

Article

Reclaimed Water Use Regulations in the U.S.: Evaluating Changes and Regional Patterns in Patchwork State Policies from 2004–2023

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Abstract: Water reuse, the beneficial use of highly treated municipal wastewater (reclaimed water), is expanding throughout the United States (U.S.); however, there are currently no federal reclaimed water use regulations, only guidelines. As a result, state policies on reclaimed water vary widely, emphasizing the need for a comprehensive understanding to facilitate coordinated national planning. Our systematic literature review, utilizing an online legal research database, presents an updated overview of U.S. reclaimed water policies from 2004 to 2023. A novel categorization scheme tracks policy changes, highlighting a 38% increase in states regulating reclaimed water between 2004 and 2023. We also created maps of current reclaimed water use regulations across the U.S. including: (1) a national overview of the reclaimed water policy landscape; and (2) documentation of non-food crop and food crop irrigation policies. As of November 2023, 74% of states (37/50) intentionally regulated reclaimed water use. Regions with historically low water scarcity, such as the Midwest, exhibited lower participation rates in reclaimed water regulation than water-scarce regions in the West. Of the 37 states regulating direct reclaimed water use in 2023, all allowed for at least some agricultural uses; 23 permitted non-food and food crop production use, while 14 states have statutory allowances for direct reclaimed water use on non-food crop production. As climate change stresses freshwater resources, our work provides up-to-date information for policymakers to navigate existing reclaimed water use policies.

Keywords: reclaimed water; agriculture; reclaimed water policy; water reuse; recycled water; water management



Citation: Thilmany, E.A.; Newton, S.; Goeringer, P.; Rosenberg Goldstein, R.E. Reclaimed Water Use Regulations in the U.S.: Evaluating Changes and Regional Patterns in Patchwork State Policies from 2004–2023. *Water* **2024**, *16*, 334. <https://doi.org/10.3390/w16020334>

Academic Editors: Zhongyang Li and Yuan Liu

Received: 16 December 2023

Revised: 16 January 2024

Accepted: 16 January 2024

Published: 19 January 2024



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1. Introduction

The increasing global demand for freshwater, coupled with climate change-related water stresses such as higher temperatures, sea level rise, and weather events, impact the distribution and quality of water sources [1]. Further, the world's growing population is causing increased freshwater demands, linked to increased food and fiber production [2]. Without more effective management of current water resources, water demand will outpace the U.S.'s freshwater supply, with some states already rationing water among their growers [3]. Agricultural practices, including crop irrigation, account for the most significant global, freshwater withdrawals accounting for an average of 70% of withdrawals [4]. In the U.S., agriculture accounts for approximately 42% of surface and groundwater withdrawals [5]. Water withdrawals for agricultural can have significant impacts on water sources, including groundwater. The Ogallala aquifer in the U.S. stretches from South Dakota to Texas and extensive water withdrawals for agricultural irrigation have led to varying levels of groundwater declines, including one well in Texas with 256 feet (78 m) of

decline [6]. Water's significant role in producing food and energy makes water security a key factor in domestic economic security in the U.S. [3]. Consequently, it is necessary to identify more effective water management techniques and alternative irrigation water sources [3].

Water reuse, the beneficial use of highly treated municipal wastewater (reclaimed water), is a potentially safe and reliable alternative water source for multiple applications [6]. Water reuse is practiced to varying degrees around the world, including in Saudi Arabia, Egypt, Israel, and Spain, among others [7]. The U.S. uses the largest volume of reclaimed water and uses this water for various purposes such as irrigation, silviculture, aquifer recharge, and wetland restoration [7]. Despite not having any regulations in place, the U.S. Environmental Protection Agency (EPA) states in the "2012 Guidelines for Water Reuse" that using reclaimed water for agriculture production is "widely supported by regulatory and institutional policies" [8]; however, the absence of federal reclaimed water use regulations, with only guidelines from the EPA, has led to considerable variability in state-level policies.

