Universities Council on Water Resources
Journal of Contemporary Water Research & Education
Issue 153, Pages 66-78, April 2014

Challenges and Opportunities for Collecting and Sharing Data on Water Governance Institutions

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Abstract: This article explores the usability and availability of data needed for investigating the interplay between institutional arrangements (i.e. rules, regulations, policy, compacts, laws) and water resource outcomes. It examines a sample of 33 water governance and water research organizations' websites for publicly available datasets containing linked information on institutions and water resource conditions or outcomes. While scholars and decision-makers alike have identified institutional arrangements as an important aspect of improving water governance, their calls for enhancing publicly available institutional data remain unanswered. Within our sample of websites, few datasets link institutions and water resource conditions or outcomes and those that do limit the institutional data to jurisdictional boundaries. More in-depth and diverse institutional data are required to understand which governance tools and structures do and do not work in varying contexts. This will require funding of strategically located, place-based data collection efforts, more transparent and replicable data collection instruments, and coding and storage of institutional data for enhanced data integration.

Keywords: *Institutional arrangements, water governance, public datasets*

Water resource governance concerns in the U.S. and internationally are widespread and persistent. Governance concerns commonly focus on whether and how the organizational and institutional arrangements address the challenges of supplying, storing, treating, maintaining, protecting, and sharing water for growing populations and competing demands (Blomquist et al. 2004a; Steele and Regan 1955). In order for water managers, policymakers, and scholars to understand which governance arrangements are successful, they must be able to systemmatically diagnose and study "the black box of institutional processes and effects" (Blomquist et al. 2004a, 927). Doing so requires in-depth and contextually rich data that describe the structure of governance organizations and institutions (i.e. rules, policies, and regulations) across space and time (Blomquist et al. 2004a; Meinzen-Dick 2007). It also requires the ability to link institutional data to data and evidence on "outcomes" related to water, such as water quantity, quality, usage patterns, and ecological conditions.

Conducting systemmatic and rigorous research on water governance institutions and linking institutional data to outcomes has proven challenging (Braden et al. 2009; National Research Council 2001; National Research Council 2009; National Reserach Council 2001; Braden et al. 2014). This challenge is related to the complexity of water governance institutions. Water is governed by an array of policies, plans, rights, agreements, and mandates across multiple jurisdictional scales. Moreover, water governance is typically fragmented around sectoral or functional domains such as water allocation, water quality, endangered species protection, storage and distribution systems, and hydropower production. These complexities make it difficult to measure, prioritize, and standardize data on water governance institutions and to connect such data to outcomes.

In this paper, we examine the challenges and limitations of collecting and providing data on water governance institutions, with a focus on the U.S. First, we provide an overview of the literature

and research that points to the importance of institutional arrangements in studying water systems and their outcomes. Second, we show the need for more water-related institutional data and some of the challenges that scholars have identified in collecting data on water governance institutions. Then, through an assessment of data from a sample of public and academic water governance organizations and publications, we discuss the current status of water governance institutional data. The analysis focusses on water institutions linked to water management outcomes. We then offer conclusions and recommendations for expanding and enhancing these data sources.

Importance of Water Governance Institutions

Water governance, or our collective decisions and choices about the use and management of water, emerges through institutions. Broadly speaking, institutions are the formal or informal rules that structure human interactions and shape understanding about "what actions (or states of the world) are required, prohibited, or permitted" (Ostrom 2007, 36). In this paper, we focus on formal institutions such as laws, agreements, regulations, and policies. Informal institutions are often thought of as norms or societal expectations. Some examples of formal water institutions in the U.S. include federal and state regulations on water quality, state water rights regimes, instream flow laws, water lease agreements between irrigators and municipalities, and an international treaty on hydropower development.

Defining institutions as formal or informal "rules" suggests that institutions are not the same as organizations. However, institutions may establish organizations and organizations frequently create, implement, or administer institutions. In the water sector, these organizations may be public, quasi-public, private, or non-governmental. Examples can include irrigation associations, local water utilities, state water agencies, river basin commissions, and task forces. Multiple organizations may also work together, as in the case of a watershed collaborative, to create or implement water institutions. Such organizations therefore are important in how we observe and understand water institutions and governance.

