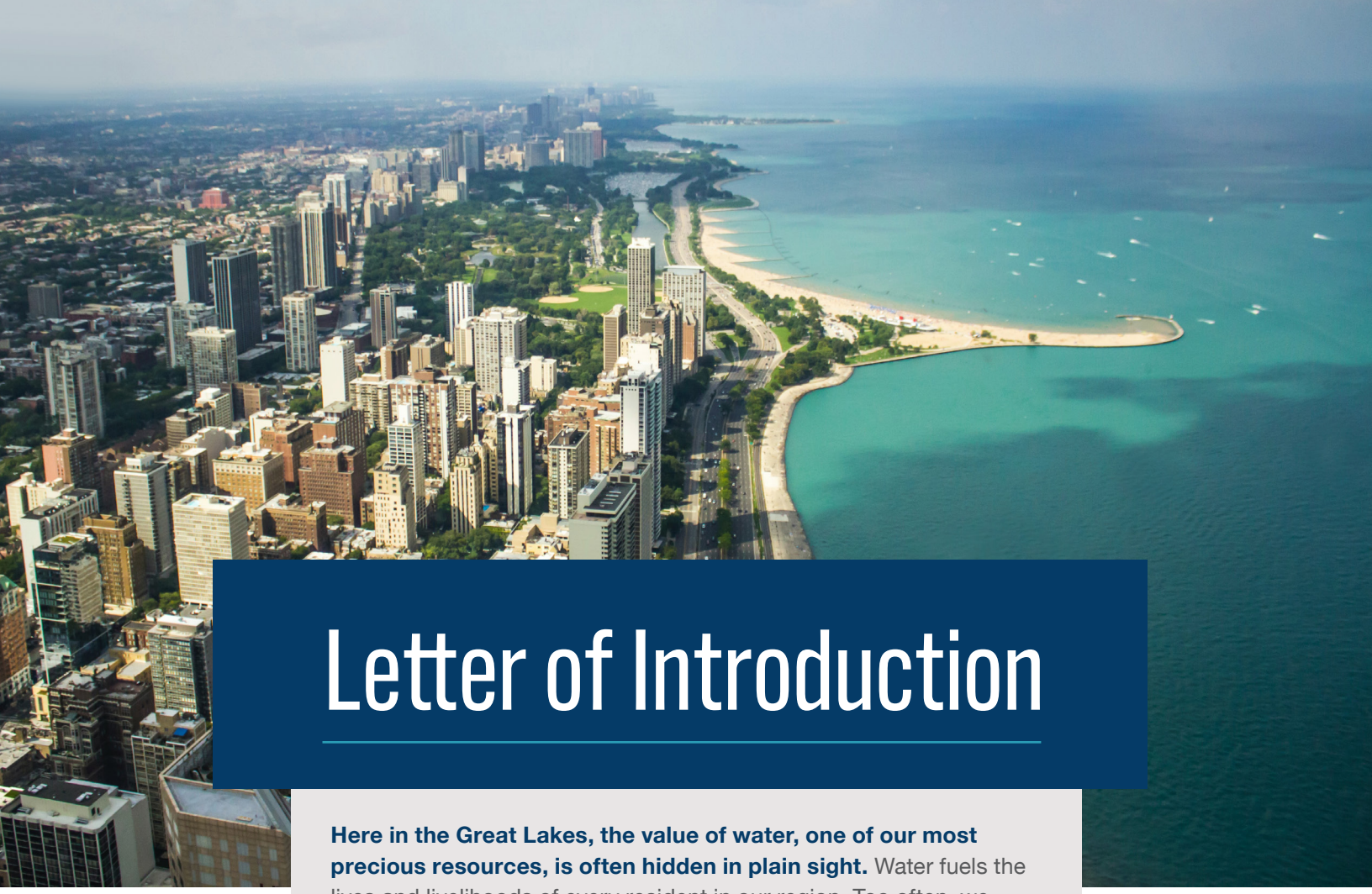
# UPSTREAM ILLINOIS

## Strategies to Boost Illinois' Blue Economy

Anchored by Current

Prepared by RW Ventures, LLC; In partnership with Elevate, Mass Economics, and MKM Consultants



# Letter of Introduction

**Here in the Great Lakes, the value of water, one of our most precious resources, is often hidden in plain sight.** Water fuels the lives and livelihoods of every resident in our region. Too often, we take it for granted, assuming that we will always be able to count on access to clean, abundant, and affordable water, and missing key opportunities to leverage our globally significant water resources to create economic opportunity.

We know, however, that **shifting global demands on limited water resources are sharpening the focus on water as an economic, political, and environmental risk.** As we watch other regions struggle to meet demand for water from industry and consumers, we can anticipate and better prepare for increased pressures on the precious natural resources right here in our back yards. Further, as climate migration becomes more of a reality and we begin welcoming people and businesses to our region for our relative water abundance, we must prepare to use our resources carefully and hold ourselves accountable for protecting the Great Lakes for generations to come.

At the intersection of growing demand for water and growing concern for environmental stewardship sits innovation: **innovative solutions to water challenges create vital economic opportunities for the Great Lakes region and its residents.** Transformative federal

investments in infrastructure and State investments in clean energy and jobs are providing unprecedented resources for communities to prepare for climate futures while catalyzing job creation, entrepreneurship, patents, foreign direct investment, exports and more. Accelerated by climate change, interest in corporate water stewardship is driving demand for more and better water technologies. Illinois can harness this moment for lasting inclusive growth — meaning that the people and places most in need and most underrepresented in the water and technology clusters should be first in line to benefit from new opportunities as our Blue Economy grows.

This strategy is a roadmap to guide civic, nonprofit, and industry leaders towards building the kinds of innovative programs and partnerships that will **make Illinois the center of a strong, nation-leading Inclusive Blue Economy**. None of the strategies recommended in this report can be achieved by any one sector alone. The region will benefit most from cross-sector leadership uniting around a shared vision and goals to 2030, and beyond.

We invite you to join us on this journey to securing, sustaining, and stewarding our water resources to ensure the prosperity of our region and its residents. Read the full report and learn more about how to engage in implementation at **www.currentwater.org**.

Signed,

**Michael Fassnacht**
World Business Chicago

**Name Here**
Illinois Department of Commerce and Economic Opportunity

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# Acknowledgments

The project team would like to thank the following individuals for their contributions to this work.

## Advisory Group

**Erika Allen,** Green Era

**Erik Birkerts,** Evergreen Climate Innovations

**Megan Clifford**, Argonne National Lab

**Patrick Combs**, Chicago Cook Workforce Partnership

**Naomi Davis**, Blacks In Green

**Colleen Egan**, Illinois Science and Technology Coalition

**Michael Fassnacht**, World Business Chicago

**Michelle Frey**, ADM

**Andrew Hollis**, Slater Infrastructure Group

**Bill Jackson**, Discovery Partners Institute

**Paul May**, DuPage Water Commission

**Paige Peters**, Rapid Radicals

**Garr Punnett**, Rheaply

**John Robak**, Greeley and Hansen

**Juan Salgado**, City Colleges of Chicago

**Catherine Zimmerman**, Ingredion

## Working Group

**Chicago Metropolitan Agency for Planning**

**The Water Council** (Milwaukee)

**Elevate**

**World Business Chicago**

**Intersect Illinois**

# I. Executive Summary

## VISION

**By 2030, the Chicago region will be home to a thriving and inclusive Blue Economy where water companies, corporate water users, utilities and research institutions collaborate on developing and manufacturing nation-leading treatment and monitoring technology, catalyzing environmental solutions and inclusive economic growths.**

**This strategy is a roadmap** for Illinois and the Great Lakes, grounded in the Chicago region, to grow and sustain a globally significant Inclusive Blue Economy. With the right strategies in place and the right leaders at the table, we can support a greater volume of environmental and public health solutions, while narrowing opportunity gaps and centering jobs and economic growth around the people and places who have long been underrepresented and underserved. Only with leadership cross-cutting government, industry, research, and investors, will we be able to transition Illinois from a rust belt to a clean belt economy by 2030.

**What do we mean by Blue Economy?**
The Blue Economy is the collection of companies that develop and provide technologies, products and services that manage the movement, quality and use of water – in addition to inputs to make these products, supporting industries, and the customers that demand these products. (See **Section III "What is the Blue Economy?"** for a deeper explanation.)

**We have the building blocks.** In 2020, the water cluster (companies that develop and provide technologies, products and services that manage the movement, quality and use of water) in Illinois was a $16.7 billion industry supporting 186,000 jobs. Illinois' Blue Economy, which more broadly encapsulates the inputs and end-users of the water cluster as well, employed nearly 1.5 million people — approximately 30% of all employment in the state.

Illinois needs to take advantage of this important moment in time by leveraging our world-class resources — research institutions, incubators and accelerators, headquarters companies, and the right concentration of growing manufacturing, engineering, and data

industries — to make the region a home for water innovation that solves both local and global water challenges. Illinois, anchored by the Chicago region, can leverage local assets and promote cross-regional collaboration by:

1. Linking research and development strengths in the Chicago region with manufacturing and commercialization strengths in the Milwaukee region,

2. Developing manufacturing and water efficiency technologies for export to water-scarce regions,

3. Leveraging manufacturing strengths to supply pipes and fittings to aid increased global demand,

4. Accelerating the commercialization of advanced treatment and resource recovery technologies,

5. Expanding adoption of monitoring technologies by matching products with end-users,

6. Growing and diversifying the workforce to meet employer demands for development and production of these products and services.

(See **Market Analysis** section for more detail on local strengths and positioning)

**What do we need to do to build a thriving and inclusive Blue Economy by 2030?**
Achieving the vision of an Inclusive Blue Economy by 2030 requires city, state, and federal leaders to align around and invest in implementing the specific strategies identified below, and anchor water within existing priorities to combat climate change. It needs leaders in water-using industries (including food and beverage, agriculture, manufacturing, energy, and health and life sciences) to recognize where water is hidden in their operations and supply chains and to be better stewards of the environment. And finally, it requires research institutions, investors, and the broader entrepreneurship-supporting ecosystem to center water innovation as a business opportunity and solve challenging barriers to commercialization. None of this important work can be achieved alone — each of the strategies below require cross-sector collaboration.

1. **Industry-Led Collaboratives:** to promote growth of a strong Blue Economy, enable the continuous innovation and commercialization needed to bring research to market, and build the region as a competitive global center for water-related innovation and product development.

2. **Industry-Led Workforce Development:** to reform labor market systems to be more skills-based, responsive and targeted, and designed with specific opportunities and challenges for women and people of color in mind.

3. **Testing, Certification, and Demonstration Center(s):** to accelerate market integration of new products with one another and with older systems, increase pathways to certification to different water standards, and to increase opportunities for entrepreneurs to develop and pilot products.

4. **Business Growth Assistance Program:** to provide sophisticated business and finance support services to firms to enable them to scale-up their operations and grow into established companies.

5. **Manufacturing Initiative:** to establish a hub for manufacturers capable of manufacturing water technologies and assist in strengthening regional supply chains in the water cluster.

Let's get started.

**$16.7 BILLION**

**The 2020 water cluster industry in Illinois**

# II. Introduction

## The Blue Economy: A Growing Economic Opportunity for Illinois

In the Great Lakes region, the ubiquity of water in our lives and its ready supply can make it easy to take for granted. However, as an economic development opportunity, water as an input to supply chains, along with the needed tools, technologies, and services that improve its delivery, treatment, and use, is often hidden from view. Better management of water resources is a growing global challenge, with implications for the health of the public and the growth of industries — from food and beverage manufacturing to metal working. New environmental and economic trends are driving increasing demand for water quality and efficiency across retail, commercial and industrial users. In response, demand is growing globally for a next generation of processes, products and technologies for the **cleaning, movement, and use of water**.

Because of its concentration of economic assets — headquarters companies, utilities, research universities and national labs, talent — Illinois is well positioned to claim a leadership position in the production of these new products, technologies and services. However, before strategic investments can occur, Illinois needs to define its unique positioning, "right to win," and focus areas within this broader set of industries and technologies. This paper defines the Blue Economy as **the collection of companies that develop and provide technologies, products and services that manage the movement, quality and use of water — in addition to inputs to make these products, supporting industries, and the customers that demand these products.**

UPSTREAM

An array of emerging economic and environmental trends is reshaping where and how growth is occurring in these water-related technologies and industries. For instance:

- **Treatment.** Continually emerging contaminants from industrial processes, agricultural runoff, pharmaceuticals and more are demanding advanced treatment technologies to keep our drinking water safe.
- **Monitoring.** Utilities and municipalities are investing in solutions to monitor and report on water quality in real-time.
- **Water infrastructure.** The infrastructure for delivering water and disposing of wastewater is generally aging and, in some places, inadequate to meet demand. Large federal investments in infrastructure improvements (like lead service line replacement) are also driving demand for this industry.
- **Water saving products.** Environmental, Social, and Governance (ESG) goals and regulations are driving demand for water efficient and water reuse practices. Companies — both industrial and agricultural — are looking to reduce their need for water, motivating the creation of pumping and processing technologies that use water more efficiently.
- **Resource recovery.** Wastewater treatment plants are transitioning to resource recovery facilities that recover and use by-products from water, including energy, nutrients, and critical minerals. Many are assessing zero liquid discharge (ZLD) practices, an approach that recovers all water and reduces all contaminants to solid waste.
- **Water-energy nexus.** The growing awareness of the relationship between energy and water is reshaping processes and even the valuation of water.
- **Data in water systems.** Artificial intelligence (AI) and robotics are disrupting water management, treatment and conservations processes.

## DEFINING BLUE ECONOMY

**The collection of companies that develop and provide technologies, products and services that manage the movement, quality and use of water — in addition to inputs to make these products, supporting industries and the customers that demand these products.**

In addition, climate change is already and will continue to significantly impact water-related economic opportunities and challenges — in ways we can anticipate and ways we do not yet understand. Globally, freshwater supplies are dwindling from increased demand and the impacts of climate change (for example, the western US appears to be experiencing a "megadrought," with low rainfall conditions not seen in over 400 years).[1] In other areas, higher temperatures are resulting in increased rainfall due to higher water vapor volume, often increasing the frequency and intensity of flooding events.[2] Population and business growth are driving increased demand for water in rural areas and high-growth cities alike. Desalination processes are becoming more advanced in an effort to increase fresh water in regions with limited supplies. All of these conditions are driving up demand for water technologies that can be produced in Illinois.

In the Great Lakes region in particular, availability of fresh water may attract industry and eventually climate refugees to the area, but will simultaneously underscore the need for water conservation and water quality efforts as additional burdens are placed on our freshwater supply.

These developments and more are affecting a vast range of water industries and users, presenting new opportunities for advanced products and services. For regions with the right resources and assets, these changes provide an avenue to driving economic growth.[3] Many of the treatment, monitoring and infrastructure solutions to address global challenges and opportunities are, or can be, produced in the Great Lakes region and exported around the world.

Leveraging a strong backbone of industry, research, and civic leadership, Illinois has a unique opportunity to invest in inclusive growth in the water industry and create opportunities for transformative economic growth. To build on these strengths, we must first understand the size, shape, and unique opportunities of our region's water industry and identify the strategies needed to create a globally significant Blue Economy by 2030. This report explores the landscape of our existing Blue Economy, and then makes strategic recommendations grounded in deep market analysis.

Perhaps most importantly, our region needs civic, academic and industry leaders to boldly champion these inclusive growth strategies. We hope these leaders use this report as a roadmap to guide investment and strategic priorities to make Illinois a global hub for water innovation by 2030.

# Project Goals

## VISION

**By 2030, the Chicago region will be home to a thriving and inclusive Blue Economy where water companies, corporate water users, utilities and research institutions collaborate on developing and manufacturing nation-leading treatment and monitoring technology, catalyzing environmental solutions and inclusive economic growths.**

Given the growing demand for water and the associated processes, products and technologies to manage it, the time is right to create a strategy to guide economic growth within the water sector.

First, this strategy examines how to **grow the "core water cluster"** — that is, the technologies, products and services that manage the movement, quality and use of water.

Following from core water cluster growth, secondary goals of the project include:

- **Grow/Attract Users** — Municipal, commercial and residential users of water, and the technologies, products and services of the core cluster to manage it.
- **Market Water as an Asset** — Grow the sale of water — as well as its efficient stewardship, given that water is chronically undervalued (its high costs of energy are not taken into account). In addition, this focuses on the by-products within water (that can be reused in other markets).

Finally, tied to the economic growth objectives are water conservation objectives. As described above, water conservation and water quality management **create demand** for growth of the water sector.

STRATEGY

To assess opportunities within the water cluster, this strategy first defines and draws bounds around the water cluster (to the extent possible, given that it has "fuzzy" edges). To identify what is clustering in the region, data analysis is used as a starting point — and is complemented with interviews and literature reviews to heavily inform the conclusions, all of which will be continually refined as the market continues to evolve and additional interviews focus the report's findings even further. assesses global markets and trends, analyzes the Illinois and Wisconsin region assets and identifies where the Chicago MSA can best compete, creates a vision for the Chicago MSA and defines a set of strategies to realize the vision.[4]


## Project Geography

The economy — or water for that matter — does not follow political boundaries. Instead, the economic growth of neighborhoods, regions, and even multiple adjacent metropolitan areas are deeply linked, because these places are largely parts of the same economy. They share labor pools and housing markets; business-to-business relationships and supply chains; infrastructure and commuting patterns; cultural, recreational, retail, and other amenities; and anchor institutions, such as hospitals and universities.

Generally, metropolitan regions are considered a key unit of economic analysis — as described in more detail in the **Economic Framing** section. This Strategy encompasses the states of Illinois and Wisconsin — and analyzes metropolitan regions within these two states. The proposed strategies are targeted to the Chicago MSA. In some cases, the strategies aim to connect assets across metropolitan regions, given that they share a significant water resource (Lake Michigan) and supply chains.

LOCATION

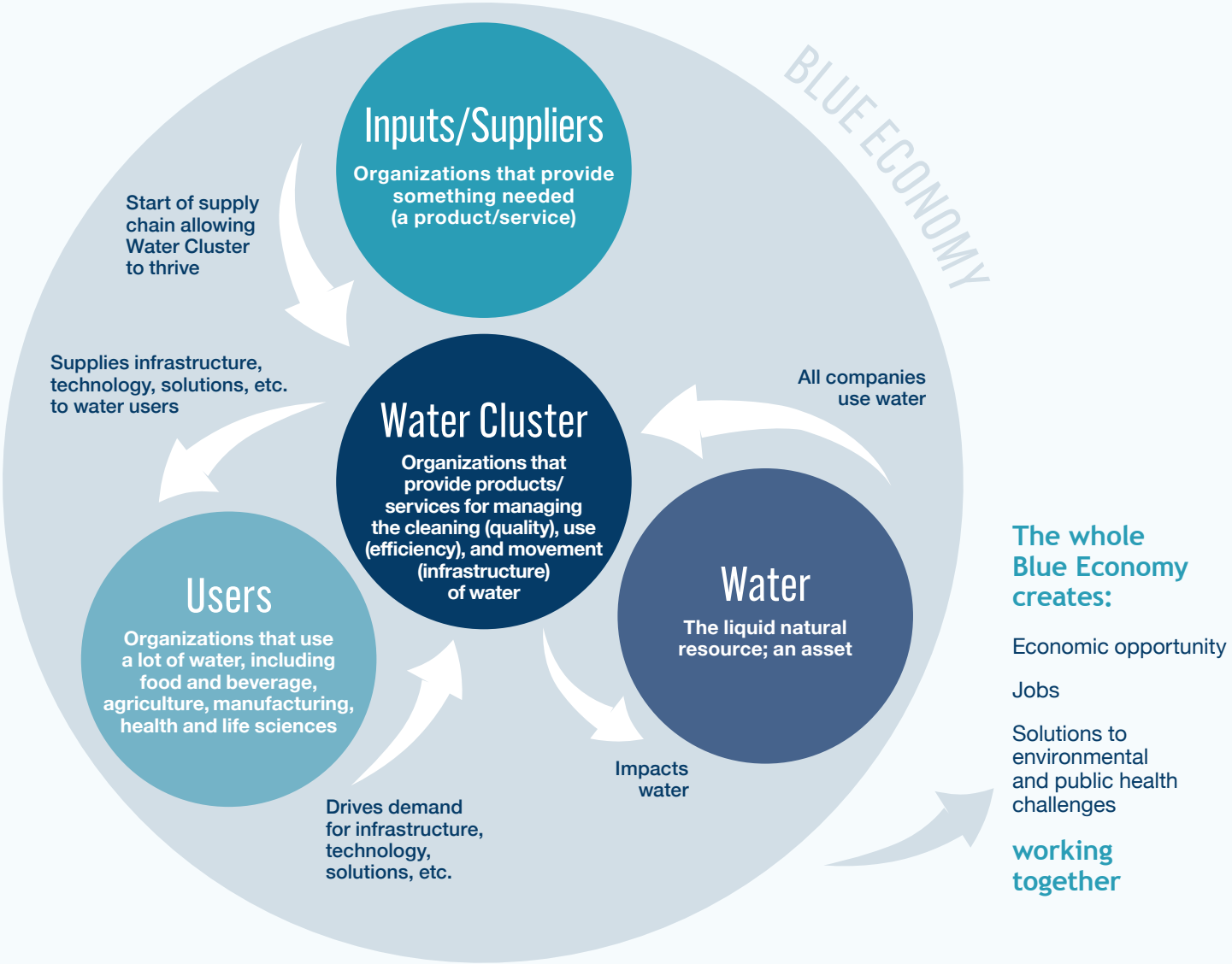
# III. What is the Blue Economy?

## DEFINING BLUE ECONOMY

**The collection of companies that develop and provide technologies, products and services that manage the movement, quality and use of water — in addition to inputs to make these products, supporting industries, and the customers that demand these products** (see Figure 1).

FIGURE 1

### What is Blue Economy and Water Cluster?



**Other definitions:** Globally, the Blue Economy has several definitions — each of them broad.[5] The World Bank defines the Blue Economy as the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem." The Center for the Blue Economy addresses its three focuses: "the overall contribution of the oceans to economies, the need to address the environmental and ecological sustainability of the oceans, and the ocean economy as a growth opportunity for both developed and developing countries."

The measurements of its impact are similarly vast, with one source stating that in 2018, the US Blue Economy, "supported 2.3 million jobs and contributed $373 billion to our GDP" — and, globally the Blue Economy is expected to reach $3 trillion by 2040."[6] In San Diego, their analysis of the Blue Economy found that every "dollar invested in our local Blue Economy goes farther and creates more return ($2.26 dollars) than other industries per dollar invested."[7]

**The opportunity:** The Blue Economy encompasses tremendous economic opportunity, but these opportunities are vast and disparate. For our region to best develop a Blue Economy, we need a deliberate, focused economic growth strategy that leverages existing assets and investments and catalyzes new ones. With federal investments in infrastructure, increasing interest in corporate stewardship, and the ever-changing landscape of global water challenges, the moment is right to invest in creating a globally-significant, nation-leading, inclusive Blue Economy in Illinois and the Great Lakes region by 2030. Defining viable inclusive economic growth opportunities where Illinois has the "right to win" is the first step. To do this, we must develop a deeper understanding of the market dynamics at play in the Blue Economy.

> "For our region to best develop a Blue Economy, we need a deliberate, focused economic growth strategy that leverages existing assets and investments and catalyzes new ones."

# IV. Economic Framing

This analysis is guided by a series of key principles drawn from extensive research, analysis and practice addressing the changes in the next economy. These changes have implications for economic development practice and inform a methodology for market analysis, and strategy development. This section summarizes these principles and the methodological approach. See **Appendix D** for more detail.

## Market Dynamics in the Blue Economy

Clustering is a natural market phenomenon that occurs when related firms group together in a specific geography due to the benefits they derive from that co-location. More precisely, a cluster is a group of firms and related economic actors and institutions that are located near each other[8] and "draw productive advantage from their mutual proximity and connections."[9] A cluster that is operating optimally can drive regional economic growth by enhancing firm productivity through:

- Reducing transportation and infrastructure costs due to close firm proximity;
- Enabling the development and sharing of specialized labor pools and other inputs common across firms;
- Providing firms more efficient access to customers, who may also be geographically concentrated (either as a cause or effect of firm clustering); and
- Facilitating innovation through "knowledge spillovers" — the informal learning and knowledge exchange that results from in-person interactions.

WEALTH BUILDING

To constitute a cluster, the concentrated firms, suppliers, institutions, labor pools, infrastructure, R&D, and so on,[10] must be interdependent actors linked economically, socially and technologically within a region.[11]

Developing a strategy aligned with regional water cluster opportunities requires carefully assessing each of these components to identify what firms and economic activities are in fact clustering locally and why, and identifying which sub-parts of the water cluster our region is most competitive in, current and emerging market opportunities, determine what supporting factors are most in need of development (e.g., suppliers, workforce skills, R&D and commercialization), etc. This complete definition and analysis of the cluster will show the regionally specific opportunities and point toward the strategies and initiatives that are tailored to those unique conditions.

