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Understanding Water Security in Portland, Oregon: Using Newspapers as Tools for Science Communication and Education

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Understanding Water Security in Portland, Oregon: Using Newspapers as Tools for Science Communication and Education

by

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Abstract

Water insecurity is faced by a large percentage of the global population, particularly in urban areas, which face greater and more complex needs for water resources. Better tools are needed to be able to recognize and communicate water security issues in a way that reinforces water systems, engages all stakeholders, and recognizes early warnings of environmental injustice. This research examines utilizing public newspaper articles to produce these tools. Using a case-study approach, this thesis explores newspaper articles about water from 2014-2020 in the urban center of Portland, Oregon, to understand local water security issues and to build a system of analyzing and mapping them. By coding articles for water security terms (safety, affordability, reliability, and accessibility), this research unveils a method of newspaper data analysis that can be used to understand local water security issues, map newspaper articles, and promote water security education and communication through building action competence. This research is useful in the beginning stages of building an early detection system for water security issues and water injustice, which can inform environmental education, communication, policy, and management contexts.

1. Introduction

1.1 Using Local Knowledge to Build Educational Tools

Throughout history, communities have been fighting for and demanding solutions to environmental problems they face (Cole & Foster 2001). Members of these communities often experience the cumulative effects of environmental issues long before they are able to recognize the cause or source. On the other hand, some have confronted environmental issues since the introduction of colonial practices to their communities, and have faced generational impacts. Though communities may be intimately familiar with environmental issues they face, their causes, and their historical contexts, laypeople often lack access to resources to solve environmental problems (Wynne 1992). Primarily, this is due to systemic barriers in political and scientific infrastructure that discourages access to scientific environmental knowledge and political power, while discouraging the use of integrating local or community-based knowledge into scientific policy (Corburn 2003; Wynne 1992). In combination, the production of environmental knowledge isn't always useful in responding to real-time environmental issues. Environmental knowledge often lacks actionability, or the ability to be used in practical ways to solve environmental problems (Beier et al. 2016; Dewulf et al. 2020; Vogel et al. 2016; Wynne 1992). This non-usability generates a disconnect between policymakers and scientists in utilizing a science-based understanding to inform policy and action, specifically in the face of current environmental concerns such as climate change (Kirchhoff et al. 2013).

One possibility in bridging the disconnect between environmental knowledge and policy involves recognizing local knowledge as scientifically based and integrating it into environmental tools

(Corburn 2003). Though frequently underacknowledged, local knowledge is vital in understanding temporal and spatial dynamics of environmental issues and the interconnections of social dimensions to environmental problems (Corburn 2003). Community members facing the brunt of environmental issues can be active advocates for their own health and safety, but the information and tools need to exist publicly in order for laypeople to access, understand, and utilize it. In this research, I look at one environmental resource that is globally relevant and necessary for life: water. I aim to explore a pathway where local water knowledge can be translated into a map tool that informs environmental education and science policy. Public environmental outreach using this tool could help build community action competence, public deliberation, civic leadership, and social responsibility that re-inserts itself into the tool over time, improving its contextuality and usability. In that, this research explores utilizing a combination of methods aimed at making environmental knowledge more usable in order to inform environmental education and communication practices and improve water security.

1.2 Water (in)Security in Portland, Oregon

Water, our most basic resource, is at the forefront of many global environmental concerns. In 2020, 1 in 4 people lacked access to safely managed drinking water, while nearly half of the global population lacked access to safely managed sanitation services (WHO & UNICEF 2021). The COVID-19 pandemic has exacerbated this impact, as many public restrooms and water stations closed down due to concern of spreading the virus. In addition, extreme climatic changes and rapid urbanization are increasing concern over impacts to water resources and encouraging global responses to water crises (Mueller & Gasteyer 2021; WHO & UNICEF 2021; Wutich 2019; Young et al. 2019).

Water insecurity is defined by Wutich (2019) as “the lack of adequate and safe water for a healthy and productive life”. Though water insecurity is widely credited as an issue of developing nations, lack of access to potable water and sanitation in the United States is disturbingly large (Mueller & Gasteyer 2020). Across the country, over 13 million households experience incomplete plumbing, a phenomenon also known as plumbing poverty or “lacking any plumbed connection to potable water or sewerage…” (Dietz & Meehan 2018; Mueller & Gasteyer 2020). In addition, plumbing poverty and water insecurity are disproportionately faced by historically vulnerable groups, such as Black, Indigenous, and people of color, low-income, disabled, and young or old populations due to structural inequalities in water infrastructure systems (Dietz & Meehan 2019; Mueller & Gasteyer 2020). Certain water issues across the United States have gained greater attention in recent years due to their interconnectedness with socio-demographic issues, such as the lead crisis in Flint, Michigan (Pauli 2020; Takahashi et al. 2020), per- and polyfluorinated substances (PFAS) concerns (Richter et al. 2020), and the increased awareness of plumbing poverty's impacts to vulnerable groups (Deitz & Meehan 2019; McGraw & Fox 2019). Though water insecurity is faced by a large percentage of the global population, it is often called a “silent emergency”, as it goes largely unconsidered by those who are not experiencing it (Moszynski 2006). In addition, water insecurity is a social issue, as the quality, affordability, accessibility, reliability, and availability of freshwater ultimately affects humans quality of life. Left unmanaged, inequitable access to water leads to environmental injustice.

Cities in particular are a prime location for water insecurity to arise due to rapid urbanization and an increased need for water resources. Water scarcity, or when water needs are greater than availability, is expected to increase by 2.065 billion people in urban populations by 2050 (He et al. 2021). Portland, Oregon, fits these concerns as a rapidly growing urban center with a great need and disproportionate distribution of water resources across the city. With a population of over 650,000 people and growing, the Portland Metro area is the largest city in Oregon with a high demand for affordable and reliable water. Though Portland does not suffer from water scarcity, one only needs to read the news to identify that water availability, safety, affordability, and reliability issues are often faced throughout the Metro area. For example, despite Portland's image of clean and abundant water, recent concerns of drought due to changing climatic conditions, fire, and increasing summer temperatures have circulated through news sources (McGinness 2022). Similarly, following coverage of the lead injustice in Flint, Michigan, lead in drinking water caused by the acidic nature of Portland's drinking water source and the city's aging infrastructure have been forefront in the public and policymakers' concerns (Parks 2021; The Portland Medium 2022).