Understanding and analyzing water institutions can be essential to improving water resource management and allocation. In the U.S., maintaining adequate, safe, and reliable water supplies for diverse needs has been a major concern of governments, farmers, industry, and environmental organizations. For many years, water research and analysis focused on the engineering and technical solutions to these concerns. In the 1950s and 1960s some scholars began to call for more attention to the role of institutions in water resource management; this was significant since much of the research at the time emphasized the need for large-scale water diversion and storage projects (Ciriacy-Wantrup 1967; V. Ostrom 1953, 473). As the political feasibility of developing large water projects in the U.S. started to wane by the 1970s (Bromley et al. 1974), awareness of the need to evaluate and understand water institutions began to grow among practitioners and scholars. As Gleick (2003) has argued, institutions provide "soft path" solutions (as opposed to the "hard path" of large scale infrastructure) for managing for improving water resource management.

A growing body of research has begun to collect and analyze data on institutions to understand water systems and their performance. An exhaustive review of these studies is beyond the scope of this paper. However, a few examples help illustrate the breadth and depth of this literature across different domains and contexts. Some investigations have compared and evaluated how the design of institutions influence social and political outcomes related to water. For instance, Schlager and Heikkila (2011) found the design of water allocation rules in interstate compacts shapes disputes over water resources. Other studies have explored how the design of water markets affect water use efficiency and environmental performance (Garrick and Aylward 2012; Garrick et al. 2011). Others have looked at how institutions such as water pricing or conservation incentives influence water consumption (Campbell et al. 1999; Nauges and Whittington 2010). Another example of institutional research related to water has explored how the rules governing decision-making, such as allowances for public participation and dialogue among diverse water sectors, have influenced the success of collaborative water management processes (Kallis et al. 2009; Leach and Sabatier 2005; Weber et al. 2005).

In recent years, the interest in understanding the impacts of different types of institutions has been reiterated in global water governance discussions (Conca 2006; Pahl-wostl et al. 2008; Wagener et al. 2010; Wiek and Larson 2012). Scholars and decision-makers alike acknowledge that today's global water governance challenges will be met by better management and understanding of the human element, namely the institutional arrangements, in the water system (Blomquist et al. 2004a; Goulet 2005; Jury and Vaux 2005; National Research Council 2009).

The Need for and Difficulties Acquiring Data on Water Institutions

Despite the growing attention to water institutions in the scholarly and practitioner communities, research describing the relationship "between human behavior and institutional performance" is still considered inadequate (Berger et al. 2001; Braden et al. 2009, 5; Scholz and Stiftel 2005; Ostrom et al. 2007). Jury and Vaux (2005) found that issues related to organizational and institutional arrangements and water management have been "largely neglected in recent decades" (15717) and that research related to institutions surrounding water resources has been negligible over the past twenty years. Blomquist and colleagues (2004a) describe a need to better understand "what institutional features work well under different settings or how certain rule arrangements are shaped by particular environments" (Blomquist et al. 2004a, 930). In response to such calls, the National Research Council has made research on institutions and resource use a priority for over a decade (Braden et al. 2009). Additionally, scholars have begun to call for greater integration of social and natural sciences to grasp the interrelationship between water and society over space and time and to understand, predict, and effectively utilize the water environment (Braden et al. 2009).

One potential reason for the inadequacy of institutional data is that the collection and analysis of institutional data is fraught with difficulties. Our experience in studies of water policies in Colorado (Gallaher et al. 2013), and our experience with collecting data on the design of institutions governing interstate water agreements (see Schlager and Heikkila 2011; Heikkila et al. 2011), on large-scale watershed restoration programs (Heikkila and Gerlak 2005; Gerlak and Heikkila 2006), and on conjunctive water management programs in the West (Blomquist et al. 2004b) suggests that in-depth data collection takes significant time and resources. In part, this is because institutions can change slowly, are often influenced by their societal and geographic context, and their impacts are not immediately obvious. Data collection that can capture both geographic and temporal variation in institutions and in physical water processes therefore may be needed to achieve meaningful analysis of institutional outcomes or performance.