## The Water Cluster

Based on an assessment of the products, technologies and services that are supplied to high-volume water users, a definition of the water cluster arose:

**DEFINING WATER CLUSTER**

**The companies that develop and provide technologies, products and services that manage the movement, quality and use of water.**

FIGURE 2

### The Water Cluster and its Relationships to Inputs, Related Industries, and Demand Conditions

#### Government Regulations

1. Great Lakes Compact
2. Illinois SB 2408 ("CEJA") establishes a "Climate Bank" to "develop opportunities to ... provide clean water, drinking water, and wastewater treatment in the State."

#### FIRM STRUCTURE, STRATEGY AND RIVALRY

**How is competition between firms in the region pushing them to distinguish themselves in the marketplace?**

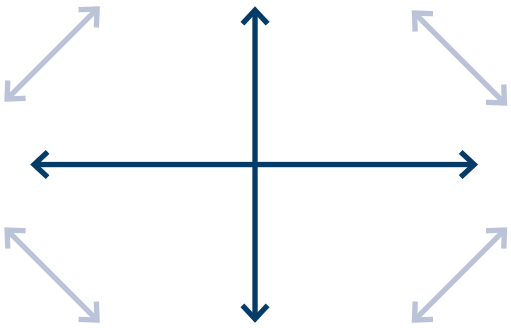
#### Chance Factors

Extreme weather events can cause harm (e.g., rising lake levels, increased run-off and water pathogens, damage to crops and infrastructure)—and increase the pace of water technology innovation.

#### FACTOR CONDITIONS

**What existing inputs (labor, infrastructure, knowledge) in the region feed into the water cluster?**

**EXAMPLES**
- Freshwater supply
- Workforce (~110,000 water-related jobs)
- R&D strengths (national laboratories, university research centers, etc.)
- Institutional support



#### DEMAND CONDITIONS

**Who are the main users of the product/services provided by the core firms in the water cluster?**

**EXAMPLES**
- Manufacturing sector
- Agriculture sector
- Food & beverage industry
- Semiconductor industry

#### RELATED AND SUPPORTING INDUSTRIES

**Do the core firms in the water cluster have access to quality suppliers and support services?**

**EXAMPLES**
- Metals manufacturing
- Electrical equipment manufacturing
- Chemistry & biopharma
- Engineering
- Data processing

*Diagrammed using the Porter Diamond method (see **Appendix E** for more detail on cluster theory)*

FIGURE 3

## The Water Cluster: Examples of the Products and Services Within the Cluster

| | CLEANING (water quality) | USE (water efficiency) | MOVEMENT (water infrastructure) |
|---|---|---|---|
| **Products** | • Microfiltration<br>• Ultrafiltration<br>• Ion exchange/electro-deionization<br>• Degasification<br>• UV products<br>• Reverse osmosis water filters<br>• Activated carbon water filters<br>• Filters/screens<br>• Membrane technology<br>• Desalination technology<br>• Aeration technology<br>• Chemicals<br>• Centrifuges<br>• Measurement instruments<br>• Data platforms<br>• Sensors | • Low-flow plumbing fixtures<br>• Appliances<br>• Space cooling systems<br>• Space heating systems<br>• Rain barrels<br>• Landscape and irrigation systems<br>• Other (e.g., swimming pools)<br>• Building automation systems<br>• Building management systems | • Pipes<br>• Pumps<br>• Meters<br>• Controls<br>• Valves<br>• Nozzles<br>• Motors<br>• Fasteners<br>• Mixing technologies |
| **Associated Services** | **Water treatment and purification**<br>• Physical water treatment<br>• Biological treatment<br>• Chemical water treatment<br>• Sludge treatment<br>• Boiler/cooling water treatment<br>• Reverse osmosis solution<br><br>**Inspection and testing**<br>• Water safety testing<br>• Inspection, cleaning, disinfection | **Water management consulting**<br>• Water reuse and recycling<br>• Energy saving solutions<br>• Water saving solutions<br>• Pumping/delivery<br><br>**Tech**<br>• Automation, monitoring, control<br>• Real-time data analysis, reporting<br>• Artificial Intelligence development | **Building services**<br>• Maintenance and operations<br>• Boiler system specifications<br>• Cooling tower specifications<br>• Architecture, engineering, construction<br>• Installation<br><br>**Conservation**<br>• TBD |

The products and services within the water cluster may include, but are not limited to, those in Figure 3. This list is provided as an example of the range and variety of products that are used to assist in the use, cleaning and movement of water.

Products, technologies, and services in the water cluster supply a diverse audience of water users throughout the region and are also exported globally. Every industry, and residence, uses water, which creates demand conditions for treatment, monitoring and infrastructure products. Water users range from high-volume water users like food and beverage manufacturers and energy production facilities to public water management facilities like wastewater treatment plants. The needs of each user vary according to the level of water purity required, level of contamination post-use, and existing processes. This work aims to accelerate the market for water products, technologies and services and connect

the region's water cluster with users who stand to benefit from more efficient processes and better water quality. Successful strategy design and implementation will require regional partner participation and collaboration.

## A New Approach to Economic Growth

The economy is changing — becoming more global and dynamic, rewarding continuous innovation, heightening the importance of rich, flexible cross-sector networks efficiently deploying and connecting human capital, business, technology and other assets. This means, for regional economic development, regions must move away from opportunistic firm attraction efforts[12] to instead create production-driven economies that compete by adding value, building on their unique assets, strengths and opportunities. New practices emphasize:

- Competing on value added, instead of low-cost
- Identifying unique strengths and "building from the inside out"
- Acting strategically through context-specific, integrated solutions
- Focusing on inclusive growth (see **Inclusive Growth** section)

Successful regions are developing and implementing comprehensive, integrated and inclusive strategies across the five market levers (discussed below) that determine productivity. Responding successfully to these economic principles requires that the Chicago MSA deliberately builds upon its unique assets — all of them — to clearly define its competitive advantage in the water sector.

## Inclusive Growth

A core dimension of market-based growth is inclusion. Inclusive growth does not refer to a separate inclusion practice, nor to traditional equity work, as important as those remain. Rather than let growth occur and then ask how the people and places left out can get some set-aside, redistribution or limited participation, inclusive growth is a different approach to all growth, seeking to fundamentally reposition disadvantaged people and places, particularly communities of color, as drivers and beneficiaries of the enormous growth opportunities in the new economy.[13]

The economic analysis views inclusion as central to growth — and sets goals with respect to inclusive growth, focusing on four dimensions for underserved individuals/communities (*BIPOC; women; Environmental Justice (EJ) communities*):

- **Ownership/Entrepreneurship** — growing company and real estate ownership by — and increasing entrepreneurship in— underserved individuals/communities;
- **Employment** — increasing employment of underserved individuals, particularly in quality jobs with strong career ladders;
- **Location and Access** — siting and supporting firms in places that are readily accessible to underserved populations and assuring transportation and other infrastructure access to centers of jobs and other economic activity;
- **Participation** — ensuring underserved representation at the relevant private, public and civic sector "tables," where growth strategies are shaped and deals get done.

Quality, inclusive growth practices that increase the employment, ownership, access and participation of BIPOC communities in the region's emerging water sector opportunities are essential to achieving lasting economic growth. Each of the growth strategies that have evolved from this plan have been shaped by the opportunities in those four avenues to inclusion.

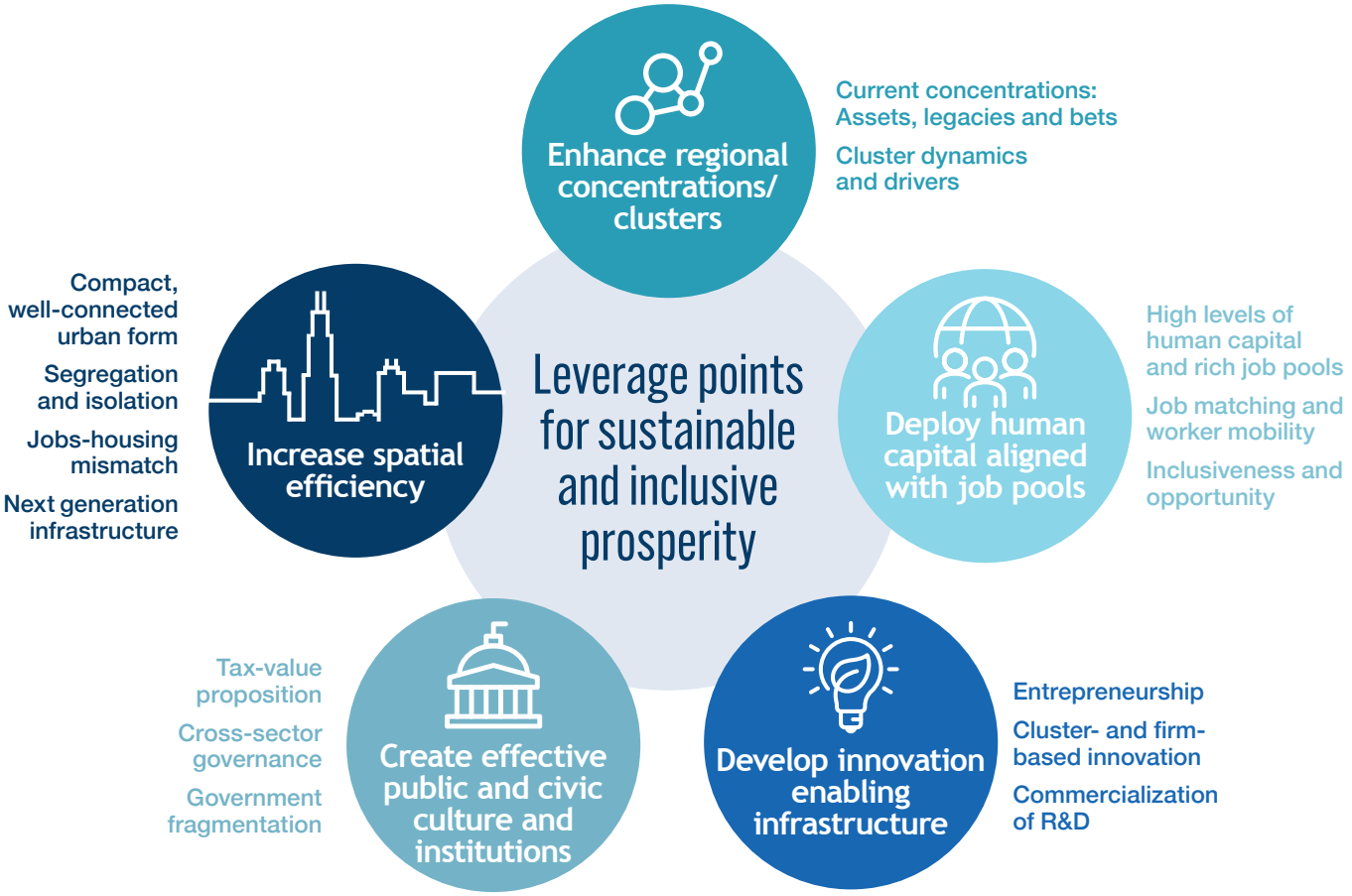

INCLUSION

## Key Drivers of Growth

In the new economy, five market levers (listed below and diagrammed in Figure 4) account for the efficiency and productivity of regional economies and drive how much complementary, concentrated assets realize synergies.[14] Together, they provide a framework for understanding a region's economic assets, challenges and opportunities.

FIGURE 4

## Five Market Levers for Economic Growth




This market analysis leads to a set of strategies that will grow the economy — specifically, the technologies, products and services that manage the movement, quality and use of water. Growth occurs:

- Primarily through growth of **existing businesses**
- Secondarily through **entrepreneurship**
- Finally through **business attraction** (particularly, flowing from existing business growth and entrepreneurship)

Successful economic growth, focused on growing existing businesses, depends on how well each of the five market levers relate. This project will focus on analysis of the water cluster, as well as the key intersections of the workforce and technology (innovation) that — when connected by the right built and virtual environment (spatial efficiency) and institutional environment (governance) — will create the synergies that make the Chicago MSA the most productive and thus competitive for water-related industries, firms and associated workforce.


# V. Market Analysis

A deep market analysis assessed which products and services are clustering within the Illinois and Wisconsin region. This report focuses on opportunities within the Chicago MSA to develop and grow the water cluster, and opportunities to strengthen connections to assets across the state and in the Milwaukee region.

Taking a closer look at the products in Figure 3, their distinct supply chains (diagrammed in Figure 4) — as well as factor conditions, related industries, and demand conditions — broadly fall into three categories:

1. **Treatment**
2. **Monitoring / Sensing**
3. **Infrastructure and Fixtures**

Although there are overlaps within this complex sector, for the sake of clarity the market analysis highlights findings within these three categories. The market analysis also explores trends impacting these categories:

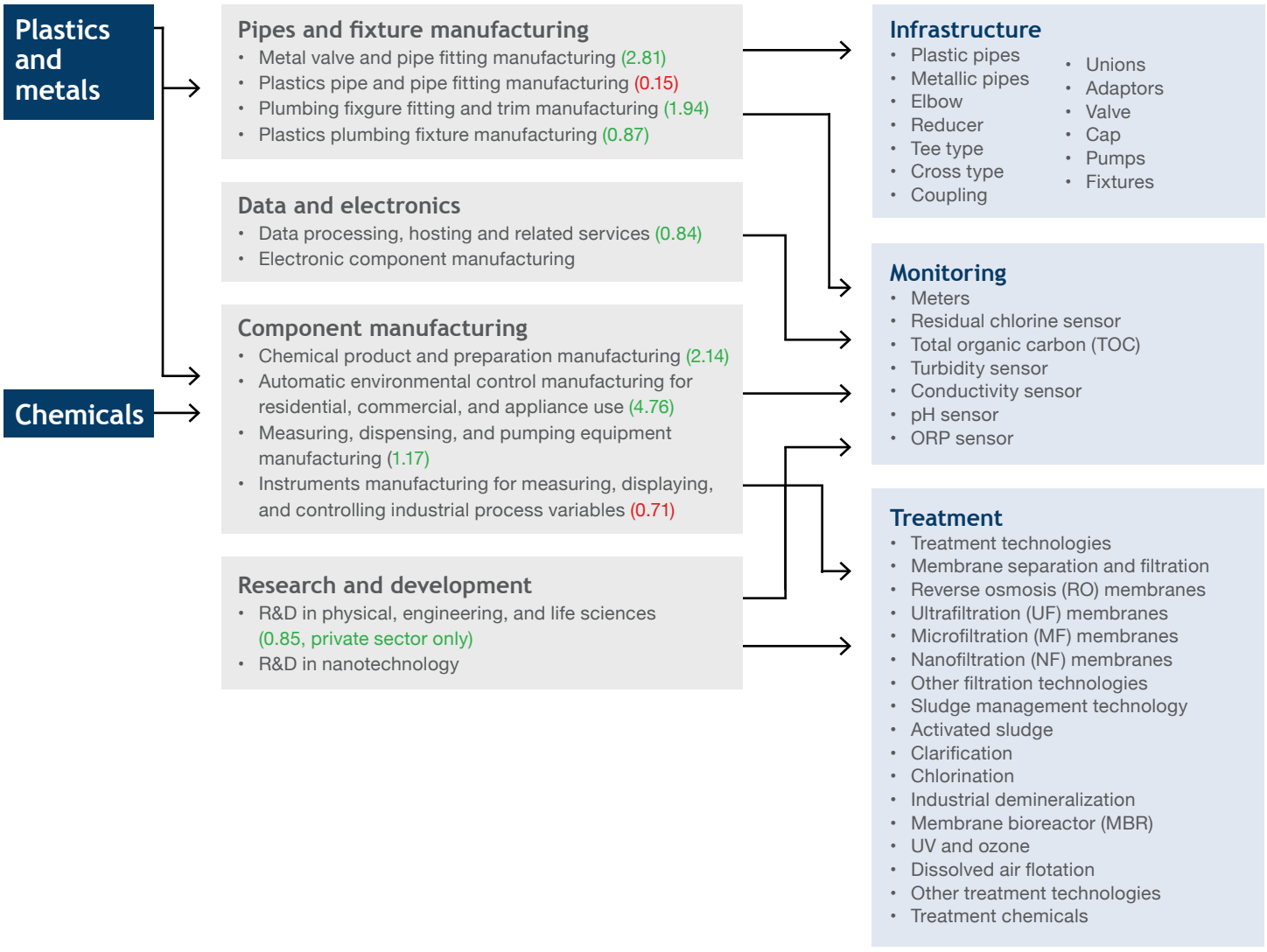
1. **Data Integration in Water Systems**
2. **Water-Energy Nexus**
3. **Resource Recovery**

The report also highlights the need for systems-wide collaboration. For instance, data platforms and other smart technology are often integrated into aging infrastructure — creating a need for systems-wide troubleshooting (e.g., deploying smart meters in Chicago resulted in increased lead exposure from disrupting pipe infrastructure).[15] An added challenge is

that each building and application is different, creating a need for customized rather than standardized water products. Despite these challenges, there is significant investor interest in water sector growth. After largely flat growth in overall M&A transactions in the water sector from 2012 to 2017 (2 percent per year), growth has jumped to 16 percent annually" — with activity from private-equity and infrastructure funds increasing to 26 percent annually.[16] These challenges and opportunities are explored in the next section.

FIGURE 4

## Relationship/Supply Chains Across Water Movement, Use and Quality




*Note: Location Quotients (LQs) listed are for Chicago MSA. Numbers in red represent low LQs, threshold of 0.8. LQs listed are for Chicago MSA.*

# Global Markets

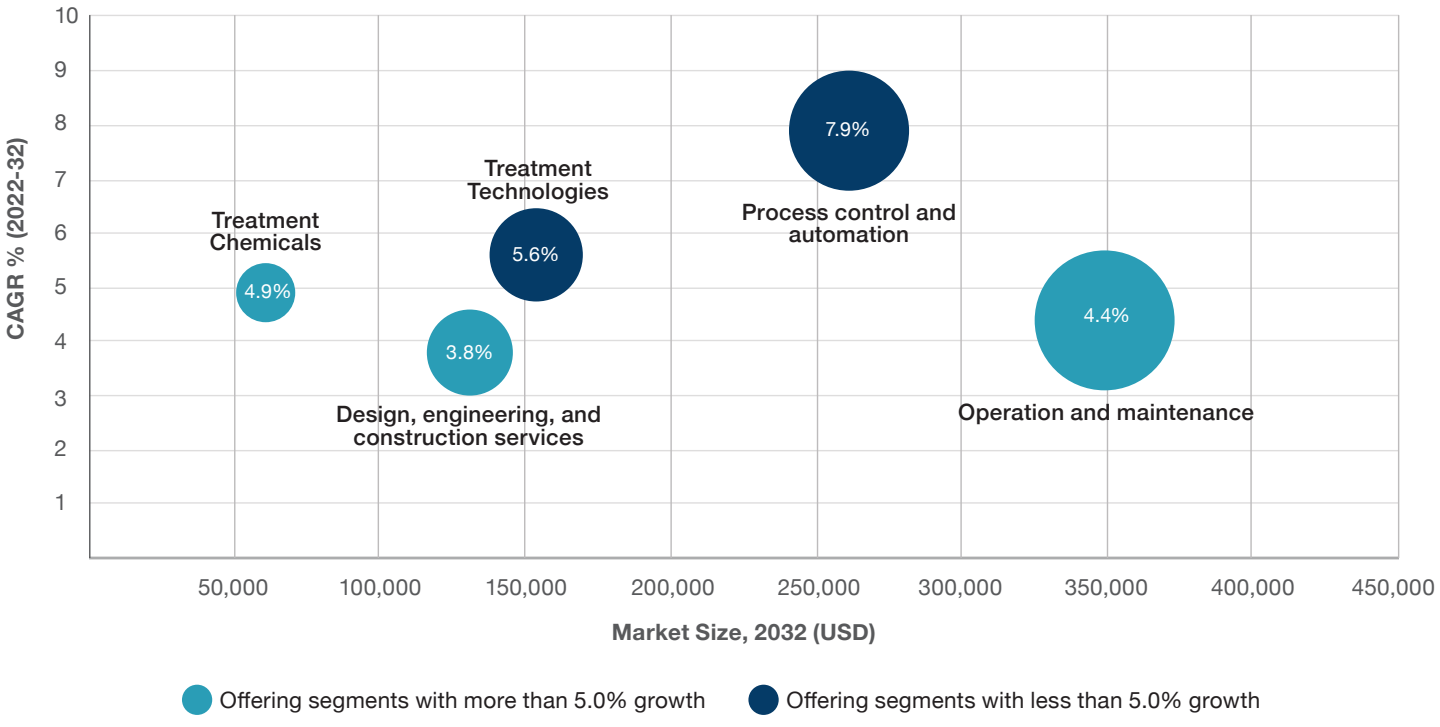
## Treatment

There is a pressing need to manage the many emerging contaminants that enter our water supply, generated by things like pharmaceuticals, fertilizers, pesticides, and consumer products. 90% of oral drugs end up in the water supply after passing through our bodies.[17] Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) — manufactured chemicals used to make products across several industries (e.g., aerospace, automotive, construction, electronics, and military) — are difficult to break down, end up in our water supply, and cause significant health concerns.[18] In addition to known contaminants, the list of emerging contaminants is ever-growing, demanding an increased pace of technology development to treat these chemicals (and increased pace of regulatory development as well).

**The water and wastewater treatment market is expected to reach a value of $956.48 billion by 2032, with a compound annual growth rate (CAGR) of 5.4% between 2022-2032.**[19] Segmented by offering, the market includes: treatment technologies, treatment chemicals, process control and automation, design, engineering, and construction services, and operation and maintenance services (see Figure 5). Major companies in this market include Xylem, Inc. and Suez SA.

**FIGURE 5**

### Growth Among Water and Wastewater Treatment Segments




*The size of bubbles represent the market size in 2032.*

*Source: Global Water and Wastewater Treatment Market, Meticulous Research*

Within this market, wastewater treatment accounts for 62.3% while water treatment accounts for 37.7%.[20]

- **Wastewater treatment** removes both suspended and dissolved organic and inorganic substances, as well as natural and synthetic organic chemicals. Industrial wastewater in particular is a higher risk than domestic wastewater as its toxins can cause poisoning, immune system suppression, or reproductive failure. Industrial wastewater treatment is moving towards recycling and reuse of treated water, energy generation during purification (see Water-Energy Nexus sub-section below), and nutrient recovery (see Nutrient Recovery sub-section below).

- **Water treatment** removes suspended impurities, solids, colloids, and living organisms from raw water and delivers potable water to users. In addition to providing drinking water, water treatment is especially important to industrial manufacturing processes to meet standards for process water requirements in pharmaceutical, food and beverage and semiconductor manufacturing.

Operation and maintenance represents the largest segment, largely due to the increasing complexities of water and wastewater treatment facilities as innovative water technologies are integrated into processes.[21] The segments that are expected to grow at the highest CAGR are **process control and automation**, and **treatment technologies**.

Treatment technologies includes sub-segments like membrane separation and filtration, sludge management technology, activated sludge, clarification, chlorination, industrial demineralization, membrane bioreactor (MBR), UV and ozone, and dissolved air flotation. Of these, **membrane separation and filtration** is projected to dominate the market ($28 Billion, 8.4% CAGR) and is further segmented into:[22]

- Reverse Osmosis (RO) membranes
- Ultrafiltration (UF) membranes
- Microfiltration (MF) membranes
- Nanofiltration (NF) membranes

Advanced filtration techniques are becoming more prominent because they can filter out more complex contaminants – and also replace chemicals as a means of water treatment. Innovations in membrane filtration

are growing to remove contaminants — ranging from PFAS, to organic matter such as algae, to micropollutants — with greater accuracy and efficiency.[23] The increasing prevalence of new contaminants demands innovation in treatment. This could involve integration of membrane filtration with biological processes, or Forward Osmosis systems which help comply with regulations like zero liquid discharge or recovery of 95-99% of water from waste streams for reuse.[24]

Applications of treatment technologies are largely for municipal treatment (69.1% of the market) but also industrial treatment (30.9%) — with the industrial treatment market projected to grow at a higher CAGR (6%). Municipal treatment often goes through several rounds of treatment, with preliminary focused on screening for sediments and later-stage treatment using biological treatment processes. The technologies used in industrial treatment largely depend on the specific contaminants and end-use, but for instance: food and beverage manufacturers use chemical and biological processes to treat the high amount of sugar, flavorings and additives in discharge. Many pharmaceutical manufacturers must use advanced wastewater treatment technologies (e.g., electrochemical advanced oxidation processes) to address the growing presence of Active Pharmaceutical Ingredients (APIs) that enter water streams.[25]

To adopt new technologies, within both industry and municipal settings, typically significant proof of concept is needed to be sure there are no negative impacts – to food quality, or to drinking water quality.

