Groundwater Law

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Abstract

This chapter reviews fundamental legal principles relating to groundwater quantity and quality in the United States, Australia and the European Union. It also examines legal approaches to three key "integration" challenges in groundwater law, which arise in relation to many of these foundational principles. First, groundwater law must deal with the relationship between groundwater and surface water—specifically, how abstraction of one should be controlled due to impacts on the other. A second and related challenge is making legal provision for integrating groundwater with its environment, that is, making legal provision for ecological water requirements. Finally, legal frameworks face the significant challenge of dealing with groundwater management in the cross-boundary context. By comparing and contrasting approaches to common and burgeoning legal challenges across different regions, this chapter seeks to highlight the key issues that regulators and groundwater users must consider and confront in dealing with them, and a range of potential legal solutions.

7.1 Introduction

Despite their many differences, Australia, the western US and Europe, and indeed major regions of the world, all rely on groundwater as an important water source for cities, agriculture, and ecosystems (Chap. 2). Their systems of groundwater law—a powerful tool for controlling access to groundwater, groundwater depletion, and

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pollution—have proven to be useful for each other to consider, as well as for other nations worldwide (e.g. Garry 2007; Grafton et al. 2009; Thomas 2009; Folger 2010; Ross and Martinez-Santos 2010; Nelson 2011a). This chapter describes key aspects of the groundwater law systems of these three regions and the ways in which they deal with key emerging challenges, both as a guide and a caution to areas facing similar issues. In most countries, groundwater regulation has typically proceeded in "laissez faire mode" (Kemper 2007). But as varying combinations of population growth and its associated industry and agriculture, climate variability, and water quality challenges threaten groundwater in many places of the world (e.g. Bates et al. 2008), the importance of legal tools for dealing with these issues increasingly will come to the fore.

This chapter is structured in three parts. Part One deals with the fundamental legal nature of groundwater, and ownership of groundwater. Part Two describes key differences in the levels of government responsible for regulating groundwater quantity, and introduces key approaches to controlling the extraction of groundwater at two levels: the macro, or basin scale, and the micro scale of individual rights. This part also deals with four key emerging challenges in the context of groundwater extraction: permit- or licence-exempt wells; the emergence of a human right to water; integrated management of groundwater with hydrologically connected surface water and dependent ecosystems, and integrated management across political jurisdictions that share the same water source. These groundwater quantity issues have been particularly dominant in the legal discourse of the western US and Australia, where water scarcity is common and competition for water is high. Lastly, Part Three deals with groundwater quality protection, a regulatory concern in relation to both point-source pollution and, increasingly, diffuse sources of pollution.

The approaches taken in the western US, the EU and Australia to the groundwater law issues discussed here vary richly, not only in terms of the legal principles and tools available, but also in the extent to which they have developed and matured. The fundamental aim of this chapter is to highlight several key emerging issues that regulators, in particular, must consider and confront in groundwater management, and a range of potential legal approaches to these issues.

We draw on examples from each of the three focus regions in each part of the chapter, but in each part, emphasise the experience of jurisdictions in which the subject issue is particularly critical. Accordingly, in describing groundwater quantity concerns, we emphasise the experience of the western US and Australia, presenting these first; and in describing groundwater quality concerns, we emphasise the experience of the EU and the western US, presenting these first.

A final note: a comprehensive treatment of groundwater law, and notable subjects within it, lie outside the scope of this chapter. These include legal aspects of groundwater monitoring, trading, enforcement, pricing, managed aquifer recharge, stakeholder involvement in management, and non-regulatory aspects of groundwater law, such as private legal actions.

7.2 Envisioning Groundwater in Law: Its Nature and Ownership

7.2.1 What Is Groundwater, for the Purposes of the Law?

Different legal systems conceive of groundwater differently. The way in which groundwater is defined is of central importance in groundwater law. Too narrow a legal definition can unduly constrain the reach of the law, putting important resources beyond its control. An overly broad definition could complicate administration of the law if it means that permission is required to undertake activities affecting resources that are not, in fact, subject to concern about depletion or contamination.

Definitions of groundwater vary along several dimensions. Key points of difference include whether the definition includes water in the unsaturated zone, as well as in the saturated zone of the soil profile; whether it includes saline water or only freshwater; whether there is a depth limit to the water that is considered "groundwater"; the extent to which the definition includes things that are associated with groundwater, like the aquifer structure; how to distinguish surface water and groundwater where they are subject to different allocation arrangements; whether to distinguish between naturally occurring groundwater and groundwater that has been "artificially" stored using managed aquifer recharge; and how different administrative units of groundwater are defined. While these issues are too numerous to discuss in detail here, some examples of this variation are given here to illustrate notable approaches.

Law plays a unique place in defining groundwater in western US states—because the legal view can differ so radically from the scientific view. Some western US states draw complex, narrow legal distinctions between different legal "types" of groundwater, treating some groundwater (often called "percolating" groundwater) differently to groundwater that is closely connected to a river (often called "underflow", "subflow" of a surface stream, or "underground streams"). These distinctions bear no resemblance to geological reality (Klein 2005). Different allocation regimes and rules can apply to each legal "type" of groundwater, and the geographical boundaries of these types are rarely clear. This can result in a troublesome lack of clarity about exactly what legal regime applies to groundwater in a particular location—confusion that may only be able to be resolved through extensive technical studies or litigation (Sax et al. 2006).

Among the regions under discussion here, arguably the broadest definition of groundwater is found in Australia's federal *Water Act 2007*. That legislation defines "ground water" as "(a) water occurring naturally below ground level (whether in an aquifer or otherwise); or (b) water occurring at a place below ground that has been pumped, diverted or released to that place for the purpose of being stored there; but does not include water held in underground tanks, pipes or other works". "Water resources", which are the basis of administrative planning units, are defined extremely broadly to include, among other things, "ground water", an aquifer whether or not it currently has water in it, and "all aspects of the water resource (including water, organisms and other components and ecosystems that contribute to the physical state and environmental value of the water resource" (sub-section 4 (1)). The broad definition of groundwater clearly includes water artificially stored in aquifers using managed aquifer recharge, and the broad definition of water resources clearly indicates the importance of dependent ecosystems, including those that depend on groundwater, within the Australian federal water governance framework.

