The Impact of Earlier Spring Snowmelt on Water Rights and Administration: A Preliminary Overview of Issues and Circumstances in the Western States

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Table of Contents

Abstract 2

Introduction 3
Changes in the Timing of Spring Snowmelt 3
The Treatment of Timing in Water Rights Systems 4
Variations in State Water Law 4
Interstate Compacts 6
The Interplay of Earlier Snowmelt and Water Rights 8
Themes and Findings 10
Concluding Thoughts and Recommendations 12

Appendix A: Climate Change and the Functioning of Water Rights: A Search of the Literature 13
Appendix B: Overview of State Statutes, Administrative Rules and Applicable Case Law . 18
Appendix C: Calendar Date Requirements in Colorado's Water Compacts29
Appendix D: Case Studies 34

Literature Cited 38

Figures and Tables

Figure 1. Trends in the Spring Pulse Onset 4
Table 1. Timing Elements in Western Water Allocation Compacts 7
Table 2. Hydrologic and Legal Trends in Streamflow Timing in the 11 Western States 9
Table 3. Key Calendar Dates in Colorado's Compact Apportionments 30

ABSTRACT: The paper reviews the potential for administrative problems/disputes associated with western prior appropriation water rights in those sub-regions experiencing increasingly early spring snowmelt and the lengthening of growing seasons. In those areas, potential problems of two general types are envisioned. First, in those states that link water rights to specific calendar dates (that are becoming increasingly out-of-step with natural hydrographs), the yield and/or utility of those rights can theoretically become increasingly devalued. Second, in states that do not attempt to limit the exercise of rights to specific dates, water consumption under a given right may increase, thereby threatening the yield and reliability of other (particularly more junior) users. These problems can potentially occur at many scales, including interstate basins. To date, the study finds that problems of both types are exceptionally rare, and can be managed using existing administrative discretion and water system flexibility—a situation that is unlikely to persist given additional shifts in streamflows and water demands, and given increases in competition for limited water resources. The authors recommend that water managers explicitly design and operate water system models (to the extent possible) to account for interactions between shifts in streamflow timing and water rights, and that states plan for a growing strain on water administration personnel and systems.

Introduction

In many watersheds in the western US, global climate change is manifest as earlier snowmelt (i.e., earlier runoff), reduced late-summer streamflows, and longer growing seasons (Knowles et al., 2006; Stewart et al., 2005; and Regonda et al., 2005). These trends can be problematic for several facets of water supply management, invalidating many of the design and operational assumptions underlying the West's water resources infrastructure (Milly et al., 2008), and modifying patterns and quantities of water demand. At this interface of supply and demand are systems of water rights and water rights administration. Many surface water rights in the western states are defined in part by seasonal characteristics, either generally through terms such as "irrigation season" rights, or more specifically in rights that use explicit calendar dates to describe the start and end of diversion (or storage) seasons. A similar phenomenon exists in the apportionment of interstate rivers.

In conversations with Western Water Assessment (WWA) researchers, several water managers have expressed concern that this growing mismatch between dates found in water rights and the shifting of the hydrograph has the potential to impact the functioning of water rights, thereby modifying yields, demands, reliabilities, and other elements of water systems, with impacts resonating throughout the entire community of rightsholders and water users. To date, this issue generally has not been the subject of scholarly inquiry[2] (see Appendix A) or real-world disputes, but given projected trends in snowmelt, it is reasonable to expect that this issue will grow in salience. The following pages and attached appendices provide a reconnaissance level review of this issue in the 11 westernmost continental states.[3]

Changes in the Timing of Spring Snowmelt

Several recent studies have examined the relationship between climatic trends in the western US and the timing and magnitude of snow and snowmelt. Five of the most relevant studies (Hamlet et al., 2005; Knowles et al., 2006; Mote et al., 2005; Regonda et al., 2005; and Stewart et al., 2005) are summarized by Udall and Bates (2007). Of these, Stewart et al. (2005) and Regonda et al. (2005) most directly focus on changes in the timing of snowmelt in western US basins, using data from the USGS Hydro Climate Data Network (HCDN). Stewart et al. (2005) used 241 US gauges from 1948 to 2002, while Regonda et al. (2005) used data from 89 stations from 1950 to 1999. Both studies are consistent in showing earlier runoff over the study period at many stations—as great as 4 weeks earlier in the Pacific Northwest. This is shown below in Figure 1:

[2] A search of the academic literature on this subject identifies no major studies that have examined this issue directly, although several acknowledge and touch upon the issue without providing additional analysis.

[3] The states are: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming. Within these states, the focus is primarily on those areas associated with snowmelt dominated watersheds.

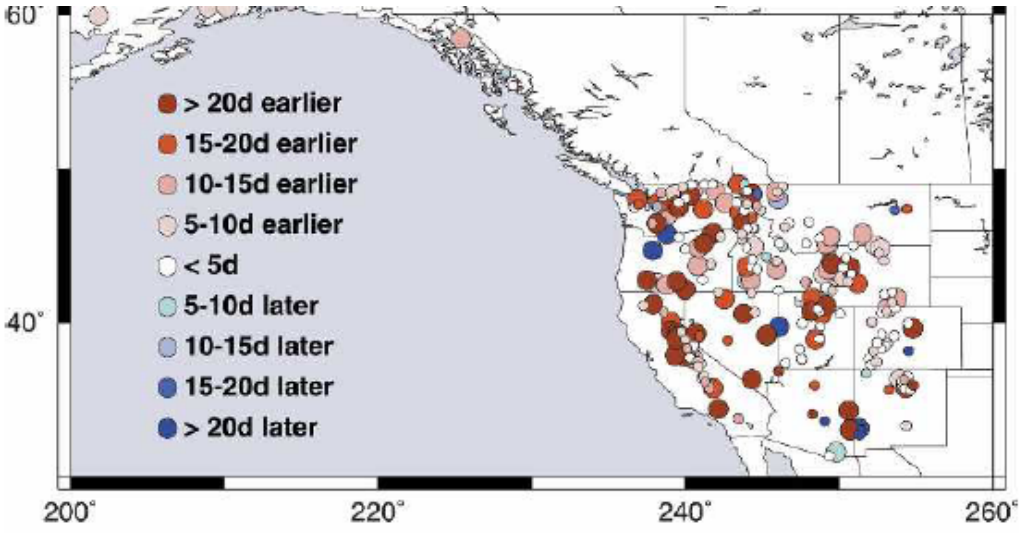

Figure 1. Trends in the Spring Pulse Onset. Adapted from Figure 2 in Stewart et al. (2005:1141). The figure shows trends in the spring pulse onset of snowmelt-dominated gauging stations over the 1948-2000 period. Larger symbols indicate statistically significant trends (at the 90% confidence level).

In general, trends in earlier runoff are closely correlated with elevation: i.e., locations with the majority of basins below 2500 meters (8,200 feet) elevation--primarily the Cascade and Sierra Nevada Mountains--show the strongest trend toward earlier runoff. Conversely, areas of higher elevation (e.g., including large parts of Colorado, Utah, Arizona, and northern New Mexico) often lack clear trends, or exhibit trends that are not statistically significant. Since higher elevation regions are generally colder than lower elevation areas, they are furthest from the temperature threshold at which snow turns to water; thus, snowmelt in many high elevation watersheds, to date, has been largely unaffected by global warming. The effect of decadal phenomenon such as the Pacific Decadal Oscillation (PDO) and even shorter term climatic events such as the El Nino Southern Oscillation (ENSO) may also partially influence the observed trends.

The Treatment of Timing in Water Rights Systems

Variations in State Water Law

Rules requiring that time of year limitations be specified for prior appropriation water rights can be found in statutes, administrative rules, and/or case law. Since water allocation in the West is a product of state law, it is not surprising that requirements vary from state to state, sometimes in significant ways. Several states are explicit in requiring time of year limitations in those documents establishing water rights, while a smaller number are silent (or nearly silent) on the issue. In the middle are several states that address the issue partially, in multiple and often highly nuanced ways, and/or in ways that provide for multiple interpretations. For example, in several states, questions arise regarding whether a requirement for calendar dates in water right applications is carried

forward into the document establishing a water right[4]. Additionally, in some states, not all categories of water rights (e.g., irrigation/municipal, direct flow/storage) are treated equally with regard to specifying calendar dates.[5] Perhaps most importantly, the on-the-ground interpretation and application of these rules by water administrators can vary significantly from state to state and even within states, often following local *ad hoc* customs that have evolved over decades of local administration. Snapshots of relevant state laws are provided below; more complete descriptions are provided in Appendix B:

Arizona: Claimants must state time of year in their application forms or claims statements, but the statutes are silent on whether that information must be included in final documents establishing water rights.

California: All permits/decrees for post-1914 water rights and in stream adjudications must include the dates or seasons when the water right will be used. Pre-1914 water rights are not subject to the permit system and, in many cases, dates and seasons of use are not specified. However, actual beneficial use determines both the amount and season of diversion which can be used under these rights.

Colorado: There is no general requirement that water rights decrees (with certain specific exceptions such as recreational rights) contain time of year limits. Courts have discretion to include time of year limitations in transfer decrees, and often do, to assure there is not an expansion of use over that which occurred historically to the detriment of other water rights.

Idaho: Since at least May 1967, water rights must include a period of use with a specific beginning and ending date.

Montana: Time of year limitations must be included in final decrees under the statewide adjudication procedure. While period of use is a required element of a permit application form, and administrative rules even define standard periods of diversion and use, the statutes are silent as to whether this element must be included in post 1973 water rights permits or certificates of water rights.

Nevada: Statutes describing the appropriation process do not require that permits include time of year limits; however, this information is required in the permit application forms. Statutes on contents of stream adjudication claims forms and decrees are silent on the issue, although time of year or season of use limits are routinely included in those decrees.