## Monitoring/Sensors

Treatment cannot occur without monitoring and testing; these sectors are closely linked. **The projected global market for Water Quality Monitoring Devices is $4.1 billion by 2026, at a CAGR of 5% (2021-2026).**[26]

Some of the most notable segments within this are:

- TOC Analyzers ($1.3 billion, 6.3% CAGR)
- pH Meters ($810.2 million, 5% CAGR)

Used across municipal, commercial and residential applications, water sensors can detect pressure, flow, acoustics, temperature and chemical measurements.[27] They can also detect the presence of unexpected pollutants within water.[28] Examples of sensors and their use:[29]

- **pH Sensor** — determines how much acidity and alkalinity is present in water and other liquids; critical to ensure safety of water (for instance, in water treatment plants or manufacturing operations)
- **Turbidity Sensor** — determines number of suspended particles in water by projecting a light beam into the sample and measuring light that is reflected back
- **Conductivity Sensor** — evaluates the ion concentration in the solution (conductivity increases with more ions present)
- **ORP Sensor** — provides more information than pH sensors; for instance, can be used to assess chemical treatment in waster has the desired effect
- **TOC Analyzers** — test the dissolved oxygen present in water bodies to determine pollution levels

Increased demand for both treatment and monitoring is driven by stringent water treatment regulations (that differ by state), rapid population growth and urbanization, the growing emphasis on water quality and public health, and the increasing prevalence of waterborne diseases. There is a growing need across industry for high quality water — particularly to demonstrate compliance


**The projected global market for Water Quality Monitoring Devices by 2026, at a CAGR of 5%**

in pharmaceutical, environmental, and food sectors (see **Global Markets: Treatment** section). Government regulations require industries to test and treat wastewater before it is discharged into water bodies, pushing private industry to invest in instruments like TOC analyzers, as well as measurement devices to assess basicity, turbidity and alkalinity.[30]

Examples of major companies present in this market are Thermo Fisher Scientific, Inc., Evoqua Water Technologies LLC, Siemens, Danaher Corporation, Agilent Technologies, and General Electric Company.

## Infrastructure and Fixtures

Water infrastructure includes a diverse range of products, for instance: pipes (both plastic and metallic), fittings (e.g., elbow, reducer, tee type, cross type, coupling, unions, adaptors, valve, cap)[31] — as well as pumps and mixing equipment. Trillions of dollars need to be spent to repair, upgrade, and build water infrastructure worldwide over the coming decades.[32] **The water infrastructure repair technologies market is expected to reach $131.6 billion by 2027, with a CAGR of 6.5%.**[33] Water-pipe replacement rates are projected to peak in 2035 (at 16,000 to 20,000 miles of pipes replaced per year — four times the current annual replacement rate of 4,000 to 5,000 miles).

Additional market reports highlight some of the notable segments within water infrastructure:

- The **pumps market** is expected to reach $13.5 billion by 2026, with a CAGR of 3.4%.[34]
- The **pipes and fittings market** is expected to reach $8 billion by 2025, with a CAGR of 4.7%.[35]
- The **stainless steel plumbing pipes market** is expected to reach $4.9 billion by 2030, with a CAGR of 4.8%.[36]

Water professionals in the US and Canada rank their most pressing water industry challenge as “renewal and replacement of

$131.6 BILLION

**The projected water infrastructure repair technologies market by 2027, at a CAGR of 6.5%**

aging water and wastewater infrastructure."[37] The market for pipes and associated infrastructure is projected to grow significantly due to:

- **Aging Infrastructure** — Most water systems are piecemeal and aging. The United States water-pipe network pipe is 45 years old, with some cast-iron pipes more than a century old,[38] and water utilities only replace about 0.5% of pipes every year.[39]

- **Lead** — The EPA estimates that it could take an investment of up to $839 million per year to replace and monitor the 9.7 million to 12.8 million lead service lines that are currently in use in the United States as a response to the updated Lead and Copper Rule.

- **Leaks** — 14-18% of treated potable water is lost through leaks in the US (with some water systems over 60%).

With the significant demand for new pipes — and associated products like meters and valves — there is also an opportunity to time their replacement with integration of new systems (smart meters, measuring devices, data platforms). This presents a unique challenge where a legacy industry is converging with new innovative technologies.

Water saving plumbing products like low-flow fixtures have similar inputs (plastics manufacturers, metals manufacturers) as pipes and fittings — and therefore this section includes them as well. **The water saving plumbing market is expected to reach a value of $5.4 billion by 2030, with a CAGR of 6.8% between 2021-2030.**[40] Global water demand is expected to increase by 1.8% annually (and grow significantly over the next 2 decades), primarily in industry, domestic and agriculture.[41] Of the world's *freshwater* supply, 70% is consumed by agricultural irrigation, 20% by industry, and 10% by individuals.[42] In response, globally, water-use efficiency has risen by 9% (15% in industrial sector, 8% in services, 8% in agriculture)[43] — so, demand for water saving products is growing.

Further demand for water efficient products, particularly in municipal and commercial settings, is driven by regulations, building codes and plumbing fixture standards — as well as increasing water prices. Small/medium buildings are often a market left behind for water efficiency technologies because of the high upfront costs. In this market, most water conservation strategies are more ad-hoc and related to daily maintenance activities.

**$5.4 BILLION**

**The projected water saving plumbing market by 2030, with a CAGR of 6.8%**

## Global Trends

As the global markets grow for water treatment, monitoring and infrastructure products and services, additional trends are influencing and, in some cases, disrupting these markets, such as:

1. **Data Integration in Water Systems**
2. **Water-Energy Nexus**
3. **Resource Recovery**

### Data Integration in Water Systems

The water industry is undergoing a digital transformation of processes and infrastructure, enabled by technology like sensors that can collect real-time data and analytics platforms that can integrate and process high volumes of data.[44] While the integration of these platforms with legacy systems and processes poses a challenge, there is significant opportunity to use AI-based data analytics platforms not just for greater management efficiencies but also to decarbonize water and wastewater treatment infrastructure.[45] Keys to successful water data platforms often include legislative support, clear development plans with milestones and long-term funding to support and maintain tools over time.[46]

Artificial intelligence (AI), along with robotics, cognitive computing and big data, is likely to play a major role in water management, water treatment and water conservation[47] — in addition to fueling innovation. Increased demand for software-as-a-service (SaaS) and network-as-a-service (NaaS) in multi-family, commercial, and utilities includes real-time data access, predictive technologies, data collection from sensors (one-way) and/or control of physical equipment through user input or automation with optimization algorithms (two-way). “Ten years ago, utilities were mainly looking for engineering solutions like new membranes, sensors, and the like, but in the last three years or so everything has a digital element to it.”[48]

The growing integration of data into water infrastructure and processes also creates a growing need for cybersecurity. EPA has discussed adding a cybersecurity component to National Pollutant Discharge Elimination System (NPDES) permits.[49]

## Water-Energy Nexus

The interdependency of water and energy systems has become a growing research topic with many applications (see Figure 6).[50] The cost of water use is inextricably tied to energy. Energy is used to extract, pump, deliver, and treat water - creating an additional driver of innovation in the water sector (to lower energy usage and its associated cost). For instance, utilities can now claim energy savings associated with building projects that reduce water use (e.g., low-flow toilets). In addition, energy production uses significant amounts of water, shifting demand to lower water-intense energy production, such as wind and solar PV (rather than more water-intense sources like biofuels).[51] By 2040, the amount of energy used in the water sector is projected to more than double.[52]

The future of water as a significant asset class depends on the willingness of governments — and ultimately of society at large — to price water at its long-run social marginal cost as a scarce renewable resource (including the cost of energy, and addressing the negative environmental externalities associated with its production and distribution).

Opportunities to reduce energy consumption within treatment systems or industrial applications include:[53]

- Pumping systems — proper maintenance of the motors, pumps, and the overall system, as well as pump optimization software
- Energy-efficient ballasts for fluorescent fixtures and ultraviolet disinfection or pretreatment systems

Water's intersections with energy use will have impacts on growth of the water cluster.

FIGURE 6

### Interdependency of Water and Energy Systems

#### How we use water for energy

**Electricity generation**

Nearly half of all water withdrawn in the U.S. keeps power plants cool enough to function safely and efficiently

**Oil and gas**

Water is used for hydraulic fracturing, enhanced oil recovery and other fossil fuel production processes

**Renewables**

Essential for hydropower, water is also used for concentrated solar power, for geothermal energy and to produce bioenergy

#### How we use energy for water

**Pumping**

We use energy to pump water from aquifers for agriculture and to transport to treatment facilities and consumers

**Water treatment**

Energy is needed to desalinate water and treat wastewater before it's returned to the environment

**Heating and cooling**

Energy and water work together to keep buildings and equipment at safe, comfortable temperatures

**Delivery**

We use energy to distribute and heat water for cooking, showering, cleaning and drinking

*Source:* ***https://www.energy.gov/articles/ensuring-resiliency-our-future-water-and-energy-systems***

Global energy trends will impact water usage and associated demand for water-related products. While growing renewable production can be seen as a demand condition that influences growth of the water cluster, there is also significant overlap in the products associated with the water cluster and energy sector.

## Resource Recovery

Pioneering methods in nutrient recovery, biogas generation and biosolids as a beneficial resource will shift perspectives of wastewater treatment plants to become "water resource recovery facilities" that can produce clean water and recover by-products. These facilities recover resources such as nutrients (phosphorus and nitrogen), high-value carbon products, rare earth elements (metals), and high-quality biosolids.[54] It is estimated that half of the wastewater utilities in the United States are on a pathway to become resource recovery facilities.[55]

Although these processes are not yet widespread,[56] treatment plants are beginning to recover and use by-products such as (see Figure 7):[57]

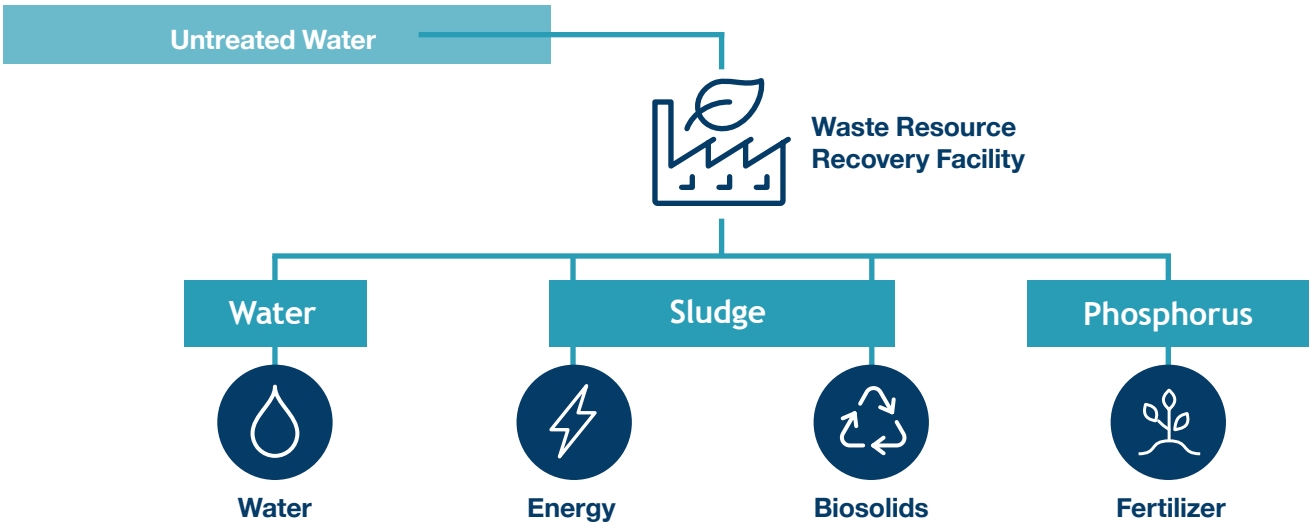
- Nutrients like nitrogen or phosphorus for fertilizer
- Sewage sludge for energy
- Biosolids (treated sewage sludge) for compost
- Bioplastics for manufacturing processes

In 2016, the Metropolitan Water Reclamation District of Greater Chicago (MWRD), opened the world's largest nutrient recovery facility at the Stickney Water Reclamation Plant. It has the potential to recover 2.3 million pounds per year of usable phosphorus, which can be sold in stores and used in fertilizers.[58] As another example, MWRD is also recovering biosolids (the solid residuals from the wastewater treatment process) and mixing it with wood chips to produce high-quality compost.[59]

These recovery efforts have the potential to become significant revenue streams for the region, in addition to the environmental benefits of recovering waste. The products and processes needed to recover by-products and grow new markets will drive further demand for water-related products — and will contribute to water cluster growth and growth of new markets.

**FIGURE 7**

### Waste Resource Recovery Facility By-Products




*Source:* ***https://www.worldbank.org/en/topic/water/publication/wastewater-initiative***

# Illinois and Wisconsin: Assets and Market Position

## Water Cluster Size

To estimate the size of the water cluster in the region, the products and services listed in Figure 3 were mapped to their most relevant industry code (see **Appendix D**). It should be noted: the list of industry codes includes things like "Data Processing, Hosting, and Related Services," which serve industries well beyond the water cluster. While the data includes more than just water-related firms, it is over-inclusive in order to broadly assess the strengths across the region, many of which can be pivoted to serve water industries.

**TABLE 1A**

### Water Cluster Summary, by Geography

| Geography | Output | Establishments (2020) | Employment (2020) | Female | BIPOC | <HS (age 25+) | HS (age 25+) | Assoc. (age 25+) | Bach+ (age 25+) |
|---|---|---|---|---|---|---|---|---|---|
| US | $483.6 billion | 505,127 | 5,347,925 | 30% | 29% | 12% | 25% | 30% | 32% |
| Illinois | $16.7 billion | 19,169 | 186,476 | 31% | 30% | 13% | 26% | 30% | 30% |
| Chicago MSA | $12.6 billion | 11,756 | 133,958 | 30% | 30% | 12% | 22% | 29% | 37% |
| Wisconsin | $6.6 billion | 7,000 | 90,000 | 32% | 14% | 10% | 30% | 33% | 27% |
| Milwaukee MSA | $2.2 billion | 1,645 | 27,508 | 29% | 16% | 9% | 27% | 32% | 31% |

**TABLE 1B**

### Blue Economy Comparative Summary, by Geography

| | Water Cluster | | Blue Economy | | Total Economy | |
|---|---|---|---|---|---|---|
| Geography | Establishments (2020) | Employment (2020) | Establishments (2020) | Employment (2020) | Establishments (2020) | Employment (2020) |
| US | 505,127 | 5,347,925 | 1,960,884 | 36,820,791 | 10,185,381 | 117,940,040 |
| Illinois | 19,169 | 186,476 | 74,614 | 1,454,614 | 368,119 | 4,822,617 |
| Chicago MSA | 11,756 | 133,958 | 49,031 | 1,012,892 | 235,146 | 3,490,816 |
| Wisconsin | 6,982 | 90,231 | 33,305 | 763,761 | 170,628 | 2,365,659 |
| Milwaukee MSA | 1,645 | 27,508 | 8,165 | 216,206 | 46,359 | 703,171 |

## Water Cluster Strengths

Looking at top 10 employment concentrations in water-related industries with high LQs:

- **Chicago MSA:** strengths in R&D, professional services, metals manufacturing (see Table 2)
- **Milwaukee MSA:** manufacturing strengths specific to water technologies (chemicals, measurement devices) (see Table 3)

Given that the regions share supply chains and economies, there is potential to commercialize more of Chicago's R&D (e.g., water sensors) through greater collaboration across geographic boundaries, linking supply chains with specialty manufacturing in chemicals, electrical, metals, and even material innovations in 3D printing.

While inclusion metrics in employment (female, BIPOC, those without a degree) are slightly better than national averages within these industries, this work aims to further

**TABLE 2**

### Chicago MSA, 10 Largest Industries by Employment

| | | | ESTABLISHMENTS | | | EMPLOYMENT | | | INCLUSION | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NAICS | NAICS Description | 2019 AP ($K, nominal) | 2019 Estabs | 2019 Est LQ | 2010-2019 Estab Growth | 2019 Emp | 2019 Emp LQ | 2010-2019 Emp Growth | Percent Female | Percent BIPOC | Percent <Bachelors (age 25+) |
| 238220 | Plumbing, Heating, and Air-Conditioning Contractors | 2050782 | 2801 | 1.08 | 3% | 26288 | 0.77 | 34% | 15% | 19% | 35% |
| 541330 | Engineering Services | 2013535 | 1309 | 0.71 | -12% | 20374 | 0.67 | 18% | 31% | 27% | 26% |
| 541715 | Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology) | 1320715 | 211 | 0.54 | 36% | 11373 | 0.88 | -22% | 37% | 31% | 24% |
| 518210 | Data Processing, Hosting, and Related Services | 1196773 | 424 | 0.68 | -4% | 8925 | 0.86 | 31% | 37% | 31% | 25% |
| 541310 | Architectural Services | 759872 | 929 | 1.59 | -19% | 8300 | 1.42 | 23% | 31% | 27% | 26% |
| 541990 | All Other Professional, Scientific, and Technical Services | 541625 | 1592 | 1.60 | 108% | 6131 | 1.17 | 206% | 63% | 26% | 28% |
| 811310 | Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance | 357310 | 629 | 0.91 | -7% | 5125 | 0.79 | 15% | 19% | 26% | 32% |
| 541380 | Testing Laboratories | 444246 | 208 | 0.87 | -7% | 5003 | 0.95 | 9% | 31% | 27% | 26% |
| 541690 | Other Scientific and Technical Consulting Services | 367709 | 732 | 0.65 | -15% | 4019 | 0.68 | 38% | 47% | 34% | 26% |
| 332722 | Bolt, Nut, Screw, Rivet, and Washer Manufacturing | 261572 | 96 | 5.22 | 7% | 3888 | 3.23 | 28% | 23% | 37% | 30% |

TABLE 3

## Milwaukee MSA, 10 Largest Industries by Employment

| | | | ESTABLISHMENTS | | | EMPLOYMENT | | | INCLUSION | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NAICS | NAICS Description | 2019 AP ($K, nominal) | 2019 Estabs | 2019 Est LQ | 2010-2019 Estab Growth | 2019 Emp | 2019 Emp LQ | 2010-2019 Emp Growth | Percent Female | Percent BIPOC | Percent <Bachelors (age 25+) |
| 238220 | Plumbing, Heating, and Air-Conditioning Contractors | 416372 | 423 | 0.83 | 4% | 5573 | 0.82 | 36% | 13% | 9% | 38% |
| 541330 | Engineering Services | 456310 | 462 | 1.27 | 60% | 5297 | 0.88 | 31% | 27% | 12% | 30% |
| 518210 | Data Processing, Hosting, and Related Services | 588596 | 62 | 0.50 | 11% | 4427 | 2.16 | -5% | 48% | 20% | 29% |
| 811310 | Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance | 88937 | 133 | 0.98 | -10% | 1232 | 0.96 | 24% | 18% | 11% | 38% |
| 541310 | Architectural Services | 105122 | 96 | 0.84 | 2% | 1193 | 1.03 | 29% | 27% | 12% | 30% |
| 333318 | Other Commercial and Service Industry Machinery Manufacturing | 70239 | 22 | 2.26 | -8% | 985 | 2.53 | 12% | 26% | 17% | 32% |
| 325199 | All Other Basic Organic Chemical Manufacturing | 60540 | 11 | 2.62 | 22% | 813 | 3.43 | 28% | 29% | 32% | 33% |
| 334513 | Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables | 44373 | 18 | 1.95 | 13% | 680 | 1.79 | -5% | 31% | 23% | 31% |
| 237110 | Water and Sewer Line and Related Structures Construction | 50892 | 37 | 0.64 | -23% | 606 | 0.54 | -3% | 13% | 10% | 32% |
| 541380 | Testing Laboratories | 35791 | 47 | 1.00 | 0% | 519 | 0.50 | 14% | 27% | 12% | 30% |

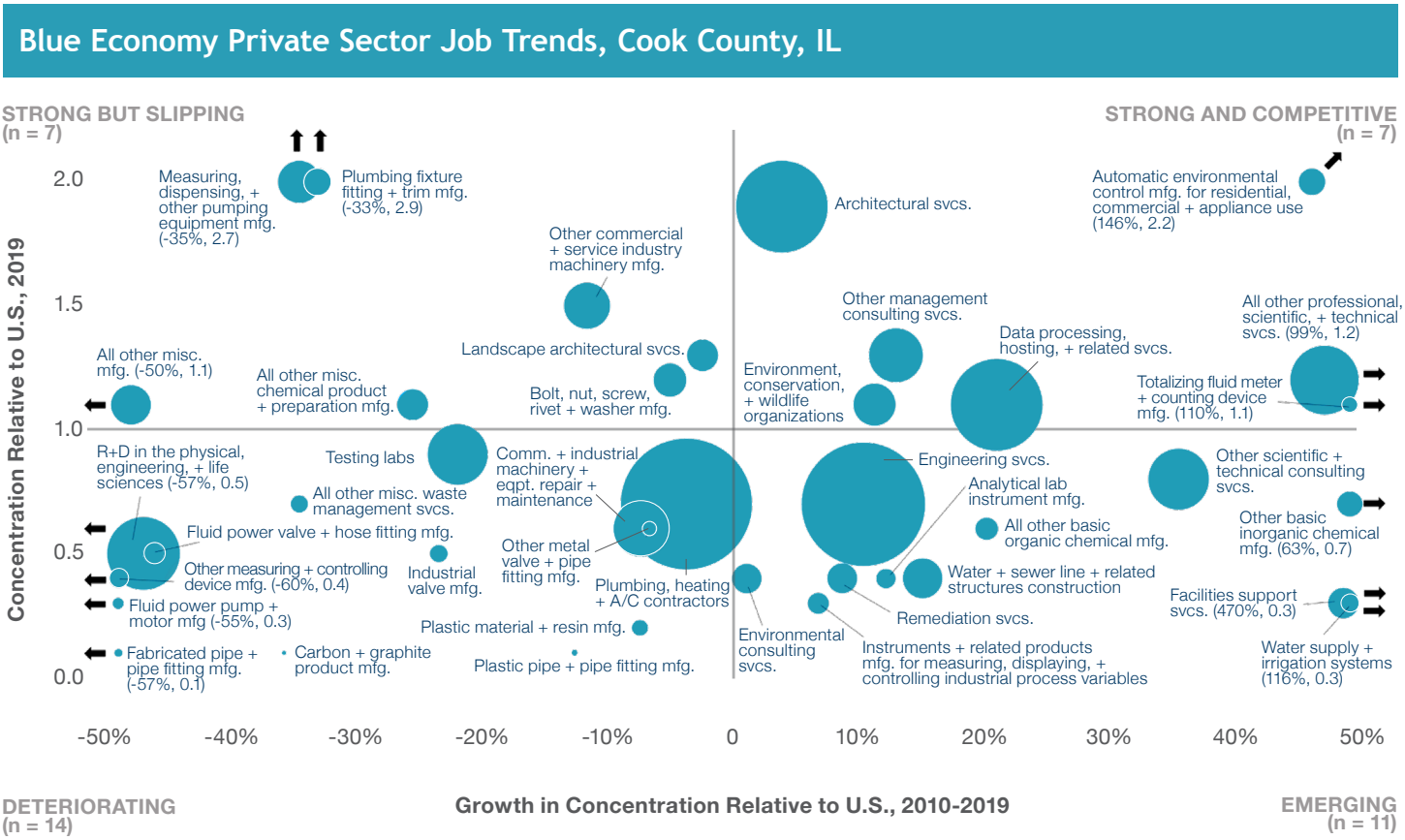
diversify employment and ownership — as their national averages are also low. Estimated BIPOC ownership within water-related industries is incredibly low, at around 5%.[60]

Looking instead at industry concentrations and growth at both the County and MSA level, data assessment of all NAICS within the water cluster definition reveal that:

- **Chicago MSA** has the right concentration of growing manufacturing, engineering, and data industries to support growth of the water cluster, particularly in:
  - Automatic environmental control manufacturing
  - Industrial valve manufacturing
  - Pipe fitting manufacturing
  - Engineering services
  - Data processing and hosting
- **Milwaukee MSA** has a strong water cluster (most of the industries within it are experiencing growth)