With these concerns in mind, there is a need to better inform the public of water issues and produce adaptive strategies that minimize water insecurity in urban areas. Though, scientific information on water issues is hard to publicly disseminate for several reasons. Primarily, water issues are hard to collect data on, as climatic patterns are changing, and the social dimensions of water issues are less clear. Water issues are additionally hard to thoroughly map across spatial and temporal scales in a visually appealing and publicly informative manner. Though water issues have been linked to social issues in recent years (Deitz & Meehan 2019; McGraw & Fox 2019; Pauli 2020; Takahashi et al. 2020), social indicators of environmental problems are not well explored or understood. There is a low level of systems-based understanding from the public in general about environmental issues, though there exists a large desire to learn about environmental topics like sustainability and climate change in recent years, best expressed by the growing number of youth-led environmental and social movements (Raphael 2019). A vast body of environmental knowledge is held by local community members, though barriers to utilizing that knowledge are both structural and systemic (Corburn 2003). There exists a great need for better tools to collect, organize, understand, disseminate, and communicate water security issues globally so that lay people can be informed about potential impacts on themselves and their communities and can access the resources needed to take action.

1.3 Research Goals

This thesis aims to understand how we might bridge the gaps between community knowledge and scientific communication tools for water security issues in Portland through utilizing public news data. News can be a beneficial 'citizen science' tool in understanding environmental issues and public perception, but the path from news to education and policy is non-linear and complex (Raphael 2019). News media however can give scientists the information to produce "...interactive tools that allow advocates and others to describe, depict, map, monitor, and analyze…" environmental issues and their socio-demographic interconnections (Raphael 2019).

In this research, I explore two questions:

> **1) How can we use public information to understand what water issues are occurring in Portland, OR?** By utilizing a subset of water news data from newspapers based in Portland, Oregon, my primary objective is to gain a better understanding of what water issues are occurring in Portland by coding them based on a water security model.

2) How can we spatially organize this information for use as a science education/communication tool? In understanding what water issues are occurring in Portland and producing a coded dictionary, I aim to organize the news information so that it can be mapped spatially and uploaded to Oregon Water Stories, a public-facing website that explores water security.

2. Environmental Science Communication

2.1 The Evidence-Policy Gap

Best practices for widespread environmental communication and education to the public have been debated for decades among the scientific community, and therein lacks clear guidelines for which methodology to pursue (Bucchi & Trench 2021; Breiting & Mogensen 1999; Corburn 2003; Raphael 2019; Wynne 1992). How to use these practices to produce just and equitable educational tools that inform the public is lacking in current scientific literature. Overwhelmingly, current understandings of scientific communication and education cite the lack of connection between research and action (Beier et al. 2016; Bucchi & Trench 2021; Cairney 2016; Dewulf et al. 2020; Vogel et al. 2016; Wynne 1992). Specifically, Cairney (2016) and other scholars term this the "evidence-policy" gap, where data is oftentimes, if not always, under acknowledged in the environmental decision and policy making process.

Despite this, scholars have defined various approaches that aim to make science more 'actionable' through education or communication, including 'transdisciplinary', 'coproduction', and 'citizen-science' methods (Dewulf et al. 2020). Transdisciplinary methods draw on various disciplines, such as health sciences or art, to combine alternative interests with education of the environment, thereby encouraging student motivation in the subject. Co-production methods often involve working directly with organizations that enact environmental policy in order to communicate specialized findings and build the science-to-action pipeline, or working collaboratively with students in a class to co-create material based on students interests (Beier et al. 2016; Paul et al. 2018; Vogel et al. 2016). Lastly, citizen-science is a public outreach and knowledge collection methodology that involves utilizing laypeople to collect data via scientific methods, where community members become more knowledgeable and build social responsibility in the process (Corburn 2003; Paul et al. 2018). Scholars have not yet succeeded in outlining a process that utilizes each of these methods in combination.

2.2 Building Action Competence

Theorized approaches specific to environmental education and communication aim to mitigate the action disconnect by implementing strategies that build student's 'action competence', or aid in "developing their ability to take part in democratic processes which concern human's dependence and exploitation on natural resources" (Breiting & Mogensen 1999). Rather than measuring behavioral milestones that solely indicate comprehension of environmental issues, action competence aims to build "critical, reflective, and participatory" thinking skills that enable students to make decisions in response to environmental and social problems that will impact the future of the environment and society (Breiting & Mogensen 1999). For example, rather than teaching students not to litter and measuring a student's success on the behavior of not littering (behavior model), action competence models teach students to identify pollution in their communities, a strategy that not only encourages the behavior to follow but improves student's critical thinking and problem-solving capacity in the face of dynamic environmental issues (Breiting & Mogensen 1999). Transdisciplinary, coproduction, and citizen-science methods to build action competence have been utilized more in recent years in formal environmental education, as observed by my own experience as a higher-education student of environmental science.

Outside of an educational setting, these concepts can be applied to public-facing educational tools for the purpose of building action competence in larger communities and in response to environmental problems and environmental injustice. Public uptake of science has been previously thought to be difficult due to the public's ‘distrust’ of scientific entities in positions of power or authority (Breiting & Mogensen 1999; Wynne 1992). However, this framing harmfully “...reifies scientific knowledge as if it were objective and context-free” (Wynne 1992). Instead, public uptake of science has recently been understood in relation to social dimensions of the public, focusing on power dynamics, social relationships, identities, networks, and belief systems, which when combined inform the public’s decision-making process in response to environmental issues (Wynne 1992). In that, trust and distrust become dependent on the nature of evolving social interactions, networks, and relationships between the public and their communities or associated scientists (Wynne 1992). Public knowledge deficit is another common theme among science communicators, despite studies overwhelmingly revealing that community members can contribute key political, technical, and lived insights to solving environmental issues by utilizing ways of knowing that are different from traditional ways of conducting science and testing theory (Breiting & Mogensen 1999; Corburn 2003; Wynne 1992). Therefore, attempts to build public action competence must consider social dimensions, local knowledge, and build relationships with public members in order to be successful, just, and equitable.

