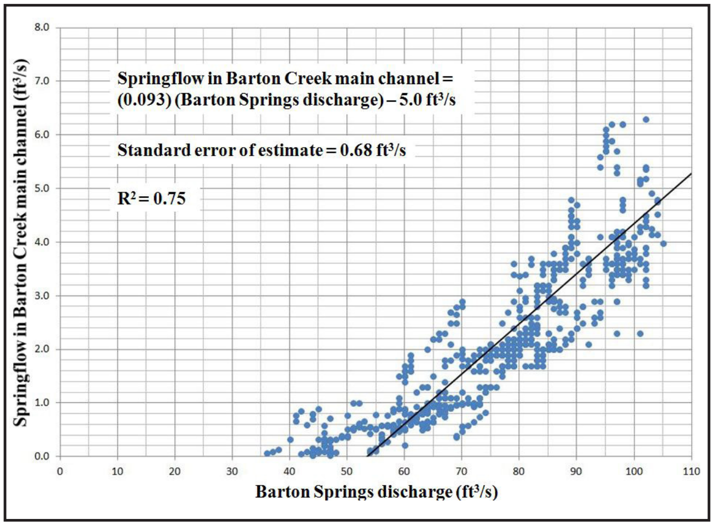

Figure 3. Relation between springflow contribution from the Barton Creek main channel and Barton Springs discharge.

However, the source and discharge for any such springs are unknown.

Prior to the construction of Longhorn Dam, a streamflow gain-loss study was conducted on August 10, 1918 along the Colorado River that included streamflow measurements made immediately upstream and downstream from the river's contact with the Edwards Aquifer. In addition to indicating that 3.7 cubic feet per second discharged from Cold and Deep Eddy Springs (Table 1) and 14.3 cubic feet per second from Barton Creek, these data indicate only 0.4 cubic feet per second of remaining streamflow gain along the reach from Tom Miller Dam (near the western contact of the river and the Edwards Aquifer) to Congress Avenue (about a mile east of the eastern contact between the river and the Edwards Aquifer (TBWE 1960). It is possible that most or all of the 0.4 cubic feet per second gain resulted from groundwater discharge through terrace deposits along the river, from groundwater discharge from the north side of the river, or from surficial runoff outside the Edwards Aquifer. It is also possible that no streamflow gain occurred due to potential error in the streamflow measurements. However, even if the entire 0.4 cubic feet per second represents discharge from the Edwards south of the river, such flow is minor compared to the known springflow discharges and, therefore, deemed too small to appreciably affect the water budget.

Additionally, the results of a streamflow gain-loss study on the Colorado River in 1925 (TBWE 1960) confirm that any other discharges from the Edwards Aquifer to the Colorado River to be nonexistent or insignificant compared to the discharge from Barton Springs and Cold and Deep Eddy Springs.

CALCULATED WATER BUDGET

The 32-month water budget (December 1979–July 1982) as published by Slade et al. (1986) indicates 144,000 acre-feet of surface recharge. During the period, Barton Springs discharged 114,000 acre-feet and pumpage was 10,100 acre-feet (based on 3,800 acre-feet per year (Slade et al. 1986). However, during this period, the mean flow from Barton Springs was 64 cubic feet per second (59 cubic feet per second from Barton Springs and 5 cubic feet per second of pumpage), which is 25% greater than its long-term mean springflow of 51 cubic feet per second. Therefore, the mean springflow from Cold and Deep Eddy (5.5 cubic feet per second) was increased by 25% to account for this springflow during the budget period. This accounts for 6.9 cubic feet per second or 13,300 acre-feet of water from Cold and Deep Eddy Springs during the 32-month period. Additionally, because the component of springflow that occurs in the Barton Creek streambed represents about 1.0 cubic feet per second (1,900 acre-feet during the 32-month period), the total discharge is 139,300 acre-feet—a value about 3.3% less than the recharge. For the budget, the potential error is about 6% for the discharge value and about 8% for the recharge value.

The percentage difference between recharge and discharge for the budget is less than the potential error for each of the 2 components, thus the discharge sources identified in the budget calculations are assumed to represent the vast majority of, if not all, stream recharge. Based on the small percentage difference by which recharge exceeds discharge, the discharge rate for any springflow sources not identified in these analyses would be minor compared to those for the identified sources.

During dry periods, a relatively small amount of subsurface recharge enters the Barton Springs segment of the Edwards Aquifer south from an area underlying the southern groundwater divide (Slade et al. 1986). Such inflow is considered insignificant for all but the driest conditions with respect to the 32-month budget period discussed above. The BSEACD has conducted several dye studies to qualify subsurface water movement into and from the Barton Springs segment of the Edwards Aquifer. Such reports can be found at http://www.bseacd.org/publications/reports#DyeTracing.

RECHARGE IN MAIN STREAMBEDS

This section presents details involved in the calculation of the total recharge that occurred in the main channel of each of the major streams crossing the recharge area. The period for this analysis is the same as that for the water budget (December 1979–July 1982).

Runoff from the contributing area can recharge in the main channels of the streams within the recharge area, or it can pass through the recharge area. However, runoff within the recharge area can pass through the recharge area, or it can become recharge within 3 source areas: overland-flow areas, tributaries to the main channels, and in the main channels. The origin of runoff measured at the downstream end of the recharge area cannot be distinguished with respect to specific source (whether from the contributing area or recharge area). Therefore, the analysis below is limited to calculation of total recharge in the main channels, regardless of source.

Streamflow is gaged on the main stream channels at the upstream and downstream ends of the recharge area. As explained later, each main channel has a maximum potential recharge rate that can be conveyed to the aquifer. For each stream, when the gaged flow at the upstream end of the recharge area is less than the maximum recharge rate for the channel, the gaged flow represents the total recharge in the main channel. However, when the gaged upstream flow exceeds the maximum recharge rate, the recharge rate in the main channel is limited to that of the maximum recharge rate.

Maximum recharge rates for main streambeds

The results of previous streamflow gain-loss studies (Slade et al. 1986) and review of daily-mean streamflow data for the streamflow gaging stations reveal that recharge to the Edwards Aquifer through each main channel is limited to a maximum rate. Based on results from these studies and data, such recharge rates were estimated by Slade et al. (1986), as presented in Table 2.

During extreme flooding conditions, instantaneous (short-term) maximum recharge rates likely exceed those indicated above by the streamflow gain-loss studies and daily-mean streamflow because higher water levels in the streams increase the wetted perimeter of the channel and likely inundate additional surface porosity associated with the faults and fractures that convey recharge to the aquifer. Also, greater water levels likely cause increased recharge due to higher water pressure over the inundated porosity. However, the maximum recharge for large floods probably cannot be documented; such discharges exist only during highly unsteady flow conditions, when stream channel flow losses are difficult or impossible to document. However, extreme floods rarely occur (perhaps a few times per year at most) and exist for only short durations, thus it is likely that any increased maximum recharge from such floods produces only a minimal increase on the recharge volumes as calculated herein.

Table 2. Maximum recharge rates for main streambeds.

Stream	Maximum recharge (cubic feet per second)
Barton	30 to about 70
Williamson	13
Slaughter	52
Bear	33
Little Bear	about 30
Onion	about 120

Table 2 indicates the extent to which maximum recharge rates vary for Barton Creek. The indicated observations are based on varying stream channel losses from streamflow gain-loss studies on the creek (Slade et al. 1986) and on varying differences between the same-date gaged streamflow at the upstream and downstream boundaries of the recharge area for Barton Creek. Additionally, a substantial part of the total recharge in Onion Creek often occurs through Antioch Cave near the downstream end of the recharge area in the Onion Creek streambed. However, the cave often becomes partially plugged with debris, thus reducing its recharge rate. Therefore, 100 cubic feet per second was used in this analysis as the maximum recharge for the Onion Creek main channel.

Maximum recharge rates for Barton Creek streambed

The maximum recharge rate for Barton Creek varies from 30 cubic feet per second to about 70 cubic feet per second depending upon the relative height of groundwater levels under the streambed. When groundwater levels are low, the saturated zone is below the altitude of the Barton Creek streambed throughout the recharge area, such that the maximum recharge that can occur is limited to a rate of about 70 cubic feet per second. When the groundwater levels are extremely high, their altitudes are comparable to or higher than the streambed for a long reach of the creek immediately upstream from Barton Springs, and thus, that reach will reject recharge. During periods of high groundwater levels, a maximum of only about 30 cubic feet per second of recharge will occur on Barton Creek.

An effort was made herein to document, for various groundwater-level conditions, the maximum recharge rate that occurs in the main Barton Creek channel. A streamflow gain-loss study, conducted by the USGS during high steady-flow conditions on May 29, 1980 (Slade et al. 1986), indicated that the upstream end of the recharge reach on Barton Creek is located near Lost Creek Boulevard (station 08155240). Beginning about October 1, 1998, a streamflow station (08155400) was installed on Barton Creek immediately upstream from Barton Springs; it is located at the downstream boundary of the recharge reach for the creek.

For selected dates representing various groundwater level conditions, streamflow values for the downstream station (08155400) were subtracted from same-date streamflow values for the upstream station (08155240) to obtain maximum recharge rates that occurred on the main channel of the creek. The selected dates represent extended periods after runoff-producing rainfall and relatively steady-flow conditions during which streamflow was occurring at the downstream station. Additionally, efforts were made to exclude extended "wet" periods—periods for which tributary flow, bank storage, and perched groundwater flow might be contributing flow to the channel reach between the gaging stations. Groundwater pumpage and return flows to the creek are believed to be minimal or nonexistent, and no major impoundments exist in the streambed between the stations. The discharge at Barton Springs is directly and highly correlated with groundwater levels in the area. Eighty-four dates met the above criteria and were identified within the 14-year common period.

Figure 4 presents the relation between the maximum recharge rates for the selected dates and the same-date discharge from Barton Springs. The equation for the best-fit line from the graph was used to calculate, based on Barton Springs discharge, the maximum recharge rates for the main Barton Creek streambed.

Calculation of recharge in main streambeds

The daily-mean recharge for the water budget period (December 1979–July 1982) was calculated and summed for the main channels of 5 of the 6 major streams. Little Bear Creek was excluded from this calculation because a streamflow station was not installed at the upstream end of its recharge area.

The recharge calculation is based on daily-mean streamflow values for the following stations near the upstream end of the recharge area: 08155200 Barton Creek at Highway 71, 08155240 Barton Creek at Lost Creek Boulevard, 08158920 Williamson Creek at Oak Hill, 08158840 Slaughter Creek at FM Road 1826, 08158810 Bear Creek below FM Road 1826,

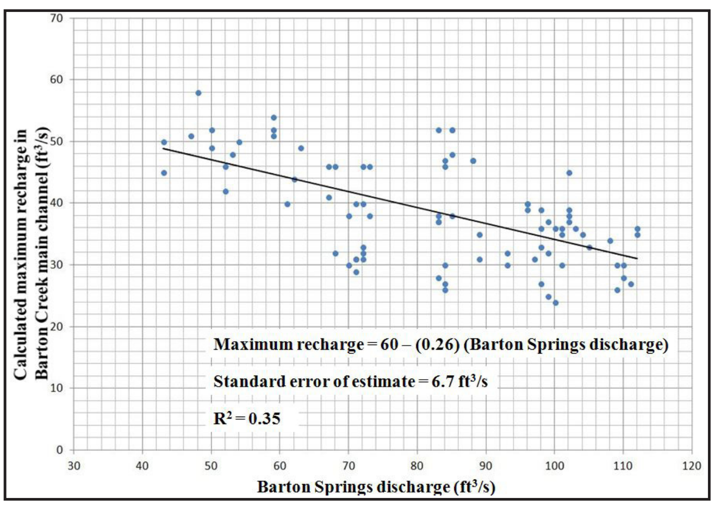

Figure 4. Relation between maximum recharge rates in Barton Creek main channel and Barton Springs discharge.

and 08158700 Onion Creek near Driftwood. The data are available from the USGS online at http://waterdata.usgs.gov/tx/nwis/dv/?referred_module=sw.

The gaging station Barton Creek at Lost Creek Boulevard was not yet in operation during the water budget period; all of the remaining stations listed above were in operation during the period. Review of the same-date streamflow for the Lost Creek Boulevard station and the upstream station Barton Creek at Highway 71 indicate that streamflow at the Lost Creek Boulevard station is 21% greater than that at the Highway 71 station. Therefore, the streamflow at the Highway 71 station was increased by 21% to represent the streamflow at the upstream end of the recharge reach for Barton Creek.

The calculation of recharge in the main streambeds is based on gaged streamflow at the upstream end of the recharge area and does not account for runoff entering the main channels from the recharge area. However, most recharge in the main channels is from the contributing area because this area is about 3 times larger than the recharge area. Additionally, unit runoff (runoff per square mile) from the recharge area to the main channels likely is slightly less than that from the contributing area because some of the runoff from the recharge area is lost as recharge within the recharge area, thus is not received in the main channels.

Nevertheless, runoff from the recharge area sometimes enters the main channels. However, because of the relatively limited size of the recharge area and its tributaries, most such runoff occurs within a few days after runoff-producing storms. During such periods, streamflow in the main channels usually is substantial and often exceeds the maximum recharge rate for the streams. The calculated main-channel recharge for such periods is based on the maximum recharge rate for the main channels, thus most of the runoff from the recharge area into the main channels does not cause increased recharge in the main channels. However, on some occasions, runoff from the recharge area enters the main channels when the main-channel streamflow is less than the maximum recharge rate. For such periods, the actual main-channel recharge would be greater than calculated by this analysis. Therefore, the main streambed recharge as calculated herein is considered to be a minimum value.

Based on the calculation, the total recharge on the main channels is 99,900 acre-feet, which represents 69% of the total recharge of 144,000 acre-feet for the period. However, Little Bear Creek was excluded from this analysis. The length of the main channel and the size of the drainage area of Little Bear Creek are comparable to those of Bear Creek, thus the assumption was made that Little Bear Creek produces an equivalent volume of main-channel recharge as does Bear Creek. Therefore, the total main-channel recharge for the 6 streams is 108,200 acre-feet—a value representing a lower limit of 75%

of total recharge. Main-streambed recharge and total-basin recharge, by basin, is presented in Table 3.

Main-channel recharge as a percentage of total recharge ranges substantially between the basins. However, as Table 3 indicates, such percentages are directly related to the relative size of the contributing area as a percentage of the total drainage area that contributes to recharge (contributing area and recharge area). Additionally, main-channel recharge as a percent of total recharge is directly related to the maximum recharge rate for the main channel. The maximum recharge rate for the main channel of Onion Creek is substantially greater than that for any of the other streams (Table 2). Therefore, most recharge in the Onion Creek Basin occurs in its main channel.

RECHARGE AS OVERLAND FLOW AND IN TRIBUTARIES TO MAIN STREAM CHANNELS

Recharge that does not occur in the main channels occurs within the recharge area as overland flow (including local karst features) or in tributaries to the main channels. Therefore, the upper limit of such recharge is 25% of total recharge.

The long-term (1917–1982) mean discharge from the aquifer is about 56 cubic feet per second (Barton Springs [50 cubic feet per second] + Cold and Deep Eddy Springs [5.5 cubic feet per second] + pumpage [0.8 cubic feet per second]). If discharge is about equal to (within a few percent of) recharge, as indicated by the 1979–1982 water budget, then the long-term mean upper limit for recharge from overland flow and tributaries is about 14 cubic feet per second (0.25 x 56 cubic feet per second). Fourteen cubic feet per second is equivalent to a recharge rate of 2.1 inches per year over the 90-square-mile recharge area, or about 6.6% of the long-term mean precipitation of 32 inches per year over the recharge area.

SUMMARY AND CONCLUSIONS

Recharge-discharge water budgets

The recharge-discharge water budget presented herein (December 1979–July 1982) contains inherent potential error. During the budget period, Barton Springs represented most of the total discharge. Springflow from Barton Springs is gaged by the USGS and has minimal potential error. Withdrawals during the budget period averaged only about 5 cubic feet per second—less than 10% of total discharge. Therefore, even though a relatively large potential error exists for much of the pumpage (which is not metered), the potential error for the total discharge is minimal.

A recharge-discharge water budget analysis for a period other than that presented in this report (December 1979–July 1982) would provide beneficial additional information regarding analyses of the volumes of surface recharge and surface discharge. However, the author is unaware of any other recharge-discharge budgets for this area.

The streamflow station at the downstream end of the recharge area for Onion Creek was discontinued in 1996, thus a budget since then would contain substantial uncertainty for recharge on that stream. Additionally, any attempts to calculate recent recharge and discharge volumes would result in large potential errors in such values due to the following:

- Groundwater withdrawals have been increasing substantially over the past many years and currently represent more than 20% of the long-term mean discharge for Barton Springs. Much of the pumpage is not metered, thus estimates of recent total pumpage and, thus total discharge would contain large potential errors.
- Urban development has increased substantially over the recharge area during the past many years. Recharge volumes due to water leakage in water distribution pipes,

Table 3. Main-channel recharge and total-basin recharge by basin, December 1979–July 1982.

Stream name	Recharge (acre-feet)		Main-channel recharge as % of total-basin recharge	Contributing drainage area as % of contributing area and recharge area
	Main channel	Total basin		
Barton	34,800	39,541	88	87
Williamson	3,400	9,248	37	33
Slaughter	5,800	17,163	34	36
Bear	8,300	14,388	58	51
Little bear	8,300[1]	14,421	58	11
Onion	47,600	49,146	97	86
Total	108,200	144,000	75	75

[1] Estimated from main-channel recharge in Bear Creek main channel.

landscape irrigation, disposal of wastewater, and leaking wastewater pipes are unknown.

- Recharge enhancement structures and strategies in Onion and Little Bear creeks have created large uncertainties in estimating recharge rates for those streams.

Recharge in main streambeds

The analysis method used herein to calculate recharge in the main streambeds contains inherent bias that probably represents most of the potential error in the calculated values. For example, as explained earlier, runoff occasionally enters the main channel from the recharge area when the maximum recharge rate for the main channel is not occurring. Such runoff is not included in the calculations of recharge on the main channels. Also, as explained within the report, during relatively large floods, recharge rates for main channels likely exceed those documented in this report. Both of these factors are the source for additional main-channel recharge not calculated herein. The total calculated main-channel recharge is qualified as representing a minimum (lower limit) value. It is unlikely that the volumes for either of the 2 sources of additional recharge could be estimated without substantial potential error in their values. The author believes that it is likely that actual main-channel recharge could represent as much as 78-80% of total recharge.

Groundwater tracer studies

Much data and information regarding the hydrology of the Barton Springs segment of the Edwards Aquifer have been collected during the past years by many entities and individuals. It is likely that groundwater tracer studies could provide the most beneficial information regarding the advancement of hydrologic knowledge of the aquifer. As discussed earlier, the BSEACD and city of Austin have conducted groundwater dye tracer studies for 18 sites in the study area (Hauwert et al. 2004). Much has been learned from such studies but additional dye studies could provide substantially more knowledge.

Because of the karstic nature of the aquifer and because most recharge occurs on the main channels of the stream, substantial porosity has developed under the stream channels and along a major path to the discharge point of Barton Springs. For example, results from groundwater models document large transmissivity values under streambeds and, in the eastern part of the aquifer, along a conduit flow path to Barton Springs (Slade et al. 1985; SRI 2009). However, one-half of the existing dye studies represent off-stream point injections (in wells and sinkholes) for which the dyes "were generally flushed into the aquifer with approximately 10,000 gallons of water to carry the dye to the water table." It is likely that the travel paths and travel times of the dye from the off-stream sites are not indicative of paths and travel times for streambed recharge.

Additionally, flow paths and travel times can vary substantially with flow conditions. For 1 of the only 2 sites with a repeated dye injection, Antioch Cave on Onion Creek, the flow path for the injections differed during the low-flow and high-flow conditions for Barton Springs (Hauwert et al. 2004). Single dye studies represent the flow path and travel time during a specific flow condition; additional injections for a range in Barton Springs flow conditions would document the range in flow paths and travel times.

All the dye studies represent point injections; no stream reaches have been tested. Needed are dye studies for which dye is injected at the upstream end of the recharge reach of each of the main streams during periods when recharge is occurring throughout or at least throughout most of the recharge reach. Additionally, such studies should be repeated for varying flow conditions at Barton Springs. The results of such dye studies would represent the time of travel of most of the recharge to the aquifer—that in the main stream channels and thus would represent actual recharge conditions.

Finally, documentation of the groundwater travel time from the streams to the springs would provide valuable information regarding spills of toxic substances into the streams or watersheds of the streams. The area is rapidly developing and it is likely that such a spill would occur in the future. Additionally, several groundwater models (Slade et al. 1985; SRI 2009) have been developed for the Barton Springs segment of the Edwards Aquifer. All such models contain substantial potential error, which could be reduced if recharge travel times from the streams to the springs were documented. Finally, a viable water quality model has not been identified for the aquifer. Information about the time of travel and dispersion characteristics from the streams to Barton Springs would be needed for such a model. In summary, tracer studies on the stream reaches would provide needed data and information for toxic spills and future groundwater models involving flow or water quality characteristics.

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A battle ends, but the fight for water in Oklahoma continues

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Abstract: As the lifeblood of land and communities, water will forever remain at the center of people's lives in the arid Southwestern United States and, given the scarcity of water resources, at the center of their disputes. In Oklahoma, disputes over water seem unending with entities in North Texas seeking access to desperately needed water supplies in the Red River Basin, and Indian Nations claiming tribal rights to water in southeastern Oklahoma. Given the recent decision in *Tarrant Regional Water District v. Herrmann*, Oklahoma seems to have at least settled, for the time being, one dispute, leaving North Texas entities looking to develop additional water supplies elsewhere. But, Oklahoma's battle with the Chocktaw and Chickasaw Nations over rights to water in southeastern Oklahoma appears to just be heating up as drought conditions do the same.

Key words: water supply, constitutional law, interstate compacts, tribal water rights

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Terms used in paper

Short name or acronym	Descriptive name
TRWD	Tarrant Regional Water District
OWRB	Oklahoma Water Resources Board
OCWUT	Oklahoma City Water Utility Trust

VAST, UNTAPPED WATER SUPPLIES IN OKLAHOMA

Surface water supplies abound in Oklahoma with flowing streams and relatively full reservoirs. The State of Oklahoma recognizes the vast water supplies it has and that it is "blessed with an abundance of water."[1] Of its prolific surface water supplies, Oklahoma taps only 1.87 million acre-feet and allows the remainder to be discharged to the Gulf of Mexico, unused and wasted.[2] This unused and wasted amount is a staggering 36 million acre-feet of stream water.[3] By 2060, Oklahoma is only expected to use 2.48 million acre-feet, which means that water will continue to be unused as a public water supply for *decades* while other regions desperately needing such supply continue to suffer.[4]

Although Oklahoma has experienced drought conditions, such drought conditions pale in comparison to the devastating conditions experienced in Texas. The year 2011 marked the state of Texas's worst recorded 1-year drought since rainfall data was first recorded in 1895.[5] According to the U.S. Drought Monitor, a majority of Texas was rated as being in "exceptional drought," the worst rating for drought conditions, and other areas of Texas were rated as at least "extreme" or "severe."[6] The drought caused streams to run low, if at all, and reservoirs to operate at 50% capacity.[7] In August 2011, lake levels at Lakes Travis and Buchanan were so low that only one boat ramp remained open for both lakes—significantly impacting recreation on the lakes.[8] Not surprisingly, the drought's impact on agriculture was just as crippling and resulted in a record $5.2 billion in agricultural losses, making it the most costly drought on record.[9]

In addition to these ongoing drought conditions, the State of Texas also faces a growing population that demands additional water supplies. The *Water for Texas 2012 State Water Plan* provides that Texas is the second most populated state in the United States, and it had a greater population growth than any other state between 2000 and 2010—increasing from 20.8 million to 25.1 million.[10] And, from 2010 to 2060, this population is expected to grow approximately 80% to 46.3 million.[11] This estimated growth luckily does not have a corresponding percent increase in demand for water; water demand is only projected to increase by 22%, given the implementation of water conservation and water reuse.[12] Even so, based on the current inability to meet existing water demands due to ongoing drought conditions, additional water supplies must be developed to also meet this increased demand.

In North Texas, securing additional water supplies is extremely critical. The North Texas region that includes the Dallas-Fort Worth Metroplex contains approximately 26% of Texas's population.[13] By 2060, the population of the region is projected to grow 96% with water demands increasing 86%.[14] To meet these demands, North Texas water suppliers, in addition to continuing water conservation efforts, must develop new supplies of water, and with the vast supplies of water in Oklahoma going unused, obtaining water supplies from Oklahoma seems the most logical source from which to obtain such water. Unfortunately, Oklahoma is fighting to keep every drop of its water supplies, even if keeping this water means wasting it by discharging it into the Gulf of Mexico.

TARRANT REGIONAL WATER DISTRICT'S FIGHT FOR WATER IN OKLAHOMA

The fight for water supplies along the Texas-Oklahoma border culminated in a legal battle before the highest court in the land in *Tarrant Regional Water District v. Herrmann*, 133 S.Ct. 2120 (2013). Tarrant Regional Water District (TRWD), a state water agency serving the populous North Texas region, ignited this fight when it sought to obtain water

[1] Oklahoma Water Resources Board, *2012 Oklahoma Comprehensive Water Plan Executive Report 3* (Feb. 2012), *available at* http://www.owrb.ok.gov/supply/ocwp/pdf_ocwp/WaterPlanUpdate/draftreports/OCWP%20Executive%20Rpt%20FINAL.pdf.

[2] Oklahoma Water Resources Board, *Oklahoma Comprehensive Water Plan*, Water Demand Forecast Report Table 27 (Dec. 2012), *available at* http://www.owrb.ok.gov/supply/ocwp/pdf_ocwp/WaterPlanUpdate/WaterDemandForecastReport.pdf.

[3] *Oklahoma Water Facts*, Oklahoma Water Resources Board, http://www.owrb.ok.gov/util/waterfact.php/ (last updated Jan. 14, 2014).

[4] *Id.*

[5] Dan Huber, *The 2011 Texas Drought in a Historical Context*, Center For Climate & Energy Solutions (August 26, 2011), http://www.c2es.org/blog/huberd/2011-texas-drought-historical-context.

[6] *Id.*

[7] *Id.*

[8] *Id.*

[9] Blair Fannin, *Texas agricultural drought losses reach record $5.2 billion*, AgriLife Today (Aug. 17, 2011), http://today.agrilife.org/2011/08/17/texas-agricultural-drought-losses-reach-record-5-2-billion.

[10] Texas Water Development Board, *Water for Texas 2012 State Water Plan* at 129 (2012), *available at* http://www.twdb.state.tx.us/publications/state_water_plan/2012/03.pdf.

[11] *Id.* at 132.

[12] *Id.* at 136.

[13] Texas Water Development Board, *Water for Texas 2012 State Water Plan* at 46 (2012), *available at* http://www.twdb.state.tx.us/publications/state_water_plan/2012/02.pdf.

[14] *Id.*

rights in Oklahoma.[15] In one of the water rights applications it filed with Oklahoma, TRWD proposed to take a portion of Texas's share of water from the Red River Basin within Reach II, subbasin 5 in the Kiamichi River.[16] In anticipation of the Oklahoma Water Resources Board (OWRB) rejecting its water right application, TRWD filed suit in 2007 against the OWRB.[17] Ultimately, the constitutional law arguments central to this legal battle would make their way through the justice system all the way to the U.S. Supreme Court.

TRWD's efforts to export water from Oklahoma and the Red River Compact

In light of the current and future population growth in its service area, TRWD has an ongoing obligation to secure additional water supplies to serve its customers.[18] In an effort to fulfill this obligation, in early 2007 TRWD submitted 3 applications to the OWRB[19] seeking authority to export water from Oklahoma to serve its customers in North Texas.[20] One of these applications sought a permit to appropriate and export 310,000 acre-feet of water from the Kiamichi River in southeastern Oklahoma.[21] At the time TRWD filed its application, Oklahoma state statutes required OWRB to treat in-state applicants more favorably than out-of-state applicants.[22] For example, one set of statutes placed a 5-year moratorium on the export of water outside the state,[23] another applied the moratorium to state, tribal, or intergovernmental cooperative agreements regarding the export of Oklahoma water,[24] and a third provision required legislative approval for out-of-state water use.[25] Collectively, these statutes effectively prohibit the issuance of any permit appropriating Oklahoma surface water for use in another state.

The Kiamichi River—from which TRWD sought to appropriate and export water—is located within the Red River Basin. Water within the Red River Basin is apportioned by the Red River Compact—an interstate compact that was entered into by the states of Oklahoma, Texas, Arkansas, and Louisiana in 1978 after 20 years of negotiations.[26] The U.S. Congress approved the Compact in 1980.[27] The Compact's purpose was to "provide an equitable apportionment" of water within the Red River Basin in an effort to "promote interstate comity and remove causes of controversy" among the signatory states.[28] The Compact divided the river into 5 distinct subdivisions called reaches, each of which was further divided into smaller subbasins.[29]

Ultimately, the Supreme Court's interpretation of the Compact foreclosed TRWD's ability to obtain a water right permit from Oklahoma so long as Oklahoma statutes continue to effectively prohibit out-of-state use of water. The section of the Compact most central to the dispute in *Tarrant Regional Water District v. Herrmann* was Section 5.05(b)(1) that sets forth: "Signatory States…have equal rights to the use of runoff originating in subbasin 5 . . . provided no state is entitled to more than 25 percent of the water in excess of 3,000 cubic feet per second."[30] This section governs Reach II, subbasin 5 and was the subject of major tension during the Compact's negotiation because it requires the upstream states of Oklahoma and Texas to release water from storage to the downstream states of Arkansas and Louisiana. Another section of the Compact that OWRB relied heavily upon during the lawsuit explicitly provides that the signatory states are free to regulate water within their boundaries so long as those regulations are "not

[15] *See* Danny DeBelius, et al., *Water Fight*, National Public Radio, http://stateimpact.npr.org/oklahoma/tarrant-regional-water-district-v-herrmann/ (last visited January 17, 2014) (providing an overview of the water battle before the U.S. Supreme Court case); Janice Francis-Smith, *Water Wars: Can Oklahoma quench Texas' thirst without getting parched?*, Oklahoma City Journal Record, Apr. 29, 2008, http://www.questia.com/newspaper/1P2-16431729/water-wars-can-oklahoma-quench-texas-thirst-without; Tim Talley, *North Texas Eyes Oklahoma Water*, Fort Worth Star-Telegram, Feb. 11, 2011, http://newsok.com/north-texas-eyes-oklahoma-water/article/3540133.

[16] Linda Christie, *Interstate Water Compacts: A License to Hoard?*, 1 Texas A&M Journal of Real Property Law, 15, 26 (2013).

[17] Tarrant Reg'l Water Dist. v. Herrmann, No. CIV-07-0045-HE, 2009 WL 3922803, at *1 (W.D. Okla. Nov. 18, 2009).

[18] The North Texas area encompassing Dallas and Fort Worth increased from 5.1 million residents in 2000 to nearly 6.4 million in 2010, a spike of over 23% and among the most substantial in the United States during this period. *See* Tarrant Reg'l Water Dist. v. Herrmann, 133 S.Ct. 2120 (2013) (citing Dep't of Commerce, Census Bureau, P. Mackun & S. Wilson, Population Distribution and Change: 2000 to 2010 (Mar. 2011)).

[19] Oklahoma created the OWRB to regulate water and issue permits to appropriate water in the state. *See* Okla. Stat. tit. 82, § 105.9.

[20] *Tarrant Reg'l Water Dist.*, 2009 WL 3922803, at *1; Leslie Wimmer, *TRWD Working to Revise Suit in Oklahoma Water Battle*, Fort Worth Business Press, Dec. 7, 2009.

[21] *Tarrant Reg'l Water Dist.*, 2009 WL 3922803, at *1.

[22] *See* Okla. Stat. tit. 82, § 105; Tarrant Reg'l Water Dist. v. Herrmann, 656 F.3d 1222, 1228 (10th Cir. 2011).

[23] Okla Stat. tit. 82 § 1B(A).

[24] *Id.* tit. 74, § 1221.A.

[25] *Id.* tit. 82, § 1085.2(2).

[26] Red River Compact, Pub. L. No. 96-564, 94 Stat. 3305 (1980).

[27] *Id.*

[28] Red River Compact §1.01(a)-(b). Other purposes of the Compact were to promote a program to reduce pollution in the river, provide a means for enforcement for anti-pollution and anti-deterioration efforts, conserve water, and provide a system for state and joint state planning in allocating the river water. *Id.* §1.01(c)-(e).

[29] Red River Compact §§ 2.12, 4.01.

[30] Red River Compact § 5.05(b)(1).

inconsistent with its obligations under the Compact."[31]

In its efforts to obtain water in Oklahoma, TRWD sought to export both surface water and groundwater from within Oklahoma.[32] TRWD sought to appropriate water from Beaver Creek and Cache Creek, both located in Reach I, subbasin 2 of the Red River Basin, and from the Kiamichi River located in Reach II, subbasin 5 of the Red River Basin—with all such water being governed by the Compact.[33] Additionally, TRWD sought to export groundwater by entering into an agreement with private landowners in Stephens County, Oklahoma and through a memorandum of understanding with the Apache Tribe.[34]

District Court's opinion

Concurrent with the filing of its water right applications for water from the Red River Basin, TRWD filed suit in federal district court against the board members of OWRB and the Oklahoma Water Conservation Storage Commission (collectively referred to herein as "OWRB"), seeking a declaratory judgment that "Oklahoma laws unconstitutionally prevented it from appropriating or purchasing water in Oklahoma."[35] Specifically, TRWD argued that Oklahoma's statutes that prevent out-of-state water sales are barred by the Dormant Commerce Clause and Supremacy Clause of the U.S. Constitution.[36] Defendant OWRB filed a motion to dismiss, or in the alternative for summary judgment as to both of TRWD's claims.[37] OWRB argued that the district court lacked subject matter jurisdiction because Oklahoma repealed its restrictions on out-of-state water sales (even though there was no explicit repeal of the statutes), that the Compact controls the issues such that the Red River Compact Commission has primary jurisdiction over resolution of the dispute, and that the Compact constitutes congressional approval precluding TRWD's Dormant Commerce Clause and Supremacy Clause claims.[38] The Commerce Clause, Art. I, § 8, cl. 3 of the U.S. Constitution, grants Congress the exclusive power to regulate the flow of interstate commerce.[39] Interstate commerce has been defined and explained in common law and specifically includes the interstate movement of water.[40] Congress's enumerated grant of power to regulate commerce includes an implicit restriction on state interference with interstate commerce that is referred to as the Dormant Commerce Clause.[41] Congress may, however, approve of state interference with interstate commerce such that it precludes any Commerce Clause violation.[42] In other words, a state will not run afoul of the Commerce Clause if Congress has expressed intent to allow the states to regulate interstate commerce in some way.

The Supremacy Clause of the U.S. Constitution provides that, if Congress exercises authority over a field or "occupies the field," state law within that field's purview is preempted.[43] If Congress has not occupied the field, state law will be preempted only to the extent that it is inconsistent with federal law.[44]

In November 2009, the district court denied OWRB's motion to dismiss on mootness and primary jurisdiction claim, while granting its motion for summary judgment with regard to the Dormant Commerce Clause and Supremacy Clause claims.[45] In addition, the court granted TRWD leave to amend its complaint to address claims not covered by the Compact.[46] In granting OWRB's motion for summary judgment, the court held that Congress's approval of the Compact constituted "a sufficiently clear expression" of intent to authorize Oklahoma's regulatory scheme that would otherwise be contrary to Commerce Clause and Supremacy Clause principles.[47] The court also found that Oklahoma's restriction on out-of-state sales was consistent with the Compact's purpose and language.[48]

TRWD's amended complaint alleged that Oklahoma state law prohibiting the export of water was unconstitutional

[31] *Id.* § 2.10.

[32] *Tarrant Reg'l Water Dist.*, 656 F.3d at 1228.

[33] *Id.*

[34] *Id.*

[35] *Tarrant Reg'l Water Dist.*, 2009 WL 3922803, at *1.

[36] *Id.* at *3.

[37] *Id.* at *1.

[38] *Id.* at *1.

[39] U.S. Constitution article I, § 8, cl. 3.

[40] *See* New England Power Co. v. New Hampshire, 455 U.S. 331, 338 (1982) (The Commerce Clause "precludes a state from mandating that its residents be given a preferred right of access, over out-of-state consumers, to natural resources located within its borders . . . "); Sporhase v. Nebraska, 458 U.S. 941, 953 (1982) (stating that water is an "article of commerce" under the Commerce Clause).

[41] United Haulers Association, Inc. v. Oneida-Herkimer Solid Waste Mgmt. Auth., 550 U.S. 330, 338 (2007).

[42] Northeast Bancorp, Inc. v. Bd. of Gov. of Fed. Reserve Sys., 472 U.S. 159, 174, 105 S.Ct. 2545, 86 L.Ed.2d 112 (1985) ("When Congress so chooses, state actions which it plainly authorizes are invulnerable to constitutional attack under the Commerce Clause.").

[43] U.S. Constitution article VI, cl. 2; Crosby v. Nat'l Foreign Trade Council, 530 U.S. 263, 372 (2000).

[44] Cal. Coastal Comm'n. v. Granite Rock Co., 480 U.S. 572, 581 (1987).

[45] *Tarrant Reg'l Water Dist.*, 2009 WL 3922803, at *8.

[46] *Id.*

[47] *Id.* at *4 -7.

[48] *Id.* at *6.

because it barred TRWD's purchase of water from private persons in Stephens County, Oklahoma and from the Apache Tribe.[49] OWRB again moved to dismiss, arguing that no justiciable controversy exists and that the amended complaint failed to state a claim.[50] The court granted OWRB's motion to dismiss and rendered judgment for OWRB for a second time.[51] The court explained that no justiciable claim existed because TRWD's Stephens County agreement was just that, an agreement, and TRWD had not yet filed a permit application for the exportation of groundwater.[52] Similarly, the court explained that TRWD's memorandum of understanding with the Apache Tribe was "far too speculative and subject to too many contingencies to set out a controversy ripe for judicial resolution."[53] TRWD appealed the district court's decisions to the U.S. Court of Appeals for the Tenth Circuit on August 12, 2010.[54]

Tenth Circuit's opinion

On appeal, the Tenth Circuit addressed the Dormant Commerce Clause and Supremacy Clause claims originally decided by the district court. Specifically, the court considered (1) whether the Compact allows signatory states to safeguard their water supply through means that would otherwise violate the Dormant Commerce Clause, and (2) whether the Compact preempts Oklahoma laws to the extent the laws interfere with TRWD's alleged right to apportion water located in the Oklahoma section of Reach II, subbasin 5 for exporting to, and for use in, Texas.[55] Reviewing each of the district court's decisions *de novo*,[56] the court ultimately affirmed the district court's decision on the same grounds as the district court and expounded upon the district court's reasoning.[57]

Dormant commerce clause

The court examined Dormant Commerce Clause jurisprudence in detail, first explaining the Commerce Clause and the implied restriction on state regulation of interstate commerce.[58] In general, a court will strike down as unconstitutional state discrimination against interstate commerce "unless the state can show a strong public purpose" for such discrimination.[59] A state law that facially discriminates against interstate commerce must be examined with the strictest scrutiny to determine if the state is promoting a legitimate local purpose and that there are no nondiscriminatory alternatives.[60] And, nondiscriminatory state statutes may be invalid if they impose an undue burden on interstate commerce.[61] On the other hand, if the statute's effects on interstate commerce are inconsequential and the statute regulates a legitimate local interest, "it will be upheld unless the burden imposed on such commerce is clearly excessive in relation to the putative local benefits."[62]

In addressing TRWD's Dormant Commerce Clause claim, the court explained that Congress can approve a discriminatory state action that would normally be a violation of the Commerce Clause.[63] Citing a line of cases, the court provided that whether Congress has consented to state regulation of interstate commerce, thus shielding a Dormant Commerce Clause challenge, "depends upon the language of the particular federal statute."[64] The court also concluded that under the *Sporhase v. Nebraska, ex. rel Douglas* and *South-Central Timber Development, Inc. v. Wunnicke* cases, congressional consent should be determined based on whether Congress "affirmatively contemplate[d]" its intent to allow a state to engage in economic protectionism with "unmistakable" clarity.[65]

The court then presented a detailed examination of the Compact and determined that the Compact explicitly defers

[49] Tarrant Reg'l Water Dist. v. Herrmann, No. CIV-07-0045-HE, 2010 WL 2817220, at *1 (W.D. Okla. July 16, 2010).

[50] *Id.* at *1.

[51] *Id.* at *3.

[52] *Id.* at *2.

[53] *Id.* at *3.

[54] Linda C. Martin, *Oklahoma v. Texas: Water Wars*, American College of Environmental Law, (Aug. 24, 2010), *available at* http://www.acoel.org/post/2010/08/24/Oklahoma-v-Texas-Water-Wars-.aspx/.

[55] *Tarrant Reg'l Water Dist.*, 656 F.3d at 1227.

[56] *Id.* at 1233.

[57] The Tenth Circuit also affirmed the district court's dismissal of TRWD's claims associated with its agreement for groundwater in Stephens County, Oklahoma and its MOU with the Apache Tribe. *See Tarrant Reg'l Water Dist.*, 656 F.3d at 1247-50.

[58] *Id.* (stating that the Commerce Clause "is both an enumerated grant of power to Congress and an implicit restriction on state interference with interstate commerce.").

[59] *Id.* (citing City of Philadelphia v. New Jersey, 437 U.S. 617, 628 (1978)).

[60] *Id.* (citing Hughes v. Oklahoma, 441 U.S. 322, 337 (1979)).