Within the European Union, the EU Water Framework Directive (adopted by the Council representing EU Member States and the European Parliament) provides a framework for water management, including groundwater. It should be stressed that each country of the 28 EU Member States must transpose EU directives into their national laws but that the practical implementation remains each nation's responsibility. The WFD defines groundwater more narrowly than does Australia's federal Water Act, as "all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil" (Article 2, item 2). The Directive also refers to a "Body of groundwater", which is a distinct volume of groundwater within an aquifer or aquifers. This volume is generally used to define administrative reporting units. Some Australian states take a similar approach, for example, defining groundwater as comprising only underground water in aquifers (e.g. sub-section 3(1), *Water Act 1989* (Victoria), Schedule 4, *Water Act 2000* (Queensland)).

7.2.2 Who Owns Groundwater?

The difficulty of conceiving of ownership in relation to water has been noted in very disparate jurisdictions as well as at the international level (Burke and Moench 2000; McKenzie 2009). Ownership of groundwater can be an emotion-charged issue: on the one hand, it is closely connected to land and ownership of land; on the other, it is often vital for public water supply systems and supporting ecosystems of high public value. In some places, groundwater has historically been treated very differently to surface water in relation to questions of ownership and allocation because its flowpath is less obvious, and even "secret" and "unknowable" (Klein 2005). This view was considered to justify the traditional English common law rule of absolute ownership of groundwater by overlying landowners, which was imported to both the US and Australia (Klein 2005; Gardner et al. 2009). Today, however, it may surprise some to know that across our three diverse focus regions, public or government ownership of groundwater is the norm, though principles for allocating it differ markedly between jurisdictions.

In the western US, with a few exceptions (as in Texas, where the English common law rule of absolute ownership still stands), the public as a whole owns the water and the state is its trustee. In other words, the state has a non-proprietary, regulatory interest in groundwater (Surett et al. 2013). A landowner generally has a proprietary right to *use* the water underlying the land, rather than ownership of the water itself (Surett et al. 2013). The question of whether water rights are property rights is not completely settled, however (e.g. Ross-Saxer 2010). Different states use different systems of allocation, relying on a variety of principles and procedures contained in statues and judge-made law. The doctrine of prior appropriation, which applies in most western US states, gives greater reliability to groundwater rights that developed earlier in time, rather than treating uses as generally equal in reliability and subject to correlative reductions in reliability in conditions of scarcity. Other systems are "correlative" groundwater rights among overlying landowners in California and Nebraska; and absolute ownership in Texas (Chapman et al. 2005). Judicial allocation necessarily involves court processes, and litigation has the potential to be lengthy and expensive—though this is not always the case, particularly where courts are used to formalise water rights in a basin, to which the parties have already agreed out of court.

Australian law also has its origins in the English common law, originally giving overlying landowners absolute, almost unrestricted rights to own and extract the resource. Legislative changes then vested groundwater in the Crown, and introduced a system of administrative regulation, under which the Crown grants individuals the right to use groundwater. Common law rights were generally abolished (Gardner et al. 2009). In some cases, statutes expressly sought to avoid the extensive water rights litigation that were perceived to occur under western US judicial allocation processes (Clark and Myers 1969). Rights to use groundwater in Australia are now generally considered property rights. Indeed, the creation of a highly regulated property rights system for water is an express premise of two decades of celebrated Australian water reforms aiming to improve economic efficiency and environmental sustainability (Gardner et al. 2009; McKenzie 2009).

Similar to Australia, in the EU, the entitlement to use groundwater (owned by the State) is given by public authorities through licences and permits which are issued for varying periods of time in different states. These are, however, not considered private property rights, but rather rights to exploit the resources in compliance with legally binding rules.

7.3 Controlling Groundwater Extraction

Establishing what groundwater is and who owns it is just part of the task of groundwater law. Its main function is to manage groundwater quantity by setting limits on total extraction to achieve a variety of objectives, and by controlling extraction as between individual users, in many cases by assigning individual rights to extract. The first step towards doing that is to decide what level of government to entrust with those regulatory tasks. The experiences of Australia and the EU show varying degrees of supra-state (federal and EU, respectively) involvement and coordination in certain high-level aspects of groundwater policy and law, but allocating water to individual users remains uniformly the task of lower levels of government. In the western US, the federal government has almost no formal role.

7.3.1 Who Regulates Groundwater Quantity?

Different jurisdictions allocate responsibility for regulating groundwater differently as between local, state and federal governments. Broadly, the locus of responsibility for groundwater quantity regulation reflects the general degree of acceptance of centralised government in each region, with responsibility tending to lie higher in government hierarchies in the EU and Australia and lower in the western US.

Western US states are generally responsible for regulating groundwater quantity, though in some states (as in Nebraska and most regions of California), this role is assumed by local governments. The federal government is directly involved in groundwater quantity concerns to a much lesser degree, for example, through funding mechanisms (Leshy 2008b).

Until very recently, Australia approached groundwater quantity regulation in much the same way: states had carriage of water allocation issues, and federal influence was felt mainly through funding mechanisms. However, after over a decade of federal water policy driven by economic incentives offered to the states, the federal *Water Act 2007* introduced a much more direct federal role. This is particularly so in the Murray-Darling Basin, an agriculturally and ecologically critical basin the size of France and Spain combined. Under arrangements that are yet to come fully into effect, the federal government sets Basin-wide limits on surface water and groundwater extraction, while states continue to allocate water to individual users within those overall caps.

In contrast to western US states (among which there is no coordination on groundwater quantity administration) and Australian states (among which there is coordination in policy, through the National Water Initiative, but relevant overarching law only in the Murray-Darling Basin), the EU's Water Framework Directive more strongly coordinates the regulation of groundwater quantity among Member States by establishing goals and planning processes in supra-national law. Actual water allocation is carried out by different authorities and agencies at different levels.