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[4]A note about terminology: All of the western states included in this study except Colorado administer water rights through a permit system administered by a state agency. Water right permits, licenses and certificates are issued by administrative agencies. A permit authorizes the permittee to develop a water project, but is not a water right itself. If all conditions are met the agency will issue a license or certificate which constitutes a vested water right. Decrees are determinations of water rights issued by courts. In Colorado, water rights are established exclusively through the courts. The remaining western states also provide for judicial adjudication of water rights under some circumstances..

[5] Our summary does not attempt to resolve these areas of confusion, but merely to highlight some areas where legal ambiguities will likely need to be addressed.

New Mexico: State law requires period of use to be stated in both applications for water permits and in stream adjudication decrees.

Oregon: Defining a period of use is required in several facets of Oregon water law administration: e.g., applications for a permit, registration of pre-1909 rights, and adjudication processes. Additionally, case law is clear that courts *may* impose time of year limits, particularly with respect to irrigation rights. However, it is unclear whether or not the requirement that water right certificates describe the "extent of the right" must do so using actual calendar dates.

Utah: Utah law is clear that the period of use must be specified in judgments in adjudications as well as certificates of appropriation for permit cases.

Washington: Applications for water permits ask for time of year limits, but the statutes don't explicitly require this information in permits or certificates. However, an online "Proof of Appropriation of Water" form asks for time of year of use, and may (after approval) function as a certificate of water right. Certificates in general adjudications must include time of year limitations.

Wyoming: Wyoming's statutes do not require time of year limits for water rights, though administrative rules require that changes of use be limited to historic use. Local water commissioners determine the irrigation season based on whether beneficial use can be achieved.

Interstate Compacts

The focus of this study is primarily on the definition and administration of state water rights featuring specific timing elements; however, it is worthwhile to appreciate that timing elements also exist at the interstate level.[6] As shown in Table 1, of the sixteen interstate water apportionment compacts found in the eleven western states, at least six compacts (affecting eight states) feature formulas that rely, to various degrees, on key spring calendar dates.[7] These agreements were negotiated, literally, in a different climate, well before global warming was a concern in the water management community (or elsewhere).[8]

[6] This subject is explored in more depth in the WWA working paper: "The Effect of Changing Hydrographs on Compact Apportionments in the Western United States: A Preliminary Analysis of Potential Trouble-Spots" (Kenney et al., 2007).

[7] Note that in Table 2, the five categories used under the heading "Dates Used to Define Apportionment & Accounting Periods" are ordered, left to right, with respect to their general likelihood of being problematic given current and growing shifts in snowmelt patterns. As a practical matter, determining which compacts will prove problematic on this and other points is much more complex and subject to case-specific conditions; nonetheless, all else being equal, compacts that rely heavily on specific spring dates, especially if they are associated with low-elevation watersheds, perhaps are most deserving of concern and further investigation.

[8] Of these six compacts, the most recent was negotiated in 1962; the average negotiation date of the others is 1941.

Table 1. Timing Elements in Western Water Allocation Compacts								
Compact			Dates Used for Apportionment & Accounting Periods					Comments & Notes
Basin	Signatory States	Year	Key Spring Dates	Key Fall Dates	Calendar Year Accounting	Multi-Year Accounting	No Time Element Needed	
Arkansas	CO, KS	1948	X	X				Defines winter storage season dates (Nov 1 to March 31) and summer storage season dates (April 1 to Oct 31).
Bear	ID, UT, WY	1955, 1978		X				Measures depletions over a water year from Oct 1 to Sept 30.
Belle Fourche	WY, SD	1943			X			Apportionments defined over a calendar year.
Canadian	NM, TX, OK	1950					X	Apportionment based on limiting storage capacity.
Colorado	WY, CO, UT, NM, NV, AZ, CA	1922				X		Apportionment based on 10-year moving averages.
Costilla Creek	CO, NM	1944, 1963	X	X				Defines irrigation season from May 16 to September 30; storage season from October 1 to May 15.
Klamath	OR, CA	1957			X			A few calendar year references; otherwise, no timing elements.
La Plata	CO, NM	1922		X				Defines a period of unrestricted use (Dec 1 to Feb 15) and an apportionment period (Feb 15 to Dec 1).
Pecos	NM, TX	1948			X	X		Primarily a 3-year apportionment; measured over calendar years.
Republican	CO, NE, KS	1942			X			Apportionments in annual volumes.
Rio Grande	CO, NM, TX	1938	X	X	X			Some delivery obligations tied to flows from April 1 to Oct 31 or Oct 1 to June 30.
Snake	WY, ID	1949		X				Apportionment based on annual water-year basis from Oct 1 through Sept 30.
South Platte	CO, NE	1923	X	X				An irrigation season apportionment is defined from April 1 through Oct 15.
Upper Colorado	WY, CO, UT, NM	1948		X				Measurements based on a water year extending from to Oct 1 to Sept 30.
Upper Niobrara	WY, NE	1962	X	X				Multiple storage seasons defined, beginning on Oct 1, and ending on either May 1, June 1, or Sept 30 depending upon the project and direct flow rights.
Yellowstone	WY, MT, ND	1950	X	X				Apportionment between MT and WY is based on annual water-year basis measured from Oct 1 through Sept 30, while the MT-ND apportionment runs from May 1 to Sept 30.

To date, there is no evidence to suggest that these timing elements have been problematic, an observation that is perhaps linked to the fact that high-altitude Colorado watersheds are the upstream component in four of the six basins. (A review of compacts to which Colorado is a signatory is provided in Appendix C.) Nonetheless, the potential for eventual timing-related controversies seems very real, in part since no compact features a commission expressly empowered to modify apportionments or administration based on climate change considerations. Additionally, this primitive effort to identify potentially problematic compacts by merely focusing on the presence/absence of calendar dates likely understates the issues associated with a growing mismatch between interstate water rights and hydrology. For example, even though the La Plata Compact does not feature spring calendar dates, it does require the maintenance of minimum summer flows—a challenge that is likely to grow in areas with earlier runoff and longer growing seasons. Additionally, climate change is likely to force attention on many other topics currently omitted from compacts.[9]

The Interplay of Earlier Snowmelt and Water Rights

Table 2 features a very rough categorization of the eleven western states based on the two criteria relevant to this analysis: first, an assessment of whether or not the state (or sub-state region) is experiencing clear trends in the earlier onset of spring snowmelt, based on the findings of Stewart et al. (2005) and Regonda et al. (2005)[10]; and second, a review of the language used in the statutes, administrative rules and case law in each of the eleven states concerning timing of water rights under the prior appropriation system.[11] This is an imprecise exercise in many respects. For example, since many basins within a state have widely varying altitudes, it is difficult and inherently imprecise to categorize entire states as having a uniform signal regarding earlier snowmelt. Yet, since legal regimes referring to the timing of water rights are uniform within a state from basin to basin regardless of any elevation changes, it was necessary to use the state as the standard unit of analysis. Additionally, the summary of legal requirements suggests an administrative regime than may be more theory than reality; interviews of many state officials have confirmed that patterns of water rights administration often vary significantly within a state depending on local conditions and traditions. With these caveats, Table 2 is offered here as a way to organize the variety of different circumstances seen throughout the West, and as a tool for selecting case studies—as done below—that may offer transferable lessons.

[9] Of the 22 western compacts (including the 16 in Table 1) reviewed by Kenney (2002) in other research, none mention climate or climate change, only one mentions drought, only four mention fish or wildlife, only six mention water quality or pollution, only three mention groundwater, and only eight mention Native American water claims. At some point, all of these issues will require examination, and climate change may be the stimulus.

[10] Cf. Clow (2007)'s contrary findings for Colorado.

[11] California, Oregon, and Washington also recognize riparian water rights to some extent, but the impact of climate change on those rights, if any, is outside the scope of this study.

Table 2. Hydrologic and Legal Trends in Streamflow Timing in the 11 Western States		
Inclusion of Timing Elements in Water Rights	Trend Toward Significantly Earlier Spring Snowmelt	
	Strong	Weak / Inconclusive
(A) Explicit Timing Requirement. Statutes, rules and/or case law explicitly require time of year limitations in documents establishing water rights	▪ Washington ▪ California (post-1914) ▪ Idaho (post-May 1967) ▪ northern Utah ▪ northwestern Montana (stream adjudications)	▪ New Mexico ▪ Utah (except northern) ▪ Montana stream adjudications (except northwest)
(B) Some Attention to Timing. Statutes, rules and/or state-prescribed application forms require that time of year be stated in the application for a right, but are silent as to whether time of year must be included in documents establishing water rights	▪ eastern Oregon ▪ eastern Arizona ▪ northwestern Montana (permits) ▪ Nevada (permits) ▪ western Wyoming (transfers)	• Oregon (except eastern) • Arizona (except eastern) Montana permits (except northwest) • Eastern Wyoming (transfers)
(C) Silent on Timing Issues. Neither statutes, application forms, nor case law generally require time of year limitations as an element of water rights (though exceptions exist such as transfers and recreational rights)	▪ western Wyoming (except transfers) ▪ Nevada (stream adjudications) ▪ California (pre-1914)	▪ Colorado ▪ Eastern Wyoming (except transfers)

To better understand how timing issues are addressed in practice, data were gathered from water decrees and interviews with water administrators in four states: Idaho, Utah, Wyoming, and Colorado. These states, chosen because they fall at the four corners of the typology in Table 2, provide an overview of the range of circumstances that characterize the water rights timing issue in the West. Specifically,

- Idaho is showing a strong earlier snowmelt signal[12], and state law explicitly requires time of year limitations for water rights;
- Most of Utah is showing a weak or inconclusive earlier snowmelt signal[13], and state law explicitly requires time of year limitations for water rights;
- Western Wyoming is showing a stronger earlier snowmelt signal[14], and state law is silent on time limitations in water rights (except for transfers);
- Colorado is showing a weak or inconclusive earlier snowmelt signal[15], and state law, for the most part, is silent about time of year limitations in water rights (except for transfers).