2.3 Newspaper Articles as Data

Throughout history, news and media have played crucial roles in documenting and delivering key environmental information across wide spatial boundaries. News and media can produce "...interactive tools that allow advocates and others to describe, depict, map, monitor, and analyze…" environmental issues, making news and media important avenues for communicating science to the public (Raphael 2019). In addition, with recent advances in media technologies, communities facing environmental issues have oftentimes gained country-wide or even global attention (Takahashi et al. 2020). National coverage of environmental issues is an effective form of long-distance science communication, though many local networks cover important environmental information for residents in specific localities, and community journalism is equally as important as national (Takahashi et al. 2020). Though, news communication methods like community journalism, or even physical printed newspapers have declined in the wake of "flashier" news sources or social media sites that provide a "constant feed of information" to the public (Takahashi et al. 2020).

Despite their importance, news and media outlets are often expressed as biased and/or politically charged in that they censor information and dictate what is shared (Polk & Diver 2020; Takahashi et al. 2020). These outlets are heavily influenced by framing, which affects how their information influences the public (Goffman 1974; Polk & Diver 2020; Raphael 2019; Takahashi et al. 2020). Despite their bias, science communication via news and media outlets has several benefits, including wider access across spatial, temporal, and socioeconomic barriers, as news can be accessible in public spaces such as public libraries, with satellite technology, and with physical or digital copies that have unique accessibility standards. News reporting has additionally shifted over the years to become more holistic, acknowledging local and alternative knowledge more widely than previous decades (Raphael 2019). Scholars of communication science have shown that community members and local knowledge is essential in identifying place-based environmental risks, though community members' concerns for environmental risk are often ignored and left out of environmental policy and decision-making (Corburn 2003; Raphael 2019).

News is oftentimes collected by the public, for the public, supporting an important direct relationship for environmental science dissemination. Public to public communication via community journalism promotes reciprocal exchange between journalist and audience, fostering the responsibility to build "trust, connectedness, and social capital" (Takahashi et al. 2020). Thus, local news is increasingly important as it is covered by the public, for the public, and promotes the health of the locality and people within the locality it covers (Takahashi et al. 2020). In addition, newspapers throughout history have been archived in web-based platforms that can be accessed easily by the public. Thus, a large amount of environmental data already exists in these archives, which can be harnessed to explore specific environmental issues or themes such as water security.

2.4 News-Competence Conceptual Model

To understand how we might use news and newspapers to produce action competence and avoid reproducing the evidence-policy gap through education, I have outlined a theoretical four-step circular process that begins at the data collection stage (*Fig. 1*). This step acts as a 'citizen science' step, where the public is collecting information on environmental issues themselves, and building public participation and motivation in doing so. Thus, this step begins as local residents identify an environmental issue in their community and report it to a news station or other authority. From there, community journalists can report a written story, and that story is archived along with the others in that newspaper. In the data collection stage of traditional Western science, science professionals generally identify community members as ‘subjects’ in or of research, not as researchers themselves (Bromley et al. 2015). This denotation has long been debated among scientists as a term that objectifies and reifies community members as subjects to which environmental hazards can recurrently act upon, rather than active members of science and knowledge production (Bromley et al. 2015). As news is inherently community data, recognizing community and local knowledge in environmental issues may be crucial in recognizing community members' agency and disrupting colonial practices of objectification.

Figure 1. Conceptual map of the circular process of news information in building public action competence and environmental understanding, or the "news-competence" process. **1. Data collection.** News reporters and citizen scientists collect data from various public reports on environmental issues and observations. **2. Analyses and mapping.** This data is taken up by scientists and methodically analyzed and organized to understand specific occurrences of certain environmental issues (such as water) so that it can be mapped. **3. Outreach and education.** Scientists can then take the tools to the public, demonstrating and teaching the public how they can utilize the tool to stay informed about environmental issues. **4. Competence and observation.** With greater recognition ability in current issues, the public can better identify environmental issues or disparities that exist around them or within their communities and report them.

After the news data has been collected by reporters, broadcasted, and then archived into web-based databases, scientists can compile decades of community knowledge and utilize unique tools to analyze the data. This step requires trained analyzers who are deeply familiar with a particular theme that is being analyzed in order to identify and observe nuances within the theme. Static media texts often are buried in context and media framing (Goffman 1974) that can be difficult to unearth without in-depth environmental and sociological analyses and dynamic monitoring, processes requiring in-depth training and expertise. In the process of compiling large temporal periods of environmental data via newspaper reports, patterns begin to emerge from that data that show recurrences of environmental risks or hazards. Patterns also emerge that highlight the communities most impacted over time, which can inform adaptive response and management strategies for water security or other environmental issues. Additionally, newspaper data contains direct quotes from community members about local environmental risks and hazards. Applying concepts of frame analysis can aid in understanding the community's perspective and perceived nature of a hazard, with which scientists can better understand what environmental hazards are occurring and who or what they are affecting most. In this way, newspapers can be useful tools in identifying and filling environmental gaps and recognizing community knowledge, while identifying patterns that tell the story of the communities affected by water issues.

Once the news articles are analyzed to uncover patterns and themes, mapping tools to display identified themes can be visually informative and publicly appealing (Raphael 2019). A number of organizations have succeeded in mapping environmental issues by utilizing community-based knowledge, for example, an interactive Environmental Justice (EJ) Atlas (http://ejatlas.org) using case studies of environmental justice conflicts was produced by Academics at the Universitat Autonoma de Barcelona to support teaching and advocacy of environmental justice issues (Raphael 2019; Temper et al. 2015). A similar program, Environmental Justice Screen (https://www.epa.gov/ejscreen) has been developed by the Environmental Protection Agency (EPA) that uses demographic census data along with environmental indicators to understand where environmental justice issues might occur. EJ Atlas and EJ Screen both demonstrate the usefulness of mapping environmental data and social factors to show spatial correlation, and provide an outline for specialized maps to inform certain environmental themes. Though, these maps must be visually informative and accessible publicly in order to be useful. Working in collaboration with other disciplines that focus on mapping technologies such as GIS or with sociologists may prove useful as a transdisciplinary approach to producing the most usable mapping tool.