FIGURE 8

## Cook County: 2019 LQ vs 2010-2019 Growth in LQ




*Notes: The size of bubbles represent employment concentration; Black arrows indicate those that are "off the chart;" All other pipeline transportation and sewage treatment facilities are not shown because the industries had less than 10 jobs in 2019; Reflects private sector jobs only; Cook, Rest of MSA, and Rest of IL bubbles are at the same scale on size basis*

*Source: dF-QCEW*

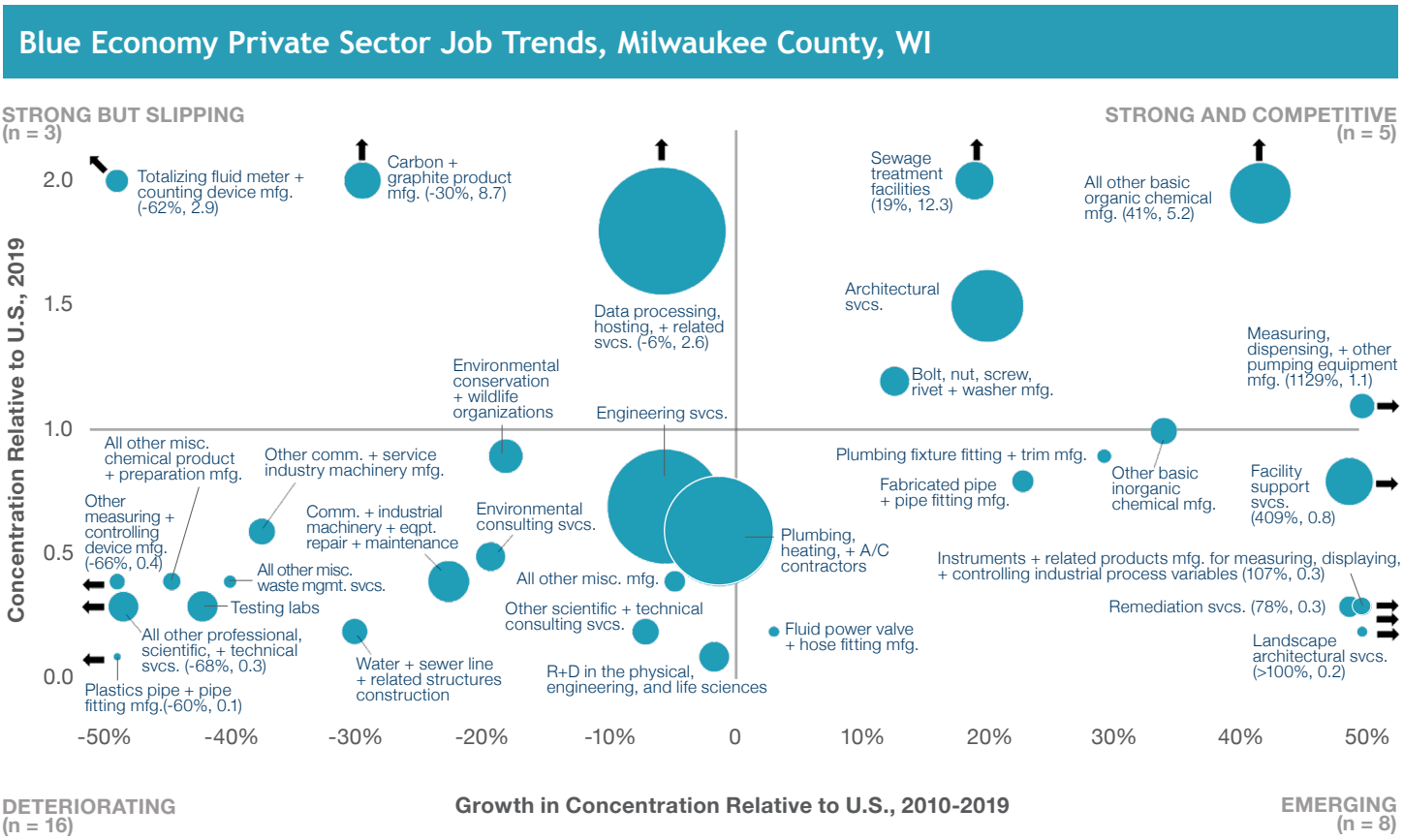
See Figures 8-9 for County data (and see **Appendix A** for MSA data, excluding the County). While the Milwaukee region has many less firms and thus lower employment, its water-related industries are typically strong, competitive or emerging.

Looking more closely at the Chicago MSA, it has several industry strengths that relate to treatment, monitoring, and water infrastructure and fixtures — indicating that, with the right strategic support, the region is poised to compete globally across each of these categories.

- **Treatment**
  - Automatic Environmental Control Mfg. (LQ 7.6)
  - All Other Misc. Chemical Product and Prep. Mfg. (LQ 2.14)
- **Monitoring**
  - Automatic Environmental Control Mfg. (LQ 7.6)
  - Automatic Env. Control Mfg. for Res., Com., and Appliance Use (LQ 4.76)
  - Measuring, Dispensing, and Other Pumping Equipment Mfg. (LQ 1.17)
- **Water Infrastructure and Fixtures**
  - Other Metal Valve and Pipe Fitting Mfg. (LQ 2.81)
  - Plumbing Fixture Fitting and Trim Mfg. (LQ 1.94)
  - Industrial Valve Mfg. (LQ 2.5)
  - Fabricated Pipe and Pipe Fitting Mfg. (LQ 1.5)

**FIGURE 9**

## Milwaukee County: 2019 LQ vs 2010-2019 Growth in LQ




*Notes: The size of bubbles represent employment concentration; Black arrows indicate those that are "off the chart;" All other pipeline transportation, analytical laboratory instrument mfg., automatic environmental control mfg. for residential, commerical, and appliance use, fluid power pump and motor mfg., industrial valve mfg., other management consulting svcs., other metal valve and pipe fitting mfg., plastics material and resin mfg., and water supply and irrigation systems are not shown because the industries had 10 or fewer jobs in 2019; Reflects private sector jobs only; MKE County and Rest of MSA bubbles are at the same scale on size basis.*

*Source: dF-QCEW*

# Innovation

## Universities and Research Labs

The region has several regional research and development institutions, which have water-related research focuses and help accelerate innovation. Highlights include:

- **Northwestern University Center for Water Research** — A hub for research and partnerships including the US-Israel Collaborative Water-Energy Research Center, which has developed a pipeline for scaling up and pilot testing water technologies and materials for desalination, safe water reuse, and resource recovery; the SAGE National Sensing and Edge Computing Infrastructure; the Illinois and Chicago Wastewater Surveillance networks; and NSF and DOE-funded efforts on resource recovery from wastewater.

- **UChicago's Pritzker School of Molecular Engineering (PME)'s joint Water Initiative with Argonne National Laboratory (ANL)** — Specializes in molecular engineering approaches to water production, purification, and preservation.

- **Research Center on Advanced Materials for Energy-Water Systems** — Led by Argonne, this DOE-funded, includes multiple PME/UChicago faculty members.

- **Argonne National Laboratory (ANL) initiatives** — Broadly, ANL has expertise in water science and engineering, additional research in materials, selective separation, sensors and controls, modeling and AI/ML, manufacturing, and sustainability. It moves materials, sensors and process technologies from discovery to application by tapping into multiple specialized facilities, including the Center for Nanoscale Materials (CNM) and Materials Engineering Research Facility (MERF). Argonne's "Water + AI" initiative leverages AI to address many

INNOVATION

scientific challenges relevant to the nexus between energy and water. ANL recently announced the development of water filtration membranes that can clean themselves — which can be used by water treatment facilities or industry.

- **UIC's proposed Institute for Water Research** — Will focus on extracting energy from water, selective separation and conversion of contaminants and feedstocks, computational expertise in materials design and data science, metabolic flow modeling of the water-energy-waste nexus, life cycle cost and impact analysis of technology innovations, and natural resource policy and planning.

- **University of Illinois Urbana-Champaign** — Expertise in chemical phosphorus recovery from wastewater treatment plants and grain processing facilities, bio-electrochemical sensing and applications of AI at wastewater treatment plants, electrochemical technologies for energy-efficient selective separations and wastewater treatment, including nutrient recovery (N and P), and remediation of emerging contaminants.

- **Marquette University (MU) and the University of Wisconsin** — Milwaukee's Water Equipment and Policy Center (WEP) creates new sensors and devices, novel materials, innovative systems, and water policies to manage acutely stressed global water resources. Research strengths include point of use and point of entry technologies, emerging contaminants, sustainability, reduced energy consumption, biotech and used water energy recovery and the "internet of things" for the consumer, industrial, and municipal markets.

- **UWM Great Lakes Genomics Center** — Applies genomics to issues of freshwater management.

- **MWRD** — Operates the largest nutrient (phosphorus) recovery facility in the world, with the annual capacity to remove 1,500 tons of phosphorus and convert it into a slow-release fertilizer.

The region's universities and research labs produce leading-edge research in the water sector, particularly leading efforts around molecular engineering and genomics as it relates to water production, purification and preservation; resource recovery; and data-driven modeling and AI, and their application to nutrient recovery, biogas generation, biosolid use, and water treatment. These areas of focus provide enormous potential for tech transfer and commercialization of products that can grow our region's water cluster and be exported across the world. As of 2020, Illinois ranks 8th in industry-funded research at institutions of higher learning, with businesses providing $169 million in support.[61]

"As of 2020, Illinois ranks 8th in industry-funded research at institutions of higher learning, with businesses providing $169 million in support."

## Private Sector Innovation

A region's capacity to develop and commercialize technologies is dependent on assets like universities and research labs as well as private sector investments in R&D. In 2019, private companies in Illinois spent $14 billion in R&D expenditures, ranking #9 out of all states.[62] About 95% of all business R&D expenditures were paid by private companies, 0.5% by Federal sources, and 4.6% by non-Federal sources.[63] This suggests that Illinois has a robust private sector R&D ecosystem. According to the Illinois Science & Technology Coalition, as of 2022, Illinois ranks #10 out of all states for R&D activity at universities, federally funded R&D centers (FFRDCs), businesses, and other entities.[64]

The level of venture capital investment in a region also plays a role in supporting innovation, particularly for early startups. In the Illinois water cluster, six companies received $69 million in funding in 2021 (see Table 4).[65] Although a small sample, this set of companies reflects long-standing and emerging strengths, from manufacturing to specialized sensors and cloud-based platforms.

**TABLE 4**

### IL Water Cluster, VC Investment in 2021

| Company | Transaction Name | Money Raised (2021) | Description | Location |
|---|---|---|---|---|
| 120Water | Venture Round | $4,500,000 | 120Water is the end-to-end solution used by water professionals across the country to manage critical lead and drinking water programs. Comprised of secure cloud-based software, services and point of use kits, 120Water's solution provides tailored workflows for complying with lead and water quality programs that protect public health. | Chicago<br>Zionsville, IN |
| Varuna | Angel Round | — | Varuna provides alerts, recommendations, and predictions to help water utility leaders to effectively manage a water system. | Chicago |
| Stemloop | Non Equity Assistance | — | Stemloop is a cell-free biosensors platform designed to create sensors that operate outside of cells. The sensors can detect a range of water contaminants, including antibiotics, small molecules and metals. Applications include municipal water supplies. | Evanston |
| Rheaply | Funding Round | — | Rheaply provides a platform that enables organizations to exchange materials and resources effectively. | Chicago |
| | Venture Round | $2,200,000 | | |
| | Series A | $8,000,000 | | |
| Intellihot | Venture Round | $50,000,000 | Intellihot manufactures tankless water heater systems for residential and commercial applications. | Galesburg |
| Serionix | Venture Round | $4,800,000 | Serionix is a research and development company that develops materials for water and air purification. | Champaign |
| | **TOTAL** | **$69,500,000** | | |

Patent activity is an indicator that can provide insights on the scale and type of innovation occurring in a region. According to 2017 data, in terms of patent applications filed across all industries, Illinois ranks #14 out of all states (see **Appendix A**), followed closely by Wisconsin. Although Illinois is one of the top-ranking states, its patent activity lags behind top performers like Massachusetts and California.

In terms of patents filed for water technologies in the past ten years, Illinois is often one of the top 10 states.[66] A broad patent search[67] for different types of water technology applications and technologies reveals strengths in water treatment, inventions incorporating sensors, and pumps (see Tables 5-9).

**TABLE 5**

## 2010-2021 Patents: Treatment

| | State | Number of Water Technology Patents: Treatment (2010-2021) |
|---|---|---|
| 1 | Texas | 397 |
| 2 | California | 225 |
| 3 | New York | 116 |
| 4 | Pennsylvania | 110 |
| 5 | New Jersey | 106 |
| **6** | **Illinois** | **103** |
| 7 | Minnesota | 84 |
| 8 | Florida | 81 |
| 9 | Michigan | 76 |
| 10 | Ohio | 70 |

**TABLE 6**

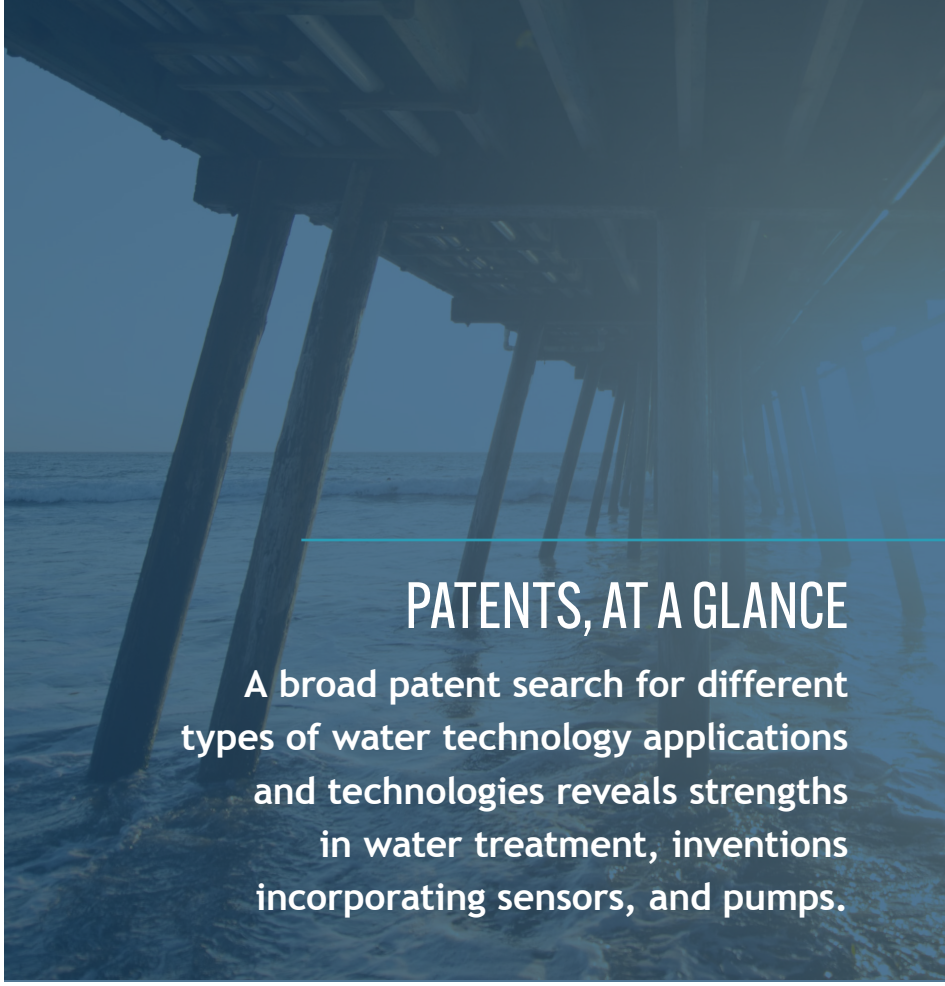
## 2010-2021 Patents: Sensors

| | State | Number of Water Technology Patents: Sensors (2010-2021) |
|---|---|---|
| 1 | California | 239 |
| 2 | Texas | 160 |
| **3** | **Illinois** | **99** |
| 4 | New York | 97 |
| 5 | Michigan | 80 |
| 6 | Massachusetts | 65 |
| 7 | Wisconsin | 62 |
| 8 | Minnesota | 54 |
| 9 | Florida | 46 |
| 10 | New Jersey | 45 |

TABLE 7

## 2010-2021 Patents: Pumps

| | State | Number of Water Technology Patents: Pumps (2010-2021) |
|---|---|---|
| 1 | California | 173 |
| 2 | Texas | 133 |
| 3 | Michigan | 95 |
| 4 | New York | 87 |
| **5** | **Illinois** | **82** |
| 6 | New Jersey | 69 |
| 7 | Wisconsin | 67 |
| 8 | North Carolina | 67 |
| 9 | Minnesota | 56 |
| 10 | Delaware | 54 |



# PATENTS, AT A GLANCE

A broad patent search for different types of water technology applications and technologies reveals strengths in water treatment, inventions incorporating sensors, and pumps.

TABLE 8

## 2010-2021 Patents: Filters

| | State | Number of Water Technology Patents: Filters (2010-2021) |
|---|---|---|
| 1 | California | 169 |
| 2 | New York | 96 |
| 3 | Texas | 88 |
| 4 | Minnesota | 80 |
| 5 | Michigan | 73 |
| 6 | New Jersey | 70 |
| 7 | Florida | 65 |
| 8 | Delaware | 56 |
| 9 | Illinois | 47 |
| 10 | Pennsylvania | 43 |

TABLE 9

## 2010-2021 Patents: Pipes

| | State | Number of Water Technology Patents: Pipes (2010-2021) |
|---|---|---|
| 1 | California | 30 |
| 2 | Texas | 22 |
| 3 | New York | 15 |
| 4 | Pennsylvania | 15 |
| **5** | **Illinois** | **12** |
| 6 | Wisconsin | 12 |
| 7 | Colorado | 11 |
| 8 | Florida | 8 |
| 9 | North Carolina | 8 |
| 10 | Ohio | 7 |

TABLE 10

## Water Technology Companies Filing Patents between 2000-2022

| Company | Number of Patents |
|---|---|
| Nalco Water | 82 |
| Intellihot | 26 |
| Culligan International Company | 17 |
| Aqua-Aerobic Systems, Inc. | 14 |
| Ecolab USA Inc | 14 |
| Schneider Electric Buildings | 8 |
| UOP LLC | 5 |
| Dober Chemical Corporation | 4 |
| Aquion, Inc | 3 |
| Heritage-Crystal Clean | 3 |
| Everpure, LLC | 2 |
| Nano Gas Technologies Inc. | 2 |
| Semler Industries Inc. | 2 |
| Serionix, Inc. | 2 |
| Air Diffusion Systems | 1 |
| ANDalyze, Inc. | 1 |
| Aqua Control Inc | 1 |
| Backflow Solutions, Inc | 1 |
| Cerro Flow Products | 1 |
| Deere & Company | 1 |
| Gasvoda and Associates | 1 |
| Hydro Flow Products | 1 |
| International Valve Manufacturing | 1 |
| LiquiTech | 1 |
| Natural Science | 1 |
| Opencel LLC | 1 |

Taking a closer look at patents filed by Illinois water technology companies[68] reveals further insights. A total of 196 patents were filed between 2000-2022 by 26 companies (see Table 10) — focusing on industrial uses (see Table 11) and treatment (see Table 12). Private sector patent activity in Illinois is driven by 8 large companies; the remaining have between 1-3 patents. There were a total of 20 patents, filed between 2001-2022, contained an automatic element — incorporating the use of sensors and measuring devices to track and/or collect data to process and enable automatic decisions.

TABLE 11

## Patents, by Sector

| Sector | Number of Patents |
|---|---|
| Residential | 35 |
| Commercial | 36 |
| Industrial | 117 |
| Municipalities | 22 |
| None specified | 36 |

*Note: There is overlap.*

TABLE 12

## Patents, by Categories

| Category | Number of Patents |
|---|---|
| Treatment | 41 |
| Heating/Cooling | 27 |
| Oil/solid/water separation | 16 |
| Microbial/Biological Control | 16 |
| Corrosion Control | 14 |
| Control (controlling water flow - direction, amount) | 13 |
| Anti-Fouling | 13 |
| Monitoring | 11 |
| Contaminants/impurities | 10 |
| Detection | 9 |
| Control/Maintenance of water systems | 7 |
| Oxygenation/Aeration | 6 |
| Water Removal/Dewatering | 5 |
| Water Quality | 4 |
| Heavy Metals | 4 |
| Water Transport | 3 |
| Area: Includes Plumbing Systems | 3 |
| Clarification (coagulation, flocculation and sedimentation) | 3 |
| Fluid/Water Recovery | 3 |
| Water Pressure | 1 |
| Nutrient Removal | 1 |
| Pressure | 1 |
| Water-Energy Nexus | 1 |

Illinois private sector patents have developed new innovations across several categories that are experiencing growth globally (see **Global Markets** section):

- **Treatment and Monitoring** — Treating water, monitoring for potential issues that can affect water quality (including microbes, corrosion, and fouling); filter technology (filtering out metals, particulate matter, organic and inorganic contaminants, oils, process contaminants).
- **Monitoring** — Detecting specific contaminants in the water (ranging from organics like sugar to metals like copper).
- **Water Infrastructure Components and Assemblies** — New assemblies for control valves, filters, and sensors; singular parts that are incorporated into apparatuses, assemblies, and systems; home and business water treatment systems such as water softeners and filtration systems.
- **Data in Water Systems** — Communication systems that control water systems.

**196** patents focusing on industrial uses and treatment were filed between 2000-2022 by 26 companies

## Small Business Innovation

Another measure of innovation, particularly among small businesses, can be assessed through SBIR and STTR grants. Between 2010-2022, Illinois received 53 SBIR/STTR awards ($17M) for water technologies and Wisconsin received 27 ($9M) — comprising 3-4% of all SBIR/STTR awards. Some companies received more than 1 award (Table 13). By comparison, Massachusetts, which has a more established water sector, received 130 awards ($42M) — indicating that there is room for growth in innovation and commercialization within Illinois.

In Illinois, 28 of awards went to companies with affiliations with University of Illinois at Urbana-Champaign. There were 13 awards that focused on water/wastewater treatment, and 11 awards that focused on contaminants in water.

TABLE 13

### Companies That Received More Than One SBIR/STTR Award

| Company | Number of Awards |
|---|---|
| Serionix, Inc. | 6 |
| ANDalyze, Inc. | 4 |
| EDEN PARK ILLUMINATION, INC. | 4 |
| Advanced Diamond TechNologies, Inc. | 3 |
| DIOXIDE MATERIALS, INC. | 3 |
| Cbana Laboratories | 2 |
| EP Purification, Inc. | 2 |
| Fluidic microControls, Inc. | 2 |
| NuMat Technologies, Inc. | 2 |
| QUESTEK INNOVATIONS LLC | 2 |

## Barriers to Commercialization

While Illinois has incredible research strengths — its ability to commercialize research, among both universities and entrepreneurs — could be improved. Interviews with water industry stakeholders revealed challenges that the region can address, particularly for treatment and monitoring technologies, to improve commercialization and adoption of new products. These include:

- Need for **patient capital**,[69] given long commercialization times, to help collect data and prove out a concept, and implement new solutions at scale.
- **Access to pilot sites** or some way to acquire test data for new technologies. Pilot sites can fill a gap between research conducted in universities and laboratories and commercial-scale development. Wastewater treatment facilities and industrial users are reluctant to buy new technology if there is no evidence of it working in a real-world scenario,[70] and even better working for their specific application.
- **Technical assistance** in establishing viable business and operational plans, particularly for scientists and engineers who have developed a new technology but do not have business experience to assess its marketability.

Given the increased interest from investors and private-sector in water-related innovations (both traditional and tech-enabled),[71] there may be momentum to increase innovation capacity and its adoption into the market.

## Workforce

Both the Chicago and Milwaukee MSAs have employment concentrations in water-related industries, primarily in data processing, machinery manufacturing, chemical manufacturing, measurement device manufacturing, bolt/nut/screw/rivet/washer manufacturing.

Across all water-related industries, those occupations that are currently experiencing high demand range from biological technicians, to machinists, to engineers, to general/operations managers (see Table 14). Occupations that are currently not picked up in the data, but may be required to drive continuous innovation in the region, are nanotechnology and genomics researchers. There will be opportunities to increase diversity within these high-growth careers pathways as strategies are developed. In developing strategies, note that educational requirements in the Chicago MSA are higher than the national average (see Table 1), indicating the region has an opportunity to increase non-degree employment pathways in high-growth water careers.

