REACHING WATERSHED SCALE THROUGH COOPERATION AND INTEGRATION

A REPORT FROM THE 2018 ASPEN-NICHOLAS WATER FORUM

Duke
NICHOLAS INSTITUTE
FOR ENVIRONMENTAL POLICY SOLUTIONS

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REACHING WATERSHED SCALE THROUGH COOPERATION AND INTEGRATION – A REPORT FROM THE 2018 ASPEN-NICHOLAS WATER FORUM. 2018. Lauren Patterson, senior policy associate, Nicholas Institute for Environmental Policy Solutions at Duke University; Martin Doyle, director of the Water Policy Program, Nicholas Institute for Environmental Policy Solutions at Duke University; David Monsma, former Executive Director, Energy and Environment Program, the Aspen Institute and Greg Gershuny, Interim Director and James E. Rogers Energy Fellow, Energy and Environment Program, the Aspen Institute.

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The 2018 Aspen-Nicholas Water Forum is the seventh forum in which the Aspen Institute and the Nicholas Institute have partnered. The first, in 2005, on water, sanitation, and hygiene in the developing world, produced *A Silent Tsunami*, which made a material contribution in advancing priorities in U.S. foreign assistance for basic water services. The report ultimately helped spur passage of the Paul Simon Water for the Poor Act. In 2011, the two institutions again joined together to host a one-day forum to take stock of progress, documented in *A Silent Tsunami Revisited*. The success of these endeavors provided the impetus for additional forums focused on water concerns in the United States.
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PREFACE

The scale of water challenges of the 21st century is regional and encompasses multiple jurisdictions — whether depletion of multi-state aquifers, basin-scale flooding, or the wide-spread accumulation of nutrients leading to large estuarine dead zones. Yet decisions, practices, and policies are predominantly made at the local scale and are often sector specific, creating mismatches between problems and policy. Regional scale problems often require regional scale solutions, so how do we reach scale?

The 2018 Aspen-Nicholas Water Forum explored opportunities to change the scale of water management through regional integration. The term regional integration refers to the entire spectrum of collaborations for water management, from informal partnerships, to merging of staff and resources, to the physical consolidation of infrastructure. Increasing the scale of water management through regional integration can lead to much-needed efficiencies such as incentives for technological innovation, conservation and water quality enhancements, and novel approaches to source protection and infrastructure. The central question for the 2018 Aspen-Nicholas Water Forum was: **How can regional integration be used to address chronic and emerging water challenges?** Regional integration may be geographically based, between sectors (such as industry-utilities), or between functions (such as financial).

The Aspen-Nicholas Water Forum is an annual roundtable event that convenes thought leaders to address ongoing challenges to water sustainability in the United States. Participants come from the private sector, government, academia, and non-governmental organizations—representing expertise in industry, finance, philanthropy, government, academia, agriculture, food and technology companies, investors and entrepreneurs. Topics discussed have ranged from water and big data, to innovative financing, to groundwater, and now to regional integration as a means to manage our water resources for sustainability.

Each year, a summary of the forum is written by the Nicholas Institute for Environmental Policy Solutions at Duke University and the Aspen Institute. Not all views were unanimous nor were unanimity and consensus sought. Forum participants and sponsors are not responsible for this summary's content.

We thank the following sponsors for their generous support of the forum: Bechtel Foundation, Schlumberger, Walton Family Foundation, Intel, Spring Point Partners, Xylem, Water Asset Management, Mitchell Foundation, Esri, and Arizona State University. A special thanks to Ryan Barr at Gallo Wines for the great wines, and to Alan Boyce at Materra Farming for providing us with dates and pistachios.

VISION

The forum's overarching conversation centered on the need to develop a broad vision for water governance in the United States by starting to ask, "what is good governance for water?" What does water governance look like in terms of balancing liberty and equity with efficiency and community (**Figure 1**)? What is the legacy of these broad ideals on water, and what do we want our legacy to be in the future? It can be argued that the focus of water governance in the United States over the past few decades has largely maximized efficiency within the local context. The result has been a fragmented patchwork of individual actors working towards localized solutions. However, we are now grappling with challenges that impact large geographic regions, multiple sectors, and different community functions. The forum discussed whether shifting towards a more equitable vision for water governance is not only necessary, but key to enabling collaborative approaches to address these broader challenges. This shift in vision was viewed by some as a means of moving away from business as usual and towards disruptive changes that could enable access to resources and adequate investment in infrastructure to meet emerging social, economic, and environmental needs. The 2018 forum attempted to *define an approach to drive shared outcomes at an optimal scale that best serves the needs of local communities while addressing chronic problems with equity.* Specifically, we explored the role of regional integration. Regional integration refers to the entire spectrum of integrative strategies from informal partnerships, to merging of staff and resources, to the physical consolidation of infrastructure. ***Integration is not about optimizing what each entity already has, but rather is intended to synergistically combine efforts and resources to create benefits that could not have been achieved individualistically.***

Regional integration requires change from business as usual. Change inherently comes with fear, uncertainty, mistrust, and conflict. As a result, forum participants agreed on three key principles for successful regional integration. First, there is a need for leadership. Leaders need to have courage and be responsive to a variety of stakeholders, which means leaders must be highly skilled at navigating uncertainty, mistrust, and conflict to enable robust integration and progress. Since water is deeply rooted with local communities, leadership will often need to be connected with those communities. Second, there must be trust and transparency. Transparency means

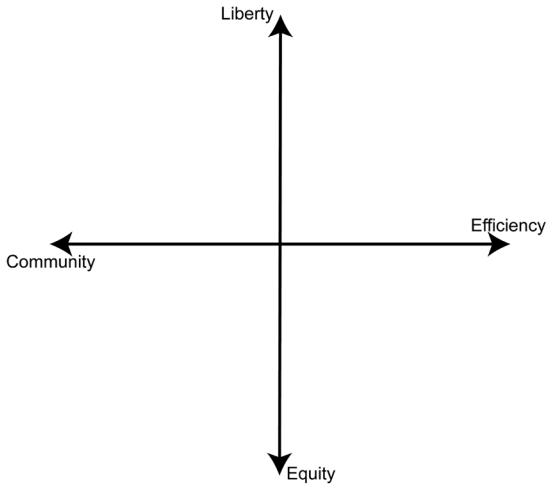

Figure 1. Adopted from The Executive's Compass: Business and the Good Society, James O'Toole, 1993.

equal access to information and resources. It enables trust between and within diverse stakeholder groups. The third principle recognizes that water is a public good and therefore government must provide guardrails to protect access, ensure affordability, and create equity. Equity refers to providing what each group needs to achieve positive outcomes, such that success for the whole means success for the individual.

Integration is a tool to reach new scales that may change our vision for water management in the United States. As the scale of water management changes, there must be concerted effort to rethink water governance, develop new leaders, and build trust amongst local communities. This forum is a starting point for collectively addressing water challenges across the U.S. and for beginning to articulate a new vision for water governance.

REGIONAL SCALE CHALLENGES

Water challenges of the 21st century continue expanding at regional scales that encompass multiple jurisdictions — whether depletion of multi-state aquifers, basin-scale flooding, or the wide-spread accumulation of nutrients leading to large estuarine dead zones. The prevalence of regional scale problems is growing due to several trends impacting the water sector. The first trend is **increased water supply variability**. Climate change is impacting weather patterns, snowpack, and extreme events. For instance, precipitation during Hurricane Harvey exceeded 60 inches in parts of Texas[1] while prolonged drought has altered expectations for the water security provided by Lake Mead and other reservoirs in the Western United States. As surface water has become more variable, groundwater in many aquifers are undergoing sustained depletion, particularly in those aquifers serving as the main source of irrigation for the nation's primary sources of grain (High Plains Aquifer), fruits and vegetables (Central Valley Aquifer), and rice (Mississippi Embayment).