[61] *Id.* (citing Bibb v. Navajo Freight Lines, Inc., 359 U.S. 520, 529 (1959)).

[62] *Id.* (citing Pike v. Bruce Church, Inc., 397 U.S. 137, 142 (1970)).

[63] *Id.* at 1233-34 ("Congressional consent can transform otherwise unconstitutional state action into permissible state action").

[64] *Id.* at 1237 (citing Ne. Bancorp, Inc. v. Bd. Of Governors of Fed. Reserve Sys., 472 U.S. 159, 175 (1985), New England Power Co. v. New Hampshire, 455 U.S. 331 (1982), and Prudential Ins. Co. v. Benjamin, 328 U.S. 408 (1946)).

[65] *Id.* at 1235 (citing South-Central Timber Devel. Inc v. Wunnicke, 467 U.S. 82, 91 (1984) and Sporhase v. Nebraska, ex. rel Douglas, 458 U.S. 941, 960 (1982)).

to and recognizes plenary state authority over water use.[66] In making this determination, the court noted that the interpretive comments of the Compact also provide that "each state is free to continue its existing internal water administration, or to modify it in any manner it deems appropriate."[67] Accordingly, the court held in Oklahoma's favor, stating that the Compact's language "contains the clear statement of congressional authorization of state regulation [of interstate commerce] that *Sporhase* and *Wunnicke* require."[68] The court concluded that the Compact gives Oklahoma wide authority to protect its water against out-of-state transfer and use.[69]

Preemption

The court also affirmed the district court's decision that the Compact does not preempt the Oklahoma water statutes pursuant to the Supremacy Clause.[70] The court began by examining TRWD's standing, the preemption doctrine derived from the Supremacy Clause, and the Compact's deference to state water regulation.[71] The court stated that TRWD had standing to raise the claim because if Oklahoma's statutes are invalid, then TRWD would suffer injury through the substantial burdens imposed upon it as an out-of-state water right applicant.[72] Additionally, the court stated that TRWD has standing because its grievance is specific to its application to appropriate Oklahoma water in Reach II, subbasin 5 for use in Texas, and therefore is not a generalized grievance outside the area protected by law.[73]

With regard to the preemption doctrine, the court emphasized that the presumption against preemption is especially strong in areas of longstanding state policy such as water regulation.[74] The court explained the standards applicable to express preemption and implied preemption, but ultimately rested its decision on the presumption against preemption regarding when a state has historically policed a subject area.[75] The court stated that "the presumption against preemption is particularly strong in this case because history reveals 'the consistent thread of purposeful and continued deference of state water law by Congress.'"[76]

The court explained that the Compact's key provisions indicate that Congress did not intend to preempt state water laws.[77] The court looked to the Compact's statement that "[e]ach state may freely administer water rights and uses in accordance with the laws of that state" and that the Compact must not be interpreted to "interfere . . . within [a signatory state's] boundaries the appropriation, use, and control of water . . . not inconsistent with its obligations under the Compact."[78]

Having been denied any relief from the Tenth Circuit, TRWD made one final appeal to the U.S. Supreme Court. The Supreme Court granted TRWD's petition for certiorari on January 4, 2013.[79]

U.S. Supreme Court's opinion

Before the Supreme Court, TRWD argued that Section 5.05(b)(1) of the Compact allows each signatory state the right to obtain up to 25% of excess water within Reach II, subbasin 5 from any part of the river, even if such water is within the boundary of another state, because the Compact does not expressly prohibit cross-border water rights—meaning cross-border rights were intended.[80] As such, TRWD claimed that the Compact preempts Oklahoma statutes that prohibit TRWD's ability to export its apportionment of Compact water pursuant to Section 5.05(b)(1) from Oklahoma. In the alternative, TRWD argued that the Oklahoma statutes constituted an unconstitutional restraint on interstate commerce in violation of the Dormant Commerce Clause.[81] Oklahoma argued that the Compact drafters' silence on cross-border rights, on the other hand, meant that cross-border rights were *not* intended.[82] Oklahoma claimed victory again when the Court affirmed the judgment of the Tenth Circuit.[83] The Court held that (1) the Compact does not preempt Oklahoma statutes because the

[66] *Id.* at 1237.

[67] *Id.* at 1238.

[68] *Id.* at 1237.

[69] *Id.* at 1239.

[70] *Id.*

[71] *Id.*

[72] *Id.* at 1240 (citing Skull Valley Band of Goshute Indians v. Nielson, 376 F.3d 1223, 1234 (10th Cir. 2004)) ("a party seeking a license from a governmental agency generally has standing to challenge an allegedly invalid law that either imposes substantial burdens upon the applicant or flatly prohibits the activity in question").

[73] *Id.* at 1241 (citing Raley v. Hyundai Motor Co., Ltd., 642 F.3d 1271, 1275 (10th Cir. 2011) (explaining prudential standing factors).

[74] *Id.* at 1242.

[75] *Id.* at 1241-42.

[76] *Id.* at 1242 (citing California v. United States, 438 U.S. 645, 653 (1978)).

[77] *Id.* at 1242-43.

[78] *Id.* at 1242 (citing Red River Compact, at § 12.10).

[79] *Tarrant Reg'l Water Dist.*, 656 F.3d 1222, cert. granted, 2013 WL 49810 (U.S. Jan. 4, 2013).

[80] *Tarrant Reg'l Water Dist.*, 133 S.Ct. at 2129.

[81] *Id.* at 2136.

[82] *Id.* at 2130.

[83] *Id.* at 2129.

Compact does not grant cross-border rights to water; and (2) Oklahoma statutes do not violate the Dormant Commerce Clause.[84]

First, the Court addressed TRWD's argument that Section 5.05(b)(1) of the Compact provided TRWD with the right to cross state lines to obtain water and that Oklahoma's water laws interfered with its ability to exercise that right.[85] The Court reiterated that properly construing Section 5.05(b)(1)'s silence is "the key to resolving whether the Compact preempts the Oklahoma water statutes."[86]

Statutory interpretation of the Compact

The Court began its analysis by noting that interstate compacts are to be interpreted as contracts using the principles of common law.[87] Relying on this, the Court examined the express terms of the Compact as the best indication of the parties' intent to determine whether cross-border rights were intended.[88] In its argument that cross-border rights are granted by Section 5.05(b)(1), TRWD noted that this section does not specifically restrict the allocation of water to within each state's respective borders.[89] TRWD compared this to other sections of the Compact, like Section 5.03(b) of the Compact that provides: "[t]he States of Oklahoma and Arkansas shall have free unrestricted use of the water of [Reach II, subbasin 3] within their respective states."[90]

To evaluate TRWD's *expressio unius* canon of construction argument[91]—the argument that when the drafter includes language in 1 portion of a statute and excludes the language in another, then the drafter intended the inclusion or exclusion—the Court looked to other sections of the Compact.[92] The Court found that TRWD's argument was not persuasive because it ignores other sections of the Compact that cut squarely against its interpretation and would result in "absurd results."[93] The Court stated that "at the very least, the problems that arise" from TRWD's interpretation suggest the section's "silence is ambiguous regarding cross-border rights."[94] However, the Court went on to say it is not convinced by TRWD's interpretation because of the well-established principle that states do not easily cede their sovereign powers, the fact that other interstate water compacts have treated cross-border rights explicitly, and the parties' course of dealing.[95]

The Court then echoed the Tenth Circuit's finding regarding a state's sovereign powers, specifically its power over its navigable waters.[96] In finding that the Compact should not be interpreted as the signatory states expressing intent to cede their powers, the Court stated:

> States rarely relinquish their sovereign powers, so when they do we would expect a clear indication of such devolution, not inscrutable silence. We think that the better understanding of § 5.05(b)(1)'s silence is that the parties drafted the Compact with this legal background in mind, and therefore did not intend to grant each other cross-border rights under the Compact.[97]

The Court further examined the language of the Compact using the contract interpretation method of looking to "usage of trade."[98] The Court reviewed several interstate compacts and found that those compacts generally included clear and unambiguous language if cross-border rights were granted.[99] The Court stated that the absence of clear language in the Compact counts heavily against TRWD's interpretation of it.[100] Furthermore, the Court stated that if it were to accept TRWD's interpretation, monitoring cross-border rights under the Compact "would be a herculean task because the Compact does not require ongoing monitoring or accounting . . . and not all of the water in subbasin 5 is located or originates in Oklahoma."[101] The Court subsequently looked to the conduct of the signatory states to the Compact. The Court determined the fact that neither TRWD nor any of the signatory states have pressed for cross-border diversion rights prior to the filing

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[84] *Id.* at 2137.

[85] *Id.* at 2129.

[86] *Id.*

[87] *Id.* (citing Texas v. New Mexico, 482 U.S. 124, 128 (1987)).

[88] *Id.* (citing Montana v. Wyoming, 131 S.Ct. 1765, 1771-72 & n.4 and Restatement (Second) of Contracts § 203(b)(1979)).

[89] *Id*. at 2130.

[90] *Id*. at 2130-31; Red River Compact § 5.03(b) (emphasis added).

[91] *Expressio unius est exclusion alterius* stands for the maxim that when "Congress includes particular language in one section of a statute but omits it in another section of the same Act, it is generally presumed that Congress acts intentionally and purposely in the disparate inclusion or exclusion." *Bates v. United States*, 522 U.S. 23, 29–30 (1997).

[92] *Tarrant Reg'l Water Dist.*, 133 S.Ct. at 2131.

[93] *Id.*

[94] *Id*. at 2132.

[95] *Id.* at 2132 (citing Oklahoma v. New Mexico, 501 U.S. 221, 235 n. 5 (1991)).

[96] *Id.* at 2132-33.

[97] *Id.* at 2133.

[98] *Id.*

[99] *Id.* at 2133-2136 ("Tellingly, many of these compacts provide for the terms and mechanics of how such cross-border relationships will operate, including who can assert such cross-border rights, . . . who should bear the costs of any cross-border diversions, . . . and how such diversions should be administered.").

[100] *Id.* at 2134.

[101] *Id.* (referencing section 2.11 of the Compact).

of the suit further undermined TRWD's position that Section 5.05(b)(1) grants cross-border rights.[102]

Dormant commerce clause

Lastly, the Court addressed TRWD's Dormant Commerce Clause argument. TRWD argued that Oklahoma's statutes impermissibly discriminate against interstate commerce so as to favor local interests by erecting barriers to the distribution of water left unallocated under the Compact.[103] TRWD's argument was based on the idea that if the Supreme Court were to "adopt the Tenth Circuit's or respondent's interpretation . . . a substantial amount of Reach II, Subbasin 5 water located in Oklahoma [will not be] apportioned to any State and therefore is available" to any permit applicant.[104]

The Court rejected TRWD's argument and asserted that TRWD's assumption that the Compact leaves some water "unallocated" is erroneous because the Compact clearly provides that all signatory states are free to use as much water as they can put to beneficial use, up to the 25% cap or until another state calls for an accounting.[105] Therefore, the Court concluded, "[t]he Oklahoma water statutes cannot discriminate against interstate commerce with respect to unallocated waters because the Compact leaves no waters unallocated."[106]

No cross-border rights to the Red River?

The holding of the Court that no cross-border rights to water in the Red River exist between Oklahoma and Texas likely came as quite a shock to a number of Texas water rights holders currently permitted to use water from the Red River. In its argument before the Supreme Court, TRWD unfortunately failed to point out that virtually all Texas water rights granting permittees the authority to divert water from the Red River constitute cross-border rights because the boundary between Texas and Oklahoma is the south bank of the Red River.

In 1999, the states of Texas and Oklahoma entered into the Red River Boundary Compact to definitively locate the state boundary along the Red River. The compact defined the Oklahoma-Texas state boundary as the vegetation line along the south bank of the Red River.[107] Consequently, Texas diversions of water from the Red River are diversions of water from Oklahoma because such diversions are clearly north of the Oklahoma-Texas state boundary—the vegetation line along the south bank of the Red River. So what does the Court's opinion mean for Texas water rights holders diverting water from the Red River? Although this opinion calls into question the validity of the rights of these Texas water rights holders, these rights remain protected based upon the Adams-Onís Treaty of 1819 between the United States and Spain (8 Stat. 252).[108] This Treaty guarantees the people of Texas a right of reasonable access to the waters of the Red River along the state boundary to enable them to reach the waters at all stages and to use the same for beneficial purposes in common with the inhabitants of the State of Oklahoma.[109] The U.S. Supreme Court recognized Texas's right of reasonable access granted by the Adams-Onís Treaty of 1819 in *Oklahoma v. Texas*, 261 U.S. 340 (1923).[110]

Impact of *Tarrant* decision on other interstate compacts

Given that more than 2 dozen interstate compacts exist in the United States governing allocation of water, what impact will *Tarrant* have on these other compacts, and any disputes arising from these compacts? The decision in *Tarrant*, although it appears to be of limited applicability, shows the Supreme Court's clear support for allowing compacting states to maintain exclusive control over water resources within their boundaries unless the interstate compact includes express language to the contrary. The Supreme Court recognized a state's ability to control water within its boundaries as a "core state prerogative."[111] *Tarrant* also indicates that when the language of a compact is deemed ambiguous, the Court will look to interpretive tools with a presumption that each state has a sovereign prerogative to control its water resources that it must expressly relinquish.[112] Regarding the Dormant Commerce Clause, the Court side-stepped addressing whether Oklahoma statutes placed an undue burden on interstate commerce by disposing of this claim in 2 simple paragraphs explaining, "[t]he Oklahoma water statutes cannot discriminate against interstate commerce with respect to unallocated waters because the Compact leaves

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[102] *Id.* at 2135.

[103] *Id.* at 2136 (quoting TRWD's brief).

[104] *Id.*

[105] *Id.* at 2137.

[106] *Id.*

[107] Texas Natural Resources Code Ann. § 12.002, Art. II(b).

[108] Oklahoma v. Texas, 261 U.S. 340, 342-43 (1923).

[109] *Id.*

[110] *Id.*

[111] *Tarrant Reg'l Water Dist.*, 133 S.Ct. at 2133.

[112] Holly Taylor, *Tarrant Regional Water District v. Herrmann: Interpreting Silence in Interstate Water Compacts with Respect to State Boundaries and the Right to Access Water,* 17 University of Denver Water Law Review 138, 154-55 (2013).

no waters unallocated."[113] This side-step leaves open the possibility that the Dormant Commerce Clause might have future applications in interstate compact disputes if statutes place an undue burden on interstate commerce with respect to waters that remain unallocated.

The Supreme Court's method for interpreting the Red River Compact in *Tarrant*—examining the express terms of the compact, and then if such terms are ambiguous, deferring to the sovereign power of states, looking to customary practices in other interstate compacts, and examining the conduct of the parties—will likely be employed in future compact disputes.[114] In fact, this method may soon be employed in a dispute involving the State of Texas over the Rio Grande Compact. On January 27, 2014, Texas was granted leave to file a complaint with the Supreme Court regarding Texas's allegation that the State of New Mexico is violating the Rio Grande Compact by allowing New Mexico water users to use Rio Grande surface water, tributary flow, and return flows below Elephant Butte Reservoir beyond what is authorized in the compact.[115] New Mexico alleges that the compact only requires it to deliver a certain quantity of water to the Elephant Butte Reservoir and that it is not required to deliver any specific quantity to the Texas state line.[116] A clear dispute between Texas and New Mexico over what the Rio Grande Compact requires appears to exist, meaning the Supreme Court, if it hears Texas's complaint, will likely employ the interpretive tools used in *Tarrant* to also resolve this dispute.

Tarrant could have more specific implications for other intestate compacts, such as the Upper Niobrara Compact to which the State of Wyoming is a signatory.[117] Only a small portion of the Upper Niobrara River is located within the boundaries of Wyoming with the majority of the river flowing within Nebraska.[118] The compact provides "no restrictions on the use of the surface waters of the Upper Niobrara River by Wyoming."[119] The language of the compact does not expressly grant Wyoming rights to divert water in Nebraska, but only limits the use to Wyoming laws and certain limitations within Nebraska.[120] *Tarrant* could give Nebraska the authority to set further limitations on Wyoming diverting water from within Nebraska since the compact fails to expressly grant cross-border rights to Wyoming.[121] Like Oklahoma, Nebraska could enact protectionist statutes prohibiting out-of-state applicants from obtaining rights to divert water, thereby preventing Wyoming residents from accessing their share of water from the Upper Niobrara River under the compact.[122]

Future water supplies for North Texas

Following *Tarrant*, it would appear that the ability of an individual or entity within Texas to obtain water within Oklahoma is foreclosed—and for the time being, that may be true. But hopefully, a day will come when Oklahoma realizes that it is wasting a valuable resource that currently just flows wasted into the Gulf of Mexico—a valuable resource for which North Texas entities would be willing to pay significant sums. But that day is no time soon, and until then, TRWD and other entities in the rapidly expanding North Texas region must identify other sources of water supplies to meet growing demands for water. Water supplies from Oklahoma were expected to annually provide 165,000 acre-feet of water or more for North Texas[123]—so additional supplies must be identified and developed to replace this substantial water supply. It typically takes about 5 years to build a reservoir—but that doesn't occur until after 10-15 years of going through the permitting for such reservoir.[124] Another potential water supply option for North Texas is the proposed Marvin Nichols Reservoir that could cost upwards of $3.3 billion to build and require permitting to flood more than 70,000 acres—no guarantee when federal regulators and environmentalists weigh in on the project.[125] A second option is moving water from the Toledo Bend Reservoir, but with the reservoir being more than 200 miles from the Dallas/Fort Worth Metroplex, and

[113] Christine Klein, *The Lesson of Tarrant Regional Water District v. Herrmann: Water Conservation, not Water Commerce,* Center for Progressive Reform Blog, http://www.progressivereform.org/CPRblog.cfm?idBlog=-5CA2075E-9126-E28C-666D65E902073C68 (June 19, 2013); *Tarrant Reg'l Water Dist.*, 133 S.Ct. at 2137.

[114] *See* Taylor, *supra* note 112, at 154-55.

[115] *Texas v. New Mexico and Colorado*, SCOTUSblog, http://www.scotusblog.com/case-files/cases/texas-v-new-mexico-and-colorado/ (last visited April 27, 2014); Brief for United States as Amicus Curiae at 12, Texas v. New Mexico, No. 220141 (Dec. 10, 2013).

[116] Brief for United States as Amicus Curiae at 13-14, Texas v. New Mexico, No. 220141 (Dec. 10, 2013).

[117] Brian A. Annes, *Water Law—Cooperation Abandoned to Allow Hoarding of Water: The Supreme Court Denies Right to Divert Waters Across State Borders Under the Red River Compact*; *Tarrant Reg'l Water Dist. v. Herrmann,* 133 S. Ct. 2120 *(2013)*, 14 Wyoming Law Review 105, 131 (2014).

[118] *Id.*

[119] *Id.* (quoting Upper Niobrara River Compact, art. V, 83 Stat. 86 (1969)).

[120] *Id.*

[121] *Id.*

[122] *Id.*

[123] Region C Water Planning Group, *2011 Region C Water Plan* at 4C.7 (2011), *available at* http://www.regioncwater.org/Documents/2011RegionCWaterPlan/Chapter%204C_final.pdf.

[124] Jeremy P. Jacobs, *Water: Supreme Court wades into bitter Texas-Okla. feud ahead of expected 'flood of litigation,'* Greenwire (March 12, 2013), http://www.eenews.net/stories/1059977696.

[125] *Id.*

downhill, the costs for such a water supply option would be significant.[126]

Although the obstacles seem insurmountable, the future development of water supplies in Texas isn't completely bleak. The State of Texas, recognizing that its communities desperately need to develop new water supplies, enacted legislation in 2013 that enables the state to create 2 funds—the State Water Implementation Fund for Texas and the State Water Implementation Revenue Fund for Texas—that will set aside $2 billion to help finance projects in the Texas state water plan.[127] The funding available will assist communities ranging from small rural towns to large metropolitan areas to develop drought-proof water supplies.[128] Projects for which funding is available include, but are not limited to, conservation and reuse projects, desalination projects, infrastructure projects, and reservoir projects.[129] It may be but a small step, given that one large water supply project can easily cost $2 billion, but it is a *significant* small step nonetheless.

TRIBAL FIGHT FOR RIGHTS TO WATER IN OKLAHOMA

TRWD's efforts to secure water in southeastern Oklahoma previously included attempts to secure water, along with other North Texas entities, jointly from Indian Tribes in Oklahoma and the State of Oklahoma.[130] Presently, the ability to purchase Oklahoma water directly from these Indian Tribes depends on the outcome of an ongoing dispute between Oklahoma and the Chickasaw Nation and Choctaw Nation of Oklahoma ("Indian Nations") that could tie up Oklahoma water supplies for years. On August 18, 2011, the Indian Nations filed a lawsuit in the U.S. District Court for the Western District of Oklahoma to protect the Indian Nations' alleged rights to water in Oklahoma.[131] The lawsuit names as defendants Governor Mary Fallin, the members and Executive Director of the OWRB, the city of Oklahoma City, and the Oklahoma City Water Utility Trust (OCWUT).[132] The lawsuit claims the Indian Nations have federally protected rights to the water within a 22-county territory in southeastern Oklahoma that are "prior and paramount" to any water rights granted by Oklahoma.[133]

The capstone case *Winters v. United States* first recognized federally reserved Indian water rights in 1908.[134] The U.S. Supreme Court's ruling in *Winters*, referred to as the "Winters doctrine," provided that when the federal government reserved lands for Indian Tribes, this land reservation included by implication a reservation of water appurtenant to such lands to the extent the water was necessary to achieve the purposes intended by the land reservation.[135] The U.S. Supreme Court expanded the *Winters* doctrine in *Arizona v. California* almost 50 years after the *Winters* decision and held that Indian reserved water rights are not only for the present needs of the reservation, but also to satisfy the future needs of the reservation.[136] In reserving water for future needs, the Court held that "enough water was reserved to irrigate all the practicably irrigable acreage on the reservations" because this appeared to be the only feasible and fair way to determine the quantity of water reserved.[137]

The Indian Nations claim that federal rights to water in Oklahoma are guaranteed to them by the Treaty of Dancing Rabbit Creek, Act of September 30, 1830, 7 Stat. 333, that was later modified by the 1866 Treaty of Washington, Act of April 28, 1866, 14 Stat. 769.[138] The Indian Nations' lawsuit generally seeks (1) declaratory judgments against any action by OWRB on a pending application by Oklahoma City and OCWUT for a permit to use stream water from Sardis Reservoir in southeastern Oklahoma, or any other withdrawal or export of water from the area at issue, unless and until there is initiated a general stream adjudication that satisfies the requirements of the federal law known as the McCarran Amendment;[139] and (2) permanent injunctions against any such action unless and until a general stream adjudication that satisfies the McCarran Amendment is completed.[140]

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126 *Id.*

127 *SWIFT: What's in the legislation?*, Texas Water Development Board, http://www.twdb.state.tx.us/swift/hb4/index.asp (last visited April 27, 2014).

128 *SWIFT: What will SWIFT fund?*, Texas Water Development Board, http://www.twdb.state.tx.us/swift/projects/index.asp (last visited April 27, 2014).

129 *Id.*

130 Oklahoma Water Resources Board, J*oint State/Tribal Water Compact & Water Marketing Proposals* 25 (March 2002), *available at* https://www.owrb.ok.gov/studies/legislative/southeast/southeast_pdf/Status%20Report_Part%201.pdf.

131 *Legal Matters*, Oklahoma Water Resources Board, http://www.owrb.ok.gov/util/legal.php/ (last updated December 2, 2013).

132 Seconded Amended Complaint at 8-9, Chickasaw Nation v. Fallin, No. CIV-11-927-W (W.D. Okla. Jan. 26, 2012).

133 *Id*. at 19-21.

134 207 U.S. 564 (1908).

135 *Id.*

136 373 U.S. 546, 600 (1963).

137 *Id.*

138 Seconded Amended Complaint, *supra* note 133, at 2.

139 The McCarran Amendment authorizes the adjudication of federal water rights, including Indian water rights held in trust by the United States, and grants consent to join the United States as a defendant in such adjudication. *See* 43 U.S.C. § 666; Co. River Water Conservation Dist. v. United States, 424 U.S. 800, 809-13 (1976).

140 *Legal Matters*, Oklahoma Water Resources Board, http://www.owrb.ok.gov/util/legal.php/ (last updated December 2, 2013).

In response to the Indian Nations' lawsuit, on February 10, 2012, the Oklahoma Attorney General filed on behalf of OWRB to initiate such McCarran Amendment adjudication proceedings to protect and accurately determine all rights to the use of water in the Kiamichi, Clear Boggy, and Muddy Boggy stream systems and moved to dismiss the Indian Nations' federal lawsuit as "a premature effort to have federal courts usurp Oklahoma's management of waters of its state."[141] At the time of this filing, the Oklahoma Attorney General transmitted a letter to "Oklahomans and Others with water rights to protect" regarding the Indian Nations' lawsuit and how it threatens the security of the water resources in southeastern Oklahoma.[142] Of particular note, the Attorney General discounted the Indian Nations' claim that they are "protectors of waters and natural resources" because the Indian Nations have, on multiple occasions, expressed interest in selling water to Texas.[143]

OWRB's stream adjudication was subsequently removed by the United States to the U.S. District Court for the Western District of Oklahoma on March 12, 2012, in part, because removal of the case would facilitate resolution of the common federal questions underlying the Oklahoma stream adjudication and the Indian Nations' lawsuit.[144] After removal to federal court, the federal judge assigned to both cases requested briefing regarding whether the 2 suits should be consolidated.[145] The request for briefing on consolidation was subsequently withdrawn and both cases were stayed so that the parties could continue mediation that began in January 2012.[146] Mediation ended in January 2013, and with the foundation of a full year of mediation, the parties began direct negotiations. As of June 2014, both lawsuits continue to be stayed as negotiations continue.[147] In July 2013, the Chickasaw Nation Governor and a spokesman for the Governor of Oklahoma both felt that the negotiations were moving in the right direction and appeared hopeful that a settlement could be reached.[148]

If a settlement cannot be reached between Oklahoma and the Indian Nations, the U.S. District Court for the Western District of Oklahoma will likely have to interpret the Treaty of Dancing Rabbit Creek to determine whether it grants the Indian Nations reserved rights to water.[149] Although the Treaty of Dancing Rabbit Creek does not expressly provide for reserved water rights, the court could hold in accordance with U.S. Supreme Court jurisprudence that the Indian Nations have implied reserved water rights.[150] But, the quantity of water that may be granted to the Indian Nations by those implied rights is completely uncertain. What is certain is that if the lawsuit between Oklahoma and the Indian Nations is not settled, this legal battle will likely drag out for years, if not decades,[151] meaning any future rights to use water in southeastern Oklahoma will be on hold and water will continue to be wasted and inaccessible to those entities that really need it in North Texas.

THE FIGHT FOR WATER CONTINUES

As populations continue to grow and drought conditions persist, there is no doubt that additional water supplies must be developed to meet these needs. In an ideal world, the States of Texas and Oklahoma and the Chickasaw and Choctaw Nations would work together to ensure that sufficient water supplies are developed for the good of all. Sadly, we do not live in an ideal world—meaning as water resources become scarcer, the legal battles for these water supplies will continue.

[141] *Id.*

[142] Letter from Attorney General of Oklahoma E. Scott Pruitt to Oklahomans (Feb. 10, 2012), *available at* http://www.owrb.ok.gov/util/pdf_util/lawsuitdocs/CoverLetter_OWRB-App.pdf.

[143] *Id.*

[144] Notice of Removal, Okla. Water Res. Bd. v. United States, No. CIV-12-275-W (W.D. Okla. March 12, 2012).

[145] Order, Okla. Water Res. Bd. v. United States, No. CIV-12-275-W (W.D. Okla. March 13, 2012).

[146] Order, Okla. Water Res. Bd. v. United States, No. CIV-12-275-W (W.D. Okla. March 27, 2012).

[147] F*requently asked questions: Water Control*, City of Oklahoma City, https://www.okc.gov/waterrights/faq.html (last visited February 13, 2014); Order, Okla. Water Res. Bd. v. United States, No. CIV-12-275-W (W.D. Okla. May 13, 2014).

[148] Sean Murphy, *Chickasaw governor hopeful on water lawsuit talks*, Native American Times (July 21, 2013), http://www.nativetimes.com/index.php/news/environment/8987-chickasaw-governor-hopeful-on-water-lawsuit-talks459.

[149] Wyatt M. Cox, *A Reserved Right Does Not Make A Wrong*, 48 Tulsa Law Review 373, 395-96 (2012).

[150] *Id.* at 396.

[151] *See* Charles Carvell, *Indian Reserved Water Rights: Impending Conflict or Coming Rapprochement Between the State of North Dakota and North Dakota Indian Tribes*, 85 North Dakota Law Review 1, 49 (2009) (identifying other state water rights adjudications involving Indian water rights that often took decades to complete and typically cost in the millions of dollars).

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Observed trends in air temperature, precipitation, and water quality for Texas reservoirs: 1960-2010

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Abstract: Changes in climate, environmental management, and land use can affect water quality in lakes and reservoirs. Here, we quantify observed trends in water temperature and water quality in the 57 Texas reservoirs that have sufficient data for the period 1960 to 2010. We also quantify trends in air temperature and precipitation at 120 long-term weather stations adjacent to those reservoirs. Annual average temperature, seasonal average temperature, and cold temperature extremes are all becoming warmer near many Texas reservoirs. These air temperature trends are highly correlated with observed increases in water temperature across the state. Slight statewide increases in annual and winter, spring, and summer precipitation have contributed to greater increases in precipitation intensity, which are moderated by increases in the average number of dry days per year. Changes in precipitation can affect runoff and evaporation rates, which may alter levels of salts and minerals in the lakes. In addition, local human activities could be an important contributor to the observed increases in pH and phosphorus across the state and changes in specific conductance, sulfate, and chloride throughout Texas.

Key Words: water quality, trends, reservoirs, climate change

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Terms used in paper

Short name or acronym	Descriptive name
DO	dissolved oxygen
NCDC	National Climatic Data Center
NPS	nonpoint source
USGS	U.S. Geological Survey

INTRODUCTION

The quantity and quality of water stored in surface reservoirs across Texas and the South-Central United States is an important concern. Reservoirs serve as water sources for many municipalities; they provide irrigation water for farmers and ranchers; and some are used to generate hydropower. Reservoirs support a wide variety of aquatic ecosystems and wildlife. Many reservoirs support the economies of local communities as well as contribute significantly to local, county, and state government income. For example in 2006, 1.7 million fresh water anglers spent $2 billion in Texas (USFWS 2006).

Population growth and large-scale depletion of West Texas aquifers have put stress on Texas surface water availability and water quality. Surface water quality has improved largely since the passage of the Clean Water Act, which regulates the discharge of pollutants from point sources (USDA 1997). However, challenges to water quality improvement remain due to unregulated nonpoint source (NPS) pollution, pollution associated with runoff from urban and agricultural lands (USEPA 2000). For example, in the 1980s large amounts of phosphorus (260,000 metric tons) entered the environment from fertilizer and manure application and from wastewater-treatment plant discharges (Litke 1999). Likewise, evaporative dissolution, proximity to ditches for oil-field brine discharge, and anomalously saline salt water wells contributed to an increase in chloride and sulfate in West Texas and Texas Gulf Coastal Plain surface waters (Nance 2006).

Surface water in Texas can also be affected by temperature, precipitation, and other climate conditions, including both short-term extreme events and long-term shifts in mean conditions. Changes in climate can directly affect water quality, water quantity, biogeochemical cycles, and the aquatic biological communities in lakes and rivers (Soh et al. 2008; Paull and Johnson 2011; Delpla et al. 2009). In general, decreases in precipitation and increases in temperature can increase evaporation and reduce inflow, which causes the increase in concentration of salts, minerals, and contaminants (Roelke et al. 2011, 2012). Heavy rains following long dry periods can cause runoff events with elevated episodic inputs of herbicides, pollutants, animal waste, and other contaminants into rivers and lakes (CCSP 2008). Warmer temperatures and shifts in the timing and amounts of precipitation can affect fish community structure, life history traits, feeding modes, behavior, and survival (Jeppesen et al. 2010; Morrongiello et al. 2011; Baez et al. 2011; Roelke et al. 2011).

Climate trends across the broader Great Plains region over the past 50 years include increases in average annual and seasonal temperatures, precipitation intensity, and the amount of rain falling during the most intense 1% of storms (USGCRP 2009). At the other end of the spectrum, the year 2011 was the driest year on record for the state of Texas, and ongoing dry conditions (as of 2014) continue to affect reservoir water quantity and quality. Impacts on communities and ecosystems across the state range from demographic changes, as young adults preferentially move to urban areas (USCB 2009), to loss of wildlife habitat, as increased temperature and evaporation rates can cause playa lakes to dry out more frequently and affect the ability of waterfowl to migrate, mate, and nurture their offspring (Haukos and Smith 1992). Recent fish kills by golden algae (*Prymnesium parvum*) have been linked to low inflows and elevated salinity, which were affected by precipitation and evaporation rates (Roelke et al. 2011, 2012).

Average temperature is also increasing on a global scale. Severe cold is becoming less frequent, and heat waves more frequent. Precipitation patterns are shifting, with dry areas (in general) becoming drier and wet areas becoming wetter. Precipitation intensity is increasing over mid-latitudes, including much of the United States. The upcoming 2014 Third National Climate Assessment documents the potential impacts of these recent trends (Walsh et al. 2014) and highlights the need to quantify ongoing changes in climate and water quality at the local to regional scale.

Here, we quantify observed trends over time in 2 different datasets. The first set of data consists of 31 indicators of seasonal means and extremes, derived from air temperature and precipitation at 120 long-term weather stations. These stations are located nearby or upstream of 59 Texas reservoirs for which long-term water quality data is available from 1960 to 2010 (Figure 1). The second set of data consists of deseasonalized water temperature and 24 other indicators of water quality at 57 of the 59 reservoirs that have sufficient data to assess trends.

The Data section describes the 2 datasets, as well as the quality control and processing methods applied to the data prior to conducting the trend analysis. The Results section summarizes the trend analyses for atmospheric and water variables. Finally, in the Discussion and Conclusions section, we summarize the primary results of this analysis and discuss the implications of observed trends in air temperature and precipitation for water quality, past and future.

DATA

The 2 datasets used in this study consist of: (1) daily maximum and minimum air temperature at 2 meters above land surface and daily 24-hour cumulative precipitation measured continuously at 120 long-term weather stations and (2) daily (but far more sparse) measurements of water temperature and water quality parameters measured sporadically at 59 reservoirs across Texas. The locations of the weather stations and the reservoirs are shown in Figure 1.

Air temperature, precipitation, and secondary climate indicators

To identify which weather stations to use, we first plotted the locations of all long-term weather stations in or near Texas with daily data archived by the National Climatic Data Center (NCDC).[1] We then superimposed rivers, river basins, and reservoirs on this map to identify up to 3 "closest" and up to 7 "upstream" stations for each reservoir. Upstream locations were included because we hypothesized that stations upstream might better capture spatially inhomogeneous precipitation events affecting the reservoirs compared to locations that, while closer, may be located downstream, or in a different watershed. Weather stations were further filtered by removing any data records that had less than 80% coverage of the period between 1960 and 2010 (to be consistent with the same period as the reservoir observations). Daily maximum and minimum temperatures and 24-hour cumulative precipitation observations were then obtained from the NCDC database for each of these stations.

Preliminary evaluation of NCDC raw data had previously revealed the presence of obvious errors such as days with minimum temperature values greater than maximum temperature or outliers beyond the value of plausible observations in the continental United States. Although a few individual outliers would not have a strong influence on the trend analyses conducted here, we still processed the daily air temperature and precipitation observations using a quality control algorithm before conducting the trend analysis (see Appendix A for more details). After quality control, we used the daily time series of temperature and precipitation to calculate a set of secondary climate indicators, 19 for temperature and 12 for precipitation (Table 1). Secondary indicators capture aspects of climate related to annual and seasonal means, as well as to extremes (hot/cold and wet/dry). Each indicator was calculated on an annual basis (i.e., 1 value per weather station for each year in the historical record).

Water data

Data on water temperature and 24 other water quality parameters had been previously compiled from the U.S. Geological Survey (USGS) National Water Information website, hard-copy USGS Texas Water Data Reports, databases maintained by the Texas Commission on Environmental Quality, and other secondary sources, including the Texas

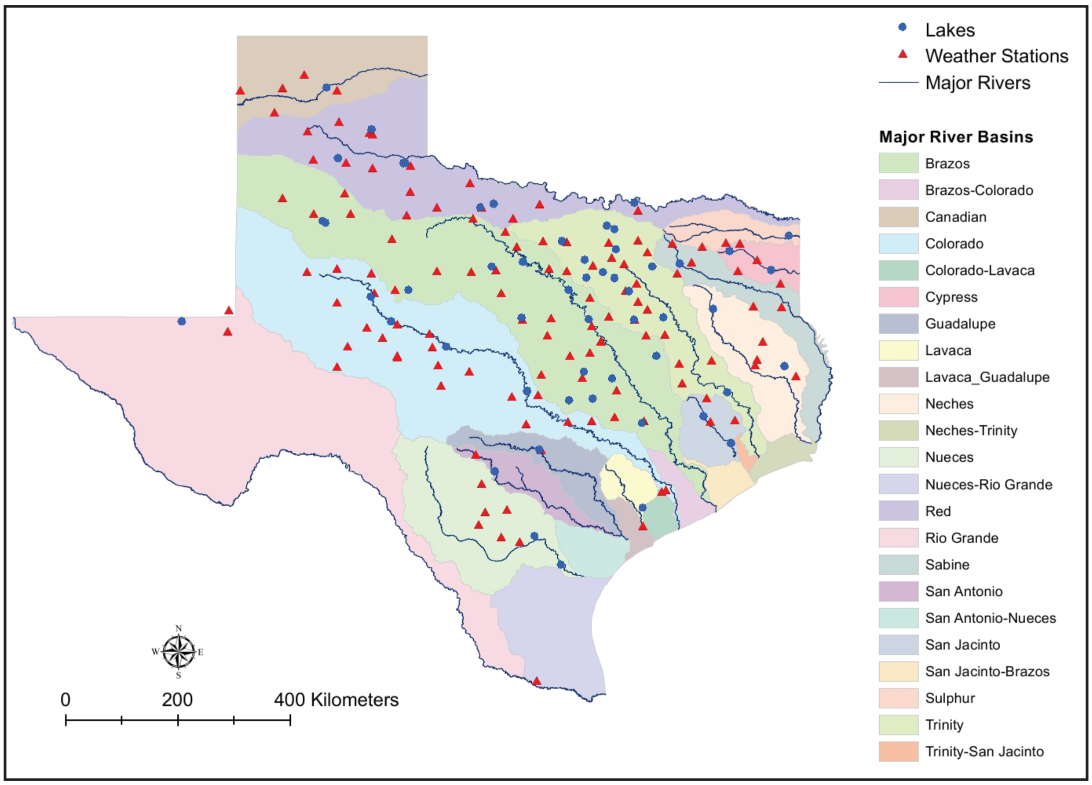

Figure 1. Locations of the 120 weather stations used to quantify surface temperature and precipitation for each of 59 reservoirs. Weather stations were selected to be near to or upstream from each reservoir.

[1] Climate Data v2.0 Summary of the Day, available online at: http://cdo.ncdc.noaa.gov/pls/plclimprod/poemain.accessrouter?datasetabbv=SOD

Water Development Board and independent river authorities data (as described in Burley et al. 2011). Reservoir data was reviewed to identify anomalous points that could be indicative of observational error: water temperature readings of 55 °C or 131 °F, for example, or hardness readings > 8000 milligrams/liter (all others <500 milligrams/liter). For some of these points, there may be a legitimate reason for the anomalous observation; accidental discharge of chemicals into the watershed could temporarily raise levels of certain water quality parameters beyond observed ranges. However, as the water data is a smaller dataset than the daily air temperature and precipitation data, these outliers have a greater potential to affect the trend analysis than anomalies in weather station data. For this reason, we removed outliers from the water temperature and water quality data using hard limits (listed in Table 2) based on inspection of the data. These hard limits were usually an order of magnitude or more beyond the typical range. Observation depths varied within and between reservoirs, such that we standardized the water data to 2 sets of mean depths, 1 above and 1 below 10 feet (see Appendix B for more details).

Finally, certain water parameters showed a strong seasonal cycle while others did not (Table 2). Seasonal variation, for most reservoirs, occurred in water temperature, dissolved oxygen (DO), pH, nitrate and nitrite, and potassium (unfiltered). While this would not pose a problem for the trend analysis if the observations were evenly distributed throughout the year (as they are for air temperature and precipitation), water data for many reservoirs is sparse and is often unevenly distributed in time. Thus, the water data for reservoirs fails to account for a seasonal cycle in water quality characteristics that may compromise our ability to detect a trend or lack thereof.

For that reason, annual cycles were determined by fitting the data series to the first 2 terms of a Fourier series (the mean value and a cosine term), which is a function commonly used to describe data as a set of oscillating or periodic waves. A least-squares fit was performed on the sin(theta) and cos(theta) to determine the magnitude and phase of the annual cycle. The resulting sinusoid was subtracted from the overall signal,

Table 1. Secondary climate indicators used in trend analysis, including descriptions and abbreviations.

