Compliance, cooperation, and credibility: institutions and enforcement in California groundwater

James H. Skurray [a, b, *]

[a] Centre for Environmental Economics & Policy, University of Western Australia
M089, 35 Stirling Highway, Crawley, W.A. 6009, Australia

[b] National Centre for Groundwater Research & Training
Adelaide, South Australia

* Corresponding author
E-mail address: jhs36@cornell.edu

12th December 2014
Working Paper 1404, School of Agricultural & Resource Economics
www.are.uwa.edu.au

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieve International Excellence

Citation: Skurray, J.H., 2015. *Compliance, cooperation, and credibility: institutions and enforcement in California groundwater*. Working Paper 1404, School of Agricultural & Resource Economics, University of Western Australia. Available via: http://ageconsearch.umn.edu/handle/35880.

NOTICE: This is a draft of an article to be submitted for consideration in *Society & Natural Resources: An International Journal*. Once published, a link will be provided here to the definitive version.
The version dated 12/12/2014 is a preliminary draft; content will be added / changed.

Abstract

The success of any groundwater management plan depends on user compliance. There is an intimate relationship between regulatory regimes and pumper perceptions. As well as its enforcement powers, an agency's behavior sends information to users. While enforcement power need not always be used to be effective, it must be seen as credible as well as legitimate. Perceived legitimacy has different sources – or may be lacking – depending on the origins, and implementation, of the regulatory apparatus. This paper examines a number of California groundwater basins, employing variables from Ostrom's analytical frameworks. In comparison with a West Australian regulated basin - where compliance is low, monitoring weak, and enforcement ineffective - we examine the effect on compliance of the adjudicated basin approach. We focus on the role of enforcement provisions, and their origins and implementation, in shaping appropriator attitudes towards compliance. Key attributes of effective systems include perceived legitimacy among users, mutual visibility of actions, and the credible threat of enforcement or sanction. We examine the extent to which 'administrative adjudications' may more cost-effectively provide the benefits of court adjudications. The paper illustrates that monitoring and enforcement are more effective and less costly when institutions encourage cooperation than when they promote competition. While norms, social capital, and trust must bear upon and inform the types of rules chosen at the collective-choice level, they also arise from the operation of those rules – i.e., from users' iterative reactions to the arrangements chosen. Groundwater management plans should incorporate design elements encouraging collaborative attitudes among users.

Keywords

Institutions; governance; common-pool resources; commons; collective action; institutional analysis; sustainability; coercion; institutional design; groundwater management; voluntary compliance;

1 Introduction

The compliance of resource users with management regimes is central to their success or failure. Given the credible threat of overwhelming force, even the most recalcitrant of resource users would comply. In the absence of a dictatorial regime, however, levels of compliance vary greatly. In the West Australian case considered here, for example, there are explicit and publicly available extraction limits on each user. But these are in many cases not adhered to, and their exceedance is largely unsanctioned. Yet this is a so-called 'command-&-control' regime. By contrast, the literature on 'voluntary compliance' shows that there are conditions under which users will willingly comply with resource extraction limits, and that these conditions do not necessarily include the threat of overwhelming force. Indeed, the level of sanctions required for effectiveness can be "surprisingly low" (Theesfeld 2010, p. 137).

The over-use of renewable but limited natural resources is rife. This is not always a result of non-compliance; legitimized extraction limits may be set too high. Whereas Skurray & Pannell (2012) addressed the need (in the groundwater context) to establish extraction limits in accordance with an aquifer's sustainable yield, this paper is concerned with the causes and origins of user compliance with limits on resource use (rather than with the appropriateness or otherwise of the limits themselves). These are the two central aspects of the single issue: unsustainable resource extraction. We use the example of groundwater throughout, but the origins and nature of compliance, and their usefulness in designing resource use governance regimes should be broadly applicable.

Some resources are famously over-exploited, and California groundwater carries that stigma. While Texas is known for the 'right of capture' doctrine, parts of California may be familiar for the unwillingness of their groundwater users to submit to limitations on their pumping. (See, for example, 'California Lagging Other Western States in Groundwater Management' - Figure 8 in LAO 2010.) It is now several decades since a map of overdrafted California groundwater basins was produced, showing the extent of the problem (the 1980 Department of Water Resources map is reproduced as 'Basins in Overdraft' in Choy & McGhee 2014). And the well-known USGS photograph illustrating land subsidence due to groundwater extraction in the San Joaquin Valley was taken even

earlier. There are, however, (and perhaps equally famously due to the work of Ostrom, Blomquist, and others) parts of California where groundwater has been managed successfully for many years. While the 'problem areas' have suffered from a higher-order problem than non-compliance (i.e., the absence of anything to comply *with*) the successfully managed areas are of interest not only because their users willingly submitted to extraction limits and to the monitoring of their usage, but also because of the high compliance levels that have persisted for decades in those cases. This paper relates the origins and the attributes of these monitoring and enforcement regimes to their success, and contrasts these with the very different origins and attributes – and with the ineffectiveness – of the regime in a state-regulated basin case in Western Australia.

In this paper we examine two types of governance arrangement: the state-regulated basin, and the adjudicated basin. The state-regulated basin approach is represented by the case of the Gnangara groundwater system (GGS) around the city of Perth in the state of Western Australia. The adjudicated basin examined is the Central Basin in Southern California.

In common-pool resource settings, compliance is a form of cooperation (and non-compliance a form of free-riding). As so many negative environmental impacts result from the excess indulgence in certain human activities as they relate to common-pool resources, we can consider the question of how to foster compliance (i.e., cooperation in limitation of resource use) to be one of importance. We consider coercion's role as a means of promoting compliance, rather than as a solution in itself.[1]

Ostrom's work illustrates many examples of sustainability in resource appropriation across a range of settings and resource types. The paper applies variables synthesized from Ostrom's frameworks. As well as employing some of her 'design principles' (1990; 1993), we also employ some of the variables she proposes for the analysis of institutional

1 This approach is not only more interesting theoretically, but avoids the political unpalatability of governance by fiat. The fact that all environmental problems could be solved coercively by a well-informed and benevolent dictator is not considered further here. As Ackerman has pointed out, “[t]he problem is not describing how to reduce American carbon emissions; the problem is creating incentives that will make people feel like they have been allowed to do it in a free market way” (DN, 2009). In other words, command & control in its truest sense (coercive enforcement) is unpalatable at this stage.

choice – of when and how certain institutional decisions are arrived at by groups of cooperating individuals or entities (1990, 2009, 2010).