A second trend is the **degradation of water quality**. The U.S. Environmental Protection Agency (EPA) estimates that 44% of stream miles and 64% of lakes are not clean enough for swimming or human consumption of fish. Lower water quality has led to ecosystem decline as well as negative public health outcomes with as many as 19.5 million Americans becoming ill through biological contaminants in drinking water.[2] While some of these challenges still arise from point source pollution by municipalities and industry, the cumulative impacts of non-point source pollution remains largely unchecked. The most downstream points of large watersheds, such as estuaries, commonly struggle with degraded water quality.

A third trend is the **concentration of population in fewer dense cities and depopulation in others**. Today, more than 80% of the U.S. population lives in urban areas compared to 64% in 1950.[3] Rapidly expanding urban water providers may benefit from a growing revenue base; however, they often face challenges to expand infrastructure and ensure reliable water supplies. While rapidly growing municipalities may struggle to keep pace with explosive growth, a number of rural

[1] NOAA. 2018. Tropical Cyclone Report: Hurricane Harvey

[2] Clean Water Laws Are Neglected, at a Cost in Suffering. 2009.

[3] Padowski & Jawitz. 2012. Water availability and vulnerability of 225 large cities in the U.S. *WRR* 48, W12529.

areas and some large cities (such as St. Louis, Cleveland and Detroit) have stagnant or declining populations (**Figure 2**). These systems struggle with oversized treatment and distribution infrastructure, coupled with a declining revenue base to cover capital and operating costs. Improved technologies have lowered per capita water use and, while decreases in per capita water use are a positive development for conservation, it creates tremendous challenges for water providers to cover costs as their revenue base declines.

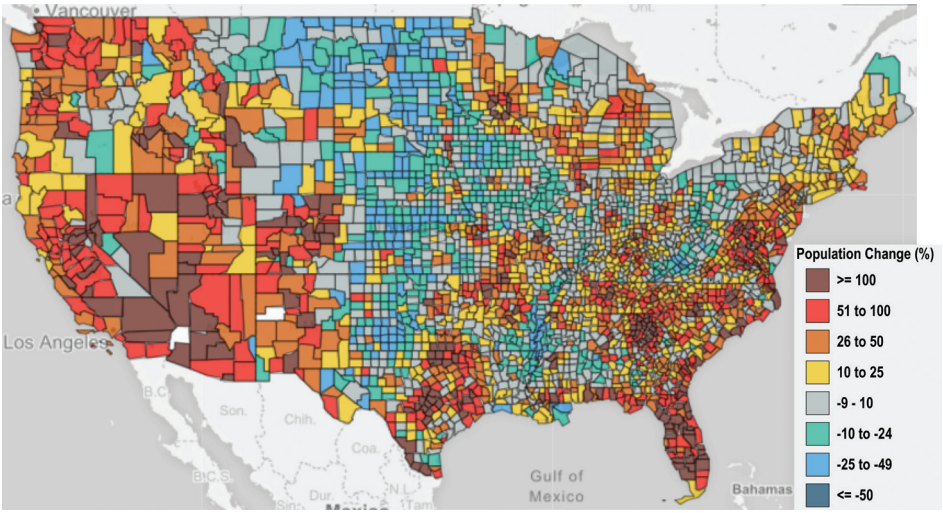

Figure 2. Population change by county from 1980 to 2010. Data are from U.S. Census Bureau.

A fourth trend is the **lack of investment in water infrastructure and technology**. The average age of levees and reservoirs in the U.S. is 56 years (average life expectancy of 50-100 years). Likewise, one million miles of pipelines are nearing the end of their life expectancy.[4] The American Society of Civil Engineers estimates that $1.27 trillion in water and wastewater infrastructure investments will be required over the next 25 years, which is more than twice the current investment by all levels of government. This is especially problematic given that federal, and in recent years both state and local, government spending on water related infrastructure have declined.[5] Degrading infrastructure leads to water quality and quantity problems, as well as non-revenue water (through leakage), which is approaching 1.7 trillion gallons ($2.6 billion worth) of treated drinking water lost each year.[6]

[4] ASCE. 2017. Infrastructure Report Card.

[5] Eskaf. 2015. Four Trends in Government Spending on Water and Wastewater Utilities since 1956.

[6] Murray. 2007. Aging Water Infrastructure Research Program: Addressing the Challenge through Innovation.

A fifth trend is increased regulation. In the past, environmental regulations, such as the Clean Water Act (CWA), often came with both a carrot (incentives such as grant programs that enabled organizations to begin complying with newly introduced regulations) and a stick (penalties typically in the form of fines). In recent years, the carrots have been disappearing while regulations have increased. As regulations and pre-existing standards become more stringent, it has become increasingly difficult for individual organizations to comply at acceptable cost levels.

These trends are introducing significant change in the water sector, yet the decisions, practices, and policies influencing these trajectories are predominantly made at the local scale and are sector specific. This creates a fragmented patchwork of solutions that are mismatched for the problem. Regional scale problems often require regional scale solutions, yet there has been little inertia to make significant changes in water management approaches.

THE POLICY TRILEMMA

Business as usual has not addressed emerging regional scale problems, nor provided the financial investments needed to maintain water infrastructure consistently across water providers. Water providers are caught in a "policy trilemma" in which there are a number of goals that cannot be simultaneously achieved. This requires decision-makers to make trade-offs. For water providers, the policy goals can be grouped into (1) maintain business as usual, (2) maintain affordability, and (3) meet investment needs (**Figure 3**).

Currently, water providers are prioritizing maintaining business as usual and affordability. Business as usual refers to the fragmented nature of the water industry, with each focused on maintaining autonomy through ensuring regulatory compliance and minimizing risk. Strong cultural ties and identity further promote maximizing autonomy. Affordability refers to the challenges of providing water at cost and ensuring that those served are able to bear the costs. Already 12% of Americans may find current water rates unaffordable, and this number could triple to 36% of the populations as rates are raised to meet capital needs[7]. Some utilities have the capacity and economies of scale to address affordability through subsidies and rate structures, but many utilities don't have the financial capacity. Greater investments, and revenue, are needed to meet the challenges of aging infrastructure, responding to climate or regulatory changes, growing or shrinking demand, and so on. It is not possible to meet investment needs and maintain affordability while operating under business as usual.

There are several potential disruptions to the water trilemma that can help shift towards addressing investment needs while maintaining affordability.

1. **Technology:** Technological improvements can improve productivity, enabling more to be accomplished with less resources, whether time or money. For instance, new technology using artificial intelligence and high-resolution sensor networks may enable meeting increased regulations more efficiently.

[7] Mack and Wrase. 2017. A Burgeoning Crisis? A Nationwide Assessment of the Geography of Water Affordability in the United States.

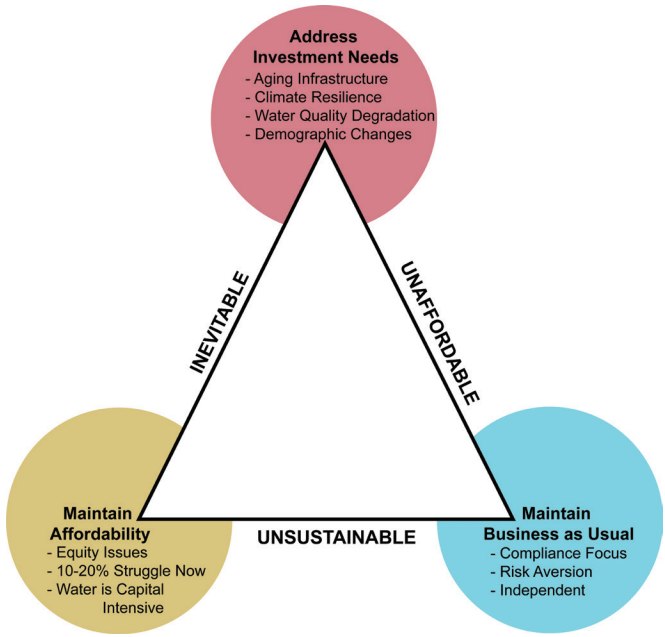

Figure 3. The water policy trilemma. Currently, water utilities straddle between maintaining business as usual and affordability. This is *unsustainable* given our growing infrastructure investment needs. These investment needs will have to be met to continue providing acceptable water services. If investment needs are addressed while maintaining business as usual, water will become *unaffordable*. Therefore, it is *inevitable* that investment needs will have to be met while maintaining affordability.