The issue of regulatory responsibility aside, the key substantive function of groundwater law is to manage groundwater extraction to achieve particular objectives. This can occur at both a macro- (i.e. basin-) scale, or at the level of individual rights to extract the resource. Though not discussed here, another focus of groundwater quantity law is requiring well spacing to control interactions between wells, and regulating well construction methods to prevent pollution.

7.3.2 Macro-Level Controls: Establishing Groundwater Withdrawal Limits Through Plans and Other Means

Jurisdictions use a variety of principles for establishing overall (e.g. basin-wide) withdrawal limits that restrict the allocation of groundwater rights—concepts like "safe yield" (western US), "good groundwater status" (EU), and "environmentally sustainable diversion limits" (Australia). In some cases, these overall withdrawal limits are established by management plans—an approach strongly favoured in Australia and the EU.

In most western US states, there is a weaker focus on overall basin extraction limits than in Australia or the EU, perhaps because of the absence of a water planning tradition (Chapman et al. 2005), and reliance on a common law tradition of water allocation. A disadvantage of the western US common law approach in contrast to Australia's water allocation planning approach is the relative difficulty of changing vital concepts like the principles that limit extraction, and how those principles are exercised in a particular year, to match changing water availability and also the modern recognition of the environmental water needs of groundwater-dependent ecosystems (Pilz 2010).

Walnut Creek Intensive Groundwater Use Control Area, Kansas

In the middle of Kansas, Cheyenne Bottoms lies on one of the busiest, globally significant shorebird migration paths. During their spring migration, about 45 % of North America's shorebird population, up to 600,000 individuals, use these wetlands, which are the largest in the interior US. By 1989, groundwater pumping to support the agricultural economy surrounding the wetlands had depleted Walnut Creek, the source of a surface water right held by the Kansas Department of Wildlife and Parks to water the wetlands. They were completely dry during the height of spring migration (Hays 1990). In response to these effects, the Kansas water rights administrator, the State Engineer, took the unprecedented step of declaring an "intensive groundwater use control area" and establishing rules to ban new groundwater pumping, cut back on existing groundwater rights, and introduce a "cap and trade" system for irrigation water rights. At the time, farmers predicted that groundwater pumping restrictions would have devastating economic effects. However, a 2011 economic analysis suggests that the initially significant economic effects of these rules diminished rapidly, so that in the long-run, producers made the same amount of money from crops while using less water (Golden and Leatherman 2011).

Where they exist, water plans in the western US tend to be used as water supply planning tools "designed to insure that adequate water is available for certain kinds of uses" (Wadley and Davenport 2013) rather than tools for setting basin-scale limits on water allocation. California provides an example of this approach: the California Water Code provides for various kinds of water management plans, including groundwater management plans, but these generally do not affect groundwater allocation (Nelson 2011b). Some western US states that have made recent changes to their groundwater management regimes have introduced the concept of water plans that are capable of constraining groundwater allocation to within cumulative caps (as in groundwater planning processes that aim to achieve "desired future conditions" in Texas (Witherspoon 2010)). Some other western states have water plans that affect groundwater allocation in a few designated groundwater areas that are recognised to require special management (e.g. Intensive Groundwater Use Control Areas in Kansas (Sophocleous 2012; and see text box)). In some eyes, a water planning approach is highly controversial, interpreted as an attack on a "pure" prior appropriation system, where seniority and "beneficial use" are the major determinants in allocating water (Wilkinson 1991).

Rather than using a planning mechanism, western US states tend to express overall extraction limits through state statutes and sometimes through judicial precedent, though on occasion neither is particularly clear. Some western US state statutes explicitly limit extraction to "safe yield"—roughly, constraining groundwater extraction to the level of natural and artificial recharge (e.g. Arizona Revised Statutes section 45-561(12), 45–562)—or some variation of that concept. However, as a technical concept, safe yield has been discredited as a management tool capable only of protecting against groundwater over-exploitation, since it ignores discharge points at surface water bodies and ecological users of groundwater (Alley et al. 1999). Some states increase or decrease the allowable extraction above or below the level of recharge by qualifying the concept of safe yield to include other aspects, for example, those related to economics and water quality impacts. In Washington, safe yield prohibits the state from granting appropriative rights beyond the basin's capacity to yield water within a reasonable or feasible pumping lift in case of pumping developments, or within a reasonable or feasible reduction of pressure in the case of artesian developments (Revised Code of Washington § 90.44.070). In Utah, safe yield means extracting the amount of groundwater that can be withdrawn from a basin over a period of time without exceeding the long-term recharge of the basin or unreasonably affecting the basin's physical and chemical integrity (Utah Code Annotated § 73-5-15). Generally speaking, however, environmental considerations in relation to groundwater quantity (i.e. seeking to maintain some portion of natural basin discharge that supports ecosystems) have not yet become a prominent consideration in setting basin-scale limits on extraction in the western US.

In Australia, macro-scale extraction limits are set by statute, usually through legislatively prescribed water planning processes. Broadly, two major goals of national water policy are "to increase the productivity and efficiency of Australia's water use . . . and to ensure the health of river and groundwater systems by establishing clear pathways to return all systems to environmentally sustainable levels of extraction." (Preamble, *Intergovernmental Agreement on a National Water Initiative*). National assessments of the progress of states in achieving these goals have repeatedly found shortcomings in relation to groundwater, however (e.g. National Water Commission 2009, National Water Commission 2011).

Australian water statutes generally cite both environmental and socio-economic objectives (e.g. section 3, New South Wales *Water Management Act 2000*). They limit extraction in a basin to a level that reflects a combination of environmental and economic principles, with the balance between the two varying depending on the jurisdiction. The federal *Water Act 2007* gives an example of an environment-led limit: under that legislation, a legally binding federal management plan for the Murray-Darling Basin requires states to ensure that aggregate groundwater pumping does not exceed "sustainable diversion limits" set to reflect "an environmentally sustainable level of take" (section 23). Key elements of that term, however, remain undefined in the legislation, and have been the subject of contestation. By contrast, the state of Victoria provides for "permissible consumptive volumes" to be set for groundwater administrative units without detailing the criteria to be applied to set these limits (section 22A, *Water Act 1989*), and they have not traditionally been set with regard to ecological water requirements. While Australian jurisdictions strongly emphasise the value of pre-planning acceptable extraction volumes, and constraining allocation through licences accordingly, some states do not impose allocation plans and general controls on groundwater extraction in basins that are only lightly exploited, preferring to wait until more intensive exploitation occurs before undertaking the technical work necessary to nominate extraction limits (e.g. prescribed water resources in South Australia: sections 76, 125, *Natural Resources Management Act 2004*).