There is a further objective. If groundwater extractions in the Australian case were stringently monitored and the pumping limits firmly enforced, the system would be successful in meeting its overall extraction limits. (The problem would remain that these themselves are too high.) This would be an admittedly expensive and time-consuming undertaking, given that all monitoring and enforcement is provided by the state-level agency in that case. This paper is partly motivated by the question as to how governance regimes can best be designed in order to minimize the monitoring and enforcement costs of their operation. In the successful adjudicated basin cases, compliance is high. While it is true that the original court-adjudication processes of arriving at the respective judgments was expensive and time-consuming, once established, these systems achieve high compliance relatively inexpensively. "In 1985, the annual costs of monitoring these water rights were $3.00 per acre-foot in Raymond Basin and $2.40 per acre-foot in West Basin" (Ostrom 1990, p. 122). As California groundwater management has entered a state of recently unprecedented flux in the past 18 months, it is timely to examine the means by which compliance can most cost-effectively be attained. There has also been a proposal (CWF 2014a) that 'administrative adjudications' could provide many of the benefits enjoyed by the court-adjudicated basins, while requiring less time and financial resources in the process of their establishment. In view of the paper's analysis, we reflect on the prospects for this approach.

Given the parlous state of California groundwater resources generally, the reference baseline is one of unsustainable use and – in general – one of management regimes of limited scope, ambition, and effectiveness. The interest lies in the exceptions to this baseline, and in their points of difference with it. In view of the currently entrenched interests and attitudes that pertain to – and that prevent the effective management of – much of California water, it is highly pertinent to to look further into why those enclaves that do work well are different. The contribution of this paper lies in its examination particularly of the sources of compliance under certain regimes, both in terms of their institutional origins, and their ongoing reinforcement via the rules in use. We use a

contrasting (and non-Californian) regulatory regime to illustrate the point that the promulgation of operational rules is not, in and of itself, sufficient to sustainable resource use.

The adjudication approach has received criticism, both within California and elsewhere, with some advocating the regulatory approach as preferable. Known (and necessarily flawed) adjudications may elsewhere have been unfavorably compared with idealized regulatory systems. This paper offers a direct comparison between adjudicated and regulatory approaches, using a recently documented case of sub-optimal regulator behavior as the point of comparison.

Ostrom points out that "[e]xtensive empirical studies by scholars in diverse disciplines have found that the users of many (but not all) resources have invested in designing and implementing costly governance systems to increase the likelihood of sustaining them" (2009, p. 420). The adjudicated basins considered here are examples of such user investment in governance. One of the relationships examined in this paper is therefore that between these resource-user investments in institutional design and the increased likelihood of sustainability to which Ostrom points.

The origins and operation of the monitoring and enforcement regime (or 'game') in the California adjudicated basins are distinctive, with their differences having potentially profound effects on the perceptions, calculations, and behaviors of groundwater pumpers, and therefore potentially important implications for the sustainability of the basin and its governance regime.

The paper aims to address the following questions.

- What is the relationship between institutional choices and appropriator behavior, specifically in terms of the different sources of monitoring and enforcement powers, and their relations to the propensity to collaborate versus compete for resource units?

- How do the source and perceived effectiveness of enforcement power affect compliance, and monitoring & enforcement (M&E) costs?
- What particular attributes of a management plan / governance system could be used to encourage cooperation and stewardship, and to discourage myopic behaviors?
- How do the source and perceived effectiveness of enforcement power affect compliance, and M&E costs?

Ostrom's frameworks provide the structure to analyze questions of institutional choice (1990, 2009, 2010) as well as of design (1990, 1993). A central feature of the successful cases illustrated in Ostrom's work is that users have agreed that limitations on resource extraction are necessary (or at least desirable). But further, users have also agreed both upon the appropriate limits themselves, *and* upon how compliance with these is to be monitored and enforced. In this analysis, the relevant variables from Ostrom's frameworks provide the lens through which to examine governance arrangements in the respective cases, from the point of view of how compliance has been successfully inculcated in some cases, and not in others.

Ostrom provides two types of criteria, both of which are relevant here. The first is those variables posited to affect the likelihood of collective action, when viewed prospectively (from the collective-choice level). These are the 'situational variables' in the framework for analyzing institutional choice (1990), the 'second-level variables' in the framework for analyzing social-ecological systems (2009), and the 'structural variables' (2010). (Ostrom's 2010 paper goes beyond the structural variables to consider broader issues such as heuristics and norms, and the influence on cooperation of the “core relationships: reputation, trust, and reciprocity” (p. 162).)

The second type of criteria is the 'design principles' which have characterized the governance arrangements of “long enduring” irrigation systems; these are features which help to “account for the success of these institutions in … gaining the compliance of generations of users” (Ostrom 1993, p. 1907). A similar set of design principles was presented in 1990 (as “still quite speculative”) at which time Ostrom noted that, “for

these design principles to constitute a credible explanation for the persistence of these CPRs and their related institutions, [it will be necessary] to show that they can affect incentives in such a way that appropriators will be willing to commit themselves to conform to operational rules devised in such systems, to monitor each other's conformance, and to replicate the CPR institutions across generational boundaries" (1990 p. 91). These principles are concerned with the explanation of what worked and why.

In analyzing the sources of compliance with existing rules, attention to the design principles alone (the latter of these two types of criteria) could be justified. This paper's attention to some of the situational variables as well, stems from the position that compliance – at least with rules whose purpose is considered legitimate – has some sources in common with collective action. Clearly, from this perspective, the perceived legitimacy is important. But given that, compliance can be seen as cooperation – potentially involving the sacrifice of short-term individual financial gain – in the interests of some larger (i.e., collective) perhaps longer-term and perhaps non-monetary benefit. In the absence of complete coercion (overwhelming force) compliance can be seen as a collaborative act.

As the paper examines the influence of governance instruments on compliance, the variables used are those that relate to perceptions of legitimacy, subjective conditions, monitoring, and credibility of enforcement power. We focus on key variables relating to monitoring & enforcement, but also on those relating to social capital and the likelihood of cooperation, because these affect compliance incentives. Initially, we look at attributes of the governance systems examined, in terms of Ostrom's variables relating to:

- a) monitoring / sanctions / enforcement;
    - monitoring - "design principle four" (1993, p. 1908)
    - sanctions - "design principle five" (1993, p. 1909)
- b) legitimacy / fairness / collective-choice arrangements;
    - fairness - (2010)

- collective-choice arrangements - “design principle three” (1993, p. 1908) and second-level variable GS6 (2009, p. 421).

We examine the state of each of these, across a representative range of management systems. We relate the states of these variables to the available data on compliance and monitoring & enforcement costs.

The data sources used for this study include:

- adjudicated basins: court judgments (as amended), and watermaster annual reports;
- state-regulated basin: water licensing documents obtained under a Freedom of Information Act request, including records of the interactions between the Department of Water (and other regulatory bodies) and water users in the Gnangara groundwater system.[2]

The paper is organized as follows: Section 2 introduces the types of governance regimes considered and the particular case-studies examined; Section 3 provides the analysis; Section 4 includes discussion and is followed by concluding remarks in Section 5.