At the same time, data on institutions often must be collected from multiple sources and sub-divided and organized in a way that is meaningful to the questions at hand. For instance, in studying and comparing how different interstate water compacts perform, Schlager and Heikkila (2011) collected data from formal laws, compact commission reports, meeting minutes, interviews, and news sources. These data sources were then "coded" in order to draw out the different types of sub-rules and institutions embodied within the compacts and the commissions that administer the compacts. The data collected included different types of water allocation rules found within a compact, the funding mechanisms for compact administration, the rules governing the compact commission, the mechanisms for monitoring and compliance with compact agreements, and changes to the compacts and their outcomes over time. Finally these data were linked with data on related water conflicts that emerged in the basins over the course of the agreement, data on state water laws and state water administration, and streamflow data. Because efforts like these take time and amass a large quantity of information, they require significant resources; the aforementioned example was funded by the National Science Foundation and required a team of research assistants and three years of data collection to complete.

Furthermore, answering new research questions with existing datasets can be a challenge. For example, while analyzing policy issues and tools in Colorado (Gallaher et al. 2013) we attempted to glean indicators of major versus minor policy change using data previously collected on

Colorado water laws. This task was untenable as the dataset described each policy, not its context or any related conflicts or events. Indeed, as other water researchers have shown, to answer new questions with existing datasets typically requires new and "append-able" information (Benjamin et al. 1994; Wolf 1998). Related to this issue, Bakker (2012) argues there is a mismatch between academic research output and the needs of policy-makers and practitioners, which limits integration of different types of data.

Even when assuming a perfect world of "adequate" data, it is difficult to assess the effects of institutions on water outcomes because of the interactions between different types of institutions with the contextual settings in which they play out (Bakker 2012, 915). As a result, one institutional arrangement may work in one place or time, but not in the next (Meinzen-Dick 2007). Moreover, because water resources are complex social-ecological systems, it can be extremely difficult to determine the effects of a particular institution of interest in the face of confounding environmental and social factors (Lubell et al. 2013).

How we deal with and move beyond these data limitations is of critical importance if we are to meet the imperative to study and analyze water institutions. In the following section we offer an assessment of the current state of publicly available data on water institutions before offering recommendations on how to move forward.

Exploring the Availability of Data on Water Institutions

As mentioned above, U.S. water governance is an amalgamation of overlapping institutional arrangements which include laws, policies, rules, and regulations from multiple levels of government. To analyze publically available data on water institutions in the U.S., we reviewed a sample of websites from government, academic, and research organizations and academic publications of water institution researchers. State, sub-state, and municipal website data was collected through a stratified random selection of states: we randomly selected one state from six different regions of the U.S. Within each state we included the state's water governing departments,

Table 1. Organizations sampled for water institution data.

Federal
U.S. Geological Survey: USGS Water Use Data for the Nation
Regional
Delaware River Basin
The Council of Great Lakes Governors
State
Colorado Water Conservation Board
Colorado's Decision Support System
Florida Department of Environmental Protection
New York Department of Environmental Conservation
New York State Department of Health
New York State GIS Clearinghouse
Ohio Department of Natural Resources: Division of Soil and Water Resources
Ohio Environmnetal Protection Agency
Oregon Water Resources Department
Texas Commission of Water Quality
Texas Natural Resource Information System
Texas Water Development Board
Sub-State Organization
Colorado Basin Roundtable
Northwest Florida Water Mangement District
City
Austin Water
Austin Watershed Protection Department
City of Columbus
City of Tallahassee
Denver City
Denver Water
New York City Environmental Protection
New York City Waterboard
Portland Water Bureau
Portland Water District
Water Research Institutes
Columbia Water Center
Institute for Water and Watersheds
Pacific Institute
Academic
Bren School of Environmental Science & Management: California Water Records
ETH Zurich Center for Comparative and INternational Studies
ICPSR: Inter-university Consortium for Political and Social Research

the state capital's municipal water managing department, and any sub-state water governance organizations. We also purposefully sampled the websites of two multi-state regional water governance organizations and the U.S. Geological Survey (USGS). Finally, we included academic and research sources for water data. The academic and research organizations were selected because of their prominence and expertise in the water field, while the research consortium was reviewed because it provides datasets from researchers who may study institutions related to water.