This regulatory gap brings forth the significant influence of other federal policies on reclaimed water use at a local level. Some key federal policies impacting state reclaimed water use policies in the U.S. include EPA's National Pollutant Discharge Elimination System (NPDES) permits, the Clean Water Act (CWA) 33 U.S.C. §§ 1251 et seq., and the Food Safety Modernization Act (FSMA) PL 111–353. An example of an application for reclaimed water use impacted by federal policies is wetland restoration. Several states, such as Florida and Pennsylvania, allow the addition of reclaimed water to existing wetlands with limited risk for human contact, but only when the reclaimed water adheres to specific, water quality, treatment standards (Fla. Admin. Code Ann. r. 62-610.554 [9]; PA-BPNSM, 2012 [10]). Wetlands, along with waters associated with interstate or foreign commerce, subsequent tributaries, and other bodies of water, are deemed "waters of the U.S." and are therefore "protected under" EPA's NPDES. Hence, the quality of reclaimed water added to "waters of the U.S." is regulated by federal, state, and local agencies and must be treated to at least secondary treatment levels [8].

Multiple U.S. regulatory agencies encourage reclaimed water use at the federal level. In 2020, the EPA released the National Reclaimed Water Use Action Plan (WRAP) to promote cross-sector reclaimed water use progress. The U.S. Department of Agriculture (USDA) has also expressed interest in reclaimed water use in agriculture through funding opportunities led by the Natural Resources Conservation Service Conservation's Innovation Grants and Foundational and Applied Science Programs [11].

Although there are existing federal programs with some overlapping functions, the regulation of reclaimed water use is predominantly within the purview of individual states, leading to a diverse array of regulations on reclaimed water use across different states [8]. Consequently, the landscape of reclaimed water use regulation in the U.S. is varied and complex. A key example of reclaimed water use policy complexity is the interchangeable use of terms including "reclaimed water", "water recycling", or "reclaimed water use" across state regulations, programs, and other formal documentation [8]. EPA defines reclaimed water as treated municipal wastewater that meets state-specific water quality standards and is intended to be reused for multiple purposes [8]. There are both incidental and direct reclaimed water use policies. EPA defines "incidental", "unplanned", or "indirect" reclaimed water use as "where the intent of the regulations or guidelines (of a state) is to facilitate disposal and reclaimed water use is considered incidental" as compared to "planned", "direct", or "intentional" allowed reclaimed water use [8]. As the interest in direct reclaimed water use grows, complexities emerge as potential sources of conflict [12]. Factors such as the absence of a comprehensive regulatory framework can introduce uncertainty among those seeking to utilize reclaimed water, impeding adoption, and hindering public acceptance [13]. Other differences between states or regions can result in regional-scale challenges, including transporting and consuming products that source

reclaimed water in production across state lines, food safety concerns, and acceptance in different markets [13].

The EPA's "2012 Guidelines for Water Reuse" published the most recent and complete federal government inventory of all state regulations on reclaimed water use in the U.S. [8]. According to the 2012 Guidelines, the EPA found that 17 states had guidelines and 22 states had regulations [8]. Regulations are developed by agencies to implement legislation passed by legislatures. When implementing regulations, agencies will typically need to conform to administrative procedure laws in the respective state, i.e., notice and comment of proposed rules and notice of final rules before implementing the regulations. Typically, an entity following the regulations would need to comply with the regulations to stay in compliance with the law. Guidelines on the other hand are suggestions on how to do something. Guidelines will include all the most recent scientific knowledge on how to best handle the situation. Guidelines are meant to be loosely applied whereas regulations will typically not be loosely applied to situations. For example, the federal guidelines are suggestions to assist the states in developing either their own guidelines for water reuse or regulations to allow for water reuse.