Secondary indicator	Abbreviation
TEMPERATURE (19 indicators)	
Annual mean temperature	T(ann)
Seasonal mean temperature (Winter: Dec-Jan-Feb; Spring: Mar-Apr-May; Summer: Jun-Jul-Aug; Autumn: Sept-Oct-Nov)	T(DJF), T(MAM), T(JJA), T(SON)
Cold days (days per year with minimum temperature below 0 °C or 32 °F)	Tn<32 °F
Average temperature of the coldest consecutive 1, 3, 5, and 10 days of the year	T-cold(1d) to T-cold(10d)
Hot days (days per year with maximum temperature above 32 °C or 90 °F)	Tx>90 °F
Average temperature of the warmest consecutive 1, 3, 5, and 10 days of the year	T-hot(1d) to T-hot(10d)
Duration of summer, defined as the number of days between the first and last day of the year with maximum temperature > 32 °C or 90 °F	Summer(begin/end)
Duration of the growing season, defined as the number of days between the last day in spring and the first day in fall with minimum temperature <0 °C or 32 °F	Growing(begin/end)
PRECIPITATION (12 indicators)	
Annual total precipitation	Pr(ann)
Seasonal total precipitation (Winter: Dec-Jan-Feb; Spring: Mar-Apr-May; Summer: Jun-Jul-Aug; Autumn: Sept-Oct-Nov)	Pr(DJF), Pr(MAM), Pr(JJA), Pr(SON)
Dry days per year, defined as 24h cumulative precipitation <0.01 inches, according to the U.S. National Weather Service definition of "trace"	DryDays
Days per year with more than 1 or 2 inches of precipitation in 24 hours	Pr>1(1d), Pr>2(1d)
Number of 5-day periods per year with more than 3 inches of accumulated precipitation	Pr>3(5d)
Annual precipitation intensity, defined as total precipitation divided by the number of wet days per year	Pr(int)
Hydroperiod – day of the year (in Julian Date) by which 25% and 50% of annual precipitation has accumulated	Pr(25%), Pr(50%)

with the residual signal representing the contribution from all non-annual cycle effects. The magnitude and phase of the annual cycle from all lakes in the region combined were also calculated, and these values were used as a proxy for the annual cycle at any lake where there were insufficient points (<25) to estimate the local annual cycle. For records with more than 25 data points per variable per reservoir, the annual cycle was fit to the data from that reservoir. For variables with less than 25 data points, the regional mean was used to remove the annual cycle. Annual cycles were not removed from reservoirs with more than 25 data points that did not show an annual cycle, even if an annual cycle was evident at the aggregated level.

Statistical trend analysis methodology

Statistical trend analysis was conducted individually for each weather station on the 31 secondary climate indicators listed in Table 1 and for each reservoir on all water variables with sufficient data. As indicated in column 2 of Table 2, variables with sufficient data included water temperature, DO, specific

Table 2. Water temperature and water quality variables collected and analyzed in this study for (a) shallow depths (between the surface and 10 feet) and (b) deeper water (between 10 feet of depth and the bottom of the reservoir). The number of reservoirs for which sufficient data was available for trend analysis is listed in column 3. The water quality variables that displayed seasonal cycles are indicated in column 4 (Yes or Uncertain; no entry implies No). "F" indicates filtered and "U" unfiltered. (Table 2 continued on next page.)

(a) SHALLOW (surface to 10 feet)

Water variable	Reservoirs	Hard limits	Annual cycle?
Calcium-F	48	0-1000	
Chloride	59	0-10000	
Dissolved oxygen	58	0-25	Y
Fluoride-F	46	0-5	
Fluoride-U	50	0-5	
Hardness (as $CaCO_3$)	51	0-2500	
Magnesium-F	37	0-300	
Magnesium-U	48	0-300	
Nitrate-Nitrite	55	0-12	Y
Nitrogen-F	16	0-10	
Nitrogen-U	8	0-5	
Non carbonate hardness-F	10	0-12000	
Non carbonate hardness-U	15	0-12000	
pH	59	0-12	Y
Phosphorus-F	21	0-2	
Phosphorus-U	58	0-10	
Potassium-F	42	0-100	
Potassium-U	34	0-50	U
Salinity	25	0-3	
Sodium-F	42	0-2000	
Sodium-U	36	0-1500	
Specific conductance	52	0-25000	
Sulfate	59	0-2500	
Temperature	59	-5-40	Y

conductance, pH, phosphorus, chloride, and sulfate. Trends were only calculated for climate indicators and water parameters with data points that were distributed over at least 10 years.

We applied 3 different statistical methods (Pearson product-moment correlation, Spearman's rank correlation, and Kendall rank correlation, also referred to as Mann-Kendall tau) to calculate:

- the total number of weather stations with significant ($p<0.1$) trends in each variable,
- the magnitude of the trend for each climate indicator at each station,
- the number of reservoirs with significant trends in each variable,
- the magnitude of the trend for water temperature and water quality indicators.

For some atmospheric indicators, such as annual and summer average temperature, the number of dry days, and precipitation intensity, the number of significant trends was slightly greater using Pearson, which detects for linear trends. For other atmospheric indicators, such as winter average temperature or average temperature on the coldest days of the year, the nonparametric tests (Kendall and Spearman methods)

Table 2. Water temperature and water quality variables collected and analyzed in this study for (a) shallow depths (between the surface and 10 feet) and (b) deeper water (between 10 feet of depth and the bottom of the reservoir). The number of reservoirs for which sufficient data was available for trend analysis is listed in column 3. The water quality variables that displayed seasonal cycles are indicated in column 4 (Yes or Uncertain; no entry implies No). "F" indicates filtered and "U" unfiltered. (Table 2 continued from previous page.)

(b) DEEP (10 feet to bottom)

Water variable	Reservoirs	Hard limits	Annual cycle?
Calcium-F	25	0-1000	
Chloride	44	0-10000	
Dissolved oxygen	57	0-25	Y
Fluoride-F	24	0-5	
Fluoride-U	2	0-5	
Hardness (as $CaCO_3$)	21	0-2500	
Magnesium-F	25	0-300	
Magnesium-U	9	0-300	
Nitrate-Nitrite	33	0-12	Y
Nitrogen-F	8	0-10	
Nitrogen-U	13	0-5	
Non carbonate hardness-F	10	0-12000	
Non carbonate hardness-U	8	0-12000	
pH	57	0-12	Y
Phosphorus-F	21	0-2	
Phosphorus-U	34	0-10	
Potassium-F	24	0-100	
Potassium-U	8	0-50	Y
Salinity	19	0-3	
Sodium-F	24	0-2000	
Sodium-U	8	0-1500	
Specific conductance	21	0-25000	
Sulfate	43	0-2500	
Temperature	57		Y

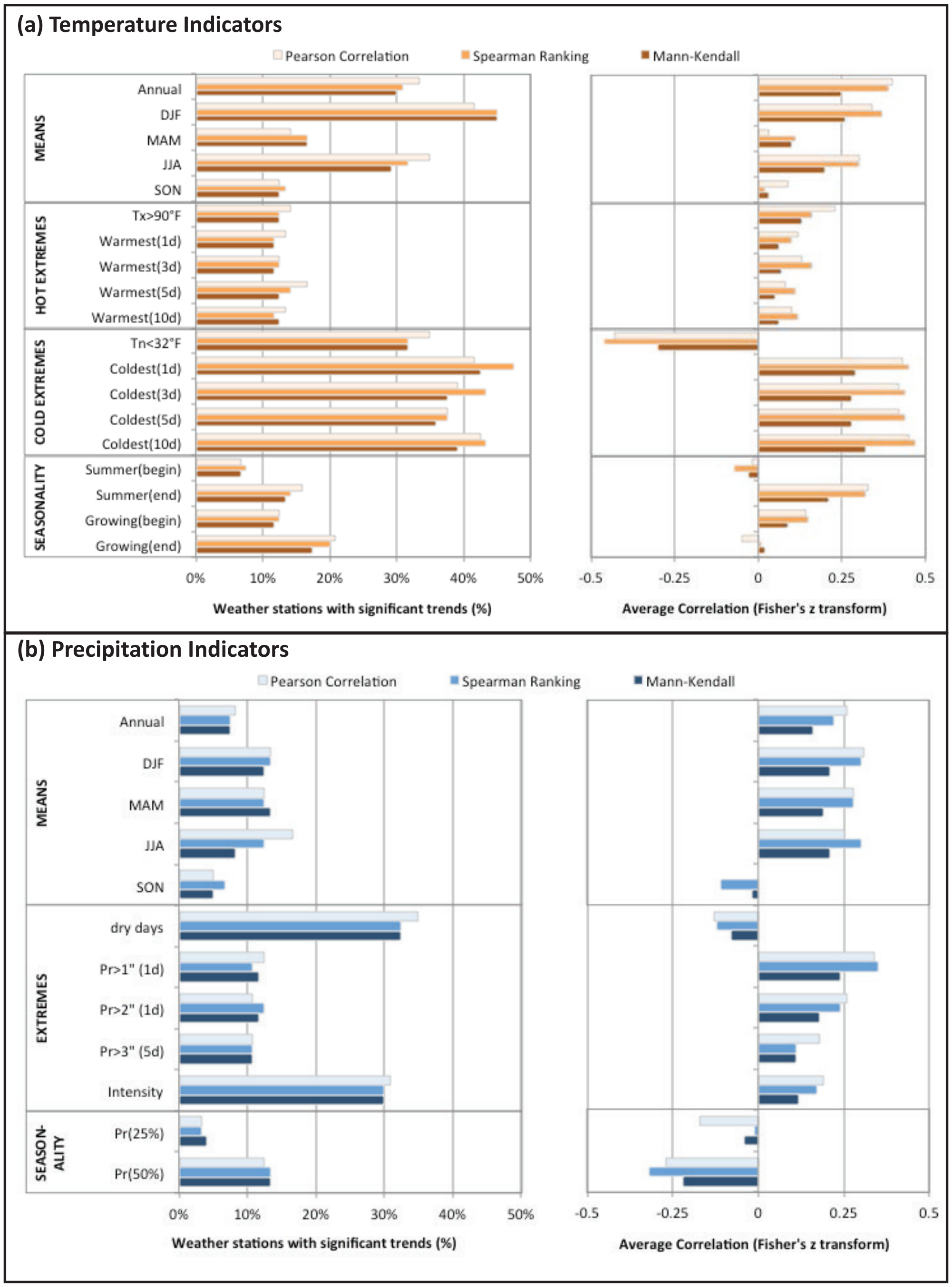

Figure 2(a) (top); 2(b)(bottom). Percentage of weather stations with significant trends according to Pearson, Spearman, and Mann-Kendall tests (left). Fisher's z transform of the correlation coefficient between time and each indicator, averaged across all stations (right).

found more significant trends. To compare the direction and magnitude of trends, we used the average of Fisher's Z transform correlation coefficients (Figure 2, right). An average of coefficients of correlation themselves is statistically unsound because the sampling distribution of coefficients of correlation is not normally distributed (Thomas et al. 2011), that is why we used the Fisher's Z transform of the correlation coefficients to calculate the average. Fisher Z transformation is a method of approximating normality of a sampling distribution of linear relationships.

For water temperature and water quality indicators, with the exception of DO, nonparametric methods also yielded a greater number of significant trends in water parameters than the parametric test for a linear trend using Pearson (Figure 3, left). In terms of the magnitude and direction of the trend, estimates were consistent across all 3 methods (Figure 3, right).

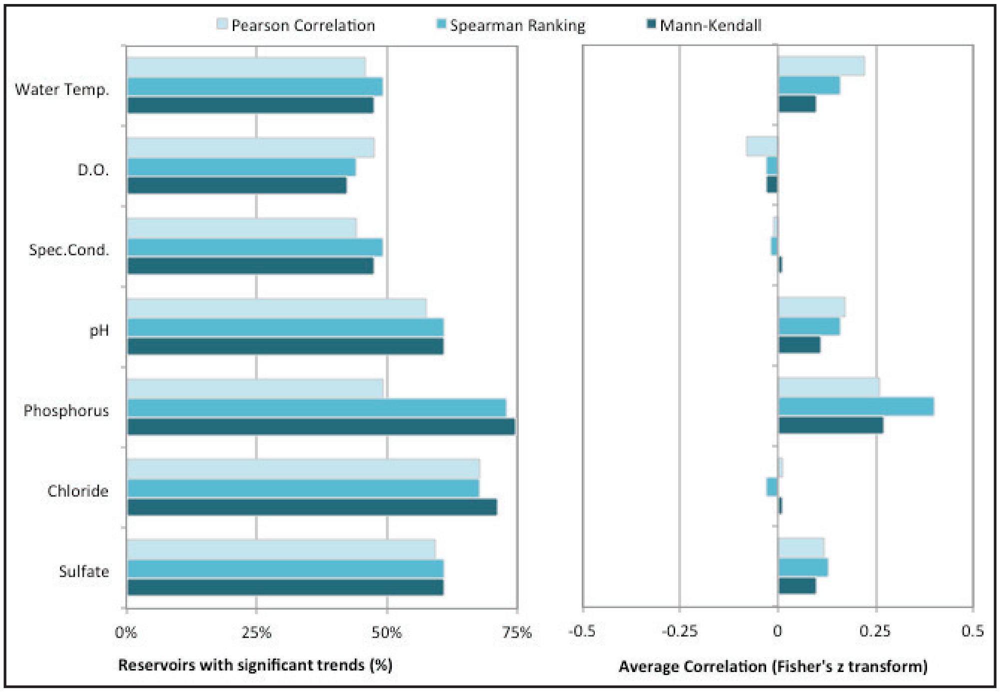

Figure 3. Water trend analysis showing: the percentage of reservoirs out of 59 with a significant ($p<0.1$) trend in water temperature and water quality according to the Pearson, Spearman, and Mann-Kendall trend tests (left); and Fisher's z transform of the correlation coefficient between time and each water quality indicator, averaged across all reservoirs (right).

The only exception was a slightly greater average trend of phosphorus using Spearman's rank.

Overall, all 3 methods of trend analysis show fairly consistent results in terms of the direction of trend and the approximate number of weather stations or reservoirs with a significant trend. However, trends estimated using the Spearman approach are more consistent than those estimated using either Kendall or Pearson, both in the number of stations or reservoirs showing a significant trend and the trend magnitude. For that reason, the data plotted in Figures 4, 5, and 6 are based on Spearman's rank correlation only.

RESULTS

Air temperature trends

Analyses of the mean and extreme indicators of air temperature listed in Table 1 reveal historical trends that, despite some variations from one location to the next, are relatively consistent in the direction of warming temperatures. All trends for temperature are positive, except for days per year below freezing, where a negative trend signifies warming.

Significant ($p<0.1$) increasing trends for temperature-related indicators were identified at many stations (Figure 2a). The variables with the greatest percentage of stations (out of 120) with significant correlations and the largest trends (out of 1.0) were

- annual mean temperature: 31% of stations with a correlation coefficient of 0.39,
- winter (Dec-Jan-Feb) mean temperature: 45% of stations with a correlation coefficient of 0.37,
- summer (Jun-Jul-Aug) mean temperature: 32% of stations with a correlation coefficient of 0.3,
- average temperatures on the coldest 1 to 10 days of the year: between 38% to 48% of stations with correlation coefficients between 0.44 and 0.47, depending on the number of consecutive days,
- days per year below freezing: 32% of stations with a correlation coefficient of -0.46.

Spring and fall average temperatures show largely positive trends at only 17% and 13% of stations, respectively. Trends in warm temperature extremes are also consistent with warming but are much weaker than those in cold temperature extremes, with significant trends observed at only around 15% of all stations and correlation coefficients between 0.1 and 0.16. In terms of seasonality, between 7% to 20% of stations show significant trends in the date of the beginning or end of summer or the growing season, with the greatest correlations and most stations for trends showing an earlier beginning to the growing season and a later end to summer.

Mapping indicators with significant trends in at least 25%

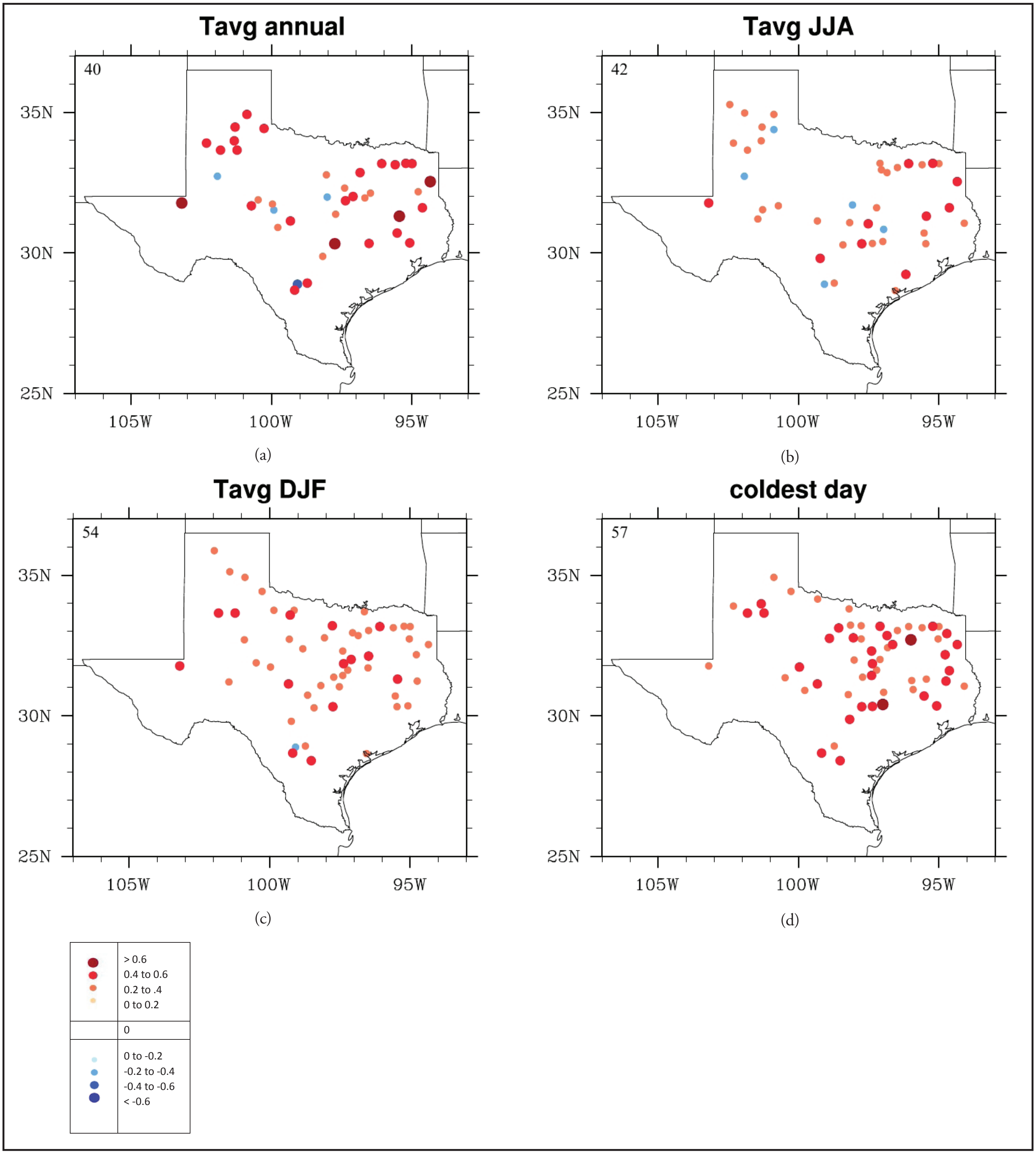

Figure 4 (a-d). Observed temperature trends in weather stations near reservoirs as determined by Spearman ranking. The number of points on each map varies, as only weather stations with a significant ($p<0.1$) trend for that variable are shown. Color indicates a positive (red) or negative (blue) trend, while size indicates the relative strength of the trend. Indicators with more than 25% of stations showing a significant trend consist of: (a) mean annual temperature, (b) summer (Jun-Jul-Aug) temperature, (c) winter (Dec-Jan-Feb) temperature, (d-g) coldest 1, 3, 5, and 10 days of the year, and (h) days per year with minimum temperature <32 °F or 0 °C. (Figure 4(e-h) continued on next page.)

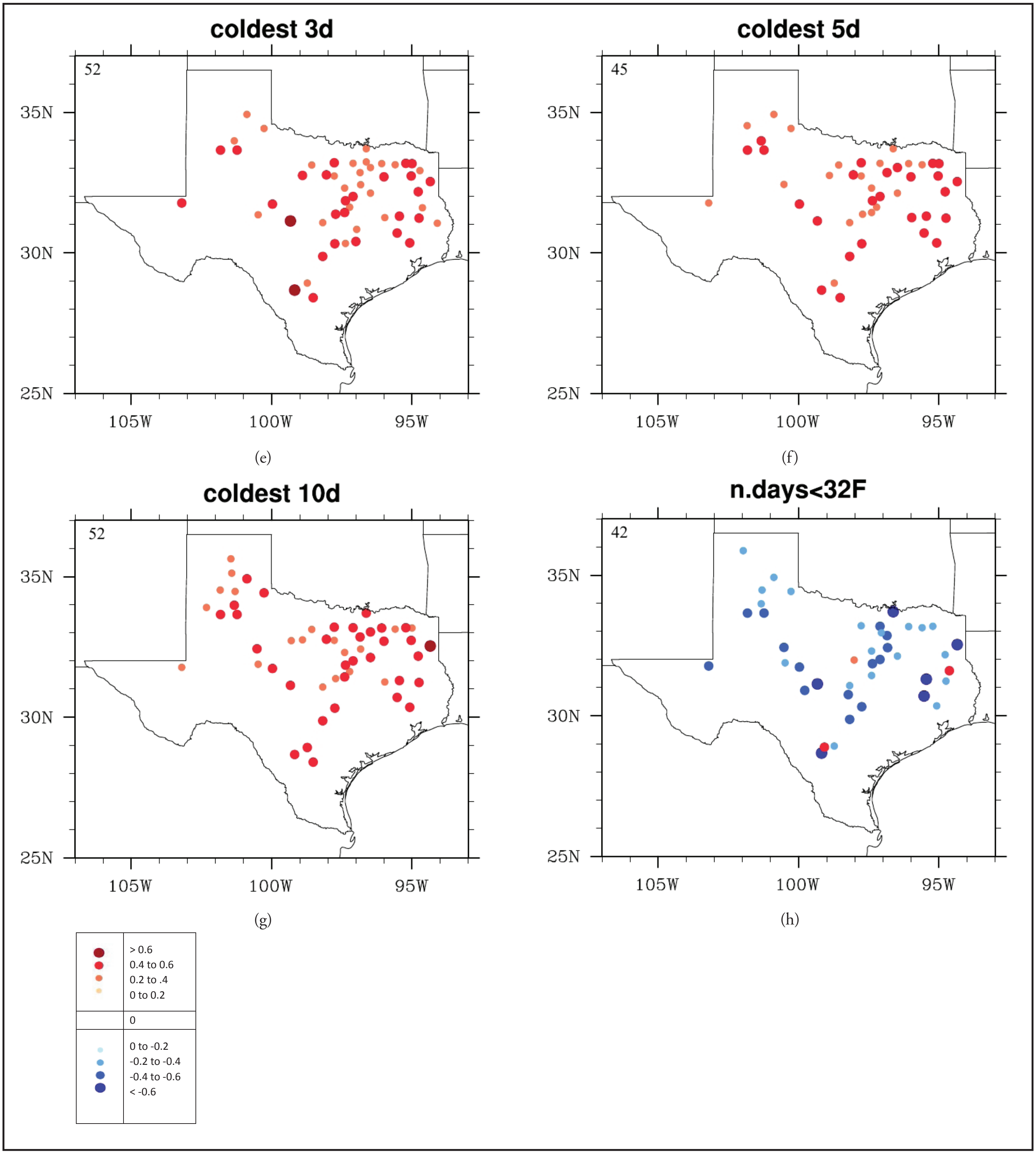

Figure 4(e-h). Observed temperature trends in weather stations near reservoirs as determined by Spearman ranking. The number of points on each map varies, as only weather stations with a significant (p<0.1) trend for that variable are shown. Color indicates a positive (red) or negative (blue) trend, while size indicates the relative strength of the trend. Indicators with more than 25% of stations showing a significant trend consist of: (a) mean annual temperature, (b) summer (Jun-Jul-Aug) temperature, (c) winter (Dec-Jan-Feb) temperature, (d-g) coldest 1, 3, 5, and 10 days of the year, and (h) days per year with minimum temperature <32 °F or 0 °C. (Figure 4(a-d) on previous page.)

of weather stations shows that, across the state, annual average temperature shows the strongest trends among all climate indicators, while increases in winter temperature tend to be more geographically consistent than increases in summer temperature (Figure 4(a-c)). These results do not indicate a specific region or set of watersheds that are warming more than others; instead, trends seem to be distributed consistently across the state. A few stations exhibited a negative or cooling trend, as indicated by blue dots. Most of these trends were relatively small and may be associated with local factors, such as irrigation or land use change that can alter humidity levels and temperature. Kueppers et al. (2007) found that climate effects of irrigation can be relatively large on a regional scale and hypothesized that expansion of irrigation may have masked regional increases in temperature due to increases in greenhouse gases. Changes in temperature trends were observed also with rural to urban land use/land cover changes (e.g. Gallo et al. 1999; Hale et al. 2006). It is likely that the rapid increase in population in South Central Texas and extensive irrigation in the North West region have an impact on temperature variability across the state. Alternatively, given the large sample of 120 stations, these could also be statistical anomalies.[2]

These trends signify the strong positive trends in cold temperatures, specifically the temperature of the coldest 1, 3, 5, and 10 days of the year (Figure 4(d-g)). A greater number of stronger trends are seen in the eastern as compared to the western half of the state, but every station with a significant trend in these variables shows a warming. Trends in the number of days per year below freezing (Figure 4(h)) show a similar geographic distribution to trends in cold temperature extremes, but the results are less consistent due to the comparison to an artificial threshold (0 °C or 32 °F), e.g., days below freezing might be quite common in the northwest part of the state, but relatively rare in the southeast.

Precipitation trends

Trends in annual and seasonal total precipitation from 1960 to 2010 are generally positive in all seasons except fall, with correlation coefficients ranging from 0.22 to 0.3 (Figure 2b, right). Seasonal precipitation trends are generally significant at 13% of stations (Figure 2b, left). This small number could be the result of 2 factors: (1) weaker trends as compared to temperature, and/or (2) greater inter-annual variability in precipitation than for temperature, both of which would make detection of significant trends more challenging. About 13% of stations showed that the date of the year at which 50% of precipitation has occurred is moving to an earlier date, consistent with increases in winter and spring precipitation, with an average correlation coefficient of -0.32. Due to the relatively small number of stations with significant trends in mean precipitation and the seasonality of precipitation, we do not plot the geographic distribution of these trends.

For precipitation extremes, 30% of stations have significant trends in precipitation intensity (defined as average annual precipitation divided by the number of wet days per year) and 33% have significant trends in the average number of dry days per year (defined as days with less than 0.01 inches of cumulative precipitation in 24 hours; Figure 5a-b). For these 2 variables, however, there is significant spatial inhomogeneity in the magnitude and the direction of observed trends. For precipitation intensity, approximately two-thirds of stations with significant trends show increases, and one-third show decreases. For the average number of dry days per year, it is the opposite: approximately one-third of all stations show an increase and two-thirds, a decrease.

Changes in precipitation intensity are related to either annual precipitation and/or the number of dry days per year. With some evidence for increasing seasonal and annual precipitation, locations with increases in precipitation intensity are likely driven by a general increase in average precipitation, combined with either little change or an increase in the number of dry days per year. In contrast, locations with decreasing precipitation intensity likely also have decreases in dry day frequencies, combined with decreases or no change in average precipitation. We explore these relationships in Figure 5c, which shows the combined direction of trends in mean precipitation, precipitation intensity, and dry day frequency. As expected, stations with an increase in precipitation intensity also show an increase in the number of dry days per year (14 stations; red/pink colors). Similarly, stations with a decrease in precipitation intensity show a decrease in the average number of dry days per year (11 stations; dark blue/green colors). Only 8 stations show trends in intensity but not in dry days and 12 stations show trends in dry days but not in intensity. The mean of Fisher's Z transformed correlation coefficient over all stations with significant trends shows an overall positive trend in precipitation intensity and average annual precipitation and a decrease in dry day frequency (Figure 2b, right). This can be explained by the predominance of strong negative trends in dry days and strong positive trends in precipitation intensity.

Trends in water variables

Almost 50% of reservoirs show significant ($p<0.1$) trends in water temperature and 43% show significant trends in DO, a related indicator (Figure 3, left). Trends in water temperature from 1960 to 2010 across the state are largely positive, reflecting the increase in water temperature likely because of increase in air temperature shown in Figure 6a. A few reservoirs show negative trends in water temperature; these have no significant

[2] A p-value of 0.1 implies a 10% chance of a false trend being identified at a given station.

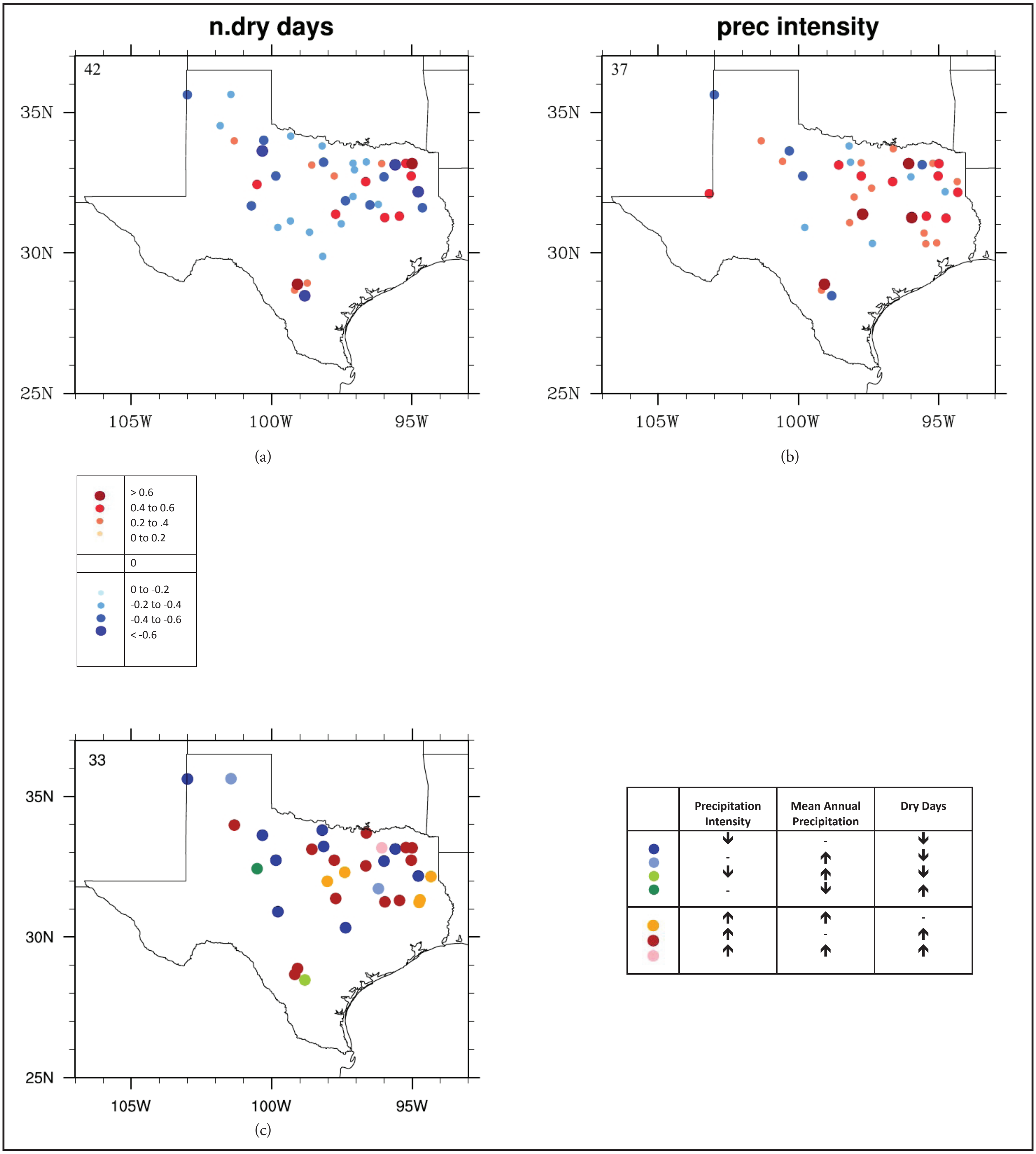

Figure 5(a-c). Observed precipitation trends in weather stations near reservoirs as determined by Spearman's rank. The number of points on each map varies, as only weather stations with a significant (p<0.1) trend for that variable are shown. Color indicates a positive (red) or negative (blue) trend, while size indicates the relative strength of the trend. Indicators with more than 25% of stations showing a significant trend consist of: (a) total number of dry days per year, and (b) mean annual precipitation intensity. Also shown is (c) a combined analysis highlighting the relationship between observed trends in precipitation intensity, mean annual precipitation, and the number of dry days per year.

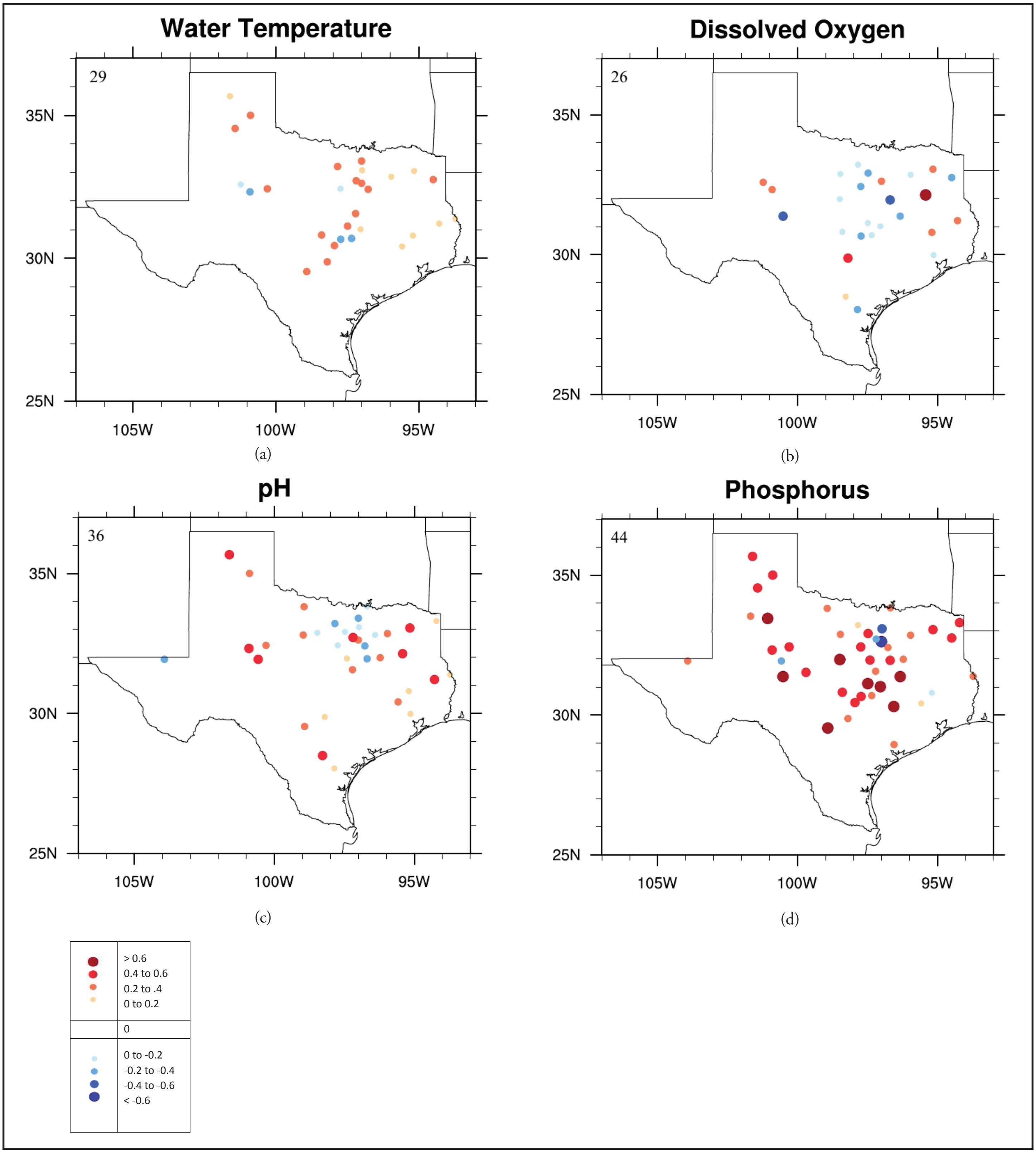

Figure 6(a-d). Observed trends in Texas reservoirs as determined by Spearman's rank. The number of points on each map varies, as only reservoirs with a significant ($p<0.1$) trend for each variable are shown. Color indicates a positive (red) or negative (blue) trend, while size indicates the relative strength of the trend. Indicators consist of: (a) reservoir water temperature, (b) dissolved oxygen, (c) pH, (d) specific conductance, (e) phosphorus, (f) chloride, and (g) sulfate at depths above 10 feet. No significant trends for variables at depths below 10 feet were detected, at least in part due to data sparseness.(Figure 6(e-h) continued on next page.)

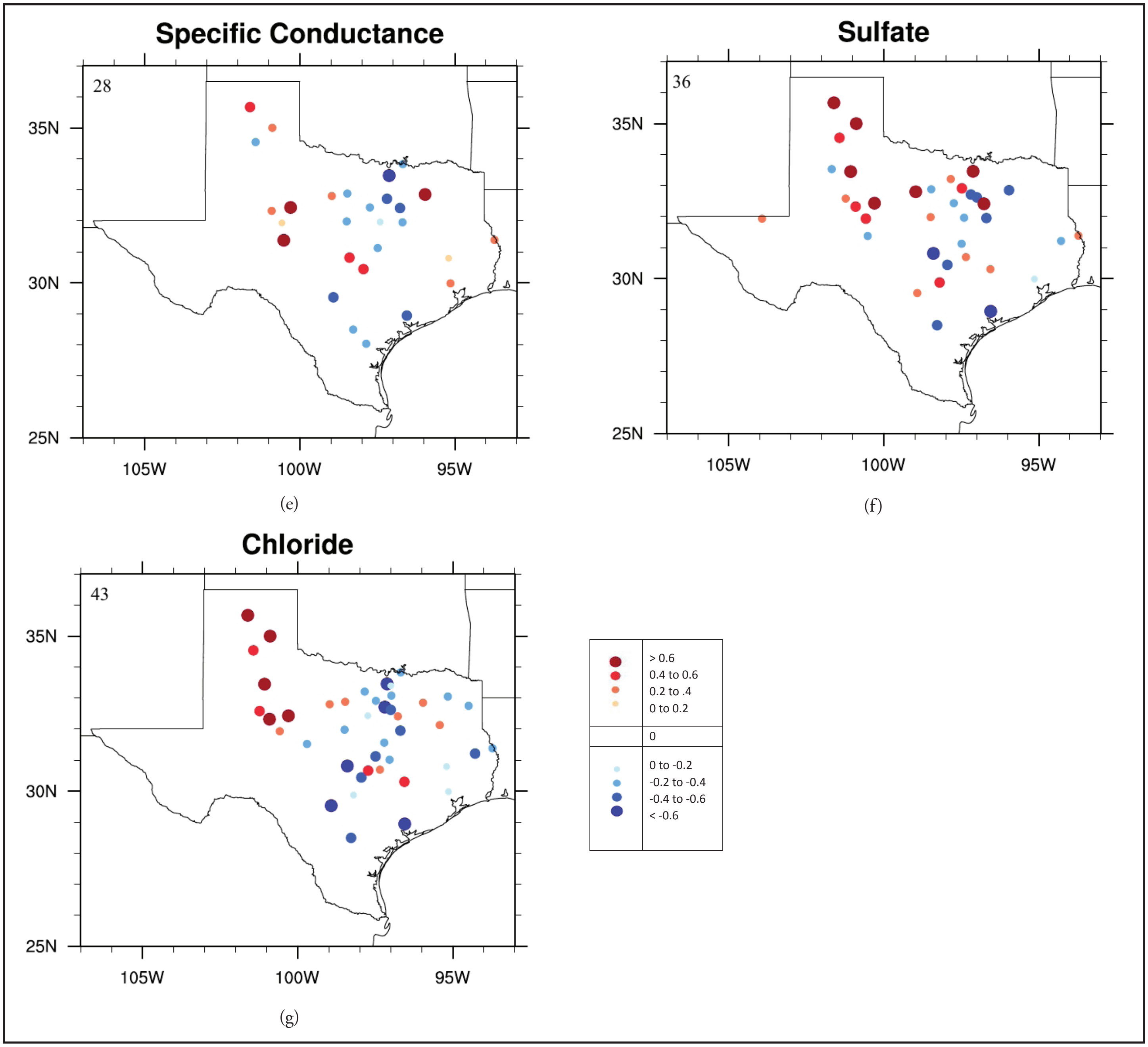

Figure 6(e-g). Observed trends in Texas reservoirs as determined by Spearman's rank. The number of points on each map varies, as only reservoirs with a significant ($p<0.1$) trend for each variable are shown. Color indicates a positive (red) or negative (blue) trend, while size indicates the relative strength of the trend. Indicators consist of: (a) reservoir water temperature, (b) dissolved oxygen, (c) pH, (d) specific conductance, (e) phosphorus, (f) chloride, and (g) sulfate at depths above 10 feet. No significant trends for variables at depths below 10 feet were detected, at least in part due to data sparseness. (Figure 6(a-d) on previous page.)

trend in air temperature at nearby weather stations.