The case studies themselves are presented in Appendix D; the major trends and findings from these case studies—as supplemented with insights from other states and interviews—are summarized below.

Themes and Findings

Although there is significant variation from state to state, it is generally fair to say that collecting statistical information about water rights—and in particular, the timing elements in those water rights—is difficult and time-consuming. Collecting evidence of how those rights are actually exercised and administered on an annual basis is dramatically more difficult; in lieu of a "call" or a lawsuit, almost no data is available to track patterns and changes over time. In fact, many water rights are not even adjudicated . Given this reality, much of what we have learned about issues in water administration has come from interviews with administrators, water users, and attorneys. Those interviews—when combined with our review of legal regimes, case studies, and the relevant literatures—support the following tentative findings:

[12] Both Stewart et al. (2005) and Regonda et al. (2005) indicate that the majority of stations are reporting as much as over 20 days earlier onset of snowmelt in comparison to the historic record. The results are statistically significant.

[13] Stewart et al. (2005) report that at several stations in central and northern Utah, spring pulse onset was between 15 to over 20 days earlier than during the 1948-2002 period. However, Regonda et al. (2005) found that several stations in Utah had later peak flows, though none of the trends observed was statistically significant.

[14] Stewart et al. (2005) report that several stations in western Wyoming show a snowmelt signal over 20 days earlier than the historic record. Regonda et al. (2005), however, did not find any of the Wyoming stations statistically significant.

[15] Stewart et al. (2005) found that the spring pulse signal in Colorado is inconclusive, with the exception of one station in central Colorado that showed snowmelt onset over 20 days earlier than during the 1948-2002 period. Similarly, none of the snowmelt trends for Colorado in Regonda et al. (2005) were statistically significant. However, Clow (2007), using the Regional Kendall test (RKT), which is a relatively new test derived from the Seasonal Kendall test, found that Colorado's spring snowmelt is already occurring approximately 0.5 days/year earlier based on analysis of 72 SNOTEL sites and 40 high elevation streamflow gaging stations from 1978 to 2004.

Many Irrigation Water Rights Appear to Be Lengthening (and Growing). The earlier onset of spring snowmelt has increased the length of the irrigation season in many locations. As expected, in states that do not feature calendar dates on these rights (but rather are silent or simply define rights as corresponding to the irrigation season), it is generally accepted (although poorly documented) that these rights are being exercised earlier and longer. Perhaps more surprising, however, is the observation that in states that do feature actual calendar dates on water rights, we have not found examples where a serious effort has been made to enforce these dates. As long as the water is being used beneficially (and in a similar way and location as historically done), and in lieu of any protests from other water users, earlier diversions are generally seen as appropriate and are not deterred. In fact, the distinction made in this report between the four states that do and do not require time of year limitations in water rights seems to have very little significance in current practice.

A Lot of Administrative Flexibility is Being Exhausted. Systems of water administration generally have sufficient flexibility built into them to accommodate annual hydrologic variability. This same flexibility is being drawn upon to accommodate more fundamental shifts in climate and hydrology, although this reality may not be readily obvious—after all, on-the-ground, climate change can be indistinguishable from climate variability. However, it appears that, at least in the four case study states, the extent of available flexibility may be near an end. Colorado water administrators, for example, report that "gentleman's agreements" regarding diversion schedules among water users are eroding, and in Wyoming, the growing frequency of late-season calls is focusing more attention on early season water-use practices.

Legal Disputes Associated with Water Rights Timing are Not Yet Apparent. Despite repeated inquiries to water rights attorneys and ongoing literature searches, we did not find any evidence of a lawsuit in any western state that can be directly attributed to a controversy over the mismatch between timing elements in water rights and the shifting hydrograph associated with climate change. This lack of litigation is perhaps explained by the apparent legality in many contexts of modifying diversion schedules to meet shifting hydrologic conditions, and in those situations where such actions are presumably barred, the failure of injured parties to appreciate the role of this behavior in creating observed problems. We did not encounter any groups of water rightsholders arguing for more scrutiny or enforcement of water rights terms. Nonetheless, some interviewed parties suggested that this period of calm is expected to erode in coming years, with the first wave of lawsuits perhaps focusing on better defining the discretionary limits (and obligations) of water administrators.[16]

Winners and Losers Are Tough To Predict. Beyond the simple observation that seniors are almost always better off than juniors, it is difficult to predict the distribution of winners and losers to emerging problems (and responses) associated with the growing mismatch between hydrology and timing elements in water rights. To the extent that water rights feature no timing restrictions (or feature timing restrictions that are not enforced), then seniors are in a position to increase water diversions often at the expense of juniors—an advantage perhaps most evident during late-season low-flow periods. Similarly, a strict enforcement of timing elements in water rights may prevent an expansion of senior rights that benefits some juniors, although these same users are

[16] As one potential example, see *North Sterling Irrigation Dist. v. Harold Simpson and James Hall*, 2005 CW 125 (Div. 1 Water Court), filed June 2005).

likely to also feature demand patterns that are increasingly out of synch with their rights. The salience of case specific factors precludes further generalizations. For example, one wildcard in any situation is the interplay between direct-flow rights and storage rights. Minimizing interference among the exercise of these two types of rights is a familiar administrative challenge that can become more complicated by changes in the hydrograph. Additionally, changes in the timing of water diversion and use can have huge consequences, either positive or negative, for water users reliant on return flows. This is particularly true for trans-basin diversions. Other complications can arise from management needs for environmental protection, water quality, and even power generation, and in all situations, the availability (and use of) storage can be of great importance.

Concluding Thoughts and Recommendations

Our review of the relationship between climate change and the functioning of water rights has led us to two overriding conclusions: first, significant on-the-ground problems associated with the growing mismatch of rights and hydrographs have yet to emerge, even though snowmelt in many locations has advanced several weeks; and second, that this period of calm may not last much longer. It remains unclear exactly where and how intensely these problems may be manifest, and whether they will present as legal or water management problems. In a state that explicitly requires that water rights be exercised within specific calendar dates, it is reasonable to expect lawsuits to emerge, likely initiated by juniors harmed by increased consumption from seniors that have expanded their season of use. In a state without such timing requirements, the issue perhaps is better characterized as a management problem, as water rightsholders—especially juniors—search for means to manage reduced yields and higher vulnerabilities from their water rights portfolios. Problems at the interstate level may be particularly difficult to resolve, as the zero-sum nature of compact apportionments can be a formidable barrier to resolving disputes through compromise and negotiation. In those settings, litigation may be unavoidable. Further speculation is difficult to support and may be largely irrelevant, as the other impacts and challenges on water resources associated with climate change may subsume or overwhelm the specific issue of water rights timing. So in lieu of a better vision of what the future entails, we conclude with only two simple recommendations. First, if they are not already doing so, we encourage water managers to design and operate their models and modeled scenarios in a way that considers how shifts in the hydrograph may influence the yield and vulnerability of their water rights portfolios. And second, states should expect the demands on water administrators to increase, and should make appropriate investments in personnel, budgets and training.

Appendix A: Climate Change and the Functioning of Water Rights: A Search of the Literature

This memo presents the results of a literature search conducted in May-June 2007 as a preliminary step toward the study of how climate change-induced variations in the hydrograph (i.e. earlier snowmelt and peak flows) may impact the temporal elements of water rights. This memo does not review the large body of scientific literature that documents and forecasts the onset of earlier snowmelt and reduced snowpacks in the western United States. Rather, the focus here is upon the relatively smaller body of policy, law, and management papers that link the science of climate change with issues of water rights in this region.

The literature search was conducted using a variety of online databases including Westlaw, Lexis Nexis, LegalTrak, SSRN (Social Science Research Network), JSTOR, and Google Scholar. The search also included a journal-by-journal review of all online journals accessible through the University of Colorado library system that contain the words "water" or "climate" in their titles. Search terms included "climate," "climate change," "global warming," "snow," "snowmelt," "early snowmelt," "runoff," "early runoff," "water," "water rights," "water law," and combinations of these terms. Papers were also identified through personal references as well as references from academic papers. Finally, the search included a Lexis Nexis search of major western U.S. newspapers for recent articles (2002 to present) that focused upon relationships between early snowmelt and water resources.

The literature search produced no papers that expressly address the issue of the timing of snowmelt/runoff and the timing of water rights. However, several papers touch upon the broader relationships between climate change, water resources, and policy/law/social sciences in the western United States. These papers include law review and other journal articles, book chapters, conference and symposium proceedings, reports and assessments from government agencies and NGOs, and newspaper articles.

Other researchers have also noted the lack of research considering the nexus of snowmelt timing and the operation of water rights. For example, in a survey of academic literature on climate change and California water resources, Kiparsky and Gleick (2003) note, "Few analyses have tried to evaluate how climate change impacts may affect, and be affected by, water laws and regulatory structures." In a similar, more recent literature review of climate change impacts on California's water, Dracup and Vicuna (2007) note that most studies are hydrological: "the authors believe that there has been a dearth of studies on the impact associated with changes in reliability (and therefore economic costs) among different water users (with different water rights and water sources) in the California system." Typical of this trend is a study by Brekke et al (2004) that models the impacts of climate change and hydrologic change on reservoir storage levels in the San Joaquin River Basin, but does not expand upon management alternatives or issues of rights.

In a rare example of a non-hydrological empirical study, Baldwin et al (2000) surveyed western water managers to identify the degree of concern over potential impacts of climate change on water management. They found that "systematic changes in timing of runoff could have the most significant impact" of any climate change-induced water

management issue. Furthermore, one survey respondent from Nevada noted that "water right holders would likely have difficulty obtaining their decreed water rights," and that these rights assume a consistent period of runoff.