The EPA also published these results with additional updates on their site in 2017, "State Reclaimed Water Use Resources" [14]. In 2021, the WaterReuse Association, the sole trade association in the nation devoted exclusively to promoting legislation, policy development, funding, and public acceptance of recycled water, released "The State Policy and Regulations Map" with U.S. state resources and policies related to reclaimed water use, accessible only behind a membership paywall [15].

In November 2022, the EPA released the "Regulations and End-Use Specifications Explorer" (REUSExplorer Tool) [16] [www.epa.gov/waterreuse/regulations-and-end-use-specifications-explorer-reuseexplorer (accessed on 30 November 2023)]. This tool updates the EPA's previous webpage and provides information on water reuse policies in 35 U.S. states [16]. The REUSExplorer Tool, last updated in February 2023, provides additional resources but does not include a complete inventory of state policies nor a spatiotemporal analysis of the U.S. reclaimed water use policy [16]. While the REUSExplorer Tool lists specific state policies, our study analyzes all current state policies within their geographic context to explain patterns and inform policy decisions to reflect public sentiment best. Additionally, the current study furnishes comprehensive documentation that outlines the methodology for identifying and sourcing state water policies.

A comprehensive and complete review of statewide reclaimed water use policies by state and region is needed, including an analysis of changes over the past two decades. Our study sought to classify intentional state reclaimed water use policies by end-use and analyze trends from 2004 to 2023. We created a novel policy categorization system and developed maps to visualize overall reclaimed water use trends. The database resource developed in this study will address a critical knowledge gap in reclaimed water use policy trends and highlight regions with less direct reclaimed water use policy developments.

2. Materials and Methods

This study is part of CONSERVE (COordinating Nontraditional Sustainable waterER use in Variable climatEs): A Center of Excellence at the Nexus of Sustainable Reclaimed water use, Food, and Health. The mission of CONSERVE is to facilitate the adoption of transformative on-farm treatment solutions that enable the safe use of nontraditional irrigation water, including reclaimed water, on food crops. CONSERVE is assessing the quality of these water sources, developing on-farm water treatment technologies, and analyzing legal, policy, economic, and social constraints to adoption.

2.1. Regulation Search and Initial Categorization

We collected reclaimed water use state policies from the EPA's "State Reclaimed Water Use Resources" webpage [<https://www.epa.gov/waterreuse/state-water-reuse-resources> (accessed on 20 August 2022)] [14] in the Spring and Summer of 2022. Next,

we searched alphabetically for state legal codes on Westlaw, an online proprietary legal research database used by attorneys and legal researchers, using the following search terms in this order: reclaimed water, reclaimed water use, recycled water, reclaimed wastewater, water reclamation, and reuse of reclaimed water. Following the EPA “2012 Guidelines for Water Reuse”, ref. [8] we initially categorized states as follows: reclaimed water use regulations exist, only guidelines exist, and no intentional regulations or guidelines exist. Figure 1 presents the decision tree that classifies states’ reclaimed water use policies.