In the EU, the Water Framework Directive sets a groundwater quantity goal of achieving "good quantitative status" for all water bodies by 2015. This will be achieved if the long-term annual average rate of abstraction is compensated by the aquifer recharge. This definition is complemented by principles that go beyond traditional "safe yield" concepts. The status definition also implies that the abstraction should not lead to alterations in flow directions which would result in saltwater or other intrusion. In addition, the level of groundwater should not be subject to anthropogenic alterations such that it would result in failure to achieve the environmental objectives (good chemical and ecological status) for associated surface waters, any significant diminution in the status of such waters, and any damage to terrestrial ecosystems which depend directly on the groundwater body. The policy framework opens the possibility for the Member States to use artificial recharge, providing that this does not jeopardise the quality of the groundwater.

As a general observation, to a greater or lesser degree, depending on the state, there seems to be a general movement towards basin-wide withdrawal limits that take some account of the impacts of extracting groundwater on the environment. This is quite a historical shift, which has generally mirrored the inclusion of such considerations in earlier surface water frameworks, or in a few cases occurred alongside it. This shift is proving much more advanced in Australia and the EU, at least on paper, than is the case in the western US, where often highly developed environmental protections for surface water are not replicated in relation to groundwater. The ease of modifying overarching principles through statute- and water plan-based processes may be one factor explaining this. Another might be the political difficulty of constraining economically important and water-intensive agricultural sectors in the western US, which have a much greater dependence on groundwater than does agriculture in most European countries or Australia (van der Gun 2013).

7.3.3 Micro Level Controls: Rights, Entitlements and Licences

Other than through basin-scale limits on extraction, the other major way in which groundwater law controls groundwater pumping is through rights, entitlements and licences at the scale of the individual groundwater user. Most jurisdictions within our focus regions require a person to obtain a right or entitlement to extract groundwater for particular end uses in all or many geographic areas. Notable exceptions to this are California and Texas in the western US, which do not generally require that a person obtain a permit to use groundwater, even for very large uses, except in small geographic areas. The requirements to obtain a permit or licence to use groundwater, and the processes involved, vary quite dramatically among our three focus regions, as well as within them (Patrick and Archer 1994; Bryner and Purcell 2003; Chapman et al. 2005; Gardner et al. 2009).

Western US groundwater allocation regimes tend to focus on a relatively narrow range of considerations that emphasise the human, rather than the environmental impacts of extracting groundwater. When considering an application for a permit, western US decision-makers commonly must consider: whether water is available for appropriation, the possibility of impairing existing rights, the applicant's ability to put the water to immediate beneficial use, public interest considerations, which are often undefined, and water conservation considerations (e.g. Idaho Code § 42-203A). A third party usually has strong rights of review; often, they not only have the right to protest a licensing decision, but in doing so, trigger a public hearing on the matter (e.g. Idaho Code § 42-203A, Montana Code Annotated §§ 85-2-308, 85-2-309). However, mirroring arrangements in relation to basin-scale extraction limits, in very few jurisdictions are environmental matters explicitly mentioned as a groundwater permitting consideration (e.g. Montana Code Annotated § 85-2-311(3)(b)(vi), Idaho Administrative Code § 37.03.08.045(e)(ii); North Dakota Century Code, § 61-04-06(4)(c)), and in any case, it appears that these matters are rarely considered with great rigour in practice.

By contrast, Australian legislation tends to produce long lists of matters that a decision-maker must consider in determining whether to grant a licence, with a heavier focus on environmental impacts. A key consideration is whether granting the licence would be consistent with any applicable overall consumptive limit for the area or applicable management plan (e.g. section 147, *Natural Resources Management Act 2004* (South Australia); section 40, *Water Act 1989* (Victoria)), which may itself contain further location-specific considerations relevant to licensing. Additional statutory considerations relate to the impacts on third parties of granting the proposed right to extract, and impacts on elements of the environment, such as water quality; water conservation policies; impacts on the aquifer structure (e.g. sections 40, 53, *Water Act 1989* (Victoria)); and impacts on connected resources, discussed further below. Opportunities for the public to be involved in the issuing of groundwater licences—and the emphasis that agencies place on this form of participation—are often relatively limited, with most of the focus of public participation being at the water planning stage (Nelson 2013). This may be problematic where the effects of extracting groundwater—particularly ecological effects—are very localised, and likely able to be anticipated only by locals. Local-scale groundwater-dependent ecosystems (GDEs) are unlikely to have been captured in macro-scale planning processes, and are not guaranteed to be addressed by centralised decision-making (Nelson 2013). Recent efforts to map GDEs at a fine scale (Bureau of Meteorology (Australia) 2013) may go some way towards addressing this danger by making this information easily available to decision-makers and the public.

The relative paucity of western US legal arrangements in relation to water planning, basin-scale caps, and even the brevity of permitting considerations can be explained in part by its very different conception of the role of time, compared with Australia. Rather than focusing heavily on prospective caps or groundwater permitting considerations, western US groundwater law deriving from prior appropriation principles controls the impacts of groundwater extraction primarily by looking backwards. That is, it seeks to avoid over-pumping by curtailing the exercise of a groundwater right that has been found to impair an earlier water right. Dangers with this approach lie in the political difficulty of reducing established uses, and dealing with the time lags that can separate ceasing to pump groundwater and the remediation of adverse impacts.

In the EU, authority to pump groundwater is generally given through permits that refer to the quantity of water abstracted and/or pumping capacity. The permits are closely linked to the risks of not achieving the Water Framework Directive's goal of "good quantitative status", i.e. implying that the level of groundwater in the groundwater bodies is such that the available groundwater resource is not exceeded by the long-term average rate of abstraction. This implies that issued exploitation licences are operated in such a way that they comply with the good status objectives (i.e. restrictions may be imposed in case of water scarcity).