By mapping environmental risks, scientists are able to conduct community outreach to the public and aid in both preventing environmental impacts, improving distributive justice, and improving public deliberation and action competence through educational outreach (Breiting & Mogensen 1999; Raphael 2019). Outreach initiatives presently occur within scientific institutions and contexts, as research often requires collecting public knowledge (e.g., survey data) or practicing public education efforts. Public deliberation of environmental issues can produce several benefits including improved trust of governance processes and scientific entities, better developed understanding of environmental processes, improved local policy outcomes, and better distributive environmental justice (Raphael 2019). For example, EJ Screen's public website supports these efforts by offering free educational sessions on how to use their mapping tool which aids in accessibility and public understanding.

Through building the public's action competence with educational outreach, community members are then able to contribute more to these tools over time by building expertise to understand, identify, and report environmental risks and hazards in their communities (Breiting & Mogensen 1999; Covitt et al. 2009; Raphael 2019). By having access to these tools and education surrounding utilizing these tools, the public can better understand risks and issues in their communities and have the language to identify, discuss, explore, and advocate for their own and their communities health and safety. Building action competence also aids in empowering the public in becoming civic leaders by reporting identified issues to news outlets, reporters, and scientists. With more issues identified and reported by empowered community members, more news stories will be produced and archived which can be analyzed, building the map's database both in size and in usefulness.

2.5 Water Security Model

This research focused on the analysis and mapping stage of the conceptual news-competence process. In order to analyze and map news data based on a particular theme such as water or water security, these themes must be understood in-depth. Though numerous scholars have defined water security through various terminology (Broyles et al. 2022; Dietz & Meehan 2019; He et al. 2021; Jepson et al. 2017; Mueller & Gasteyer 2021; Padowski & Jawitz 2012; Young et al. 2019), in this research, water security is conceptualized as the interactions between water safety, affordability, reliability, and availability. In that, water security considers how water issues might manifest in different ways for different groups based on various socio-political and geographic contexts. Importantly, water security concerns are most felt and faced by the world's vulnerable populations, including Black, Indigenous, and people of color, low-income, disabled, and young or old groups, and global climate change will likely intensify these concerns (Broyles et al. 2022).

Water safety refers specifically to concerns around the quality of water. These concerns can appear due to water pollutants, dramatic fluctuations in temperature and/or pH, or waterborne diseases. The Centers for Disease Control and Prevention estimates that each year 1 in 44 people get sick from waterborne diseases and illnesses in the United States, a statistic that has likely increased since the data was analyzed in 2020 (WHO & UNICEF 2021). Water safety is a primary concern in many urban centers, as waste disposal in cities is expensive, infrastructure may be outdated, and safe, clean water is not affordable for everyone. Global climate change is likely to impact overall water quality by increasing extreme weather events that lead to increased water temperature, runoff, erosion, and sedimentation (EPA 2021).

Water affordability refers to the concern around cost or prices of water. The cost of water can be impacted by inflation, water infrastructure reliability, natural events, and global poverty, and has been continually rising in many major cities in the United States and across the world (Colton et al. 2018). In a report analyzing 12 U.S. cities for water affordability, Colton et al. (2020) found that in 2018, water bills were "universally unaffordable" for city residents living in the lowest income ranges. Urban centers face the most unaffordable water due to a greater need for water resources within them, and rising rates puts lower-income residents at the forefront of water insecurity (Colton et al. 2020).

Water reliability refers specifically to physical water infrastructure that aids in the delivery of water services to residents. Infrastructure can be impacted by age or unpredictable events, damages, or needed repairs. The delivery of water to the public requires a number of infrastructural processes including pipes, levees, dams, wells, and/or storage areas for the water, such as reservoirs. Issues in any of these processes may have dramatic effects on a place's water security. In addition, any infrastructural flaws or unforeseen damages may cross-impact water safety, affordability, and availability.

Lastly, **water availability** refers specifically to the amount of available water, both in a ‘natural’ systems perspective and in the water storage capacity of humans. Water availability can be impacted by precipitation amount or lack thereof, shortages due to drought conditions or overuse, or flooding. Water availability concerns have been relevant throughout history, for example, as agriculture and other businesses have relied on precipitation and snowpack to fill water stores throughout the growing season. In recent years, dry, hot summers and drought conditions have increased and caused concern for agricultural and other industries. Additionally, global climatic changes will undoubtedly impact water availability in the natural environment.

3. Methodology

3.1 Newspaper Article Scraping

Newspaper articles from 26 newspapers across the state of Oregon and the publication years 2014-2020 were scraped using a web scraping tool for the single keyword “Water”. Found articles were then downloaded to an Excel spreadsheet and organized by the newspapers city of publication. Articles in the spreadsheet were then cleaned by a process of reading each individual article’s complete text in order to remove articles unrelated to water (for example, obituaries or recipes). For the purpose of this research, a subset of the articles published in the city of Portland, OR were analyzed. Newspapers scraped within Portland included the Oregonian (www.oregonlive.com), Street Roots (www.streetroots.org), and Willamette Week (www.wweek.com). After removing unrelated articles, the initial sample of Portland-published articles contained 539 articles across the three newspapers. A total of 10 articles from Willamette Week during the dates 2005-2013 were removed from this sample for the purpose of consistency, producing a final sample size of 529 articles: 380 from the Oregonian, 78 from Street Roots, and 71 from Willamette Week.

To understand the water issues specifically occurring within the Portland Metro, articles that discussed water concerns occurring in non-metro cities throughout Oregon, despite the articles being published in Portland, were not coded. The Portland Metro area includes Portland and the neighboring cities of Vancouver, Beaverton, Gresham, Hillsboro, Milwaukie, Lake Oswego, Oregon City, Fairview, Wood Village, Troutdale, Tualatin, Tigard, West Linn, Battle Ground, Camas, and Washougal. This step was done simultaneously during the coding process (*see 3.2*). During the coding process, as articles were re-read they were checked again for relevance to the Portland Metro area. After all articles were coded, a final check to ensure all Portland metro articles were coded was done by using the function "CTRL + F" and searching for "portland", "metro", and/or the included cities across the database, re-reading articles without these terms in their complete text, and then removing articles that were not relevant. These cleanings produced a final sample size of 346 articles from the dates 2014-2020 of water issues throughout the Portland Metro.