2. **Institutional Change:** Innovative forms of regional integration within institutions and across geographies can create economies of scale. For instance, several small communities in Michigan were struggling to meet new regulatory requirements from the 1986 Safe Drinking Water Act (SDWA) amendments. The Lansing Board of Water and Light (BWL) entered into a multi-stakeholder process with surrounding communities that resulted in 17 communities joining BWL through complete asset transfers or long-term operational contracts. Smaller communities have access to more resources and BWL can maximize their asset usage through economies of scale.

3. **Inter-sectoral Collaboration:** Similarly to diversifying a stock portfolio, integration between sectors and across functions can diversify cost structures and access resources from different sectors. For instance, utilities have the highest marginal cost to abate pollution at a fixed location while the costs are relatively low for agriculture or private land owners throughout the watershed. DC Water recently launched an initiative to identify more cost-effective upstream solutions to meet more stringent water quality regulations.

4. **Policy and Regulations:** Policy and regulations can require organizations to rethink how they do business in order to have the resources to comply with new policy drivers. For instance, California passed the Sustainable Groundwater Management Act (SGMA) in 2014 to create new regional agencies to devise solutions to collectively address groundwater challenges.

TYPES OF INTEGRATION

The forum focused on how to match the scale of water management with regional problems through institutional change and inter-sectoral collaborations. The term regional integration refers to the entire spectrum of integrative strategies for water management, from informal partnerships, to merging of staff and resources, to the physical consolidation of infrastructure (**Figure 4**). ***Integration is not about optimizing what each entity already has, but rather about synergistically combining efforts and resources to create benefits that could not have been achieved individually.*** There are three broad categories of integration: geographic, sector, and functional. There appears to be a scale at which efficiencies are gained for environmental, institutional, economic, and technological benefits. The optimal scale of integration will depend on the desired outcome, such as financial health, regulatory compliance, or improved water quality.

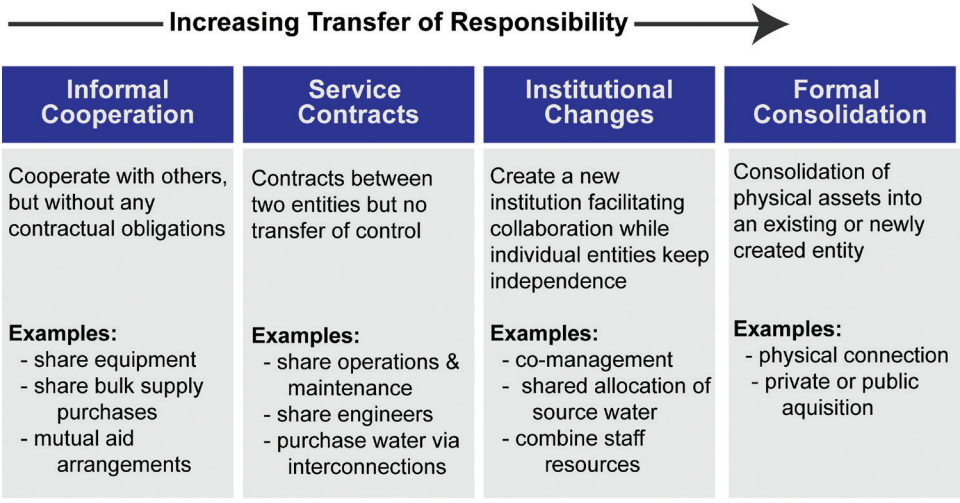

Figure 4. A sample of a spectrum of informal and formal agreements used in regional integration[8]

[8] Adapted from Leurig. 2010. Water Ripples: A Ceres Report. EPA. 2009. Gaining Operational and Managerial Efficiencies through Water System Partnerships.

Geographic integration attempts to match the scale of governance with the scale of interconnected water. Rivers form natural boundaries for states and local governments, and therefore often have multiple jurisdictions within multiple watersheds, creating a patchwork of governance over each watershed. Aquifers have different boundaries from surface water and can encompass multiple states, with withdrawals in one state impacting groundwater levels in another. Geographic integration uses these natural boundaries as the contours for establishing collaborative governance mechanisms. Examples range from water allocation for the Colorado River compact to water quality management in the Delaware River Basin. The integration of regulatory requirements and governance, such as interstate compacts, are often needed for large-scale geographic integration (**Figure 5**).

Sector integration can occur when multiple sectors access the same water source, allowing opportunities to take advantage of the different needs and resources of each sector for water management. No single sector can solve large scale water problems, making it essential to invest in partnerships across sectors for mutually-beneficial solutions. Sector integration may be ideal to address issues arising from demographic shifts (e.g. industry moving to a city with excess capacity and a declining population), inadequate infrastructure funding (e.g. industry investing in a municipal treatment plant to enable reuse), or the cost burdens of increased regulation (e.g. utilities investing in upstream best management practices for land owners and agriculture to reduce nonpoint source pollution). Water transactions

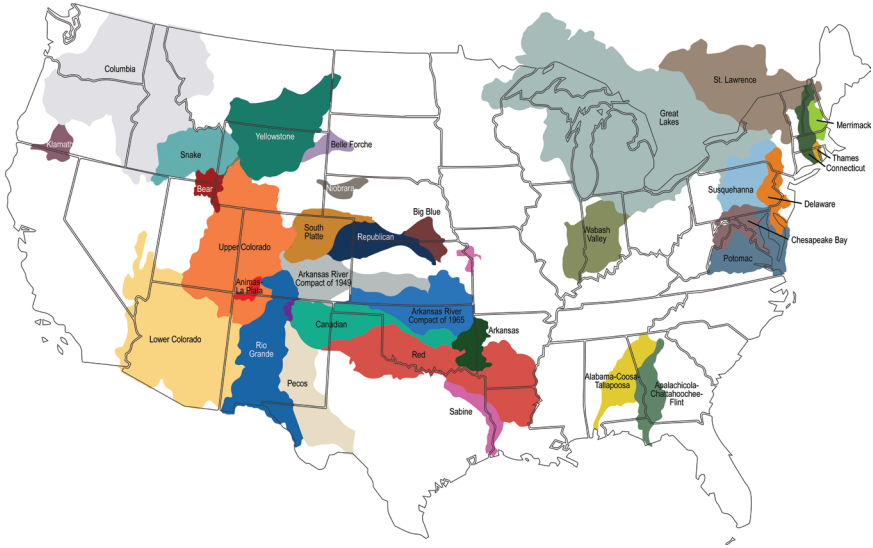

Figure 5. Interstate Water Compacts listed on the National Center for Interstate Compacts[9]

[9] Wilson et al. 2018. SCOTUS Wades into Water Wars.

between urban and agricultural entities could help address variability in water supply or curb sustained groundwater depletion.