To assess *existing* opportunities for inclusive career pathways, within the 10 largest industries in the Chicago MSA, occupations

**TABLE 14**

### Highest Demand Occupations in 2022 for the Water Economy Workforce

| Occupation |
|---|
| Architects, Except Landscape and Naval |
| Architectural and Engineering Managers |
| Biological Technicians |
| Chemists |
| Chief Executives |
| Computer Occupations, All Other |
| Computer User Support Specialists |
| Computer and Information Systems Managers |
| Construction Managers |
| Cost Estimators |
| Electrical and Electronic Engineering Technologists and Technicians |
| Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers |
| Engineers, All Other |
| Environmental Engineers |
| Environmental Scientists and Specialists, Including Health |
| Financial Managers |
| First-Line Supervisors of Mechanics, Installers, and Repairers |
| General and Operations Managers |
| Hazardous Materials Removal Workers |
| Helpers—Installation, Maintenance, and Repair Workers |
| Helpers—Pipelayers, Plumbers, Pipefitters, and Steamfitters |
| Human Resources Specialists |
| Industrial Engineers |
| Industrial Production Managers |
| Janitors and Cleaners, Except Maids and Housekeeping Cleaners |
| Logisticians |
| Machinists |
| Maintenance and Repair Workers, General |
| Marketing Managers |
| Office Clerks, General |
| Personal Service Managers, All Other; Entertainment and Recreation Managers, Except Gambling; and Managers, All Other |
| Photographers |
| Project Management Specialists and Business Operations Specialists, All Other |
| Welders, Cutters, Solderers, and Brazers |

*Source: Intersect Illinois analysis*

that pay above $29/hour and have a positive growth projection from 2021-2030 are listed in Table 15. Of these, the 5 occupations that do not require a Bachelor's degree are:

- First-Line Supervisors of Mechanics, Installers, and Repairers
- Mobile Heavy Equipment Mechanics, Except Engines
- Calibration Technologists and Technicians and Engineering Technologists and Technicians, Except Drafters, All Other
- Computer Network Support Specialists
- Plumbers, Pipefitters, and Steamfitters

These 5 occupations may provide the most inclusive pathways into the water cluster; of particular interest is "Calibration Technologists and Technicians and Engineering Technologists and Technicians" — as, interviews also emphasized the importance of technicians for the water workforce (particularly as the industry becomes more technology-dependent and complex; technicians who can troubleshoot a variety of problems will be important).

In addition to the growing workforce needs of emerging Blue Economy industries, near-term workforce needs have surfaced from trends including retirement cliffs in the trades, influxes of federal dollars for infrastructure replacement, and underrepresentation of women and people of color in existing water-related jobs. Current opportunities for inclusive workforce development include jobs in lead service line replacement, manufacturing, wastewater and drinking water operations, manufacturing, wastewater epidemiology and climate resilient infrastructure.[72]

TABLE 15

## Occupations With Pay Above $29/hour and Positive Growth Projection from 2021-2030

### Within the 10 largest industries in Chicago MSA (as listed in Table 2)

| Occupational Makeup (top 10 occupations) | Relevant to X water cluster NAICS | Employed in Industry (2021) | % Change (2021 - 2030) | Median Hourly Earnings | Typical Entry Level Education | Work Experience Required | Typical On-The-Job Training |
|---|---|---|---|---|---|---|---|
| Marketing Managers | 2 | 391 | 37% | $60.62 | Bachelor's degree | 5 years or more | None |
| Management Analysts | 1 | 1,272 | 15% | $43.71 | Bachelor's degree | Less than 5 years | None |
| First-Line Supervisors of Mechanics, Installers, and Repairers | 1 | 284 | 12% | $35.29 | High school diploma or equivalent | Less than 5 years | None |
| Market Research Analysts and Marketing Specialists | 3 | 325 | 11% | $30.62 | Bachelor's degree | None | None |
| Construction Managers | 1 | 1,020 | 10% | $39.25 | Bachelor's degree | None | Moderate-term on-the-job training |
| Mobile Heavy Equipment Mechanics, Except Engines | 1 | 277 | 7% | $31.26 | High school diploma or equivalent | None | Long-term on-the-job training |
| Computer and Information Systems Managers | 1 | 555 | 4% | $70.35 | Bachelor's degree | 5 years or more | None |
| Chemists | 1 | 305 | 4% | $35.00 | Bachelor's degree | None | None |
| Computer Occupations, All Other | 1 | 318 | 4% | $43.22 | Bachelor's degree | None | Moderate-term on-the-job training |
| Software Developers and Software Quality Assurance Analysts and Testers | 4 | 1,003 | 4% | $50.74 | Bachelor's degree | None | None |
| Computer Systems Analysts | 2 | 609 | 4% | $44.35 | Bachelor's degree | None | None |
| Industrial Engineers | 1 | 171 | 3% | $42.33 | Bachelor's degree | None | None |
| Calibration Technologists and Technicians and Engineering Technologists and Technicians, Except Drafters, All Other | 1 | 332 | 3% | $32.65 | Associate's degree | None | None |
| Electrical Engineers | 1 | 754 | 2% | $46.91 | Bachelor's degree | None | None |
| Computer Network Support Specialists | 1 | 358 | 2% | $30.05 | Associate's degree | None | None |
| Plumbers, Pipefitters, and Steamfitters | 1 | 12,206 | 0% | $43.17 | High school diploma or equivalent | None | Apprenticeship |

*Source: Intersect Illinois analysis*

## Assessment: IL and WI Opportunities

Around the world, several regions have begun to leverage their water-related assets through strategic investments to drive economic (see **Appendix B**). As demonstrated in both the Chesapeake region and the Midwestern states of Ohio, Kentucky and Indiana, regional water cluster organizations have helped to remove barriers to growth, for instance — by enabling collaboration between state regulators to develop cooperative agreements, allowing for reciprocity of new technology testing across multiple states.

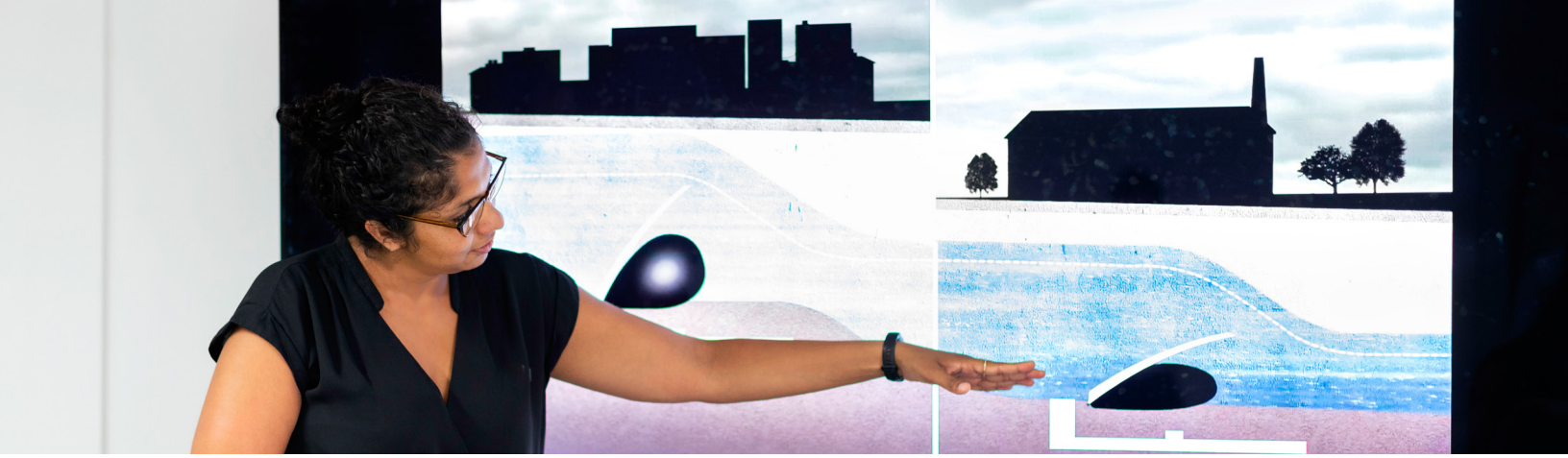
The Illinois and Wisconsin region has the opportunity to similarly foster collaboration across innovation, finance, workforce and network. in order to grow the water cluster deliberately and strategically. Current has the capacity to staff many of the recommended strategies for the Chicago MSA, and the Water Council has many existing initiatives with which the Chicago MSA region can align. Current builds relationships across research, government, utility, industry, and community organizations and can leverage its network to create additional programming with partners.

Some of the biggest opportunities in the region are:

- Linking R&D strengths in Chicago MSA with manufacturing/commercialization strengths in Milwaukee MSA
- Developing and manufacturing water efficiency technologies for export to water-scarce regions
- Leveraging manufacturing strengths to supply pipes and fittings to meet increased global demand


- Accelerating commercialization of advanced treatment technologies
- Expanding production and adoption of monitoring technologies by matching products with end-users
- Growing and diversifying the workforce to meet employer demands for development and production of these products and services

**By 2030, the Chicago region will be home to a thriving and inclusive Blue Economy where water companies, corporate water users, utilities and research institutions collaborate on developing and manufacturing nation-leading treatment and monitoring technology, catalyzing environmental solutions and inclusive economic growth.** Water cluster growth will be assessed by metrics including business revenue growth, BIPOC ownership growth, BIPOC employment growth, and others (see **Implementation** section).



# VI. Recommended Strategies for Inclusive Growth

To realize this vision, a set of high level, mutually re-enforcing strategies are presented below, designed to focus the Chicago region's resources on new opportunities within the water cluster. These strategies are also intended to ensure that inclusion is inherent in and drives all of the growth activity, focusing on four dimensions: employment, ownership, location (e.g., whether new growth is in or accessible to disadvantaged communities) and participation (in formal and informal organizations that drive growth).

The five inclusive growth strategies are:

1. **Industry-led collaboratives**
2. **Industry-led workforce development**
3. **Testing, Certification and Demonstration Center(s)**
4. **Business Growth Services Program**
5. **Manufacturing Initiative**

These strategies will be refined in the future into initiatives. As a guidepost in deciding on new water cluster strategies and interventions, the most successful cluster initiatives have five traits.[73]

1. **Focused on establishing a robust ecosystem, not quick job gains**
2. **Industry-driven, university-fueled, government-funded**
3. **Placing a collective big bet on a unique opportunity**
4. **Championed by passionate, dedicated leaders**
5. **Anchored by a physical center**

# Industry-led Collaboratives

## Overview

Industry-led collaborative strategies should be designed to promote growth of a strong Blue Economy, enable the continuous innovation and commercialization needed to bring research to market, and build the region as a competitive global center for water-related innovation and product development.

This requires deliberately creating the synergies that make these collaborations succeed by efficiently connecting firms to researchers, entrepreneurs, workforce organizations, investors, suppliers, supporting industries, and data analytics. It also requires fostering collaboration across innovation, finance, workforce, etc. (e.g., develop a collaborative solution to lead service line replacement issue, which demands new technology and construction within century-old systems).

The region has significant R&D strengths and is producing leading-edge water technologies that have the potential to be implemented in our region as well as exported to others to solve water challenges — but, to realize these opportunities will need of greater connectivity between this research and industry, workforce programs, supply chains and networks.

## Recommendation and Relevant Models

The region's water cluster would benefit from greater industry collaboration in developing and implementing deliberate strategies to promote inclusive growth. Strategies and subsequent implementation activities must be informed and led by cross-sector and particularly private-sector partnerships. Current's role may be to strengthen inter-firm networks and cross-sector networks, and supporting these networks in development of strategies and subsequent initiatives.

In addition to addressing the strategies identified here, industry-led leadership tables will continuously identify new strategies as the market evolves, for instance by:

- Performing continuous market research to identify latest opportunities in a fast-changing sector
- Facilitating regulatory-industry collaboration (e.g., looking at liability of source of pollution and implementing greater accountability for the chemicals corporations produce from manufacturing processes)
- Supporting supply chain development to manufacture water technologies
- More deliberately connecting newer companies with specialty manufacturing services
- Identifying nutrient recovery streams and associated supply chains needed to support them — or, bolstering existing nutrient recovery programs (e.g., MWRD's phosphorus recovery and conversion to a slow-release fertilizer)
- Generating ideas to drive innovation (e.g., release RFPs for solutions to specific water quality issues in Chicago communities; run "hackathon" events to solve private sector water quality challenges)

Current already undertakes programming such as Chicago Water Week, ESG leadership and events, and a Board Corporate Engagement Committee — but the list above proposes expanding this programming to include market-based strategies to grow the economy.

> "This requires efficiently connecting firms to researchers, entrepreneurs, workforce organizations, investors, suppliers, supporting industries, and data analytics."


For models of other industry-led organizations and their associated programming, see the Chicagoland Food and Beverage Network, a cluster organization that connects over 4,000 companies in the Chicago region to collaboratively drive innovation and growth a cluster organization that offers talent development, accelerator programs, and food safety training and space for food and beverage firms to co-locate. For an example of industry-led innovation, see AB InBev, a global industry-led incubator solving challenges including water stewardship, supply chain challenges, sustainable agriculture, and more. Or, for a water-related example, see Accelerate H2O in Texas which leads investor forums and industry roundtables, authors water technology reports, conducts cluster analyses, identifies opportunities for startups, and leads demonstration hubs.[74] Models to inform the development of additional initiatives to drive innovation in the region include The Water Council's Tech Challenge and WaterStart Nevada's solicitation of applications for water technology companies that can address challenges identified by member organizations.

## Industry-Led Workforce Development

### Overview

Economic transformation has dramatically impacted labor markets. Particularly in the Blue Economy, the rise in innovation within a dated water infrastructure system and regulatory environment is leading to new occupations and technologies, along with shifts in how work is organized (for example, towards more outsourcing and independent workers). This requires new skills as well as continuous skills upgrading.

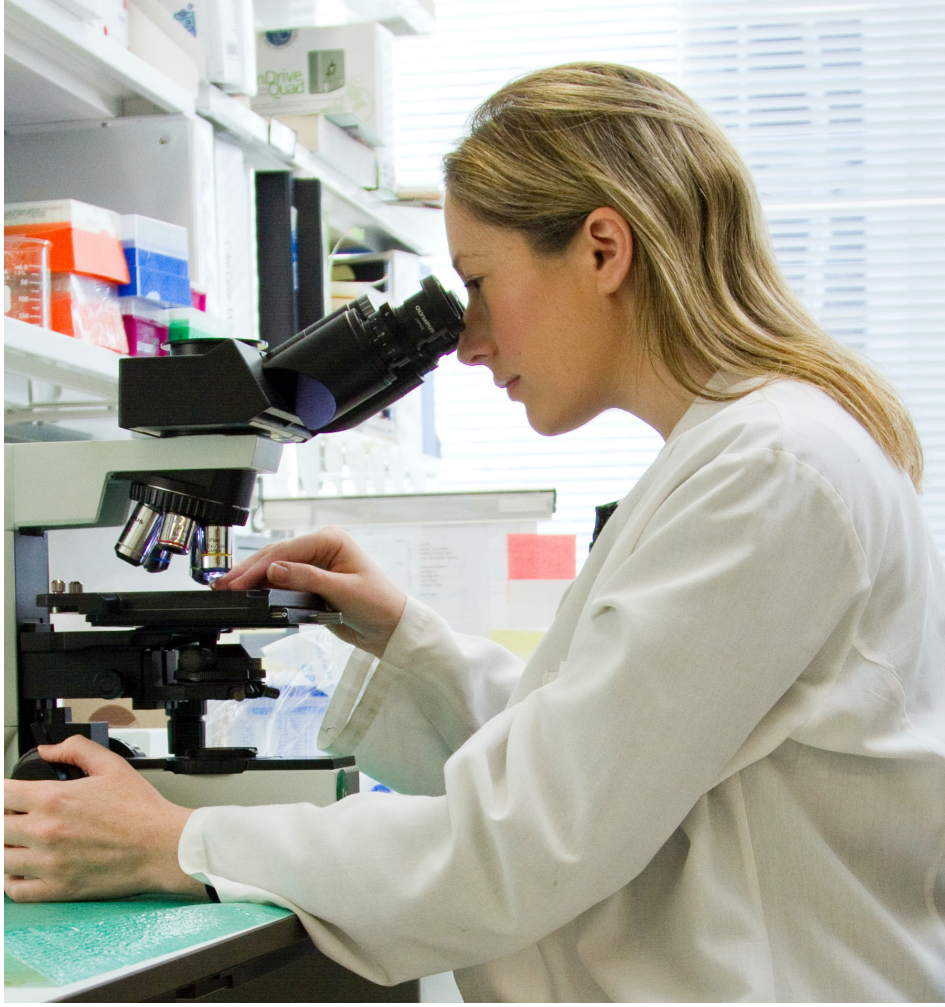
Water cluster products and services are varied and complex (e.g., ranging from reverse osmosis filters to PFAS sensors) — meaning, it is very difficult for water sector employers to identify associated skill sets and project those that will be needed in the future. This leads to under-developed systems for efficiently upskilling incumbent employees, as well as a reliance on outdated credentials to assess potential employees that may not accurately reflect their skill sets.

In addition, due to number of emerging technologies and services in the water cluster, associated career paths are also not as obvious to employees looking to enter the sector. Workers are not only hampered in their ability to identify job opportunities that match their skills (or that they could be qualified for with targeted training), but also to identify a career pathway in the first place.

There is opportunity to upskill workers for entry-level through executive-level jobs. Interviews and market research to date have projected growing demand for occupations including:

- operation and maintenance staff
- engineers
- technicians
- trades
- water technology manufacturing
- nanotechnology and genomics researchers

Trainers and educators remain slow to respond to opportunities to teach in-demand skills in truly market- and employer-driven ways, still overly focused on legacy processes and programs (such as infrastructure replacement). All these actors are insufficiently connected through systems and platforms that can collect, analyze and share skills data to inform the effective functioning of the labor market. These labor market deficiencies, of course have an outsized impact on traditionally disconnected populations.[75] Employer stewardship of workforce development will allow existing programs and pathways to better adapt to emerging needs as the Blue Economy grows.



## Recommendation and Relevant Models

Within the water cluster, there is a need to reform labor market systems to be more skills-based, responsive and targeted — designed with the specific opportunities and challenges for women and people of color in mind. Employer-led, on-the-job training will likely be needed to create a workforce adept at innovating to develop new products, troubleshooting their implementation within dated water infrastructure systems, and using data collected to inform new actions and processes.

This strategy will align workforce skills with demand-driven occupations in high-growth, high-tech emerging water industries. It will increase avenues for labor force participation and develop clear paths for upward mobility.

This strategy suggests convening **sector-based, industry-led employer consortia** that collect market intelligence on talent demand, help design and lead responsive training programs and collectively develop means to update hiring practices. It is critical that companies are at the head of the table defining the agenda and co-creating relevant programs. These programs may include:

- **Market research** to outline high-growth near-term career pathways (e.g., civil engineers within water sector to complete large infrastructure projects)[76] and long-term high-growth career pathways (e.g., intersections between water and public health; molecular engineering and nanotechnology scientists) in the water sector — and associated skills demand forecasting. This will help identify workforce with skillsets that can pivot to water-related careers.

- **Contextualized Training**, in partnership with community colleges, for these opportunities with curricula tailored to specific industries and their demand for specialized skills. This will lower degree-based barriers to entry in water-related careers. This may include continuous credentialing and on-the-job training for:
  - Technicians — to troubleshoot issues on water systems that are increasing in complexity
  - Machinists — to produce products
  - Cybersecurity — coding skills to improve security alongside integration of data collection capabilities into water systems

- **Blue Economy Academy** offering training, certificates and degrees for all career levels. It could include skills-based training programs, stackable credentials, and innovative apprenticeship models.

The sector-based consortia model has preliminary efforts to build upon, such as the U.S. Chamber of Commerce Foundation's Talent Pipeline Management (TPM) Initiative which encourages assembling industry-led, sector-specific bodies to lead the charge on labor markets change. Applications of this model include TalNet, which brings cohorts of Michigan-area employers together to employ an evidence-based selection model around hiring based on skillset assessments. Additional examples include the Talent-to-Industry Exchange (TIE), managed by the Mid-America Regional Council (MARC) in Kansas City, which has helped assemble collaboratives in Skilled Trades, and the Manufacturing Roundtable in Milwaukee, a consortium of major regional manufacturers currently in the design phase of demand-driven workforce development programming.

*In the near-term*, workforce development programs for middle-skill jobs can help to meet existing needs caused by influxes of federal dollars for infrastructure, retirement cliffs in trades, and underrepresentation of women and people of color in water-related fields. In particular, current opportunities include lead service line replacement, manufacturing, wastewater and drinking water operations, manufacturing, water epidemiology and climate resilient infrastructure.

To support development of career pathways and closing opportunity gaps in water-related occupations by 2030:

- Invest in pre-apprenticeship programs and barrier reduction funds that support opening opportunity to careers in the Trades for people from underrepresented groups. These pre-apprenticeship programs will help local trades unions, including plumbers and pipefitters, which are crucial to lead service pipe replacement, drinking water utility and

wastewater utility operations, diversify their apprenticeship classes and close gaps in opportunity. Connect these pre-apprenticeship programs to other industry employers in the water sector to help participants become registered apprentices in these valuable trades.

- Investigate partnerships with organizations like SkillsUSA Illinois to create US Department of Labor registered apprenticeships for water workers with local water departments or assist in scaling apprenticeship programs (see Evanston, IL as an example) with other municipalities.

- Connect community-based workforce development organizations to the expanding opportunities presented by lead service line replacement and other water-related infrastructure work, including field technician positions that require community-based workers. Work with utilities to expand relationships with community-based workforce development organizations to help them identify civil-service job opportunities for their clients.

- Illinois already has the right concentration of growing manufacturing industries to support growth of the water cluster, for example in automatic environmental control manufacturing, industrial valve manufacturing and pipe fitting manufacturing. Connect water-related employers to community colleges and trades programs [for example, Daley College and Jane Addams Resource Corporation (JARC)] manufacturing programs to help them meet the needs of employers and find quality jobs for graduates to support growth of people in manufacturing career pathways.

- Create additional career pathways connected to water quality sampling, including those in engineering and the biological sciences and create additional career pathways in climate resilient infrastructure, including those in engineering or design. Partner with community colleges to develop certificate programs, where possible, and connect them clearly to degree programs.

- Investigate whether a social enterprise or transitional jobs program could be developed to encourage new entrants to the landscaping and maintenance of green infrastructure work.[77]

> **“Workforce development programs for middle-skill jobs can help to meet existing needs caused by influxes of federal dollars for infrastructure, retirement cliffs in trades, and underrepresentation of women and people of color in water-related fields.”**

Consistent employer engagement in these strategies will allow programs to adapt to meet the changing skills needed by a growing Blue Economy and build on existing workforce development infrastructure.

Current has begun to undertake several workforce programs that work to bring employers to the table and increase awareness of Blue Economy career opportunities. These include Blue EDU STEM programs and other training programs recommended for federal funding. This programming can be expanded with further employer input.

## Testing, Certification & Demonstration Center(s)

### Overview

Stringent regulations within the water cluster mean that new products must first be validated with test data (to de-risk their integration with a customer's processes; or, to certify to a certain standard). One of the barriers to scaling innovation in the water cluster is the lack of testing and validation resources for companies to bring new products to market. Substantial risks arise when a large company, for instance a food manufacturer, integrates a new water quality product into its processes. It poses a risk to its own products and their quality and presents a significant monetary investment. To combat this, cross-sector initiatives are needed that lower the risk and remove some of these barriers, specifically to:

- Accelerate market integration of new products with one another and with older systems
- Increase pathways to certification to different water standards
- Increase opportunities for entrepreneurs to develop/pilot products

## Recommendation and Relevant Models

Across the region, innovative water cluster companies need greater access to and availability of testing and validation resources. This may include access to flowing wastewater or surface-water streams to test a water technology, or access to an industrial facility (e.g., to test a new software's integration with a manufacturing process). This will facilitate the adoption and scale-up of innovative water products.

Testing and validation resources could be provided through:

- Facilitating cooperative agreements among companies that have developed a new product, and an industry or utility partner with the right processes or water streams on which to test the product. These agreements would state the partner's intent to assist in regional innovation efforts by allowing innovative solutions (that could one day be implemented in their water stream or processes, and are highly applicable to their industry) from small- and mid-sized enterprises to be tested or demonstrated at their facility.

- Providing a physical demonstration facility (or multiple facilities), given that each water technology is tailored to different industries/customers (e.g., purification products for pharmaceutical companies), or water streams (e.g., agricultural runoff), or areas of integration (e.g., within stormwater pipes; surface runoff). Demonstration facilities could provide access to flowing water streams or could replicate specific industry processes, to accommodate the wide variety of testing and demonstration needs for water technology innovations.

As the network grows, it could also begin to document case studies, or gather those from other municipalities, to guide solutions to specific municipal or industrial water treatment and monitoring challenges.