A variety of papers and reports connect scientific trends with suggestions for management strategies, but few emphasize issues in water law and water rights. Much of the literature (i.e. Riebsame, 1988; Stakhiv, 1998; Frederick and Gleick, 1999; Gleick, 2000; Hancock, 2004; D'Antonio, 2006; and WGA, 2006) emphasizes management options including water markets and transfers, "no regrets policies of water efficiency," adaptive management, demand management, sustainable development, reoperation of infrastructure, and development of new infrastructure. In some instances (e.g., Miller, 1997; Gleick, 2000; USBR, 2005; D'Antonio, 2006; and WGA, 2006), papers and reports assert the need for institutional reform, the clarification of rights, and the removal of legal barriers, but do not elaborate on these concepts.

Several recent papers address climate change and water law, but do not necessarily focus on issues of prior appropriation and water rights. Osofsky (2007) explores supranational institutions and their role in arbitrating conflicts over melting snow and ice in regions such as California's Sierra Nevada Range. Salzman and Hunter (2007) examine the role of duty and care (tort law) in climate change cases, including in *California v. General Motors*, in which California argues that greenhouse gas emissions have caused reduction in the Sierra Nevada snowpack and changes in water availability. Zinn (2007) discusses the adaptability of environmental law to climate change; a brief section of the paper discusses hydrology in the West but, overall, the paper emphasizes environmental regulations and impacts.

Most relevant to the purposes of the proposed study are those papers that meaningfully engage with questions of climate change and water rights, often focused on the limits/constraints associated with prior appropriation. However, as noted above, none of these papers specifically address issues of timing of water rights. Trelease (1977) provides an in-depth analysis of how prior appropriation rights may be adaptable to climate change-induced drought. The analysis does not consider changes in the timing of snowmelt and streamflow, but is applicable in its thoughtful approach to the functioning of water rights in general under climate change scenarios. Tarlock (1991) explores the adaptability to climate change of prior appropriation and USBR regulations, arguing (in Tarlock, 2000) that property rights in western water law provide a good model for international adaptation to climate change, an argument that runs counter to much of Dellapenna's (1999) analysis calling for the treatment of water as a public resource. Miller et al (1997) discuss capacity for institutional adaptation of the prior appropriation and riparian systems and highlight the need for clarification of consumptive versus non-consumptive rights and the limits upon these rights. Carter and Morehouse (2001) examine the legal and policy frameworks of water management in Arizona and discuss problems of inflexibility within the state's prior appropriation system. Getches (2003) discusses the constraints of water law and policy on water management under conditions of climate change. Slaughter and Wiener (2007) explore the adaptability of prior appropriation rights in the Pacific Northwest. They discuss the changes in the hydrograph, but their focus is upon how property rights influence the ability to resolve water shortage conflicts.

The newspaper article search produced many articles that link climate change with melting snowpacks, but only a handful that link these trends with water management

issues. Articles reviewed (listed in the bibliography) discuss issues of early snowmelt, late winter flooding, decreased summer water availability, reservoir management, proposals for new reservoirs, rural-to-urban water reallocation, and water conflicts. An article from *The Oregonian* ("Report: Global warming costs coming soon," 13 Jan 2007) quotes a Washington official as noting that "Disputes over water rights and other water issues already are highly controversial, and it's not going to get any better if you have smaller snowpacks and warmer summer temperatures." No articles explicitly addressed in detail water rights issues associated with climate change.

In summary, this literature search produced no papers that directly analyze relationships between temporally-delineated water rights and temporal shifts in the hydrograph. Compared to the body of literature addressing climate science and hydrologic modeling, the body of literature addressing climate change implications for water management, policy, and law in general is relatively small. The literature that does exist tends to emphasize adaptation and institutional reform. Papers that emphasize water rights do not examine temporal issues. Thus, further research and analysis is needed to identify and address issues related to temporal water rights and climate change.

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Appendix B: Overview of State Statutes, Administrative Rules and Applicable Case Law

Introduction

This memo reviews and summarizes requirements that prior appropriation water rights include limitations on the time of year that the rights can be exercised. The following eleven western states are included in this review: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. For each state this memo reviews online application forms, administrative rules, statutes, and case law for time of year requirements. Except for Colorado and Wyoming, this memo does not review each state's change of use procedures.[17] Further, although California, Oregon and Washington recognize riparian water rights in addition to prior appropriation rights, this memo does not address riparian rights. Such rights are not limited by time of year and thus the impact of climate change on those rights is not within the scope of this study.

Review of State Law

Arizona

Arizona's general procedures for obtaining surface water rights are described as follows.[18]

Permit to Appropriate Public Water of the State of Arizona or to Construct a Reservoir. Section 45-152, which describes the contents of the application for a permit, is silent regarding months of use. However, the online application form for a permit to appropriate water requires the applicant to state the specific months of use if water is not to be used for the entire year.[19] Section 45-162 does not specify that time of year limitations be included in a certificate of water right.

Statement of Claim of Rights to Use Public Waters of the State of Arizona. This procedure applies to anyone who before March 17, 1995 was using and claimed the right to use public waters of the state based on state law. Such person may file a "Statement of Claim" for both pre and post June 12, 1919 claims. Under section 45-183, the statement of claim for each water right shall include "the quantities of water and times of year use is claimed." The online form to file a statement of claim asks for specific months of use.[20] However, the filing of such a claim does not constitute an adjudication of a claim. Section 45-185.

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[17] Change of use procedures in these two states were reviewed because these states do not require time of use limitations in applications for water rights/permits.

[18] See http://www.azwater.gov/WaterManagement_2005/Content/WaterRights/default.htm; http://www.azwater.gov/WaterManagement_2005/Content/WaterRights/surface_water_faqs.htm#05dot1.

[19] See http://www.azwater.gov/dwr/Content/Find_by_Category/Permits_Forms_Applications/Files/WaterRights/33reservoir123002.pdf.

[20] See http://www.azwater.gov/dwr/Content/Find_by_Category/Permits_Forms_Applications/Files/WaterRights/36socpublic1233002.pdf.

General stream adjudication. This procedure currently applies to water rights in the Gila River system and the Little Colorado River system. Section 45-254 specifies that a statement of claim in a general stream adjudication must include "the quantities of water and the periods of time during the year for which use is claimed." However, there is nothing specific in the statute governing a final judgment, sec. 45-257, regarding time of year limits.

No applicable administrative rules or case law were found.

California[21]

Since enactment of the California Water Commission Act on December 19, 1914, one must obtain a permit from the state to have a right to appropriate or use water (other than in certain limited exceptions). California water rights permits include the following boilerplate language:

"The water appropriated shall be limited to the quantity which can be beneficially used and shall not exceed # cubic feet per second/gallons per day by direct diversion from *Date* to *Date* of each year for Use purposes; # cubic feet per second/gallons per day by direct diversion from *Date* to *Date* of each year for Use purposes. The maximum amount diverted under this permit for all uses shall not exceed # acre-feet per year." (dates to be filled in).[22]

Appropriative rights could be acquired before 1914 under then-applicable procedure. Pre-1914 water rights are not subject to the permit system and thus do not include the boilerplate language referenced above. However, regardless of the amount originally claimed, the amount which now can be claimed under a pre-1914 appropriative right generally becomes fixed by actual beneficial use as to both amount and season of diversion. A record of water use under "pre-1914 Appropriative Rights" should be established by filing a Statement of Water Diversion and Use which asks for the amount of water used each month.[23] The filling of this statement: provides a record of water use, enables the State to notify such users if someone proposes a new appropriation upstream from their diversion, and assists the State to determine if additional water is available for future appropriators. However, according to the California Division of Water Rights, there are many claimed pre-1914 water rights where the use dates and seasons are not specified.

California has a separate statutory adjudication procedure to determine rights of the various claimants to the water of that stream system. Cal. Wat. Code Title 85, § 2769,

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[21] California also recognizes riparian water rights. A riparian right enables an owner of land bordering a natural lake or stream to take and use water on his riparian land. Riparian land must be in the same watershed as the water source and must never have been severed form the source of supply by an intervening parcel without reservation of the riparian right to the severed parcel. Generally, a riparian water user must share the water supply with other riparian users. As previously stated, riparian rights are not within the scope of this study.

[22] See http://www.waterrights.ca.gov/wrinfo/permit-terms/permit.doc

[23] http://www.waterrights.ca.gov/forms/updated_statement_062907.pdf

enacted in 1943, governs the contents of a water rights decree in a statutory adjudication:

"The decree shall in every case declare as to the water right adjudged to each party, the priority, amount, *season of use*, purpose of use, point of diversion, and place of use of the water; and as to water used for irrigation, the decree shall also declare the specific tracts of land to which it is appurtenant, together with such other factors as may be necessary to define the right (italics added)."

No applicable administrative rules or case law were found.

Colorado

In Colorado a water right is formally obtained by filing an application with the water court. Colorado statutes do not require that an application for a water right include information about time of use, see CRS 37-92-302(2)(a), nor do the state-prescribed application forms ask for such information.[24]

In general, Colorado statutes contain no requirement that a time of year limitation be included in water decrees. *See* CRS 37-92-304(7), C.R.S., which provides that "the water judge's judgment and decree shall give the names of the applicants with respect to each water right or conditional water right involved, the location of the point of diversion or place of storage, the means of diversion, the type of use, the amount and priority, and other pertinent information. In the case of a plan for augmentation, the judgment and decree shall contain a complete statement of the plan. In the case of applications for determination of water rights or conditional water rights, the judgment and decree shall state the date of the filing of the application."