Functional integration refers to collaboration that reaches economies of scale in terms of functionality in order to achieve a desired outcome more efficiently. For instance, several utilities or agricultural growers could partner to share human, technical, or financial resources. Functional integration can occur across organizations or within a single organization. Municipalities frequently have separate stormwater, wastewater, and water utilities that each have their own financial officer, technology team, and administrators. Water is interconnected, yet utilities within the same municipality often operate independently and do not collaborate on projects and plans that could result in financial, institutional, and water savings. Consolidating these functions can create 30-40% cost reductions by reducing duplicative staff (such as financial and administrative). Integrating these functions can produce efficiencies and lower costs within a utility. Functional integration can be as small as sharing human resources between two entities to as large as an association that pools resources to advocate on behalf of their constituents (such as the National Association of Clean Water Agencies for utilities and AgGateway for agriculture and technology industries).

ELEMENTS OF SUCCESSFUL INTEGRATION

Participants identified several components that were consistently present where regional integration was successful.

- **Trust** must be established for integration to even be considered, let alone implemented. Trust is built over time and usually starts small, such as sharing financial programs, and then grows into institutional integration or even physical consolidation. Oftentimes, a neutral third party that is trusted by all stakeholders can help create transparency and facilitate integration.
- A **leader, or local champion**, who is perceived to be trustworthy, is needed to take ownership and continually work towards institutional change. The leader must be someone who can paint a unifying vision for the future and clearly convey how those involved will benefit.
- Typically, **integration needs to be locally driven**. While there may be external forces driving the need for integration, the majority of successes occur when integration comes from the bottom-up. Locally driven integration enables *frequent connections and informal touchpoints* within the community, as well as *in-person* meetings.
- **A clear vision** needs to be articulated with desired outcomes that are shared by all stakeholders. This includes clearly defining desired outcomes and the scale needed to reach that outcome. Oftentimes layering multiple benefits can lead to higher success than focusing on singular outcomes in a piecemeal fashion.
- **Messaging** that focuses on the benefits of regional integration, such as improved efficiencies and service quality, receive more support than messaging that focuses on the process of integration. Similarly, *responsible, solutions-based* journalism that shares success stories and lessons learned can broaden the imagination and possibilities for others seeking to address similar challenges.
- **Incentives** are key to changing behavior, and it is important to align those incentives with the values of the community. The incentives to participate in regional integration to achieve desired outcomes must be *economically viable* for all participants with equity between diverse stakeholders.

GOVERNANCE

One of the driving questions at the forum was whether current governance is enabling or disabling regional integration opportunities. Water governance is particularly complex and convoluted; fragmented between different levels and branches of government. At the federal level, the U.S. Congress passed 10 acts specific to water between 1964 and 1974. Each of these acts focused on regulating single point sources or single species, encouraging the development of site-specific solutions. The initial legislative focus on point source pollution was very successful, as the nations' rivers ceased to catch fire. However, 20 years later, as poor water quality persisted, Total Maximum Daily Loads (TMDLs) were introduced to address growing nutrient concentrations. TMDLs are an approach that encourages regional integration to address the collective problem of non-point source pollution. There have been some successes (such as collective permits, see *Markets as an Integration Tool*), but regional integration has remained limited, and despite investing billions of dollars, nutrient concentrations continue to rise for many rivers, estuaries, and aquifers.

While the federal government regulates water quality, water quantity is regulated by states. Each state has different laws and rules about how surface water and groundwater are managed. Some states give local governments (such as water management districts or groundwater conservation districts) regulatory authority. States may attempt to provide governance structures for regional integration through: (1) mandates, (2) incentives, and (3) engaging in state and regional planning efforts. Kentucky and Alabama both provide examples of where the governor successfully mandated widespread consolidation of utilities. In 2015, the California legislature granted the state the authority to mandate consolidation of persistently non-compliant water systems. But without a clear leader, this authority has yet to be exercised. Florida and California both provide examples of states threatening to intervene on local water management agencies if local they are unable to collaborate. Oklahoma provides an example of trying to incentivize regional integration by offering 30% loan forgiveness on collaborative infrastructure projects. Despite the generous offer, there have been no applicants. Oklahoma's experience is not unusual. California also introduced incentives to facilitate consolidation, including a zero-interest loan program that to date has not received any applicants.[10]

[10] Global Water Intelligence. May 2018. California mulls bills to tackle small systems.

States have governance structures in place for regional integration through inter-state compacts. Most inter-state compacts are in Western states and focus on water quantity (Figure 5). In the Eastern U.S., seven compacts focus on water pollution control and seven on flood control. Litigation is often used when compacts fail to resolve an issue.

At the end of the day, water is largely governed at the local scale through cities and districts. There are both benefits and challenges in governing water at the local scale. Local governments have short political cycles and are juggling a plethora of pressing issues unrelated to water. There are also significant pressures to not change the status quo. To overcome these hurdles, states may have to provide the incentives for local governments to spend time, energy, and financial resources on water management.

GOVERNANCE IMPLICATIONS FOR REGIONAL INTEGRATION

When considering governance implications for regional integration, there are some particular features of water that must be taken into consideration. First, water infrastructure is invisible, with the most expensive aspects of a water system located underground or at the edge of a community. This makes it easier to defer investments for infrastructure repair in a way that is not transparent to decision-makers until there is a leak or crisis (out of sight out of mind). In contrast, communities will quickly notice the absence of police officers or a deteriorating road or school building. Second, water is essential for life and for every aspect of the economy and society. This has led to utilities being very good at water provision and the establishment of governance mechanisms to secure water resources and ensure access to everyone. Unfortunately, the cost is often unaffordable and therefore unsustainable. This means utilities will likely need more formalized governance structures for integration to ensure all have access to safe, affordable water. Other sectors can integrate through more informal mechanisms because they don't carry the burden of providing water to civil society. Any integration must grapple with these two aspects of water governance – water is invisible, yet essential.

REGIONAL INTEGRATION BY SECTOR

INTEGRATION IN WATER, WASTEWATER, AND STORMWATER UTILITIES

There are an estimated 2,552 natural gas utilities and 3,300 electric utility providers in the United States (**Figure 6**). In contrast, there are over 52,000 community water systems (CWS), of which 82% serve less than 3,300 connections. The plethora of small water utilities presents significant challenges, including increasing costs to meet regulations and replace infrastructure, limited access to capital, limited technical and managerial capacity, and diseconomies of scale. The magnitude of water systems, each with their own culture and political identities, can seem overwhelming, but there have been comparable politically and culturally charged integrations that have been successful in other sectors (see *Box: School Integration*).

The inefficiencies of fragmented water systems have led some utilities to geographically integrate with a larger, centralized utility. For instance, the Great Lakes Water Authority (GLWA) began operating as an independent regional water and wastewater authority in 2016. Today they serve 3.9 million residents (more than 40% of Michigan's population) in 8 counties. Regional integration took place after a cumbersome process to establish a governance structure that represented the interests of each community. GLWA is now governed by 6 members representing Detroit, large counties, and the State. GLWA has noticed that the institutional change brought on by integration served as a disruption that has sparked new collaborations between communities within GLWA. For instance, Community A invested in a storage tower and shares the storage with Community B, creating an economic benefit by saving on peak charges. The economic savings for the two communities and GLWA was $40 million. Once a little autonomy has been released and the benefits of integration realized, additional integrations becomes an increasingly viable opportunity and easier to implement.

SCHOOL INTEGRATION

In 1940, there were over 117,000 school districts in the U.S. and now 13,000 school districts (11%) remain. Motivations for consolidation were driven by different state goals that included funding equality, desegregation, rural development, and cost savings. The capacity for large-scale consolidation came from regulatory pressure (such as minimum population thresholds) and incentives (mostly financial). State efforts to consolidate schools were often met with local resistance because schools have strong ties to community identity and implications for culture, race, wealth, and so on. One big lesson learned was that the upfront cost for integration is large, while the benefits accumulate and are realized over time. The potential for cost savings were greatest in consolidating the smallest districts.