Partners may include:

- **Current** — the Current Research Consortium already includes a framework for supporting pilots across two major utilities and research universities. Current's H2NOW water-quality monitoring platform provides a test bed for sensors and other monitoring technologies in the Chicago River, and may be expanded to utilize new monitoring technologies and publicize test data.

- **Water Quality Association** — At the association's Mirage Lab, companies book time on equipment to test their product on specialty water types (for a specific client, or to test against a new standard to achieve certification).

- **The Water Council** — their Pilot Program identifies specific sites for funded pilots (validation stage, not prototypes). Typical focuses are wastewater treatment, stormwater/green infrastructure or water quality.

Others are successfully implementing variations on this strategy: the Water Campus in the Netherlands (which emphasizes the importance of demonstration sites in scaling technologies), The Water Tower in Georgia (which offers a Demonstration Facility that provides access to 3 live wastewater streams from the treatment plant), and research from a 2019 study in Massachusetts[78] (which noted three key attributes of water technology demonstration centers: access to flowing wastewater and flowing surface-water streams; proximity to a research university; access to stakeholders and end users). If a future demonstration center is considered (rather than cooperative agreements with several sites), energy/building related demonstration site best practices may inform development (e.g., ORNL Building Technologies Research and Integration Center[79]).

## Business Growth Services Program

### Overview

As mentioned in the Economic Framing section, economic growth occurs primarily through the growth of existing businesses, and next through entrepreneurship, followed by attraction of firms from elsewhere (which is enabled by support for existing businesses and entrepreneurship). Support for entrepreneurship and business growth generally is most successful when it's highly tailored to the circumstances of each firm. Tailoring support requires organizing and varying delivery of technical/financial assistance differently by stage of firm and by sector. Generally, earlier stage firms need more generic support (e.g. business planning, operating systems) and larger firms need more sector-specific expertise (e.g. technologies, specialized product and market development).

Supporting firms requires deep engagement, often best accomplished and delivered by coaches or mentors that have extensive practical experience in the same industry as the supported firm, and whom the businesses view as peers or more accomplished, and whom are able to assemble the right suite of additional resources to complement their mentorship (e.g., lawyers, finance experts, architects). Business support further has to combine technical support and finance, with finance normally following from technical support (e.g. developing growth plans for a business leads to identification of working capital needs). It requires building trust — by mentors listening to the firms' needs and responding to those, acting in the best interest of firms. In addition, it benefits from a longer-term relationship between firms and mentors that extends beyond the period of immediate technical/financial assistance. This model of business assistance is in contrast to historic small business walk-in centers, which provided similar resources to all businesses regardless of their specific needs (and did not have access to a specialized, tailored network of resources according to industry and stage of growth).

The water cluster is so varied in its products and services (see Figure 3) that each business needs highly tailored assistance to scale its products. For instance, just looking at sensors — each sensor tests for a different contaminant (e.g., PFAS, pharmaceuticals, pesticides) and may be applicable to varied customers (depending on the level of water purity that an industry demands). Companies developing these products will require specific assistance in identifying testing sites to validate their product, identifying customers,

commercializing their product, and continuing to scale their business operations.

Startups and small firms in the water cluster cited a need for greater assistance in bringing their product to market and scaling operations. Individual business support can assist startups as well as small- and mid-sized enterprises (SMEs) in accelerating commercialization of R&D, in efficiently matching products with customers, and in scaling operations.

## Recommendation and Relevant Models

This strategy recommends a Business Growth Services Program to provide sophisticated business and finance support services to firms to enable them to scale-up their operations and grow into established companies. This will ensure products have not only anticipated the market (in a rapidly changing environment) but that entrepreneurs developing products go on to build successful companies.

Building this program will first require setting up the program infrastructure (e.g., staff including a Program Manager and "concierges" to field business support requests; a robust CRM system; a clear operational process). This program could build a network of mentors with expertise in water-related industries and company scale-up, a network of specialized services (e.g., lawyers, accountants, marketing professionals) and partner programs (e.g., cohort-based courses), and a network of startups and SMEs with growth potential. Concierges will screen businesses and match them with the right mentor. Mentors will begin with deep assessment of the particular firm's challenges and opportunities, and deliver services directly or with specialized services or partners that may include (but are not limited to):

- **Business Planning** — work with firms to develop a robust business and operations plan;
- **Management Advising** — services to address the major management challenges presented by growth, from establishing human resources functions to finding new talent to separating and organizing diverse business functions;

- **Professional Services** — enhanced capabilities in financial management; legal and regulatory support; intellectual property; marketing and public relations; IT and web-based services; among others;
- **Market Analysis and Acquisition** — custom market research services, understanding relevant supply chains, understanding and targeting potential customers, etc;
- **Product Development** — support for R&D, testing, certifications, etc;
- **Production** — support for the substantial re-working of production at much larger scale entailed by transition to scale-up: developing or expanding manufacturing capabilities and adapting new processes and technologies;
- **Finance** — assist firms in identifying/securing the specific form of working capital needed to scale, e.g., early-stage VC for commercialization, scale up fund (working capital), equipment financing for product adoption, or even Exchange-Traded Funds (ETFs), which invest in companies involved in the treatment and purification of water.

In addition, mentors could connect firms with specialized services and partner programs, such as:

- Specialized Services — experts that can enhance firm capabilities in areas like financial management, legal and regulatory support, intellectual property, marketing and public relations, and IT and web-based services.
- Partner Programs — industry partners, networks of similar firms, accelerators, and training programs. Building longer-term relationships with partner programs, such as accelerators, also provides an opportunity to host sub-cluster-specific cohorts or union training shops to test good ideas (and implement in communities/regions of need), or to build a more robust mentorship network (with mentors who may be interested in working with mentees long-term).

The region has existing initiatives that a business growth services program could be modeled from, such as the Cook County Small Business Source[80] or the Southland Business Growth Services Program.[81] There are also several regional accelerators to which the program could facilitate connections (see: **https://heartland-climate.org/resources-accelerators**), in addition to others in development (e.g., Current's Upstream Innovation Accelerator).

# Manufacturing Initiative

## Overview

The Chicago region has the key competitive "ingredients" — from raw materials to workforce to manufacturing variety (metals, chemical, electrical) — to do larger scale manufacturing to support growth of the water cluster. Production of metal pipes and fittings is already a regional strength, but there is potential to increase production of water treatment and monitoring products as well. The COVID-19 pandemic has disrupted manufacturing and supply chains — creating additional impetus for building new, integrated local and regional supply chains.

In particular, smaller companies making innovative water technologies — ranging from sensors to chemical treatment innovations — have cited difficulties in establishing manufacturing relationships (given that, often, niche specializations are needed to make the product, high levels of quality control are needed, and batch sizes vary).

Establishing a hub for manufacturers capable of manufacturing water technologies could assist in strengthening regional supply chains in the water cluster — and, matching manufacturers with water technology innovations in need of production. The range of regional fabrication firms and their collective capabilities offer a nucleus to realize these opportunities.

## Recommendation and Relevant Models

A Manufacturing Initiative will address two near-term market opportunities:

- **Collaborative supply chain development** — Opportunity exists to develop and capture new supply chains and business attraction targets. Identifying such shared revenue opportunities and assembling competitive supply chains from Chicagoland firms will deliver new contracts and markets.

- **Technology-enabled competitiveness** — Assembling proactive, strategic supply chains can both capture growing markets beyond what individual firms can deliver and also create the business driver and monetary catalyst to invest in enhanced production approaches. ROI-driven, holistic technology integration support and training will enable the right suite of solutions to win immediate business and drive productivity and profitability — at the production worker, firm, and region levels — into the future.

The initiative can provide services including but not limited to:

- Create a center of gravity for manufacturers
- Identify manufacturers with capability to provide the specialized, niche manufacturing needed for products like sensors
- Assemble manufacturers to collaboratively bid on RFPs for water technologies
- Assist companies in identifying the right customized manufacturing solutions for their products, inclusive of 3D printing opportunities
- Increase government connections to local pipe manufactures

Models that can guide the creation of this initiative include the Southland Metals Hub[82] and models for wraparound services to build the strength of a manufacturing initiative include the MxD Cyber Resource Hub.[83]

## Next Steps

In each of the strategies proposed, next steps involve assembling a group of stakeholders to define and lead specific programs. In some cases, Current may act as the lead, in other cases the facilitator, and in other cases may provide staffing support to move the strategy forward and pass it to another organization or collaborative. For instance, Current's role may be to strengthen inter-firm networks and cross-sector networks, and support these networks in development of strategies and subsequent initiatives — or, assemble a network of partners (e.g., to launch a Business Growth Services Program or to create a network of testing and demonstration partners).

Current already undertakes programming such as Chicago Water Week, ESG leadership and events, a Board Corporate Engagement Committee, and Blue EDU STEM program. Current can expand this programming to include market-based strategies to grow the economy (such as those suggested above), or leverage existing work (e.g., employer tables to increase awareness of blue economy career opportunities) to define additional programs.

# VII. Strategy Implications and Implementation Goals

The set of mutually-reinforcing strategies are designed to work together to grow the water cluster. Long term success may be measured by increase in gross regional product (GRP) specifically within the water cluster — which includes increases in business revenue, income and assets; increases in number of companies (start-ups and in-movers); increased market share of the water cluster; ownership increases by people of color; and increase in median incomes.

Working towards this goal, to measure impact by 2030, metrics are proposed to track collective progress of the strategies:

### Programs and Communications

- New programs launched
- Funding received
- Media coverage of program activities

### Leadership/Partnerships

- Number of overall partners participating in strategies
- Levels of partner commitments of time, money, other resources
- Diversity of partnerships

### Program inputs

- Businesses receiving technical assistance
- Businesses receiving financial assistance
- Financial products launched
- Businesses utilizing testing, certification or demonstration center services
- Products connected with manufacturers (or vice versa)

### Program outputs

- Business revenue growth
- Business productivity increases
- BIPOC ownership growth
- Employment growth (including BIPOC %)
- Improvements in BIPOC wages and occupations (career path progression)

# VIII. Conclusion

**By 2030,** the Chicago region will be home to a thriving and inclusive Blue Economy where water companies, corporate water users, utilities and research institutions collaborate on developing and manufacturing nation-leading treatment and monitoring technology, catalyzing environmental solutions and inclusive economic growth.

**This strategy is a roadmap** meant to inspire action across all parts of the Blue Economy, including civic and nonprofit organizations, companies that identify as part of the water cluster itself (who develop and provide water technologies, products and services), those who provide input and support to the water cluster, and the end users that drive demand for better water products and strategies. By implementing targeted inclusive economic programs now, we can grow a globally significant Blue Economy here in Illinois and the Great Lakes Region by 2030.

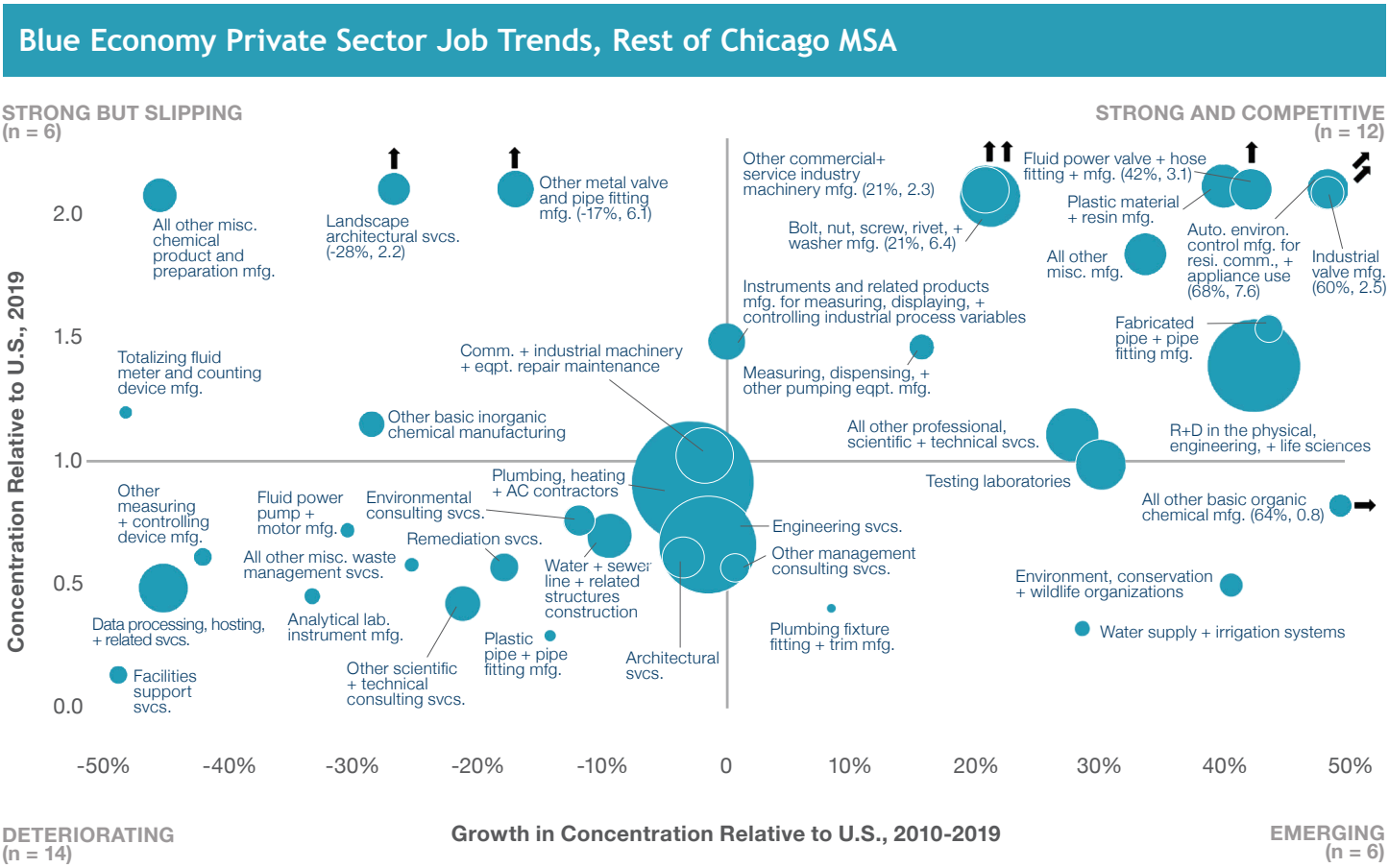
**With the right leaders at the table,** Illinois can create transformational economic growth while also prioritizing climate resilience and environmental stewardship. The region stands to benefit from business growth and attraction, more diverse business ownership, investment, exports, patents and innovation, all while solving the water challenges that affect people here in the Great Lakes Region and around the world. Cross-sector alignment and collaboration is essential — this vision can't be achieved by any sector alone.

**Now is the time to build an inclusive Blue Economy in Illinois. Let's do it together.**

# IX. Appendix A SUPPORTING DATA

**FIGURE 10**

## Chicago MSA (Excluding Cook County): 2019 LQ vs 2010-2019 Growth in LQ



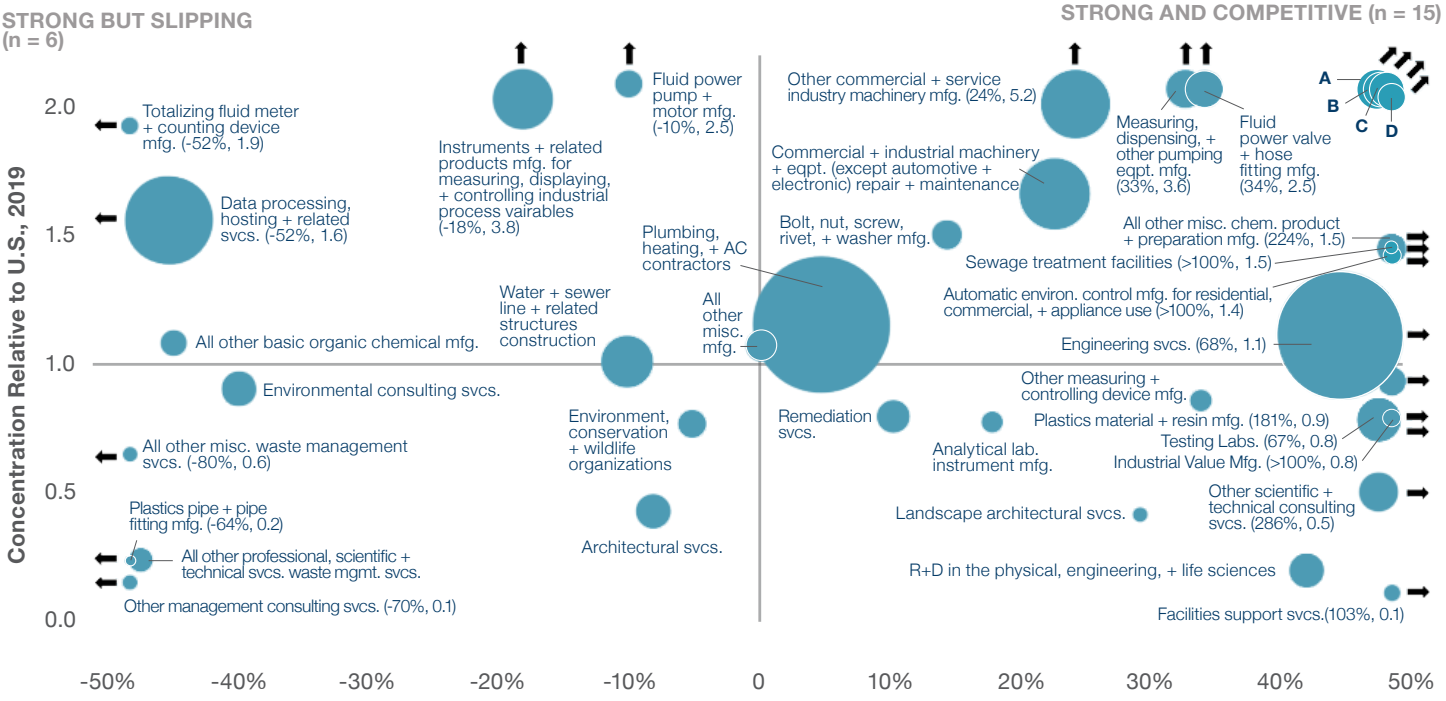

*Notes: The size of bubbles represent employment concentration; Black arrows indicate those that are "off the chart;" Rest of Chicago MSA reflects the IL and WI portions of the Chicago MSA, exclusing Cook County; All other pipeline transportation, sewage treatment facilities, and carbon and graphite product mfg. are not shown because the industries had 10 or fewer jobs in 2019; Reflects private sector jobs only; Cook, Rest of MSA, and Rest of IL bubbles are at the same scale on size basis*

*Source: dF-QCEW*

FIGURE 11

# Milwaukee MSA (Excluding Milwaukee County): 2019 LQ vs 2010-2019 Growth in LQ

## Blue Economy Private Sector Job Trends, Rest of Milwaukee MSA




*Notes: The size of bubbles represent employment concentration; Black arrows indicate those that are "off the chart;" All other pipeline transportation, other basic inorganic chemical manufacturing, and water supply and irrigation systems are not shown because the industries had 10 or fewer jobs in 2019; Reflects private sector jobs only; MKE County and Rest of MSA bubbles are at the same scale on size basis.*

*Source: dF-QCEW*

**A** Other metal valve + pipe fitting mfg. (52%, 6.7)

**B** Fabricated pipe + pipe fitting mfg. (73%, 2.6)

**C** Plumbing fixture fitting + trim mfg. (123%, 7.0)

**D** Carbon + graphite product mfg. (49%, 6.1)

TABLE 16

## Patent Applications Across All Industries

| | State | Patent Applications per 10,000 Residents |
|---|---|---|
| 1 | Massachusetts | 23.65 |
| 2 | California | 22.13 |
| 3 | Washington | 22.13 |
| 4 | Oregon | 15.42 |
| 5 | Minnesota | 15.12 |
| 6 | Connecticut | 14.95 |
| 7 | New Hampshire | 13.59 |
| 8 | Utah | 12.31 |
| 9 | Michigan | 12 |
| 10 | New Jersey | 11.23 |
| 11 | Colorado | 10.82 |
| 12 | Vermont | 9.54 |
| 13 | New York | 9.5 |
| 14 | Illinois | 8.41 |
| 15 | Wisconsin | 8.34 |
| 16 | Idaho | 8.33 |
| 17 | Ohio | 8.26 |
| 18 | Rhode Island | 8 |

# X. Appendix B NATIONAL SCAN OF WATER CLUSTERS

## Current: Chicago's Water Innovation Hub Organization

Current is Chicago's water innovation hub. Their mission is to grow Chicago and Illinois' Blue Economy — the companies developing innovative water technologies and industries that use them — to build solutions that will solve the world's water challenges. Launched in 2016, Current is a local collaborative that leverages partnerships with the state's world-class utilities, research institutions, industries, and innovation community to achieve global environmental and economic impacts. As a cross-sector connector of local and global water sector stakeholders, Current builds networks, organizes events and convenings, and helps develop pilot projects to demonstrate new technologies in real-world settings.

Current helps solve our region's persistent water issues by identifying promising technological solutions from around the world and connecting them with end users, including industry and utilities. In light of the COVID-19 global pandemic, they believe that Current's work is even more essential. They stay abreast of emerging research and technologies to help partners adapt and innovate. They are also heavily invested in working to keep water in focus for our state and local policy communities and making the Blue Economy a pillar of our economic recovery. In Chicago and Illinois, they believe that the Blue Economy presents significant opportunities for collaboration, innovation, and growth, leading to a more resilient economy. There is a clear need to capitalize on our region's potential to grow companies and jobs in a set of industries that offer the possibility of improving management and stewardship of one of Chicago's most precious natural resources.

## Regional Water Clusters and Initiatives

Other regional initiatives around water sectors, listed below, are spearheading various initiatives around the world. Each of these regions has taken a different approach to defining the water cluster (e.g, ranking by priority; US Cluster Mapping Project data, etc.). Several notable clusters and efforts include:

### Wisconsin Water Cluster

- **Water Sector definition: The Water Council's water cluster is technology-based**, focused on firms in water technologies involving instruments, equipment, and services. Their definition of the water cluster excludes water users, water and wastewater utilities and service providers. They also focus on water stewardship, connecting corporations of any size and industry with the resources they need to mitigate their water risk.
- **Methodology to define water sector:** market analysis
- **Mission/Vision:** dedicated to solving critical global water challenges by driving freshwater innovation and advancing water stewardship.

- **Key Strategies/Initiatives:**[84]
  - **Brew 2.0 Post-Accelerator** — a next-stage post-accelerator created to help late-stage startups build connections and grow their company's capacity. This virtual and in-person hybrid program focuses on expert-led sales and growth training along with a pitch event, all tailored for water tech businesses.
  - **Tech Challenge** — empowers anyone with a freshwater technology innovation to vet their concept with industry professionals from leading corporations. Twice per year, our corporate sponsors — some of the largest water technology companies in the industry — select challenge topics, review applications and select finalists. Finalists present their solutions to the sponsors to compete for a cash prize, as well as an opportunity to work with a sponsoring corporation to turn their innovation into a viable commercial product.
  - **Pilot Program** — helps water technology innovators from around the world bridge the gap from prototype to real-life application by facilitating in-field piloting. The program provides technical support services, funding and potential sites to help validate cutting-edge products and move them forward.

## Israel Water Cluster

- **Water Sector definition**: Water treatment, Water Purification, Wastewater treatment, Water Security, Water Management, Desalination, Filtering, Irrigation, Water recycling, and more.[85] Israeli Watertech is spearheading the shift towards sustainable water management through a broad range of technologies.[86] US$2 billion industry for Israel, consisting of at least 300 companies and over 100 startups. Growth has been rapid; the sector has seen an increase in exports of almost 200% in just three years.[87]
- **Methodology to define water sector:** N/A
- **Mission/Vision:** Turn severe water scarcity into an economic opportunity with the right investments in technology, financing, policy, and institutions.[88]
- **Key Strategies/Initiatives:** Universities in Israel have already developed water research partnerships with universities in Illinois including Northwestern University and University of Chicago. It's also sustained by the country's progressive approach to water pricing, which aims to promote water conservation while also ensuring that investments in water supply and delivery are sustainable, with operation and maintenance expenses financed by tariffs paid by water users.