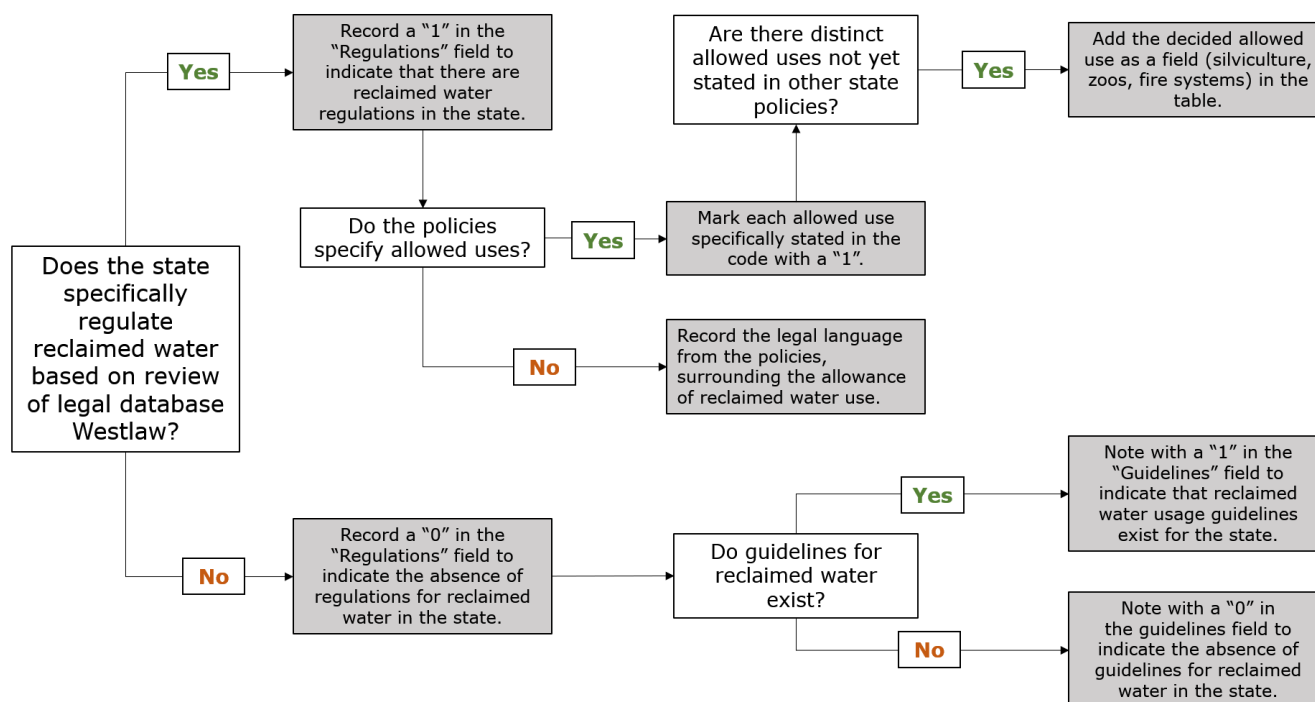


Figure 1. Reclaimed water policy classification flowchart.

Specific allowable direct uses of reclaimed water were recorded for states with intentional reclaimed water use regulations utilizing the most recent legal codes. A total of 10 uses were identified: (1) drip irrigation; (2) surface or spray irrigation; (3) aggregate washing or sieving; (4) discharge into aquifers; (5) landscaping, recreational, or impoundment; (6) non-contact cooling water; (7) fire protection systems; (8) soil compaction or dust control; (9) golf course irrigation; and (10) snowmaking. We also documented instances of disallowed uses of reclaimed water.

Next, we consolidated the regulated, direct allowable uses for reclaimed water into four categories (Table 1). Our categories stemmed from the classes utilized by the U.S. Geological Survey’s (USGS) “Reclaimed Wastewater” [17] and EPA’s reclaimed water use categories in Tables 1 and 2 of the “2012 Guidelines for Water Reuse” [8]. For example, the USGS divides reclaimed water into five categories: “Urban Uses”, “Agricultural Uses”, “Recreational Uses”, “Environmental Uses”, and “Potable Uses” [17], whereas the EPA has seven primary categories: “Urban Reuse”, “Agriculture Reuse”, “Impoundments”, “Environmental Reuse”, “Industrial Reuse”, “Groundwater Recharge”, and “Potable Reuse” [8]. We did not evaluate or classify indirect or direct potable reuse policies in our study. As of November 2023, Colorado is the only U.S. state regulating direct potable reuse from municipal wastewater nationwide [16]. Given the nascent nature and evolving regulatory landscape of direct potable reuse, its examination falls beyond the scope of this study, which centers on more common reclaimed water uses and policies. However, it should be noted that potable reuse is being practiced in other countries including Namibia and Singapore [18].

Table 1. Final reclaimed water use categories (adapted from EPA, 2012 and USGS, 2018).