7.3.4 The Challenge of Exempt Uses

Permit or licence-exempt groundwater uses can be a significant governance issue, in that they escape many standard legal controls, and may pose a cumulatively significant draw on the resource. Dealing with the potential impacts of such uses has been a particular issue in the western US and Australia (Bracken 2010; Sinclair Knight Merz et al. 2010). The particular end uses that are exempt from the general requirement to obtain a permit or licence vary from place to place. Uses of groundwater for domestic use and livestock watering are an important use category that rarely requires a permit in Australia and the western US (Bracken 2010; Sinclair Knight Merz et al. 2010).

In addition to the problem of many small exempt uses, sometimes even large individual uses of groundwater are exempt from regular groundwater licensing or permitting processes. An important example is groundwater produced as a by-product of extracting coal seam gas, or CSG (also known as coalbed methane). CSG production has raised concerns in relation to its groundwater impacts in both the western US and Australia (National Research Council (U.S.). Committee on

Management and Effects of Coalbed Methane Development and Produced Water in the Western United States 2010; Nelson 2012b). Petroleum and gas legislation in the Australian state of Queensland, where much of Australia's CSG production occurs, explicitly enables CSG producers to withdraw an unlimited amount of groundwater as part of their CSG activities, without requiring a water entitlement (section 185(3), *Petroleum and Gas (Production and Safety) Act 2004*). The same position was recently reversed in Colorado after a state Supreme Court decision (*Vance v. Wolfe*, 205 P.3d 1165 (Colorado 2009)). Similar issues have arisen in other western states (Klahn and Tuholske 2010; Valorz 2010).

7.3.5 The Challenge of a Human Right to Water

Whereas exempt groundwater uses can challenge groundwater governance by evading regular controls, nascent concepts of a human right to water could add further complexity to groundwater administration by conferring a different sort of special status on select groundwater uses. There are many areas of uncertainty in the meaning and practical implementation of a human right to water, in general (Good 2011). Regardless of the jurisdiction, key issues in relation to operationalising a human right to water will be its possible fiscal implications, the precise obligations that it creates, on whom, and how the right would be enforced (Thor 2013). A human right to water seems likely to attach to relatively small uses, like direct consumption and sanitation, which likely already benefit from permit-exempt status in many areas. Accordingly, new governance issues associated with the right seem more likely to be associated with groundwater quality, than groundwater quantity. An exception to this might be situations in which large-scale groundwater pumping for other uses affects the availability of water sources that are used to satisfy the human right to water. In any case, a human right to water is an emerging issue which each of the focus regions will likely need to address in the future.

Internationally, various political statements acknowledge a "right to water", including a resolution by the UN General Assembly (Thor 2013). Our focus regions take different approaches to this issue. There is no explicit reference to a human right to water in EU law but the first recital to the Water Framework Directive says "Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such", which is an implicit reference to human rights and principles of sustainability. Similarly, in Australia, a human right to water is not thought to be recognised at the federal level, but it has been argued that it could include principles of sustainability that would have a bearing on groundwater management, were it recognised (Good 2011).

California law has been more explicit. The state recently recognised a right to water in statute (Assembly Bill 685, codified as California Water Code § 106.3), though its formulation is relatively weak. AB 685 declares that it is state policy that every human being has the right to clean, affordable, and accessible water for human consumption, cooking, and sanitary purposes. However, the only duty that AB 685 imposes is a duty of "relevant" state agencies to "consider" the state policy on the human right to water when revising, adopting, or establishing policies, regulations, and grant criteria. It does not expand any state obligation to provide water, require the development of additional water infrastructure, or create an enforceable right for water system customers to demand immediate access to safe and affordable water. Though the precise legal implications of the law are not yet clear, recent focus on the lack of access to clean water of many disadvantaged communities in California, who rely on contaminated groundwater (Salceda et al. 2013), promises that it will be an important area of future legal development.

7.3.6 The Challenge of Connecting Groundwater Abstraction to Surface Water and Ecosystems

Integrating different elements of the environment, institutions, and actors is a noted challenge in water and environmental law (Klein 2005; Godden and Peel 2010; Thompson 2011). A particular challenge for groundwater law is how to deal with the relationship between groundwater and surface water—specifically, how abstraction of one should be controlled due to impacts on the other—particularly where these connections are affected by significant technical uncertainty. In general, the key issue is how groundwater pumping impacts rivers (though withdrawing surface water may also affect groundwater systems). A major related challenge is making legal provision for integrating groundwater with its environment, that is, making legal provision for ecological water requirements, thereby extending the now well-established concept of protected in-stream flows to groundwater. In most jurisdictions, this is an emerging and unsettled area of law, which seeks to address the water requirements of species and ecosystems that depend entirely on groundwater, as well as those that are associated with streams that receive water from groundwater-derived baseflow. The experiences of our focus jurisdictions demonstrate that key issues in determining a regulatory response to integrating groundwater, surface water and ecosystems will be determining trade-offs between using a complex, accurate, relatively certain, but administrative expensive mechanism (as in some states of the western US); and using broader, simpler, cheaper mechanisms, which offer arguably less certain results (as in Australia).

Western US mechanisms for integrating groundwater and surface water are arguably the most developed of the focus regions. They are also probably the most expensive to administer, since they require case-by-case technical assessments. Many western US states establish a threshold for the maximum proportion of the water withdrawn by a well that is predicted to be captured from a river over a certain period of time. States differ radically in the degree to which they will permit groundwater pumping to "impair" surface water rights. The relevant proportion in Colorado, for example, is 0.1 % of the annual pumped volume within 100 years of continuous withdrawal (Hobbs Jr 2010). Oregon, on the other hand, adopts a default threshold assumption that a well would usually cause substantial interference with a river if it is located less than a mile from the river, and derives 25 % of the withdrawal from the river within 30 days (Oregon Administrative Rules § 690-009-0040). States that have low regulatory thresholds for acceptable impairment of surface water rights tend to use flexible market-type mechanisms to enable groundwater pumpers to offset these impacts, and thereby meet the regulatory requirements for having their development proceed.