Newspaper articles have been scraped since 2014 by Melissa Haeffner, Ph.D. and students in the Haeffner Water Justice Lab for the following cities in Oregon: Warm Springs, Vale, Tillamook, The Dalles, Sisters, Salem, Roseburg, Portland, Pendleton, Ontario, Newport, Medford, Lakeview, La Grande, Klamath Falls, Hood River, Dallas, Coos Bay, Clatskanie, Burns, Brookings, Bend, Baker City, and Astoria. Portland articles from 2021 were not analyzed as part of this research.

The total database and updated map up to 2020 articles consists of 3319 water security articles across the aforementioned cities.

3.2 Coding Articles

After initial cleaning, articles were systematically coded for safety, affordability, reliability, and availability based on their definitions discussed in the water security model. This was done by a process of reading each individual article and assigning it a ‘code’ based on the articles title, main subject, and/or text body. For example, articles were coded “safety” when the article discussed changes in water temperature, specific pollutants or water hazards, chemicals, organic matter, or other water quality concerns. Articles were coded “affordability” if it discussed rates, taxes, payments, costs, funding, or other water cost concerns. Articles were coded “reliability” if it discussed physical infrastructure related to water, such as dams, water mains, pipes, drainage mechanisms, or other water infrastructure or delivery mechanisms. Articles were coded “availability” when it related specifically to the presence or absence of water, such as precipitation, flooding, drought, or related availability concerns.

A word dictionary was built through the process of coding and understanding certain keywords that would indicate the different water security issues, and additional keywords were added when they signified issues related specifically to Portland (*see Table 1 in Appendix*). For example, “superfund” and “combined sewer overflow” were added as a safety keyword specific to Portland’s piping system and water safety issues regarding the Superfund site along the Willamette River. After the articles were systematically coded, the codes on each article were then color-coded in order to organize them visually and implement them onto the Oregon Water Stories website map. Safety was designated red, affordability was designated green, reliability was designated yellow, and availability was designated blue. Summary statistics were additionally performed in Excel using the COUNTIF command to sum the count of articles reading each code and understand their frequency.

3.3 Putting the Articles into the Oregon Water Stories Map

In order to add the articles to the Oregon Water Stories website, the complete master database of articles was first organized into an Excel template which included 4 columns: location of publication, citation, link to the article, and hex color code. Articles identified as "safety" issues were designated red with the hex color #B90E0A, articles identified as "affordability" issues were designated green with the hex color #028A0F, articles identified as "reliability" issues were designated yellow with the hex color #FFE800, and articles identified as "availability" issues were designated blue with the hex color #0492C2. The remaining articles not included in this case-study were coded a gray hex color #CCCCCC. HTML and CSS base code prepared by Jackson Voelkel and Melissa Haeffner, Ph.D., was uploaded to RStudio in order to update the code via the R console. The base code was updated using the R console in order to replace the master spreadsheet and update the hex colors and key for the new water security codes. The output code was replaced on the oregonwaterstories.com server to update the map.

4. Oregon Water Stories Map Demonstration

The final produced interactive map with articles embedded can be accessed at https://www.oregonwaterstories.com/interactive-map. The initial map screen contains an overlay of a global map, with the state of Oregon populated with bubble-like points that indicate the number of articles in each Oregon city center (*Fig. 2)*. Clicking on the numbered bubble points populates a circular web containing a display of each article published in that city in a dot-based matrix (*Fig. 3A & 3B*). Clicking on the color-coded dots in the open web-like matrix opens a pop-up which contains the city of publication, water security code, citation, and clickable link to the complete online newspaper article (*Fig. 3C*). Non-coded articles in other cities in the matrix are colored gray.