Has the integration of school districts been successful, or has it led to new types of fragmentation? Yes. Having alternative options is a big difference between school districts and water systems. Those dissatisfied with their local school district can opt into private schools, and districts are offering more alternatives through magnet and charter schools. In contrast, water systems have fixed infrastructure that rules out alternative providers. Water's natural monopoly is created by high capital costs bolstered by state laws that enforce service monopolies and create legal obligations to serve within designated areas. Bottled water and private wells are not feasible options for many uses or locations. The inability to opt out raises the stakes on how water services are integrated.

Geographic integration does not necessarily mean smaller utilities will necessarily partner with a nearby larger utility, as in the case of GLWA. Rather, some utilities form cooperatives. EJ Water Cooperative, Inc. in rural Illinois has grown from serving 480 households to serving rural communities within 12 counties and selling wholesale water to nine other utilities. Cooperatives are an attractive way to bring together rural systems because the co-ops are a familiar model for rural communities that brings integration around different functions. Aside from geographical integration, EJ Water Cooperative is focused on the functional integration of finances to diversify revenue streams. Because they serve rural communities, they are able to access grant money from the U.S. Department of Agriculture, contract services of human resources with nearby utilities, and joint ventures with neighboring utilities. Physical consolidation has provided opportunities to put unused CAPEX offline and create savings in overall operations and maintenance, but there are a range of additional services (such as communication and outreach, SCADA services, lab testing, and so on) that EJ cooperative has been able to provide without physical consolidation.

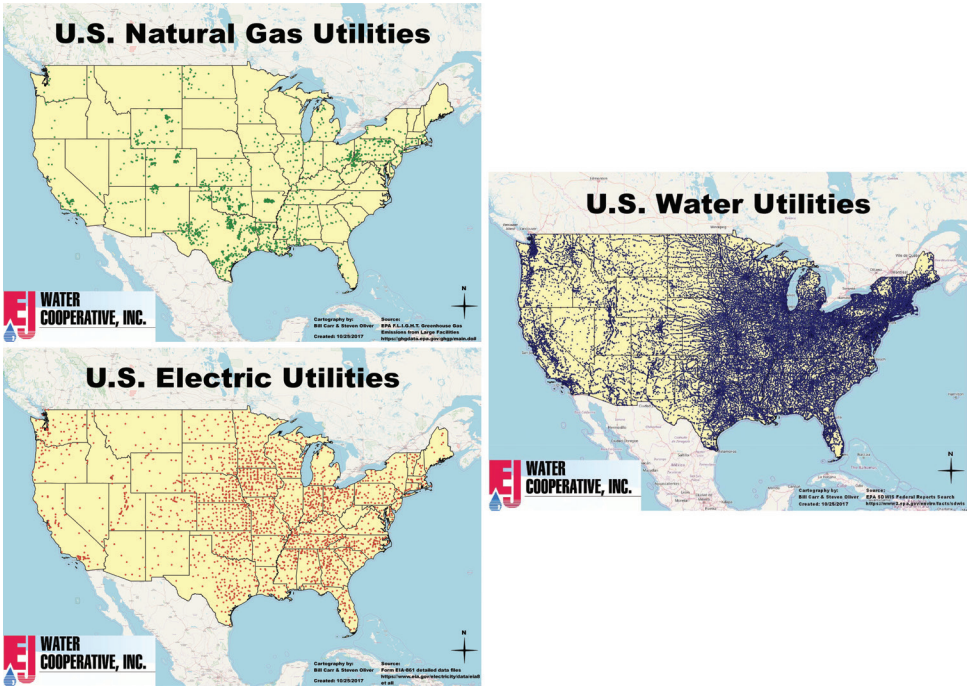

Figure 6. Number of natural gas, electric, and water utilities in the United States.[11]

The privatization of water systems can be viewed as regional integration (typically functional). Aqua America serves 3 million customers in 8 states across the United States. Suez North America owns and operates 16 water and wastewater utilities, while operating 90 municipal water and wastewater systems through public-private partnerships and contracts. Private water utilities typically benefit from economies of scale for particular functions, such as technical/engineering expertise and some back-office functions (e.g., IT, financial management). The regulatory environment may also be changing in some states to enable more functional integration (particularly human, financial, and technical) through privatization. In 2016, Pennsylvania joined five other states in passing fair market value legislation that allows investor-owned utilities to recover costs through rates at independently appraised fair market value.[12] This legislation seeks to address the gap between what municipalities want to sell their systems for and what prospective buyers are willing to pay given the risk of cost recovery.

[11] Cartography by Carr & Oliver. 2017. EJ Water Cooperative.

[12] GWI. December 2016. Investor-owned utilities benefit as fair value legislation incentivizes system scales.

INTEGRATION IN AGRICULTURE

The irrigated agricultural community is the largest water consumer in the U.S. and is a critical part of the solution when seeking to address large scale problems. There has been a significant shift in the demographics of farms and farmers, particularly a loss of younger or mid-career farmers; this, along with the increasing economies of scale in farming (e.g., technology, finance) have created a shift toward farm consolidation. Over the past 25 years, the number of large farms (>2,000 acres) has increased by more than 60% while the number of smaller farms has decreased (**Figure 7**). Farm consolidation is geographic integration and may provide opportunities to reach economies of scale that can expand access to water sources, technological advancements, agricultural infrastructure, and innovative partnerships.

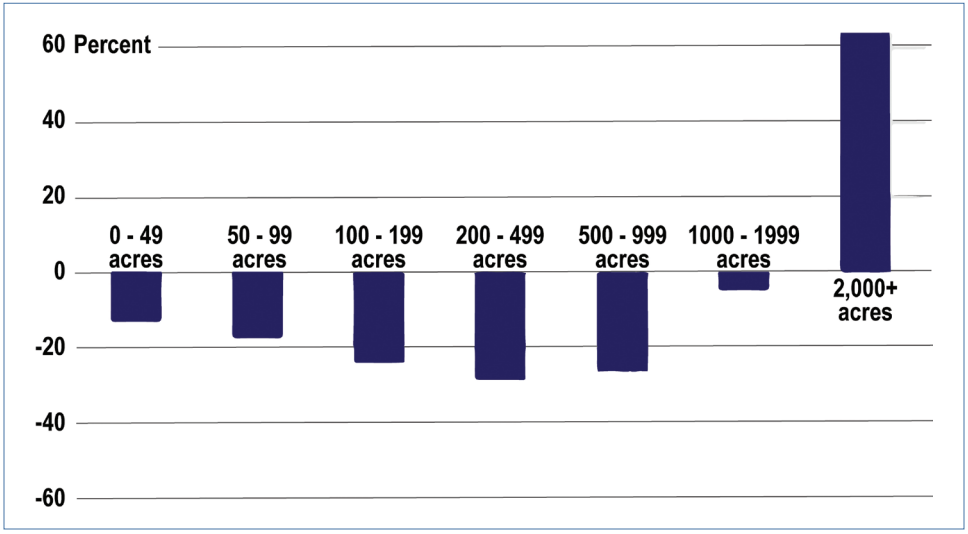

Figure 7. Change in the number of farms by size, 1997-2012 (figure modified)[13]

In the Western United States, water markets (see more in Markets as an Integration Tool) have been a widely adopted tool for sectoral integration, particularly in agriculture. A large farm may fallow fields and lease a portion of the water rights to urban areas or industrial water users. The farmer maintains ownership of their water and fields, while generating revenue from reduced operational costs and payments for leased water rights. Consolidated farms may have access to larger water rights that provide security during droughts. For these approaches to work, there needs to be regulatory policy and institutional capacity to enable smooth transactions.