2 Case-studies

California groundwater governance is a varied tapestry of arrangements, as well as of their near-absence. California code authorizes the establishment of groundwater management plans (GMPs), of which there are many currently in the state. These range in their respective levels of ambition and effectiveness. The legislation, however, stops short of authorizing districts, via their GMPs, to limit groundwater extraction. For the purposes of this paper, these GMP-only districts are not considered 'regulated', as their

2 License records were obtained for approximately 500 licence numbers, and relate to such matters as: licence application; licence renewal; water entitlement allocations; applications to transfer or lease water rights; reports on compliance inspections; some metering records (for a small subset of the total number of licences); estimates of water use, made during compliance inspections; enforcement notices and warnings. The documents relate to groundwater management sub-areas being of particular interest for reasons including: over-allocation; the presence of groundwater-dependent ecosystems; the partial introduction of groundwater metering. A subset of 176 files were selected for analysis, with selection based on their informational richness and relevance.

groundwater extractions are not limited other than by the 'reasonable and beneficial use' doctrine embodied in California water law. The absence of limits on resource use also changes the discussion of compliance. It would be possible to assess the compliance of users within the GMP districts with the provisions that the GMP does make, and also to analyze the causes of success and failure in the respective management plans to achieve their goals. Given the patent unsustainability and the urgency of transformation from excess to sustainable consumption levels, however, in this paper we consider only management areas / districts which place actual limitations on their users' extraction.

There are also 13 special act districts in the state: four in the northeast, three near the central coast, one in each of Mendocino and Mono counties, and four in Southern California. Of the 13, 11 are empowered to regulate groundwater extraction by ordnance (CWF 2014b). (The other two may do so only by levying taxes on pumping.) The Fox Canyon Ground Water Management Agency is an example, and is one of the few districts requiring that flow meters be installed and regularly calibrated, and that extraction volumes be reported to the agency regularly. The discussion of special act districts such as Fox Canyon may be expanded in a future version of the paper.

In 2014 CWF released a report which applied scoring criteria to 120 California groundwater management plans. It found that "[s]takeholder outreach and participation was either non-existent or not described adequately in many, if not most, of the plans" (CWF 2014b, p. 1). The California cases examined here differ in this regard also; in them, resource user cooperation has played a pivotal role in the formation of the management entity and of the rules by which it governs – that is, they (or their antecedents in interest) have participated in institutional decisions.

As already established, the sustainably managed basins in CA are the exception. And, while criticism of the management of the Gnangara groundwater system is certainly justified (see Froend et al., 2004; Malcolm, 2004 ; Appleyard & Cook, 2009; Skurray & Pannell 2012; Clohessy et al., 2013; Skurray 2015) it does have quantified per-user entitlements, nominally based on an overall withdrawal limit. That fact alone distinguishes it from most of the non-adjudicated California management areas / basins.

The contrast between the extremes that exist within California itself is in some ways stronger than that between the state's adjudicated basins and the Gnangara case.

2.1 Court Adjudication

There are 24 adjudicated basins in California (DWR 2014); these are mainly concentrated around and to the northeast of the Los Angeles area. While all of these offer the potential for interesting comparative analysis, space constraints dictate that this paper consider a small subset. Several of those in Los Angeles and San Bernardino counties have been studied extensively (Ostrom 1990, Blomquist 1992, Steed & Blomquist 2006, Ostrom & Blomquist 2008). There are advantages to furthering the analysis of the basins examined by Ostrom, Blomquist, and others. The California Department of Water Resources (DWR) is the watermaster under both the Central and West Basin judgments. The judgment in the Central Basin case was amended in December 2013, resulting in a change of watermaster (CBW 2014a). While the new watermaster has issued only one draft annual report (CBW 2014b), the amendments contribute to the value of an examination of conditions in Central Basin.

Overdraft conditions existed in Central Basin by 1942 (Ostrom 1990). Central Basin was "prodded into action by their downstream neighbors, who feared that lack of action in Central Basin might eventually negate the benefits of conservation in West Basin" (Ostrom 1990, p. 125). Prior adjudicated cases (Raymond and West basins) had used a somewhat protracted and expensive court-ordered referee's report to establish basin conditions and safe yield.[3] Seeking to reduce costs relative to the earlier judgments, the Central Basin parties avoided this by undertaking the initial survey of conditions and of past groundwater use prior to the initiation of litigation (i.e., the reference procedure was not ordered by the court, as it had been in West Basin) (Ostrom 1990). A "considerable effort was made to achieve a general agreement ... before they actually went to court in 1962" (Ostrom 1990, p. 123).

3 The West and Central basin judgments identified a fixed annual 'safe yield', so that adjudicated rights of each pumper were to fixed amounts. By contrast, the judgments in the Main San Gabriel Basin (Los Angeles County) and the Chino Basin (Riverside County) both allow for the establishment of annual safe yields, of which pumpers are allocated a share.

The original judgment trial in the Central Basin case took place between May 17th and 24th, 1965, and (after a break) the matter was concluded on August 27th (Second Amended Judgment). A "final settlement, signed by parties holding over 75% of the rights", went into effect in October 1966"; the process had taken four years, with estimated costs of $450,000 (Ostrom 1990, p. 124).

Hearings for the Second Amended Judgment began and ended on May 6 1991, and the court retains "reserved and continuing jurisdiction" (Second Amended Judgment, p. 2). Hearings for the Third Amended Judgment began on December 18th, 2013 , and the judgment was entered on December 23, 2013 (Third Amended Judgment; CBW 2014a).

2.2 State-regulated Basin

The distinction between 'regulated' and 'adjudicated' basins is not necessarily clear, thus we use the term state-regulated basin to describe the former. Groundwater extractions are regulated in both cases – in the former by the state government's limiting of individual pumpers' licensed entitlements, and in the latter by similar limitations embodied in the court's adjudication of extraction rights. The – very considerable - differences between the two approaches lie elsewhere, including in the original motivation for limiting resource extractions. In the adjudicated basin case the impulse to limit extractions originates amongst the users themselves. Whether or not this arises from some form of threat or encouragement from downstream users outside the basin, or from the basin's own users' recognition of the finite nature of their own resource, is another important difference, but less so. Thus the fundamental contrast between the adjudicated and the state-regulated basins considered here is not whether or not extractions are 'regulated' (i.e., limited) but why, how, and by whom.