As water temperature increases, DO would be expected to decrease, since warmer water holds less oxygen. This general trend is illustrated in Figure 3 (left). However, Figure 6b shows that out of the 16 reservoirs that have significant trends in both water temperature and DO, only half of those show the expected inverse relationship between temperature and DO (i.e., that one is increasing while the other is decreasing or vice versa). This highlights the importance of other variables besides mean temperature, such as precipitation events, natural and human-induced loading of organic materials and associated bacteria-mediated decay, and biological processes (photosynthesis and respiration), in determining the amount of DO in the water.

In terms of water quality, specific conductance, pH, phosphorus, chloride, and sulfate show significant trends in 49% to 73% of Texas reservoirs (Figure 3, left). The most consistently positive trends across the entire state are seen in pH, sulfate, and phosphorus, respectively (Figure 3, right and Figure 6c,d,f). Specific conductance and chloride also show a large number of significant trends (Figure 6e,g), but the Fisher's Z transform of the correlation coefficients across the state averages out to near zero (Figure 3, right) because of large increases in West Texas contrasted with large decreases in East Texas.

In Figure 7, we summarize statewide trends in the primary air and water variables that have consistent trends across the state. We compare the direction and magnitude of trends in water quality parameters with those in atmospheric variables. We exclude DO, sulfate, and chloride, as they show both positive and negative trends and the Fisher's Z average is close to zero. This figure illustrates the complex nature of the interactions between trends in atmospheric variables such as temperature and precipitation and trends in water temperature and quality. Comparing Texas-wide average trends in air temperature (red symbols) with trends in water temperature (diamond shapes) shows that both are increasing but with proportionally greater changes in air temperature. The observed increase in average annual precipitation (blue symbols) is correlated with an increase in water temperature, phosphorus, pH, and specific conductance (upper right). Large increasing trends in phosphorus (circles) appear correlated with temperature and cold days (red and purple symbols).

Although our trend analysis was applied to all the water quality variables listed in Table 2, we do not discuss the results for variables where fewer than 20 reservoirs recorded significant trends over the period of record. However, it is important to note that lack of a significant trend with $p<0.1$ does not necessarily mean there is no trend; instead, lack of significance could be due to data sparseness. For that reason, this analysis should not be taken as definitive proof of absence of trend, but rather absence of information available to quantify a trend at this time.

DISCUSSION AND CONCLUSIONS

Using long-term water quality data collected at 59 Texas reservoirs, we identified 120 weather stations adjacent to or upstream of the reservoirs and analyzed trends in air temperature, precipitation, water temperature, and water quality parameters at the 57 reservoirs with sufficient data from 1960 to 2010. This period was defined by the length of available water data. Our purpose was to quantify recent trends in atmospheric and water conditions for Texas reservoirs, which are important sources of surface water for human consumption, recreation, agriculture, and aquatic ecosystems.

For air temperature, approximately one-third to one-half of

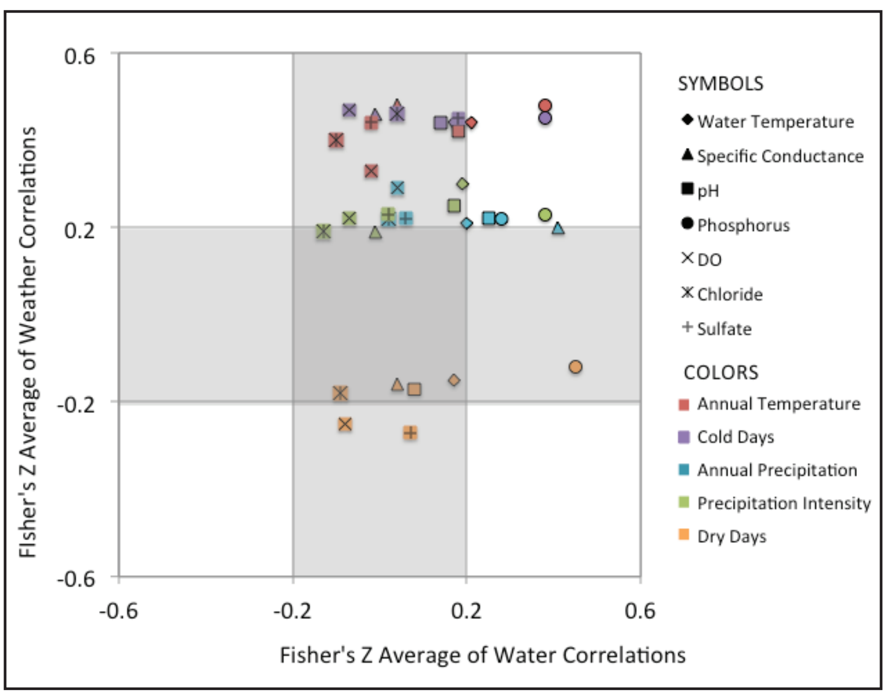

Figure 7. Comparison of the Fisher's Z transform trend magnitude (rho) of each water parameter averaged over all reservoirs showing a significant trend with that of each climate indicator averaged over all stations with significant trend and located nearby each reservoir. Colors represent water parameters and symbols represent the weather indicators.

stations showed significant increases in annual and seasonal temperatures, particularly in winter and summer (Figure 2a). The strongest and most consistent temperature-related warming trends were for cold temperatures; specifically, the average temperature of the 1, 3, 5, and 10 consecutive coldest days of the year and the number of days per year with minimum temperature below freezing.

Weather stations with significant warming trends are distributed across the state (Figure 4), suggesting that a larger-scale warming trend is being superimposed on local-scale variability that can modify the magnitude and even, for a few locations, the sign of the trend. Trends for the near-reservoir weather stations are consistent with Texas-wide trends documented by the NCDC's Climate at a Glance[3] averaging +0.3 °F per decade for annual, +0.5 °F per decade for winter, and +0.2 °F per decade in summer temperatures for the same time period.

For precipitation, a relatively small number of stations (8-13%) show significant increases in annual and seasonal amounts for every season except fall (Figure 2b). A much larger number of stations show significant trends in precipitation intensity (30%) and dry days (33%). In most locations, precipitation intensity is increasing and dry days are decreasing (Figure 5a,b). Increases in average precipitation increase the amount of rain in an event, while a decrease in dry days means that the same amount of precipitation is falling in more wet days. Additional analysis summarized in Figure 5c suggests that an increase/decrease in precipitation intensity is usually accompanied by a matching increase/decrease in the number of dry days. In some locations, an increase in precipitation intensity is also accompanied by an increase in average precipitation. These trends are consistent with an observed increase in the frequency of extreme precipitation events and time of day of DO measurement over the United States as a whole, as well as over the Great Plains region of which Texas is a part (USGCRP 2009).

In terms of changes in reservoir characteristics, nearly half the reservoirs show significant increases in water temperature (Figure 3, left). Given the widespread increases in air temperature observed across the state and the strong correlation between the magnitude of trends in air and water temperature for individual reservoirs (Figure 7), it is likely that water temperatures are responding to increases in air temperatures. Some locations show decreases in DO consistent with increases in water temperature; other locations, however, do not. This suggests that DO may also be moderated by other factors such as precipitation, where an increase in precipitation intensity and number of dry days is decreasing overall precipitation events and increasing DO, natural and human-induced loading of organic materials and associated bacteria-mediated decay, and biological processes (photosynthesis and respiration) (Figure 7).

Significant trends in 5 indicators of water quality were also identified for 49% to 73% of reservoirs (Figure 3). Of these 5 variables, pH, and phosphorus increase consistently across most locations (Figure 6c,d). The remaining 3 variables—sulfate, chloride, and specific conductance—show strong regional diversity. All are more likely to have positive trends in West Texas and negative trends in the central and eastern part of the state (Figure 6e-g).

In terms of the 2 variables that both show increases across the state, phosphorus shows the strongest and most consistently positive increases in 73% of reservoirs across the state. The majority of these increases are likely the consequence of phosphorus-containing fertilizers used in agriculture across the United States since the 1950s[4] and long-term accumulation of phosphorus in reservoir sediments. However, the increases could also be the result of an increase in nutrient runoff from other human sources: urban runoff, discharge of treated domestic waters. However, higher temperature and more intense precipitation events can also contribute by increasing evaporation and fertilizer runoff (Figure 7). With the exception of a small cluster of reservoirs in northeast Texas, pH also shows increasing trends at most reservoirs across the state. Increases in water temperature and nutrients might result in higher productivity in reservoirs; in turn, photosynthetic processes increase pH (Michaud 1994).

Specific conductance, sulfate, and chloride all show patterns of strong increases in the west and slightly weaker decreases in the east. Decreases in the central/eastern parts of Texas could be related to increased dilution of salts from increases in precipitation. Lacking any significant trends in dry days or indications of increased evaporation, which would tend to concentrate salts (other than that implied by increasing seasonal temperatures), the large increases in the western part of the state are more likely primarily from a decrease in reservoir water levels because of human withdrawals and possibly the effects of local activities such as oil and gas extraction (Vance 2006).

These findings have important implications for water quantity and quality in Texas reservoirs. Increasing air temperature may be contributing to increases in water temperature, decreases in DO, and increases in pH, which can affect the survival of aquatic life. Increases in phosphorus concentration could be from runoff from urban and agricultural lands and long-term accumulation of phosphorus in sediments. Increases in sulfate and chloride concentrations in West Texas reservoirs might be caused by proximity to ditches for oil-field discharge and saline water wells, as well as by decreases in water levels from human withdrawal. Increases in precipitation intensity (coupled, at some locations, with increases in the number of dry days) could have consequences on the streamflow rate and runoff events,

[3] http://www.ncdc.noaa.gov/cag/

[4] http://www.tfi.org/statistics/statistics-faqs

with direct impacts on reservoir water quality. Increases in precipitation intensity in areas dominated by agriculture, such as parts of West Texas, will result in increased nutrient runoff. This can contribute to reservoir eutrophication and could potentially create optimal conditions for golden algae blooms (Yates and Rogers 2011). More research is needed to determine how changes in air temperature and precipitation will affect water quality in Texas reservoirs. In our future work, we plan to quantify the influence of atmospheric predictors, flow rate, and water level on inter-annual variability and long-term trends, water temperature, and water quality variables. This will help to evaluate how long-term climate change will affect water quality over the coming century and the impact on aquatic biota, the local economy, water availability and treatment, and recreational activities throughout the state of Texas.

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APPENDIX A. WEATHER STATION DATA QUALITY CONTROL

Our quality control process for daily weather station data checks for and removes the following errors:

- minimum temperature greater than maximum temperature on the same day
- temperature values above the maximum or below the minimum record values in the continental United States
- precipitation values above the maximum record value in the continental United States or less than zero
- any values that are repeated exactly, to within one-tenth of the measurement unit, for 5 or more consecutive days

Through the quality control process, we identified errors in all but 1 of the 120 stations tested. Days where minimum temperature exceeded maximum temperature were identified in 4 out of 120 stations. No range errors were found for temperature or precipitation. The largest source of error came from temperature repeats. Both maximum and minimum temperature repeats occurred in more than 99% of the records, but non-zero repeats in precipitation were found in only 1 of the 120 stations. Despite the number of errors identified, the actual number of data points removed to account for all errors or questionable data points from each file was small (<1% and in most cases <0.1%), so this quality control process is not likely to affect the robustness of the trend analysis.

APPENDIX B. WATER DATA STANDARDIZATION PROCEDURE

The water temperature and quality observations used in this analysis come from a variety of sources. These observations were made at different depths at the same location over time, at different locations within the same reservoir, and different depths in different reservoirs. Before analyzing the data, it had to be standardized. To differentiate between water closer to the surface, which would be more strongly affected by short-term variations in temperature and precipitation over timescales of days to weeks, and deeper water, which would respond more slowly to longer-term changes over timescales of months to years, we standardized the water data to 2 mean depths: 1 above 10 feet (i.e. between the surface and 10 feet of depth) and 1 below 10 feet (i.e. between 10 feet of depth and the bottom of the reservoir).

A weighted mean of each water quality parameter for depths above and below 10 feet was computed for each available day using the concept of a layered model. Available depths in each reservoir determined the width of the layers within each zone (above and below 10 feet). The center of each inner layer was set at half the distance between 2 sampling depths, and the boundary layers were centered at 0, 10 feet or the lowest sampling depth by doubling the distance from the boundary to the center of the nearby layer. The weight for each layer was calculated as the vector sum of the layer width weight and inverse variance weight divided by 2. These weights were then used to calculate the weighted mean of each parameter in each zone (above or below 10 feet).

Texas Water Resources Institute
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Commentary: Fifth Circuit Decision in *The Aransas Project v. Shaw:* the Whooping Crane Case

Robert L. Gulley[1]

Editor's Note: The opinion expressed in this commentary is the opinion of the individual author and not the opinion of the Texas Water Journal or the Texas Water Resources Institute.

Keywords: Endangered Species Act, surface water, whooping crane

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Terms used in paper

Short name or acronym	Descriptive name
ESA	Endangered Species Act
TCEQ	Texas Commission on Environmental Quality
TAP	The Aransas Project
USFWS	U.S. Fish and Wildlife Service

On June 30, 2014, the United States Court of Appeals for the Fifth Circuit issued its decision on the appeal in *The Aransas Project* (TAP) *v. Shaw*. The district court had found that the Texas Commission on Environmental Quality (TCEQ) had violated section 9 of the Endangered Species Act (ESA) by authorizing the diversion of water on the San Antonio and Guadalupe rivers that proximately caused the alleged take of whooping cranes during the 2008–2009 drought.[1] The Fifth Circuit reversed, holding that the district court had applied the wrong test for proximate causation and that, applying the proper standard, "only a fortuitous confluence of adverse factors caused the unexpected 2008–2009 die-off" of whooping cranes.[2] The Fifth Circuit concluded that, "Finding proximate causation and imposing liability on the State defendants in the face of multiple, natural, independent, unpredictable and interrelated forces affecting the cranes' estuary environment goes too far."[3]

The TAP case involves the question of "indirect" or "vicarious" liability under section 9 of the ESA. Section 9 of the ESA prohibits the "take" of listed endangered fish and wildlife.[4] "Take" is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct."[5] "To establish a violation of section 9, the plaintiff must prove that the defendant was the proximate cause of the "take."[6]

In reversing the district court decision, the Fifth Circuit did not find that the issuance of a permit could never constitute a "take"—only that the requisite proximate causation had not been established in the case before it.[7] Although the Fifth Circuit expressly left the issue open, it appeared that it might be prepared in a subsequent case to hold that a state agency's authorizing an action, such as through the issuance of a permit, may not, as a matter of law, constitute a "take." Such a decision would create a conflict between federal courts of appeals that could result in subsequent review by the Supreme Court.[8]

In the TAP case, the plaintiff alleged that TCEQ, in administering permits for the diversion of water from the Guadalupe and San Antonio rivers, foreseeably and proximately caused the deaths of whooping cranes in the winter of 2008–2009.[9] The Court found that the district court had not explained "why the remote connection between water licensing, decisions to draw water by hundreds of users, whooping crane habitat, and crane deaths that occurred during a year of extraordinary drought compels ESA liability."[10] The Fifth Circuit concluded that the district court either "misunderstood the relevant liability test or misapplied proximate cause when it held the defendants responsible for the remote, attenuated, and fortuitous events following their issuance of water permits."[11] Based on this conclusion, the Fifth Circuit made its own independent determination regarding liability.[12]

The practical importance of the case, for now, lies in the Fifth Circuit's explanation of the requisite showing for establishing proximate causation. The Court explained, quoting from a recent Supreme Court case, that "a requirement of proximate cause thus serves … to preclude liability in situations where the causal link between conduct and result is so attenuated that the consequence is more aptly described as mere fortuity."[13] The Court further explained that in the context of the

[1] *See The Aransas Project v. Shaw,* 930 F. Supp. 2d 716 (S.D. Tex 2013).

[2] *The Ara*nsas Project v. Shaw, slip op. at 31 (5th Cir. June 30, 2014).

[3] Id.

[4] 16 U.S.C. § 1538(a)(1).

[5] 16 U.S.C. § 1532(19).

[6] *Babbitt v. Sweet Home Chapter of Communities for a Greater Or,* 515 U.S. 687 (1995).

[7] *The Aransas Project v. Shaw,* slip op. at 21, n. 9.

[8] *See Strahan v. Coxe*, 127 F.3d 155 (1st Cir. 1997).

[9] *Id.* at 21. The permits at issue had been issued many years prior to the alleged "take."

[10] *Id.* at 24.

[11] *Id.*

[12] *Id.*

[13] *Id.* at 23 (citing *Paroline v. United States*, 134 S. Ct. 170 (2014).

ESA "liability may be based neither on the "butterfly effect"[14] nor on remote actors in a vast and complex ecosystem."[15] "The causal factors and the result must be reasonably foreseeable."[16]

Proximate causation and foreseeability are concepts well-grounded in tort law and well-understood by courts. In that context, the Fifth Circuit's determination of the requisite proof for establishing proximate causation was not remarkable. How that burden can be met in a "vast and complex ecosystem" is what remains to be worked out in subsequent cases. In TAP, the Fifth Circuit focused both on the "number of contingencies affecting the chain of causation from licensing to crane deaths" and the fact that all of the contingencies were "outside the state's control and often outside human control."[17] The Court, however, *in dicta*, also provided its views on the possible boundaries for meeting that burden in the Fifth Circuit: "a landowner who knowingly drained a pond that housed endangered species" would not avoid ESA liability but a farmer who "tills his field, causes erosion that makes silt run into a nearby river, which depletes oxygen in the water, and thereby injures protected fish might avoid liability."[18] What does seem clear is that all of the contributing causes will have to be considered and weighed by the courts in making the liability determination. The number and complexity of the contributing causes of "take" with respect to some listed species, such as mussels, may make it difficult to establish liability in section 9 cases. In many instances, it will make the already costly litigation more expensive and time consuming.

The Fifth Circuit addressed another issue that has loomed over threatened section 9 cases since the Court's decision in the *Sierra Club v. City of San Antonio* case in 1997.[19] The *City of San Antonio* case involved a challenge to a preliminary injunction against the users of the Edwards Aquifer to protect springflow during a severe drought to protect eight listed species at the Comal and San Marcos springs. In that case, also brought under section 9 of the ESA, the Fifth Circuit found that the district court abused its discretion in not abstaining under the Burford abstention doctrine to avoid entangling federal courts in issues of essential state law and policy. The defendant-intervenors in the TAP case argued that, as in the *City of San Antonio* case, the district court should have abstained under the Burford doctrine rather than adjudicating the case. The Fifth Circuit, while acknowledging that the cases were "similar in certain ways" found the district court did not abuse its discretion in the TAP case in refusing to abstain because of "the intrastate focus in *City of San Antonio*, more highly developed environmental protections there, and the broader grant of administrative and judicial authority by state law to remedy environmental grievances."[20]

Finally, the Fifth Circuit found the district court abused its discretion in claiming a "relaxed" standard existed for granting injunctive relief in an ESA case. The Fifth Circuit acknowledged that the standard is more relaxed with respect to balancing the equities in granting or denying an injunction but found that the fact that listed species are involved does not relieve courts of the obligation to consider the likelihood of future harm before granting an injunction. The Court held that the district court in granting the injunction in the TAP case failed to properly consider whether there is "a reasonably certain threat of imminent harm to a protected species." The Fifth Circuit found error in the district court having focused almost exclusively on the injury that occurred in 2008–2009 in granting the injunction. It explained that injunctive relief for the indefinite future cannot be predicated on the unique events of one year without proof of their likely, imminent replication."[21] This finding by the Fifth Circuit is noteworthy because the court, having found no liability, was not compelled to address this issue.

Since *Sweet Home*, proximate causation has been recognized by most ESA practitioners as an element of a section 9 case. As such, the Fifth Circuit's decision does not represent a change in the law. However, after the TAP decision, proximate causation, which has not been the focus in many section 9 cases, is likely to get more attention in all circuits and involve courts in the impacts on listed species in the context of a "vast and complex ecosystem." This will be particularly likely with respect to water cases where the effects of drought can be a contributing factor. The time and cost of bringing such a case will increase, and a plaintiff can realistically be confident of success only where the defendant's actions are patently tied closely to the "take" and, at least in the Fifth Circuit, the elements necessary for obtaining injunctive relief are clearly demonstrable.

Habitat conservation plans, safe harbor agreements, and candidate conservation agreements with assurances, are among the voluntary programs available to private landowners and entities to avoid or limit section 9 liability. The U.S. Fish and Wildlife Service (USFWS) has been relatively successful in encouraging and creating incentives for the use of these voluntary programs. Private parties enter into such programs for a wide variety reasons, including a desire to obtain certainty, environmental stewardship, and economic considerations.

[14] The butterfly effect is the idea that a butterfly stirring the air today in China can transform storm systems next month in New York.

[15] *The Aransas Project v. Shaw,* slip op. at 23.

[16] *Id.* at 27.

[17] *Id.* at 29.

[18] *Id.* at 25 and 23.

[19] *Sierra Club v. City of San Antonio*, 112 F.3d 789 (5th Cir. 1997).

[20] *The Aransas Project v. Shaw,* slip op. at 15.

[21] *The Aransas Project v. Shaw,* slip op. at 33.

However, to the extent that "risk avoidance" is an important consideration, voluntary participation in such programs may be reconsidered by some in the Fifth Circuit as private parties re-evaluate the threat of section 9 liability or the likelihood that the USFWS or third parties will invest the resources necessary to bring such an action. The USFWS, which has heretofore been largely uneager to bring such complex cases, may need to make such an investment, in an appropriate case, if it expects to maintain a credible threat under section 9.

The recent Edwards Aquifer Habitat Conservation Plan should not be jeopardized by the Fifth Circuit's decision. The causation facts in a section 9 case against the principal pumpers seem to fit squarely within the Fifth Circuit's paradigm of "take" liability involving a "landowner who knowingly drained a pond that housed endangered species." This paradigm appears to be particularly apt because modeling by the Edwards Aquifer Authority and others has already demonstrated that at Comal Springs during a repeat of the drought of record, the lowest flows that would have occurred without any pumping would have been slightly below 300 cubic feet per second—a level well above where take is likely to occur.[22]

Although section 7 applies only to actions by federal agencies, such as permits issued by an agency, it is an important tool of the USFWS in protecting threatened and endangered species. If the USFWS's proposed critical habitat regulations are promulgated as proposed, they will provide the USFWS with a significant tool under section 7 to help to recover these species.[23] Although the USFWS often applies the broader "but for" test in evaluating the effects of agency actions, proximate causation may be the standard that should be applied.[24] Accordingly, it remains unclear what impact the TAP case will have, if any, on biological opinions issued under section 7.

For a case that simply confirmed existing law, *The Aransas Project v. Shaw* is likely to have an impact on species protection. The full magnitude of that impact remains to be determined.

[22] Edwards Aquifer Authority, *Draft Edwards Aquifer Authority Habitat Conservation Plan," July 2004, as amended on September 21, 2004*, at Appendix H, Table 4-1; David Thorkildsen and Paul D. McElhaney, Texas Water Development Boards Report 340, "Model Refinement and Applications for the Edwards (Balcones Fault Zone) Aquifer in the San Antonio Region, Texas," July 1992.

[23] 79 Fed. Reg. 27,060 (May 12, 2014); 79 Fed. Reg. 27,066 (May 12, 2014).

[24] *See Nat'l Ass'n of Home Builders v. Defenders of Wildlife*, 551 U.S. 644, 667-68 (2007) ("But the basic principle announced in Public Citizen—that an agency cannot be considered the legal "cause" of an action that it has no statutory discretion not to take—supports the reasonableness of the USFWS's interpretation of § 7(a)(2) as reaching only discretionary agency actions."); *Florida Key Deer v. Paulison*, 522 F.3d 1133 (11th Cir. 2008); *but see* e.g., U.S. Fish and Wildlife Service and National Marine Fisheries Service, Endangered Species Consultation Handbook, March 1998 at 4-58 ("In determining whether the proposed action is reasonably likely to be the direct or indirect cause of incidental take, the Services use the simple causation principle; *i.e.*, 'but for' the implementation of the proposed action and its direct or indirect degradation of habitat, would actual injury or mortality to individuals of a listed wildlife species be reasonably likely to occur").

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Texas groundwater rights and immunities: from *East* to *Day* and beyond

Dylan O. Drummond [1, 2 *]

Abstract: For well over a century, the debate has raged over what interest, if any, landowners possess in the groundwater beneath their property, as well as what degree of tortious immunity a neighboring landowner enjoys for draining adjoining groundwater. After the Texas Supreme Court's 2012 decision in *Edwards Aquifer Authority v. Day*, and the Texas Legislature's 2011 amendments to the Texas Water Code, these debates appear to have been finally settled—for now!

This article traces the jurisprudential development of Texas groundwater law, from its earliest origins in ancient Rome through to the most influential and substantive decisions of the Texas Supreme Court and legislation from the Texas Legislature. It also examines what cases are on the horizon that may yet affect Texas groundwater law in the coming years.

Keywords: groundwater law, rule of capture, absolute ownership, Day, East, Supreme Court of Texas

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[2] The author would like to extend special thanks to: (1) the reviewers and staff of the Te*xas Water Journal*, whose exhaustive efforts greatly improved upon this work; (2) Professor Megan Benson, Ph.D., whose exhaustive and engaging work on the *East* case has been invaluable in drafting this article; and (3) Robert E. Mace, Cynthia Ridgeway, John M. Sharp, Jr., Robert F. Flores, and Edward S. Angle, whose authorita-tive and comprehensive efforts analyzing the factual background to the *East* case, as well as compiling most of the original case materials has been crucial to the research of this presentation. *See* Megan Benson. *Railroads, Water Rights and the Long Reach of* Houston and Texas Central Railroad Company v. W. A. East *(1904)*, 116 Southwestern Historical Quarterly 261 (Jan. 2013); Robert E. Mace et al., *Groundwa-ter Is No Longer Secret and Occult—A Historical and Hydrogeologic Analysis of the* East *Case, in 100 Years of the Rule of Capture: From* East *to Groundwater Management*, Texas Water Development Board Rep. 361 (2004).

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Terms used in paper

Short name or acronym	Descriptive name
EAA	Edwards Aquifer Authority
Act	Edwards Aquifer Authority Act
GCDA	Groundwater Conservation District Act
HCUWDC	Hudspeth County Underground Water Conservation District
MCUWCD	Medina County Underground Water Conservation District
PRPRPA	Private Real Property Rights Preservation Act
PUC	Public Utility Commission
Railroad	Houston & Texas Central Railroad Company
TIA	takings impact assessment
TCEQ	Texas Commission on Environmental Quality

INTRODUCTION[1]

Few states have as robustly developed and hotly debated an area of law so central to the rights and immunities of its citizens as does Texas in groundwater law. From the Texas Supreme Court's first groundwater decision in *Houston & Texas Central Railroad Co. v. East* in 1904[2] to its most recent opinion in *Edwards Aquifer Authority v. Day*,[3] well over a century of debate has raged in the literature, the courts,[4] and the legislature.[5]

But where does Texas groundwater stand after *Day* in 2012 and the Legislature's sweeping changes to the Texas Water Code in 2011, and what are the next cases and issues that might continue to shape groundwater jurisprudence in the years to come?

[1] *See* Megan Benson. *Railroads, Water Rights and the Long Reach of* Houston and Texas Central Railroad Company v. W. A. East *(1904)*, 116 Southwestern Historical Quarterly 261 (Jan. 2013) [hereinafter *Long Reach*]; Robert E. Mace et al., *Groundwater Is No Longer Secret and Occult—A Historical and Hydrogeologic Analysis of the* East *Case, in 100 Years of the Rule of Capture: From* East *to Groundwater Management,* Texas Water Development Board Report 361 (2004) [hereinafter East *Historical Analysis*].

[2] 98 Tex. 146, 81 S.W. 279 (1904).

[3] 369 S.W.3d 814 (Tex. 2012).

[4] Of minor note, some 288 volumes of cases were published in the *Southwestern Reports* between *East* and *Day*. *Compare East*, 81 S.W. 279, *with Day*, 369 S.W.3d 814. Of perhaps even less note, a little over 40 years elapsed between the first Texas case published in the first series of the *Southwestern Reports* (*Poole v. Jackson*, 66 Tex. 380, 1 S.W. 75 (1886)) and the first Texas case published in the second series (*Sovereign Camp W.O.W. v. Boden*, 117 Tex. 229, 1 S.W.2d 256 (1927)), and just over 70 years between *Boden* and the first Texas case published in the third series—a groundwater law case (*Sipriano v. Great Spring Waters of Am., Inc.*, 1 S.W.3d 75 (Tex. 1999)). *Compare Poole*, 1 S.W. 75, *Boden*, 1 S.W.2d 256, *with Sipriano*, 1 S.W.3d 75. Put another way, between pages 75 of the first and third series of the *Southwestern Reports,* over 11 decades passed. *Id.* As of September of this year, the most recent Texas case published in the third series of the *Southwestern Reports* is *In re J.D.*, 436 S.W.3d 105 (Tex. App.—Houston [1st Dist.] 2014, no pet.). Therefore, in just over 15 years, a little less than half of the current series of the *Southwestern Reports* has been filled. While it took 70 years for Texas jurisprudence to consume the second series of the *Southwestern Reports*, it appears the third series, if it keeps up with its current pace, will exhaust itself in about half that time.

[5] For a comprehensive—if now somewhat dated—compendium of the relevant literature, cases, and laws touching upon the groundwater debate in Texas, please see Dylan O. Drummond, Lynn Ray Sherman, and Edmond R. McCarthy, Jr., *The Rule of Capture in Texas—Still So Misunderstood After All These Years*, 37 Texas Tech Law Review 1, 3 n.3, 4 n.5, 8 n.7 (Winter 2004) [hereinafter *Still So Misunderstood*].

PRELIMINARY HISTORICAL CONTEXT INFLUENCING TEXAS GROUNDWATER LAW

As Justice Oliver Wendell Holmes remarked just 7 years before the Texas Supreme Court issued its opinion in *East*, the "rational study of law is still to a large extent the study of history."[6] Before the rule of capture was first recognized and the concept of groundwater ownership in place was first discussed more than a century ago in *East*,[7] the underpinnings of the debate between these 2 legal concepts had already raged for some 2,000 years.[8] Because the historical formulation of these 2 doctrines trace a uniquely direct lineage to *East*, some investigation of this historical exposition of Texas groundwater development is necessary.

Ancient legal development

Although Rome was founded in 753 B.C., the first written expression of Roman law was not completed until 300 years later in 451 B.C.[9] Rome's first written code is referred to as the *Twelve Tables* after the 12 bronze tablets upon which it was inscribed.[10]

A few hundred years after the promulgation of the *Twelve*

[6] Hon. Oliver Wendell Holmes, Jr., *The Path of the Law*, 10 Harvard Law Review 457, 469 (March 1897) [hereinafter *Path of the Law*]. Justice Holmes served as an Associate Justice on the United States Supreme Court for 3 decades from December 1902 until his retirement in January 1932. Federal Judicial Center, Biographical Directory of Federal Judges: Holmes, Oliver Wendell Jr., http://www.fjc.gov/servlet/nGetInfo?jid=1082&cid=999&ctype=na&instate=na (last visited Feb. 12, 2013).

[7] *East*, 98 Tex. at 150, 81 S.W. at 281–82. The Court later said of this passage that, in it, it "adopted the absolute ownership doctrine of underground percolating waters." *Friendswood Dev. Co. v. Smith-S.W. Indus., Inc.*, 576 S.W.2d 21, 25 (Tex. 1978).

[8] *See, e.g.*, Dylan O. Drummond, *Groundwater Ownership in Place: Fact or Fiction?* at 4–5, in UTCLE, Texas Water Law Institute (2008) [hereinafter *Fact or Fiction*]; *Still So Misunderstood*, 37 Texas Tech Law Review at 15–29.

[9] Alan Watson, The Law of the Ancient Romans 10, 13 (1970) [hereinafter Law of the Ancient Romans]; Pharr et al., the Theodosian Code and Novels and Sirmondian Constitutions xxiii (1952) [hereinafter [Theodosian Code].

[10] Law of the Ancient Romans, at 13. A commission, charged with the task of "'writing down the laws,'" produced the *Twelve Tables* in order to settle authoritatively many controversial cases that had arisen under the application of the unwritten, customary law of the time. Peter Stein, *Interpretation and Legal Reasoning in Roman Law*, 70 Chicago-Kent Law Review 1539, 1539–40 (1995) [hereinafter *Legal Reasoning in Roman Law*]. The *Twelve Tables* were so crucial to the later development of modern property law that they have been called "'the foundation of modern Western jurisprudence.'" Steven M. Wise, *The Legal Thinghood of Nonhuman Animals*, 23 Boston College Environmental Affairs Law Review 471, 492–93 (1996) (quoting Alan Watson, Rome of the XII Tables: Persons and Property 3 (1975)).

Tables, a system of nationally renowned jurists developed in Rome during the first century B.C., who interpreted the *Twelve Tables*, as well as the numerous edicts of the Roman emperors.[11] Because the writings of these jurists were drafted mainly as a critique of or in response to Imperial edicts and the *Twelve Tables*, such writings were called *responsa*.[12] These jurists were somewhat akin to modern-day law professors except that their written legal critiques were accorded precedential weight and applied by Roman judges of the day,[13] thereby becoming legally binding in many instances.[14]

The *responsa* of these jurists were eventually collected into a single comprehensive code some 600 years later by the Roman Emperor Justinian[15] in 533[16]—along with previous Roman codes,[17] constitutions, and Imperial edicts—called the *Digest of Justinian* (*Digest*).[18] As part of this monumental effort,[19] a sort of legal textbook for students—not unlike a first-year law student's casebook—called the *Institutes of Justinian* (*Institutes*) was also promulgated (Figure 1).[20] Indeed, the *Institutes* later formed the basis of much of Western jurisprudence, including being relied upon by common law judges in England

[11] W.W. Buckland, A Text-Book of Roman Law From Augustus to Justinian 21–23 (3d ed. 1966) [hereinafter Roman Law Textbook]; Law of the Ancient Romans, at 26–27.

[12] *See Still So Misunderstood*, 37 Texas Tech Law Review at 19 n.71, 21 n.91; Black's Law Dictionary 1427 (9th ed. 2010) (the legal opinions of leading jurists were called *responsa*).

[13] Some may argue modern-day law professors believe this to currently be the case as well! *See*, *e.g.* Black's Law Dictionary 1427 (9th ed. 2010) (quoting Hank Taylor, The Science of Jurisprudence 90–91 (1908)) ("the *judex*, or as we would call him, the referee, might have no technical knowledge of law whatever. Under such conditions[,] the unlearned judicial magistrates naturally looked for light and leading to the jurisconsults who instructed them through their *responsa prudentium*, the technical name given to their opinions as experts")). At Roman law, a *judex* was a "private person appointed by a *praetor* or other magistrate to hear and decide a case," who was "drawn from a panel of qualified persons of standing." Black's Law Dictionary 916 (9th ed. 2010).

[14] During the reign of Emperor Augustus from 31 B.C. to 14 A.D., he issued the right of *public respondere* (referring to the Juristic Responses to the Imperial Edicts) to certain jurists, which made their *responsa* binding. Roman Law Textbook, at 23. Around a century later, when jurists of equal stature would issue conflicting opinions, Emperor Hadrian settled the resulting quandary by declaring *responsa* binding only if opposing jurists were in agreement with each other. *Id.*

[15] Justinian officially became emperor in April 527, but he was forced to share his reign until the death of the former emperor (his uncle) on August 1, 527. A.M. Honore, *The Background to Justinian's Codification*, 48 Tulane Law Review 859, 864 (1974) [hereinafter *Justinian's Codification*].

[16] The *Institutes* and the *Digest* were issued on December 30, 533. Law of the Ancient Romans, at 93.

[17] The Roman Empire split in half during the fourth century A.D. Theodosian Code, at xxiv. This schism began around 305 under the rule of the Emperor Diocletian and was finalized in 395 during the reign of Theodosius I. *Id.* Two distinct yet connected empires resulted, which were ruled from 2 capitals—Constantinople in the east and Rome in the west—until the fall of the Western Empire in 476 *Id.* at xxiv, xxvi. The Eastern Empire, founded by the Emperor Constantine in 330, survived until 1453 when the Turks captured Constantinople. *Id.* Theodosius II ruled the Eastern Empire from 408–50. *Id.* Theodosius II issued a decree at Constantinople on March 26, 429 appointing a commission of 9 scholars to collect and combine all of the previous imperial edicts, constitutions, and the 3 then existing codes—*Gregorianus*, *Hermogenianus*, and *Theodosianus*—and then to publish them together in one single code. *Id.* at xvii; *Justinian's Codification*, 48 Tulane Law Review at 866. The *Theodosian Code*, as it is now known, was completed 9 years later and was formally adopted by the Empire on Christmas Day 438. Theodosian Code, at xvii.

[18] Law of the Ancient Romans, at 92–93; Roman Law Textbook, at 40–41. Through the intervening centuries, the *Digest* has sometimes been referred to as the *Pandects*. Roman Law Textbook, at 41.

[19] In February 528, Justinian appointed a 10-member commission to compile and update the many existing Imperial constitutions. *Justinian's Codification*, 48 Tulane Law Review at 866; Law of the Ancient Romans, at 92; Roman Law Textbook, at 40. This commission successfully issued a code 14 months later in April 529, but it was replaced in 534 by a second code because the inordinate amount of legislation passed during the intervening years had already made the first code obsolete. *Justinian's Codification*, 48 Tulane Law Review at 866; Law of the Ancient Romans, at 92–93; Roman Law Textbook, at 47.

In order to draft the *Digest* and *Institutes*, Justinian gave instructions to one of his trusted legal advisors to organize another commission to accomplish the task, and the result was a 16-member body comprised of some of the greatest legal minds of the day. Roman Law Textbook, at 41; Law of the Ancient Romans, at 91. Justinian's aim in this pursuit was not to alter or even modernize the old writings, but to conflate them and make the law less unwieldy. Roman Law Textbook, at 41; Law of the Ancient Romans, at 92–93. As such, Justinian instructed the commission to delete only that which was obsolete or superfluous. Law of the Ancient Romans, at 92. This goal of staying true to the original texts was evidenced by the express citation to each jurist's work in the Digest. *Id.* at 93. Throughout the following 3 years, the commission reduced some 3,000,000 lines of legal text, taken from around 2,000 separate books, to just some 150,000 lines comprised of 800,000 words eventually included in the *Digest*. *Justinian's Codification*, 48 Tulane Law Review at 866, 879; Law of the Ancient Romans, at 92–93.

[20] Roman Law Textbook, at 28; Law of the Ancient Romans, at 17, 93.

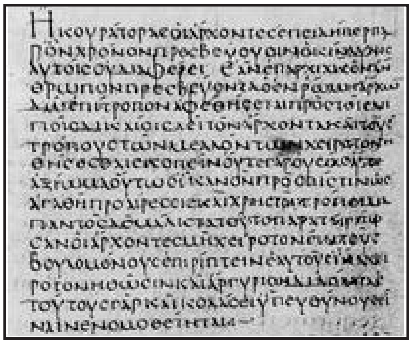

Figure 1. This page is from the *Pandectarum codex Florentinus* and is the oldest existing edition of the *Digest*, copied just after its promulgation in the sixth century A.D. Roman Legal Tradition And The Compilation Of Justinian, The Robbins Collection, School Of Law (Boalt Hall), University Of California At Berkeley, https://www.law.berkeley.edu/library/robbins/RomanLegalTradition.html#just (last visited Feb. 27, 2013).

and throughout Europe,[21] in addition to forming the basis of Spanish mainland law.[22]

Groundwater-related juristic excerpts

Although several jurists wrote extensively on groundwater law concepts,[23] only 2 merit examination here because of their direct influence upon Texas jurisprudence: Marcellus and Ulpian.

Marcellus's responsum

The jurist most pertinent to the exploration of current groundwater law in Texas is Marcus Claudius Marcellus, who died in 45 B.C. and was a contemporary of Cicero.[24] Marcellus was made *Curule Aedile* in 56 B.C. (the sixth-highest elected office in Rome) and was named *Consul* 5 years later in 51 B.C. (the second-highest elected office in Rome).[25]

His original formulation of the rule of capture—the first ever recorded—held that:

> [N]o action, not even the action for fraud, can be brought against a person who, while digging on his own land, diverts his neighbor's water supply.[26]

Ulpian's responsa

While Marcellus's musings on what would become the modern-day rule of capture were no doubt important in their day, their subsequent inclusion in the *Digest* and recounting by perhaps the most famed jurist in antiquity made Marcellus's work immortal.[27]

Ulpian was one of the most renowned jurists to ever live, and even served as the *Praefectus Praetorio* (commander of the Praetorian Guard and chief advisor to the Emperor) for

[21] *See, e.g.*, *Acton v. Blundell*, 152 Eng. Rep. 1223, 1234 (1843) (allowing that, while "Roman law forms no rule, binding in itself, upon the subject these realms," it has nevertheless formed the "fruit of the researches of the most learned men, the collective wisdom of ages and the groundwork of the municipal law of most of the countries in Europe"); IV Sir William Holdsworth, A History of English Law 221 (1926) [hereinafter History of English Law] ("The text of Justinian was both the Aristotle and the Bible of the lawyers."); Alan Watson, Roman and Comparative Law 167 (1991) ("[t]hroughout many centuries, when Continental lawyers had to find a ruling, they looked for it in Justinian's *Corpus Juris Civilis*") [hereinafter Roman and Comparative Law]. The *Corpus Juris Civilis* was comprised of Justinian's *Institutes*, *Digest*, and second Code. Hans W. Baade, *The Historical Background of Texas Water Law: A Tribute to Jack Pope*, 18 St. Mary's Law Journal 1, 57–87 (1986) [hereinafter *Tribute to Jack Pope*]; Law of the Ancient Romans, at 93.