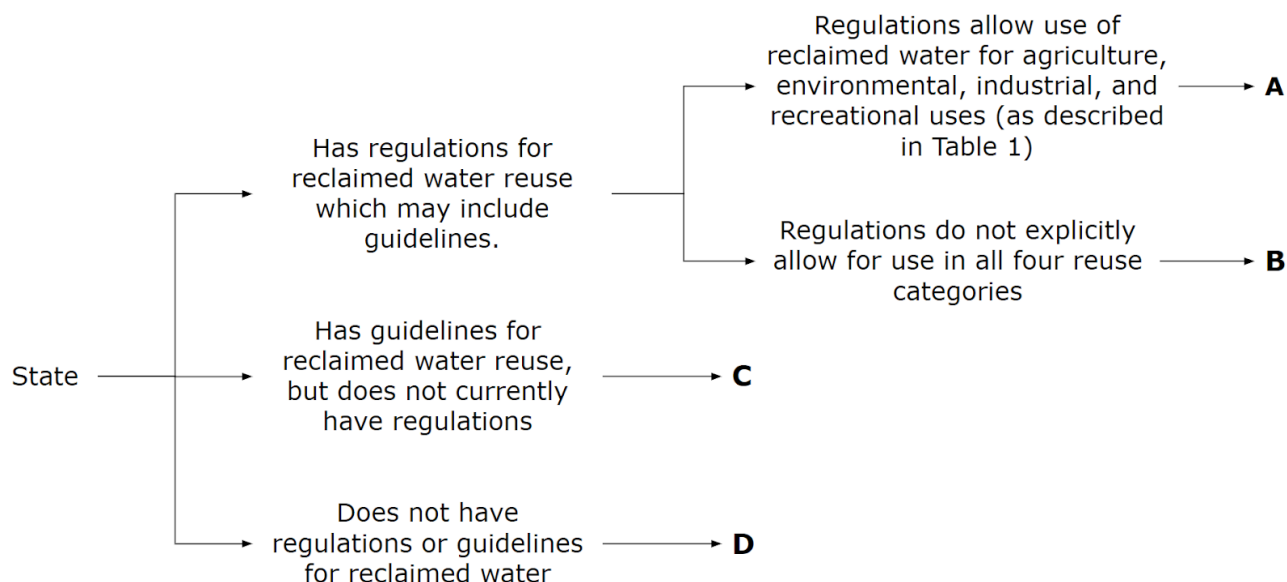
Combined Reclaimed Water Use Category	EPA Category [8]		Summarized EPA Category Description of Reclaimed Water Use [8]	USGS Category [17]	Abbreviated USGS Listed Uses of Reclaimed Water Use [17]	Common, Categorical Examples of Reclaimed Water Uses from State Regulations
Agricultural	Agricultural Reuse	Food Crops	Irrigated food crops that are intended for human consumption.	Agricultural Uses	Pasture for milking animals; Orchards; Food crops not commercially processed; Food crops commercially processed; Ornamental Flowers.	Irrigation of pasturelands for dairy cows; Irrigation of ornamental crops; Land application/irrigation of crops, turf, or trees;
		Processed Food Crops and Non-food Crops	Irrigate crops that are either processed before human consumption or not consumed by humans.			
Environmental	Environmental Reuse		Enhance water features, including wetlands, aquatic habitats, or stream flow, through water reuse.	Environmental Uses	Silviculture; Wetlands; Marshes; Stream augmentation; Aquifer recharge.	Aquifer recharge; Silviculture; Wetland creation and preservation.
	Groundwater Recharge—Non-Potable Reuse		Recharge aquifers not used for drinking water purposes.			
Recreational	Impoundments	Unrestricted	In an unrestricted recreational water impoundment.	Recreational Uses	Golf course irrigation; snowmaking; recreational impoundments with or without public access (such as fishing, boating, or bathing).	Golf course irrigation; Snowmaking; Cemeteries and freeway landscapes.
Urban and Industrial	Industrial Reuse		Water reuse in industry, power generation, and fossil fuel extraction.	USGS does not have an Industrial category		Residential and nonresidential fire protection; Street cleaning; Soil compaction; Closed-loop air conditioning systems; Mixing concrete.
	Urban Reuse	Unrestricted	Urban non-potable water reuse for municipal purposes with unrestricted public access.	Urban Uses	Irrigation of public parks; Street cleaning; Fire protection systems; Dust control.	