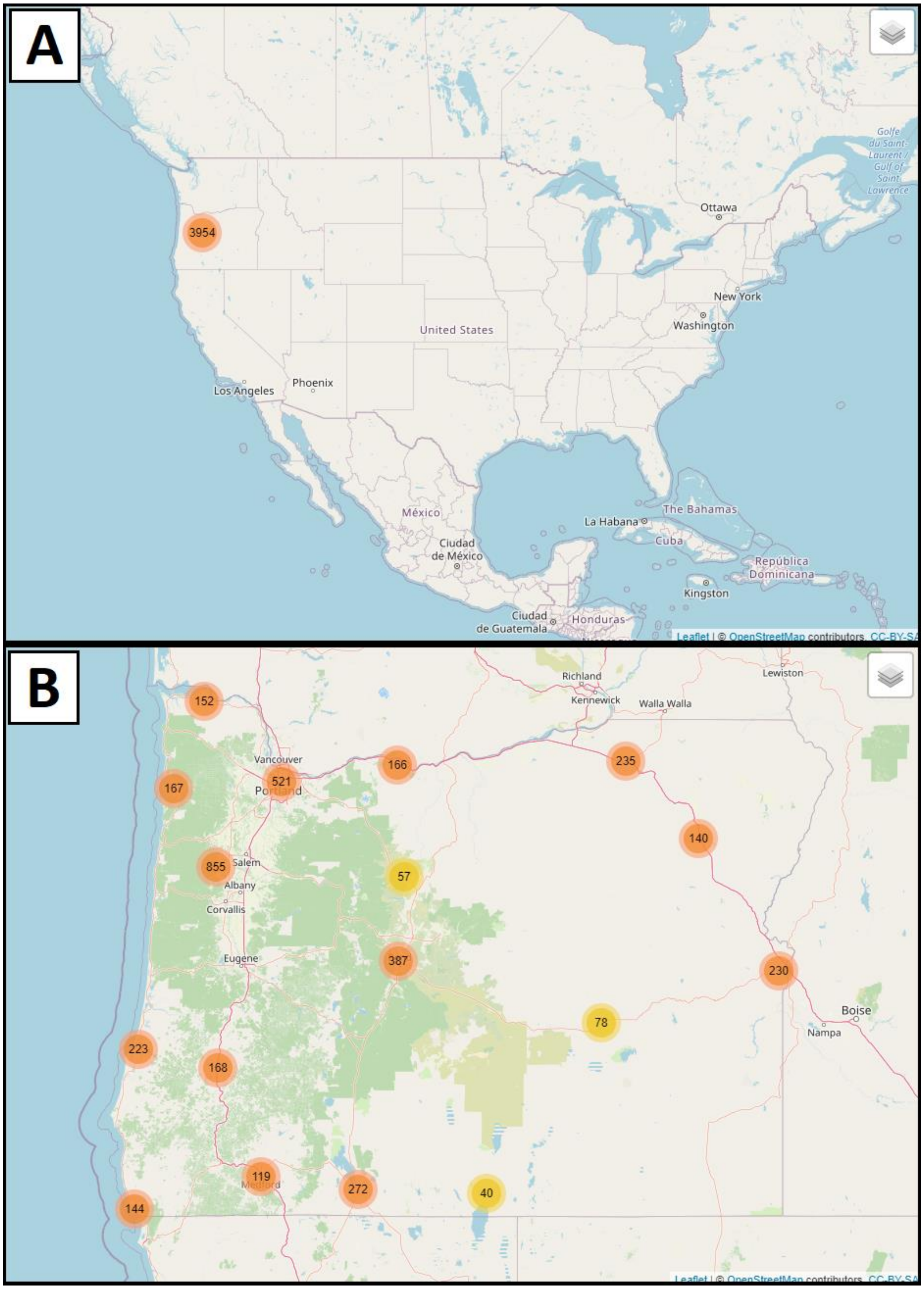

Figure 2. A. Zoomed out view of the United States on the Oregon Water Stories Interactive Map with OpenStreetMap overlay. Bubble-like points are clickable and indicate the number of articles in each location of publication. Bubble indicates a total of 3954 water articles in Oregon. **B.** Zoomed out view of Oregon on the Oregon Water Stories Interactive Map.

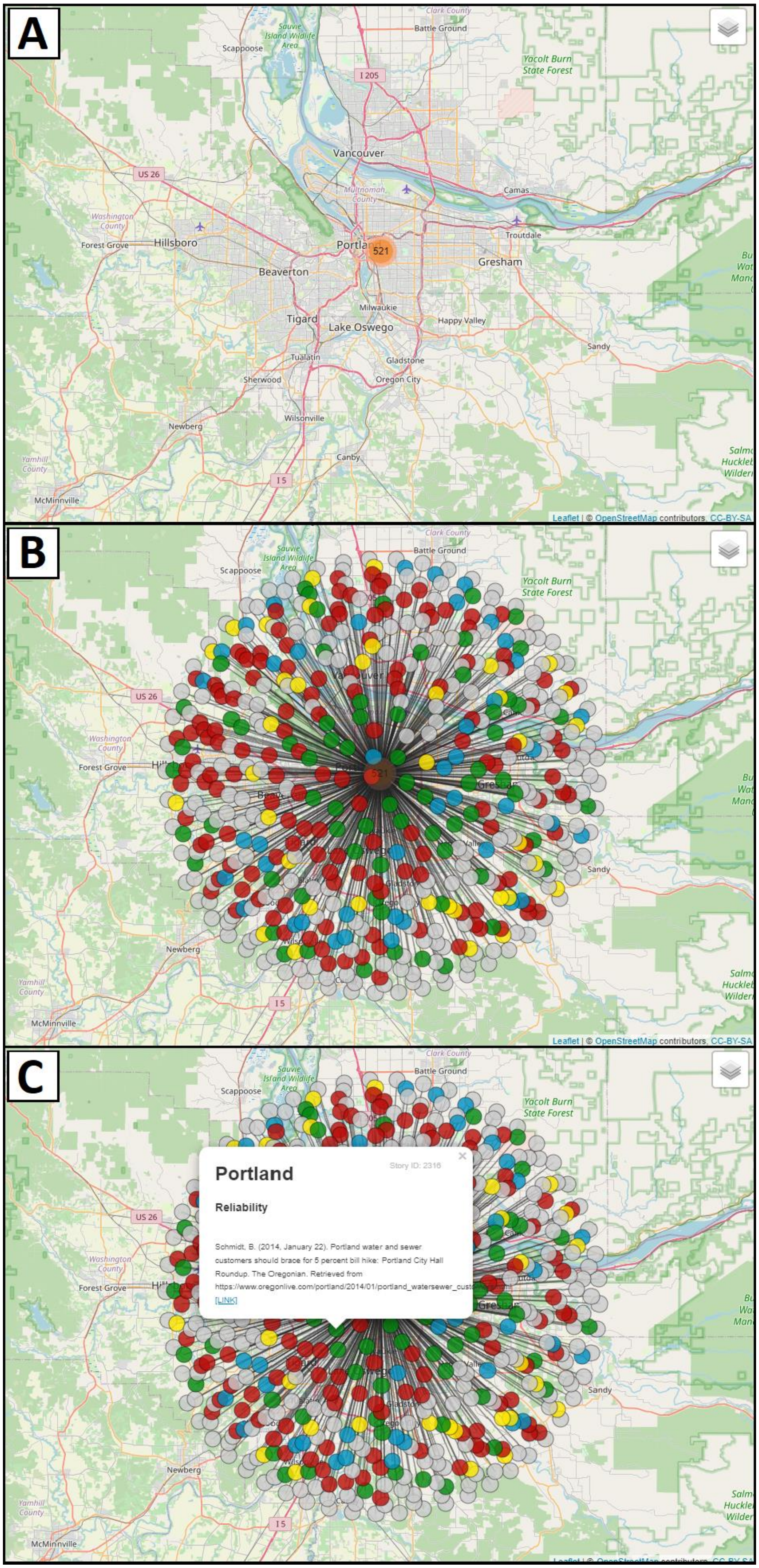

Figure 3. A. Zoomed in view of Portland on the Oregon Water Stories Interactive Map with OpenStreetMap overlay. Clickable center bubble indicates 521 total articles in the matrix that have been published in Portland from 2014-2021. **B. Bubble has been clicked in the middle, showing the full matrix of articles.** 295 articles are color-coded due to being published in Portland and written about issues within Portland. Red articles indicate water safety issues, green dots indicate water affordability issues, blue dots indicate water availability issues, and yellow dots indicate water reliability issues. Gray dots indicate non-coded articles. **C. A green (water affordability) dot has been clicked from the web of articles published in Portland.** This action produces a pop-up of information including city of publication, water security code, full article citation, and clickable link to the complete online newspaper article.