[22] Harbert Davenport & J. T. Canales, *The Texas Law of Flowing Waters with Special Reference to Irrigation from the Lower Rio Grande*, 8 Baylor Law Review 138, 157–58 (1956) (the "law as declared in the *Las Siete Partidas* [which governed peninsular Spain], . . . was taken almost bodily from the Roman Law; and, more particularly, from the *Institutes*") [hereinafter *Law of Flowing Waters*]; Las Siete Partidas lii, liv (Samuel Parsons Scott trans., 1931); *Still So Misunderstood*, 37 Texas Tech Law Review at 1, 31, 31 n.196, 32; *see also State v. Balli*, 144 Tex. 195, 248, 190 S.W.2d 71, 99 (1944) (referring to the *Institutes* as the foundational text of the *Las Siete Partidas*); *Valmont Plantations I*, 346 S.W.2d at 857.

[23] One such jurist was Quintas Mucius, who reached the zenith of his influence during his service as *Consul* around 95 B.C. *Legal Reasoning in Roman Law*, 70 Chicago-Kent Law Review at 1544; *Comparative Law*, 48 American Journal of Comparative Law at 21. He wrote that a downstream property owner would have no recourse against a spring owner who diverts or uses the water before it reaches the downstream property owner's land. *See* Digest 39.3.21 (Pomponius, Quintas Mucius 32) (as translated in 3 The Digest of Justinian 402 (Theodor Mommsen & Paul Krueger trans., Alan Watson ed., 1985) [hereinafter Digest]).

Pomponius was another first century A.D. jurist who, along with Ulpian, was one of the "principal writers on water law" that appear in the *Digest*. *See* Eugene F. Ware, Roman Water Law: Translated from the Pandects of Justinian 23 (1905) [hereinafter Pandects of Justinian]. His contributions to groundwater law mainly center on his commentary describing the legal theories of Quintus Mucius Scaevola from more than a century earlier. Digest 39.3.21 (Pomponius, Quintus Mucius 32); *see also Legal Reasoning in Roman Law*, 70 Chicago-Kent Law Review at 1544; *Comparative Law*, 48 American Journal of Comparative Law at 21. Specifically, Pomponius wrote of Quintas Mucius's earlier *responsum*, recounting that:

> If water which has its sources on your land bursts onto my land and you cut off those sources with the result that the water ceases to reach my land, you will not be considered to have acted with force, provided that no servitude was owed to me in this connection nor will you be liable to the interdict against force or stealth.

Digest 39.3.21 (Pomponius, Quintus Mucius 32).

[24] Columbia Encyclopedia 1752 (6th ed. 2000).

[25] *Id.*

[26] Digest 39.3.1.12 (Ulpian, Ad Edictum 53).

[27] *See Still So Misunderstood*, 37 Texas Tech Law Review at 22.

a time.[28] Not only do his works form the basis for approximately one-third[29] to one-half[30] of the *Digest*, the name Ulpian was almost synonymous with Roman law during the Middle Ages.[31] Ulpian was among 5 noted jurists whose writings were made authoritative due to their inclusion in the *Law of Citations*,[32] which was issued in 426.[33] He is also considered to be one of the 3 "principal writers on water law" featured in the *Digest*.[34] Indeed, after his death at the hands of his own guards in 228, the study and development of Roman law went into decline until the publication of the *Theodosian Code* in the fifth century A.D.[35]

In Book 53 of his collection, *Ad Edictum*, Ulpian reasoned that "anyone who fails to protect himself in advance . . . against anticipated injury [by work carried out on neighboring land] has only himself to blame."[36] Construing the *responsum* of another jurist—Trebatius—who lived some 250 years before him,[37] Ulpian explained how this theory of damage without injury—described some 1,600 years later by the maxim, *damnum absque injuria*[38]—applied to groundwater rights:

> Again, let us consider when injury is held to be caused; for the stipulation covers such injury as is caused by defect of house, site, or work. Suppose that I dig a well in my house and by doing so I cut off the sources of your well. Am I liable? Trebatius says that I am not liable on a count of anticipated injury [because] I am not to be thought of as having caused you injury as a result of any defect in the work that I carried out, seeing that the matter is one in which I was exercising my rights.[39]

As Ulpian commented regarding the *responsum* of the jurist Proculus,[40] no action may lie:

> [U]nder this stipulation; the grounds for this are that a person who prevents somebody from enjoying an advantage which he has hitherto enjoyed should not be held to be causing injury, there being a great difference between the causing of injury and the prevention of enjoyment of an advantage previously enjoyed.[41]

The late-1600s French legal scholar Jean Domat summarized Ulpian and Proculus's property rights *responsa*, cautioning that an aggrieved landowner ought to have acted "so as to be out of danger of this inconvenience, which he had no right to hinder, and which he might have easily foreseen."[42] Specific to groundwater law, Domat wrote that a landowner "may dig for water on his own ground, and if he should thereby drain a well or spring in his neighbor's ground, he would be liable to no action of damages on that score."[43]

"Recent" legal developments

Roman law was instrumental in influencing much of the law throughout Western Europe nearly a millennia after Justinian promulgated his *Digest*,[44] including the laws of Spain and

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[28] Law of the Ancient Romans, at 93 ("Ulpian was the most popular jurist."); *see* Roman Law Textbook, at 32–33.

[29] *See* Roman Law Textbook, at 32.

[30] *See* Law of the Ancient Romans, at 93.

[31] *See* Roman Law Textbook, at 33.

[32] *See* Law of the Ancient Romans, at 91; Roman Law Textbook, at 32. This group of honored jurists was sometimes referred to as the "favoured five." *See* Roman Law Textbook, at 32. Not to be confused of course with the "Furious Five" that gained some repute (if only fictional) much later. *See generally*, Kung Fu Panda (Dreamworks Animation 2008).

[33] *See* Law of the Ancient Romans, at 91; *Justinian's Codification*, 48 Tulane Law Review at 862.

[34] *See* Pandects of Justinian at 23.

[35] Law of the Ancient Romans, at 90; Roman Law Textbook, at 32.

[36] Digest 39.3.3.3 (Ulpian, Ad Edictum 53).

[37] Trebatius lived from 84 B.C. to 4 A.D. Alan Watson & Khaled Abou El Fadl, *Fox Hunting, Pheasant Shooting, and Comparative Law*, 48 American Journal of Comparative Law 1, 21 (2000) [hereinafter *Comparative Law*].

[38] Although the *Acton* and *East* courts are more famously known for applying *damnum absque injuria* to groundwater law, the maxim was first applied to this debate by the Massachusetts Supreme Court in its 1836 opinion in *Greenleaf v. Francis*, 35 Mass. (18 Pick.) 117, 123 (1836). Incidentally, Greenleaf was issued in March 1836, the same month and year that some 190 militiamen bravely stood against 2,400 Mexican troops for 13 days in an old, crumbling Spanish mission just outside of San Antonio de Béxar. Amelia Williams, *A Critical Study of the Siege of the Alamo and of the Personnel of its Defenders*, 36 Southwestern Historical Quarterly 251, 265 (April 1933); *Amelia Williams, A Critical Study of the Siege of the Alamo and of the Personnel of its Defenders*, 37 Southwestern Historical Quarterly 237, 237–38 (1934); *see also* James A. Michener, Texas 325 (Univ. Tex. Press 1985).

[39] Digest 39.2.24.12 (Ulpian, Ad Edictum 81).

[40] Proculus was an active jurist in the first century A.D. *Comparative Law*, 48 American Journal of Comparative Law at 25. His writings were held in such high regard around 27 that one of the 2 dominant schools of juridical thought in Rome—the more liberal and interpretative school—was named after him (the "Proculians"). *Legal Reasoning in Roman Law*, 70 Chicago-Kent Law Review at 1545. The other dominant school—the Sabinians—were more conservative and textualist. *Id.;* Roman Law Textbook, at 27. Although the Proculians took their name from Proculus, the school was actually founded by Antistius Labeo (a republican—in the Roman sense) who died around 21. *Id.*; *Comparative Law*, 48 American Journal of Comparative Law at 25. In fact, Proculus was a follower of Nerva, who was himself a follower of Labeo. Roman Law Textbook, at 27.

[41] Digest 39.2.26 (Ulpian, Ad Edictum 81).

[42] Jean Domat, The Civil Law in its Natural Order §1047 (William Strahan trans. Luther S. Cushing ed. 1980) (1850).

[43] *Id.* § 1581.

[44] George Toumbouros, Parallel Legislations of England, U.S.A., France, Germany, Italy and Comparative Law: Volume I: The Laws of the Ancient Greece 21 (1959).

England.[45] The laws of Spain bear powerfully upon Texas jurisprudence today because of Texas's former colonial status to the Spanish Crown.[46] Although Britain never actually held title to Texas soil,[47] the Texas Republic expressly recognized and adopted English common law in 1840[48] and explicitly relied on the common law of England just over 60 years later in *East* (citing, quoting, and discussing the 1843 British Exchequer-Chamber court decision in *Acton v. Blundell*).[49]

Indeed, "[l]ands in Texas have been granted by 4 different governments, namely, the Kingdom of Spain, the Republic of Mexico, the Republic of Texas, and the State of Texas."[50]

[45] Although, "Texas's first legal advocate in recorded history" might very well have been an anonymous Karankawa warrior who successfully lobbied a Native-American court called a *mitote* to spare what was left of Cabeza de Vaca's crew in early 1529 near present-day Galveston. James L. Haley, The Texas Supreme Court: A Narrative History, 1836–1986, 3–4 (Univ. Tex. Press 2013) [hereinafter SCOTX Narrative History].

[46] *See State v. Sais, 47 Tex. 307*, 318 (1877); SCOTX Narrative History at 2–3; David A. Furlow, *"The Separation of Texas from the Republic of Mexico Was the Division of an Empire": The Continuing Influence of Castilian Law on Texas and the Texas Supreme Court, Part I: Spanish Texas, 1541–1821*, Journal of Texas Supreme Court Historical Society, Winter 2011, at 1 [hereinafter *Influence of Castilian Law*].

[47] *See S. Pac. Co. v. Porter*, 160 Tex. 329, 334, 331 S.W.2d 42, 45 (1960).

[48] Act approved Jan. 20, 1840, 4th Cong., R.S., reprinted in 2 H.P.N. Gammel, The Laws of Texas 1822–1897, at 177, 177–78 (Austin, Gammel Book Co. 1898). However, as the Texas Supreme Court clarified 12 decades later, English common law was only adopted so far as it was consistent with Texas's constitutional and legislative enactments, as well as the "rule of decision" in Texas. *Porter*, 160 Tex. at 334, 331 S.W.2d at 45. No English statutes were similarly adopted, and the Republic's congressional act adopting English common law "was not construed as referring to the common law as applied in England in 1840, but rather to the English common law as declared by the courts of the various states, of the United States." *Id.* This adoption is still enshrined in Texas statute to this day. Texas Civil Practice And Remedies Code § 5.001 ("The rule of decision in this state consists of those portions of the common law of England that are not inconsistent with the constitution or the laws of this state, and the laws of this state.").

This distinction may be largely without jurisprudential difference because Texas did not address groundwater rights either legislatively or judicially until *East* in 1904, and American courts from 1836 to 1861 largely held consistently with the Texas Supreme Court's later pronouncements in *East. See Still So Misunderstood*, 37 Texas Tech Law Review at 38–41; *Fact or Fiction* at 7–8, in UTCLE, Texas Water Law Institute. Put another way, from the time of the English common law's adoption in 1840 until *East* was delivered in 1904, both the English common law itself, as well as the "English common law as declared by the courts of the various states[] of the United States," was generally consistent the explicit framing of Texas groundwater law in *East*. *See Still So Misunderstood*, 37 Texas Tech Law Review at 38–41; *Fact or Fiction*, at 7–8.

[49] *Fact or Fiction*, at 9–10.

[50] *Miller v. Letzerich*, 121 Tex. 248, 253, 49 S.W.2d 404, 407 (1932) (citations omitted). "Where one government succeeds another over the same territory, in which rights of real property have been acquired, the preceding government is not a foreign government, whose laws must be proved in the courts of the succeeding government." *Sais*, 47 Tex. at 318.

Spanish derivation

Spain laid legal claim to Mexico, and subsequently present-day Texas, when Hernan Cortés discovered New Spain in 1518.[51] Ten years later in 1528, Álvar Núñez Cabeza de Vaca[52] became the first Spaniard to set foot on Texas soil.[53] Spanish Texas was essentially rectangular in shape, with the coastal strip stretching from modern-day Corpus Christi, Texas, to Lake Charles, Louisiana, surrounded by the Nueces and Calcasieu rivers and extending from that point inland to the Medina River slightly west of the city of San Antonio to the Arroyo Hondo, just west of Natchitoches.[54] This area, added to the rest of the northern frontier of New Spain south of the Nueces River, stretched more than 2,000 miles from east to west and almost 1,500 miles from north to south, encompassing some 960,000 square miles.[55]

During the 1600s, Spanish settlers referred to the westernmost of the Caddo Native American peoples as "the great kingdom of Tejas."[56] "Tejas" was the way Spanish soldiers and colonial administrators spelled the Caddo word, *taysha*, which meant "friend" or "ally."[57] Tejas then, or early Spanish Texas, referred to the realm of Spain's allies[58] and was the friendly buffer zone that protected the Spanish Empire from decidedly unfriendly Native Americans to the north and east.[59]

Texas first appeared as a geographical designation in 1691 nearly 200 years after Cabeza de Vaca first landed near what is now Galveston, when the governor of the Spanish territory of Coahuila in northern Mexico received an appointment to serve as the governor of the territory.[60] Twenty-seven years later in early May 1718, the first permanent settlement was established about halfway across the breadth of Texas, along

[51] *Influence of Castilian Law*, Journal of Texas Supreme Court Historical Society, Winter 2011, at 2; Robert L. Dabney, Jr., *Our Legal Heritage, in Two Parts: Part One: Texas—The Land of the Brave* (1518–1821), 39 The Houston Lawyer 12, 14 (2002).

[52] His surname came from his mother's side, and originated from an ancestor's marking of a strategic pass with a cow's skull ("cabeza de vaca"). SCOTX Narrative History, at 3.

[53] *Id.*

[54] *Influence of Castilian Law,* at 2; *Tribute to Jack Pope*, 18 St. Mary's Law Journal at 26.

[55] *Influence of Castilian Law*, at 2; Michael C. Meyer, Water in the Hispanic Southwest: A Social and Legal History 1550–1850, 3 (1984) [hereinafter Social and Legal History].

[56] *Influence of Castilian Law*, at 2.

[57] *Id.*

[58] *Id.*

[59] *Id.*

[60] Andrew Walker, *Mexican Law and the Texas Courts*, 55 Baylor Law Review 225, 232 (2003); *Influence of Castilian Law*, at 5.

the banks of the San Antonio River at the eastern edge of a range of limestone hills—San Fernando de Béxar.[61] The settlement included a Franciscan mission (later and more popularly known as the "Alamo") as well as the chartered municipality itself, best described as a *villa* (a *villa* was more than a mere village, but not yet a *ciudad* (city)).[62] Playing politics, Fray Antonio de San Buenaventura de Olivares named the villa after the Duc de Béjar, the brother of the Viceroy of New Spain.[63] The villa's *notario*,[64] Francisco de Arocha, was called upon to devise a system to prepare cases for legal process.[65] Because of this, Arocha has been called Texas's "first lawyer."[66]

Spanish law governing Texas was contained in 2 distinct, yet related sources: (1) *Las Siete Partidas* (*Partidas*), compiled in 1265 by King Alfonso X[67] and which governed peninsular Spain;[68] and (2) the *Recopilacion de Leyes de los Reynos de las Indias* (*Recopilacion*), promulgated in 1681,[69] which governed New Spain.[70] Both these codes were authoritative in New Spain because of a passage in the *Recopilacion* that provided, "when colonial law [was] silent on a topic, one must look to the laws of peninsular Spain."[71]

The *Partidas* were founded upon the works of Justinian.[72] The influence of Roman law upon that of Castilian Spain was so great that the *Institutes* formed the "substance[] of civil law instruction at the Spanish and [Colonial][73] universities" and even furnished the text.[74]

However, as great as Justinian's influence was over its promulgation, the *Partidas* were much more than just a "'[p]oor copy of the pandects of Justinian.'"[75] The *Partidas* were a modification, not a recitation, of Justinian's writings in that they were "modified by custom and usage in medieval Spain," and Justinian's texts were only used to clarify the corresponding provisions of the *Partidas*.[76] While the whole of peninsular Spain was governed by the *Partidas*, the *Partidas* itself was supplemented by provincial codes and laws enacted in each region of the country.[77]

In particular, one such provincial code was the *Constitutiones de Cataluna*, which governed 13th-century Cataluna and provided that "live springs" belonged, not in common, but to the lords of the land "without impediment or contradiction from anybody."[78] This ownership right was described as exclu-

[61] SCOTX Narrative History, at 6; *see also Influence of Castilian Law*, at 5.

[62] *Influence of Castilian Law*, at 5.

[63] *Id.*

[64] Secretary to the *ayuntamiento* (town council). SCOTX Narrative History, at 7.

[65] *Id.* The system he devised was shorter by many steps than what was then required under the common law of England. *See Id.* He required only that a "plaintiff who came to court set down who he was, what wrong had been done him and by whom, and what redress he sought." *Id.*

[66] *Id.*

[67] *See* M. Diane Barber, *The Legal Dilemma of Groundwater Under the Integrated Environmental Plan for the Mexican-United States Border Area,* 24 St. Mary's Law Journal 639, 639, 656–58 (1993) [hereinafter *Legal Dilemma of Groundwater*]. King Alfonso was also referred to as "Alfonso the Wise of Castile." *Law of Flowing Waters*, 8 Baylor Law Review at 157. Like Justinian before him, Alfonso "the Learned" took up the compilation of the *Partidas* almost immediately after his ascension to the throne. *See* Las Siete Partidas l (Samuel Parsons Scott trans., 1931). Ironically, while the *Digest* took only roughly 3 years to complete, the *Partidas* took 3 times as long to finish—9 years. *See Id.* at li n.21.

[68] *In re Adjudication of Water Rights in the Medina River Watershed of the San Antonio River Basin*, 670 S.W.2d 250, 252 (Tex. 1984). Indeed it was termed "the essence of the law of Peninsular Spain after 1348." *State v. Valmont Plantations*, 346 S.W.2d 853, 857 (Tex. Civ. App.—San Antonio 1961, writ granted) (op. adopted) [hereinafter "*Valmont Plantations I*"], *aff'd*, 163 Tex. 381, 355 S.W.2d 502 (1962) [hereinafter "*Valmont Plantations II*"]; *see* Las Siete Partidas, at lii–liii.

[69] *Legal Dilemma of Groundwater*, 24 St. Mary's Law Journal at 657–58. The drafting of the *Recopilacion* was a colossal task that distilled over 400,000 *cedulas* down to just under 6400 provisions. *Tribute to Jack Pope*, 18 St. Mary's Law Journal at 30. *Cedulas* were royal and special edicts. *Valmont Plantations I*, 346 S.W.2d at 866.

[70] *Medina River*, 670 S.W.2d at 252; *Valmont Plantations I*, 346 S.W.2d at 860 n.13.

[71] *Medina River*, 670 S.W.2d at 252 (quoting Book 2, Title 1, Law 1 of the *Recopilacion*).

[72] Some sources, including the Texas Supreme Court, refer specifically to the *Institutes* as the foundational text. *State v. Balli*, 144 Tex. 195, 248, 190 S.W.2d 71, 99 (1944); *Manry v. Robinson*, 122 Tex. 213, 223, 56 S.W.2d 438, 442 (1932); *Law of Flowing Waters*, 8 Baylor Law Review at 157. Additional sources refer only to "Justinian's sixth century code." *See Valmont Plantations I*, 346 S.W.2d at 857. This may have referred to all 3 components of the *Corpus Juris Civilis* or to only the second Code itself. Other sources explicitly state that the *Partidas* was based on the *Corpus Juris Civilis*. *Tribute to Jack Pope*, 18 St. Mary's Law Journal at 31; Social and Legal History, at 107; *see* Las Siete Partidas, at liv. Still other sources simply recount that the *Partidas* was derived generally from Roman law. *See Legal Dilemma of Groundwater*, 24 St. Mary's Law Journal at 656; Las Siete Partidas, at lii, liv. Still other authorities cite Spanish jurisprudence as arising from both the *Institutes* and the *Pandects*. *See Law of Flowing Waters*, 8 Baylor Law Review at 158.

[73] Throughout the literature, the territories of New Spain are described interchangeably as colonial, ultramarine, or as the Indies. *See*, *e.g.*, *Medina River*, 670 S.W.2d at 252; *Tribute to Jack Pope*, 18 St. Mary's Law Journal at 31–32.

[74] *Tribute to Jack Pope*, 18 St. Mary's Law Journal at 31–32; *see* Las Siete Partidas, at liii. Indeed, the Texas Supreme Court "has uniformly held that . . . the law as declared in *Las Siete Partidas*, . . . was taken almost bodily from the Roman Law; and, more particularly, from the *Institutes* . . . ." *Law of Flowing Waters*, 8 Baylor Law Review at 157 (emphasis added); *see* Las Siete Partidas, at lii, liv.

[75] *Law of Flowing Waters*, 8 Baylor Law Review at 158 (citation omitted).

[76] *Id.*

[77] *Valmont Plantations I*, 346 S.W.2d at 858.

[78] *Id.* at 858 n.6.

sive and hostile to others.[79]

Indeed, New Spain and the entirety of Colonial Spain were the private property of the King,[80] and ownership of land could only be achieved by virtue of a grant from the Crown.[81] One example of such a royal grant was exemplified by the territorial gift made to Hernan Cortés on July 6, 1529,[82] which expressly ceded title to the "'running, stagnant, and percolating waters'" found thereon.[83] The grant to Cortés made eminent sense in context with the provisions of the *Partidas*, which plainly mandated that springs and waters that originated on land went with it in sale.[84]

Just before Christmas 1820, a former lead-mine operator from Louisiana named Moses Austin appeared in the provincial capital, known as San Antonio de Béxar, seeking approval to settle Anglo-American colonists from the newly minted United States in the largely vacant wilderness of Texas.[85] Seeking to populate the province with Catholic Americans, who would swear allegiance to Spain and might unwittingly serve as a barrier to hostile Indian tribes, the Spanish authorities approved the proposal.[86] Unfortunately, Moses died shortly after returning to the United States to organize potential settlers.[87]

Mexican influence

Mexico achieved its independence from Spain the following year in September 1821,[88] and Stephen F. Austin—who had taken over his father's settlement efforts in Texas—obtained the Mexican Emperor's approval for the "Austin Colony" just 2 years later on February 18, 1823.[89]

After its independence, Mexico retained much of the same water law that existed under Spanish rule.[90] Indeed, the legal system in Coahuila y Tejas remained largely rooted in ancient Roman law.[91] What new legislation the Mexican Republic enacted did not elaborate on nor modify groundwater law but did concern the law of flowing waters, as was ably and exhaustively recounted by former Texas Supreme Court Chief Justice Andrew Jackson ("Jack") Pope while he was a justice on the Fourth Court of Appeals in *State v. Valmont Plantations*.[92]

One Mexican scholar, in describing Spanish colonial land grants with and without water rights, framed the existence of a private property right in groundwater as follows: "'Private property in waters not only existed, but the legislation of [the] Indies fostered the reduction of unappropriated waters to private ownership,'" revealing that private ownership of water was not only possible, but encouraged.[93] The express grants of springs described in early 20th-century Mexico also aided the private ownership of water.[94]

British derivation

Much of British water law developed from Justinian's works as well. Indeed, the English common law of waters "derive[s] . . . from the Institutes of Justinian, the ancient Roman Law."[95]

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[79] *Id.* at 858 n.7.

[80] All of New Spain, including present-day Texas, was privately owned by the Crown of Castille by virtue of the Bull of Donation (also called the "Bull Inter Cetera") of Pope Alexander VI, issued on May 4, 1493. *See In re Adjudication of Water Rights in the Medina River Watershed of the San Antonio River Basin*, 670 S.W.2d 250, 253 (Tex. 1984); *Valmont Plantations I*, 346 S.W.2d at 859.

[81] *Medina River*, 670 S.W.2d at 253; *see Tribute to Jack Pope*, 18 St. Mary's Law Journal at 70–71.

[82] *See Tribute to Jack Pope*, 18 St. Mary's Law Journal at 68.

[83] *Medina River*, 670 S.W.2d at 253 (quoting the royal grant that transferred title to a large portion of Central Mexico to Hernan Cortés) (emphasis added); *see Tribute to Jack Pope*, 18 St. Mary's Law Journal at 67–68; Corwin W. Johnson, *The Continuing Voids in Texas Groundwater Law: Are Concepts and Terminology to Blame?*, 17 St. Mary's Law Journal 1281, 1292 (1986).

[84] *Valmont Plantations I*, 346 S.W.2d at 860 n.14 (citing Law 19, Title 32, Part 3 of the *Partidas* because the *Recopilacion* did not have a provision dealing explicitly with the alienation of groundwater property rights).

[85] SCOTX Narrative History, at 9. Despite 2 1/2 centuries of dominion over the nearly million square acres of Texas, a 1783 Spanish census found only 2,819 subjects residing north of the Rio Grande river. *Id.*

[86] *Id.*

[87] *Id.*

[88] *See Tribute to Jack Pope*, 18 St. Mary's Law Journal at 47; *Law of Flowing Waters*, 8 Baylor Law Review at 176.

[89] *See Tribute to Jack Pope*, 18 St. Mary's Law Journal at 48.

[90] *Valmont Plantations I*, 346 S.W.2d at 863.

[91] SCOTX Narrative History, at 11.

[92] *Valmont Plantations I*, 346 S.W.2d at 863. Chief Pope's intermediate-appellate court opinion so impressed Texas Supreme Court Justice Bob Hamilton—who authored the Court's opinion adopting Chief Pope's lower court ruling—that he remarked, "it would serve no good purpose to write further on the subject" because Chief Pope's opinion was so "exhaustive and well documented." *Valmont Plantations II*, 355 S.W.2d at 503. It marked the first time the Court had ever adopted wholesale a lower court's opinion without refusing writ of application. *See* SCOTX Narrative History, at 199. Chief Pope's opinion in *Valmont Plantations* has more recently been described as a "lengthy, punctiliously scholarly history lesson." *Id.* at 198. Because it deftly dodged the troublesome Court precedent set in *Motl v. Boyd*, 116 Tex. 82, 286 S.W. 458 (1926), it had the welcome effect of giving Texas a "fresh start" regarding riparian water law. *Id.*

[93] *Valmont Plantations I*, 346 S.W.2d at 862 (quoting Andrés Molina Enriquez, Los Grandes Problemas Nationales 171 (1909)).

[94] *Id.* at 862–63 (citing Pena, Propiedad Inmueble en Mexico 146 (1921)).

[95] *Law of Flowing Waters*, 8 Baylor Law Review at 157.

Bracton and Blackstone

Henry of Bracton's seminal 13th-century work, *The Laws and Customs of England*, is the "earliest scientific exposition of the English common law" and relies heavily upon the *Digest*, even to the extent that the first third of *The Laws and Customs of England* contains "quotations from almost two hundred different sections of Justinian's Digest."[96] Many passages in Bracton's work "echo the language of [the] Digest and Code[,] . . . [and] show that he had made Roman law part of his way of thinking as a lawyer."[97] In turn, William Blackstone's *Commentaries on the Laws of England*, published some 500 years later in 1766, relied upon the previous works of many other early legal scholars, including Bracton.[98] In addition, the "fundamental structure" of Blackstone's *Commentaries on the Laws of England* was "a direct descendant of Justinian's *Institutes*."[99]

Blackstone is sometimes credited with introducing into western jurisprudence the legal tenet central to the modern Texas groundwater legal concept of ownership in place: absolute ownership[100]—long described by the Latin maxim, *cujus est solum ejus est usque ad coelum et ad infernos*.[101] It is translated to mean "[w]hoever owns the soil owns everything up to the sky and down to the depths."[102] However, this axiom was apparently first recorded at common law in the 1586 case of *Bury v. Pope*,[103] but therein, the King's Bench court indicated it had been applied even since the time of Edward I in the late 13th century.[104]

Hammond and *Acton*

The first English case to address tortuous immunity for groundwater drainage was *Hammond v. Hall* in 1840.[105] While the court did not ultimately reach the merits of the groundwater arguments because the claim was not yet ripe, it did recognize that the "question [pertaining to drainage of one well by another, deeper well] . . . was said never to have been discussed before, namely, whether a right or easement could be claimed with respect to subterranean water."[106] In its opinion, the court expressly recognized Marcellus's writing in the *Digest* by quoting the original Latin phrasing, which translated to read

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[96] Peter Stein, The Character and Influence of the Roman Civil Law: Historical Essays 152 (1988) [hereinafter Historical Essays].In addition to being a 13-century legal scholar, Bracton also served as Justice of the King's Central Court—or King's Bench as it is sometimes referred. *See* Encyclopedia Britannica 369 (11th ed. 1910).

[97] Historical Essays, at 152.

[98] Roman and Comparative Law, at 166.

[99] *Id.* at 173, 175–76 (noting Book 2 of Blackstone's *Commentaries on the Laws of England*, addressing the law of things, corresponds to books 2 and 3 of Justinian's *Institutes*).

[100] 2 William Blackstone, Commentaries *18; *Coastal Oil & Gas Corp. v. Garza Energy Trust*, 268 S.W.3d 1, 11 n.30 (Tex. 2008); John G. Sprankling, *Owning the Center of the Earth*, 55 UCLA Law Review 979, 982–83 (April 2008) [hereinafter *Owning the Center of the Earth*].

[101] *See*, *e.g.*, *Wheatly v. Baugh*, 25 Pa. 528, 530 (1855). While it is unlikely *cujus est solum ejus est usque ad coelum et ad infernos* comes as directly from Roman law as does *damnum absque injuria*, Roman law certainly recognized the concept of absolute ownership. *See* W.W. Buckland & Arnold D. McNair, Roman Law & Common Law: A Comparison in Outline 67, 69 (2d ed. 1952) ("[f]or the Roman lawyers ownership was absolute . . . [because] a positive root of title, with nothing relative about it . . . gave absolute ownership"). *But see Owning the Center of the Earth*, 55 UCLA Law Review at 982–83 (although "Blackstone boldly proclaimed the doctrine in his famous treatise *Commentaries on the Laws of England* . . . [i]t was not a principle of Roman law"). Indeed, Professor Goudy of Oxford even attributed some sections of the *Digest* as the theoretical forebears of the doctrine. H. Goudy, *Two Ancient Brocards*, in Essays in Legal History 230–31 (Paul Vinogradoff, ed., 2004) (2013) [hereinafter Essays in Legal History].

[102] Black's Law Dictionary 1712 (8th ed. 2004); *see*, *e.g.*, *Acton v. Blundell*, 152 Eng. Rep. 1223, 1235 (1843) (ownership of groundwater "falls within that principle, which gives to the owner of the soil all that lies beneath his surface; that he land immediately below is his property, whether it is solid rock, or porous ground, or venous earth, or part soil, part water"). It is an "ancient doctrine that at common law ownership of the land extended to the periphery of the universe." *United States v. Causby*, 328 U.S. 256, 260–61 (1946).

[103] 78 Eng. Rep. 375 (1586); Robert R. Wright, *Development of Policy for Use of Airspace*, *in* Legal, Economic, and Energy Considerations in the Use of Underground Space 7 (1974) (stating *Bury v. Pope* "is the first case to enunciate the maxim") [hereinafter *Development of Policy*]. Prior to 1865 there was no official series of law reports in England. The Bluebook: A Uniform System of Citation, at 413. (Columbia Law Review Ass'n et al. eds., 19th ed.). Instead, cases were reported in numerous commercial reporters, commonly referred to as the "nominate reporters." *Id.* at 413–14. Subsequently, most of the nominate reporters were reprinted in the *English Reports*. *Id.* at 414.

[104] *Bury*, 78 Eng. Rep. at 375 ("Nota. *Cujus est solum, ejus est summitas usque ad coelum. Temp. Ed.* I"); *Development of Policy*, at 7 ("*Bury v. Pope* does make reference, however, to the existence of the maxim during the time of Edward I (1239–1307)," and explaining that "Temp. Ed. I" means the maxim stemmed from that time); VII History of English Law, at 485 ("This maxim is referred to in Croke's reports in 1586, and is there said to be as old as Edward I"); Essays in Legal History, at 230 ("It is cited in Croke's Reports, in an action for stopping lights, as *Cujus est solum ejus est summitas usque ad coelum*, and a reference is there made to its use at the time of Edward I."). This is plausible, because Blackstone himself acknowledged the influence of Bracton, whose *Laws and Customs of England* was published in the same century that Edward I ruled England. *See* Roman and Comparative Law, at 166.

For his efforts "of ordering, of methodizing, [and] of arranging" the "too luxuriant growth" of English law, Edward I was even known as the "English Justinian." Frederic W. Maitland and Francis C. Montague, A Sketch of English Legal History 91 (James F. Colby ed. 1915). Of more recent notoriety, Edward I is perhaps better known to modern audiences as the villainous English king from 1996's *Braveheart*. IMDB.com, Synopsis for Braveheart, http://www.imdb.com/title/tt0112573/synopsis (last visited Feb. 26, 2013).

[105] *Hammond v. Hall*, 59 Eng. Rep. 729 (1840).

[106] *Id.* at 730, 730 n.1.

that "no action . . . can be brought against a person who, while digging on his own land, diverts his neighbor's water supply."[107]

Just 3 years after the *Hammond* decision, the Exchequer Chamber Court[108] heard the case of *Acton v. Blundell*.[109] In *Acton*, a coal mining company (Acton) dug a coal pit in 1837 a little less than a mile away from a neighboring cotton mill owner (Blundell), and a second pit 3 years later a little closer to the mill.[110] When the coal pits reached 105 feet in depth, the cotton mill's well water began to run dry.[111]

Perhaps more fascinating than the facts underlying the dispute are some of the excerpts from the oral argument delivered in the case, preserved in the *English Reports* reprinting of the opinion.[112] Acton's counsel began by acknowledging that "water is the party's as long as it is on his land, as every thing is his that is above or below it."[113] However, he may have gone too far in his argument when he cited as controlling authority only cases where surface water was at issue.[114] In addition, at the end of his surface water recitation, Acton's counsel mistakenly included a citation to Marcellus's writings in the *Digest*;[115] at which point one of the justices on the panel—Justice Maule—interrupted him and responded, "It appears to me that what Marcellus says is against you. The English of it I take to be this: if a man digs a well in his own field, and thereby drains his neighbour's, he may do so, unless he does it maliciously."[116] The exchange continued as Acton's attorney cited more English law adjudicating surface watercourses until Justice Maule again posed a pointed question, asking whether subterranean water could be legally defined as a watercourse.[117] Acton's counsel replied, positing that "the term 'watercourse' [whether subterranean or surface] must apply to all streams," but the court did not reach this point in its decision.[118]

In his response, Blundell's attorney cited the maxim that defined the rule of capture—*damnum absque injuria*—explaining that, in order "[t]o constitute a violation of that maxim, there must be *injuria* as well as *damnum*. There are many cases in which a man may lawfully use his own property so as to cause damage to his neighbour, so as it be not injuriosum."[119] In the same paragraph that the court cited to the *Digest* and its recital of Marcellus's *responsum*, the court noted that "[t]he authority of one at least of the learned Roman lawyers [that is, Marcellus] appears decisive upon the point in favour of the defendants; of some others the opinion is expressed with more obscurity."[120]

Chief Justice Tindal[121] delivered the opinion of the court and concluded that the case before them was:

> [N]ot to be governed by the law which applies to rivers and flowing streams, but that it rather falls within that principle, which gives to the owner of the soil all that lies beneath his surface; that the land immediately below is his property, whether it is solid rock, or porous ground, or venous earth, or part soil, part water; that the person who owns the surface may dig therein, and apply all that is there found to his own purposes at his free will and pleasure; and that if, in the exercise of such right, he intercepts or drains off the water collected from underground springs in his

[107] *Id.* at 730 n.2 (providing the untranslated version of this quote); *see* Digest 39.3.1.12 (Ulpian, Ad Edictum 53).

[108] The Exchequer Chamber court was an intermediate appellate court, established in 1822, which heard appeals from English common law courts (Court of King's Bench, Court of Common Pleas, and the Court of Exchequer), and from which appeal could only be had to the parliamentary House of Lords. *See* A.T. Carter, A History of English Legal Institutions 93 (1902) [hereinafter English Legal History]; Black's Law Dictionary 645 (9th ed. 2010). The Court of Exchequer derived its name from the checkered cloth, which was said to resemble a chef's board, that covered the bench. II John Adolphus, The Political State of the British Empire 481 (1818).

[109] 152 Eng. Rep. 1223 (1843).

[110] *Id.* at 1224–25, 1232–33; *see Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 824 n.40 (Tex. 2012); *see also Long Reach*, 116 Southwestern Historical Quarterly at 269.

[111] *See Acton*, 152 Eng. Rep. at 1224–25; *Long Reach*, 116 Southwestern Historical Quarterly at 269.

[112] *Id.* at 1226–32.

[113] *Id.* at 1226.

[114] *See Id.* at 1227–28.

[115] *Id.* at 1226; *see* Digest 39.3.1.12 (Ulpian, Ad Edictum 53).

[116] *Id.* at 1228. Justice Maule's interjection was particularly important because it represented perhaps the first formal jurisprudential restriction on the operation of the rule of capture due to a pumper's malicious conduct. *See Still So Misunderstood*, 37 Texas Tech Law Review at 35.

[117] *Id.* at 1229.

[118] *Id.* at 1229–30.

[119] *Id.* at 1230. Blundell's counsel then described the analogous situation where a wall built by one neighbor on his own land that blocks out the light of another is not held to be injurious. *Id.* Notably, he took this example almost verbatim from the *Digest*, wherein Ulpian quotes Proculus for the proposition that buildings increased in height such that they block the light reaching a neighbor's land result in "no action [for injury being] available" to the neighbor. *See* Digest 39.2.26 (Ulpian, Ad Edictum 81).

[120] *Acton*, 152 Eng. Rep. at 1235.

[121] Chief Justice Nicholas Conyngham Tindal was a 19th-century British jurist who served with great distinction. Wikipedia, Nicholas Conyngham Tindal, http://en.wikipedia.org/wiki/Nicholas_Conyngham_Tindal (last visited Feb. 27, 2013). However, he was perhaps best known not for his posthumous contributions to Texas groundwater law, but for successfully defending the then-Queen of the United Kingdom—Caroline of Brunswick—at her trial for adultery in 1820, as well as for introducing the special verdict of "not guilty by reason of insanity" into English jurisprudence. *Id.* Unfortunately though, Chief Tindal's conception of the insanity defense came at the expense of one of the author's ancestors—Edward Drummond—whose murderer Chief Tindal found not guilty in 1843 by reason of insanity. *Id.*; Wikipedia, Edward Drummond, http://en.wikipedia.org/wiki/Edward_Drummond (last visited Feb. 27, 2013).

neighbour's well, this inconvenience to his neighbour falls within the description of damnum absque injuriâ, which cannot become the ground of an action.[122]

JURISPRUDENTIAL DEVELOPMENT OF GROUNDWATER LAW IN TEXAS

Long after the general development of groundwater law from inception in antiquity through to its informal arrival on Texan shores, it was formally ushered into Texas common law and subsequently developed in both groundwater and oil and gas cases,[123] constitutional amendment, and legislative mandate.

Houston & Tex. Cent. Ry. Co. v. East (1904)

The nearly 110-year-old lineage of Texas groundwater law begins with the Texas Supreme Court's 1904 decision in *East*.[124] However, before the case ever reached the desk of the opinion's author, Justice Frank Alvin Williams,[125] it had already followed a long and tortuous path.

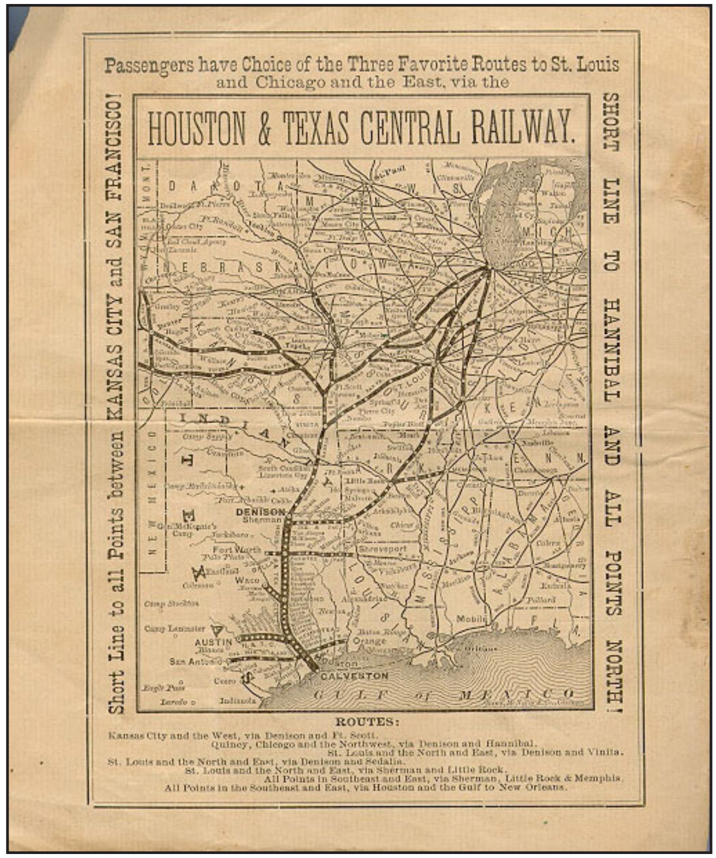


Figure 2. A Houston & Texas Central Railroad Company route map from the early 1900s, showing Denison as one of its major hubs (on file with author, courtesy of Professor Megan Benson, Ph.D.).