2.2.1 Gnangara groundwater system

The Gnangara groundwater system around Perth Western Australia provides an example of a regulated basin approach in dysfunction (Skurray 2015). Groundwater ownership rests with the Crown, and is administered by the state's Department of Water. Licences for water extraction are issued, each specifying an annual volume, a location of extraction, and a specified use for the water. Department of Water's management of this

large, multiple-level aquifer system includes responsibilities for setting allocation limits on sub-areas, granting licences applied for, and any monitoring and enforcement. The exercise of these powers has been more consistent with a development mission than with a conservation one. There has been overallocation of sub-areas (i.e., the deliberate granting of licences in sub-areas already at or above their allocation limit). Enforcement of individual licensed entitlements has also been ineffective. Monitoring has been approximate and ad hoc. Breaches have been handled with great lenience and accommodation. In sum, the management system has failed to address – indeed promotes – competition among users, and discourages cooperation, shared knowledge, and norms of resource stewardship (Skurray 2015). The fact, in this case, that there exist extraction limits for individual pumpers, and that these are ostensibly monitored by the regulatory agency, has not brought about compliance or cooperation on the part of the water users.

3 Analysis

"*[T]he long-term sustainability of rules devised at a focal SES level depends on monitoring and enforcement as well their not being overruled by larger government policies. The long-term effectiveness of rules has been shown in recent studies of forests in multiple countries to depend on users' willingness to monitor one another's harvesting practices*" *(Ostrom 2009 p. 422).*

3.1 Legitimacy / Collective choice arrangements

Users in the adjudicated cases have agreed that limitations on resource extraction are necessary (or at least desirable). This recognition is a first step in establishing perceptions of legitimacy, and one which has not been taken either in the over-exploited groundwater areas of California, or in the Gnangara case.

3.1.1 State-regulated basin

It would be difficult to overstate the fundamental differences that exist between the underlying foundational bases of the arrangements in the Gnangara case and in the adjudicated basin cases we consider here. In the Gnangara case, all rule and regulations

are established by the state-level government agency, which also established and operates the monitoring and enforcement system. Resource user input is limited to reactions to the operational rules imposed, as it were, from 'above'. This (along with the laxness of monitoring and enforcement measures) has consequences for user perceptions of legitimacy of the current arrangements, as well as for the sustainability of resource use in that case (Skurray 2015).

In the Gnangara case, 'foundational legitimacy' is lacking. Neither have the necessary measures to impart what might be called ongoing or iterative legitimacy to the current regulations been taken. Thus we see in this case a situation in which the basis of the current rules is not accorded sufficient weight to impart legitimacy to them, and also in which the current rules do not operate to reinforce their own effectiveness, accruing perceived legitimacy in the process. Instead, they operate to diminish it.

In a wide range of demonstrations, subjective legitimacy of the present arrangements in the GGS case is revealed to be low. An example is the large number of blanks and dashes in the price field of the transfer and lease application forms. Other incomplete forms also reflect a norm that the current rules are not seen as legitimate. Regardless of whether or not users are mutually aware of this low subjective legitimacy, the resulting behavior is widespread. The Department itself appears also to share a version of the same norm, as evidenced by its acceptance of incomplete applications, forms, and reports.

There appears to be an almost willful, yet tacit, shared agreement to avoid – or not to seek knowledge of – resource conditions in the GGS case. In the face of the plentitude of formal notices and warnings from the Department, the appearance is given of a tacit agreement between the users of a reciprocal non-submission of meter records. Effectively, this amounts to an attempt – facilitated through lax enforcement by the regulator – to continue with the status quo for as long as possible, with the minimum of knowledge of actual CPR conditions.

So little information is available to users in this case regarding the actual value of current and future flows, that perceptions must be based on little hard evidence. Current arrangements isolate individual users not only from each other but from the actual condition of the resource (Skurray 2015). The reverse is true in the adjudicated basins.

3.1.2 Adjudicated basins

"*Each party, ..., is enjoined and restrained in any Administrative year commencing after the date this judgment becomes final from extracting from Central Basin any quantity of Water greater than the party's Allowed Pumping Allocation*" (Second Amended Judgment, p. 9).

In the adjudicated cases, there are fundamental differences in the origins of the arrangements. This foundational legitimacy (as we refer to it in this paper) gives rise to a starkly contrasting situation.

Not only did a mutual understanding of the nature and conditions of their CPRs positively affect the institutional choices of the now-adjudicated basin users, but it helps sustain the cooperative arrangements.

Differences in language between the Central Basin judgement and the Gnangara regulatory documents are illustrative, and immediately noticeable. The judgment is a binding edict, in the language of the law. It is qualitatively different in nature from the policy statements of the Gnangara regulator. The judgment is clear and unambiguous, and explicitly intended to act with legal weight. It also carries the obvious weight – obviously absent in the Gnangara case – that the judgment was *asked* for. The language of the policy documents examined in the Gnangara case reflects the internal tension and the lack of clarity within the regulatory agency there. The agency's foundational (and apparently still persistent) development orientation is in conflict with its responsibilities as regards demand management and environmental protection. This creates an ambiguity of mission. A result is what appears to be an internal game in which the

agency promulgates policy statements but then knowingly demurs at the prospect of enforcing them.

The Central Basin judgment stipulated the bases for basin operation, including the following:

- "Base Water Rights" were established by users' highest levels of continuous use prior to the adjudication proceedings, "as to which there has been no cessation of use by that party during any subsequent period of five consecutive years" (Second Amended Judgment, p. 4).
- "Natural Safe Yield" is defined as "the maximum quantity of ground water, not in excess of the long term average annual quantity of Natural Replenishment, which may be extracted annually from Central Basin without eventual depletion thereof or without otherwise causing eventual permanent damage to Central Basin as a source of ground water for beneficial use" (Second Amended Judgment, p. 6).
- Overdraft is defined as "extractions ... in excess of the long term average annual quantity of Natural Replenishment" (Second Amended Judgment, p. 6).

By agreeing on not only on the necessity for reduced extractions, but also to a settlement of individual water rights within an annual safe yield extraction volume, which is itself within the long term average of natural recharge, the users gave themselves the foundations needed for sustainable management. (The tools with which to implement that are discussed in the next section.) Had these agreements not been aligned with sustainability goals, their nature as agreements would still have lent legitimacy within the user group. The impetus to achieve sustainability (or at least to reduce overdraft) however, added important weight. Benefiting each other by preserving the basin, given the expectations of effective monitoring and enforcement, allowed a cooperative decision to be made in which each party would accept a limitation. These limitations engendered benefits both privately and publicly (to the group), and depend on (and promote) other attributes such as social capital / trust / norms of reciprocity and reflect the 'importance of resource to users' (Ostrom's 2009 variables U6 and U8 respectively). Perceptions of legitimacy are enhanced in tandem with the prospects for effective exclusion of non-party pumpers; these were bolstered by the fact that rights are comprehensively –

'affirmatively' – defined in the judgment, that is, none exists outside the judgment (non-parties to the judgment are unauthorized to extract groundwater). This is further supported by the fact that parties may oppose the stipulation of 'new parties' to the agreement (Second Amended Judgment).