Of the 346 total Portland-based water security articles coded, 161 (~46.53%) were coded 'safety', 83 (~23.99%) were coded 'affordability', 52 (~15.03%) were coded 'reliability', and 50 (~14.45%) were coded 'availability'. Using the COUNTIF function on complete article text, words associated with water safety such as "lead" appear 182 times, "quality" appears 118 times, "safety" appears 78 times, "waste" appears 64 times, "pollution" appears 49 times, "bacteria" appears 46 times, "algae" appears 27 times, and "pesticide" appears 23 times. These results suggest that water quality is the primary concern for Portland.

5. Discussion

5.1 Using the Map: Education and Communication

The water security map can be a useful tool in science communication and education. Similar to interactive maps Environmental Justice Atlas (http://ejatlas.org) or Environmental Justice Screen (https://www.epa.gov/ejscreen), spatially organizing newspaper articles can be used to educate the public, students, or public officials about where water security issues are occurring and what issues are most relevant in those localities. Educators can draw from this tool to understand what water issues are locally important and present real-world and relevant issues to students which establish motivation, improved memory, improved retention, and increased ability to engage in discourse around the content (Breiting & Mogensen 1999; Covitt et al. 2009; Raphael 2019). Addressing real-world and locally relevant issues motivates students to participate in reflection and critical thinking in order to solve problems that are spatially relevant to them, which encourages the development of action competence (Breiting & Mogensen 1999; Covitt et al. 2009). Alternatively, educators can direct students to explore the interactive map and find an article that interests them to research and understand. In that, methods of building action competence such as encouraging students to problem-solve may be assigned by asking students to uncover the history behind a water security issue and brainstorm potential solutions. The interactive map additionally presents a pathway to informing the public about water security issues that may be locally relevant. Though the current map design may benefit from improvements to its design in order to be more publicly informative, outreach initiatives that encourage community members to explore the website and subsequent water stories may improve public engagement in water policy and environmental issues that are impacting their communities.

5.2 Using the Map: Water Quality and Management

Nearly half of all water security concerns in Portland were identified as water quality concerns. Water quality in Portland is unique for multiple reasons. On one hand, Portland's water quality is praised country wide as clean, safe, and pristine glacier water that can be consumed directly from the tap. On the other hand, articles in the database showed that old infrastructure within the city built with pipes containing lead solder has been a major concern for many years. Additionally, a major source of effluent, heavy metals, pesticides and herbicides, and per- and polyfluorinated substances (PFAS) runs directly through the city as Portland's defining environmental feature, the Willamette River. An approximate 10-mile stretch of the Willamette is a designated Superfund site by the Environmental Protection Agency's Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), meaning it contains at least 65 different toxins mostly built up in the river's sediment. Additionally, due to the Willamette's sewage effluent caused by historical infrastructure beneath the city, the river faces frequent algal blooms throughout the warmer months that are toxic to aquatic species, animals, and humans. Information and a temporal understanding of Superfund-related management and response can be observed through analyzing the newspaper articles about the Superfund site over time. Subsequent algal blooms or species mutations in the Willamette, and harm to humans utilizing the Willamette for recreation or sustenance can be analyzed and related back to the designation of the Superfund site. By following articles related to the Willamette River, a story of water quality and disproportionate effects emerges from the database that can be used to tell a story of how the Superfund site became what it is, who or what it has harmed, and who or what it will impact in the future.

For example, themes of environmental justice can emerge when following stories related to the Willamette Superfund. Water pollution in Oregon, especially related to algal blooms and the Willamette Superfund, have long concerned managers of salmon and other native fish populations. The Confederated Tribes of Siletz Indians along with other Indigenous peoples of Oregon for time immemorial have relied on salmon as a first food resource as well as a spiritually, culturally, and economically significant species. Many if not all of the salmon that return upstream to spawn in the Willamette have been impacted by the Superfund pollution (The Confederated Tribes of Siletz Indians N.D.). Some of these impacts include fish mutations and bioaccumulative effects up the trophic web which cause greater ecological dysfunction (The Confederated Tribes of Siletz Indians N.D.). The pollutants subsequently render fish in the Willamette inedible and dangerous to consume. In an Oregonian article from 2016, the Yakama nation’s Superfund coordinator, Rose Longoria, responded to the EPA initial clean-up plan with negative sentiments towards the limited attention to Tribal nations and treaty rights:

> “I was very troubled…and rather surprised…In no way shape or form does the plan address Yakama’s concerns or needs for clean healthy fish. This plan is entirely not protective of Yakama’s treaty resources. Allowing these toxins to remain in the river to be covered up or washed down to the Columbia River is unacceptable, and even more than unacceptable, it is a violation of our human rights and it is a violation of the Yakama Nation’s treaty rights. (Quirke 2016)”

Utilizing community-knowledge and community-perspectives from data such as quotes found in the articles can give context and identify gaps in management response to water security issues. In observing quotes, critical feedback, and patterns of environmental concerns, managers can uncover the communities most impacted by water security issues and focus their response on those communities. Additionally, expanding this map globally would be useful in determining local and community-based water security needs. Environmental managers can use this tool to understand what issues are most relevant to address locally, and redirect efforts towards local concerns. In doing so, understanding the story of particular water security issues through analyzing the newspaper articles can aid managers in avoiding environmental injustice by implementing management and response plans that acknowledge historical drivers and focus on restoring and aiding impacted communities.

5.3 Limitations

Several limitations exist within this study including barriers to repeating this study. Primarily, the process of coding articles individually can take a considerable amount of time. Though the time taken to code the 454 articles within this study's original sample was not recorded, approximately

2-3 minutes was spent reading and coding each individual article based on the water security model, summing to an approximate 16-24 hours of coding. Due to the tedious nature of coding articles, and the nature of other priorities as an undergraduate student, an approximate 3-4 hours of coding could be done per a week culminating to an average of 5-8 weeks to code 454 articles. In addition, due to the nature of human error, miscoded articles may exist.