Final categories for reclaimed water use are presented in Table 1, incorporating recurring definitions based on state regulations. In our classification scheme, we combined “Industrial” and “Urban” uses into a category titled “Urban and Industrial Uses” because examples provided in the USGS “Urban Uses” category correspond with the EPA’s definitions of “Industrial Uses”, such as reclaimed water usage for air conditioning and recirculating cooling towers. Moreover, we did not distinguish between unrestricted and restricted “Urban Reuse.” We combined the EPA’s “Groundwater Recharge” category in our “Environmental” category because USGS includes aquifer recharge in their environmental reuse definition.

Next, we summarized each state’s categorically allowed uses into overall classes as follows: Class A—deliberately allowed through regulations in each reclaimed water use category; Class B—deliberately allowed through regulations in at least one end-use category; Class C—does not regulate reclaimed water use but has reclaimed water use guidelines; Class D—no direct reclaimed water use policies (no adopted regulations or guidelines) (Figure 2).

Table 2. EPA Region reclaimed water policy participation rates in 2004, 2012, and 2023.

EPA Regions	States within Region	2004 Intentional Regulation Participation Rate <i>n</i> (%)	2012 Intentional Regulation Participation Rate <i>n</i> (%)	2023 Intentional Regulation Participation Rate <i>n</i> (%)	Percentage Change in Regulation Participation Rate from 2012 to 2023 <i>n</i> (%)	Percentage Change in Regulation Participation Rate from 2004 to 2023 <i>n</i> (%)
1	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	1 (17)	2 (33)	4 (67)	2 (33)	3 (50)
2	New Jersey, New York	0 (0)	1 (50)	2 (100)	1 (50)	2 (100)
3	Delaware, Maryland, Pennsylvania, Virginia, West Virginia	1 (20)	2 (40)	4 (80)	2 (40)	3 (60)
4	Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee	3 (38)	3 (38)	5 (63)	2 (25)	2 (25)
5	Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin	1 (17)	1 (17)	4 (67)	3 (50)	3 (50)
6	Arkansas, Louisiana, New Mexico, Oklahoma, Texas	2 (40)	2 (40)	4 (80)	2 (40)	2 (40)
7	Iowa, Kansas, Missouri, Nebraska	2 (50)	2 (50)	2 (50)	0 (0)	0 (0)
8	Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming	4 (67)	4 (67)	5 (83)	1 (17)	1 (17)
9	Arizona, California, Hawaii, Nevada	3 (75)	3 (75)	4 (100)	1 (25)	1 (25)
10	Alaska, Idaho, Oregon, Washington	2 (50)	2 (50)	3 (75)	1 (25)	1 (25)
	All States	19 (38)	22 (44)	37 (74)	15 (30)	18 (36)

**Figure 2.** State reclaimed water use categorization system.

For this study, states with policies focused on water disposal with incidental reclaimed water use are not classified as states that intentionally regulate or have guidelines for statewide reclaimed water use (Class A or Class B) and are instead classified as Class C if they only have guidelines and Class D if they have no deliberate or direct statewide reclaimed water policies. Figure 2 illustrates the classification system scheme.

2.2. Agricultural Reclaimed Water Use Subcategories

States were added to the “Agricultural Reuse” category if they permitted reclaimed water for food or non-food crops. We created agricultural reclaimed water use subcategories for states with direct regulations (categorized as Class A or B above) as follows:

- (1) No intentional regulations or guidelines for reclaimed water use;
- (2) Planned allowance for agricultural reclaimed water use, non-food crop irrigation only;
- (3) Planned allowance for agricultural reclaimed water use, non-food crop, and food crop irrigation.