The retention of jurisdiction by the court which made the original judgment contributes to the ongoing perceived legitimacy of these arrangements (as well as to the credibility of enforcement and sanctions – discussed in the following section). The court reserves continuing jurisdiction and may "review and redetermine" "the permissible level of extractions from Central Basin in relation to achieving a balanced basin" (Second Amended Judgment p. 82). By agreeing to an adjudicated settlement which empowers the court to revise the safe yield for the sake of balancing the basin, users turned to an existing forum to formalize arrangements which they desired, at least collectively. This entrenched the legitimacy not only of the court's role, but of the recognition of resource variability, and of their agreement that sustainability is desirable goal, as well as on their choices regarding how to achieve it. The judgment constitutes an 'inter se adjudication' – that is, one between and amongst the parties themselves.

The regulator in the Gnangara case appeared to treat its own 'metering program' as peripheral – rather than central – to its mission (Skurray 2015). This “government funded metering program" ended in 2010 (DoW, 2013, p. 12). Users, in turn, regularly failed to submit meter readings. By contrast, each year's annual report for both the Central and West basins includes the pumping volumes of each party, and instances of this information being unavailable are rare. In the Central Basin case, again in contrast to the West Australian one, the watermaster has the duty, power, and responsibility, to "require all parties ... owning or operating any facilities for the extraction of ground water from Central Basin to install and maintain at all times in good working order at such party's own expense, appropriate measuring devices" (Second Amended Judgment p. 53). The Gnangara's government-funded metering program did not approach full coverage of all users, and their reporting was *ad hoc*. In Central Basin, users have created an arrangement in which they are to fund their own meters, in addition to funding the watermaster's role in implementing and monitoring the conditions of the judgment. Enforcement of payment for watermaster services is provided for in the judgment

(including enforcement by any party to the judgment on behalf of the watermaster) (Second Amended Judgment). These arrangements both reflect and perpetuate fundamental differences in the attitudes and behaviors of resource users in these two groundwater basins.

3.2 Monitoring / Sanctions / Enforcement

Users in the adjudicated cases have agreed both upon the appropriate limits themselves, and upon how compliance with these limits is to be monitored and enforced. This step is missing, for example, from the state-regulated Australian case, in which extraction limits, and the monitoring regime, were presented to pumpers as *faits accomplis*.

3.2.1 State-regulated basin

The low level of monitoring and enforcement activities currently carried out suggests that current monitoring and enforcement costs must at least be seen to be high. Indeed the current arrangements appear to expend considerable administrative cost without garnering an appropriate level of compliance in return.

The current regulatory culture in the Gnangara case appears to be characterized by the avoidance of enforcement action; opportunities to avoid taking serious enforcement measures appear to be invited, and there is a failure to collect such basic information as amounts pumped, and prices paid on approved transfers (Skurray 2015). The Department has several forms, reports, and standard letters (the 'incident investigation briefing sheet' and 'formal letter of warning' are examples) which variously appear to substitute for enforcement, or which recommend it but are then internally ignored. An effect of this is to 'generate and make available' to users the information that there is an absence of a functioning regulator, or at least of a willing one. An unstated purpose of some of this paperwork appears to be to allow users to provide the regulator (or for the Department to provide itself) with opportunities to justify the avoidance of effective enforcement action. By highlighting every chance the user has to object or to obfuscate, the regulator not only appears to invite opportunistic behavior, but also intimates an underlying malleability, which – it appears – reflects the failure to take seriously its own regulations. Partly as a result of this, individuals also learn that the condition of the CPR

must be acceptable – or at least cannot be dire – otherwise serious regulatory enforcement would by now have been in evidence. The problem is completely obviated in the adjudicated cases.

The 'notice of proposal to direct compliance' is a striking example of lax enforcement which, overall, transmits a misleading impression to users regarding resource conditions. As is generally the case with communications between the regulator and users in this case, it is also completely private. Thus, no other user – let alone the users as a body – can have knowledge of either the non-compliance of the pumper in question, or of the Department's response.

A net effect of this regime can be seen in the disconnection between users' perceptions of their own wellbeing and the wellbeing of the CPR. It is notable that it was the awareness of their dependence on the CPR – of the importance of its wellbeing to their own welfare – that enabled and promoted agreement between the Central Basin users. The arrangements they created help to perpetuate that awareness. In the Gnangara case, the genesis of such an awareness was preempted and foreclosed by the imposition of an implementation regime which works to erode rather than accumulate that awareness.[4] Users' private knowledge of their own water table levels is not a substitute for shared knowledge of overall conditions. One of the purposes and results of effective monitoring is the promulgation of knowledge not only about appropriation levels but about resource conditions. This is one of the channels via which effective monitoring & enforcement feeds back into sustainable extraction.

In contrast to the adjudicated cases, the situation in the W.A. case provides an example of mutual reinforcement of a bilateral norm – in this case it appears that users and regulator are 'going through the motions', together and with mutual facilitation, but without beneficial effect on the CPR.

4 It is not that the rules themselves in the Gnangara case could not be implemented so as to promote this awareness. Rather, it is that the half-hearted and perfunctory way in which they have been implemented / enforced does a disservice to the CPR and thus to its users. Unambiguously intentioned and well-enforced regulations would communicate a clearer message to users and could be used to promote the understanding and protection of the resource.

3.2.2 Adjudicated basins

Watermaster has the duty, power, and responsibility, to "require of parties the furnishing of such reports, information and records as may be reasonably necessary to determine compliance or lack of compliance by any party with the provisions of this judgment" (Second Amended Judgment, p. 53).

The extraction allocation unit defined in the judgment is the 'Allowed Pumping Allocation' (APA). This is "the maximum quantity which a party should be allowed to extract annually from Central Basin ... [and] constitutes 80% of such party's Total Water Right" (Second Amended Judgment, p. 3).

The California Department of Water Resources (DWR) was appointed Watermaster "for an indefinite term, but subject to removal by the Court" (Second Amended Judgment, p. 52). The duties, powers, and responsibilities of the watermaster are set out in the judgment, with the objective that the watermaster may "assist the Court in the administration and enforcement of the provisions of this judgment" (Second Amended Judgment, p. 52). That is, the court maintains enforcement jurisdiction, and the watermaster is appointed to assist it therein. By contrast, the W.A. Department of Water does not explicitly exist within the terms of the underlying law (the Rights in Water and Irrigation Act 1914). The Act sets out powers of the responsible government minister and it is as an instrument thereof that the Department acts.[5]

The watermaster has the duty, power, and responsibility, to "make inspections of ground water production facilities and measuring devices ... and to calibrate or test such devices" (Second Amended Judgment, p. 53). That these monitoring activities of the watermaster are funded by the users expresses a mutual acknowledgement of their importance in realizing the benefits of the shared resource. This contrasts with the GGS situation in which compliance inspections appear to be influenced by vestigial development goals and to be unrelated to overconsumption problems or aquifer conditions (Skurray 2015).