However, time limitations are usually an element of decrees transferring water rights in Colorado, particularly more recent transfers. The reason such conditions are included in transfer decrees is that junior appropriators have a vested right to the continuation of stream conditions as they existed at the time of their appropriations. Changes in water rights may not injure the rights of junior appropriators. If a proposed condition will permit a change of water right to be accomplished without injuriously affecting other rights, the change should be permitted on that condition. *In re Rominiecki v. McIntyre Livestock Corp., 633 P.2d 1064 (Colo. 1981).*

CRS 37-92-305(4)(a), C.R.S. codifies these principles. It provides that, to avoid injury to other water rights, one of the terms or conditions that a water judge may include in a decree for a change of water right, implementation of a rotational crop management contract, or plan for augmentation, is "a time limitation on the diversion of water for which the change is sought in terms of months per year." This same section provides that another term or condition that can be included in a decree is "a limitation on the use of the water that is subject to the change, taking into consideration the historical use and *the flexibility required by annual climatic differences* (italics added)*."*

[24] See http://www.courts.state.co.us/chs/court/forms/waterforms/jdf296w.pdf, Application for Surface Water Rights; http://www.courts.state.co.us/chs/court/forms/waterforms/jdf297w.pdf, Application for Water Storage Right.

In addition to transfer decrees other specific types of Colorado water rights such as recreational right, CRS 37-92-305(13), C.R.S., will include time of year limitations.

In *Comstock v. Larimer & Weld Reservoir Co*., 58 Colo. 186, 145 P. 700 (1914), the reservoir company requested a decree to the effect that the irrigation season starts on April 15 and ends on September 15, and the storage season starts on September 15 and ends on April 15, and during those periods water would only be provided for those purposes regardless of priority or necessity. The basis for the request was that, for 20 years, by common consent of the users in a certain district, water had been used only for direct irrigation from April 15 - September 15, and only for storage from September 15 - April 15. The court refused the request, concluding that such a custom is directly contrary to statute and could not bind water officials or water users in other districts. "To permit courts to arbitrarily fix a definite season when water for direct irrigation may be used would be to allow them to fasten a limitation upon a vested right not attached to it by the decree itself, or by any constitutional or statutory provision or decision of this court." The court discusses various uses of water and notes, "The use of water for all these purposes, when a valid appropriation has been made, is limited only by the law of necessity. Appropriations for each of these beneficial uses take effect and may be enjoyed by the rule of priority, and under the Constitution none of them yields to the other in regard to date by reason of the character of use." The court noted two instances where a time limit would be recognized: if explicitly stated in the decree itself, or "it has been shown, by competent evidence, that the actual use had been in fact so limited."

Colorado Springs v. Bender, 148 Colo. 458, 366 P.2d 552 (1961) further clarified time of year limitations as follows: “[an] appropriator becomes entitled to take water for a beneficial use under direct appropriation, *during whatever period he can make beneficial use of the water, at the rate of flow* to which he has become entitled. If the period during which the water is needed in a particular year is short, then the total volume of water taken will be small. If the period is long and water continues to be available within the date of priority of the water right, then the amount taken will be larger…there is no direct use season, nor is there a season set apart for storage. The variable climate of Colorado from one year to another, and the widely varying growing seasons occurring in various areas of the state, furnish continuing climatic support to the rule of law announced in this respect (italics added).”

No applicable administrative rules were located.

Idaho

Prior to May 20, 1971, there were two ways in which a right to surface water could be established in Idaho. The first was to divert water and apply it to beneficial use. The second was to comply with the statutory method in effect at the time the water right was established. As of May 20, 1971, there is only one way to establish a right to surface water, and that is by following the application/permit/license procedure. The one exception to this rule is for water rights used solely for instream watering of livestock.[25]

[25] Idaho Dept. of Water Resources, http://www.idwr.state.id.us/water/rights/water_rights_establish.htm.

Currently the state is not processing applications for ground or surface water which propose a consumptive use of water within the Snake River drainage or which propose the diversion of surface water within the Salmon River and Clearwater drainages because of moratoriums on new appropriations of water.

Idaho law explicitly requires time of use limitations in all water rights decrees. See Idaho code section 42-202 (1)(C); A&B Irrigation Dist. v. Idaho Conservation League, 131 Idaho 411, 958 P.2d 568 (1998); An application for a water right must include "The period of each year during which water will be diverted, stored and beneficially used…" IDAPA 37.03.08.035.03(b)(viii). In 1999, Idaho adopted a new standard for irrigation season of use in water right adjudication, license, permit, and transfer cases that sets forth seven seasons of use for irrigation rights: February 15 – November 30; March 1 – November 15; March 15 – November 15; March 15 – October 31; April 1 – October 31; April 15 – October 31; and May 1 – October 31.[26] These diversion schedules are largely based on a 1983 report that classified consumptive use of 17 crops grown in Idaho for 54 agricultural regions based on precipitation, evapotranpiration, soil type, and wind speed data in conjunction with crop state development dates, with an emphasis on alfalfa production.[27] Diversion schedules used a two-pronged analysis of regional climate data and historic crops grown, so different diversion schedules may be applied to the same crop.

The Idaho Supreme Court has said of section 42-202(1)(c), "Since its enactment in 1967, the IDWR [Idaho Department of Water Resources] has interpreted this section as requiring the 'period of use' to be described by a specific beginning and ending date, not merely by reference to a 'season' for the use. As a result, each of the 18,175 irrigation water right licenses issued since May, 1967, has included a period of use in terms of a specific beginning and ending date." *A&B Irrigation Dist. v. Idaho Conservation League*, 131 Idaho 411, 958 P.2d 568 (1998).

Montana

Montana Water Use Act, which went into effect July 1, 1973, made changes to Montana water rights administration including the following:

1. All water rights existing prior to July 1, 1973, are to be finalized through a statewide ADJUDICATION process in state courts.

2. A PERMIT system was established for obtaining water rights for new or additional water developments.[28]

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[26] Available on the IDWR website at http://www.idwr.idaho.gov/water/rights/seasons.jpg

[27] Allen, R., and C. Brockway, (1983) "Estimating Consumptive Requirements for Crops in Idaho", Research Technical Completion Report, Idaho Water and Energy Resources Research Institute, University of Idaho.

[28] Water Rights in Montana, Feb. 2006, http://dnrc.mt.gov/wrd/water_rts/wr_general_info/waterrights_in_montana.pdf

In the statewide adjudication procedure, a statement of claim for each right arising under the laws of the state and for each right reserved under the laws of the United States which has been actually put to use shall include substantially the following: "the quantities of water and times of use claimed." MCA sec. 85-2-224(1)(c). A final decree under this procedure "must state: the inclusive dates during which the water is used each year." MCA sec. 85-2-234(6)(h).

For appropriations made after July 1, 1973, the application must be made on a form prescribed by the Department of Natural Resources and Conservation. Question 9 of this form asks the applicant to state the period of use for the proposed water right.[29] Montana's New Appropriation Rules (effective January 1, 2005), Rule 36.12.101(24) define "element" to mean "the factors which describe a water right including, but not limited to: (k) period of use."[30]

Further, Rule 36.12.112, states: (1) Deviations from the standards listed below require information supporting the period of diversion or use requested in an application:

(a) domestic January 1 to December 31

(b) stock January 1 to December 31

(c) irrigation based on the climatic area designated by the USDA natural resources and conservation service (NRCS) which is generally as follows:

(i) climatic area I March 15 to November 15

(ii) climatic area II April 1 to October 31

(iii) climatic area III April 15 to October 15

(iv) climatic area IV April 20 to October 10

(v) climatic area V April 25 to October 5.[31]

Rule 36.12.1701(12) requires that, for an application for a beneficial water user permit, "the period of diversion standards outlined in 36.12.112 must be followed." Rule 36.12.1701(19) provides "the period of time that water will be used for each purpose must be identified."

While no language specifically requires that a water permit include time of year limits, MCA sec. 85-2-311 states as one criterion for issuance of a permit that the claimant must prove "water can reasonably be considered legally available during the period in which the applicant seeks to appropriate." MCA sec. 85-2-312 states that a permit is "subject to terms, conditions, restrictions, and limitations … consider[ed] necessary to

[29]See http://www.dnrc.mt.gov/wrd/water_rts/wr_general_info/wrforms/600.pdf.
[30]New Appropriations Rules, http://www.dnrc.mt.gov/wrd/water_rts/appro_rules_ref/newappropriations_rules_1-05.pdf.
[31] New Appropriations Rules, http://www.dnrc.mt.gov/wrd/water_rts/appro_rules_ref/newappropriations_rules_1-05.pdf.

satisfy the criteria listed in 85-2-311." These statutes indicate that time of year for the appropriation logically should be an element of a permit (but, again, nothing in the statutes requires this). Upon actual application of water to the proposed beneficial use within the time allowed the permittee shall be issued a certificate of water right, MCA sec. 85-2-315, but the statute does not require that time of year be mentioned in the certificate. A quick scan of Montana's water rights query system[32] did not disclose that time of year limits are included in the online water rights information.

No applicable case law was found.

Nevada

Nevada has separate procedures for obtaining a permit to appropriate water (NRS 533.324 et seq.), and for adjudicating the rights of all claimants to water of stream or stream system (NRS 533.090 et seq.).

NRS 533.325 requires a permit to appropriate water. The statutes describing the contents of a permit application do not require a statement of period of use. However, NRS 533.350 provides that "all applications for permits shall be accompanied … by …such other data as may be prescribed by the State Engineer." The application form provided online by the state engineer asks the applicant to state the month and day on which use will begin and end each year.[33] In addition, an online Proof of Appropriation of Water for Irrigation form asks the applicant to state the beginning and ending day of the month that water has been used each year.[34] Nothing in the statutes requires that permits include period of use. See NRS 533.370. Nor does the statute governing the contents of a certificate of appropriation, to be issued after perfection of the right, require time of year limitations in the certificate. NRS 533.425. However, NRS 533.070 provides that, "where the water is to be diverted for irrigation purposes, or where the water is to be stored for subsequent irrigation purposes, the State Engineer in determining the amount of water to be granted in a permit to appropriate water shall take into consideration the …*growing season*…(italics added)."

Nothing in the statutes governing statements in stream adjudications specifically requires time of year limits. NRS 533.115. An online statement of claim form was not located. The statutes governing decrees in stream adjudications are also silent about time of year limits. NRS 533.170 and .185.