Although our primary focus was on U.S. data, in exploring research institutes, we found references to notable datasets at the international scale, which we discuss further below. Since the population of organizations that might collect or provide data on water institutions is unknown, our purposive sampling approach was meant to provide sufficient variation in geography, organizational type, and jurisdictional scale to draw initial insights on the type of data that are available. Table 1 provides the individual organizations included in the study.

Data were collected through a search of each organization's website for reports and datasets in June, 2013. If an internal search engine was available, then key word Boolean phrases such as ["water" AND "data" or "water" AND "database"] or simply ["water"] were used to identify potential water related information that was not found during the initial review of the website. Each resulting internal webpage or online dataset was evaluated for three attributes: 1) the availability and type of water institution data (e.g. jurisdictional boundaries, polices, rules, by-laws); 2) if data on water resource conditions or water related outcomes were available (e.g. conflicts, water quality, drought, flood, water levels); and 3) if water institution and outcome data were linked in the same dataset. To be considered "linked," the water institution and outcome data needed to be explicitly in the same dataset or model. For example, a Geographic Information Systems (GIS) tool containing both layers of water districts and water quality test outcomes was considered linked. On the other hand, data on the same webpage that includes a list of regulations and a number of separate reports related to water quality was not considered linked.

Table 2. Summary of sampled websites where data on water institutions and outcomes are linked.

Online Datasets with Linked Institutional and Outcome Data		
Organization Type	Only Jurisdictional Linkages	Beyond Jurisdictional Linkages
Federal (n=1)	1	0
Multi-State (n=2)	0	0
State (n=12)	8	3
Sub-state (n=2)	1	0
City (n=10)	2	0
Water Research (n=3)	1	1
Academic Databases (n=3)	3	0
Total (n=33)	**16**	**4**

Finally, using Google Scholar and key searches, we reviewed academic publications to scan for datasets used by water institution researchers. Boolean phrases, such as ["water" AND "institutions" AND "dataset"] and ["water" AND "policy" AND "dataset"], were used to limit the Google Scholar search results. The results were added to our current set of academic manuscripts and are discussed in the text of the results and conclusion sections.

Summary results of available data on water-related institutions and outcomes are shown in Table 2. The table provides the count of organizations from the sample that had institutional information linked to water resource outcome data. The institutional data is split between jurisdictional information (i.e. county, state, and water district information) and other information (i.e. water policy tools, compacts, and voting rules).

Within our sample, public online datasets that link institutions and outcome data are limited, both in terms of usability and breadth. The website reviews found public water governance organizations often provide rich information regarding the institutions, such as descriptions of events leading up to a new policy or the regulations guiding a program or data collection effort, but this information typically is embedded in the text of the website or

separate PDF documents. For example, the New York Department of Environmental Conservation provides in-depth information through a series of webpages on the agency's involvement in the New York City watershed, the physical water sources and boundaries of the New York City watershed, and related programs and regulations pertaining to the watershed. The information is neither ready for analysis nor is it linked to water quality, use, levels, or in most cases, events before or after the institution was begun.

The most common methodology for linking institutions to outcomes is geospatial referencing. Federal, state, and municipal governments have used geospatial referencing to link jurisdictional boundaries and individual water rights information to water outcome data. The water outcome data include water level and flow for lakes, streams, rivers, and reservoirs, water quality, and water monitoring sites. Though these datasets are often comprehensive for a state or specific region within the state, the files must be collected separately and sometimes from various sites. For example, the Oregon Water Resource Department GIS files only include water rights, rule, and jurisdiction boundary areas, and water gauge station locations; the outcome data such as water quality and contamination sites for the state are found at Oregon Department of Environmental Quality. The Institute for Water and Watersheds includes GIS data with the greatest breadth and variety of institutional and physical boundaries (country boundaries, river basins, and treaties) as well as outcome data, which include project counts, discharge, runoff, and water stress levels. The second most commonly found institution-and-outcome-linked datasets were Microsoft Excel based datasets that included water contamination, flow, or level alongside county, water district, or individual water rights.

The largest water-related dataset found is housed at the USGS, links to which were found at multiple state and municipal organization websites. The USGS Water Data for the Nation includes historical data for surface water (e.g. flows and levels in streams and lakes), groundwater (e.g. well water levels), water quality (e.g. chemical data from water sources), and water use information. The USGS water datasets are searchable by state, county, or hydrologic unit.