Factual background

The Houston & Texas Central Railroad Company (Railroad) was first established in 1853 as the Galveston & Red River Railway (G&RR Railway) by Thomas William House and 2 other partners.[126] House was a Houston planter who originally constructed the G&RR Railway to transport his crops from Houston to the Brazos River.[127] The Railroad later reached Denison in the 1870s, where it connected with rail lines to the north[128] (Figure 2).

After Thomas died in 1880, his youngest son, Edward M. House, took over his father's railroad empire.[129] Edward soon became heavily involved in Texas politics and was a charter member of a group comprised of the wealthiest businessmen in Texas that came to be known as "Our Crowd."[130] So influ-

[122] *Acton*, 152 Eng. Rep. at 1235.

[123] As the Court recounted in *Day*, it considered the rule of capture as it applies to groundwater in 4 cases after *East*. However, through its line of oil and gas cases, the Court has also refined its approach both to the rule of capture and ownership in place, each of which have had a direct impact on the evolution of Texas groundwater law. *See Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 826, 828–32 (Tex. 2012) (listing the 4 decisions: *Sipriano v. Great Spring Waters of Am., Inc.*, 1 S.W.3d 75 (Tex. 1999); *City of Sherman v. Pub. Util. Comm'n*, 643 S.W.2d 681 (Tex. 1983); *Friendswood Dev. Co. v. Smith-S.W. Indus., Inc.*, 576 S.W.2d 21 (Tex. 1978); *City of Corpus Christi v. City of Pleasanton*, 154 Tex. 289, 276 S.W.2d 798 (1955)); *see also* Robert A. McCleskey, Comment, *Maybe Oil and Water Should Mix—At Least in Texas Law: An Analysis of Current Problems with Texas Ground Water Law and How Established Oil and Gas Law Could Provide Appropriate Solutions*, 1 Texas Wesleyan Law Review 207, 213 (1994) ("*East* influenced early oil and gas law as well as water law."); Hon. Joe R. Greenhill & Thomas Gibbs Gee, *Ownership of Ground Water in Texas: The* East *Case Reconsidered*, 33 Texas Law Review 620, 621 (1955) ("Beyond doubt the [*East*] decision influenced the formative stages of the Texas law of oil and gas as the courts developed the ownership-in-place rationale.").

[124] 98 Tex. 146, 81 S.W. 279 (1904).

[125] Justice Williams was from an antebellum Mississippi planter family but did not fight in the Civil War because he was only 9 years old when it began. SCOTX Narrative History at 139, 143. After being orphaned at 16, Williams migrated to Texas 4 years later to live with his sister in Crockett, Texas. *Id.* at 139. There, he read law with his sister's husband and practiced for 12 years. *Id.* Justice Williams was highly experienced when Governor Joe Sayers appointed him to the Texas Supreme Court, having already served 8 years on the Austin Court of Appeals and another 7 years on the newly created Galveston Court of Appeals. *Id.* During his time on the Texas Supreme Court, Justice Williams and Chief Justice Reuben Reid Gaines became close friends, often joining one another on hunting trips along with the Court clerk, deputy clerk, and the Court's porter. *Id.* at 141.

[126] *Long Reach*, 116 Southwestern Historical Quarterly at 265.

[127] *Id.*

[128] *Id.*

[129] *Id.*

[130] *Id.* at 266.

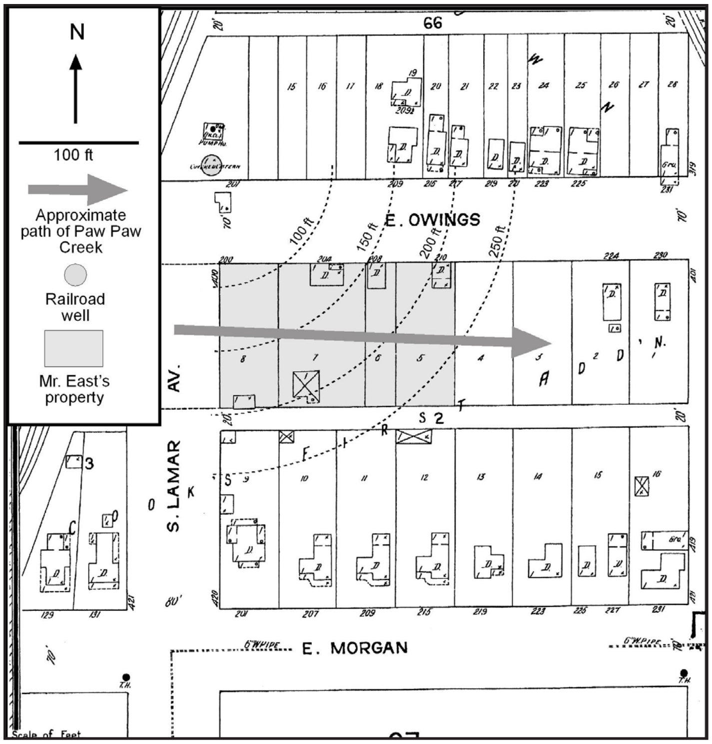


Figure 3. 1914 Sanborn fire-insurance map of East's property relative to the Railroad's well, overlaid with pertinent annotations and legend by Robert E. Mace et al., *Groundwater Is No Longer Secret and Occult—A Historical and Hydrogeologic Analysis of the East Case, in 100 Years of the Rule of Capture: From* East *to Groundwater Management*, Texas Water Development Board Report 73 (2004).

ential was House that he was thought to sway virtually every appointment made by Texas Governors Stephen Hogg, Charles Culberson, Joseph Sayers,[131] and Samuel Lanham—including all 3 Justices sitting on the Texas Supreme Court when W.A. East's suit against House's railroad came before the Court in 1904.[132]

In 1872, the Missouri, Kansas, and Texas Railroad (Mo-Kan Railroad) established the town of Denison, Texas and named it after its vice-president, George Denison.[133] By 1901, Denison had grown to more than 10,000 residents and was a bustling railroad town that served as a shipping center and stopping point for more than 10 railways.[134]

William Alexander East was born in Grayson County in 1851, 2 years before the Railroad was formed.[135] He would later own 4 lots near the intersection of Lamar Avenue and Owings Street in Denison[136] (Figure 3). Sometime prior to 1901, East sunk a well on one of his lots that was 33 feet deep and 5 feet in diameter.[137]

During 1901, there were newspaper accounts of a drought plaguing Denison, and the recorded rainfall was about 30% lower than normal that year.[138] In need of water for its passengers at the station, its machine shops, and the steam boilers in its locomotives,[139] the Railroad went searching during the summer of 1901 for nearby land upon which to drill a groundwater well.[140] Finding several wells already in place near the intersection of Owings Street and Lamar Avenue—including East's—that indicated accessible groundwater below, the Railroad drilled a well that August, measuring 20 feet in diameter and 66 feet deep, just some 100 to 250 feet away from East's well[141] (Figure 4). While the Railroad's new well was producing 25,000 gallons a day,[142] it was by no means the largest railroad well nearby.[143] The *Sunday Gazeteer* newspaper reported that Mo-Kan Railroad had sunk a well 2 1/2 miles from Denison that was piping 750,000 gallons per day.[144]

Trial Court proceedings

Sometime between August 1901 and April 1902, East and his neighbors' wells began to run dry, prompting him to file suit seeking $1,100 in damages[145] (Figure 5). In December, just days after East filed his First Amended Original Petition, Judge

[131] In August 1898, Governor Sayers wrote to House, promising that he would "not commit myself to any person on anything, in my own mind, until we shall have canvassed it fully and thoroughly together." *Long Reach*, 116 Southwestern Historical Quarterly at 275.

[132] *Id.* at 266.

[133] East *Historical Analysis*, at 63.

[134] *Id.*

[135] *Compare Id.* at 87 n.6, *with Long Reach*, 116 Southwestern Historical Quarterly at 265.

[136] East *Historical Analysis*, at 71. While East's pleadings in the case state he owned only 2 1/2 lots on the corner of Lamar Avenue and Morgan Street, the deed records show he owned 4 lots on the corner of Lamar Avenue and Owings Street. *Compare* East *Historical Analysis*, at 71, *with id.* at 100.

[137] East *Historical Analysis*, at 71; *see Long Reach*, 116 Southwestern Historical Quarterly at 266; *see also Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 823 (Tex. 2012); *Houston & Texas Central Railroad Co. v. East*, 98 Tex. 146, 148, 81 S.W. 279, 280 (1904).

[138] East *Historical Analysis*, at 80–81.

[139] *Day*, 369 S.W.3d at 824.

[140] East *Historical Analysis*, at 63.

[141] *Id.* at 63, 71; *see Long Reach*, 116 Southwestern Historical Quarterly at 267; *see also Day*, 369 S.W.3d at 824.

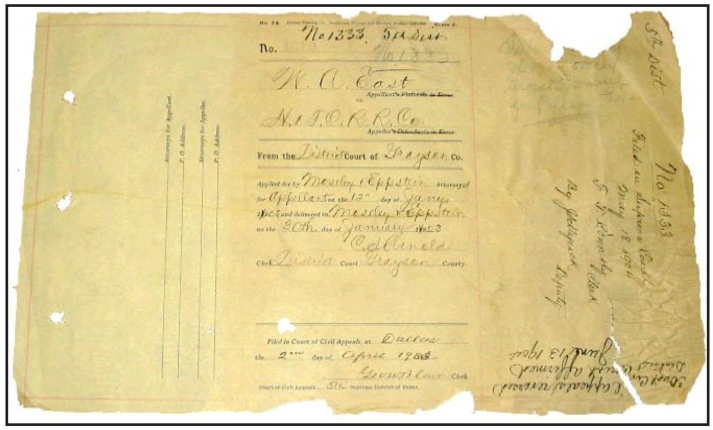
[142] *Day*, 369 S.W.3d at 824.

[143] East *Historical Analysis*, at 63, 81.

[144] *Id.* at 81.

[145] *Id.* at 63. The historical record is not clear when East first filed suit, but it is certain that the Railroad sank its well in August 1901 and filed its Original Answer to East's suit on April 5, 1902. *Id.* at 87 n.7, 104.

Figure 4. Looking north at the intersection of Owings Street and Lamar Avenue in Denison, Texas, with the probable location of the Railroad's well circled. Robert E. Mace et al., *Groundwater Is No Longer Secret and Occult—A Historical and Hydrogeologic Analysis of the* East *Case, in 100 Years of the Rule of Capture: From* East *to Groundwater Management*, Texas Water Development Board Report 74 (2004).



No. 1333, 5th Dist

No.

W. A. East

Appellant's

vs.

H. & T. C. R. R. Co.

Appellee's

From the District Court of Grayson Co.

Applied for by Mosley & Eppstein Attorneys for Appellant on the 12th day of Jany 1903 and delivered to Mosley & Eppstein on the 20th day of January 1903

C. S. Arnold

Clerk District Court Grayson County

Filed in Court of Civil Appeals, at Dallas the 2nd day of April 1903

Clerk

Attorneys for Appellant

P. O. Address

Attorneys for Appellee

P. O. Address

5th Dist

No 1333

Filed in Supreme Court May 18 1904

By Deputy

Figure 5. Dallas Court of Appeals's file coversheet in East with annotations by the clerk showing eventual disposition at the Texas Supreme Court. Robert E. Mace et al., *Groundwater Is No Longer Secret and Occult—A Historical and Hydrogeologic Analysis of the* East *Case, in 100 Years of the Rule of Capture: From* East *to Groundwater Management*, Texas Water Development Board Report 97 (2004).

Rice Maxey of the 15th District Court in Grayson County (sitting in Sherman) found in favor of the Railroad, concluding that no "correlative rights exist between the parties as to underground, percolating waters, which do not run in any defined channel."[146]

Review by the Dallas Court of Appeals

After Judge Maxey denied East's motion for new trial, East sought review in the Dallas Court of Appeals in early 1903.[147] On appeal, the Railroad retained the law firm of Baker, Botts, Baker & Lovett (now more commonly known as Baker Botts, L.L.P.) as appellate counsel.[148] Even in 1903, Baker Botts was a venerable Texas law firm based in Houston that counted among its clientele railroad companies and businesses just beginning to brave the burgeoning oil and gas industry.[149] The contrast between East's local counsel, Moseley & Eppstein, and Baker Botts was evident: the Railroad's briefs "were professionally printed and leather bound," while East's were "roughly typed."[150]

While acknowledging that *Acton* governed in England and had even been adopted by some American states, authoring justice John Bookhout[151] reasoned in the court's November 1903 opinion that applying the rule stated in *Acton* to the case before him would "shock our sense of justice"[152] (Figure 6). Recognizing that the question before it had "not been passed upon by any of the appellate courts of this State," the Dallas Court of Appeals chose to rely on the reasoning from an 1862 case issued by the Supreme Court of New Hampshire.[153] That case expressly rejected the tenets of ownership in place and the rule of capture as laid out in *Acton* and founded what is

[146] *Id.* at 63, 107–08; *see Long Reach*, 116 Southwestern Historical Quarterly at 266, 268.

[147] East *Historical Analysis*, at 64.

[148] *Id.* at 113.

[149] *Compare Long Reach*, 116 Southwestern Historical Quarterly at 271, *with* Baker Botts, History, http://www.bakerbotts.com/about/history/ (last visited Feb. 27, 2013).

[150] *Long Reach*, 116 Southwestern Historical Quarterly at 271.

[151] *Long Reach*, 116 Southwestern Historical Quarterly at 274. Justice Bookhout served on the Dallas appellate bench for nearly 15 years, being first appointed in October 1897 and submitting his resignation in early 1912. *Compare* W.J. Clay, Statistical Report: 1904, 18 (Von Boeckmann-Jones Co.—State Printers 1904), *available at* http://books.google.com/books?id=DABDAQAAMAAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false (last visited Feb. 28, 2013), *with Domestic*, The Bastrop Advertiser, February 2, 1912, at 1, *available at* http://texashistory.unt.edu/ark:/67531/metapth206029/m1/1/zoom/ (last visited Feb. 28, 2013). Of note, in 1881, Justice Bookhout became the first telephone subscriber in Dallas. *Why Dallas?*, Texas Monthly, December 1973, at 58 (incidentally, 1973 marked the inaugural volume for *Texas Monthly*, whose first issue published earlier that year in February, *From the Publisher*, Texas Monthly, February 1973, at 1, 3 (*Texas Monthly*'s original publisher, Michael R. Levy, penned a spirited introduction to the magazine, vowing not to compete with "vapid Sunday supplements …, with the promotional magazines with their prostitutional story-for-an-ad format or with the chamber of commerce magazines with their Babbitt perspectives")).

[152] *East v. Houston & T. Cent. Ry. Co.*, 77 S.W. 646, 648 (Tex. Civ. App.—Dallas 1903), *rev'd* 98 Tex. 146, 151, 81 S.W. 279, 282 (1904); *Long Reach*, 116 Southwestern Historical Quarterly at 273; East *Historical Analysis*, at 129.

[153] *Bassett v. Salisbury Mfg.*, 43 N.H. 569, 573–79 (1862).

now known as the American branch of the Reasonable-Use doctrine.[154]

Upon reversing the district court's judgment, Justice Bookhout rendered judgment awarding East $206.25 in damages.[155] The Railroad immediately moved for rehearing on December 10, 1903, which was denied 9 days later on December 19, 1903.[156]

The Texas Supreme Court's opinion

During the era of the Court in which the *East* case was decided, the Court became known as the "Consensus Court," due to the near unanimity with which the Court almost invariably issued its opinions.[157]

The Railroad filed its application for writ of error at the Texas Supreme Court on January 16, 1904, which the Court granted on April 28, 1904.[158] Just over 6 weeks later on June 13, 1904, the Court issued its unanimous opinion reversing the Dallas Court of Appeals and affirming the original judgment of the district court.[159]

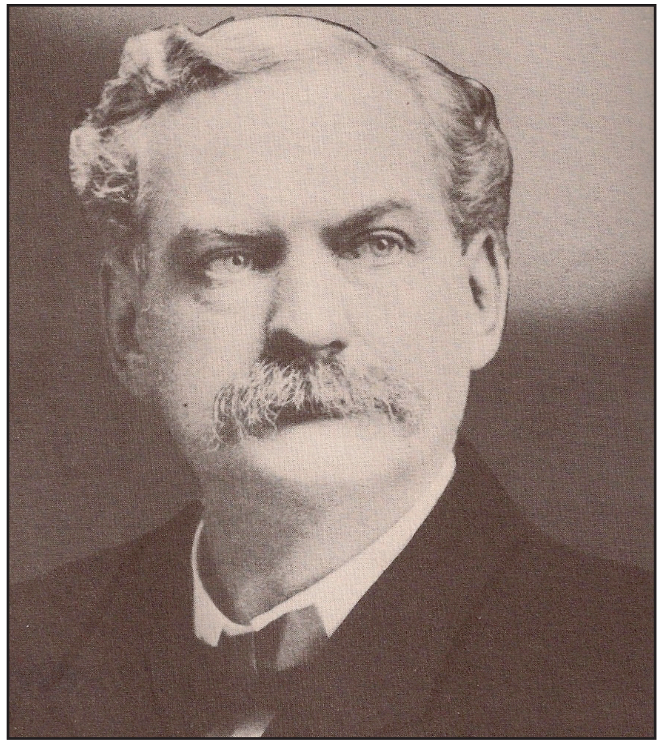


Figure 6. Justice John Bookhout of the Dallas Court of Appeals. Megan Benson. *Railroads, Water Rights and the Long Reach of* Houston and Texas Central Railroad Company v. W. A. East *(1904)*, 116 Southwestern Historical Quarterly 261, 274 (Jan. 2013).

Writing for a unanimous Court, Justice F.A. Williams[160] began by noting that *Acton* was then "recognized and followed . . . by all the courts of last resort in this country before which the question has come, except the Supreme Court of New Hampshire"[161]—the one jurisdiction Justice Bookhout relied upon below[162] (Figure 7). Therefore, the Court found to be persuasive *Acton*'s passage restating the rule of capture.[163]

The Court quoted extensively from a passage in a decision by the high court of New York in *Pixley v. Clark*, opining that:

> An owner of soil may divert percolating water, consume or cut it off, with impugnity. It is the same distinguished in law from land. So the owner of land is the absolute owner of the soil and of percolating water, which is a part of, and not different from, the soil. No action lies against the owner for interfering with or

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[154] *East*, 77 S.W. at 647–48, *rev'd* 98 Tex. at 151, 81 S.W. at 282; *Long Reach*, 116 Southwestern Historical Quarterly at 273; East *Historical Analysis*, at 127–29. For an extended discussion of the American branch of the Reasonable-Use Doctrine, please see Dylan O. Drummond, Comment, *Texas Groundwater Law in the 21st Century: A Compendium of Historical Approaches, Current Problems, and Future Solutions Focusing on the High Plains Aquifer and the Panhandle*, 4 Texas Tech Administrative Law Journal 173, 197–99 (Summer 2003) [hereinafter *21st Century Groundwater Law*].

[155] *Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 824 (Tex. 2012); *East*, 77 S.W. at 648, *rev'd* 98 Tex. at 151, 81 S.W. at 282; *Long Reach*, 116 Southwestern Historical Quarterly at 273; East *Historical Analysis*, at 64, 129.

[156] *Compare* East *Historical Analysis*, at 130, *with id.* at 148.

[157] SCOTX Narrative History at 140. Chief Justice Reuben Gaines, Justice Williams, and Justice T.J. Brown served together for nearly 12 years. *Id.* During this time—encompassing a dozen volumes of the *Texas Reports*—only 6 dissents were filed (1 by Chief Gaines, 2 by Justice Williams, and 3 by Justice Brown), and only 1 concurrence (by Justice Williams). *Id.* at 139–40.

While some have said that the Consensus Court "escorted Texas from the frontier into the industrial age with wisdom, discretion, and impeccable judicial temperament," other historians have taken a more critical view of that Court's legacy. *Compare* SCOTX Narrative History at 150, *with Long Reach*, 116 Southwestern Historical Quarterly at 278–79.

[158] East *Historical Analysis*, at 147. Until 1997, the mechanism to invite the Texas Supreme Court to review a case was by filing at the Court an application for writ of error under former Texas Rule of Appellate Procedure ("TRAP") 133(a). *See*, *e.g.*, Dylan O. Drummond, *Citation Writ Large*, 20 App. Advoc. 89, 104 (Winter 2007). After the massive overhaul of the TRAPs in September 1997, Rule 133(a) was supplanted by Rule 56.1(b)(1), which introduced the current process of petitioning the Court for review. *Id.*; *see* Texas rules of Appellate Procedure 56.1(b)(1), *reprinted in Texas Rules of Appellate Procedure*, 60 Texas Bar Journal 878, 936 (Oct. 1997).

[159] *Houston & Texas Central Railroad Co. v. East*, 98 Tex. 146, 81 S.W. 279 (1904).

[160] *Long Reach*, 116 Southwestern Historical Quarterly at 276. After being re-elected 3 times to his office, Justice Williams retired from the Court in 1911, just 2 1/2 months after his longtime friend and colleague, Chief Justice Gaines. *Id.* at 279; SCOTX Narrative History at 155, 242.

[161] *Id.* at 149, 280; *see Day*, 369 S.W.3d at 825.

[162] *East*, 77 S.W. at 647–48, *rev'd* 98 Tex. at 151, 81 S.W. at 282.

[163] *East*, 98 Tex. at 149, 81 S.W. at 280 (quoting *Acton*, 152 Eng. Rep. at 1235).

> destroying percolating or circulating water under the earth's surface.[164]

In the closing paragraphs of the *East* opinion, the Court explained that, because the Railroad was "making . . . use of the water which it takes from its own land . . ., [n]o reason exists why the general doctrine [(as stated in *Acton* and *Pixley*)] should not govern this case."[165]

Justice Williams did caution, though, that East had made "no claim of malice or wanton conduct of any character," so no such inquiry was before the Court.[166] The jurisprudential import of this statement was to—at the same moment Texas formally adopted the rule of capture—simultaneously limit its operation in cases where a withdrawing landowner acted maliciously or wantonly (i.e., wastefully).[167]

Although East initially moved for rehearing on June 28, 1904, he subsequently requested the Court dismiss his motion for rehearing the following month.[168] And with that, *East* became enshrined in Texas jurisprudence.

Tex. Co. v. Daugherty (1915)

Although it is an oil and gas case, *Texas Co. v. Daugherty* is notable in groundwater law lineage for 2 reasons: (1) it represented the first opportunity the Court had just 11 years after its decision in *East* to narrow its discussion of absolute ownership (which it declined to do); and (2) it contains one of the most masterful explanations before or since of the real property interest that attaches to fugacious or fleeting substances while in place.[169] Therein, the first Chief Justice Phillips to preside over the Court[170] reasoned that the mere:

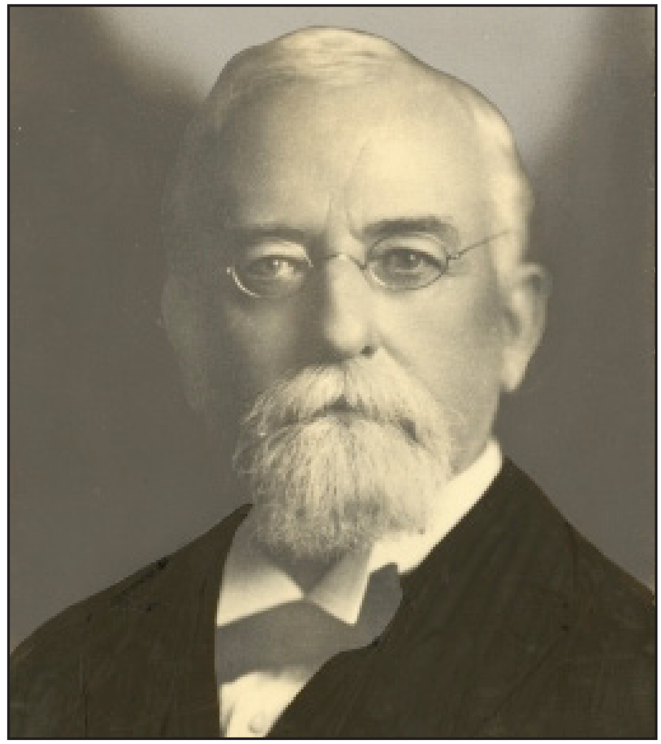

Figure 7. Justice F.A. Williams of the Texas Supreme Court. Megan Benson. *Railroads, Water Rights and the Long Reach of* Houston and Texas Central Railroad Company v. W. A. East *(1904)*, 116 Southwestern Historical Quarterly 261, 276 (Jan. 2013).

> [P]ossibility of the escape of the oil and gas from beneath the land before being finally brought within actual control may be recognized, as may also their incapability of absolute ownership, in the sense of positive possession, until so subjected. But nevertheless, while they are in the ground, they constitute a property interest.[171]

Chief Justice Phillips concluded that a landowner's "right to the oil and gas beneath his land is an exclusive and private property right . . . inhering in virtue of his proprietorship of the land, and of which he may not be deprived without a taking of private property."[172]

The Conservation Amendment (1917)

Following severe droughts in 1910 and 1917, Article XVI, Section 59 of the Texas Constitution was adopted in 1917,

[164] *Id.* at 150, 281–82 (quoting *Pixley v. Clark*, 35 N.Y. 520, 527 (1866)). Although the Court flatly rejected in *Day* that "any issue of ownership of groundwater *in place* was presented in *East*," it stated some 3 decades before that it "adopted the absolute ownership doctrine of underground percolating waters." *Compare Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 826 (Tex. 2012), *with Friendswood Dev. Co. v. Smith-S.W. Indus., Inc.*, 576 S.W.2d 21, 25 (Tex. 1978).

[165] *East*, 98 Tex. at 151, 81 S.W. at 281–82.

[166] *Id.* at 151, 282; *see Day*, 369 S.W.3d at 825.

[167] Justice Williams was undoubtedly referring to *Acton*'s earlier incorporation of a malicious restriction to the concept of *damnum absque injuria*. *See Acton v. Blundell*, 152 Eng. Rep. 1223, 1228 (1843).

[168] East *Historical Analysis*, at 167–73.

[169] 107 Tex. 226, 231, 235–36, 176 S.W. 717, 719–20 (1915).

[170] Chief Justice Nelson Phillips sat on the Court as Justice from 1912 to 1915 and as Chief Justice from 1915 to 1921. SCOTX Narrative History at 240, 242. After he came to the Court, one change Chief Phillips wrought was to have the deputy clerk organize a tennis club, which competed on 2 courts that the deputy clerk had laid out on a nearby vacant lot. *Id.* at 156. In turn, Chief Justice Thomas R. Phillips served as Chief Justice from 1988 to 2004. *Id.* at 244.

[171] *Daugherty*, 107 Tex. at 236, 176 S.W. at 720; *see Day*, 369 S.W.3d at 829.

[172] *Daugherty*, 107 Tex. at 237, 176 S.W. at 720; *see Day*, 369 S.W.3d at 829.

commonly referred to as the "Conservation Amendment."[173] It provides that:

> The conservation and development of all of the natural resources of this State, . . . and the preservation and conservation of all such natural resources of the State are each and all hereby declared public rights and duties; and the Legislature shall pass all such laws as may be appropriate thereto.[174]

The Conservation Amendment makes it incumbent upon the Legislature to implement public policy in accord with its provisions,[175] and—for the first time—empowered the Legislature to "promulgate laws creating conservation districts and water regulations."[176] It was intended, at least in part, to provide citizens and lawmakers with a remedy to water depletion.[177] Designed to ameliorate the effects of cyclical floods and droughts that had plagued Texas landowners, the Conservation Amendment "promised stable water usage for the future."[178]

Tex. Co. v. Burkett (1927)

The first chance the Court had to re-evaluate its groundwater law holdings in *East* arose in *Texas Co. v. Burkett*.[179] In Burkett, the Court briefly examined the nature of "percolating" groundwater.

Therein, the Court reasoned that, if groundwater was not either "add[ing] perceptibly to the general volume of water in the bed of [a] stream" (underflow), or "of sufficient magnitude to be of any value to riparian proprietors" (underground streams), it is presumed to be percolating.[180] It confirmed as well that percolating groundwater was "the exclusive property of [the landowner], who had all the rights incident to them that one might have as to any other species of property."[181]

Of note, the ultimate holding in *Burkett* was an important one—that a "landowner has the absolute right to sell percolating ground water for industrial purposes off the land."[182]

Brown v. Humble Oil & Ref. Co. (1935)

Although *East* is commonly and accurately cited as the conceptual genesis of the rule of capture in Texas, the actual phrase appears nowhere in the opinion.[183] It would not be until 30 years after it decided *East* that the Texas Supreme Court would first pen the phrase, "law of capture," in the oil and gas decision in *Brown v. Humble Oil & Refining Co.*[184]

In doing so, the Court also elaborated on its previous discussion in *Daugherty*, explaining that:

> The rule in Texas recognizes the ownership of oil and gas in place. . . . Owing to the peculiar characteristics of oil and gas, the foregoing rule of ownership of oil and gas in place should be considered in connection with the law of capture. This rule gives the right to produce all of the oil and gas that will flow out of the well on one's land; and this is a property right. And it is limited only by the physical possibility of the adjoining landowner diminishing the oil and gas under one's land by the exercise of the same right of capture.[185]

Implicitly recognizing the Conservation Amendment's impact on groundwater law nearly 3 decades earlier, the Court held that "[b]oth rules are subject to regulation under the police power of a state."[186]

Elliff v. Texon Drilling Co. (1948)

Yet another oil and gas case that came later to shed light on modern Texas groundwater law was *Elliff v. Texon Drill-*

[173] Texas Constitution art. XVI, § 59 (amended 2003); *Barshop v. Medina Cnty. Underground Water Conservation Dist.*, 925 S.W.2d 618, 626 (Tex. 1996); *In re Adjudication of the Water Rights of Upper Guadalupe Segment of Guadalupe River Basin*, 642 S.W.2d 438, 440 (Tex. 1982) ("The droughts in 1910 and 1917 prompted the citizens of Texas to adopt the 'Conservation Amendment' to the Texas Constitution, mandating the conservation of public waters."); *City of Corpus Christi v. City of Pleasanton*, 154 Tex. 289, 304, 276 S.W.2d 798, 808 (1955) (Wilson, J., dissenting) (noting the Conservation Amendment's passage in 1917).

[174] Texas Constitution art. XVI, § 59(a); *see also Barshop*, 925 S.W.2d at 626 (the Conservation Amendment "provides that the conservation, preservation, and development of the state's natural resources[—including groundwater—]are public rights and duties."). citing Texas Constitution art. XVI, § 59(a)

[175] *Corpus Christi*, 154 Tex. at 296, 276 S.W.2d at 803.

[176] Stephanie E. Hayes Lusk, *Texas Groundwater: Reconciling the Rule of Capture with Environmental and Community Demands*, 30 St. Mary's Law Journal 305, 322 (1998) (citing Texas Constitution art. XVI, § 59).

[177] *Id.*

[178] *Id.*

[179] 117 Tex. 16, 296 S.W. 273 (1927). The opinion's author, Chief Justice Calvin Maples Cureton, had served first as Texas Attorney General before accepting nomination to the Court, which he would serve as Chief Justice longer than any other (19 years), before or since. SCOTX Narrative History at 164, 173, 235–39, 243–44.

[180] *Burkett*, 117 Tex. at 28–29, 296 S.W. at 278.

[181] *Id.* at 29, 278.

[182] *Friendswood Dev. Co. v. Smith-S.W. Indus., Inc.*, 576 S.W.2d 21, 25–26 (Tex. 1978) (citing *Burkett*, 117 Tex. at 29, 296 S.W. at 278).

[183] *Fact or Fiction* at 3, in UTCLE, Texas Water Law Institute.

[184] 126 Tex. 296, 305, 83 S.W.2d 935, 940 (1935). *Brown* was authored by Justice John Henry Sharp, a Central Texan who served on the Court for 18 years from 1934 to 1953. SCOTX Narrative History at 170–71, 243–44.

[185] *Brown*, 126 Tex. at 305, 83 S.W.2d at 940; *see Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 829 n.86 (Tex. 2012).

[186] *Brown*, 126 Tex. at 305, 83 S.W.2d at 940.

ing Co.[187] Being now 44 years after *East* and 33 years after *Daugherty*, the Court sought the opportunity to restate the law regarding ownership of oil and gas in place:

> In our state the landowner is regarded as having absolute title in severalty to the oil and gas in place beneath his land. The only qualification of that rule of ownership is that it must be considered in connection with the law of capture and is subject to police regulations. The oil and gas beneath the soil are considered a part of the realty. Each owner of land owns separately, distinctly and exclusively all the oil and gas under his land and is accorded the usual remedies against trespassers who appropriate the minerals or destroy their market value.[188]

However, for the next 64 years, the Court declined to directly apply this construction of ownership in place to groundwater,[189] deferring instead to the Legislature to address such questions.[190]

Groundwater Conservation District Act (1949)

Just 1 year after the Court issued *Elliff* and some 3 decades after passage of the Conservation Amendment, the Legislature first exercised its constitutional authority related to groundwater regulation under the Texas Constitution. During the 51st Legislative Session in 1949, the Legislature enacted the Groundwater Conservation District Act (GCDA), which established groundwater conservation districts throughout the state.[191]

After the predecessor agency to the Texas Water Development Board issued a report in 1934 calling for underground water to be "subject to the same control as surface water" and a statutory declaration that the "underground water of the State [is] the property of the State," public opposition to such action by the Legislature was pronounced.[192] One more colorful High Plains farmer said that even just the proposition of creating groundwater conservation districts "should be met with 30-30s (rifles) and its sponsors not only driven back to the City of Austin, but on south across the San Jacinto battlefield and into the Gulf of Mexico where they can get their fill of water."[193] This landowner continued:

> You can say you prefer local control to state control or federal control. I don't want any control by anybody but the landowner. That's like asking who you'd rather be hanged by. I don't want to be hanged. . . . All the water under my land belongs to me . . . nobody can tell me how to use it. . . . If my neighbor wants to drill wells right next to me, that's all right with me. If the wells go dry, we will all run out together.[194]

Needless to say, in order to enact any bill that would fulfill the Conservation Amendment's mandate, a compromise would have to be struck between the state's regulators and those they sought to oversee. The Texas Farm Bureau provided just such a compromise by suggesting the creation of locally controlled groundwater conservation districts similar to the soil conservation districts with which many farmers were already well acquainted.[195] The general sentiment during this time toward passage of the GCDA was best approximated by the comment offered by another High Plains man: "I favor no control, but if we must have it, let it be local."[196]

Local control won the day. The GCDA was subsequently enacted and created local groundwater districts that would provide for the "conservation, preservation, protection, recharging, and prevention of waste of underground water."[197] In doing so, the Legislature recognized the "ownership and rights of the owner of the land, his lessees and assigns, in

[187] 146 Tex. 575, 210 S.W.2d 558 (1948). The opinion's author, Justice A.J. Folley of Amarillo, served the Court just 4 years between 1945 and 1949, but would later serve as State Bar president. *See* SCOTX Narrative History at 194, 252. As the State Bar president, Justice Folley dedicated the new Texas Supreme Court building located on the northwest corner of the Capitol grounds. *Id.* at 194.

[188] *Elliff*, 146 Tex. 580, 210 S.W.2d at 561 (internal citations omitted).

[189] *But see Day*, 369 S.W.3d at 831–32.

[190] *Friendswood Development Co. v. Smith-Southwest Industries, Inc.*, 576 S.W.2d 21, 30 (Tex. 1978) ("Providing policy and regulatory procedures in this field is a legislative function").

[191] Act of May 23, 1949, 51st Leg., R.S., ch. 306, 1949 Texas General Laws 559 (codified at Texas Revised Civil Statutes Annotated art. 7880–3c(D), later codified as Texas Water Code § 52.002) [hereinafter GCDA]; *see Day*, 369 S.W.3d at 832; *Sipriano v. Great Spring Waters of Am., Inc.*, 1 S.W.3d 75, 79 (Tex. 1999).

[192] *See* John T. Dupnik, A Policy Proposal for Regional Aquifer-Scale Management of Groundwater in Texas, at 5 (Dec. 2012) (unpublished M.S. thesis, University of Texas at Austin), *available at* https://repositories.lib.utexas.edu/bitstream/handle/2152/19658/dupnik_thesis_20129.pdf?sequence=1 (last visited Sept. 25, 2014) (quoting Donald E. Green, Land of the Underground Rain: Irrigation on the Texas High Plains, 1910–1970, at 172 (1973)).

[193] *Id.* at 5 n.14 (quoting Green, at 181, 183).

[194] *Id.*

[195] *Id.* at 6 (citing Green, at 189).

[196] *Id.*

[197] GCDA; *Friendswood Dev. Co. v. Smith-S.W. Indus., Inc.*, 576 S.W.2d 21, 26 (Tex. 1978).

underground water,"[198] which would come to reside in section 36.002 of the Water Code from 1995 to 2011.[199]

City of Corpus Christi v. City of Pleasanton (1955)

In the midst of a sustained drought in the 1950s,[200] *City of Corpus Christi v. City of Pleasanton* came before the Court.[201] Indeed, because a drought in the early 1900s prompted the *East* suit,[202] droughts in 1910 and 1917 helped to create the requisite public outcry to pass the Conservation Amendment,[203] and the drought of the 1950s led to the Court's consideration of *Corpus Christi*, "[t]he story of water law in Texas is also the story of its droughts."[204]

While the Court enshrined a waste exception to the rule of capture in *East*,[205] it had not been called upon in the intervening half century to address the contours of that exception. In *Corpus Christi*, the Court finally got its opportunity.

The parties in the case each owned wells pumping from the same groundwater formation.[206] The Lower Nueces River Supply District, though located in Atascosa County,[207] was under contract to furnish groundwater to the city of Corpus Christi, which it did by transporting withdrawn groundwater down the Nueces River and Lake Corpus Christi some 118 miles to a settling basin at Calallen.[208] Evidence in the case showed that "63 to 74% of the water discharged into the river escaped through evaporation, transpiration and seepage and never reached its destination to be put to a beneficial use."[209] Because the majority of the withdrawn groundwater admittedly never reached its destination, the city of Pleasanton in Atascosa County brought suit, alleging waste.[210]

Writing for the majority, then-Justice Robert W. Calvert[211] reasoned that the Legislature—in enacting 2 statutes allowing for the transport of groundwater via "'river, creek or other natural water course or drain, superficial or underground channel, [or] bayou,'"[212]—certainly conceived that some of the water might be lost in transport and "could hardly have intended that what it had approved as legal should become illegal. . . ."[213] The Court also noted that it was unaware of any "judicial modification in this state of the rule of the *East* case."[214]

In response to a vigorous dissent by Justice Meade F. Griffin[215] (one of 2 dissenting opinions filed in the case)[216] that was perhaps understandably indignant that the Court could find the loss of some 70% of transported groundwater did not constitute waste,[217] Justice Calvert admonished that the Conservation Amendment mandated the Legislature to preserve Texas's natural resources—including water—but "[n]

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198 GCDA at § 1, 1949 Texas General Laws at 562.

199 *See Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 832 (Tex. 2012); *compare* Act of May 29, 1995, 74th Leg., R.S., ch. 933, § 2, 1995 Texas General Laws 4673, 4680 (adopting Texas Water Code § 36.002) ("The ownership and rights of the owners of the land and their lessees and assigns in groundwater are hereby recognized, and nothing in this code shall be construed as depriving or divesting the owners or their lessees and assigns of the ownership or rights, subject to rules promulgated by a district."), *with* Act of May 29, 2011, 82nd Leg., R.S., ch. 1207, 2011 Texas General Laws 3224 (codified at Texas Water Code § 36.002) ("The Legislature recognizes that a landowner owns the groundwater beneath the surface of the landowner's land as real property.").

200 SCOTX Narrative History at 189; *Still So Misunderstood*, 37 Texas Tech Law Review at 42.

201 *See* 154 Tex. 289, 276 S.W.2d 798 (1955).

202 *See* East *Historical Analysis*, at 80–81.

203 *See Barshop v. Medina Cnty. Underground Water Conservation Dist.*, 925 S.W.2d 618, 626 (Tex. 1996).

204 In re *Adjudication of the Water Rights of the Upper Guadalupe Segment of the Guadalupe River Basin*, 642 S.W.2d 438, 441 (Tex. 1982).

205 *Houston & Texas Central Railroad Co. v. East*, 98 Tex. 146, 151, 81 S.W. 279, 282 (1904); *see Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 825 (Tex. 2012).

206 *Day*, 369 S.W.3d at 826.

207 SCOTX Narrative History at 190.

208 *Corpus Christi*, 154 Tex. at 290, 276 S.W.2d at 799–800; SCOTX Narrative History at 190; *Still So Misunderstood*, 37 Texas Tech Law Review at 47.

209 *Corpus Christi*, 154 Tex. at 291, 276 S.W.2d at 800.

210 *Id.*

211 Justice Calvert—a former Speaker of the Texas House—was first appointed to the Court in 1950 and later became one the Court's most respected and distinguished Chief Justices from his election to the post in 1960 until his retirement in 1972. SCOTX Narrative History at 186, 244–45. Calvert is said to have credited, in part, his first election to the Court to a timely and unrelated advertising campaign in the state for Calvert Whiskey. *Id.* at 186.

212 *Corpus Christi*, 154 Tex. at 295, 276 S.W.2d at 802 (citation omitted).

213 *Id.*

214 *Id.* at 294, 802.