EPA’s “2012 Guidelines for Water Reuse” defined agricultural reuse of water for food crops as “the use of reclaimed water for surface or spray irrigation of food crops intended for human consumption, consumed raw” [8]. However, each state defined the agricultural reuse of wastewater for food crops differently. Therefore, we chose the 3 categories listed above and included any allowances for agricultural reclaimed water use, even if there were restrictions on crop variety, irrigation timing, treatment level, or irrigation type. For example, California did not permit spray irrigation of food crops allowed for surface and subsurface irrigation, such as edible root crops (potatoes and carrots)” (Cal. Code Regs. tit. 22, § 60304) [19]. In contrast, in North Carolina, agricultural reclaimed water use for food crops was permitted so long as they “will be peeled, skinned, cooked, or thermally processed before consumption”, but not consumed raw (15A N.C. Admin. Code 2U.1401) [20]. For this classification scheme, California and North Carolina were both classified as “Planned allowance for agricultural reclaimed water use, non-food crop, and food crop irrigation”.

2.3. Database

We compiled the reclaimed water use classification system and agricultural reclaimed water use subcategories into an online Google spreadsheet hosted by the University of Maryland, titled “The CONSERVE Map Regulation Projects Reclaimed Wastewater Database”, available at https://go.umd.edu/CONSERVE_map. The database includes internal links hosted by the University of Maryland Google Drive containing PDFs of all state reclaimed water regulatory documents. Figure 3 presents a static version of the database, outlining the following information for all states:

- The state’s associated governing body that oversees reclaimed water use regulations, guidelines, or projects. For states without any regulatory framework on reclaimed water, the governing body that oversees NPDES permits.
- The state’s reclaimed water policy status from the “Overall Summary of States’ Regulations” (Table 4-5) in the EPA’s “2012 Guidelines for Water Reuse” [8] and “Summary of State Reuse Regulations and Guidelines” (Table 4-1) in the EPA’s “2004 Guidelines for Water Reuse” [21].
- An inventory of each state’s water policies through November 2023—Figure 2 illustrates how we classify each state based on the allowed uses of reclaimed water.
- A change in the policy of reclaimed water code adopted from the EPA’s “2004 Guidelines for Water Reuse” [21] from 2004 to 2012 and 2012 to 2023:
 - NC = No change;
 - GR = Guidelines to regulations;
 - NG = No guidelines or regulations to guidelines;
 - NR = No guidelines or regulations to regulations.