5 The Act defines the 'Department' as “the department of the Public Service principally assisting in the administration of this Act ” (Gov. WA 2011, p. 2).

Over-extractions may be permitted ('permissible overextractions') where a party is otherwise compliant with the judgment, and where the over-extraction either a) does not exceed 20% of their Allowed Pumping Allocation (or 20 acre-feet, which ever is greater) or b) is approved in advance by the Watermaster. Such permissible over-extractions result in a reduction of the user's APA for the following year, by the amount over-extracted (Second Amended Judgment).[6]

Over-extractions in excess of 20% of the party's APA (or 20 acre-feet) and without the watermaster's advance approval, result in the user's APA for the following year being reduced by the full amount of the over-extraction (i.e., including the 20%). That is, the repayment of such over-extractions cannot be prorated. These provisions mean that water in addition to the party's APA cannot really be obtained other than by borrowing it from future years' extractions. And importantly, the years from which such borrowing is made are at most five years in the future.

Not only are future years' APAs reduced to effect the repayment of over-extractions, but over-extractions exceeding 20% of a party's APA (or 20 acre-feet) without prior watermaster approval, “such shall constitute a violation of the judgment and the Watermaster shall make a written report to the Court for such action as the Court may deem necessary” (Second Amended Judgment, p. 61). The watermaster's annual report is filed with the court, and is mailed to all parties to the judgment. It is required to include information on parties' groundwater extractions, and on "violations of judgment and corrective action taken" (Second Amended Judgment, p. 54).

Table 1 summarizes the non-permitted over-extractions listed in the Central Basin annual reports for the years 2001 – 2014. In none of these years are more than four parties listed as extracting in violation of the judgment. And while some over-extractions are large relative to the party's 'allowed pumping allocation' (e.g., Midland Park Water Trust, 2001–2005) the total volume of violating extractions is never greater than 0.3% of the combined volume of all parties' APAs (217,367 acre-feet). Even when the permissible over-extractions are included, this figure is at most 0.7% of total APAs. The number of

6 The watermaster my prorate this reduction over five years if it determines that a single-year reduction would impose "unreasonable hardship" on user (Second Amended Judgment, p. 60).

parties in the period of Table 1 ranges from 143 (2000-2001) to 131 in 2013-2014. This is a remarkably high level of compliance, in several ways. At one level, it would not be possible to provide a table such as Table 1 for the Gnangara case, because of non-compliance with even the provision to the Department of meter-recorded extraction volumes. At a higher level, the relative scarcity of meters themselves, and the confidential nature of the records which do exist, militate against the possibility of providing such a comprehensive summary as the publicly available Central Basin annual reports allow. (Skurray et al., note that metering is "by no means comprehensively implemented [in the Gnangara case]: of 1682 licences in a sample of 15 GGS groundwater sub-areas, only 36% were reported as metered" (2013, p. 1064).)

	Violating party	Non-permitted Overextraction (AF)	Non-permitted Overextraction as % of APA	Party violations as % of total APA	Party overextractions as % of total APA (1,2)
2001	Ashland Chemical Co	57.84	#DIV/0!	0.2%	0.4%
	Coast Packing Co	22.18	4.2%		
	Midland Park Water Trust	218.73	383.7%		
	St. John Bosco School	34.84	83.0%		
2002	Ashland Chemical Co	106.83	#DIV/0!	0.2%	0.7%
	Lynwood Park Mutual Water (	146.02	65.8%		
	Midland Park Water Trust	193.63	339.7%		
	St John Bosco School	53.08	126.4%		
2003	Ashland Chemical Co	134.57	#DIV/0!	0.3%	0.7%
	Lynwood Park Mutual Water (	72.56	32.7%		
	Midland Park Water Trust	136.63	239.7%		
	City of Whittier	251.83	28.1%		
2004	Midland Park Water Trust	79.63	139.7%	0.1%	0.7%
	St John Bosco School	21.04	50.1%		
	Southern Service Co & Envi:	104.65	161.0%		
2005	Midland Park Water Trust	22.63	39.7%	0.1%	0.7%
	City of Whittier	246.91	27.6%		
2006	None (apart from State of/Caltrans)				0.1%
2007	None (apart from State of/Caltrans)				0.03%
2008	San Gabriel Valley Water C	621.31	23.8%	0.3%	0.39%
2009	City of Artesia	24.5	102.1%	0.03%	0.1%
	Farmers and Merchants Trus	40	285.7%		
2010	Farmers and Merchants Trus	26	185.7%	0.01%	0.08%
2011	None (apart from State of/Caltrans)				0.01%
2012	None (apart from State of/Caltrans)				0.02%
2013	California-American Water (	433.08	21.0%	0.20%	0.27%
2014	Frampton, William H. (3)	21.77	#DIV/0!	0.01%	0.08%

Notes

1 Includes permissible overextractions

2 This figure is 3.4% if the Caltrans non-party overextraction is included.

3 Not listed as a violation in the draft 2014 report.

Table 1. Non-permitted over-extractions in Central Basin, 2001 – 2014. (Source, Watermaster annual reports.)

The 2013 amendments to the Central Basin judgment made significant changes to the watermaster arrangements. The new watermaster consists of three separate bodies,

each with “restricted powers, duties and responsibilities ..., it being the court’s intention that particular constituent bodies of Watermaster have only limited and specified powers over certain aspects of the administration of this Judgment” (Third Amended Judgment. p. 17). Of the three bodies, only the Water Rights Panel has the “authority to move the Court to take such action as may be necessary to enforce the terms of the Judgment with regard to the extraction of Allowed Pumping Allocation and the maintenance of adjudicated groundwater extraction rights” (Third Amended Judgment, p. 24).

4 Discussion

As Ostrom notes, “one must view [institutional-choice processes] as historical processes whereby current decisions are built on past decisions” (1990, p. 202). Existing impediments to compliance and cooperation arise from the cumulative effects of past decisions. In the Gnangara case, both the formal institutional choices and the tacit decisions of the appropriators and regulator alike, continue to sustain the current institutional edifice.

To the extent that they are not coerced, compliance decisions can be seen as a form of institutional choice. While these decisions do not occur at the collective-choice level, each decision to commit to – by complying with – extraction limits and other rules, represents an affirmation of their intent as well as of their perceived legitimacy. Norms arise from the accumulation of congruent individual decisions. Sequential compliance decisions, and any norms or social capital to which they give rise, result from an iterative process in which the user may refer back to their own previous decisions and the consequences thereof, as well as referring back to the origins and perceived intent of the rule with which they are (or are not) complying.