215 *Id.* at 297, 804 (Griffin, J., dissenting). Justice Griffin hailed from the Texas Panhandle, was a past president of the Texas Bar, and served as a prosecution subsection chief during the Nazi war crimes trials. SCOTX Narrative History at 185. Following his appointment to the Court in 1949, Justice Griffin was elected 3 times to keep his seat until his retirement in 1968. *Id.* at 252.

216 *See Corpus Christi*, 154 Tex. at 299, 276 S.W.2d at 805 (Wilson, J., dissenting, joined by Culver, J.).

217 Justice Griffin rebuked the majority opinion, arguing that its reasoning would hold that, if only .0001% of transported groundwater reached its destination, there still could be no finding of waste. *Corpus Christi*, 154 Tex. at 298, 276 S.W.2d at 804 (Griffin, J., dissenting).

o such duty was or could have been delegated to the courts."[218] He continued, noting that the "Legislature is now in session. It will have this opinion before it before adjournment. It will recognize the problem. If it wishes to declare that the transportation of water in conduits which permit the escape of a large percentage is wasteful and unlawful it will have ample time in which to do it."[219]

Friendswood Dev. Co. v. Smith-S.W. Indus., Inc. (1978)

In 1978, the Court recognized another, albeit narrow, exception to the immunity granted under rule of capture in *Friendswood Development Co. v. Smith-Southwest Industries, Inc.*—that of negligent subsidence.[220]

Five years before the Court's opinion was issued, several landowners in Harris County, including Smith-Southwest Industries, Inc., brought suit against Friendswood Development Co. and its parent company, Exxon Corp., alleging that withdrawals of large quantities of groundwater from nearby lands caused severe subsidence on their land.[221]

While the suit was pending that same year, and likely not by coincidence, the 63rd Legislature amended the original 1949 legislation that enabled the creation of groundwater conservation districts to include subsidence control among the list of purposes for which a district could be created to address.[222]

When the Court finally heard the merits of the case in 1978 after 2 intervening legislative sessions worth of changes to the Water Code, the Court proceeded cautiously. It went to great pains to rule only prospectively that a landowner could be liable for the "negligent, willfully wasteful, or . . . malicious[ly] injur[ious]" withdrawal of groundwater that was the "proximate cause of the subsidence of land of others."[223]

Cautious though the application of the Court's holding may have been, the holding itself creating the first new common law exception to the rule of capture since the rule's adoption three-quarters of a century before was amply bold.

City of Sherman v. Pub. Util. Comm'n (1983)

After Luella Water Supply Corporation sought to have the Public Utility Commission (PUC) prohibit the city of Sherman from drilling wells on the city's own land, but within Luella's service area, the PUC asserted jurisdiction to regulate the city's groundwater withdrawal.[224]

The dispute reached the Court in *City of Sherman v. Public Utility Commission*.[225] Observing that the "only possible order which the PUC could issue with respect to Luella's complaint, other than dismissing the complaint altogether, would involve restricting or otherwise conditioning City's right to produce its groundwater," the Court flatly rejected the notion that the PUC had any authority "to regulate groundwater production or adjudicate correlative groundwater rights."[226] Notably, *Sherman* was the first time the Court explicitly held that a

[218] *Id.* at 295–96, 803.

[219] *Id.* at 296, 803.

[220] 576 S.W.2d 21, 30 (Tex. 1978). "Subsidence" occurs when a reservoir of groundwater is overdrafted intensely and long enough to drain a sufficient quantity of the water out of the aquiferous soil strata, thereby weakening the structural latticework of the soil by leaving air in place of water. David Todd, *Common Resources, Private Rights and Liabilities: A Case Study on Texas Groundwater Law*, 32 Natural Resources Journal 233, 238 (1992). This, in turn, causes the drained soil to collapse, thereby lowering each higher level of soil sediment up to the surface. *Id.* "Overdrafting" is a process by which water is withdrawn from an underground reservoir at a rate greater than that of the natural recharge. *21st Century Groundwater Law*, 4 Texas Tech Administrative Law Journal at 193.

[221] *Friendswood*, 576 S.W.2d at 21–22.

[222] *See* Act of May 26, 1973, 63rd Leg. R.S., ch. 598, 1973 Texas General Laws 1641. During the following legislative session in 1975, the Legislature created the first underground water conservation district specifically tasked with managing subsidence. *See* Act of May 12, 1975, 64th Leg., R.S., ch. 284, 1975 Texas General Laws 672.

[223] *Friendswood*, 576 S.W.2d at 30; *see Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 827 (Tex. 2012).

The opinion's author, M. Price Daniel, was a former U.S. Senator from Texas, Texas Attorney General, and Texas Governor. SCOTX Narrative History at 204. In fact, when *Friendswood* was being deliberated in 1978, Daniel was in the unique position as authoring Justice to persuade his fellow Justices to join his opinion—2 of whom he appointed (future Texas Supreme Court Chief Justice Joe Greenhill in 1957 and Justice Zollie Steakley in 1961). *See Id.* at 245, 251.

However, Justice Daniel would fail to persuade another future Chief Justice of the Court—Jack Pope—who dissented in *Friendswood* by keenly arguing that the matter was not a groundwater ownership case at all, but was instead a *lateral-support* dispute. *Friendswood*, 576 S.W.2d at 31 (Pope, J., dissenting, joined by Johnson, J.). Justice Pope analogized the fatal flaw in the Court's logic as he saw it: "It is no more logical to say that this is a case concerning the right to ground water than it would be correct in a case in which an adjoining landowner removed lateral support by a caterpillar to say that the case would be governed by the law of caterpillars." *Id.*

The realization that his illustrious past would not aid him at the Court set in early for Justice Daniel, as Chief Justice Calvert—who insisted on punctuality—began Justice Daniel's own swearing-in ceremony without him when Justice Daniel failed to be seated and ready at the appointed time. SCOTX Narrative History at 199.

The *Friendswood* opinion would prove to be one of Justice Daniel's last, as he retired just a month after it issued. *Compare Friendswood*, 576 S.W.2d at 21, *with* SCOTX Narrative History at 250.

[224] *City of Sherman v. Pub. Util. Comm'n*, 643 S.W.2d 681, 682–83 (Tex. 1983).

[225] *Id.* at 681.

[226] *Id.* at 686; *see Day*, 369 S.W.3d at 827. The author of the unanimous opinion was Justice Charles W. Barrow, who served with great distinction as both a Justice and Chief Justice of the San Antonio Court of Appeals for 15 years prior to his appointment to the Court in 1977. SCOTX Narrative History at 207, 209, 247. Justice Barrow left the Court in 1984 in order to become the new dean of Baylor Law School. *Id.* at 214, 247.

"corollary to absolute ownership of groundwater is the right of the landowner to capture such water."[227]

The Edwards Aquifer Authority Act (1993)

The tale of the formation of the Edwards Aquifer Authority (EAA) and the role the federal bench played in the saga is important to the examination of the development of Texas groundwater law.[228]

In 1991, the Sierra Club sued the U.S. Secretary of the Interior in the Midland U.S. District Court "alleging that the Secretary . . . had allowed takings of endangered species by not ensuring water levels in the Edwards Aquifer adequate to sustain the flow of Comal and San Marcos Springs."[229] The trial began in November 1992 in Midland, Texas and was presided over by the late Judge Lucius D. Bunton III,[230] who ruled in favor of the Sierra Club on February 1, 1993,[231] exactly 20 days after the 73rd Legislature convened in Austin.[232]

As part of his ruling, Judge Bunton threatened the State with the "'blunt axes'" of federal intervention[233] if the Texas Legislature did not adopt a management plan that limited withdrawals from the Edwards Aquifer by the end of the Legislative Session.[234] If the Legislature failed to act in time, Judge Bunton would allow the Sierra Club to return to his court and seek additional remedies—namely subjecting the Edwards Aquifer to federal regulation by the U.S. Fish and Wildlife Service.[235] Not surprisingly, the Legislature passed the EAA Act just 1 day before Judge Bunton's deadline expired.[236]

The Act imposed an aquifer-wide cap on annual total groundwater production from non-exempt wells in the Edwards Aquifer of 450,000 acre-feet[237] of water per year through calendar year 2007, dropping to 400,000 acre-feet per year thereafter[238] until the cap is increased upon a determination that "additional water supplies are safely available from the aquifer."[239] To implement the objectives of the legislation, the EAA was authorized to adopt regulations and issue permits limiting the amount of groundwater a landowner could produce.[240]

The Act was originally set to take effect on September 1, 1993 but was delayed after the U.S. Department of Justice refused administrative preclearance for the EAA under section 5 of the Voting Rights Act of 1965, and the EAA was subsequently enjoined from operating while a facial constitutional challenge unfolded.[241] The EAA would not begin operations until 3 years later in 1996 when the constitutional challenge was resolved and the injunction dissolved by the Court.[242]

Due to its unique lineage and regulatory powers, the EAA would go on to play a significant and recurring role in the coming decades as the Court examined Texas groundwater law.[243]

Barshop v. Medina Cnty. Underground Water Conservation Dist. (1996)

The dispute that helped delay the EAA's operation also appeared to be a vehicle in which the Court would finally resolve the tension between property rights in and regulation of groundwater. But the Court's decision in *Barshop v. Medina County Underground Water Conservation District* would not prove so sweeping.[244]

In 1995, a group of plaintiffs, led by the Medina County Underground Water Conservation District (collectively, MCUWCD), brought a facial constitutional challenge to the

[227] *Sherman*, 643 S.W.2d at 686.

[228] Todd H. Votteler, *Raiders of the Lost Aquifer? Or, the Beginning of the End to Fifty Years of Conflict Over the Texas Edwards Aquifer,* 15 Tulane Environmental Law Journal 257, 273 (2002) [hereinafter *Raiders of the Lost Aquifer*].

[229] Todd H. Votteler, T*he Little Fish that Roared: The Endangered Species Act, State Groundwater Law, and Private Property Rights Collide Over the Texas Edwards Aquifer,* 28 Environmental Law 845, 856 (1998) [hereinafter F*ish that Roared*].

[230] *Raiders of the Lost Aquifer*, 15 Tulane Environmental Law Journal at 274.

[231] *See Id.*; *Fish that Roared*, 28 Environmental Law at 856.

[232] *See* 1993 Texas General Laws vol. I, at iii.

[233] *Sierra Club v. Lujan*, No. MO-91-CA-069, 1993 WL 151353 (W.D. Tex. May 26, 1993) (not designated for publication) (citation omitted); *see Fish that Roared*, 28 Environmental Law at 856.

[234] *Fish that Roared*, 28 Environmental Law at 856.

[235] *Raiders of the Lost Aquifer*, 15 Tulane Environmental Law Journal at 275; *Fish that Roared*, 28 Environmental Law at 860.

[236] *See* Act of May 30, 1993, 73rd Leg., R.S., ch. 626 § 1, 1993 Texas General Laws 2350, 2360 [hereinafter Act]; *Raiders of the Lost Aquifer*, 15 Tulane Environmental Law Journal at 276; *Fish that Roared*, 28 Environmental Law at 860.

[237] An acre-foot is the amount of water necessary to cover an acre of land to a depth of one foot and equates to approximately 325,850 gallons in volume. *Barshop v. Medina Cnty. Underground Water Conservation Dist.*, 925 S.W.2d 618, 624 n.1 (Tex. 1996).

[238] *Barshop*, 925 S.W.2d at 624 (citing Act, at § 1.14(b)–(c)).

[239] *Barshop*, 925 S.W.2d at 624 (citing Act, at § 1.14(d)).

[240] Act, at §§ 1.03, .16–.20; *Barshop*, 925 S.W.2d at 624–25.

[241] *Edwards Aquifer Auth. v. Chem. Lime, Ltd.*, 291 S.W.3d 392, 396 (Tex. 2009).

[242] *Chem. Lime*, 291 S.W.3d at 396, 402; *see also Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 820 (Tex. 2012).

[243] *See, e.g., Day*, 369 S.W.3d at 814; *Chem. Lime*, 291 S.W.3d at 392; *Bragg v. Edwards Aquifer Auth.*, 71 S.W.3d 729 (Tex. 2002); *Barshop v. Medina Cnty. Underground Water Conservation Dist.*, 925 S.W.2d 618 (Tex. 1996).

[244] 925 S.W.2d 618 (Tex. 1996)

Act.[245] MCUWCD brought the suit against the individual directors, including San Antonio businessman Phil Barshop, and the State of Texas was joined as a necessary party.[246]

MCUWCD did not challenge the constitutionality of the Act as it was applied to any particular landowner or their right to produce the groundwater from beneath their land.[247] Instead, because MCUWCD brought a facial challenge to the Act, the Court reviewed it to determine whether the statute, "by its terms, always operates unconstitutionally."[248] The district court subsequently ruled that the Act was unconstitutional, and the State perfected a direct appeal to the Court.[249]

> The introduction to the Court's opinion recounted the long legal history of the rule of capture:
>
> This case concerns [ground]water rights in Texas. The clash between the property rights of landowners in the water beneath their land and the right of the State to regulate [that] water for the benefit of all is more than a century old. This case presents another chapter in this ongoing battle.[250]

But the *Barshop* "chapter" of the story of the rule of capture in Texas proved to be anticlimactic.[251]

MCUWCD's central claim was that the Act constituted an unconstitutional deprivation of an affected landowner's vested property rights in the groundwater beneath their land.[252] MCUWCD's claims were founded on the Court's adoption of the rule of capture in *East* and its subsequent reaffirmation of the doctrine in *East*'s progeny, each of which steadfastly rejected the "correlative rights" or "reasonable use" theories of groundwater ownership followed in other jurisdictions.[253] The State defended the constitutionality of the Act on the theory that "until the water is actually reduced to possession, the right is not vested and no taking occurs."[254] Under the State's defense, there could be no constitutional taking under the Act for landowners "who ha[d] not previously captured [ground] water."[255]

The Court noted that the parties "fundamentally disagree[d] on the nature of the property rights affected" by the Act, and that it had not had occasion to previously address "the point at which [ground]water regulation [by the state] unconstitutionally invades the property rights of landowners."[256] Ultimately however, the Court sidestepped the issue and did not consider whether the Act, when applied to a particular landowner, would operate unconstitutionally to "take" their rights in the groundwater in place or their right to produce such groundwater.[257] Instead, the Court addressed MCUWCD's facial challenge to the constitutionality of the Act and held that MCUWCD had not established that the Act is unconstitutional on its face.[258] Because MCUWCD's constitutional challenge was facial, the Court explained that any takings violations were "hypothetical."[259] Nevertheless, the Court opined that, "[a]s long as compensation is provided, the [Act] does not violate [the Takings Clause in] article I, section 17" of the Texas Constitution.[260]

Having resolved the issue based on the narrow constitutional question presented, the Court found it unnecessary "to definitively resolve the clash between property rights in [ground] water and regulation of [ground]water."[261]

It would not be until some 16 years later that the Court would do so.[262]

Senate Bill 1 (1997)

When it was passed, Senate Bill 1[263] was called "revolutionary"[264] and the "most exhaustive rewrite of Texas water law in the [preceding] thirty years."[265]

The signature change wrought by Senate Bill 1 was to finally

[245] *Id.* at 623. Other plaintiffs included the Uvalde County Underground Water Conservation District, the Texas and Southwestern Cattle Raisers Ass'n, Russell Brothers Cattle Co., and Bruce Gilleland. *Id.*

[246] *See id.*

[247] *Id.*

[248] *Id.*

[249] *Id.*

[250] *Id.*

[251] *Id.* at 626.

[252] *Id.* at 625.

[253] *See id.* at 626 (citing *Friendswood Dev. Co. v. Smith-S.W. Indus., Inc.*, 576 S.W.2d 21, 30 (Tex. 1978); *City of Corpus Christi v. City of Pleasanton*, 154 Tex. 289, 292–93, 276 S.W.2d 798, 801 (1955)).

[254] *Id.* at 625.

[255] *Id.*

[256] *Id.* at 625–26.

[257] *Id.* at 623, 625–27.

[258] *Id.* at 626.

[259] *Id.* at 631.

[260] *Id.*

[261] *Id.* at 626.

[262] *Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 817–18 (Tex. 2012).

[263] Act of June 2, 1997, 75th Leg., R.S., ch. 1010, 1997 Texas General Laws 3610.

[264] Chris Lehman, Comment, *Hung Out to Dry?: Groundwater Conservation Districts and the Continuing Battle to Save Texas's Most Precious Resource,* 35 Texas Tech Law Review 101, 107 (2004).

[265] Martin Hubert & Hon. Bob Bullock, *Senate Bill 1, The First Big and Bold Step Toward Meeting Texas's Future Water Needs*, 30 Texas Tech Law Review 53, 54 (1999).

and unequivocally codify that, pursuant to the Conservation Amendment's mandate to conserve and develop the state's natural resources, groundwater conservation districts were the state's "preferred method" of managing its groundwater resources.[266]

By Senate Bill 1's passage, the Legislature gave more "authority to locally controlled groundwater conservation districts for establishing requirements for groundwater withdrawal permits and for regulating water transferred outside the district."[267] The process put in place by Senate Bill 1 "permits the people most affected by groundwater regulation in particular areas to participate in democratic solutions to their groundwater issues."[268]

Senate Bill 1 also revised the "critical-area" designation process requiring the Texas Commission on Environmental Quality (TCEQ) (formerly the Texas Natural Resource Conservation Commission) and the Texas Water Development Board to identify areas anticipated to experience critical groundwater problems and streamline the process by which TCEQ or the Legislature can create a district in these areas.[269] In addition, Senate Bill 1 included various provisions calling for more comprehensive and coordinated water planning.[270]

Sipriano v. Great Spring Waters of Am., Inc. (1999)

When the Court handed down *Sipriano v. Great Spring Waters of America, Inc.* in 1999, it seemed to herald the demise of the ownership in place and perhaps even the rule of capture.[271] Because of its import to the jurisprudential saga of groundwater law in Texas, the background to the case is examined in more depth below.

Factual background

Ironically, 1 year after the Texas Supreme Court's decision in *East*, Great Spring Waters of America—otherwise known as

Figure 8. Henderson-County landowner Dale Groom stands next to a sign unambiguously noting his displeasure with Ozarka. *Biggest Pump Wins* (photograph by Mark Graham).

Figure 9. Bart Sipriano examines a pond on his 44-acre tract of land. *Biggest Pump Wins* (photograph by Mark Graham).

Ozarka—began operation in Arkansas in 1905.[272] Indeed, the factual setting in *Sipriano* was the first since *East* to be "virtually identical" to that presented nearly a century before.[273]

In the late 1980s, a representative from Ozarka began inquiring about leasing property in East Texas, particularly near the springhead of Roher Springs in Henderson County.[274] Roher Springs flows into Mill Creek and is itself fed by the Carrizo Aquifer.[275]

When none of the local landowners would agree to lease their property, Ozarka leased the property of a resident of Dallas's Highland Park neighborhood. The resident was also an absentee landowner in Henderson County.[276] Although Ozarka had originally planned to begin operation in the fall of 1995, it postponed doing so for 6 months due to local outrage from Henderson County residents[277] (Figure 8). Ozarka eventually began operating its pumping substation in March 1996.[278]

Bart Sipriano owned a 44-acre tract across the road from the parcel leased by Ozarka[279] (Figure 9). Since 1976, Sipriano had relied upon a 24-foot-deep, 100-year-old well, which

[266] Texas Water Code § 36.0015.

[267] *Sipriano v. Great Spring Waters of Am., Inc.*, 1 S.W.3d 75, 79–80 (Tex. 1999) (citing Texas Water Code §§ 36.113, 36.122).

[268] *Id.* at 80.

[269] *Id.* (citing Texas Water Code §§ 35.008, 35.018).

[270] *Id.* (citing Texas Water Code §§ 11.134, 11.151, 16.053, 36.1071–.1073).

[271] The unflinching concurrence by then-Justice Nathan L. Hecht, joined by Justice Harriet O'Neill, methodically listed the Justices' concerns with the rule of capture. *Sipriano*, 1 S.W.3d at 81–83 (Hecht, J., concurring, joined by O'Neill, J.); *see also Fact or Fiction* at 1-2, in UTCLE, Texas Water Law Institute (citing Corwin W. Johnson, *The Continuing Voids in Texas Groundwater Law: Are Concepts and Terminology to Blame?*, 17 St. Mary's Law Journal 1281, 1288–93 (1986)).

[272] Dylan O. Drummond, *Texas Groundwater Rights and Immunities: From* East *to* Sipriano *and Beyond*, *in* 115th Texas State Historical Association Annual Meeting(2011) (Joint Session with the Texas Supreme Court Historical Society, presented alongside Hon. Nathan L. Hecht and Prof. Megan Benson) [hereinafter East *to* Sipriano].

[273] *Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 827 (Tex. 2012).

[274] Carol Countryman, *Bottleneck*, Texas Monthly, August 1995, at 56, 57–58 [hereinafter *Bottleneck*].

[275] *Id.* at 57; Stuart Eskenazi, *The Biggest Pump Wins*, Dallas Observer, Nov. 19, 1998, *available at* http://www.dallasobserver.com/1998-11-19/news/the-biggest-pump-wins/ (last visited Mar. 1, 2013) [hereinafter *Biggest Pump Wins*].

[276] *Bottleneck*, at 57.

[277] *Biggest Pump Wins.*

[278] *Fain v. Great Spring Waters of Am., Inc.*, 973 S.W.2d 327, 328 (Tex. App.—Tyler 1998), *aff'd sub nom.* 1 S.W.3d 75.

[279] *Biggest Pump Wins.*

Figure 10. Harold Fain checks his 37-foot well near the Ozarka tract. *Biggest Pump Wins* (photograph by Mark Graham).

Figure 11. Ozarka's pumping substation in Henderson County, Texas. *Biggest Pump Wins* (photograph by Mark Graham).

he recollected had always had at least 7 or 8 feet of water in it.[280] Four days after Ozarka's facility began operations, Sipriano's well went nearly—if not completely—dry.[281] Similarly, Harold Fain—who was a retired Southwestern Bell employee and onetime black-eyed pea farmer[282]— and his wife, Doris, also lived on land nearby the Ozarka tract[283] (Figure 10). The Fains' 37-foot-deep well dropped 5 feet just days after Ozarka began pumping.[284]

Ozarka's operation itself utilized 2 pumps drilled around 80 feet deep, which together pumped some 90,000[285] to 110,000[286] gallons per day.[287] Once brought to the surface, Ozarka stored the water in twin tanks, each holding some 20,000 gallons of water[288] (Figure 11). Ozarka estimated it invested around $500,000 in constructing and developing the Henderson County facility.[289]

Trial Court proceedings

Soon after Ozarka began operation in March 1996,[290] the Fains, along with Sipriano, sought injunctive relief against Ozarka, as well as actual and punitive damages for Ozarka's alleged nuisance, negligence, gross negligence, and malice.[291] Although Ozarka disputed whether its pumping operation, in fact, affected Sipriano or the Fains' wells,[292] Ozarka moved to summarily dismiss the landowners' claims purely on legal grounds under the rule of capture and absolute ownership as failing to state a claim.[293] In their response, the landowners asserted their claims did indeed fall within the recognized exceptions to the rule of capture (negligent subsidence, waste, or malice),[294] but they failed to identify which exception specifically applied or introduce any sufficient evidence supporting any exception.[295]

Instead, they generally cited to *Friendswood*, which recognized the negligent subsidence exception to the rule of capture, as support for their contention that it was time to overrule absolute ownership and the rule of capture.[296] Accordingly, the trial court granted summary judgment in Ozarka's favor 2 days before Christmas 1996, and the landowners timely appealed.[297]

Review by the Tyler Court of Appeals

Before the Tyler Court of Appeals, Sipriano and the Fains put forward 2 points of error: (1) that the prayer in their live pleadings asserting Ozarka acted maliciously, when liberally construed, showed a genuine issue of material fact as a matter of law sufficient to defeat Ozarka's summary judgment;[298] and (2) the "absolute ownership rule should be overruled as antiquated

[280] *Id.*

[281] *See Fain*, 973 S.W.2d at 328; *Biggest Pump Wins*.

[282] *Biggest Pump Wins*. Nearby Athens, Texas is the self-proclaimed "Black-Eyed Pea Capitol of the World." City of Athens, Welcome to the City of Athens, http://athenstexas.us/ (last visited Mar. 2, 2013).

[283] *Biggest Pump Wins*.

[284] *See Fain*, 973 S.W.2d at 328; *Biggest Pump Wins*.

[285] *Sipriano v. Great Spring Waters of Am., Inc.*, 1 S.W.3d 75, 75–76 (Tex. 1999).

[286] *Biggest Pump Wins*.

[287] *Sipriano*, 1 S.W.3d at 76.

[288] *Bottleneck*, at 57 (stating that each tank could hold approximately 20,000 gallons of water); *Biggest Pump Wins* (stating that, "together, [the 2 tanks] can hold as much as 50,000 gallons of water").

[289] *Bottleneck*, at 58.

[290] *See Bottleneck*, at 58 (as of July 5, 1996, when Ozarka held a town meeting to discuss its pumping facility, no lawsuit had apparently yet been filed).

[291] *Sipriano*, 1 S.W.3d at 76; TAMES, Twelfth Court of Appeals, Case # 12-97-00044-CV, Case Events, http://www.search.txcourts.gov/Case.aspx?cn=12-97-00044-CV (last visited Mar. 2, 2013) (noting the trial court returned judgment in December 1996) [hereinafter *Fain* Case Events].

[292] *Compare Biggest Pump Wins* (relating that a Texas Water Development Board geologist asserted test wells that were located 600 to 700 feet away from Ozarka's boreholes and some 2,000 feet closer than Sipriano's well "showed no appreciable signs of change while pumping was going on."), *with Bottleneck*, at 58 (reporting that, in order to alleviate local concerns, Ozarka ceased pumping during August 1996, which was the driest month of the year) and *Biggest Pump Wins* (Sipriano alleged the only time water returned to his well was during this 1-month pumping hiatus).

[293] *Compare Fain*, 973 S.W.2d at 328, *with Sipriano*, 1 S.W.3d at 76.

[294] *Sipriano*, 1 S.W.3d at 76, 78.

[295] *Fain*, 973 S.W.2d at 329.

[296] *Id.*; *Sipriano*, 1 S.W.3d at 76. It is interesting that—in adjudging the same case on the same facts—the intermediate appellate court opinion in *Fain* does not mention the rule of capture once, instead referring only to absolute ownership, but the Texas Supreme Court's opinion in *Sipriano* only discusses the rule of capture, but never mentions absolute ownership. *Compare Fain*, 973 S.W.2d at 328–30, *with Sipriano*, 1 S.W.3d at 76–80.

[297] *See Fain*, 973 S.W.2d at 328–29; *Fain* Case Events (noting the trial court returned judgment on December 23, 1996).

[298] *Fain*, 973 S.W.2d at 329.

and violative of public policy."[299] In January 1998,[300] the appellate court affirmed the trial court's summary judgment on both grounds, finding first that the landowners' response had been too nebulously pled to show that a genuine issue of material fact existed sufficient to prevent the issuance of the trial court's summary judgment.[301] Second, the Tyler Court also rejected the landowners' oblique assault on the doctrine of absolute ownership, proposing that, "for so well-settled law as the absolute ownership rule, we conclude that it would be more appropriate for the [L]egislature or the Texas Supreme Court to fashion a new rule if it should be more attuned to the demands of modern society."[302]

The Texas Supreme Court's opinion

The majority opinion

Between the issuance of the Tyler Court of Appeals's judgment and their petition to the Texas Supreme Court, the Fains and Sipriano waived their claim that they sufficiently pled an exception to the rule of capture and instead relied solely upon their policy argument that the rule of capture should be abandoned entirely.[303]

Sipriano's actual holding was unremarkable in that it reaffirmed the state's century-long adherence to the rule of capture.[304] Writing for the majority, Justice Craig Trively Enoch[305] again explained the application of the rule of capture in Texas:

> The rule of capture answers the question of what remedies, if any, a neighbor has against a landowner based on the landowner's use of the water under the landowner's land. Essentially, the rule provides that, absent malice or willful waste, landowners have the right to take all the water they can capture under their land and do with it what they please, and they will not be liable to neighbors even if in so doing they deprive their neighbors of the water's use.[306]

The Court also reiterated that the rule of capture[307] was "not unfettered," because, while it may preclude a plaintiff's suit, it cannot escape legislative regulation pursuant to the Conservation Amendment.[308]

As the Court confirmed nearly 15 years later, no issue regarding the ownership of groundwater in place was presented in *Sipriano*.[309]

Justice Hecht's concurrence

Perhaps almost more intriguing than the governing holdings of the majority opinion was the strident concurrence by then-Justice Nathan L. Hecht (contemporaneously referred to as "Justice" in the remainder of this article),[310] joined by Justice Harriet O'Neil,[311] which "had the dulcet tones of a dissent" and unequivocally announced the Justices' dissatisfaction with the rule of capture.[312]

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[299] *Id.*

[300] *Id.* at 330 (noting the appellate court issued its opinion on Jan. 29, 1998).

[301] *Id.* at 329.

[302] *Id.* at 329–30.

[303] *Sipriano v. Great Spring Waters of Am., Inc.*, 1 S.W.3d 75, 76 (Tex. 1999).

[304] *See id.* at 80–81.

[305] Justice Enoch sat on the Court for a decade from 1993 to 2003. SCOTX Narrative History at 252.

At the beginning of the author's legal career, it was his privilege to practice with Justice Enoch at Winstead PC in Austin, Texas. *See Still So Misunderstood*, 37 Texas Tech Law Review at 1 n*.

[306] *Sipriano*, 1 S.W.3d at 76; *see Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 827–28 (Tex. 2012).

[307] One other aspect of *Sipriano* worth noting is that it translated the axiom long used to described the rule as capture, *damnum absque injuria,* to mean "an injury without a remedy." *Id.* However, *damnum absque injuria* actually translates to mean "damage without injury." *See*, *e.g.*, *Acton v. Blundell*, 152 Eng. Rep. 1223, 1230 (1843); *Fact or Fiction* at 16–17, in UTCLE, Texas Water Law Institute. The distinction, although admittedly obscure, is material because the rule of capture does not even recognize that an injury can be inflicted on a neighboring landowner resulting from withdrawal of groundwater absent malice, waste, or negligent subsidence. *Fact or Fiction* at 16–17, in UTCLE, Texas Water Law Institute. Instead, while a "neighboring landowner may be *damaged* by an overlying landowner's withdrawal of groundwater, . . . such resulting damage cannot form the basis of a compensable *injury*." *Id.*

[308] *Sipriano*, 1 S.W.3d at 79 (recalling that the *East* Court also anticipated legislative involvement in groundwater regulation, clarifying the rule of capture's operation "[i]n the absence . . . of positive authorized legislation" (quoting *Houston & Texas Central Railroad Co. v. East*, 98 Tex. 146, 149, 81 S.W. 279, 280 (1904)); *see Day*, 369 S.W.3d at 828, 828 n.70.

[309] *See Day*, 369 S.W.3d at 828.

[310] Chief Justice Hecht was appointed Chief Justice on October 1, 2013, after first being elected to the Court in 1988. *See* SCOTX Narrative History at 250. As of January 2014, Chief Justice Hecht now holds the record as the longest-serving Justice in the Court's history. On November 4, 2014, he was re-elected to the Court for a record sixth time, making him also the most-elected Justice on Court history (1988, 1994, 2000, 2006, 2012, 2014). *See id.* at 250.

It was the author's great honor to clerk for then-Justice Hecht during the Court's 2003–04 term. *See Still So Misunderstood*, 37 Texas Tech Law Review at 1 n*.

[311] Justice O'Neill served the Court for over a decade from 1999 to 2010. SCOTX Narrative History at 246.

[312] *Sipriano*, 1 S.W.3d at 81–83 (Hecht, J., concurring, joined by O'Neill, J.).

The concurrence was an unvarnished and comprehensive frontal assault on both the practical effects and theoretical foundation of the rule of capture.[313] Justice Hecht began by dryly observing that, despite 50 years having elapsed since the GCDA was passed in 1949, "[n]ot much groundwater management is going on."[314]

Making abundantly clear what he viewed as the cause of the stagnation in groundwater law, Justice Hecht surmised, "[w]hat really hampers groundwater management is the established alternative, the common law rule of capture."[315] As support for his contention, Justice Hecht reasoned that neither of the original 2 justifications that the *East* Court relied upon in adopting the rule of capture were still valid:[316]

> (1) Because the existence, origin, movement, and course of such waters, and the causes which govern and direct their movements, are so secret, occult, and concealed that an attempt to administer any set of legal rules in respect to them would be involved in hopeless uncertainty, and would, therefore, be practically impossible[; and]
>
> (2) Because any such recognition of correlative rights would interfere, to the material detriment of the commonwealth, with drainage and agriculture, mining, the construction of highways and railroads, with sanitary regulations, building, and the general progress of improvement in works of embellishment and utility.[317]

Justice Hecht continued, explaining "it is not regulation that threatens progress, but the lack of it."[318] Unimpressed with the similar arguments of the 19 some-odd amici curiae in favor of retaining the rule of capture that has been settled law in Texas for "a long time," Justice Hecht offered Justice Holmes's observance that:

> It is revolting to have no better reason for a rule of law than that so it was laid down in the time of Henry IV. It is still more revolting if the grounds upon which it was laid down have vanished long since, and the rule simply persists from blind imitation of the past.[319]

Finally, returning to the Legislative Branch's constitutionally delegated power to manage water resources, Justice Hecht went as far as to suggest that, "even if the Court abandoned the rule of capture as part of the common law, the Legislature could adopt the rule by statute. . . ."[320] Only because Justice Hecht assumed the 75th Legislature's comprehensive rewrite of the Water Code just 2 years before would "make the rule of capture obsolete," he cautioned that, "for now—but I think only for now—*East* should not be overruled."[321]

Of note, in *Day*, Justice Hecht framed his concurrence in *Sipriano* as expressing the "concern that with no common law liability for a landowner's unlimited pumping, legislators had inadequately provided for the protection of groundwater supplies."[322]

Guitar Holding Co. v. Hudspeth Cnty. Underground Water Conservation Dist. (2008)

In *Guitar Holding Co. v. Hudspeth County Underground Water Conservation Distric*t, the Court examined and rejected the contention that a groundwater conservation district's discretion in preserving "historic or existing use" was limited to the amount of water permitted.[323]

Guitar Holding Co. was one of the largest landowners in Hudspeth County but had irrigated only a small portion of its land during an historical period specified by the Hudspeth County Underground Water Conservation District (HCUWCD).[324] When the HCUWCD's rules requiring a groundwater

[313] *Id.*

[314] *Id.* at 81 (noting the creation of only some 42 groundwater conservation districts in that time).

[315] *Id.*

[316] *Id.* at 82. While Justice Williams did acknowledge the 2 policy arguments originally postulated by the Ohio Supreme Court in *Frazier v. Brown*, 12 Ohio St. 294, 311 (1861), they were arguably not the only 2 justifications for the Court's decision in *East*. *See Houston & Tex. Cent. Ry. Co. v. East*, 98 Tex. 146, 149–50, 81 S.W. 279, 280–81 (1904) (quoting Marcellus's *responsum* from *Acton* and repeatedly citing to *Acton* as justification for the adoption of the rule of capture and absolute ownership).

[317] *Sipriano*, 1 S.W.3d at 82 (Hecht, J., concurring, joined by O'Neill, J.) (quoting *East*, 98 Tex. at 149, 81 S.W. at 281 (quoting *Frazier*, 12 Ohio St. at 311)).

[318] *Id.*

[319] *Id.* (quoting *Path of the Law*, 10 Harvard Law Review at 469). While no one would credibly quibble with Justice Holmes on this point, Justice Hecht perhaps too broadly framed the amicis' concern. Indeed, one of the oldest tenets in Texas jurisprudence is that, "where a decision has been made, adhered to and followed for a series of years, it will not be disturbed, except on the most cogent reasons, and it must be shown in such case that the former decisions are clearly erroneous; and, where property rights are shown to have grown up under the decision, the rule will rarely be changed for any reason." *Groesbeck v. Golden*, 7 S.W. 362, 365 (Tex. 1887); *see also*, *e.g.*, *McLendon v. City of Houston*, 153 Tex. 318, 322–23, 267 S.W.2d 805, 807 (1954) ("The law should be settled, so far as possible, especially where contract rights and rules of property have been fixed."). Here, the concern of many observers was that, regardless of the original reasoning or wisdom of the *East* Court in adopting the rule of capture and giving heed to ownership in place, over a century of property rights had by then "grown up" and become "fixed" under the decision.

[320] *Sipriano*, 1 S.W.3d at 82 (Hecht, J., concurring, joined by O'Neill, J.).

[321] *Id.* (referring to Senate Bill 1's passage during the 75th Legislative Session 2 years before in 1997).

[322] *Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 828 (Tex. 2012).

[323] 263 S.W.3d 910, 916 (Tex. 2008).

[324] *Id.* at 914–15.

permit amount to be based on the applicant's use of water for irrigation during this historical period took effect, Guitar Holding's permits were limited in amount compared to others who had irrigated more extensively.[325]

Because a market for transporting water for consumption outside the HCUWCD had developed and landowners were interested in turning from irrigation to selling water in the new market, Guitar Holding complained that the rules preserved only historical amounts, not historical use.[326] But the Court disagreed, explaining that "use" under Chapter 36 of the Water Code included purpose as well as amount:

> [T]he amount of groundwater withdrawn and its purpose are both relevant when identifying an existing or historic use to be preserved. Indeed, in the context of regulating the production of groundwater while preserving an existing use, it is difficult to reconcile how the 2 might be separated. . . . [B]oth the amount of water to be used and its purpose are normal terms of a groundwater production permit and are likewise a part of any permit intended to "preserve historic or existing use." A district's discretion to preserve historic or existing use is accordingly tied both to the amount and purpose of the prior use.[327]

Coastal Oil & Gas Corp. v. Garza Energy Trust (2008)

Another oil and gas case to presage the progression of Texas groundwater law was the Court's 2008 opinion in *Coastal Oil & Gas Corp. v. Garza Energy Trust*.[328]

This case was of critical importance to the thriving shale oil and gas industry in Texas because at stake was whether damages caused by "fracing"[329] were precluded by the rule of capture.[330]

Writing for the majority, Justice Hecht held they were.[331] Of import to Texas groundwater law was that the Court appeared to formally announce the demise of the concept of absolute ownership—at least in oil and gas cases.[332] Relying upon precedent from the U.S. Supreme Court, Justice Hecht held that the Latin axiom that long has undergirded the concept of absolute ownership, *cujus est solum ejus est usque ad coelum et ad infernos*,[333] (meaning "[w]hoever owns the soil owns everything up to the sky and down to the depths")[334] "'has no place in the modern world.'"[335] The Court continued, explaining that the "minerals owner is entitled, not to the molecules actually residing below the surface, but to 'a fair chance to recover the oil and gas in or under his land, or their equivalents in kind.'"[336] In *Day*, a unanimous Court expressly applied this concept to groundwater as well.[337]

The *Coastal Oil* Court then concluded that "the rule of capture determines title to gas that drains from property owned by one person onto property owned by another. It says nothing about the ownership of gas that has remained in place."[338]

Senate Bill 332 (2011)

For the first time since Senate Bill 1 was passed 14 years earlier—and arguably since the GCDA was enacted more than 60 years before—the Texas Legislature made substantive changes to the groundwater ownership provision in the Water Code.[339]

Having seen the juristic writing on the wall after *Sipriano*

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[325] *Day*, 369 S.W.3d at 841.

[326] *Guitar Holding*, 263 S.W.3d at 916; Day, 369 S.W.3d at 841.

[327] *Guitar Holding, 263 S.W.3*d at *916; see also Day*, 369 S.W.3d at 841.

[328] 268 S.W.3d 1 (Tex. 2008).

[329] "Fracing" is shorthand for hydraulic fracturing, whereby fractures are propagated in a rock layer by the injection of a pressurized fluid. *See* East *to* Sipriano, at 28–29.

[330] *Coastal Oil*, 286 S.W.3d at 17.

[331] *Id.*

[332] *Id.* at 11.

[333] This maxim first appeared in Texas common law in the case of *Williams v. Jenkins*, 25 Tex. 279, 286 (1860). The opinion's author, Justice Oran Milo Roberts, served as an Associate Justice of the Court from his initial election in 1857 until he resigned in 1862 to fight in the Civil War. SCOTX Narrative History at 237. He returned to bench, this time as Chief Justice after his election to the post in 1864, until he was removed from office with the advent of Reconstruction. *Id.* at 236. He was elected as one of Texas's 2 U.S. Senators in 1866 but was never seated due to Reconstruction. *Id.* at 77, 88.

He was subsequently appointed to his former seat as Chief Justice in 1874 and would serve as Chief of the "Redeemer Court"—so called because it followed the much-maligned "Military Court" that sat from 1867 to 1870, and which operated with no Texas Constitutional basis causing its decisions to lack precedential weight under the rule of stare decisis. *See* Jim Paulsen & James Hambleton, *Confederates and Carpetbaggers: The Precedential Value of Decisions from the Civil War and Reconstruction Era*, 51 Texas Business Journal 916, 917–20 (October 1988).

After he learned of his Democratic nomination for governor in July 1878, Chief Roberts resigned from the Court to successfully run for governor. *Id.* at 95, 239.

[334] Black's Law Dictionary 1712 (8th ed. 2004).

[335] *Coastal Oil*, 286 S.W.3d at 11, 11 n.30 (quoting *United States v. Causby*, 328 U.S. 256, 260–61 (1946)).

[336] *Id.* at 15; *see Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 830 (Tex. 2012).

[337] *Day*, 369 S.W.3d at 830 ("[b]ecause a landowner is not entitled to any specific molecules of groundwater or even to any specific amount . . .").

[338] *Coastal Oil*, 286 S.W.3d at 14.