[13] Data from USDA as presented in Stratfor, 2018. The agriculture industry is losing its voice in American politics.

In the Midwest and Eastern U.S. water quality and flood risk mitigation are common challenges, as opposed to water scarcity. Sector and functional integration provides a way to collaboratively meet regulatory requirements from the Clean Water Act (CWA). For example, cities may compensate farmers to implement best management practices (BMP's), which can reduce downstream nutrient loads so that a watershed complies with Total Maximum Daily Load (TMDL) requirements. There are also mechanisms being developed to allow for urban to agricultural transfers, such as purchasing nutrient credits. These approaches are akin to water rights transactions in the West and raise the questions about how farm size impacts participation in these programs.

INTEGRATION IN INDUSTRY

Industrial water users have increasingly benefitted from water conservation and collaboration, but the emerging reality is that there are, in fact, disincentives to collaborate due to low return on investments and the risk of regulatory or media backlash. In comparison with the return on investment, putting resources into water conservation has not proven to be largely beneficial to many industrial water users, with some notable exceptions. In addition, investing in water can draw attention to industrial water users, which may raise their profile and visibility during times of water scarcity, which can be detrimental. Thus, many industrial water users have not yet found investing in conservation to be worthwhile.

However, when they do partner, industrial water users can bring relatively unusual resources to any integration effort. Industry may have technical expertise that far outpace those of other sectors. Most notably, industrial water users at the forum noted that they typically have large computational resources that are more developed than those available to local water managers. Perhaps more interestingly, participants at the forum pointed out that corporate and industrial water users have substantially more sophisticated communication and marketing capacities than can be found in utilities, agriculture sector, or government agencies.

There seem to be two primary motives for industry to engage in regional integration around water: (1) reduce risk by improving their water security and (2) reputational enhancement.

First, for industrial water users to invest in collaboration or integration, there must be an economic incentive to invest in the time and resources. As more crisis events occur where clean water is not available, the value of water becomes more evident to industrial users. Limiting production capacity for even short periods of time can have significant enough economic impacts to raise water security to a greater priority. Indeed, by considering water security a vital facet of their supply chain, industry could better accommodate the demands and safety of consumers.

Second, with regard to reputation, while broad reputational risk is widely recognized as a motivating factor for industrial water conservation, some forum participants pointed out that they typically also have high dependence on utilities for water. This not only affects their ability to produce goods, but also the end-point of their products with customers. For instance, food and beverage industries are at risk for water utility violations of arsenic and lead because they sell their products at restaurants served by such utilities. Soft drink concentrate is combined with water from the local utility, meaning that the quality of the soft drink product and their reputation is inseparable from the local utility water quality. This can be a significant impact since 3 to 10% of drinking water systems were in violation of federal Safe Drinking Water Act health standards each year between 2004 and 2015.[14] Many of these communities do not have the resources to address the water quality problems. While such levels may not be critical to a utility or regulator, they create significant reputational risk for industry. In such cases, industry has a voice and an economic incentive to help utilities and regulators drive change.

Industry has, until recently, often under-appreciated their dependence on broader water management. Yet they also have a large voice in a region or municipality due to their economic development and employment role. **When combined with their ability to market and communicate, commercial and industrial water users could be an under-utilized advocate for water sustainability within a watershed, city, state, or region.**

[14] Allaire, M. 2018. National trends in drinking water quality violations. *PNAS* 115 (9): 2078-2083.

MARKETS AS AN INTEGRATION TOOL

Markets are a diverse tool for sector and functional integration. Markets, as used here, implies a range of options from pooling resources together to investing in infrastructure to the formalization of transactions between water users. In terms of functional integration, resources are pooled together to achieve desired outcomes through incentivizing behavioral changes, establishing BMP's, or trading commodities. For example, the Turlock Irrigation District and the city of San Francisco partnered financially in 1960 to enlarge Don Pedro Lake by 2 MAF. The Turlock Irrigation District desired to enlarge the reservoir but could not afford the cost, while San Francisco had junior, insecure water rights. By combining resources, the city had access to what was, effectively, a water bank which gave the city increased water security and the irrigation district infrastructure it could not have afforded otherwise. Another example occurred during the 2016 drought in California when decreased water quantity led to degraded water supplies and the inability for the city of Modesto to meet arsenic standards from their groundwater wells. The city did not have the seniority to access surface water to replace the loss of high quality groundwater. Instead, local farmers agreed to provide long-term leases of their surface water to the city of Modesto. In return, the city would provide the agricultural community water from their wells during drought, since the water quality remains adequate for agricultural use.

These, among other examples, point toward three general types of markets: quantity, quality, and habitat. Water quantity markets involve trading volumes of water via water rights (such as allocations, diversion rights, or pumping rights). Water rights markets are ubiquitous in the Western United States and are becoming increasingly sophisticated.[15] Water quality markets are less about trading and more about creating cost effective mechanisms between participants to address water quality degradation. As an example, a wastewater treatment plant may pay upstream farmers to reduce runoff to more cost effectively remain in TMDL compliance. Habitat markets typically operate by creating a bank where developers impacting habitat (such as wetlands) must offset those damages by investing in restoration of similar

[15] The Aspen Institute. 2016. Conservation Finance & Impact Investing for U.S. Water.

habitats elsewhere. In each of these markets, there is a tendency for transactions to link different sectors. Often there are ag-urban sector deals for water rights or water quality markets and between developers and environmental sectors for habitat markets. That is, markets may be viewed as a mechanism that inherently serves to integrate across geographies and sectors.

While water quantity markets are well known and widely used, there are also some new disruptive regulatory approaches for water quality markets. For instance, National Pollution Discharge Elimination System (NPDES) "bubble permits" assemble all the entities with NPDES permits inside a basin and create a pollutant loading cap for the bubble (also known as group compliance, such as the Neuse River Compliance Association in North Carolina). A water quality trading market can be established within the bubble between point source polluters to stay below the cap in the most cost-effective manner, allowing some permit holders to increase emissions so long as others reduce theirs. Bubble permits enable a market to develop around an outcome with a defined, measurable unit that is monitored to ensure specific targets (desired outcomes) are being achieved. **Bubble permits are effectively the functional integration of regulatory compliance.** Utilities that have undergone some form of regional integration, such as GLWA, may benefit from the opportunity to operate like a bubble permit to create markets that meet regulatory compliance throughout their system in a more cost-effective manner.

Alongside regulatory disruptions, technological disruptions are beginning to enable linking together specific activities with desired outcomes. These new capacities can allow trades to occur with growing confidence as outcomes are monitored and reported. Technology and data have the opportunity to create transparency around markets as long as everyone has equal access to the information. Stakeholders could understand why certain transactions are highly valued and whether those transactions resulted in the anticipated desired outcomes. The focus on desired outcomes is key to creating market certainty. For instance, the impact of planting riparian vegetation in strategic locations can be linked to the reduction of water temperature needed to meet permit requirements. These precise restoration efforts have been defined as precision conservation, an approach that demonstrates the performance of transactions to achieve desired outcomes.

In water rights markets, inequity may arise if the monetary value of water leads to significant rural to urban water transfers that could, over time, undermine agricultural production and reduce the viability of rural communities. In water quality markets, there is the potential for some communities to increase pollution while paying others to decrease pollution, thus creating pollution hotspots. In the case of habitat markets, it is easy to imagine habitat destruction in areas of development that are offset by the creation of restoration parks-like areas in suburban fringes.