## Singapore Water Cluster

- **Water Sector definition:** three main sectors: water efficiency improvement, water treatment technologies, water infrastructure. Singapore is a leading global hydrohub and home to a vibrant and thriving ecosystem of 180 water companies with more than 20 water research centers spanning the entire water value chain.[89]
- **Methodology to define water sector:** N/A
- **Mission/Vision:** Managing water demand is as important as securing an adequate supply of water. Achieving a sustainable level of water consumption and managing the impact of water on the environment.
- **Key Strategies/Initiatives:** Mandatory Water Efficiency Labelling Scheme, Water Closet Replacement Programme, Water Efficiency Awards

## Netherlands Water Cluster

- **Water Sector definition:** three main sectors: climate resilience, finance for water, water and agrifood, water and crisis, and water technology.[90]
- **Methodology to define water sector:** N/A
- **Mission/Vision:** We believe we can work towards a future where over 9 billion people live well and in balance with the earth's resources. How? By choosing a sustainable future. A future that is water driven, for society as well as for businesses. We co-create transformative, integrated and inclusive solutions for water-related challenges, creating positive opportunities for the planet and future generations. And by cleverly collaborating, we can turn threats into opportunities and translate research and market insights into breakthroughs and innovations.
- **Key Strategies/Initiatives:** Partners for Water Programme, Water Support Programme, Water for Food Programme, Young Expert Programmes

Nationally, various regions have launched initiatives to formally define their regional water clusters, in part to help grow water-related economic opportunities. Examples include:

## Michigan's University Research Corridor[91] [92]

- **Water Sector/Initiative Scope:** two main sectors: Core Water Products Services (CWPS), Water-Enabled Industries (WEI), and Water Infrastructure. Highlights the role that the universities play in advancing water-related research and innovation. Michigan's water-related jobs are in water-enabled industries such as agriculture, mining and manufacturing, about 138,000 are in core water products and services producing water treatment facilities and solving water quality and quantity issues.[93]
- **Methodology to define water sector:** N/A
- **Mission/Vision:** Our three universities make significant commitments to support water-related research and programs. These not only support Michigan's economy and quality of life, but position the state as a knowledge wellspring for the world's most precious natural resource.
- **Key Strategies/Initiatives:** The Infrastructure Network for Water (INH2O)

## Nevada's Office of Economic Development (GOED)[94]/WaterStart

- **Water Sector/Initiative Scope:** Water technology, focused on:
  - Water efficiency
  - Water innovation
- **Methodology to define water sector:** ranked priority industries within water innovation, highlighting water efficiency and innovation as the greatest potential to inform workforce strategies to grow the water technology sector.
- **Mission/Vision:** As fresh water becomes increasingly scarce, water resource management and sustainability will be vital to maintaining quality of life and economic development in communities around the world.
- **Key Strategies/Initiatives:** WaterStart

## Texas' Accelerate H2O[95]

- **Water Sector/Initiative Scope:** Water technology, focused on: Solving challenges for residential, commercial,

agriculture and public utility end-users. Sub-clusters: Construction, Manufacturing, Operations, Wholesale distribution of water products/services

- **Methodology to define water sector:** used quantitative methods from the US Cluster Mapping Project to define the water cluster and highlight sub-clusters.

- **Mission/Vision:** Connect. Inform. Engage. We seek to be a national driver for innovating, demonstrating, and partnering in resiliency — drought, storm-flood, fire, earthquake, tsunami, cyber and critical infrastructure threats to public and private water supplies.

- **Key Strategies/Initiatives:** Investor Forums, Industry Roundtables, Water Tech Reports, Cluster Analysis, Opportunity Triages for Startups, Demonstration Hubs, Project Development Initiatives; now evolved into existing as Resilience Innovation Hub

## California's BlueTechValley Initiative[96]

- **Water Sector/Initiative Scope:** Water and Energy-oriented firms, centered around industries:
  - Industrial, Ag & Water
  - Renewable & Power Generation
  - Energy Technology Systems

- **Methodology to define water sector:** N/A

- **Mission/Vision**: The region's "water-scarce climate fuels the need for extreme water efficiency, making it the ideal place to test, develop, and commercialize new technology."

- **Key Strategies/Initiatives:** BlueTechValley Plans, Valley Ventures (biz accelerator program), Technology Innovation Evaluation, UC Davis Big Bang! Business Competition

## Cleveland Water Alliance[97]

- **Water Sector/Initiative Scope:** From 2013 to 2016, nearly 1000 new water-related jobs were created in Cuyahoga County with salaries ranging from $60k to $105k annually. This was significantly more net new jobs than Aerospace, Advanced Manufacturing, Energy, Advanced Materials and Biohealth in terms of job creation, surpassing national averages for the Blue Economy sector.* Regionally, the Blue Economy supports tens of thousands of local jobs and billions of dollars of economic impact.

- **Methodology to define water sector:** N/A

- **Mission/Vision:** seeks to better utilize the economic and job-creating potential of Lake Erie while also urging greater care of our valuable, natural asset. Build upon Ohio and the Great Lakes' assets and resources to create a clean water innovation ecosystem that harnesses technology, spurs the economy, enhances education and drives research.

- **Key Strategies/Initiatives:** Connect, Innovate, Elevate, Smart Lake Erie, Erie Hack, Smart Citizen Science Initiative

## TMA Blue Tech in San Diego[98]

- **Water Sector/Initiative Scope:** N/A

- **Methodology to define water sector:** N/A

- **Mission/Vision:** Promoting Sustainable Science-Based Ocean and Water Industries. Create the technology to understand problems and develop solutions to address them.

- **Key Strategies/Initiatives:** BlueTech Clusters, BlueTech Ecosystem, Education and Workforce Development, Events, Exports, Reports and Studies, Blue Jobs/ BlueTech Careers

## Water Tower, Georgia[99]

- **Water Sector/Initiative Scope:** N/A
- **Methodology to define water sector:** N/A
- **Mission/Vision:** creating a thriving ecosystem of water innovation fueled by imagination, informed by research, and powered by pioneers. This is being accomplished by bringing together the public and private sectors of the water industry, side by side with academia and nonprofits, to tackle the industry's greatest challenges.
- **Key Strategies/Initiatives:** Applied Research, Technology Innovation, Workforce Development, Community Engagement

## Clean Energy Center (CEC) in Massachusetts[100]

- **Water Sector/Initiative Scope:** Water and energy work together in almost every form of energy production to provide our cities and towns with the resources we need. Energy generation is one of the largest consumers of water. The water-energy nexus is the relationship between how much water is used to generate and transmit energy, and how much energy is needed to pump, collect, convey, treat and store water. This relationship is of growing importance to communities, municipalities and governments across the world.
- **Mission/Vision:** strives to lead and innovate in equitable clean energy and climate solutions. State economic development agency dedicated to accelerating the growth of the clean energy sector across the Commonwealth to spur job creation, deliver statewide environmental benefits and to secure long-term economic growth for the people of Massachusetts
- **Key Strategies/Initiatives:** Wastewater Treatment Pilot Program, Water Technology Demonstration Centers, Additional Water Innovation Funding Opportunities

## Washington Maritime Blue Initiative

- **Water Sector/Initiative Scope:** Comprehensive strategy with an active innovation accelerator program
- **Mission/Vision:** Committed to the development of maritime business, technology, and practices that promote a sustainable future contributing to economic growth, ecological health, and thriving communities.
- **Key Strategies/Initiatives:** innovation accelerator program, Youth Maritime Collaborative, Quiet Sound, Zero Emission Fast Foil Ferry, Tacoma Green Hydrogen, Covid 19 Early Detection for Fisheries/ Maritime, 5G Feasibility study Tacoma, West Coast Offshore Wind

## SeaAhead in Boston[101]

- **Water Sector/Initiative Scope:** Multi-prong entrepreneurial development initiative connected to broader innovation ecosystem. Bluetech startup platform helping build companies, run an incubator, facilitate investments and catalyzing a bluetech cluster in the Northeast.

- **Mission/Vision:** Bringing a combination of maritime, cleantech and tech sector backgrounds, where their work includes corporate business development, venture capital, start-up and operational experience. They have a global network that includes the venture ecosystem, corporations, academia and government.

- **Key Strategies/Initiatives:** Startup Platform, Blueswell Incubator, Blue Angels, Sea Ahead Ventures

## Great Lakes Commission[102] [103]

- **Water Sector/Initiative Scope:** The Great Lakes are an environmental and economic asset for the United States and Canada. The lakes fuel a $6 trillion regional economy and hold 90% of the U.S. supply of fresh surface water, providing drinking water for more than 40 million people. More than 1.5 million U.S. jobs are directly connected to the Great Lakes and those jobs generate $62 billion in wages annually.

- **Mission/Vision:** The GLC recommends policies and practices to balance the use, development, and conservation of the water resources of the Great Lakes and brings the region together to work on issues that no single community, state, province, or nation can tackle alone.

- **Key Strategies/Initiatives:** Aquatic Invasive Species Prevention and Control, Blue Accounting, Coastal Conservation & Habitat Restoration, Commercial Navigation, *Economic Development*[104] *& Waterfront Community Revitalization*, *Water Quality*, *Water Management & Infrastructure*, *Information Management*, Advocacy

## CenterState NY: AM-TEC Initiative[105]

- **Water Sector/Initiative Scope:** Manufacturers and suppliers of thermal and environmental control (TEC) equipment

- **Methodology to define water sector:** market analysis

- **Mission/Vision:** attracting and leveraging additional foreign direct investment (FDI) stands to create more opportunities to positively impact the CenterState New York economy

- **Key Strategies/Initiatives:** The development of this metro investment plan, the CenterState New York Global Investment Initiative, includes research to help educate, inform, and guide economic development and public policy makers on how to leverage global trends and attract investment from around the world for the region's economic benefit.

## Oregon Business Council Water Task Force[106]

- **Water Sector/Initiative Scope:** Despite some constraints, Oregon has a comparative strategic advantage in water resources over other western states. Over-allocation and seasonal variability are putting greater pressure on both groundwater and surface water availability for all purposes, including instream environmental health. Increasing water service costs and decreasing federal funds are pushing up water rates, making water less affordable for low-income customers. Affordability challenges are exacerbated by the economic impacts of the COVID-19 pandemic and wildfires. The current water data management system

is inadequate for water policy making, planning, management, problem solving, and investment. Agency budgets are inadequate to address this constraint. The prior appropriation doctrine in water law assures certainty for water users that is valuable to system stability and investment decision making. Water use permitting has been ineffective and inefficient, fueling adversarial conditions, inaction, and delay. Oregon has a history of adapting water laws, policies, and practices that respond to changing conditions and priorities, but the most significant reforms took place 25 years ago.

- **Mission/Vision:** The goal of the project and this report is to frame water management in a way that enables policy makers to discuss difficult but critical water issues, to apply widely accepted science, and to adopt a shared approach to modernizing Oregon's water management systems

- **Key Strategies/Initiatives:** Water Project, Task Force

# XI. Appendix C EXISTING INITATIVES

Existing initiatives across the state are summarized below (note: this list is not comprehensive but provides examples).

- **Wastewater Energy Recovery** — Wastewater thermal energy is a huge, largely untapped, renewable resource that can replace traditional fuels and reduce carbon emissions. For this project, the team from Current is summarizing examples of sewage thermal energy use (STEU) and other emerging water-energy-waste technologies in decentralized and distributed applications, as well as identifying barriers and gaps to guide future research agendas in this important area of sustainability and resilience. See: **https://www.currentwater.org/accelerate-innovation**.

- Many of the industries with a strong presence in the Chicago MSA — such as glass production and finishing, hospitals, biomedical/biotechnology, semiconductors, chemicals food/beverage and metals — **require high quality water processing for their operations**, creating market demand for sophisticated water treatment technology. For example, semiconductor manufacturing requires large volumes of ultra-pure water (two to four million gallons a day) to avoid the contamination of electronic devices and generates wastewater that contains heavy metals and toxic solvents. Innovative semiconductor companies are building on-site water purification and waste treatment facilities, and as Chicago's semiconductor industry continues to grow, so too will demand for water treatment technology.

- **H2NOW** — Tests new sensing and analytic technologies to measure water quality parameters and communicate them with the public in real-time. H2NOW aims to increase public understanding about Chicago River water quality and empower Chicago residents and visitors to be more informed and engaged river users and stewards.[107]

- **COVID-19 Wastewater Surveillance** — The Metropolitan Water Reclamation District of Greater Chicago is tracking COVID-19 levels through wastewater monitoring.

- MWRD is focusing on utilizing big data in areas including nutrient recovery, biogas generation, biosolid use, and water treatment. **Mining the waste stream** input of sewage plants could provide an enormous amount of information about diseases, genetic information, pharmaceuticals and even micro-constituents.

- **Illinois Nutrient Trading Initiative (INTI)** — With funding from The McKnight Foundation, Current partnered with the University of Chicago to explore a market-based approach to nutrient runoff reduction.

- **Stickney Water Reclamation Plant Nutrient Recovery Facility** — The Metropolitan Water Reclamation District of Greater Chicago (MWRD) operates the largest nutrient (phosphorus) recovery facility in the world, with the annual capacity to remove 1,500 tons of phosphorus and convert it into a slow-release fertilizer.[108] Since 2016, technology recovers phosphorus and nitrogen

from wastewater to create a high-value commercial fertilizer that creates a new revenue stream through fertilizer sales.

- **Lead Service Pipes Replacement**[109] — IL has the most lines in the country by far. There are multiple approaches and costs vary from $25k to $1500 per line. "Chicago is the epicenter for lead service lines (LSLs) in the United States. In a report submitted to Illinois Environmental Protection Agency (IEPA) in April, Chicago Water reported having 392,614 LSLs — 75% of the total service lines in its water system that serves 2.7 million people living in the city and the city's 125 suburbs. The number of LSLs is over three times higher than any other city. For additional context, this number represents 58% of the known LSLs in Illinois and 6% of the estimated 6.1 million LSLs in the country."[110]

- **Chicago Water-Efficiency Pilot** — "Enterprise Community Partners (Enterprise) and Elevate Energy are working to develop solutions that will help affordable housing providers mitigate the impact of increased water rates. As a first step, the team launched the Chicago Water-Efficiency Pilot in 2016. A water-efficiency specialist visited 14 affordable housing properties across the Chicago region, providing recommendations to organizational decision-makers, along with light training and procedural recommendations for maintenance staff."[111]

- Current hosts an **online, curated list of water-related roles** (ranging from internships to full-time positions) for professionals at any stage in their career and across all sectors.

- **Blue Edu**
  - River Lab: A Virtual Field Trip of the Chicago River — Current's free High School STEM curriculum.
  - A list of water-related virtual educational resources for K-12 students and the families, caregivers and teachers who support them.

- **Brew 2.0 Post-Accelerator** — A next-stage post-accelerator created to help late-stage startups build connections and grow their company's capacity. This virtual and in-person hybrid program focuses on expert-led sales and growth training along with a pitch event, all tailored for water tech businesses.

- **Tech Challenge** — Empowers anyone with a freshwater technology innovation to vet their concept with industry professionals from leading corporations. Twice per year, corporate sponsors — some of the largest water technology companies in the industry — select challenge topics, review applications and select finalists. Finalists present their solutions to the sponsors to compete for a cash prize, as well as an opportunity to work with a sponsoring corporation to turn their innovation into a viable commercial product.

- **Pilot Program** — Helps water technology innovators from around the world bridge the gap from prototype to real-life application by facilitating in-field piloting. The program provides technical support services, funding and potential sites to help validate cutting-edge products and move them forward.

- **Exchange-Traded Funds** Are being developed that contain funds that trade on exchanges that track the water index. These ETFs invest in companies involved in the treatment and purification of water, as well as its distribution. Examples: First Trust Water ETF is an exchange-traded fund; Invesco Water Resources ETF.

# XII. Appendix D NAICS

The “water cluster” has been defined as the following NAICS:

**TABLE 17**

## NAICS Water Cluster Definition

| | |
|---|---|
| 221310 | Water Supply and Irrigation Systems |
| 221320 | Sewage Treatment Facilities |
| 237110 | Water and Sewer Line and Related Structures Construction |
| 238220 | Plumbing, Heating, and Air-Conditioning Contractors |
| 325180 | Other Basic Inorganic Chemical Manufacturing |
| 325199 | All Other Basic Organic Chemical Manufacturing |
| 325211 | Plastics Material and Resin Manufacturing |
| 325998 | All Other Miscellaneous Chemical Product and Preparation Manufacturing |
| 326122 | Plastics Pipe and Pipe Fitting Manufacturing |
| 332722 | Bolt, Nut, Screw, Rivet, and Washer Manufacturing |
| 332911 | Industrial Valve Manufacturing |
| 332912 | Fluid Power Valve and Hose Fitting Manufacturing |
| 332913 | Plumbing Fixture Fitting and Trim Manufacturing |
| 332919 | Other Metal Valve and Pipe Fitting Manufacturing |
| 332996 | Fabricated Pipe and Pipe Fitting Manufacturing |
| 333318 | Other Commercial and Service Industry Machinery Manufacturing |
| 333914 | Measuring, Dispensing, and Other Pumping Equipment Manufacturing |
| 333996 | Fluid Power Pump and Motor Manufacturing |
| 334512 | Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use |
| 334513 | Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables |
| 334514 | Totalizing Fluid Meter and Counting Device Manufacturing |
| 334516 | Analytical Laboratory Instrument Manufacturing |
| 334519 | Other Measuring and Controlling Device Manufacturing |
| 335991 | Carbon and Graphite Product Manufacturing |

## NAICS Water Cluster Definition, cont.

| | |
|---|---|
| 339999 | All Other Miscellaneous Manufacturing |
| 486990 | All Other Pipeline Transportation |
| 518210 | Data Processing, Hosting, and Related Services |
| 541310 | Architectural Services |
| 541320 | Landscape Architectural Services |
| 541330 | Engineering Services |
| 541380 | Testing Laboratories |
| 541618 | Other Management Consulting Services |
| 541620 | Environmental Consulting Services |
| 541690 | Other Scientific and Technical Consulting Services |
| 541715 | Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology) |
| 541990 | All Other Professional, Scientific, and Technical Services |
| 561210 | Facilities Support Services |
| 562910 | Remediation Services |
| 562998 | All Other Miscellaneous Waste Management Services |
| 811310 | Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance |
| 813312 | Environment, Conservation and Wildlife Organizations |

# XIII. Appendix E ECONOMIC FRAMING

## The Next Economy

The global economy is undergoing a transformation that is fundamentally changing how productivity and growth occur. Knowledge assets embedded in technology and people are redefining how products are made, moved and sold across all sectors (not just “knowledge industries"). With the impact and value of knowledge greater than ever, human capital is solidifying its place as the single most important input for economic growth. A resulting more global, dynamic economy rewards continuous innovation, heightening the importance of rich, flexible cross-sector networks efficiently deploying and connecting human capital, business, technology and other assets. The pace of change in the economy is increasing: “creative destruction” is disrupting industries, occupations and places; while new products, firms, industries and markets are rapidly emerging, leading to enormous new wealth creation.[112]

One effect of these changes is that workers and businesses are experiencing ever greater benefits from locating close to each other, and thus are increasingly concentrating – and, more importantly, are more productive – in metropolitan regions. Metropolitan regions are dynamic, flexible and complex systems that nurture unique economies, which arise from an area's distinctive blend of industries, human capital, technologies, institutions and the built environment. Metropolitan areas have thus become the most important unit of geography in the global economy.[113]

Each region's unique combination of assets, markets, institutions and culture creates a “whole greater than the sum of the parts.” Each of the key dimensions — industry concentrations, labor pools, infrastructure — succeeds or fails within the context of the whole region. Therefore, strategies to grow an entire regional economy must be tailored to the region's distinct strengths and opportunities and should align across all aspects of the economy. There are no “one-size-fits-all” solutions for economic growth.[114]

## A New Approach to Economic Growth

The transformative nature of the next economy has major implications for the practice of regional economic development. Traditional strategies are no longer well-suited to today's economic opportunities. Regions need a new approach, moving away from consumption-driven growth (e.g., retail, housing) and from deal-by-deal, opportunistic firm attraction efforts based primarily on lowering costs for companies.[115]

Instead, regions must try to create production-driven economies that compete by adding value, building on their unique assets, strengths and opportunities. To do this, regions must concentrate on increasing *productivity*. Successful regions are developing and implementing comprehensive, integrated and inclusive strategies across the five market levers (discussed below) that determine productivity.

At a high-level, the shift is from business development to economic development, from opportunistic deals to improving the economic system (which enables doing better deals). New practices emphasize:

- **Competing on value added, instead of low-cost,** becoming a place where firms and people are more productive because of better human capital, infrastructure, complementary firms, governance, and so forth. This makes the place "sticky," continually attracting more firms and people;

- **Identifying unique strengths and "building from the inside out,"** recognizing that growth starts with *existing* assets: most net growth comes from a region's existing firms, followed by start-ups and only then by firms moving in. Firm attraction is the tail, not the dog, of economic development. Combined with the value-added principle, this means that initiatives should start by strengthening existing firms and industries and the assets which support them;

- **Acting strategically through context-specific, integrated solutions,** rather than having disconnected, siloed programs (or chasing isolated "big deals");

- **Focusing on inclusive, quality growth**, looking for long-term value and wealth creation rather than short-term profit extraction and other unsustainable development models.[116] A fundamental tenet of quality growth — developing and deploying ALL assets — is inclusive growth. Quality growth should also include focusing on climate conscience opportunities to grow clean jobs and industries that are more efficient and less polluting.

These principles indicate that the regions which build from the inside out, concentrating on their unique strengths, identifying their competitive advantages and then designing and launching market-based, targeted, integrated growth strategies that leverage all of their assets, will be most successful in creating strong, attractive economies and communities, resulting in more sustainable growth.

## Inclusive Growth

A central aspect of today's economy is the "inclusive growth paradox." On the one hand, in the short term, growth in this economy is disrupting (and in some cases, wiping out) legacy industries and labor markets. This is contributing to the disappearance of the middle class and creating unprecedented wealth inequality.

On the other hand, in the long term, it is increasingly clear that the regions with less inequity grow more sustainably over time. They utilize the talent of more of their workers and companies, are more efficient and productive and reduce the costs associated with poverty.[117] Sustained growth is positively correlated with lower inequality and racial segregation and smaller differences in city-suburb poverty levels.[118] A central challenge — and opportunity — for new economic development practice then, is aligning inclusion and growth. Equity and growth may have conflicted in the industrial economy; regardless, they can and must be two sides of the same coin in the next economy.

A crucial aspect of inclusive growth is that it does not refer to separate inclusion practices, nor to traditional equity work, as important as those remain. Traditionally, growth has taken place and then the people and places left out have received some set-asides or redistribution. Inclusive growth does not separate inclusion from growth — it is one thing, not two — and instead is

a different approach to all growth. It seeks to fundamentally reposition disadvantaged people and places, particularly communities of color, as leading owners, drivers and beneficiaries of the enormous growth opportunities in the new economy in the first place, not after the fact.[119]

Inclusion generally occurs across four dimensions:

- **Employment** — improving the functioning of labor markets so that workers of all skill levels and backgrounds are efficiently prepared, matched and upskilled for quality jobs with strong career ladders;
- **Ownership** — growing BIPOC company ownership to generate wealth creation and capture, especially by finding opportunities in high growth industries, as well as real estate ownership in residential, commercial and industrial development;
- **Location** — siting and supporting firms in places that are readily accessible to disadvantaged populations; and
- **Participation** — ensuring diverse representation of all races, genders, backgrounds, national origins, etc., at the relevant private, public and civic sector "tables" where growth strategies and economic policies are shaped.

Quality, inclusive growth practices that increase the employment, ownership, access and participation of BIPOC communities in the region's emerging economic opportunities are essential to achieving lasting economic growth. Each of the growth strategies that have evolved from this plan have been shaped by the opportunities in those four avenues to inclusion.

## Key Drivers of Growth

In the new economy, five market levers (listed below and diagrammed in Figure A1) account for the efficiency and productivity of regional economies and drive how much complementary, concentrated assets realize synergies.[120] Together, they provide a framework for understanding a region's economic assets, challenges and opportunities.