The majority of information posted on academic and water research group websites were publications rather than datasets. The Columbia Water Center provides a large searchable database of water-related research, but no raw datasets. Likewise, the Pacific Institute's website offers a wide range of online water-related programs to aid decision making and reports, but lacks data for others to analyze. The websites of the Institute for Water and Watersheds, the Bren School of Environmental Science & Management, and ETH Zurich CIS each provide at least one dataset with linked institution and outcome data. The Institute for Water and Watersheds' website provides two time-series databases in addition to the spatial GIS files. One of the time-series databases is a searchable database of 6,400 international water events (ranging from military action to political statements, to peaceful unification of states) between 1948 and 2008. The other database is an event-oriented database with basin and regulatory action, as well as drought and water quality indices from 1990 to 2004 for the state of Oregon (Institute for Water and Watersheds). The ETH Zurich CIS website provides data related to international river basin events with location, time, and indicators of whether events were conflictive or cooperative. The "events" covered in the Institute for Water and Watersheds databases and the ETH Zurich CIS may be related to particular types of institutions, such as a water agreement, but not all events are necessarily associated with an institution. The Bren School's dataset focuses on a particular type of institution, water markets at the state level, which focuses on the market transactions that were drawn from monthly reports of a water trade journal, the Water Strategist, from 1987 to 2010.

Based on our review of data available on the 33 organizations' websites and the reviewed academic manuscripts, we found a stronger representation of data on "outcomes" or physical properties (e.g. flows, quality) relative to institutional data. The most descriptive institution-related information provided by public agencies was embedded in reports and webpages rather than downloadable datasets. Datasets that linked institutions and outcomes were mostly focused on outcome measures and high level institutional divisions (e.g. state, county, or water district boundaries). While these data do provide potential for spatial analysis

or review of outcomes over time, in their current state they are largely inadequate to investigate research questions related to outcomes pre- and post-institutional change or to compare different institutional arrangements to one another. To perform these more nuanced analyses, institutional data would need to be added by the user. Indeed, we found that scholars studying water and institutions are not necessarily using the publicly available data from agencies or research institutes. Through Google searches for publications focused on water institutions and outcomes, the datasets typically employed by researchers are custom-built to match their research agenda (e.g. see Bardhan, n.d.; Benjamin et al. 1994; Blomquist et al. 2001; Heikkila 2004; Lubell et al. 2002).

The variety of data found in academic and quasi-academic websites and publications extends beyond the more functional datasets found at government websites and includes more historical information. For example, in addition to jurisdictional and rule boundaries, datasets also include rule or policy changes (Gallaher et al. 2013), treaties and conflicts (Bernauer et al. 2012; Institute for Water and Watersheds, n.d.), or water right transactions over time (Brewer et al. 2008). The scale of work from these academic and quasi-academic organizations is also more diverse than the government's website data. They include international river basin agreements (Wolf 2002), water transfers in the west (Brewer et al. 2008), multi-state basins (Blomquist et al. 2004b), and state-level water policies (Gallaher et al. 2013). While these academic datasets provide more time and space variance than the government-provided datasets, all the data we sampled are limited in the same fundamental way: the data are only fit to answer the questions of the organization or researcher.

Conclusions and Recomendations

The lack of publicly available data on water governance institutions is a perpetual challenge. The problem with throwing up our hands in the face of limited funding or continuing with the current pace of piecemeal data collection efforts is that such inaction could impede improvements in water governance. As other scholars have argued, the "current uncoordinated data collection programs in the U.S. are unlikely to support generalizable insights about fundamental human-nature relationships that vary at large-scale" (Braden et al. 2014, 12). A starting point to improve coordinated data collection and use is to make data accessible. Water agencies, institutes, and scholars using data that link institutions and water resource conditions or outcomes should strive to make more data publicly available.