Scanned water rights decrees are accessible at this link: http://water.nv.gov/scans/Decrees/Default.aspx. The four or five examined all included time of year limits or addressed season of use. It is unclear whether all Nevada water rights decrees are on this web page. However, an examination of several rights shown

[32] See http://nris.mt.gov/dnrc/waterrights/default.aspx.
[33] See http://water.nv.gov/Forms/pdf/wtr_app.pdf.
[34] See http://water.nv.gov/Forms/pdf/poa-irr.pdf

in the Nevada Water Rights Database[35] indicates that all such rights state a period of use.

No applicable administrative rules or case law were found.

New Mexico

Like several other western states New Mexico has dual procedures for adjudicating rights to a stream and for obtaining a water permit. In stream adjudications, NMSA section 72-4-19 provides that, "Upon the adjudication of the rights to the use of the waters of a stream system, a certified copy of the decree … shall in every case declare, as to the water right adjudged to each party, the … *periods and place of use*…(italics added)."

Appropriation of water initiated on or after March 1907 requires a permit. Applications for permits shall be on forms required by the state engineer's rules, which shall "require the applicant to state the amount of water and period or periods of annual use." NMSA section 72-5-1. One may file a notice of intent to file an application for a permit and such notice shall include "the annual water use schedule." Rule 19.26.2.9A NMAC - N. Rule 19.26.2.10A NMAC – N provides that "the application [for a permit] shall include the following information: …the annual diversion schedule."[36] The state engineer's permit application form asks for period of annual use.[37] The statutes don't specify the contents of a permit. Rather, under section 72-5-6 the state engineer "shall endorse his approval on the application, which shall become a permit to appropriate." However, "the state engineer may, in his discretion, …vary the periods of annual use, and the permit to appropriate water shall be regarded as limited accordingly," so presumably period of annual use is an element of each permit. Once a permit is issued the permittee may put water to beneficial use and then must file a proof of beneficial use form. That form must state the annual diversion schedule. Rule 19.26.2.13B(1) NMAC - N.

Persons claiming pre-March 1907 rights may file "a declaration on a form prescribed by the state engineer setting forth the history and continuity of the beneficial use to which said water has been applied." Rule 19.26.2.8 NMAC - N. That form must include, among other things, "periods of use." Rule 19.26.2.8A NMAC - N.

Oregon

Oregon requires an application for a water rights permit to appropriate water. ORS 537.130. While the statute governing contents of permits, ORS 537.140, is silent on the issue, the state-prescribed application form requires that the applicant state "the time of year you propose to use the water (For seasonal uses like irrigation give dates when

[35] http://water.nv.gov/water%20Rights/permitdb/permitdb_index.cfm
[36] See http://www.seo.state.nm.us/PDF/SurfaceRulesRegs-2005-01-31.pdf
[37] See http://www.ose.state.nm.us/doing-business/forms-inst/wr-14.pdf

water use would begin and end, e.g. March 1–October 31.)".[38] The state department makes an initial order which includes a determination whether water is available "during the times…requested." ORS 537.150. The final order must include a confirmation or modification of determinations made in the initial order, which presumably would address whether water was available during the times requested. ORS 537.153. Once an appropriation has been perfected the state issues a water right certificate, ORS 537.250, which shall conform with ORS 539.140. ORS 539.140 requires that the certificate state "extent and purpose of the right" but it is unclear whether "extent of the right" means time of year.

Persons claiming pre-1909 uses of water in areas not yet adjudicated, and federal and Indian reserved rights must file a registration statement of the claim. ORS 539.240. The registration statement shall include "the period of the year during which the claimed use of water is usually made." ORS 539.240(2)(h). Rule 690-028-0029 provides that orders of registration shall include "The period of the year during which the claimed use of water is allowed." However, registration statements are not final determinations. Rather, the right of the registrant to appropriate surface or spring water under a recorded registration statement is subject to a determination under ORS 539.010 to 539.240, and is not final or conclusive until so determined.

These pre-1909 water rights become final and conclusive through an adjudication proceeding. The responsibility of the Department in the adjudication process is to gather information about the use of water and present its findings to the circuit court in the county where the water is used. The court then issues a decree that states who has the right to use water, the amount and location of water used, and the priority date for each right. The Water Resources Department then issues a water right certificate for each decreed right.[39]

Rule 690-028-0070 provides that the director of the state agency shall summarize for all claimants in an adjudication proceeding "the period of the year during which the claimed use of water is allowed," so clearly time of year is an issue in stream adjudications. ORS 539.140 sets forth the requirement for the final water right certificate: name and post-office address of the owner of the right; the priority of the date, extent and purpose of the right, and if the water is for irrigation purposes, a description of the legal subdivisions of land to which the water is appurtenant." Again, perhaps "extent of the right" can be construed to include time of year limitations.

Oregon case law recognizes that water rights may be limited by period of use. "'An appropriation of water is limited in every case, in quantity as well as for the period of time for which the appropriation is made.' Davis v. Chamberlain, 51 Or 304, 314, 98 P 154 (1908) (citations omitted). 'It is also a well-authenticated principle that appropriations may be measured by the period or time of use, as well as by the quantity employed.' McPhee v. Kelsey, 44 Or 193, 201, 74 P 401, 75 P 713 (1903). …One of the reasons for the rule set out in the Davis and McPhee cases is demonstrated by Oliver v. Skinner and Lodge, 190 Or 423, 442, 226 P2d 507 (1951): 'A prior appropriation of a definite amount of water may be made, limited to use during a definite period of time, and a subsequent

[38] See http://www1.wrd.state.or.us/pdfs/surfacewaterapp.pdf

[39] Oregon also recognizes riparian rights that were established prior to 1909, have not been abandoned or forfeited, and are verified and quantified through an adjudication procedure.

appropriator may appropriate a like quantity of water from the same source, for use during another period.'" "The right to the use of water may be subject to time limitations in addition to quantity limitations. Traditionally the surface-water right has been considered a 'vested right to take and divert from the same source, and to use and consume the same quantity of water annually forever'. But seasonal irrigation rights allow the appropriator to exercise his right during given periods of time and other persons with junior rights may then have superior rights during other periods of time." 5 Clark supra, note 9 at 73 (citing Oliver v. Skinner, 190 Or 423, 226 P2d 507 (1951)). (Emphasis in original.)" Rencken v. Young, 300 Ore. 352; 711 P.2d 954 (1985).

Utah

In Utah's stream adjudication proceedings claimants shall file a statement including "the time during which [the claimed water] has been used each year." Utah Code sec. 73-4-5. Utah Code sec. 73-4-12 provides that judgments in uncontested water rights cases shall set forth "the time during which the water is to be used each year." Judgments in contested cases shall set forth "the rights of the several claimants to the use of the water of the river system or water source as provided in Section 73-4-12." Utah Code Section 73-4-15.

Utah courts have recognized since at least 1921 that applicable state statutes require that the document establishing a water right specify the "time during which the water is to be used each year." *See Plain City Irrigation Co. v. Hooper Irrigation Co.*, 87 Utah 545; 51 P.2d 1069 (1935); *Warren Irrigation Co. v. Charlton*, 58 Utah 113; 197 P. 1030 (1921).

Others who wish to appropriate water in Utah must file an application form that shall include "the time during which [the water] is to be used each year." Utah Code sec. 73-3-2(1)(b). The state engineer must approve an application if it meets certain requirements. Utah Code sec. 73-3-8. If the appropriation is perfected and water put to beneficial use the state engineer shall issue a certificate of appropriation which shall include "the time during which the water is to be used each year." Utah Code sec. 73-3-17.

Washington

Washington state law requires a water-right permit or certificate for any use of surface water which began after the state water code was enacted in 1917. Under ARCW 90.03.260, each application for a permit shall set forth "the time during which water will be required each year." The state's permit application form requires information about "period of use (continuously or seasonal)."[40] The statutes governing issuance of preliminary permits (ARCW 90.03.290) and final water rights certificates (ARCW 90.03.330) do not explicitly require time of year limitations. However, when an appropriation has been perfected the state must issue a certificate on a prescribed form, ARCW 90.03.330. There is an online "proof of appropriation" form that asks for the time

[40] See http://www.ecy.wa.gov/pubs/ecy040114.doc.

of year water is used and, if used seasonally, the start and end dates.[41] The form has a box indicating who it was "reviewed by" and a place for a date stamp.

For water uses before 1917 there is a separate procedure for filing a water right claim.[42] A Statement of Water Right Claim is an administrative form used for registering water rights claims during the claims registration periods. If a general water rights adjudication is initiated, holders of such claims must then file a statement of claim in the adjudication for their rights to be adjudicated. Under ARCW 90.03.240, each person entitled to diversion of water in a general adjudication will be provided with a certificate setting forth, among other things, "the period during which said right may be exercised."

R.D. Merrill Co. v. The Pollution Control Hearing Board, 137 Wn.2d 118; 969 P.2d 458 (1999), which involved a change of water right, contains some relevant language. There the court recognized "long-settled western water law" establishing that a "water right is measured not only by quantity, but by time of use." The court noted that, "an appropriated water right is limited by the time and volume of the original beneficial use. 'Universally recognized as a part of the law of waters in the western states [is the rule] that a water right may be measured by time as well as by volume.'" "Purpose of use is often tied to time of use. For example, if the purpose of use is irrigation, the right will almost always be used seasonally. Domestic water use often is year-round use."

Wyoming

Wyoming also has both a permit and a stream adjudication procedure. The statute governing contents of the permit application, W.S. 41-4-501, is silent about time of year limitations. The state's permit application form does not require time of year.[43] Nothing in the statutes requires time of year in the permit or final appropriation, see W.S. 41-4-511.

Neither the statute governing contents of statements of claim in adjudication proceedings, W.S. 41-4-305, nor the statute describing the contents of the final certificate, W.S. 41-4-325, require time of year limits.