This Strategy's market analysis will focus on clusters — in particular, the water cluster:

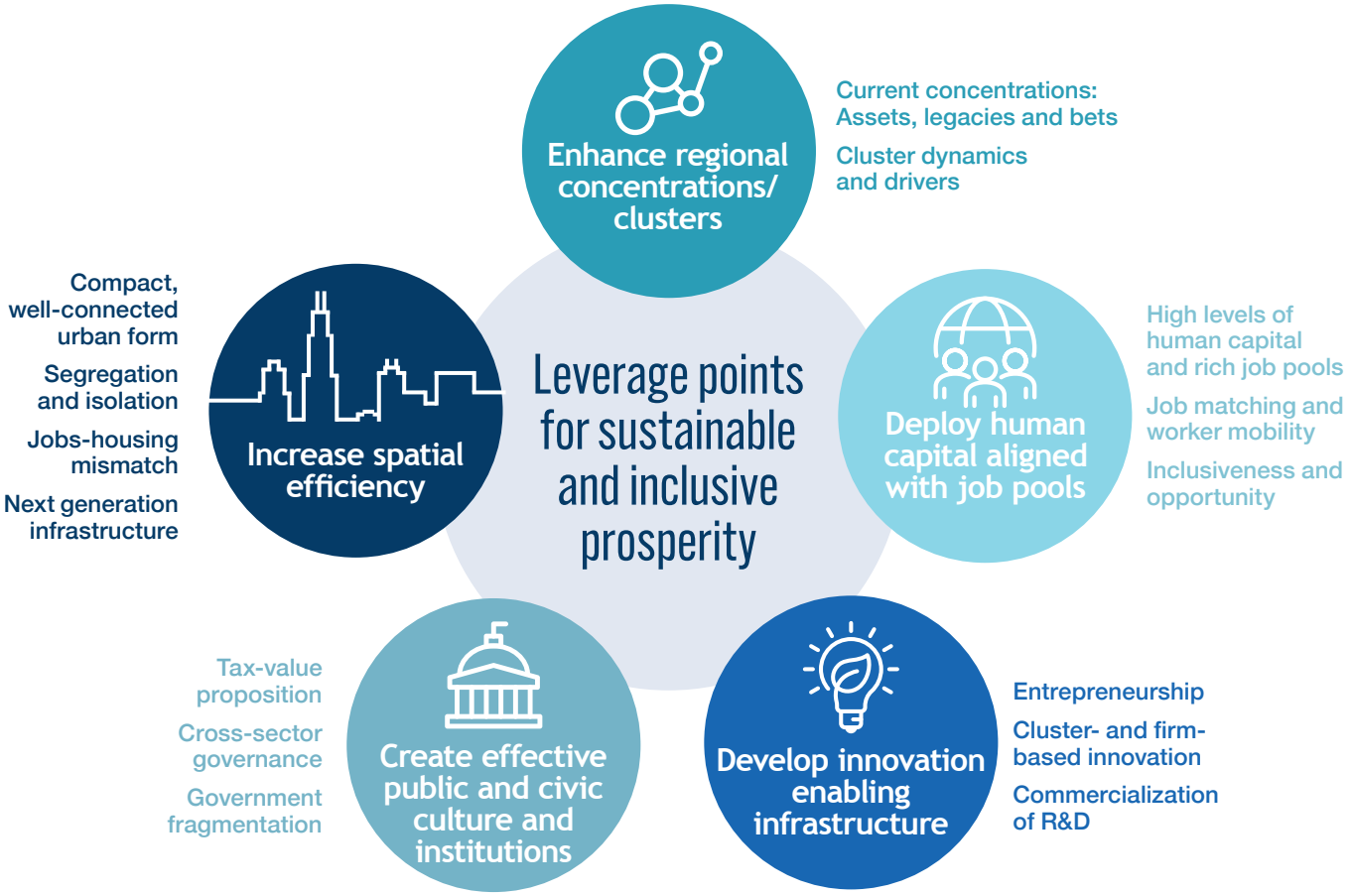
- **Clusters** — Industry-based concentrations of firms and related institutions that are more efficient and productive when co-located, due to lower transaction costs among buyers, suppliers and customers; sharing of labor pools and other common inputs; facilitating knowledge exchange; and enhancing the cluster's innovative capacity.

The analysis will also include examination of the other levers of growth as they relate to water cluster success: human capital, business, institutional and built environment all play roles in driving the performance of the water cluster.

- **Human Capital Development and Deployment** — Human capital is the most important asset in today's knowledge economy. Maximizing its impact requires better developing workers' skills to match emerging jobs and efficiently connecting workers to those jobs. This requires strategies such as changing employer hiring practices to emphasize skills over (often outdated) credentials, creating better means of matching workers with jobs and upskilling opportunities, and tailoring education and training to in-demand skills in growing clusters.

FIGURE A1

## Five Market Levers for Economic Growth




- **Innovation and Entrepreneurship** — The ability to innovate is the core driver of increasing productivity. In a more competitive, fast-paced, knowledge-based economy continual innovation, commercialization and business creation is crucial for economic success.

- **Spatial Efficiency** — The relative location of businesses, suppliers, workers and consumers within a region (and the physical and virtual infrastructure that connects them) greatly influences efficiency and productivity. Co-location and connecting infrastructure determine the costs for moving goods, people and ideas, in turn enhancing or diminishing many economic benefits of agglomeration.

- **Governance** — Not to be confused with govern*ment*, governance encompasses all the institutions that foster economic networks, innovation and other activity. The increasingly dynamic economy places a premium on rich formal and informal networks that enable exchange of ideas and facilitate relationships, transactions and coordination across the public, private and civic sectors. While government plays a key role — shaping and enabling market activity and providing the public goods that enhance productivity and efficiency — a broad range of civic, private-sector and cross-sector institutions are central to establishing an environment conducive to economic growth and fostering open, adaptive and flexible cross-sector networks.

These market levers influence each other. The point is to understand, based on a particular places' assets, where there are key intersections of firms (clusters), people (human capital) and technology (innovation) that — when connected by the right built and virtual environment (spatial efficiency) and institutional environment (governance) — will create the synergies that make the place most productive and thus competitive for certain industries, firms and people.

## Cluster Theory

Clusters drive regional economic growth by enhancing firm productivity through several mechanisms:

- Reducing transportation and infrastructure costs due to close proximity to one another;
- Enabling the development and sharing of specialized labor pools and other inputs common across firms;
- Providing firms more efficient access to customers, who may also be geographically concentrated (either as a cause or effect of firm clustering); and
- Facilitating innovation through "knowledge spillovers" — the informal learning and knowledge exchange that results from interactions between firms or the movement of employees between firms.

Industry clusters have existed in practice for centuries, but it is only within the last few decades that they have been called out as a particular way for regions to identify and build upon their competitive advantages. Michael Porter's work in this space helped to organize the components of a cluster (Porter's "Diamond Model"). It first describes the core cluster itself:

- **Firm Strategy, Structure and Rivalry (Water Cluster)** — This is the water cluster, which will be defined differently depending on what is clustering within each region (see **Appendix B**).

And, next — describes the components that lead to clustering and make a cluster competitive:

- **Factor Conditions** — Inputs to the water cluster; this includes Lake Michigan, a strong workforce, and strong R&D output in water-related topics.
- **Demand Conditions** — High-volume water users, which create demand for products and services within the water cluster. For instance: manufacturing, agriculture, food and beverage industries.
- **Related and Supporting Industries** — Suppliers and support services to the water cluster, such as data processing capabilities, chemists, or raw materials like plastics and metals.

# XIV. Appendix F ACRONYMS

Active Pharmaceutical Ingredients (APIs)

Argonne National Laboratory (ANL)

Artificial intelligence (AI)

Black, Indigenous, and people of color (BIPOC)

Clean Energy Center (CEC)

Compound Annual Growth Rate (CAGR)

Core Water Products Services (CWPS)

Customer relationship management (CRM)

Environmental Justice (EJ)

Environmental, Social, and Governance (ESG)

Exchange-Traded Funds (ETFs)

Federally funded R&D centers (FFRDCs)

Foreign Direct Investment (FDI)

Gross Domestic Product (GDP)

Gross Regional Product (GRP)

Illinois Environmental Protection Agency (IEPA)

Illinois Nutrient Trading Initiative (INTI)

Lead Service Lines (LSLs)

Location Quotient (LQ)

Marquette University (MU)

Membrane Bioreactor (MBR)

Metropolitan Statistical Area (MSA)

Metropolitan Water Reclamation District of Greater Chicago (MWRD)

Microfiltration (MF)

Mid-America Regional Council (MARC)

Nanofiltration (NF)

National Pollutant Discharge Elimination System (NPDES)

Network-as-a-Service (NAAS)

North American Industry Classification System (NAICS)

Oak Ridge National Laboratory (ORNL)

Office of Economic Development (GOED)

Oxidation-Reduction Potential (ORP)

Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)

Pritzker School of Molecular Engineering (PME)

Research and Development (R&D)

Request for Proposal (RFP)

Reverse Osmosis (RO)

Science, Technology, Engineering and Mathematics (STEM)

Sewage Thermal Energy Use (STEU)

Small- and Mid-sized Enterprises (SMEs)

Small Business Innovation Research Program (SBIR)

Small Business Technology Transfer (STTR)

Software-as-a-Service (SaaS)

Talent Pipeline Management (TPM)

The Infrastructure Network for Water (INH2O)

Thermal and Environmental Control (TEC)

Total Organic Carbon (TOC)

Ultrafiltration (UF)

Ultraviolet (UV)

Water-Enabled Industries (WEI)

Water Equipment and Policy Center (WEP)

Zero Liquid Discharge (ZLD)

# XV. Endnotes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2 Climate Central, "POURING IT ON: How Climate Change Intensifies Heavy Rain Events," May 15, 2019, **https://www.climatecentral.org/news/report-pouring-it-on-climate-change-intensifies-heavy-rain-events**, accessed May 13, 2020.

3 **Promoting Technology Innovation for Clean and Safe Water**

4 For example, strategies that have been developed in water sectors across the country include TitletownTech, an initiative to fund early-stage, high-growth businesses in five verticals (including "agriculture, water and environment") and the Port of San Diego's Blue Economy Incubator Program, an initiative to provide funding and support services to sustainable aquacultures and blue tech ventures.

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8 The degree of geographic proximity exhibited by firms in clusters varies widely from one cluster to another, ranging from a few blocks (e.g., Manhattan's garment district) to several states (e.g., the Great Lakes' auto industry cluster). For the purposes of this proposal, the primary unit of geographic reference is the metropolitan area, though the question is an empirical one: any given cluster will have a specific geography of its members, which will often be sub-regional in scale. Joseph Cortright, "Making Sense of Clusters: Regional Competitiveness and Economic Development," The Brookings Institution, March 2006, 6.

9 Cortright, "Making Sense of Clusters."

10 A cluster can consist of hundreds or even thousands of firms of various types and sizes — from Fortune 500 corporations and large professional service firms (e.g., advertising and accounting businesses) to highly specialized R&D operations and small supplier businesses. The cluster also consists of related entities such as research universities and relevant programs, industry associations, community colleges, workforce training providers and other professional entities that support and develop firms and workers.

11 Note that a cluster should not be confused with a cluster or industry organization — the cluster is defined by the economic interactions of its members, not their formal association (or not). Clusters may or may not form associations; and cluster organizations may or may not represent collections of firms that are genuinely "clustering" in the formal economic sense. See, Stuart Rosenfeld, "Industry Clusters: Business Choice, Policy Outcome, or Branding Strategy?" Journal of New Business Trends and Ideas 3(2) (November 2005): 5-6.

12 Individual firm attraction instead plays an important role as a tactic employed to implement strategies tailored to the assets and characteristics of the region — e.g., targeting particular types of firms to fill out a strong local cluster. In these circumstances, the case that is made to attract the targeted firm is also different — less focused on direct financial incentives (cost reduction) and more on adding value through infrastructure, human capital and other programs that improve the region for the entire industry and make the attracted firms "stickier" (less likely to leave for the next, lower-cost location).

13 Paul C Brophy, Robert Weissbourd, and Andy Beideman, *Transformative Economies: Emerging Practices for Aligning Growth and Inclusion*, Federal Reserve Bank of Philadelphia, October 2017.

14 For much more detailed literature review, see Weissbourd, Robert and Mark Muro, *Metropolitan Business Plans: A New Approach to Economic Growth*, Brookings Institution Metropolitan Policy Program: 2011; George Washington Institute of Public Policy and RW Ventures, LLC, *Implementing Regionalism: Connecting Emerging Theory and Practice to Inform Economic Development*, Online Publication: 2011, available at **http://rw-ventures.com/wp-content/uploads/2017/01/Surdna-Final-Paper-Combined-112111.pdf**; There are, of course, other equally good economic frameworks: this one has just proven particularly useful in translating economic theory to practice in the context of particular regional economies.

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38 https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/us-water-infrastructure-making-funding-count

39 https://www.nasdaq.com/articles/state-of-the-water-industry-2021-2021-10-04

40 Note that this segment also includes water recycling systems, which overlaps with treatment technologies. https://dataintelo.com/report/global-water-saving-plumbing-product-market/

41 https://www.nature.com/articles/s41545-019-0039-9#:~:text=Global%20water%20demand%20has%20increased,over%20the%20past%20100%20years.&text=This%20corresponds%20to%20an%20annual,this%20figure%20may%20be%20optimistic

42 https://www.theasset.com/article-esg/45699/water-as-an-asset-class-is-here

43 https://www.unwater.org/publications/progress-on-water-use-efficiency-641-2021-update/

44 https://www.idrica.com/wp-content/uploads/2021/02/Idrica-Global-Water-Trends-2021-EN.pdf; https://www2.deloitte.com/content/dam/Deloitte/pl/Documents/Reports/plWater-Tight-2-0-The-top-trends-in-the-global-water-sector.pdf; Challenges to data integration is that data is often collected in different formats that are not compatible with each other and there are many instances of data duplication. Data may also be siloed in different departments within the same facility or facilities may be reluctant to share data outside of the facility.

45 **https://www.businesswire.com/news/home/20211214006076/en/Global-Water-and-Wastewater-Treatment-Outlook-Report-2022-Leveraging-AI-based-Data-Analytics-Platforms-for-Achieving-Decarbonization-of-Water-and-Wastewater-Treatment-Infrastructure---ResearchAndMarkets.com**

46 **https://waterinthewest.stanford.edu/news-events/news-insights/building-effective-water-data-platforms**

47 A 2019 PWC report identifies the water sector as one of the industries where AI is likely to have a significant economic impact; **https://www.digitalpulse.pwc.com.au/report-ai-earth-sustainable-future/**

48 **https://h2oglobalnews.com/expert-insights-accelerating-tech-adoption-in-the-water-sector/**

49 **https://www.freshlawblog.com/2022/02/22/the-trend-toward-heightened-cybersecurity-for-the-water-utility-sector/**

50 **https://www.energy.gov/articles/ensuring-resiliency-our-future-water-and-energy-systems**

51 **https://www.energy.gov/sites/default/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf**

52 **https://www.iea.org/articles/introduction-to-the-water-energy-nexus**

53 **https://www.researchandmarkets.com/reports/5574874/water-and-wastewater-treatment-market-by-type?utmsource=GNOM&utmmedium=PressRelease&utmcode=4wrdzb&utmcampaign=1692171+-+Global+Water+and+Wastewater+Treatment+Market+Report+to+2032+-+Growing+Demand+for+Energy-Efficient+and+Advanced+Water+Treatment+Technologies+Presents+Opportunities&utmexec=jamu273prd**

54 **https://www.waterrf.org/sites/default/files/file/2022-09/4949-Resource-Recovery.pdf**

55 **https://www.cambridge.org/core/journals/mrs-energy-and-sustainability/article/from-waste-treatment-to-resource-recovery-a-chicago-sustainability-story/B3A8A2350FE8172EBCE1FDCC636397C9**

56 **https://www.waterworld.com/wastewater/article/16193701/recovering-resources-nitrogen-and-phosphorus-recovery-integral-to-nutrient-management-vision**

57 **https://www.researchandmarkets.com/reports/5574874/water-and-wastewater-treatment-market-by-type?utmsource=GNOM&utmmedium=PressRelease&utmcode=4wrdzb&utmcampaign=1692171+-+Global+Water+and+Wastewater+Treatment+Market+Report+to+2032+-+Growing+Demand+for+Energy-Efficient+and+Advanced+Water+Treatment+Technologies+Presents+Opportunities&utmexec=jamu273prd**

58 **https://mwrd.org/resource-recovery**

59 **https://www.cambridge.org/core/journals/mrs-energy-and-sustainability/article/from-waste-treatment-to-resource-recovery-a-chicago-sustainability-story/B3A8A2350FE8172EBCE1FDCC636397C9**

60 Water Cluster Initial Research 2020

61 **https://www.istcoalition.org/data/index/2022-rd-index-report/**

62 **https://ssti.org/blog/useful-stats-business-rd-expenditures-state-and-source-funding-2019**

63 Non-Federal sources can include funds from academia and nonprofit organizations.

64 **https://www.istcoalition.org/data/index/2022-rd-index-report/**

65 Crunchbase, 2021

66 Patent data from USPTO (2010-2021)

67 The patent search on USPTO was conducted using keywords in the patent documents filed by inventors and their associated companies. It is likely that this broad search has pulled in non-water technology patents as well. The figures generated by this analysis should be used only to assess the state's level of patent activity in specific application and technology areas relative to other states.

68

Defined according to Crunchbase categories: Natural Resources (Water), Sustainability (Natural Resources, Waste Management, Water Purification) and Transportation (Water Transportation)

69 **https://h2oglobalnews.com/expert-insights-accelerating-tech-adoption-in-the-water-sector/**

70 CEO of the Massachusetts Clean Energy Center

71 **https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/us-water-infrastructure-making-funding-count?cid=other-eml-alt-mip-mck&hdpid=888a6136-80c7-42bf-8eb1-2cec4ed2a8c3&hctky=10006402&hlkid=79bb31aba7-e140d7a744d727fb560b18**

72 MKM Consultants

73 **https://www.brookings.edu/research/rethinking-cluster-initiatives/**

74 **https://www.resilienceinnovationhub.com/**

75 People of color are more likely to have been or be currently employed in legacy industries that have experienced the most disruption in the new economy. This has driven greater under- and unemployment among these workers, and places them disproportionately in industries that are less likely to be employing sophisticated hiring practices. These workers also face more barriers to connecting with employment and training opportunities. Companies increasingly rely on online networks, such as LinkedIn, to source employees, and these networks have lower representation of people of color. In addition, people of color are less likely to hold academic credentials that employers tend to over-rely on.

Disconnected populations regularly face challenges in accessing education and training opportunities, be it due to costs, physical proximity, finding childcare, etc.

76 Advisory Group meeting suggestion

77 MKM Consultants

78 A technical and financial feasibility study of three potential water-technology demonstration centers around the state of Massachusetts.

79 **https://www.ornl.gov/facility/btric**

80 **https://bit.ly/3rk0vYS**

81 **https://www.southlanddevelopment.org/mid-sized-small-business-owners/**

82 **https://www.southlanddevelopment.org/mme/**

83 **https://www.mxdusa.org/cyber/**

84 **https://thewatercouncil.com/programs/**

85 **https://www.export.gov.il/en/%20Water**

86 **https://startupnationcentral.org/sector/watertech/#:~:text=Israeli%20Watertech%20is%20spearheading%20the,water%20reclamation%3B%20smart%20irrigation%20for**

87 **https://blogs.worldbank.org/water/israel-how-meeting-water-challenges-spurred-dynamic-export-industry#:~:text=Water%20has%20become%20a%20US,companies%20and%20over%20100%20startups**

88 **https://blogs.worldbank.org/water/israel-how-meeting-water-challenges-spurred-dynamic-export-industry#:~:text=Water%20has%20become%20a%20US,companies%20and%20over%20100%20startups**

89 **https://www.pub.gov.sg/watersupply/singaporewaterstory**

90 **https://www.netherlandswaterpartnership.com/**

91 In 2014, Michigan's University Research Corridor (comprising Michigan State University, University of Michigan, and Wayne State University) commissioned a report from the Anderson Economic Group, LLC to research Michigan's water cluster and assess the role of the universities in water-related research and innovation.

92 **https://www.urcmich.org/partners/in-water**

93 **https://news.umich.edu/michigan-s-university-research-corridor-plays-major-role-in-protecting-and-advancing-michigan-s-blue-economy/**

94 The study was performed in 2013. The GOED classified industries as low, medium, or high priority. The highest-ranked industries were those working on water efficiency and innovation. Nevada is one of the few regions that has already published a future-oriented plan for their regional water cluster for the post-pandemic context.

95 A statewide water technology initiative that was founded by civic and industry leaders in 2015 after a major drought in the region

96 Established in 2011 and leads the Central Valley Regional Innovation Cluster

97 **https://clevelandwateralliance.org/**

98 **https://www.tmabluetech.org/**

99 **https://www.theh2otower.org/**

100 **https://www.masscec.com/water-innovation**

101 **https://sea-ahead.com/**

102 **https://www.glc.org/news/be-092721**

103 **https://www.glc.org/**

104 **https://www.glc.org/work/blue-economy**

105 **https://www.brookings.edu/wp-content/uploads/2019/02/2019MetroGCIGlobal-Trade-PlanSyracuse.pdf**

106 **https://cdn.orbusinesscouncil.org/docs/policy/1aaREVISED2022-OBCWaterReport.pdf**

107 **https://www.h2nowchicago.org/**

108 **http://uswateralliance.org/sites/uswateralliance.org/files/publications/uswalistenbig7032618a.pdf**

109 **https://news.wttw.com/2021/12/16/biden-calls-chicago-s-lead-pipes-be-removed-within-10-years-slow-roll-out-continues**

110 **https://www.leadsafechicago.org/lead-service-line-replacement**; **https://blogs.edf.org/health/2019/09/25/llinois-lead-service-line-inventory-chicago-small-systems/**

111 **https://www.energyefficiencyforall.org/resources/increasing-water-efficiency-and-reducing-cost-in-affordable-housing-a-case/**

112 Brophy, Paul, Weissbourd, Robert, and Andy Beideman, *Transformative Economies: Emerging Practices for Aligning Growth and Inclusion*, Federal Reserve Bank of Philadelphia: 2017.

113 Evidence is emerging that there may be limits to the benefits of concentration in large metropolitan areas. As negative amenities like high housing

costs and congestion emerge, more people and firms are moving to "second tier" metropolitan areas. (See Strategies section for more on the "right-sized cities" phenomenon).

**114** Deliberate, tailored strategies are particularly important in the knowledge economy because the growth trajectories of regional economies are diverging. In the past, underperforming regions tended to "catch up" with their higher-performing peers over time. In the new economy, this dynamic has changed. As knowledge assets — such as human capital, information technologies and information sector firms — increasingly concentrate, they build upon themselves and generate increasing rather than diminishing returns. This drives a self-reinforcing growth cycle, and as a result, high-performing regions now tend to pull further ahead of their competitors. See generally: Joseph Cortright, "New Growth Theory, Technology and Learning: A Practitioner's Guide," Reviews of Economic Development Literature and Practice, 4: 2001; Weissbourd, Robert and Christopher Berry, *The Changing Dynamics of Urban America*, Online Publication: 2004.

**115** Individual firm attraction instead plays an important role as a tactic employed to implement strategies tailored to the assets and characteristics of the region — e.g., targeting particular types of firms to fill out a strong local cluster. In these circumstances, the case that is made to attract the targeted firm is also different — less focused on direct financial incentives (cost reduction) and more on adding value through infrastructure, human capital and other programs that improve the region for the entire industry and make the attracted firms "stickier" (less likely to leave for the next, lower-cost location).

**116** For more information on quality growth, see materials at **https://newgrowth.org/**, describing The New Growth Innovation Network, a new national organization that brings together economic development leaders committed to building a new field of quality economic growth practice.

**117** Pastor, Manuel and Chris Benner, *Equity, Growth, and Community: What the Nation Can Learn from America's Metro Areas*, University of California Press: 2015, available at **https://doi.org/10.1525/luminos.6**; Weissbourd and Berry, *The Changing Dynamics of Urban America*; Ostry, Jonathan D., Berg, Andrew and Charalambos G. Tsangarides, "Redistribution, Inequality, and Growth," IMF Staff Discussion Note: April 2014, available at **www.imf.org/external/pubs/ft/sdn/2014/sdn1402.pdf**; OECD Directorate for Employment, Labour, and Social Affairs, "Does Inequality Hurt Economic Growth?" Focus on Inequality and Growth, 9: 2014; OECD, *In It Together: Why Less Inequality Benefits All*, Online Publication: 2015, available at **www.oecd.org/social/in-it-together-why-less-inequality-benefits-all-9789264235120-en.htm**.

**118** Pastor and Benner, *Equity, Growth, and Community: What the Nation Can Learn from America's Metro Areas.*

**119** Brophy et al., *Transformative Economies: Emerging Practices for Aligning Growth and Inclusion*.

**120** For much more detailed literature review, see Weissbourd, Robert and Mark Muro, *Metropolitan Business Plans: A New Approach to Economic Growth*, Brookings Institution Metropolitan Policy Program: 2011; George Washington Institute of Public Policy and RW Ventures, LLC, *Implementing Regionalism: Connecting Emerging Theory and Practice to Inform Economic Development*, Online Publication: 2011, available at **http://rw-ventures.com/wp-content/uploads/2017/01/Surdna-Final-Paper-Combined-112111.pdf**; There are, of course, other equally good economic frameworks: this one has just proven particularly useful in translating economic theory to practice in the context of particular regional economies.

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