Next, data are often not user-friendly or transferable between databases. Institutional data sets are complex and unique and there is not a currently accepted set of attributes to identify various institutions, water resources, or outcome information. The geospatial reference data we found provide some guidance to improve data usability. The spatial reference points and the available software for layering geospatial files make independently created datasets easily combined. Indeed, a powerful feature of geospatial analysis is the ability to combine multiple layers from independent users. If water researchers are to follow other crowd-sourced data endeavors, an agreed upon set of reference points, institutional and descriptive typologies, and data formats needs to be determined. Standards like these would make data more easily merged or appended. Making institutional data more user-friendly also requires transparency about how data are collected, including how concepts are operationalized and measured. In other words, researchers need to share data collection instruments such as coding forms and surveys. This will allow for enhanced replication of data collection efforts over time and across different locations.

Funding is also needed to support long-term data collection to diagnose and unpack the complexity of institutions. This includes support for studies on 1) changes to institutions over time (e.g. the evolution of a states regulatory programs); 2) how institutions connect across scales (e.g., relationships of state laws to interstate agreements) and connect across sectors (e.g., the connections between non-point source policies and point source policies through water quality trading programs); 3) how similar types of institutions function in different locations (e.g., cross-state comparisons of the design of instream flow institutions); and 4) how these institutions relate to the availability and

quality of water resources and the impacts on other systems (e.g. how instream flow programs affect the protection of species). Improving data collection and access to contextual social and political data, such as the networks of actors involved in water governance or the political preferences of water users, can also enhance the analysis and understanding of water institutions and governance.

Given that funding is always a limitation, water researchers may need to prioritize place-based studies of both systems that are in stress and those that appear to be working successfully, or similar types of institutional arrangements that allow for comparisons across locations. Researchers, policymakers, and managers need to understand more directly the other's needs and questions if we want to improve the design of institutions. Researchers often "follow the data," but sometimes the important and interesting questions cannot be answered with what is available. Engaged scholarship from the research angle and forward thinking by public agencies to "go beyond compliance" with regulations and think about systems and long-term planning can also help promote a more robust data collection agenda.

As our analyses show, some agencies and researchers are already carrying out some of these recommendations. But more data are needed and these efforts can be better coordinated to make the data applicable to diverse sets of research questions. Federal and state research institutes and think-tanks can provide an important middle ground to facilitate these discussions. Funders, such as the National Science Foundation, and other large federal agencies and foundations can play a critical role in encouraging research that promotes inter-disciplinary efforts and data integration.

Some of these suggestions add effort and cost to how we carry out research or manage data in public agencies. Indeed, adding tags to datasets or creating community standards for sharing and disseminating data collection instruments for others to freely use is a collective challenge. If we wish to continue the efforts underway to understand institutions and their impact on water governance, however, researchers and decision makers alike need a wider variety of data over space, time, and contexts. If a national agenda for water-related research follows the suggestions above, a rich clearinghouse of information will develop.

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Appendix 1. Data availability from a sample of water agencies.

Level	Agency/Group	Institutional Data	Outcome Data	Institutional Data Linked to Outcome Data
Federal	USGS: USGS Water Use Data for the Nation	State Boundaries	Water use in various categories, surface water, groundwater, and water quality data overtime over time for each state	Information categorized by state
Regional	Delaware River Basin	PDF-format of regulations	Water quality reports, contaminant data by site or sample,	No
Regional	The Council of Great Lakes Governors	No	Physical data, links to other state's modeling tools	No
State	Colorado Water Conservation Board	Model - water rights, operating rules, projects over time; GIS data - hazard plan status, NFIP participation, jurisdiction boundaries, watershed restoration project locations; General data - lists and descriptions of legislation, statutes, rules, policies, guidelines, CWCB rule and regulation processes	Model - flow, capacity; GIS - NFIP savings per policy, savings per community	Model can be setup to include various institutional arrangements to estimate outcomes; GIS shows spatial association;
State	Colorado's Decision Support System	GIS: water rights, division, district and county boundaries; irrigated lands; General data: water-rights information for structures such as ditches, reservoirs, and wells	General data: historical daily (cfs) or monthly (acre-feet) diversion data	General data: historical flows or levels linked to structures
State	New York State Department of Health	No	Annual water quality reports	No
State	NYSGIS Clearinghouse	Water boundary data, designated use,	Yes	GIS map shows spatial association
State	Oregon Water Resources Department	Information on specific water rights. GIS data includes Water rights by type/use, and point of diversion; Rule Boundaries; Political Boundaries (Administrative Basins, Water Districts); Water Availability (priority WABS, Water availability basins); active and inactive stream gauge locations.	Hydrographic data set; historical stream flow datasets	GIS map tool displays multiple jurisdictional and rule boundaries, water right by type and use, water monitoring stations, and waterways.
State	New York Department of Environmental Conservation	Individual documents on guidelines and regulations	Water quality reports	No
State	Texas Natural Resource Information System	State boundaries, county boundaries, city boundaries, federal parks, state parks, and landmark boundaries (airports, universities, wildlife refuges, and military bases).	No	No