A key purpose of institutional design, therefore, is to foster the necessary iterative process. In the Gnangara case, for example, the iterative compliance decision process is negatively self-reinforcing; non-compliance begets non-compliance, by virtue of the absence of effective enforcement. The desired outcome, by contrast, is of course that the compliance iterations are positively self-reinforcing – that compliance begets compliance, both individually and collectively. (“Once some members of a population

acquire norms of behavior, they affect the expectations of others" (Ostrom 2010, p. 161).) This is one reason that mutual transparency of actions is of such importance in establishing sustainable use of common-pool resources; the positive stewardship actions of one user can reinforce and support the similar decisions of others. Thus cumulate social capital and trust (or alternatively, their absence).

Regulatory or management instruments influence incentives in two ways: directly, by requiring certain actions; and indirectly, by informing the perceptions and attitudes of appropriators.[7] The groundwater management initiatives currently underway in California present an opportunity to equip resource management entities not only with 'hard' instrumental tools, but with 'soft' ones as well; the 'local groundwater management entities' (LGMEs – the establishment of which is recommended in the California Water Foundation May 2014 report 'Recommendations for Sustainable Groundwater Management') could build in such indirect incentives.[8]

4.1 The threat of overwhelming force

One of the central aims of this paper is to examine sources and causes of the high compliance levels observed in some of the adjudicated basins. The paper has touched on several possible reasons. One Is that the judgments are accorded so much legitimacy among users that they exhibit voluntary compliance. Another relates to the deterrent effect of the censure / sanction of violator identities being printed in the annual report. A third reason is perhaps that the underlying threat of overwhelming force from the court is in fact so credible that it deters most would-be violators. All these factors play a role.

A highlight of the CWF 'Recommendations' report is its "recommendation #6: establish a clear and coordinated state role for assistance, oversight, and enforcement" (CWF 2014a, p. 27). The realization of this proposal could constitute a fundamental alteration in the incentive landscape for groundwater users in California generally. Depending on their perceptions of the credibility of the 'threat' of serious enforcement action – and on their

7 The level of legitimacy which a regulator's actions lend to its own regulatory tools can be an influence on incentives – of the indirect type (Skurray 2015).

8 This report was prepared "[i]n response to the Brown Administration's request for recommendations on groundwater legislation …" (CWF 2014a, p. 4).

weightings of the private costs involved in the actualization of such threatened sanctions / enforcement actions – local management entities could effectively inherit, under the new arrangement, the coercive power of the state. Whether this would be used, or would atrophy due to internal mission conflict and other causes as in the Gnangara case, will depend upon a range of factors.

Pumper perceptions under adjudication differ from those in a poorly-regulated basin. The 2014 California Water Foundation report recommends that local groundwater management entities be required to "develop a Groundwater Management Plan that describes how that entity will achieve sustainable groundwater management in each subbasin within its jurisdiction" (CWF 2014a, p. 24). LGMEs "should have sufficient opportunity [and appropriate support] to satisfy program requirements", before any enforcement action were taken by the State Water Resources Control Board; and that the "SWRCB should take enforcement action after making a finding of non-compliance in coordination with DWR" (CWF 2014a, p. 28).

The CWF's 'stakeholder dialogue' revealed that the representatives of some sub-basins exhibited strong sentiment against "meaningful oversight and enforcement by SWRCB"; the reasons given for this include a "general resistance to any steps that could result in reduced pumping" (CWF 2014a, p. 29). This reflects a failure to appreciated the nature of the resource, and clearly illustrates the need for changed attitudes among users, if aquifers are to be sustained.[9] This raises the questions: a) whether such resistance arises from a desire to protect existing self-governance institutions and sustainable aquifer management, or, rather, from a desire to protect myopic overuse; and b) if the latter, whether state-level enforcement powers should be pursued, or, rather, the focus should be on building collaborative attitudes through institutional design (e.g., through groundwater management plans).

More germane to the discussion here is the fact that the dichotomy presented in b) above, is false. State-level enforcement powers could be a catalyst to the formation of more collaborative and cooperative approaches at the local or basin levels. Coercion is important not only in terms of compliance with operational rules. In some cases it has been a

9 Further illustrating this, some users expressed concerns that the state agency would "intervene prematurely, before a LGME has had sufficient opportunity to meet milestones" CWF 2014a, p. 30). As the problems have been known for many decades without ameliorating actions being taken (and indeed have been allowed to worsen) this attitude is unhelpful at best; 'sufficient opportunity' has unambiguously been more than amply provided already.

motivating factor in the circumstances leading to the establishment of those rules, and in the agreement of those involved to submit to them. In the Eastern La Mancha case, depletion of the aquifer caused loss of flows in the Jucar River and impacts on ecosystems in the Jucar basin (Esteban & Albiac, 2012). Impacts on downstream users led to the "credible threat of forbidding extractions coming from the Jucar basin authority"; this was one of the catalysts for the successful cooperative arrangements now in place (Esteban & Albiac 2012, p. 862).

The credible threat will come from one quarter or another eventually; the question is whether users accept its legitimacy as coming through governance institutions of one sort or another (as in the adjudicated basins, and in the Eastern La Mancha, for example), or whether instead myopia reigns until aquifers are lost. User perceptions as regards the importance of the resource, combined with their time-horizons / discount rates, are fundamental to how these decisions play out.

The CWF report also notes that "proposals are being explored that would establish an administrative adjudication process managed by the SWRCB in conjunction with LGMEs" (CWF 2014a, p. 28). One objective of this is to streamline the allocation process, in terms of both time and financial cost. An examination is warranted of the implications of this approach for the central factor – the "retention of continuing jurisdiction by the court" (Blomquist & Ostrom, p. 195). How the proposed administrative adjudication processes would address the questions of perceived legitimacy and credible sanctions, and whether the approach will be able successfully to translate and transfer the court's role onto the SWRCB, remain to be investigated.

5 Concluding remarks

In cases where resource appropriators were involved in the negotiations leading to agreements to reduce pumping and protect the aquifer, compliance levels have generally been high. Aquifer conditions have been improved, or their further decline avoided. Conversely, where the regulatory (command & control) approach has been nominally employed but poorly implemented and enforced, over-extraction and overdraft have persisted, with the resultant deterioration in aquifer conditions.

Pumper participation ('stakeholder' involvement) in negotiations, however, is not the only reason the court-adjudicated basins in Southern California show high compliance; the court which rendered the original judgment retains continuing jurisdiction as well as the status of monitor. These cases thus embody and benefit from both perceived legitimacy in their arrangements, and the credibility of monitoring, sanctions, and enforcement provisions.