OPPORTUNITIES AND CHALLENGES TO INTEGRATION

PUBLIC AWARENESS AND EDUCATION

Water is embedded in everyday life and often goes unnoticed. Recent crises, such as the California drought and drinking water quality degradation in Michigan have increased public awareness about the prevalence of water in many facets of our lives. While many understand the natural water cycle, the built cycle is poorly understood. **Integrating civil society as an important sector to address water sustainability requires education**. Utilities could benefit from educating the public on how water gets from streams and aquifers into our homes, or on the significant cost of the infrastructure that is needed to deliver treated water to so many taps in a city. Similarly, the industrialization of food has disconnected many from the process of growing food to the food purchased in stores. Agriculture could benefit by educating the public about food production, thus reconnecting them to the amount of water and energy it takes to grow the food they enjoy. Industry may benefit by sharing how water is used sustainably to create the products we use daily. Regardless, education about the complexity of water services in society is necessary to move any water sustainability agenda forward.

LOCUS OF CONTROL

Humans trust the things, people, organizations, and institutions closest to them and support the things they help to create. Most do not like to share a lawnmower or carpool because we want to control our own assets and avoid the inconvenience of sharing. How much more prevalent is this sentiment for an asset that is imperative for life and economic development, such as a municipality's water utility, which often represents decades of community time, attention, and resources? Fears of integration go both ways. For example, a municipality fears experiencing inequality in service while a regional provider supplying water to another municipality may fear compromising its economic advantage, or its credit rating. Fears of inequity must be

addressed with transparency and engagement that gives stakeholders the opportunity to impact, or at least understand, outcomes. These concerns have led local politics and public perception to fear regional integration even though the benefits may often be not only significant, but necessary for water system survival.

IDENTITY

Water is local and often connected with community and political identity. Political identity is a major barrier because any type of integration opportunity can turn into a conversation about "us" versus "them." In these cases, there needs to be a larger identity that encompasses all groups interested in integration. This could be a river basin, geographical landmark, or a political association. For example, it may be more feasible for those in the Great Lakes region to perceive themselves as part of the Great Lakes with a sense of pride and stewardship than as one of several towns integrating. This can broaden the notion of "who my people are" and "who I am connected to". This may be challenging as many utilities have found it hard to connect communities with a stream 10 blocks away. Would it be easier or harder to help them identify with an entire region? On the other hand, customers may be less of a barrier to integration than utility or industry leaders. Interviews after a utility merger revealed that customers don't care who they are writing their checks to, but they care about having good customer service. Customers may presume that a local utility will provide better service than a larger one, but in reality, small utilities may only be open a couple hours each week, while a large utility provider may be able to provide 24-7 support.

TRUST AND FAIRNESS

Any integration will depend on trust, whether it is integration of utilities or a transfer of water rights between two farmers. Trust takes time to build yet takes only a single event to undermine. The criminal activities associated with water pollution in Flint, Michigan have created a distrustful sentiment related to water in the region; even though the utility is now providing safe, tested water, citizens continue to purchase bottled water because of a complete undermining of trust. Alongside trust is fairness, which comes from a sense of safety and a willingness to look after the interests of the others, or knowing that someone is looking out for my interests. Trust and fairness cannot be forced but must emerge through interactions and engagements that connect people at an individual level. Indeed, one of the common refrains and perpetual themes from the forum participants was that the process of integration is long and requires persistent leadership and trust on all sides.

One of the drivers of trust is transparency, although the forum disagreed on the level of transparency that should be required or needed. On one hand, radical

transparency can be messy but lead to greater trust between groups that can handle the complexity of issues and support the process, rather than attacking. On the other hand, stakeholders and leaders need to have a safe space where they can think broadly, negotiate, and compromise without coming under public scrutiny. Here, decision-makers have space to deliberate and compromise and come to decisions that are then made transparent.

WHAT IS OUR VISION?

This forum approached integration as a significant change in water management from business as usual, and thus as a potentially disruptive force which would allow combining efforts across geographies, sectors, and functions to create benefits that could not have been achieved individually. **Regional integration will not solve all problems, but it can address some of them.** Integration opens up the possibility of greater efficiencies that can address the large-scale regional problems facing the water sector across the U.S. today. However, integration is an iterative process that must begin somewhere and leads to increased fidelity, understanding, and fine-tuning of our vision for the future.

The last 30 years have seen a large shift in the income, environment, and health of many communities across America. Yet at the same time, there has been growing inequity in access to and costs of clean water, punctuated by crisis events—whether polluted water in Flint or failing levees in New Orleans—that remind us that how we govern water creates opportunities for some and challenges for others.

APPENDIX I: FORUM AGENDA

THE ASPEN-NICHOLAS WATER FORUM

REACHING WATERSHED SCALE THROUGH COOPERATION AND INTEGRATION

May 30 – June 2, 2018
The Aspen Meadows Resort
Aspen, Colorado

WEDNESDAY, MAY 30

6:30 – 9:00 PM **Opening Reception and Dinner**
Doerr-Hosier Center, Aspen Meadows Restaurant

THURSDAY, MAY 31

9:00 – 9:15 AM **Welcome and Introductions:**

A brief introduction from the hosts around the focus and goals of the Forum.

David Monsma, Energy and Environment Program, The Aspen Institute

Martin Doyle, Nicholas Institute for Environmental Policy Solutions, Duke University

9:15 – 10:30 AM **Session One: Regional-scale Issues and Trends**

This session will focus on the current state of groundwater in the nation. Groundwater has historically been a black box, challenging to measure, understand, and thus to manage. As such, "sustained depletion" has been a widespread management practice, resulting in consequences such as stream depletion, declining water quality, saltwater intrusion and land subsidence. This session will set the stage by documenting trends affecting groundwater resources in the United States, drawing on case studies of aquifers being depleted and those which have been stabilized, or even partially recovered.

Discussants:

Water Availability, Demand, and Use	**Emily Read**, USGS
Water Quality and Ecosystems	**Jerad Bales**, CUAHSI
Municipal & Industrial Trends	**Sue McCormick**, GLWA
Can We Provide What Society Expects?	**Al Cho**, Xylem

Moderator: **David Monsma,** The Aspen Institute

10:45 AM – 12:15 PM **Session Two: Current State of Regional Cooperation in Water Utilities/Authorities**

What are the legacies and current trajectories shaping water service providers? There has been rapid growth in some cities while others are either stagnant or even shrinking, all while small, rural water providers continue to face challenges. Another trend is that many water systems are small, fragmented, and have limited access to capital. Infrastructure is aging and deteriorating with utilities struggling to raise rates to meet costs, while also meeting changes in water demand from new types of water users. To address these challenges, various institutional arrangements (networks, agreements, partnerships, consolidation) have emerged to facilitate regional cooperation and access to new sources of capital to invest in infrastructure. What are the processes through which these regional solutions emerge? Who are the key participants, and what are the alleged benefits of regional cooperation? What are the policy, political, procedural barriers?

Discussants:

Large Utility Perspective	**Tera Fong**, DC Water
Challenges of Small/Med Utilities	**Bill Teichmiller**, EJ Water Cooperative
The Watershed Utility	**Jeff Hughes**, Environmental Finance Center, UNC

Moderator: **Martin Doyle,** Nicholas Institute, Duke University

1:30 – 3:00 PM **Session Three: Ongoing Policy and Regulatory Experiments: What Can Translate Elsewhere?**

What are the legacies and current trajectories shaping the agricultural community? There is a trend toward farm consolidation with ownership transitioning towards fewer, larger farms coupled with separation between operation and

land ownership. This trend is driven by market forces, including sophistication of farm equipment and increasing efficiency, demographic changes, and financial realities. What is the relationship between changing farm characteristics—whether size or ownership—and water? What are the opportunities for agriculture to lead in cooperative agreements in watersheds and regions? What examples exist for how agriculture has been essential component of water sustainability, whether for water quality or quantity?