Instead of using a stipulated season of use, Wyoming relies upon W.S. 41-3-101 to administer the seasonal application of water. Specifically, W.S. 41-3-101 states, "Beneficial use shall be the basis, the measure and limit of the right to use water at all times ...." If a warm spring/early runoff is occurring, the local water commissioner may allow early irrigation if beneficial use can be achieved. The same beneficial use test is applied for late season irrigation that may be extended due to warm fall weather.

The statute governing change of use also is silent about time of year requirements, W.S. 41-3-104. However, chapter 5 of the Wyoming Water Administration Rules states that,

[41] See http://www.ecy.wa.gov/pubs/ecy040126.pdf.
[42] Washington's 1917 Water Code left unaffected riparian rights that existed in Washington prior to 1917, although it made appropriation through the permit system the exclusive method of obtaining new water rights. Riparian rights that were perfected by 1932 are still recognized.
[43] See http://seo.state.wy.us/PDF/SW1_06-06.pdf.

in a petition for a change of use, “One important item in this petition not found in others is a comparison of the proposed use with the historic use of the water right being changed. This comparison could be in the form of a consumptive use report or study made on return flows, both historic and under the proposed use. If a water right has been exercised historically during only a part of the year, the State Board of Control shall limit the new use to that same period of time. The petitioner would have to apply for a current priority right to cover the time not covered by the historic use.”[44]

No applicable case law was located.

[44] http://soswy.state.wy.us/RULES/5741.pdf

Appendix C: Calendar Date Requirements in Colorado's Water Compacts

The summaries below include the specific seasonal (i.e., calendar date) requirements found in the 8 water apportionment compacts to which Colorado is a signatory.[45] They do not include a review of the often voluminous agreements, decrees, and operating rules that typically evolve on and around compacts (e.g., the so-called "Law of the River" on the Colorado), nor do they include those rivers for which the rules of apportionment have primarily been established by the Supreme Court using principles of equitable apportionment.[46] These, admittedly, are significant omissions, but the intent here is not to provide a detailed or sophisticated analysis of any particular basin or situation. Rather, the goal is to provide an initial screening of basins, compacts, and language that could potentially prove problematic.

As summarized below in Table 3 and the following text, only 3 of the 8 compacts in Colorado are devoid of any calendar dates, and are thus likely immune from administrative issues associated with temporal changes in the hydrograph associated with climate change.

Table 3. Key Calendar Dates in Colorado's Compact Apportionments

Compact	Some Specific Start/Stop Dates Listed
Arkansas River	March 31/April 1, October 31/November 1
Colorado River	N/A
Costilla Creek	May 15/May16, September 30/October 1
La Plata River	February 15, December 1
Republican River	N/A
Rio Grande	April 1, October 31, Oct 1, June 30
South Platte River	April 1, October 15
Upper Colorado River	N/A

[45] Note that calendar date references to items such as the filing deadlines for annual reports are not included here or in the main report, as they are irrelevant to the functioning of the allocation system described in the compact.

[46] For example, the Laramie River originates in Colorado before flowing into Wyoming to join the North Platte. The Laramie has been the subject of considerable litigation between Wyoming and Colorado, with the 1922 decree being the most salient decision (*Wyoming* v. *Colorado*, 259 U.S. 419 (1922), modified and rehearing denied, 260 U.S. 1 (1922), vacated, 353 U.S. 953 (1957)). Downstream, the North Platte has been a frequent source of litigation between Nebraska and Wyoming (and occasionally Colorado, given Colorado's interests on the Laramie). The initial North Platte decree was issued in 1945 in *Nebraska v. Wyoming*, 325 U.S. 589 (1945) and has been revisited since, including in *Nebraska v. Wyoming*, 507 U.S. 584 (1993). The case was settled and all claims dismissed in Nebraska v. Wyoming, 534 U.S. 40 (2001). In principle, the North Platte decree was not intended to modify, in any way, the arrangements on the Laramie; however, this has been an ongoing point of contention; e.g., see *Nebraska v. Wyoming*, 507 U.S. 584 (1993). This collective body of law does contain some elements based on the irrigation/non-irrigation season distinction, occasionally specified with calendar dates; thus, the potential for a mismatch between changing hydrographs and apportionment rules is a possibility on this combined system.

Arkansas River Compact of 1948 (CO-KS)

The Arkansas River is subject to 3 major apportionment compacts: one between Colorado and Kansas, one between Kansas and Oklahoma, and one between Oklahoma and Arkansas. The agreement between Colorado and Kansas primarily describes operation of John Martin Reservoir, and includes calendar dates to describe the winter and the summer storage seasons. Specifically, Article V(A) provides that the winter storage season will commence on "*November 1st of each year and continue to and include the next succeeding March 31st*." Summer storage, conversely, is defined in Article V(B) as commencing on "*April 1st of each year and continu[ing] to and include[ing] the next succeeding October 31st."* Summer storage is junior to decreed priorities (defined in paragraphs F and G) and to river flows demanded by Colorado (up to 500 c.f.s) and Kansas (750 c.f.s.).

No other significant references to calendar dates are included; however, it is worth noting that the 2 time periods specified, given their location in spring and fall, are potentially sensitive to any changes in the timing of snowmelt and the end of the irrigation season. Additionally, it should be remembered that this compact has been the subject of extensive litigation, both historically and recently, so assessing the importance of any compact provision should be done with an eye toward those agreements and decrees that now accompany the compact. Nonetheless, in sum, it would appear that this compact offers fewer concerns (regarding the timing of flows) than most.

Colorado River Compact of 1922 (CO-NM-UT-WY-AZ-CA-NV)

It is at least somewhat ironic that the most contentious compact in the region, and the one that is infamous for being based on a hydrological assumption that poorly fits actual conditions, is actually silent regarding provisions relating to calendar dates or anything related to timing of flows. Given the focus of the Colorado River Compact on flows measured in 10-year moving averages, however, this is not surprising. In this basin, as well as many others, to the extent that calendar dates play a role in water allocation, it is likely to be in delivery contracts and other elements of the Law of the River. Additionally, since many deliveries come from major (multi-year) storage facilities, calendar dates that do exist in delivery contracts are probably largely immune to perturbations associated with small time-shifts in the hydrograph, and even if such problems existed, they could likely be addressed administratively without any need to revisit the terms of the compact.

Costilla Creek Compact of 1963 (originally 1944) (CO-NM)

The Costilla Creek Compact uses calendar dates to distinguish between the "irrigation season" and the "storage season," the former extending from "*May 16 to September 30, inclusive*" (Article 2(q)) and the latter from "*October 1 of one year to May 15 of the succeeding year, inclusive*" (Article 2(r)). During the storage season, Article 5(c) provides that "*no water shall be diverted under direct flow rights unless there is water in excess of the demand of all operating reservoirs for water from Costilla Creek for storage*." This, presumably, restricts the movement of the irrigation season earlier (i.e., prior to May 16) and/or later (i.e., after September 30), provided that there is a demand to store water during these times.

La Plata River Compact of 1922 (CO-NM)

This compact uses calendar dates to describe two key time periods: a period of unrestricted uses for each state between "*the first day of December and the fifteenth day of the succeeding February*" (Article II(1)), and an apportionment period between "*the fifteenth day of February and the first day of December of each year*" (Article II(2)). During the apportionment period, use of water in each state is unlimited as long as the "*mean daily flow at the Interstate Station is one hundred cubic feet per second, or more*" (Article II(2)(a)). If this condition is not met, then "*the State of Colorado shall deliver at the Interstate Station a quantity of water equivalent to one-half of the mean flow at the Hesperus Station for the preceding day, but not to exceed one hundred cubic feet per second*" (Article II(2)(b)). In order to administer this formula, the compact requires the operation of "*suitable devices for recording the flow of water in said river at all times between the 15th day of February and the 1st day of December of each year*" (Article I).

At first glance, these temporal requirements do not appear to offer much likelihood of becoming problematic due to a modestly shifting hydrograph, as February 15 is unlikely to be near any obvious transition in the water demand season. What may prove more problematic is the minimum streamflow requirement, as one expected consequence of climate change in many basins is a reduction of flows in the summer.

Republican River Compact of 1942 (CO-KS-NE)

Much like the Colorado River Compact, the Republican River Compact has been the subject of considerable controversy in recent years, but not due to any calendar date provisions in the agreement. The compact features no mention of calendar dates or any text related to timing of flows, but rather apportions the river in terms of annual volumes.[47]

Rio Grande of 1938 (CO-NM-TX)

Several elements of the Rio Grande Compact contain provisions directly tied to calendar dates. Most key measurements (e.g., credits, debits, spills, delivery obligations) are defined and tabulated using a "common period of time," often a "calendar year," but this is generally not done in a way that is likely to be problematic given modest changes in the timing of streamflows, melt or irrigation seasons since the start of the calendar year (January 1) is not near any of the temporal elements of hydrologic thresholds (Article I). In Article III, most elements of Colorado's state-line delivery obligation to New Mexico are defined in terms of calendar years, with one notable exception. The delivery obligation is, in part, based on a Conejos Index Supply, which is defined with respect to "*the natural flow of Los Pinos River at the U.S.G.S. gaging station near Ortiz and the natural flow of San Antonio River at the U.S.G.S. gaging station at Ortiz, both during the months of April to October, inclusive*" (Article III(1)). The obligation of New Mexico to maintain streamflows downstream (ultimately for the benefit of Texas) is based on a schedule tied to measured flows upstream but is "*exclusive of the months of July,*

[47] The key issue in this basin has been, and continues to be, managing the connection between surface water and groundwater.

August, and September" (i.e., applicable only from October 1 to June 30) (Article IV). Procedures for modifying these schedules are provided to account for changes in (or problems with) gaging stations, depletions of natural runoff, and/or trans-mountain diversions, but it does not appear that a shift in the hydrograph was an anticipated change covered by the provisions listed or due to gaging station errors (Article IV(6) and Article V).