By contrast with protections for surface water rights, protections for (GDEs) are at a very early stage of development in the western US. They are achieved chiefly by way of principle-based thresholds for impairment, such as a "public interest" test for granting a groundwater permit that can include protections for fish and wildlife (e.g. Idaho Administrative Code § 37.03.08.045(e)(ii), North Dakota Century Code § 61-04-06(4)(c)). With more development, the public trust doctrine—which in most states applies only to certain surface waters, rather than groundwater—could provide a promising route to protecting GDEs (Craig 2010; Spiegel 2010).

Protections for GDEs in the Blue Mountains, New South Wales

Not far from the suburban sprawl of Sydney, Australia, lie the Blue Mountains, which have attained World Heritage status on account of their biodiversity values, cultural values, geodiversity, water production, and wilderness values. A key threat to the area's GDEs, particularly hanging swamps, comes in the form of new groundwater wells. The sensitivity of the ecosystems have warranted not only a ban on commercial wells in the Blue Mountains Sandstone Groundwater Management Area in 2007, but also short-term restrictions on the use of existing wells (NSW Office of Water 2011). Most significantly, given the generally high degree of reverence for domestic use of groundwater (see 'The challenge of exempt uses'), the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources (Sydney Basin Blue Mountains Groundwater Source) bans the granting or amending of bore approvals within 100 m of listed, high priority GDEs in the case of "bores used solely for extracting basic landholder rights", and 200 m for other uses; generally within 40 m from streams; and within 100 m from the top of an escarpment (clause 41).

Australian jurisdictions tend to use simpler volumetric or spatial thresholds to protect GDEs, such as clear drawdown limits or no-go zones for new wells around high-priority GDEs (see text box); or volumetric limits on groundwater pumping in a basin, where the limit is calculated to take into account acceptable impacts on rivers or other GDEs (Tomlinson 2011; Nelson 2013). In rare cases, caps on consumptive water use or rules that prevent extraction in response to water level triggers may cover both surface water and groundwater, where interaction effects happen over relatively short time-frames (e.g. Government of New South Wales 2010; Goulburn-Murray Water 2011). A further form of protection is offered by broad statutory considerations, such as requirements to have regard to environmental impacts when a decision-maker is considering a licence application (Nelson

2013). These approaches tend to require less case-by-case technical analysis than in the western US, but may offer less certain local protections, either because they apply at a macro level (e.g. large-scale volumetric limits), or because their requirements are not specified in detail (e.g. broad statutory considerations).

The EU's Water Framework Directive addresses groundwater-surface water interactions by incorporating connections in its key goal: achieving "good quantitative status" implies that impacts of pumping groundwater should not result in alteration of status of associated surface waters or in any damage in groundwater-dependent terrestrial ecosystems. This regulatory mechanism is, in principle, well established. The extent to which it has been achieved will be evaluated in 2015 in consideration of these possible impacts.

7.3.7 The Challenge of Connecting Groundwater Abstraction Across Boundaries

In addition to integrating different water sources and users, groundwater law frameworks also face the significant challenge of dealing with groundwater management in the cross-boundary context. This manifests, first, as rules for sharing cross-boundary aquifers; and second, as an allocation of responsibility for surface water depletions experienced in one jurisdiction, caused by upstream pumping of connected groundwater in another jurisdiction. Our focus regions illuminate several regulatory options for making these connections: proactive formal legal arrangements designed to prevent conflict, which may or may not involve creating a new regional institution; litigation to resolve conflicts; or, in some cases, a lack of coordinated management.

In the western US, litigation-based solutions to cross-boundary groundwater issues tend to be relatively common, and pro-active formal legal arrangements, at least at the interstate level, fairly rare. In particular, the impact of pumping groundwater on interstate rivers has been a key issue subject to significant litigation. Lengthy litigation has dealt with how groundwater pumping affects surface water delivery obligations under multiple interstate agreements, which do not explicitly deal with groundwater (Hathaway 2011; Thompson 2011). In some cases, this litigation has resulted in multi-million dollar damages being paid by upstream groundwater pumping states to downstream states. Such litigation in some cases has been followed by comprehensive management arrangements that seek to avoid similar problems recurring, including integrated surface water-groundwater technical models and monitoring programs. This litigation has proven to be a key driver of intrastate efforts to integrate the management of groundwater and surface water (Nelson 2012a).

Although litigation-based management of transboundary groundwater-surface water resources has proven the norm in the western US, the recent agreement between eight US states and two Canadian provinces governing management of the Great Lakes, and connected groundwater and tributaries takes a promising, different approach (*Great Lakes-St. Lawrence River Basin Water Resources*

Compact, effective 2008). The Compact applies to "Waters of the Basin", which are defined to include tributary groundwater (Article 103). The Compact establishes a central authority for management and implementation, and applies a common "decision-making standard" in relation to signatories regulating water uses within their territories (Article 203), but at the same time, grants them a relatively high degree of autonomy (Hall 2006).

In shared groundwater basins in the western US, which lack the complexity of highly connected surface water, "divided administration is the status quo" (Davenport 2008). Major interstate aquifers, like the High Plains Aquifer System (which includes the Ogallala Aquifer) underlying parts of South Dakota, Nebraska, Wyoming, Colorado, Kansas, Oklahoma, New Mexico, and Texas, are administered by each state under separate arrangements. There is no formal coordination of the sort found in interstate river basin commissions or compact arrangements (Sophocleous 2010; Hathaway 2011), and no Supreme Court litigation to apportion the groundwater (Leshy 2008a). Rather, a situation of "de facto groundwater allocation" through "a combination of unilateral actions and lack of action" occurs in many basins, for example the Hueco Bolson Basin underlying New Mexico, Texas and Mexico; in others, some mechanisms like data sharing exist, but cooperation is notably lacking (Hathaway 2011, p. 106). Commentators have noted that interstate groundwater conflicts are developing, particularly where groundwater use is growing (Hathaway 2011).