Discussants:

Changing Characteristics of Ag/Farms	**Disque Deane, Jr.**, Water Asset Management
Scaling up Ag Water Management	**Ryan Barr**, E&J Gallo Winery
Role of Ag in Water Partnerships	**Sarah Porter**, Kyl Center, ASU

Moderator: **David Monsma**, Aspen Institute

FRIDAY, JUNE 1

1:30 – 3:00 PM **Session Four: Industrial Water Users as Innovators in Collaborative Approaches**

Industrial water users are critical for water utilities; they are typically large water users and provide consistent revenue sources and water demand. Yet they also have high demand for water security, particularly for emerging types of industrial water users, such as data service centers. While many industries procure their water from utilities, others provide their own water, and thus are critical partners in any watershed sustainability programs. Further, the private sector is often an early adopter of new and emerging technologies, from fit-for-purpose treatment to sensors and data networks. What are some examples of cross-sector (public-private?) collaborations that have changed the scope and scale of management? How has the private sector driven governance or organizational change in the scale of water management? What types of approaches are on the horizon whether for private water users or for private water service providers?

Discussants:

Innovating with farms and cities	**Valeria Orozco**, Nestlé Waters
Perspectives from industries	**Joe Lima**, Schlumberger
Corporate collaborations	**Josh Henretig**, AI for Earth, Microsoft

Moderator: **Al Cho**, Xylem

10:45 AM – 12:15 PM

Session Five: Water Governance

Water governance has always been challenged by scale: the scale of solutions has rarely matched the scale of the problem, or the scale of what can be governed. Many laws, regulations, and agreements are mis-matched for the causes of the problem, let alone for what might be viable solutions or approaches. Political barriers arise for any approach to water. For utilities, the public may oppose regional cooperation in the interests of maintaining local control over management and operations. For farms, the public may oppose trading or markets that reduce agriculture to benefit distant cities or local ecosystems. What are mechanisms or methods that have proven successful in bridging the divides of scale, or location? What are opportunities to manage water at a scale that matches the problem?

Discussants:

Govt and NGOs in Scaling Solutions	**Joya Banerjee**, S.D. Bechtel, Jr. Foundation
Hydro-Federalism: Role of States?	**Julie Cunningham**, State of Oklahoma
Water Governance Politics	**Megan Mullin**, Duke University

Moderator: **David Monsma**, Aspen Institute

1:30 – 3:00 PM

Session Six: Are Markets a Solution, or a Problem?

A variety of markets exist, or are emerging in water, from water rights to water quality trading to mitigation banking. A central question is how these markets are affected by broader trends, and in turn, how they might affect such trends. Is water rights trading in the West, or water quality trading in the East, more feasible when cities work with large farms or small farms? Are trading programs a more efficient mechanism for small cities to meet

regulatory compliance? Do markets solve some of the overarching problems, or exacerbate them? What are the opportunities and the challenges?

Discussants:

Using Markets for Cities & Ecosystems	**Joe Whitworth**, Freshwater Trust
Does Rural U.S. Benefit from Markets?	**Michael Frantz**, Frantz Nursery
Are markets Equitable?	**Margaret Bowman**, Sprint Point Partners

Moderator: **Martin Doyle**, Nicholas Institute, Duke University

SATURDAY, JUNE 2

9:00 – 11:00 AM **Session Seven: What is the Vision for Groundwater?**

Where is regionalization likely/possible and unlikely/impossible? This final session will reflect on the discussions of the forum, and identify potential alternative futures for regional cooperation. What are best or worst case scenarios, and what might lead to them? What critical interventions could pivot regional cooperation in one direction or another?

Moderator: **David Monsma,** The Aspen Institute

Forum Adjourns

APPENDIX II: FORUM PARTICIPANTS

Joshua Adler, CEO, SourceWater

Jerad Bales, Executive Director, CUAHSI

Joya Banerjee, Senior Program Officer, Environment Program, S.D. Bechtel, Jr. Foundation

Ryan Barr, Director, Wine and Grape Supply, E&J Gallo Winery

Clare Bastable, Director, Catena Foundation

Kelly Bennett, Co-founder and President, B3 Insight

Margaret Bowman, Program Director, Spring Point Partners

Alan Boyce, Executive Chairman, Materra, LLC

Robert Bruant, Principal, Red Tree, LLC

Christa Campbell, Industry Specialist – Global Water Practice, Esri

Celeste Cantú, CEO, Water Education for Latino Leaders (WELL); Ricardo Salinas Foundation Scholar

Albert Cho, Vice President and General Manager, Advanced Infrastructure Analytics, Xylem

Peter Colohan, Office of Water Prediction, NOAA

Julie Cunningham, Executive Director, Oklahoma Water Resources Board

Michael Deane, Independent

Disque Deane, Jr., Co-Founder of WAM, President of WPI

Christopher Dorow, Regional Category Manager, Power and Utilities, BASF

Martin Doyle (*Moderator*), Director, Water Policy Program, Nicholas Institute for Environmental Policy Solutions, Duke University

Charles Drake, Governing Board, St Johns River Water Management District

James Eklund, Of Counsel, Squire Patton Boggs

Jay Famiglietti, Senior Water Scientist, NASA Jet Propulsion Laboratory

Tera Fong, Program Manager, Strategy, Innovation, and Metrics, DC Water

Michael Frantz, President, Frantz Wholesale Nursery, LLC

Peter Grevatt, Director, Office of Ground Water and Drinking Water, US Environmental Protection Agency

Maurice Hall, Associate Vice President - Water, Environmental Defense Fund

Josh Henretig, Senior Director of AI for Earth, Microsoft

Jeff Hughes, Director, UNC Environmental Finance Center

Tom Iseman, Strategy Director, The Nature Conservancy

Ted Kowalski, Senior Program Officer, Walton Family Foundation

Joe Lima, Director, Environmental Sustainability, Schlumberger

April Long, Clean River Program Manager, City of Aspen, Colorado

Timothy Male, Executive Director, Environmental Policy Innovation Center

Megan Matson, Partner, Table Rock Capital

Sue McCormick, CEO, Great Lakes Water Authority

Margaret Medellin, Utilities Portfolio Manager, City of Aspen, Colorado

David Monsma (*Moderator*), Vice President, Aspen Institute; Executive Director, Energy and Environment Program

Luis Montestruque, Founder and CTO, EmNet

Megan Mullin, Associate Professor of Environmental Politics and Political Science, Duke University

Valeria Orozco, Director, Sustainability, Nestlé Waters North America

Cassandra Pallai, Geospatial Program Manager, Chesapeake Conservancy

Lauren Patterson (*Rapporteur*), Senior Policy Associate, Nicholas Institute for Environmental Policy Solutions, Duke University

Sarah Porter, Director of the Kyl Center for Water Policy, Arizona State University

Jon Radtke, Water Sustainability Director, Coca-Cola North America

Emily Read, Chief, Web Communications Branch, U.S. Geological Survey

Sarah Richards, Water Program Officer, Cynthia and George Mitchell Foundation

Matthew Ries, Chief, Water Quality and Watershed Management, DC Water

Ryan Smith, Managing Director, Zoma Capital

Bill Teichmiller, CEO, EJ Water Cooperative, Inc.

David Totman, Director of Asset Management, Innovyze

Joe Whitworth, President, The Freshwater Trust

THE ASPEN INSTITUTE

Maggie Carroll, Program Associate, Energy and Environment Program, Aspen Institute

Calli Obern, Program Associate, Energy and Environment Program & International Partners, Aspen Institute

APPENDIX III: ACRONYMS

BMP	Best Management Practice
CWA	Clean Water Act
EPA	Environmental Protection Agency
GLWA	Great Lakes Water Authority
NPDES	National Pollution Discharge Elimination System
SCADA	Supervisory Control and Data Acquisition
SDWA	Safe Drinking Water Act
SGMA	Sustainable Groundwater Management Act
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
USGS	United States Geological Survey