South Platte River Compact of 1923 (CO-NE)

The South Platte River Compact is explicit in defining an apportionment based on an approximate measure of the irrigation season. Specifically, Article II(1) requires that flows near Julesburg be measured "*at all times between the first day of April and the fifteenth day of October of each year*." This time period corresponds to the irrigation season apportionment, during which "*Colorado shall not permit diversions from the Lower Section of the river … to an extent that will diminish the flow of the river at the Interstate Station, on any day, below a mean flow of 120 cubic feet of water per second of time …"* (Article IV(2)). During the rest of the year (i.e., the "*fifteenth day of October of any year and the first day of April of the next succeeding year*") Colorado has the "*full and uninterrupted use and benefit of the waters of the river flowing within the boundaries of the State,*" with the exception that some water is reserved for use by Nebraska in a canal originating in Colorado (near Ovid), with diversions "*limited exclusively*" to the annual period between "*the fifteenth day of October of any year and the first day of April*" (see Article IV(1) and Article VI(2)(a-b)).

The reliance of the compact on the April 15 date is potentially problematic, as that date is relatively near the spring snowmelt season. The text of the compact makes some allowances for adjustments, although it is unclear if climate change would be a suitable justification for action. Article IV(5) states that "*variable climatic conditions, the regulation and administration of the stream in Colorado, and other causes, will produce diurnal and other unavoidable variations and fluctuations in the flow of the river at the Interstate Station, and it is agreed that … minor or compensating irregularities and fluctuations in the flow at the Interstate Station shall be permitted*" as long as they are not a product of "*neglect, error or failure in the performance of duty by the Colorado water officials."*

Upper Colorado River Compact of 1948 (CO-NM-WY-UT)

The Upper Colorado River Compact does not prominently feature the use of calendar dates and thus does not appear directly vulnerable to problems caused by a changing hydrograph. The use of calendar dates is limited to the timing of some administrative matters, including the requirement that many measurements be based on a water year, defined as "*that period of twelve months ending September 30 of each year*" (Article II(k)).

Appendix D: Case Studies

In order to better understand how state legal regimes may or may not anticipate and/or accommodate shifts in hydrology induced by climate change, water decrees were examined in four states: Idaho, Utah, Wyoming, and Colorado.

Idaho

A review of 25 water right decrees was completed for hydrologic basins 61, 63, 65, 67 located in the Weiser, Payette, Boise, and Southside Snake basins in Southwest Idaho using the IDWR Water Right and Adjudication Search database.[48] These basins have shown a strong early snowmelt signal, and close proximity to Boise provides an important municipal element useful in examining potential management implications. Water rights examined include irrigation, municipal, recreation, fish propagation, fish habitat storage, storage, and transfers.

Each water right examined revealed specific dates of use. Diversion schedules varied depending on use. Fish propagation, fish habitat storage, and storage (including irrigation, industrial, power, municipal, and stockwater storage) had year-round schedules. Domestic use from storage consistently had a 3/15-11/15 schedule. Irrigation schedules included 4/1-10/31, 3/1-11/15, and 3/15-11/15. Municipal schedules were either 03/15-11/15 or 01/01-12/31. Recreation often had a 01/01-12/31 schedule, but we also found 04/01-10/31. Transfer schedules were difficult to discern using the database, but we did find several with a 3/15 – 11/15 schedule.

Interviews with several Idaho Water Resources Department (IDWR) personnel[49] confirmed that most, if not all, rights are bound by specific dates of use. However, administrators have the flexibility to shift diversion schedules, particularly for irrigation rights, to accommodate seasonal climatic and hydrologic conditions and demand patterns. To date, no legal challenge has arisen over conflicting diversion schedules or failure to enforce those schedules. However, expansion of consumptive use due to earlier snowmelt for rights with year-round diversion schedules could potentially be problematic in the future, especially in years of below average yield.

Utah

The Utah Division of Water Rights maintains an online database of limited pertinent information for each water right.[50] We examined 17 water right summaries from the database, some of which mention more than one water right. These summaries included rights in the Salt Lake City area, Moab, along the Green River and the Colorado River, and attempted to capture a wide variety of different types of uses. Certain trends emerged such as a rough April 1-October 31 diversion season for irrigation rights.

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[48] Idaho Water Resources Department Water Right and Adjudication Search available at: http://www.idwr.idaho.gov/apps/ExtSearch/SearchWRAJ.asp

[49] Interviews conducted on April 5, 6, 8, 2008.

[50] Accessed at http://www.waterrights.utah.gov/wrinfo/query.asp

Utah Division of Water Rights personnel indicate that dates of use are assigned to rights on a case-by-case basis rather than as defined by administrative rule as in Idaho.[51] Further, while state law requires that each water right is assigned a date of use, in reality these dates are rarely enforced. Instead, water right holders divert when the water is needed, and are only limited by the amount of water physically available. Annual climate and hydrologic conditions largely dictate when water right holders divert, and there has never been an issue brought before the courts relating to competing diversion schedules between two water right holders. Earlier snowmelt has not affected administration of water rights simply because there is a large degree of flexibility in seasonal diversion schedules.

Wyoming

No time of use limitations were found in our review of 23 certificates of record in the State Engineers Office (SEO) water rights database representing townships 13, 14 (Cheyenne area), 32, and 33 (Upper Green River basin).[52] Interviews with SEO personnel revealed that water commissioners and superintendents occasionally assign temporal limitations when deemed appropriate. For instance, if water is being used to irrigate a field that is buried by snow on April 15, the water commissioner can shut off the diversion because *beneficial use* of that water is not being achieved.

State personnel observed that earlier spring snowmelt has already led to increased late-season calls on water rights due to below average streamflows. As a result, some junior rights are receiving less water or no water at all. These (and related) problems have all been greatly exacerbated by recent drought conditions. In some cases, reservoir supplies that normally can extend the growing season have been severely stressed, and rights that have not been regulated in the past are now being regulated.

Increased regulation causes opposition from rightsholders that have historically never been subject to regulation provisions. SEO personnel anticipate that this is a growing trend in Wyoming due to an increasing population and the resulting strain on water supplies.

Colorado

We analyzed time of use language in a sample of 24 water right decrees from Divisions 1 (South Platte Basin) and 2 (Arkansas Basin). The sample was generated using the HYDROBASE database available for public access in the State Engineer's Office (SEO).[53] Within Division 1, we organized water decrees by use (i.e., irrigation, municipal, and so on), and further divided rights by appropriation date (senior to junior), and amount appropriated (largest to smallest). We then selected the 2-4 most senior and largest irrigation, instream, municipal, storage, and transfer water decrees for analysis of

[51] Interviews conducted on April 5, 6, 8, 2008.
[52] Wyoming's searchable Water Rights Database is located at http://seo.state.wy.us/wrdb/index.aspx
[53] The database is not available online.

time of use language. It is worth noting that the majority of decrees examined contained a transfer or change in use.

A review of water right decrees, including major transfers in Divisions 1 and/or 2, revealed several overarching themes. Most irrigation decrees did not include any time limitations. No clear trends were observed in the in-stream flow and reservoir decrees examined. Time limitations were most likely to appear in decrees that arose out of transfers. When temporal limitations have been included in these decrees, they were intended to prevent injury to junior rightsholders and/or prevent expansion of historic use. Most likely the parties and the water court proceeded with the assumption that there would be no changes in the hydrologic cycle, if they even considered the issue. Those temporal limitations that appeared in decrees generally were water right specific, making it difficult to identify clear trends; however, several approaches were identified. Based on the decrees examined (irrigation, storage, instream, municipal, and transfer) four time of use limitations emerged:

- Diversions allowed only during a specific time period defined by a beginning and end date;
- A "diversion season" or "storage season" referred to with no mention of specific dates;
- Different priority dates assigned for the same water rights depending on the use and time of diversion;
- Diversion rates calculated by day and/or month per share.

Those approaches that limit diversions to a specific time of year could impede diversions if those dates do not correspond to peak streamflow. Calculated diversion rates, specifically approaches with a variable schedule and a pro rata reduction system in times of shortage, provide a sustainable approach to addressing earlier snowmelt caused by increasing temperatures. Calculated diversion rates provide administrative breathing room to accommodate hydrologic variability. Rights with general mention of a diversion or storage season have the best opportunity to capture premature spring snowmelt and even expand historic use.

Discussions with personnel from the State Engineer's Office and Colorado Water Conservation Board (CWCB) revealed that, while Colorado has not yet seen any clear trends in earlier snowmelt, the potential impact of earlier snowmelt on water rights is a definite concern within the state.[54] Irrigation rights typically do not have time limits, and as long as injury is not done to other parties, a rightsholder can start irrigating several weeks earlier than usual if the water is physically in the system and does not exceed the appropriated amount. While another rightsholder could sue to force the first rightsholder to stay within historic use patterns, in reality, such lawsuits do not occur. Until recently, "good neighbor/gentlemen's agreements" have allowed water users to work out their differences. These ad hoc arrangements are beginning to crumble, however, possibly because of cultural shifts associated with transfers of water from agriculture to municipal users, a fear of trans-basin diversions, a growing suspicion of nearby water right users, and drought, which amplifies all issues.

[54] Interview conducted on July 18, 2008.

Municipal rights are often the result of transfers from irrigation and are thus limited by historic diversions. These rights could be impacted if other rights are exercised earlier as a result of changing hydrologic conditions. It is somewhat ironic to observe that municipal users relying on rights acquired from ag-to-urban water transfers are limited in their diversions by a calendar established by past irrigation practices, whereas current irrigators have no such constraints. Earlier snowmelt could also impact instream flow rights tied to biological needs which have dates of use defined by historic environmental conditions.

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- *Note*: Items listed below are those specifically cited in the text of the report and Appendices B, C and D. As a literature review, Appendix A includes its own listing of literature relating (in part) to subjects of climate change and water rights.

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