Australia's management challenges in relation to transboundary aquifers are relatively simple, since it lacks international groundwater boundaries and has relatively few states. The most significant aquifer that crosses interstate boundaries is the Great Artesian Basin, the world's largest artesian basin (Mackay 2007). Coordinated management of the basin occurs under the Great Artesian Basin Coordinating Committee, which has a largely advisory role, rather than regulatory functions. Its main focus has been a scheme to fund the capping of artesian wells that previously were allowed to run freely, causing a loss in aquifer pressure (Mackay 2007). At a smaller scale, a groundwater border agreement between the states of Victoria and South Australia, for example, controls depletion of a non-recharged aquifer by bores other than stock and domestic bores by setting zone-based caps on extraction and drawdown (Schedule 1, *Groundwater (Border Agreement) Act 1985* (Victoria)). It takes effect through state-level licensing decisions within a 40 km-wide cross-border area of the aquifer, which must be made consistent with the Agreement.

The EU Water Framework Directive deals with interjurisdictional groundwater issues in a notably more proactive and structured way than has been the case in either Australia or the western US. It requires Member States to establish international river basin districts, thus requiring cross-boundary cooperation for overall water management, including groundwater (article 13, items 2). It also recommends Member States to establish appropriate coordination with non-EU countries in river basins crossing the boundaries of the EU (this is however not as strict as the first regulation, as the article says: the Member States "shall endeavour to establish cooperation") (article 13, item 3). This is the only reference to cross-boundary aquifer situations concerning quantity aspects. In addition to this, the Groundwater Directive (daughter directive to the WFD) requests Member States to coordinate the establishment of threshold values (groundwater quality standards) in bodies of groundwater within which groundwater flows across a Member State's boundary. Similarly to the WFD, it also recommends ("shall endeavour") coordination with non-EU countries sharing a transboundary aquifer for the establishment of groundwater quality standards (threshold values).

7.4 Controlling Discharges of Pollution to Groundwater

Groundwater quality is a subject matter that regulation often treats separately to groundwater quantity. This occurs despite the physical connections between groundwater quantity and quality: polluting groundwater effectively reduces the quantity of usable groundwater, and pumping groundwater can cause quality problems in the form of spreading contaminant plumes and seawater intrusion. Groundwater quality and quantity are regulated under very different frameworks in Australia and the western US. This section briefly describes these frameworks, and introduces the EU's more integrated approach to controlling polluting discharges to groundwater. Key elements of regulatory frameworks for groundwater quality are setting quality goals, and regulating potentially polluting activities to achieve those goals—both point and diffuse sources of pollution.

7.4.1 Macro-Level Groundwater Quality Goals

Jurisdictions in each of our focus regions differ in the goals that they set for groundwater quality, the methods of setting those goals, and divisions of regulatory responsibility. In the EU, the goal and definition of "good chemical status" are given in the Water Framework Directive (article 2, item 25 and Annex V, Table 2.3.2) and elaborated in a "daughter directive" which was adopted in 2006 (Directive 2006/118/EC). In this context, the compliance regime is based on quality objectives (compliance with relevant standards, no saline intrusion) that have to be achieved by the end of 2015. The direction chosen is based on compliance with EU-wide groundwater quality standards (covering nitrates and pesticides) which reinforce the parent directives (i.e. the standards are to be applied across the EU). Regarding other pollutants, the adoption of numerical values at Community level was not considered to be a viable option, considering the high natural variability of substances in groundwater (depending upon hydrogeological conditions, background levels, pollutant pathways, and interactions with different environmental compartments). Consequently, the regime of the "daughter" Groundwater Directive requests Member States to establish their own groundwater quality standards (referred to as "threshold values"), taking identified risks into account and a list of substances given in an annex to the Directive. Threshold values must be established for all pollutants that characterise groundwater bodies at risk of not achieving the good chemical status objective and this should be done at the most appropriate level, e.g. national, river basin district or groundwater body level. They concern not only pollutants that may be naturally present in groundwater but also synthetic pollutants. Regarding compliance, evaluation will be based on a comparison of monitoring data with numerical standard values (EU-wide groundwater quality standards and/or threshold values set by individual Member States).

In contrast to the EU's single, comprehensive legislative approach to regulating groundwater pollution, the US federal approach has been characterised as an inadequate "patchwork" (Thomas 2009). In relation to groundwater, the main US federal approach has been to regulate key activities that have the potential to pollute groundwater, as described below, rather than to set quality standards, for which it provides in the case of surface water under the Clean Water Act. A form of macro-level control is adopted, though, under the Safe Drinking Water Act. That Act provides for setting "maximum contaminant levels" for public water supply sources. In addition, its "sole source aquifer" program provides for the designation of aquifers that are the sole or principal source of drinking water for an area. The federal government may not fund a project that may contaminate such an aquifer, endangering public health. Under the Safe Drinking Water Act, states must also develop wellhead protection programs to prevent pollution near wellfields that provide public drinking water (Sax et al. 2006). A small number of US state laws mirror the Clean Water Act's approach to surface water protection, prohibiting the discharge of pollutants into groundwater (Thomas 2009). Australia's federal groundwater quality policy echoes, and has been influenced by, these approaches.

In Australia, the role of the federal government in groundwater quality is largely restricted to recommending policy, undertaking joint planning with states, and offering funding (Nelson 2011a). Though groundwater quality—mainly salinity—has been a traditionally strong concern in many parts of Australia, a recent decade of extreme drought ensured that most attention focused on groundwater quantity; federal groundwater quality policy is now significantly out of date. The *Guidelines for Groundwater Quality Protection in Australia* (GGQPA), a component of the *National Water Quality Management Strategy*, were published in 1995, and recent reviews have recommended that they be updated (Nelson 2010; Sundaram et al. 2010). Separate policies apply to protecting groundwater quality in specific contexts, such as managed aquifer recharge, the application of recycled water and drinking water standards. The basic approach promoted in the GGQPA is to assess a groundwater resource, set beneficial uses for the resource and accompanying quantitative or qualitative criteria, develop protection measures, and undertake monitoring (Chap. 5, GGQPA; Nelson 2010). Australian states shoulder the major regulatory burden in relation to groundwater quality. Goals for environmental quality (including groundwater quality) are generally set out in state-level environment protection policies, which may be binding or non-binding. They typically aim to protect region-specific "beneficial uses" or "environmental values" of the groundwater, consistent with national policy.