[339] Act of May 29, 2011, 82nd Leg., R.S., ch. 1207, 2011 Texas General Laws 3224 (codified at Texas Water Code §§ 36.002, 36.101)..

and *Coastal Oil*,[340] Senator Troy Fraser introduced Senate Bill 332 during the opening days of the 82nd Session in January 2011.[341]

Prior to the 82nd Session and virtually since 1945,[342] section 36.002 governing the "Ownership of Groundwater" contained the noncommittal bromide that:

> The ownership and rights of the owner of the land and their lessees and assigns in groundwater are hereby recognized, and nothing in this code shall be construed as depriving or divesting the owners or their lessees and assigns of the ownership or rights, except as those rights may be limited or altered by rules promulgated by a district. . . . [343]

This construction, of course, substantively meant next to nothing because precisely what were the "ownership and rights of the owner of the land" was not defined and a matter of intense dispute. Specifically, the crux of the disagreement centered around whether a property right in groundwater vests only upon capture—that is, when it is "actually reduced to possession"[344]—or vests while in place beneath a surface owner's real property.[345]

So into this fray, Senate Bill 332 was introduced to provide more certainty for Texas landowners regarding exactly what property interest they possess in the groundwater beneath their land.[346] To this end, the introduced version of Senate Bill 332 proclaimed that a Texas "landowner . . . has a vested ownership interest in and right to produce groundwater below the surface of the landowner's real property."[347]

By the end of the 82nd Session, the ownership pronouncement in subsection (a) was modified to provide: "The Legislature recognizes that a landowner owns the groundwater beneath the surface of the landowner's land as real property."[348]

In its final form, Senate Bill 332's ownership provisions were somewhat moderated by balancing language added to allay fears that Senate Bill 332 would greatly restrict the ability of groundwater conservation districts to fulfill their statutory duties to regulate groundwater production. Making clear the nature of ownership interest identified in subsection (a) of section 36.002 is not absolute, subsections (d) and (e) were added:

> (d) This section does not:
>
> (1) prohibit a district from limiting or prohibiting the drilling of a well by a landowner for failure or inability to comply with minimum well spacing or tract size requirements adopted by the district;
>
> (2) affect the ability of a district to regulate groundwater production as authorized under Section 36.113, 36.116, or 36.122 or otherwise under this chapter or a special law governing a district; or
>
> (3) require that a rule adopted by a district allocate to each landowner a proportionate share of available groundwater for production from the aquifer based on the number of acres owned by the landowner.[349]
>
> (e) This section does not affect the ability to regulate groundwater in any manner authorized [for the Edwards Aquifer Authority, the Harris-Galveston Subsidence District, and the Fort Bend Subsidence District].[350]

This balancing of interests was exemplified in the changes made to section 36.101.[351] The original version of the section that existed prior to 2011, which governs the rulemaking power of groundwater conservation districts, did not expressly require the consideration of overlying landowners' ownership interests in the groundwater beneath their land (whatever those were under former section 36.002's nebulous "recognition" of same). The revised version of section 36.101 now requires a groundwater district to consider not only the "groundwater ownership and rights described by Section 36.002," but also "consider the public interest in conservation, preservation, protection, recharging, and prevention of waste of groundwater, and of groundwater reservoirs or their subdivisions, and

[340] Senate Research Center, Bill Analysis, S.B. 332, 82nd Leg., R.S. (1022) (introduced version), *available at* http://www.capitol.state.tx.us/tlodocs/82R/analysis/pdf/SB00332I.pdf#navpanes=0 (last visited Mar. 3, 2013) ("Recently, landowners' interest in groundwater below the surface has come into question in the courts.") [hereinafter S.B. 332 Introduced Version Bill Analysis].

[341] Texas Legislature Online, Actions, SB 332, 82(R), http://www.capitol.state.tx.us/BillLookup/Actions.aspx?LegSess=82R&Bill=SB332 (last visited Mar. 3, 2013).

[342] GCDA at § 1, 1949 Texas General Laws at 562.

[343] Texas Water Code § 36.002, *amended by* Act of May 29, 2011, 82nd Leg., R.S., ch. 1207, 2011 Texas General Laws 3224.

[344] *See Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 837 (Tex. 2012).

[345] S.B. Introduced Version Bill Analysis ("The argument being made by some GCDs is that the landowner does not have an interest in the water below the surface until they capture it."); *Fact or Fiction* at 10, in UTCLE, Texas Water Law Institute.

[346] Introduced Version Bill Analysis ("This bill clearly defines that a property owner has a vested ownership interest in, and the right to produce, the groundwater below the surface of their property.").

[347] Texas Legislature Online, Text, SB 332, 82(R) (introduced version), http://www.capitol.state.tx.us/tlodocs/82R/billtext/pdf/SB00332I.pdf#navpanes=0 (last visited Mar. 3, 2013).

[348] Texas Water Code § 36.002(a).

[349] *Id.* § 36.002(d).

[350] *Id.* § 36.002(e).

[351] Texas Legislature Online, Text, SB 332, 82(R) (enrolled version), http://www.capitol.state.tx.us/tlodocs/82R/billtext/pdf/SB00332F.pdf#navpanes=0 (last visited Mar. 3, 2013) [hereinafter S.B. 332 Enrolled Version Comparison].

in controlling subsidence caused by withdrawal of groundwater from those groundwater reservoirs or their subdivisions, consistent with the objectives of Section 59, Article XVI, Texas Constitution" and "consider the goals developed as part of the district's management plan under Section 36.101."[352]

Overall, the changes to Texas groundwater ownership wrought by Senate Bill 332 are substantial. Previously, the Water Code recognized that Texas landowners owned some vague interest in groundwater but provided no guidance as to what that interest actually was.[353] Now, expressly and unequivocally, the Water Code "recognizes that a landowner owns the groundwater beneath the surface of the landowner's land as real property."[354]

Edwards Aquifer Auth. v. *Day* (2012)

The climate leading up to Day

The anticipation and anxiety leading up the Court's issuance of *Day* was at a fever pitch.

During the intervening 13 years since *Sipriano* was decided, issues surrounding Texas groundwater production and supply had only grown more acute. Frustration set in amongst the groundwater law bar because, after *Sipriano*, several cases seemed poised to carry the mantle of the "next big groundwater case," but all either failed to reach review by the Court or were decided on other grounds.[355]

When *Day* finally reached the Court, some 24 amici filed briefs in the case both before and after review was granted[356]—at the time the most of any case then pending before the Court.[357] In addition, the one Justice from *Sipriano* who had most vociferously seemed to oppose the policy underpinnings and operation of the rule of capture—Justice Hecht—was the only Justice from that decision still serving on the Court.[358] Justice Hecht was also the author of 2008's *Coastal Oil*, in which the conceptual foundation of absolute ownership was dismissed as outdated and irrelevant.[359] Into this mix and after the Court requested merits briefing in *Day* in January 2010,[360] the Legislature's substantial rewrite of Water Code section 36.002 in Senate Bill 332 to explicitly recognize the ownership of groundwater in place greatly altered the statutory landscape the Court would be called upon to construe and seemed to provide the very guidance the Court had long sought from its sister branch of government.

Factual and procedural background

In 1994, Robert Burrell Day[361] and Joel McDaniel purchased some 380 acres overlying the Edwards Aquifer[362] on which to raise oats and peanuts and graze cattle[363] (Figure 12). The casing of a well originally drilled on the property in 1956 that had been used for irrigation until the early 1970s eventually collapsed, and its pump was subsequently removed sometime prior to 1983.[364] Even after the removal of its pump, the well continued to flow under artesian pressure, with most of the water flowing along a ditch several hundred yards into a 50-acre lake on the property.[365] To continue to use the existing well or drill a replacement well as Burrell and Day planned, they were required to obtain a permit from the EAA, which was created

[352] Texas Water Code § 36.101(a)(3)–(5).

[353] Texas Water Code § 36.002, *amended by* Act of May 29, 2011, 82nd Leg., R.S., ch. 1207, 2011 Texas General Laws 3224.

[354] Texas Water Code § 36.002(a).

[355] *See, e.g., Guitar Holding Co. v. Hudspeth Cnty. Underground Water Conservation Dist.*, 263 S.W.3d 910 (Tex. 2008); *City of Del Rio v. Clayton Sam Colt Hamilton Trust,* 269 S.W.3d 613 (Tex. App.—San Antonio 2008, pet. denied).

[356] TAMES, Supreme Court of Texas, Case # 08-0964, Case Events, http://www.search.txcourts.gov/Case.aspx?cn=08-0964 (last visited Mar. 3, 2013) [hereinafter *Day* Events].

[357] *See* TAMES, Supreme Court of Texas, Case # 08-0964, Parties, http://www.search.txcourts.gov/Case.aspx?cn=08-0964 (last visited Mar. 3, 2013).

[358] East *to* Sipriano, at 25, 25 n.124.

[359] *Coastal Oil & Gas Corp. v. Garza Energy Trust*, 286 S.W.3d 1, 11 n.30 (Tex. 2008) (quoting *United States v. Causby*, 328 U.S. 256, 260–61 (1946)).

[360] *Day* Events.

[361] Day was reared on his family's ranch in Zavala County, Texas, which was "the only piece of land in Zavala County that never had a deed of trust" because his grandfather never borrowed money to buy it. Colleen Schreiber, *Stockman Burrell Day Got Start At San Antonio Union Stockyards*, Livestock Weekly, Sept. 4, 2003 (internet ed.), http://www.livestockweekly.com/papers/03/09/04/whlburrell.asp (last visited Mar. 3, 2013). His grandfather, Harry Holdsworth, was an orphan who came to Texas from England when he just 17 years old. *Id.*

Day's suit against the EAA was not his first brush with the judicial system. When he was 25, he ran for county judge of Zavala County, Texas but fell 25 votes shy. *Id.* Day would not live to see the result in his namesake case, passing away at the age of 72 on April 23, 2009 in San Antonio. Harley Funeral Home, Obituary for Robert Burrell Day, 4/13/1937–74/23/2009, *available at* http://www.hurleyfuneralhome.com/services.asp?page=odetail&id=572&locid= (last visited Mar. 3, 2013) [hereinafter Day Obituary].

[362] The Edwards Aquifer is "an underground layer of porous, water-bearing rock, 300–700 feet thick, and 5 to 40 miles wide at the surface, that stretches in an arced curve from Brackettville, 120 miles west of San Antonio, to Austin." *Edwards Aquifer Auth. v. Chem. Lime, Ltd.*, 291 S.W.3d 392, 394 (Tex. 2009).

[363] *Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 818 (Tex. 2012).

[364] *Id.*

[365] *Id.*

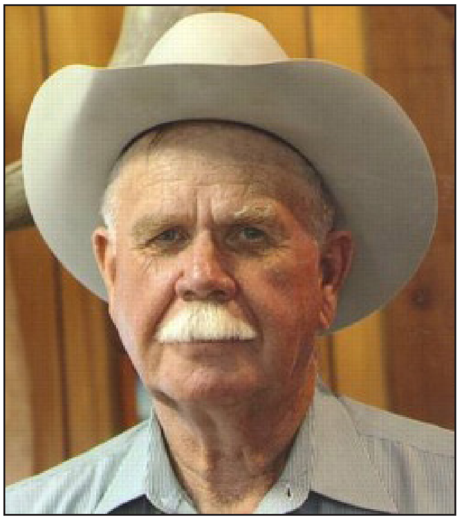

Figure 12. Lifelong stockman R. Burrell Day. Harley Funeral Home, Obituary For Robert Burrell Day, 4/13/1937-4/23/2009, available at http://www.hurleyfuneralhome.com/services.asp?page=odetail&id=572&-locid= (last visited March 3, 2013).

the year before they bought the property.[366]

Day and McDaniel sought a permit from the EAA to allow them to pump some 700 acre-feet of groundwater annually from the Edwards Aquifer to irrigate crops on their land.[367] After the EAA's general manager wrote Day and McDaniel stating that the EAA's staff had "preliminarily found" that their application "provide[d] sufficient convincing evidence to substantiate" the amount of irrigation they sought to provide, Day and McDaniel drilled a replacement well at a cost of $95,000.[368] Soon thereafter, the EAA notified Day and McDaniel that it was denying their application because the documented withdrawals from their well during the historical period were not put to a beneficial use.[369]

Day and McDaniel exhausted their administrative remedies against the EAA at the State Office of Administrative Hearings, after which the EAA agreed with the Administrative Law Judge's findings that the maximum beneficial use of groundwater shown by Day and McDaniel amounted to some 14 acre-feet annually.[370] Day and McDaniel appealed the EAA's decision to the district court, suing the EAA for taking their property without compensation under the Texas Constitution's Takings Clause contained in article I, section 17(a).[371] The district court subsequently granted summary judgment for the EAA on Day and McDaniel's takings claims.[372]

On appeal before the San Antonio Court of Appeals, the court relied upon its decision earlier that year in *City of Del Rio v. Clayton Sam Colt Hamilton Trust*, in which it held that "landowners have some ownership rights in the groundwater beneath their property."[373] Because they had "some ownership rights" in the groundwater, the court reasoned "they have a vested right therein."[374] The court concluded Day and McDaniel's "vested right in the groundwater beneath their property [wa]s entitled to constitutional protection."[375]

The Texas Supreme Court's opinion

In February 2012, the Court finally issued its long-awaited opinion in *Day*.[376] As suspected (and a little feared by ownership-in-place proponents), Justice Hecht was the opinion's author.[377] Surprising perhaps to most was that the opinion was unanimous.[378]

Common law analysis

At the outset, the Court laid out the question before it: "whether land ownership includes an interest in groundwater in place that cannot be taken for public use without adequate compensation guaranteed by article I, section 17(a) of the Texas Constitution."[379] After more than a century of debate and

[366] Act of May 30, 1993, 73rd Leg., R.S., ch. 626, 1993 Texas General Laws 2350; *see Day*, 369 S.W.3d at 818.

[367] *Edwards Aquifer Auth. v. Day*, 274 S.W.3d 742, 748 (Tex. App.—San Antonio 2008), *aff'd* 369 S.W.3d 814, 818 (Tex. 2012).

[368] *Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 820 (Tex. 2012).

[369] *Id.*

[370] *Id.* at 821.

[371] *Id.*; Article I, section 17(a) of the Texas Constitution is the state's Takings Clause, providing that "No person's property shall be taken, damaged, or destroyed for or applied to public use without adequate compensation being made . . ." Texas Constitution art. I, § 17(a).

[372] *Day*, 369 S.W.3d at 821.

[373] *Edwards Aquifer Auth. v. Day*, 274 S.W.3d 742, 756 (Tex. App.—San Antonio 2008), *aff'd* 369 S.W.3d 814, 818 (Tex. 2012) (citing *City of Del Rio v. Clayton Sam Colt Hamilton Trust*, 269 S.W.3d 613 (Tex. App.—San Antonio 2008, pet. denied)).

[374] *Id.*

[375] *Id.*

[376] *Day*, 369 S.W.3d at 814.

[377] *See id.* at 817.

[378] *See id.* The previous 3 major ownership-related groundwater law opinions issued by the Court all included separate writings. *See Sipriano v. Great Spring Waters of America, Inc.*, 1 S.W.3d 75, 81 (Tex. 1999) (Hecht, J., concurring, joined by O'Neill, J.); *Friendswood Dev. Co. v. Smith-S.W. Indus., Inc.*, 576 S.W.2d 21, 31 (Tex. 1978) (Pope, J., dissenting, joined by Johnson, J.); *City of Corpus Christi v. City of Pleasanton*, 154 Tex. 289, 297, 299, 276 S.W.2d 798, 804, 805 (1955) (Griffin, J., dissenting; Wilson, J., dissenting, joined by Culver, J.).

[379] *Day*, 369 S.W.3d at 817.

discord on this issue amongst the bar since *East* was decided, the Court held that it did.[380]

The Court was careful as well to clarify the distinction between the rule of capture and ownership in place. It reflected that, "while the rule of capture does not entail ownership of groundwater in place, neither does it preclude such ownership."[381] Therefore, the Court disagreed with the EAA that the rule of capture, "because it prohibits an action for drainage, is antithetical to such ownership."[382] To the contrary, it relied on its 2008 decision in *Coastal Oil*, in which it explained that the "rule of capture determines title to [natural] gas that drains from property owned by one person onto property owned by another," but "says nothing about the ownership of gas that has remained in place."[383] And for the first time, it confirmed that the same is true of groundwater.[384] Put another way, the Court explained that a "landowner is not entitled to any specific molecules of groundwater or even to any specific amount. . . ."[385]

In a detailed review of its long line of groundwater law decisions over the preceding 100 years, the Court reiterated that it had never addressed whether groundwater can be owned in place.[386]

It is not often that a Court distinguishes aspects of a decision it handed down more than a century before, but it did so in *Day* regarding its opinion in *East*.[387] The Court clarified that the "effect of our decision denying East a cause of action was to give the Railroad ownership of the water pumped from its well *at the surface*."[388] "No issue of ownership of groundwater *in place*," the Court continued, "was presented in *East*."[389] The Court elaborated that the Railroad escaped liability not because East owned in place the groundwater below his property, but "irrespective of whether he did."[390] The Court also sought to distinguish language it quoted in *East* from the New York Court of Appeals:

> "An owner of soil may divert percolating water, consume or cut it off, with impugnity. It is the same distinguished in law from land. So the owner of land is the absolute owner of the soil and of percolating water, which is a part of, and not different from, the soil. No action lies against the owner for interfering with or destroying percolating or circulating water under the earth's surface."[391]

Despite this passage perhaps sounding awfully close to recognizing ownership in place of groundwater,[392] the Court clarified that it "could have meant only that a landowner is the absolute owner of groundwater flowing at the surface from its well."[393]

Tacking its analysis toward finding that groundwater is indeed owned in place, the Court turned to its robust line of oil and gas decisions. It began by relying on Chief Justice Nelson Phillips's seminal explanation in 1915 of how the fugitive nature of fugacious substances, in and of itself, cannot operate to defeat their ownership in place.[394] The Court focused on its holding in *Daugherty* that a landowner's "right to oil and gas beneath his land is an exclusive and private property right . . . inhering in virtue of his proprietorship of the land, and of which he may not be deprived without a taking of private property."[395]

Concluding that no basis exists to treat groundwater differently from oil and gas, the Court observed that "*Daugherty* refutes the EAA's argument that the rule of capture precludes ownership in place."[396]

The decisive holding of *Day* was its recitation of the "law regarding ownership in place of oil and gas," which, for the first time, the Court confirmed "correctly states the common law regarding the ownership of groundwater in place":

> In our state the landowner is regarded as having absolute title in severalty to the [groundwater] in place beneath his land. The only qualification of that rule of ownership is that it must be considered in connection with the law of capture and is subject to police regulations. The [groundwater] beneath the soil are considered a part of the realty. Each owner of land owns separately, distinctly and exclusively all the [groundwater] under his land and is accorded the usual remedies

[380] *Id.*

[381] *Id.* at 828.

[382] *Id.* at 823.

[383] *Id.* at 829 (quoting *Coastal Oil & Gas Corp. v. Garza Energy Trust*, 286 S.W.3d 1, 14 (Tex. 2008)).

[384] *Id.*

[385] *Id.* at 830.

[386] *Id.* at 823, 826.

[387] *Id.* at 826.

[388] *Id.*

[389] *Id.*

[390] *Id.*

[391] *Houston & Tex. Cent. Ry. Co. v. East*, 98 Tex. 146, 150, 81 S.W. 279, 281 (1904) (quoting *Pixley v. Clark*, 35 N.Y. 520, 527 (1866)).

[392] *Fact or Fiction* at 9, in UTCLE, Texas Water Law Institute (the author regrettably providing a prime example of being jurisprudentially pwned by a unanimous court). "Pwned" is a modern term that connotes being dominated). Urban Dictionary, Pwned, http://www.urbandictionary.com/define.php?term=pwned (last visited Mar. 3, 2013).

[393] *Day*, 369 S.W.3d at 826.

[394] *Id.* at 829 (quoting *Tex. Co. v. Daugherty*, 107 Tex. 226, 231–36, 239–41, 176 S.W. 717, 718–20, 722 (1915)).

[395] *Id.* (quoting *Daugherty*, 107 Tex. at 237, 176 S.W. at 720).

[396] *Id.*

against trespassers who appropriate the [groundwater] or destroy [its] market value.[397]

Statutory analysis

The Court next acknowledged the Legislature's recognition the year before that a landowner owns as real property the groundwater beneath the surface of her land.[398] However, it noted that subsection (c)—which was largely carried over from the previous version of section 36.002[399] and provides that "[n]othing in this code shall be construed as granting the authority to deprive or divest a landowner . . . of the groundwater ownership and rights described this section"[400]—was in apparent conflict with subsection (e)—which allows that this "section does not affect the ability to regulate groundwater in any manner authorized for" 3 enumerated groundwater districts, including the EAA.[401] The Court resolved the tension between the 2 provisions by concluding that the terms, "deprive" and "divest" in subsection (c) do not encompass a "taking of property rights for which adequate compensation is constitutionally guaranteed."[402]

Constitutional analysis

For the first time in nearly 110 years, the Court recognized that "landowners do have a constitutionally compensable interest in groundwater,"[403] and concluded that the district court's grant of summary judgment in favor of the EAA was not constitutionally supported.[404]

Beginning its analysis regarding whether the EAA effected a taking of Day and McDaniel's vested property right to the groundwater beneath their land, the Court relied on its earlier decision in *Sheffield Development Co. v. City of Glenn Heights* in deferring to the U.S. Supreme Court's long line of takings jurisprudence.[405] While the Court clarified that a *Loretto* physical invasion of property was not at issue in *Day*, the Court posed the "interesting question" of whether regulations depriving an overlying "landowner of all access to groundwater—confiscating it, in effect—would fall into" the *Loretto* takings category.[406] The Court concluded that the summary-judgment record before it was inconclusive as to whether a *Lucas* category of deprivation of all economically beneficial use of property was implicated by the EAA's actions.[407] While allowing that the EAA's regulations had made it "much more expensive, if not impossible, to raise crops and graze cattle" on Day and McDaniel's land that effected the landowners a "significant, negative impact," the Court expressed doubt that the EAA's actions had denied the landowners "*all* economically beneficial use" of the property.[408] The Court again noted the limitations in the record before it regarding whether the *Penn Central* factor considering a regulations interference with investment-backed expectations could be thoroughly analyzed.[409] Nonetheless, the Court observed that, while Day and McDaniel "should certainly have understood that the Edwards Aquifer could not supply [their] unlimited demands for water, we cannot say that [they] should necessarily have expected that [their] access to groundwater would be severely restricted."[410]

The Court focused the remainder of its analysis on the third *Penn Central* factor that examines the nature of the regulation itself.[411]

While the Court found no reason to treat differently the ownership in place of groundwater as compared to oil and gas, it did distinguish the difference between the 2 when it comes to the purpose of regulation of each.[412] Specifically, the Court reasoned that, because oil and gas cannot be replenished, "land[-]surface area is an important metric in determining an owner's fair share."[413] However, because the amount of groundwater beneath the surface is "constantly changing" due

[397] *Id.* at 831–32 (quoting *Elliff v. Texon Drilling Co.*, 146 Tex. 575, 580, 210 S.W.2d 558, 561 (1948) (internal citations omitted)).

[398] *Id.* at 842 (citing Texas Water Code § 36.002(a)).

[399] S.B. 332 Enrolled Version Comparison.

[400] *Day*, 369 S.W.3d at 842–43 (quoting and citing Texas Water Code § 36.002(c)).

[401] *Id.* (quoting and citing Texas Water Code § 36.002(e)).

[402] *Id.*

[403] *Id.* at 838.

[404] *Id.* at 843.

[405] 140 S.W.3d 660, 669–70 (Tex. 2004) (perhaps better (or also) known as the "Sophistic Miltonian Serbonian Bog" opinion, see 140 S.W.3d at 671). Therein, the Court reiterated that its takings analysis would follow the framework laid out by 3 landmark decisions of the U.S. Supreme Court. *Id.* at 838–39. Specifically, 2 categories of regulatory action exist that will generally be deemed *per se* takings: (1) where government requires an owner to suffer a permanent physical invasion of the owner's property (citing *Loretto v. Teleprompter Manhattan CATV Corp.*, 458 U.S. 419, 426 (1982)); and (2) regulations that completely deprive an owner of "*all* economically beneficial us[e]" of the owner's property (citing *Lucas v. S.C. Coastal Council*, 505 U.S. 1003, 1019 (1992)). *Id.* Absent regulatory action falling within these 2 categories, the Court recounted the 3 prongs of analysis first set forth in the U.S. Supreme Court's decision in *Penn Central Transportation Co. v. New York City*: (1) the economic impact on the claimant; (2) the interference of the regulation with investment-backed expectations; and (3) the nature of the regulation itself. *Id.* at 839–40 (citing *Penn Central Transp. Co. v. City of New York*, 438 U.S. 104, 124 (1978)).

[406] *Id.* at 839

[407] *Id.* at 839–40.

[408] *Id.* at 840.

[409] *Id.*

[410] *Id.*

[411] *Id.* at 840–43.

[412] *Compare id.* at 829, *with id.* at 840-41.

[413] *Id.* at 840.

to recharge via rainfall, drainage, surface water underflow or depletion due to drought, "regulation that affords an owner a fair share of subsurface water must take into account factors other than surface area."[414]

Not unlike Justice Maule nearly 170 years before, the Court distinguished the EAA's reliance on a riparian rights surface water case as support for its argument that basing the issuance of permits based on historical use was sound because it recognizes a landowner's investment in developing groundwater resources.[415] The key difference between the 2 regimes, the Court explained, was that the riparian rights governing surface water are usufructuary—giving their owner only a right of use—while groundwater is owned in place completely.[416] Therefore, "nonuse of groundwater conserves the resource," but nonuse of appropriated surface water is "'equivalent to waste.'"[417]

Neither was the Court impressed with the EAA's warning that allowing groundwater takings claims to proceed would be "nothing short of disastrous,"[418] noting that only 3 takings claims had been filed in the more than 15 years that the EAA had existed.[419] The Court continued, qualifying that, while "Chapter 36 allows districts to consider historical use in permitting groundwater production," it "does not limit consideration to such use."[420] A landowner, the Court held, "cannot be deprived of all beneficial use of the groundwater below his property merely because he did not use it during an historical period and supply is limited."[421] The resulting "requirement of compensation" for such a taking "may make the regulatory scheme more expensive, but it does not affect the regulations themselves or their goals for groundwater production."[422] The Court concluded that the "Takings Clause ensures that the problems of a limited public resource—the water supply—are shared by the public, not foisted onto a few. We cannot know, of course, the extent to which the EAA's fears will yet materialize, but the burden of the Takings Clause on government is no reason to excuse its applicability."[423]

The Court ultimately affirmed the judgment of the San Antonio Court of Appeals, which itself had reversed the summary dismissal of Day and McDaniel's claims on constitutional grounds and remanded the cause back to the trial court.[424] On remand, the EAA settled the dispute with Day and McDaniel, which prevented any substantive ruling on whether the EAA's actions effected any taking at all.

THE *DAY* AFTER TOMORROW

What is the state of Texas groundwater law after *Day* and S.B. 332?

It now seems clear that Texas landowners "own[] the groundwater below the surface of the[ir] . . . land as real property,"[425] and that such groundwater is owned in place.[426]

Ownership in place, however, appears to have been distinguished from the traditional concept of absolute ownership. In one fell swoop, the Court recast its holding from *East* that "the owner of land is the absolute owner of the soil and of percolating water"[427]—of which the Court later said "adopted the absolute ownership doctrine of underground percolating waters"[428]—as meaning "only that a landowner is the absolute owner of groundwater flowing at the surface from its well."[429] This holding from *Day*, in conjunction with *Coastal Oil*'s 2008 pronouncement that the concept underlying absolute ownership—that land ownership extends from the earth's center up to the sky above[430]—"'has no place in the modern world,'"[431] likely indicates merely that groundwater is owned in place beneath an overlying landowner's tract where it naturally occurs.[432]

The jurisprudential contours of the rule of capture as it relates to groundwater ownership have also now been identified more

[414] *Id.* at 841.

[415] *Compare id.*, *with Acton v. Blundell*, 152 Eng. Rep. 1223, 1226, 1228 (1843).

[416] *Day*, 369 S.W.3d at 842.

[417] *Id.* (quoting *In re Adjudication of the Water Rights of the Upper Guadalupe Segment of the Guadalupe River Basin*, 642 S.W.2d 438, 445 (Tex. 1982)).

[418] *Id.* at 843.

[419] *Id.*

[420] *Id.*

[421] *Id.*

[422] *Id.*

[423] *Id.* at 843–44.

[424] *Id.* at 817–18.

[425] Texas Water Code § 36.002(a).

[426] *Day*, 369 S.W.3d at 831–32.

[427] *Houston & Tex. Cent. Ry. Co. v. East*, 98 Tex. 146, 150, 81 S.W. 279, 281 (1904) (quoting *Pixley v. Clark*, 35 N.Y. 520, 527 (1866)).

[428] *Friendswood Dev. Co. v. Smith-S.W. Indus., Inc.*, 576 S.W.2d 21, 25 (Tex. 1978).

[429] *Day*, 369 S.W.3d at 826.

[430] Black's Law Dictionary 1712 (8th ed. 2004).

[431] *Coastal Oil & Gas Corp. v. Garza Energy Trust*, 286 S.W.3d 1, 11, 11 n.30 (quoting *United States v. Causby*, 328 U.S. 256, 260–61 (1946)).

[432] Because, outside of Jules Verne, water is not generally thought to occur at the center of the Earth. *See* Jules Verne, Journey to the Center of the Earth (Jenny Bak ed., Dover Publ'ns 2005) (1864).

clearly.[433] The *Day* Court confirmed that the "rule of capture determines title to [groundwater] that drains from property owned by one person onto property owned by another," but "says nothing about the ownership of [groundwater] that has remained in place."[434] The Court also added that the rule of capture, as announced in *East*, confers "ownership of . . . [ground]water . . . *at the surface*."[435]

Finally, the Court observed that, while groundwater resources are undoubtedly subject to regulation under the Texas Constitution's Conservation Amendment, such regulation is balanced against the Texas Constitution's Takings Clause, regardless of whether required compensation makes a given regulatory scheme more costly.[436]

What are the next seminal groundwater cases following behind *Day*?

As of the date of this publication, *Day* was handed down close to 3 years ago.[437] Since that time, only a handful of cases have cited to *Day*—still fewer of which did so in the majority opinion on the merits.[438] However, all the cases that have are now pending before the Texas Supreme Court.

FPL Farming (2012) and *Coyote Lake Ranch (2014)*

Just 7 months after the Texas Supreme Court issued its decision in *Day*, the Beaumont Court of Appeals relied upon the High Court's holding that overlying landowners own the groundwater beneath their tract in allowing a common law trespass claim to stand regarding briny water affected by the subsurface migration of the appellee's waste plume.[439] The Court granted for review in *FPL Farming Ltd. v. Environmental Processing Systems, L.C.*, on November 22, 2013, and the case was submitted to the Court after oral argument was heard on January 7, 2014.

The Court's grant of review in *FPL Farming* and its grant of oral argument strongly indicate that it has taken a keen interest in the subsurface trespass questions posed by the case.

During the summer of 2014 in its decision in *City of Lubbock v. Coyote Lake Ranch, LLC*, the Amarillo Court of Appeals examined whether the Texas Supreme Court's decision in *Day* should be extended to apply the accommodation doctrine[440] to severed interests in groundwater.[441] The Amarillo court declined to read *Day* to support such an extension of the accommodation doctrine, deferring instead to the High Court or the Legislature to enact such a far-reaching modification to the law.[442]

The Texas Supreme Court will have the chance to do just that as Coyote Lake Ranch, LLC filed its petition for review on September 24, 2014.

Bragg II (2013)

The final case pending before the High Court is one that stems from an old dispute that has followed a tortured jurisprudential path.

Bragg I (2002)

In 1996, Glenn and JoLynn Bragg applied to the EAA for an initial regular permit to withdraw water from the Edwards Aquifer to irrigate 2 pecan orchards—the "Home Place Orchard" and the "D'Hanis Orchard."[443] After the Braggs applied for permits allowing the withdrawal of 228.85 acre-feet annually to irrigate the Home Place Orchard and 193.12 acre-feet annually to irrigate the D'Hanis Orchard, the EAA—after examining the documented historical use in both orchards—granted the Braggs a permit to withdraw only 120.2 acre-feet annually in the Home Place Orchard but denied their permit entirely as to the D'Hanis Orchard.[444]

The Braggs first challenged the EAA's actions asserting that the EAA had to first prepare a "takings impact assessment" (TIA) under the Private Real Property Rights Preservation Act (PRPRPA) before either adopting aquifer-wide permitting rules

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433 The rule of capture, as it applies to oil and gas, was first described as a property right in *Brown v. Humble Oil & Ref. Co.*, 126 Tex. 296, 305, 83 S.W.2d 935, 940 (1935).

434 *Id.* at 829 (quoting *Coastal Oil*, 286 S.W.3d at 14 and expressly applying the natural gas holding from *Coastal Oil* to groundwater).

435 *Id.* at 826.

436 *Id.* at 843.

437 *Id.* at 814 (noting the opinion was issued on February 24, 2012).

438 *See City of Lubbock v. Coyote Lake Ranch, LLC,* No. 07-14-00006-CV, 2014 WL 2810419, at *5–6 (Tex. App.—Amarillo July 10, 2014, pet. filed); *Edwards Aquifer Auth. v. Bragg*, 421 S.W.3d 118, 126 (Tex. App.—San Antonio 2013, pet. filed) [hereinafter *Bragg II*]; *FPL Farming Ltd. v. Envtl. Processing Sys., L.C.*, 383 S.W.3d 274, 280-81 (Tex. App.—Beaumont 2012, pet. granted).

439 *FPL Farming*, 383 S.W.3d at 280–81 (citing *Day*, 369 S.W.3d at 832).

440 The "accommodation doctrine" has been described as a relationship between the surface owner and the mineral owner:

> [W]here there is an existing use by the surface owner which would otherwise be precluded or impaired, and where under established practices in the industry there are alternatives available to the lessee whereby minerals can be recovered, the rules of reasonable usage of the surface may require the adoption of an alternative by the lessee.

Getty Oil Co. v. Jones, 470 S.W.2d 618, 622 (Tex. 1971).

441 *Coyote Lake Ranch,* 2014 WL 2810419, at *5–6.

442 *Id.* at *7.

443 *Bragg v. Edwards Aquifer Auth.*, 71 S.W.3d 729, 730–32 (Tex. 2002) [hereinafter *Bragg I*].

444 *Bragg II*, 421 S.W.3d 118, 126 (Tex. App.—San Antonio 2013, pet. filed).

or acting upon individual permit applications.[445] More than a decade ago in its 2002 decision in *Bragg v. Edwards Aquifer Authority*, the Texas Supreme Court resolved this aspect of the dispute, holding that the EAA's adoption of well-permitting rules was excepted from the PRPRPA's requirement to prepare a TIA because the EAA's rules were promulgated pursuant to its statutory authority to prevent waste or protect the rights of owners of interest in groundwater.[446] The Court disposed of the second question by relying on the plain language of the PRPRPA itself, which did not require TIAs for enforcement of a governmental action through the use of permitting.[447]

Bragg II reaches the Texas Supreme Court

The Braggs then brought civil rights and takings claims against the EAA in 2006, which were removed to federal court.[448] The federal district court dismissed the Braggs' civil rights claims and remanded the takings claims back to state court.[449] After the EAA and the Braggs both filed competing summary judgment motions, the trial court granted partial summary judgment in favor of the Braggs, finding that the EAA's partial grant of the permit for the Home Place Orchard and denial of a permit for the D'Hanis Orchard constituted a regulatory taking for which the Braggs were entitled to $597,575.00 and $134,918.40, respectively.[450]

On appeal before the San Antonio Court of Appeals, the EAA challenged the judgment on several grounds. First, it asserted that, because the trial court issued a conclusion of law holding that the EAA "acted solely as mandated by the Act and without discretion" in adjudicating the Braggs' permits, any takings liability rests with the State and not the EAA.[451] Next, the EAA disputed the trial court's finding that the EAA's actions on the Braggs' permits constituted an impermissible taking.[452] Last, the EAA challenged the method by which the trial court calculated the compensation due to the Braggs as a result of the EAA's regulatory taking.[453]

In its 2013 decision in *Edwards Aquifer Authority v. Bragg* (*Bragg II*), the San Antonio Court noted the issue was one of first impression, but considering that the Act expressly provides for the payment of "just compensation . . . if implementation of [the Act] causes a taking of private property," the Water Code specifically allows for suits against water districts, and the Texas Supreme Court's caution that the "burden of the Takings Clause on government is no reason to excuse its applicability," the court concluded the EAA was the proper party to the Braggs' takings lawsuit.[454]

The court next examined the EAA's regulatory actions in light of the *Penn Central* 3-factor test as *Day* directs.[455] Because the evidence established that the Braggs invested more than $2 million in their orchard operations, reduced the number of trees by 30% to 50%, and were rendered unable to raise a commercially viable crop in their orchards with their own permitted water, the court found that *Penn Central*'s first factor regarding the degree of economic impact on the Braggs was severe, significant, and substantial enough to weigh "heavily in favor of a finding of a compensable taking of both orchards."[456] The court also found that *Penn Central*'s second factor concerning the Braggs' investment-backed expectations militated "heavily in favor" of finding the EAA's actions constituted a compensable taking.[457] Specifically, the court reasoned that, considering "Mr. Bragg's extensive understanding of pecan crops, the Braggs' understanding that they owned the water under their land, and that no regulatory entity existed that governed the use of their water when they purchased the property as an existing pecan orchard," the Braggs' investment-backed expectations for their orchard operations were reasonable.[458] Finally, the court found that the third *Penn Central* factor regarding the nature of the regulation weighed "heavily against" a compensable-taking finding because of the unique importance of the Act's stated purpose of "protect[ing] terrestrial and aquatic life, domestic and municipal water supplies, the operation of existing industries, and the economic development of the state."[459] On balance, the court held that the record supported the conclusion that the EAA's permitting system imposed under the Act effected a regulatory taking of both the Home Place Orchard and D'Hanis Orchard.[460]

Turning to the final issue regarding the proper method for calculating compensation due the Braggs for the EAA's regulatory taking, the court disagreed with the trial court's approach

[445] *Bragg I*, 71 S.W.3d at 734, 737.

[446] *Id.* at 735–36.

[447] *Id.* at 737.

[448] *Bragg II*, 421 S.W.3d at 126; *see generally Bragg v. Edwards Aquifer Auth.*, No. SA-06-CV—1129-XR, 2008 WL 819930 (W.D. Tex. Mar. 25, 2008) [hereinafter *Bragg 1.5*].

[449] *Bragg II,* 421 S.W.3d at 126; *see generally Bragg 1.5.*, 2008 WL 819930.

[450] *Bragg II*, 421 S.W.3d at 126.

[451] *Id.* at 126–27.

[452] *Id.* at 137.

[453] *Id.* at 146–47.

[454] *Id.* at 127, 130–31 (citing Texas Water Code § 36.251, § 1.07 of the Act, and *Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 843–44 (Tex. 2012)).

[455] *Id.* at 138–146.

[456] *Id.* at 139–41.

[457] *Id.* at 142–44.

[458] *Id.* at 144.

[459] *Id.* at 143–45 (citing § 1.01 of the Act).

[460] *Id.* at 146.

to valuing the compensation owed for both orchards.[461] The court reasoned that, because the water beneath the Braggs' land is not the source of their business, but instead merely used to benefit the business in which they are engaged, just compensation should be "determined by reference to the highest and best use of the properties," which the evidence showed was as commercial pecan orchards.[462] Therefore, the court concluded, the Braggs are entitled to "compensation for the amount by which their property was impaired by [the EAA's] taking."[463] Pursuant to this holding the court remanded the case back to the trial court to determine:

> [T]he compensation owed on[: (1)] the Home Place Orchard as the difference between the value of the land as a commercial-grade pecan orchard with unlimited access to Edwards Aquifer water immediately before implementation of the Act in 2005 and the value of the land as a commercial-grade pecan orchard with access to Edwards Aquifer water limited to 120.2 acre-feet of water immediately after implementation of the Act in 2005 …[; and (2)] the D'Hanis Orchard as the difference between the value of the land as a commercial-grade pecan orchard with unlimited access to Edwards Aquifer water immediately before implementation of the Act in 2004 and the value of the land as a commercial-grade pecan orchard with no access to Edwards Aquifer water immediately after implementation of the Act in 2004.[464]

Both the EAA and the Braggs have filed petitions for review before the Texas Supreme Court in the case, and the Court ordered merits briefing in the matter in October 2014.

[461] *Id.* at 152–53.

[462] *Id.* at 151.

[463] *Id.* at 152.

[464] *Id.* at 152–53.

CONCLUSION

As contentious and enduring as the groundwater ownership and use debates have been here in Texas for the past 110 years since *East*, the roots of the controversy have proved to be as ancient as civilization's need for water itself. It is perhaps little wonder that the first serious and systematic codification of Western law contained the juristical precepts opining on the legal use and ownership of groundwater.

Although every decision by the Court over the last century and each act enrolled by the Legislature over the past 70 years have proven to be crucial junctures redirecting the juridic progression of groundwater law in Texas, no doubt *East* and *Day* bookend the heart of the debate—whether an overlying landowner owns the groundwater in place beneath. The next generation of disputes will bring into focus the regulatory mechanics and logistics broadly outlined in *Day*.

Of these coming cases, only *Bragg II* seems to present squarely so many of the questions left unanswered by *Day*—namely the application of *Day*'s non-*per se* takings framework under *Penn Central* and the appropriate calculation by which just compensation for taken groundwater interests should be determined. Because of this, it has the potential to be the next seminal groundwater case in *East* and *Day*'s jurisprudential line of succession.