If this process were to be repeated by an individual in the future with similar time constraints and methodology, the remaining 3,500 articles in the database would take an average of 20-25 weeks to complete at 3 hours of coding per a week, which does not include the initial cleaning of unrelated articles that was performed by Professor Melissa Haeffner, Ph.D. This average illustrates the necessity of automating the process of coding articles in order to cut down on the time it takes to spatially organize and utilize the newspaper articles. A data scraper with a built-in code for cleaning unrelated keywords such as "obituary", and/or assigning codes to articles based on the dictionary of water security phrases would be crucial adaptations to this research. Though the articles contain social themes, terms, and narratives only discernible by a trained sociologist or environmental scientist, automating the process of coding and cleaning would allow more time to analyze social themes across water security groups and better identify environmental justice issues.

Another limitation exists in potential media bias of the newspapers used. Much of the research on environmental issues in media and particularly environmental justice issues has explored the difference in mainstream versus alternative media and media framing (Raphael 2019). A large percentage of the articles analyzed (~69.2%) were scraped and analyzed from the Oregonian, a designated right-center biased newspaper. Conversely, Street Roots and Willamette Week are both well-known alternative newspapers with a general left or left-center bias. Street Roots specifically is well-known for its social and environmental justice reporting. Overall, the higher percentage of Oregonian newspapers may have produced some bias in summarizing the codes.

Finally, limitations in the map design could be addressed in order to improve the functionality and usability of the tool. Adding a pop-up on the side of the map when an article dot is clicked that contains the full article may be useful for navigating paywall barriers, as links to the Oregonian require a paid membership in order to read them. Interactive options could additionally be added into the map, allowing users to turn off certain water security codes (for example turn off all but "Safety") and only view articles that are of interest. Having the articles in a list format on the side, or adding a search bar within the map itself, would similarly allow users to narrow their search when researching a specific code.

6. Conclusion

6.1 Big Picture

This research is the first step in a process of producing a visual learning and communication method for water security in Oregon and globally. This research provides innumerable areas to grow and expand on the map and tool, either by automating the system of gathering and cleaning newspaper articles, or by expanding the map to encompass global narratives. In both cases, expansion of this tool could inform water security responses in the face of global climate change, which may impact our water resources in known and unknown ways. In addition, this tool may be useful in educational, agenda-setting, and management situations which lead to water security solutions and environmental justice. This research additionally highlights gaps in utilizing community knowledge, environmental education, and environmental communication, and offers an opportunity to use pre-existing data for new and environmentally relevant purposes. Lastly, though water quality may be of primary concern for Portland due to the high frequency of safety codes, the water security codes are each interconnected with one another, and all the codes work in tandem to produce water insecurity across Portland. For example, 83 instances of water affordability were calculated, showing that the other water security issues are occurring in Portland and must still be recognized.

6.1 Last Reflections and Remarks

Throughout my time as a student of Environmental Science, I have been introduced to alternative knowledge sources and ways of knowing that are often linked to historical practices of various communities, particularly Indigenous ones. In that, I have encountered the terms "local knowledge", "community knowledge", and "traditional knowledge" to mean something sacred, undeniably intertwined with spatial, temporal, and social contexts, as well as something incredibly beneficial to scientists looking to understand local issues that precede global ones. I offer two lasting remarks: first, that local knowledge and traditional knowledge sources must be received as gifts of knowledge rather than commandeered as to not repeat colonial practices and reproduce white supremacy. I have encountered this fact time and time again from Indigenous friends and scholars, and wish to pass it on in this body of research. Second, in my time as a student and researcher, I understand deeply that community members are extremely knowledgeable, if not just as much as practiced scientists with degrees and certificates. As scientists, we would do well to remember that our titles and training do not make us more than, but instead give us the responsibility to shift power back to those it has been taken from in our endeavors.

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Resources

1. Oregon Water Stories Website and Interactive Map:

   https://www.oregonwaterstories.com/

Appendix

Table 1. Dictionary of keywords for coding articles based on the water security model.

Water Safety	**Water Affordability**	**Water Reliability**	**Water Availability**
Health	Fund	renovation	drought
Quality	Funds	culvert	droughts
Chemical	Cost	renovations	flood
Lead	Costs	repair	floods
Hazardous	Low Income	dam	scarcity
Test	Vulnerable	source	precipitation
Tests	Bills	lines	rain
Temperature	Tax	pipe	snow
Chemicals	Bill	sewer	snowmelt
hazards	Taxes	recharge	rainwater
Testing kit	rate	tide gate	groundwater
Testing kits	rates	tide gates	outflow
advisory	relief	repairs	ice
Notices	payments	infrastructure	tsunami
Notice	moratorium	dams	receding
lead	funding	pipes	recede
mercury	payment	sewers	snowpack
nitrates	rate payer	storage	storms
cyanobacteria	budget	retention	overuse
arsenic	bond	construction	wasting
nitrate		irrigation	depleting
cyanobacterium		restoration	overpumping
Quality		drainage	Shortages
safety		levee	Shortage
safe		dike	aquifer
dangerous		well	

recommendations		wells	
regulations		damage	
recommendation		damages	
regulation		damaged	
fish		overflow	
advisories		Combined sewer overflow	
boil		leak	
protected		leaks	
clean		leaky	
recreation		plumbing	
chlorine		utility	
chloromine		irrigation	
estuarine		canals	
habitat		king tides	
pollution		water rights	
contamination		recycled	
oil spill		desalination	
oil pipeline		reclamation	
cleanup		delivery	
botulism		takings	
clear		permit	
organisms		conserve	
bacteria		conservation	
E. Coli		transfers	
virus		upstream	
parasite		downstream	
toxic		fire	
algae		wastewater	
blooms		drinking	
salmon		water main	
sewage		water main break	
steelhead		reservoir	
tainted			
turbid			
turbidity			
taste			
fluoride			

pesticides			
herbicides			
Superfund			