7.4.2 Micro-Level Controls: Diffuse and Point Sources

Jurisdictions commonly control the discharge of point-source pollutants to groundwater, but controls over diffuse sources of pollution uniformly have proven more challenging. In the EU, the compliance regime of the Groundwater Directive implies that values of groundwater quality standards (threshold values) should not be exceeded at any monitoring points in groundwater bodies. However, it opens the possibility for exceeding concentrations at one or more monitoring points providing that an appropriate investigation shows that the exceeding concentrations (e.g. point source pollution) are not considered to present a significant environmental risk, nor endanger the uses of groundwater. In addition, Member States are required to assess the impacts of existing plumes of pollution in groundwater bodies that may threaten their overall quality objectives, in particular plumes resulting from point sources and contaminated land. The Directive requests Member States to carry out trend assessments for identified pollutants in order to verify that plumes from contaminated sites do not expand, do not deteriorate the chemical status of the groundwater body (or bodies in case of grouping) and do not present a risk to human health and the environment. Non-legally binding guidance documents are used to guide Member States on assessing the condition of groundwater and related matters (e.g. European Commission 2007; Quevauviller 2008; European Commission 2009).

In Australia, macro-level groundwater quality goals are operationalised through pollution licensing processes, which generally apply only to point sources. State laws regulate potentially polluting activities, often requiring that an authorisation to undertake such an activity only be granted consistently with, or considering, legislative instruments that set out the beneficial uses of groundwater (e.g. section 47(1)(e) *Environment Protection Act 1993* (South Australia)). Water allocation planning processes may also include a requirement to consider beneficial uses (e.g. Tasmania Department of Primary Industries and Water 2009). Economic incentives to minimise pollution also appear in state laws in the form of fees for environmental authorisations that reward best practice (regulations 5CA, 5EA, Environment Protection Regulations 1987 (Western Australia)) and tradeable emissions schemes (e.g. Parts 9.3A *Protection of the Environment Operations Act 1997* (New South Wales)). State laws (as opposed to policies or funding programs) dealing with non-point source pollution take several forms, but are much less developed than those for point sources. They can appear as general statutory duties not to pollute the environment or cause environmental harm, supported by codes of conduct or "best practice" guidelines for non-point source activities; and statutory matters that land use planners must consider when faced with land use decisions. Voluntary guidelines, codes of conduct and self-regulatory approaches tend to be used more commonly, in practice, than mandatory obligations (Nelson 2011a). Remedial measures take the form of environment protection or abatement orders (Bates 2006).

As alluded to above, the US federal government's key water quality legislation, the Clean Water Act, does not apply to groundwater in terms of licensing point source discharges, though this is a somewhat contentious matter in relation to groundwater that is hydrologically connected to navigable waters, which are covered (Thomas 2009; Makowski 2012). Rather, the potential for groundwater pollution is addressed by a collection of federal legislation that applies to particular activities that may pollute groundwater. The federal *Safe Drinking Water Act* applies to licensing underground injection activities, including aquifer storage; the *Resource Conservation and Recovery Act* regulates solid waste including hazardous waste, and applies to underground storage tanks; and the *Comprehensive Environmental Response, Compensation and Liability Act* deals with remediating past contamination using a strict liability approach (Sax et al. 2006). Non-point sources historically have been dealt with using voluntary control measures, but there is evidence that federal encouragement of states to use more rigorous enforcement mechanisms is producing promising results (Nelson 2011a).

At the state level, jurisdictions take a variety of approaches to seeking to prevent groundwater pollution. California provides an example of a state that is generally regarded as having a promising approach to non-point source groundwater pollution, in particular. Its *Porter-Cologne Water Quality Control Act* gives the state direct power to regulate nonpoint sources, including agriculture. Regional water quality control plans set out water quality objectives and beneficial uses; waste discharges are subject to either general (based on discharge category) or individualised requirements based on the relevant basin plan and other factors (sections, 13241, 13263 California Water Code). Any person discharging waste, including from non-point sources, must report the discharge and pay an annual fee, unless a waiver applies (section 13260, California Water Code). Unfortunately, the temptation to grant waivers to agricultural non-point polluters has historically been irresistible (Nelson 2011a; Smith and Harlow 2011). More recently, examples of stronger controls on agricultural non-point source pollution of groundwater have arisen, notably requirements for certain categories of farms to have a farm water quality management plan, monitor and report on groundwater conditions, monitor and report on discharges, and have a nutrient management plan (California Regional Water Quality Control Board Central Coast Region 2012). Concerns over nitrate pollution have been instrumental in driving this approach (California Regional Water Quality Control Board Central Coast Region 2012).

7.5 Conclusion

This chapter sets out a framework of key issues that arise in groundwater law, with an emphasis on regulatory approaches adopted in the western US, Australia, and the EU. It will be apparent that these regions, and the jurisdictions within them, differ in many ways in their approaches to groundwater law—both controlling groundwater extraction and controlling discharges of pollution to groundwater. These differences begin at the most basic level of defining what groundwater is and who should regulate it, and establishing limits to groundwater withdrawal and groundwater pollution at the level of the basin and of individual users and polluters, respectively.

It is not possible to deem any one approach universally most effective or desirable for all situations, and we do not attempt to do so. We do, however, suggest a series of key issues that are likely to pose challenges to effective groundwater management, and that decision-makers should consider in establishing, evaluating, and revising their groundwater laws. In the experience of our three focus regions, these basic challenges include: dealing with groundwater uses that are exempt from licensing requirements; interpreting and applying the emerging notion of a human right to water; connecting groundwater abstraction to impacts on surface water and ecosystems; connecting groundwater abstraction across boundaries; and dealing with both diffuse and point sources of pollution.

While some of these issues have been of regulatory concern for some time, others have arisen over only several years, more recently. Despite the many differences between jurisdictions, they have one regulatory requirement in common: groundwater law must continue to evolve and adapt to newly emerging and dynamic challenges in groundwater management in order to effectively manage groundwater quantity and quality, now and in the future.

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