State	Texas Water Development Board	Yes - rules, regulations, policies, plans, etc.	Yes - flood, drought, levels, flows, contamination, etc.	No
State	Florida Department of Environmental Protection	PDF/website information on policies, regulations, programs, etc. Set of reports describing issues and programs. 52 GIS data layers with multiple institutional boundaries, physical water locations, and physical outcome data	Yes - water flows, contaminations; quality reports for surface, ground, drinking water	Through GIS. Multiple types of institutional data (jurisdiction, program boundaries, protection boundaries) and outcome data. Other datasets include outcome data with some jurisdictional connections
State	Ohio Department of Natural Resources: Division of Soil and Water Resources	Regulations and programs in report form; GIS maps of jurisdictional divisions	Water quality for surface and ground; well levels; visual maps for multiple outcomes	Jurisdictional links through GIS.
State	Ohio Environmental Protection Agency	Rules, policies, guidelines, programs, use designations in report format; GIS maps with boundaries and use designations;	Water quality (surface and ground) data sets available and GIS maps of some outcome data	Jurisdictional links through GIS and excel files.
sub-State region	Colorado Basin Roundtable	Yes - tax zones, counties, parcel divides, land ownership	No	No
sub-State region	Northwest Florida Water Management District	Yes - tax zones, counties, parcel divides, land ownership	Yes - water quality	GIS spatial association. Jurisdictional
City	Denver City	FEMA flood insurance rate map panel index and flood zone Divisions; Metropolitan Districts; Survey relinquished easements. Zoning for aquaculture; Zoning for general manufacturing of food		
City	Denver Water	Water policy, rules, regulations	Quality and use data over time	No
City	New York City Environmental Protection	Separate documents and reports for rules, regulations, MOUs	Separate reports for various water quality, usage, flows, levels for different sites and sources	No
City	New York City Waterboard	Separate documents for governing documents and policies	Financial statements	No
City	Portland Water Bureau	Yes - regulations	Some - link to EPA site for water sample results	Some- e.g. Information collection rule (1996) and link to water sample outcomes at EPA website
City	Portland Water District	No	Budgets and water quality reports	No
City	Austin Water	PDF-format policy and planning documents	Flood data	No
City	Austin Watershed Protection Department	PDF-format regulation and policy	Flood data	No
City	City of Tallahassee	PDF and webpage policies and programs	PDF format of measurement outcomes	No
City	City of Columbus	PDF database of rules/policies, discussion of watershed partnership	PDF reports	No

Appendix 2. Data Availability from Sample of Research Institutes and Academic Sources.

Level	Agency/Group	Institutional Data	Outcome Data	Institutional Data Linked to Outcome Data
Water Research Institutes	Columbia Water Center	No	Delaware River Stream flow monthly data	No
Water Research Institutes	Pacific Institute	No	No	No
Water Research Institutes	Institute for Water and Watersheds	Multiple datasets: basins, country boundaries, treaties, tenders, irrigation; regulatory action	Multiple datasets: project count, discharges, runoff, water stress level; collaboration level; drought index, news events, use index, water quality index	Multiple datasets: GIS spatial association; basins and events; regulator action, basins and events, drought, use, and water quality
Academic Database	ICPSR	County data collected	Perceptions and technology of user	Yes
Academic	Bren School of Environmental Science & Management: California Water Transfer Records	Information by state	Transaction amount, price	Yes
Academic	ETH Zurich CIS	Country identification	Water event: time, location, intensity, and if its conflictive or cooperative event	Yes