At its extremity, the regulatory (i.e., command and *really* control) approach could forego concepts such as social capital, and simply coerce users into compliance. This paper makes the point that it is easier, cheaper, and more effective, to encourage cooperation via institutional design, than to seek to enforce compliance in situations whose institutions otherwise promote myopia, competition, defection, and the resultant resource attrition. Groundwater management plans should encourage cooperation over competition among users, and long-term resource stewardship over myopic pumping behavior.

Of course, the requirement is for improvements in the 'management outcomes' themselves, rather than in the states of some abstract variables. Nonetheless, design elements which promote beneficial states of the variables considered here, can be seen as beneficial generally, as they promote not only the outcomes discussed above, but stand the district or basin in good stead as regards future institutional learning and development (Blomquist & Ostrom 2008).

Acknowledgements

Funding was provided by the National Centre for Groundwater Research & Training, which is an Australian government initiative supported by the Australian Research Council and the National Water Commission.

References

Appleyard S, Cook T (2009) Reassessing the management of groundwater use from sandy aquifers: acidification and base cation depletion exacerbated by drought and groundwater withdrawal on the Gnangara Mound, Western Australia. Hydrogeol J 17:579–588.

Blomquist, W., 1992. Dividing the Waters: Governing Groundwater in Southern California. ICS Press, San Francisco, California.

Blomquist, W., Ostrom, E., 2008. Deliberation, Learning, and Institutional Change: The Evolution of Institutions in Judicial Settings. Constitutional Political Economy 19 (3), 180-202.

CBW (Central Basin Watermaster) 2014a. About us. Available via: http://www.cbwatermaster.org/about.html

CBW (Central Basin Watermaster) 2014b. WATERMASTER SERVICE IN THE CENTRAL BASIN - LOS ANGELES COUNTY, July 1, 2013 - June 30, 2014. Draft. November 2014.

Choy & McGhee 2014. Groundwater: Ignore It, and It Might Go Away. Water in the West, Stanford. Available via http://waterinthewest.stanford.edu/groundwater/charts/basins-overdraft/index.html

Clohessy, S., Appleyard, S., Vogwill, R., 2013. Groundwater acidification near the water table of the Superficial aquifer, Gnangara Mound, Swan Coastal Plain, Western Australia. Applied Geochemistry 36, 140–152.

CWF (California Water Foundation) 2014a. Recommendations for Sustainable Groundwater Management: Developed Through a Stakeholder Dialogue. May 2014.

CWF (California Water Foundation) 2014b. An Evaluation of California Groundwater Management Planning. July 2014.

"DN (Democracy Now), 2009. 'Cap & Trade: A Critical Look at Carbon Trading'. December 15, 2009. Available via:

http://www.democracynow.org/2009/12/15/cap_trade_a_critical_look_at"

DoW (Department of Water), 2013. Gnangara groundwater areas allocation plan: evaluation statement 2009–2011. Department of Water, Government of Western Australia, Perth.

DWR 2014. List of adjudicated basins and subbasins. (Originally developed for the California Water Plan Update 2013: Last update 1/1/2014). Available via: http://water.ca.gov/groundwater/docs/List%20of%20adjudicated%20basins%20and%20subbasins_01012014.pdf

Esteban, E., Albiac, J., 2012. The problem of sustainable groundwater management: the case of La Mancha aquifers, Spain. Hydrogeology Journal 20 (5), 851-863.

Froend R, Loomes R, Horwitz P, Bertuch M, Storey A, Bamford M (2004) Study of ecological water requirements on the Gnangara and Jandakot mounds under Section 46 of the Environmental Protection Act. Task 2: determination of ecological water requirements. Water and Rivers Commission, Government of Western Australia, Perth

Gov. WA (Government of Western Australia), 2011. Rights in Water and Irrigation Act 1914 (amended), Version 08-h0-00. Perth: Government of Western Australia.

LAO (Legislative Analyst's Office), 2010. Liquid Assets: Improving Management of the State's Groundwater Resources. 2010 March 24, Sacramento. Available via: www.lao.ca.gov

link for 'List of adjudicated basins and subbasins_01012014.pdf' http://water.ca.gov/groundwater/docs/List%20of%20adjudicated%20basins%20and%20subbasins_01012014.pdf

Malcolm J (2004) Audit of compliance report – environmental management of groundwater abstraction from the Gnangara groundwater mound July 2000–June 2003. Appendix 3 to Environmental management of groundwater abstraction from the Gnangara Mound July 2000–June 2003: triennial report by the Environmental Protection Authority under section 48(1a) of the Environmental Protection Act 1986. Bulletin 1139. Environmental Protection Authority, Perth.

Ostrom, E., 1990. Governing the Commons: the Evolution of Institutions for Collective Action. Cambridge University Press, New York.

Ostrom, E., 1993. Design Principles in Long-Enduring Irrigation Institutions. Water Resources Research, 29, (7), 1907-1912.

Ostrom, E., 2009. A general framework for analyzing sustainability of social-ecological systems. Science, 325, 419-422.

Ostrom, E., 2010. Analyzing collective action. Agricultural Economics, 41, 155-166.

Second Amended Judgment, [Central Basin], 1991. Superior Court of the State of California for the County of Los Angeles. Declaring and establishing water rights in Central Basin and enjoining extractions therefrom in excess of specified quantitites. No 786,656.

Skurray, J.H., 2015 (in press). The scope for collective action in a large groundwater basin: an institutional analysis of aquifer governance in Western Australia. Ecological Economics.

Skurray, J.H., Pandit, R., Pannell, D.J., 2013. Institutional impediments to groundwater trading: the case of the Gnangara groundwater system of Western Australia. Journal of Environmental Planning and Management 56 (7), 1046-1072. http://dx.doi.org/10.1080/09640568.2012.716368.

Skurray, J.H., Pannell, D.J., 2012. Potential approaches to the management of third-party impacts from groundwater transfers. Hydrogeology Journal 20 (5), 879–891. http://dx.doi.org/10.1007/s10040-012-0868-9.

Steed, B. & Blomquist, W. (2006). Responses to Ecological and Human Threats to a California Water Basin Governance System. In , Paper presented at the 26th Annual Meeting of the Association for Politics and the Life Sciences, Indiana University, Bloomington, October 25-26, 2006. (Volume W06-41).

THEESFELD, I. (2010): Institutional Challenges for National Groundwater Governance: Policies and Issues. Ground Water, 48, 131-142.

Third Amended Judgment, [Central Basin], 2013. Superior Court of the State of California for the County of Los Angeles. Declaring and establishing water rights in Central Basin, enjoining extractions therefrom in excess of specified quantities and providing for the storage and extraction of stored water. No 786,656.