CONSERVE Map Regulation Projects Reclaimed Wastewater Database - as of December 2023										
State	State's "Responsible" Governing Body	2004 to 2012 Changes in EPA Water Reuse Policies Inventory	2012 to 2023 Changes in EPA Water Policies Inventory	2023 Intentional Water Policies Inventory	States' Classification based on Allowed Reclaimed Water Uses	Adjusted 2012 Ag Map Distinction Value	2023 Ag Map Distinction Value	Regulatory Document Internal Link	Location of Policies (regulations, codes, guidelines, etc.)	Additional Resources
		Guidelines to regulations (GR), no guidelines or regulations to guidelines (NG), no guidelines or regulations to regulations (NR), no change (NC)		Regulations (R), Guidelines (G), Other		No crop irrigation (0), only non food crop irrigation (1), allows food crop irrigation (2)		Links to a PDF document hosted in a UMD Google Drive Folder		
Alabama	Alabama Department of Environmental Management - Water Division	NC	GR	R	A	0	1	Reclaimed Water Reuse Program (Chapter 335-6-20)	Alabama Environmental Regulations and Laws	Permit Application for Reclaimed Water Reuse (RWR)
Alaska	Alaska Department of Environmental Conservation-Division of Water	NC	NC	Water reuse policies are incidental	D	0	0	Not Applicable		Alaska Water and Sewer Challenge
Arizona	Arizona Department of Environmental Quality (ADEQ) - Recycled Water Rulemaking	NC	NC	R	A	2	2	Reclaimed Water Quality Standards and End Uses (AAC Title 18, Chapter 9)	Arizona Administrative Code	AAC Title 18, Chapter 11
Arkansas	Arkansas Department of Energy and Environment - Environmental Quality - Office of Water Quality	NC	NC	Water reuse policies are incidental	D	0	0	Not Applicable		
California	California Environmental Protection Agency - State Water Resources Control Board	NC	NC	R	A	2	2	Water Quality Control Policy for Recycled Water	California Water Code Water Reuse	Water Recycling Funding Program
Colorado	Colorado Department of Public Health and Environment (CDPHE) - Water Quality Control Division	NC	NC	R	A	1	2	Regulation No.84 - Reclaimed Water Control Regulation (5 CCR 1002-84)	Code of Colorado Regulations	Water quality reclaimed water (reuse) permits
Connecticut	Connecticut State - Water Planning Council	NC	NG	G	C	0	0	Complete State Water Plan	Not Applicable	
Delaware	Department of Natural Resources and Environmental Control (DNREC) - Division of Water - Groundwater Discharges Section	NC	NC	R	A	2	2	7101 Regulations Governing the Design, Installation and Operation of On-Site Wastewater Treatment and Disposal Systems	Administrative Code: Title 7 Natural Resources and Environmental Control	Groundwater Discharges Section
Florida	Florida Department of Environmental Protection (DEP): Water	NC	NC	R	A	2	2	Chapter 62-610 Reuse of Reclaimed Water and Land Application	Rule Chapter on Reuse of Reclaimed Water and Land Application	Florida's Reuse Program
Georgia	Georgia Department of Natural Resources - Environmental Protection Division - Water Protection Branch	NC	GR	R	A	1	1	Indirect Potable Reuse Guidance Document	Rules and Regulations of the State of Georgia	Guidelines for Water Reclamation and Urban Water Reuse
Hawaii	State of Hawaii, Department of Health, Wastewater Branch, Recycled Water Program	NC	GR	R	A	0	2	Volume 1: Recycled Water Facilities - Reuse Guidelines	Admin Rules Title 11	Volume 2: Recycled Water Projects - Reuse Guidelines
Idaho	Idaho Department of Environmental Quality - Water Quality Division	NC	NC	R	A	2	2	§9.01.17 - Recycled Water Rules	Idaho Statutes: Environmental Quality - Health	IDAPA 58 Current Administrative Rules
Illinois	Illinois Environmental Protection Agency - Water Pollution	NC	NC	R	A	1	1	Illinois Design Standards for Slow Rate Land Application of Treated Wastewater	Title 35 Procedural and Environmental Rules	Regulated Recharge Areas
Indiana	Indiana Department of Environmental Management -Water Permitting Branch	NC	NC	Water reuse policies are incidental	D	0	0	Not Applicable		
Iowa	Iowa Environmental Protection Commission	NC	NC	R	B	1	1	Chapter 62: Effluent and Pretreatment Standards: Other Effluent Limitations or Prohibitions	Iowa Administrative Code for the Environmental Protection Commission	Iowa Wastewater Facilities Design Standards - Land Application of Wastewater
Kansas	Kansas Department of Health and Environment-Bureau of Water	NC	NC	Water reuse policies are incidental	D	0	0	KAR 28-16-120. Alternative ultimate disposal.	Kansas Administrative Regulations: Water Pollution Control	Potential Health Effects of Municipal Water Reuse in Kansas
Kentucky	Kentucky Department for Environmental Protection - Division of Water	NC	NC	No regulations or guidelines	D	0	0	Not Applicable		
Louisiana	Louisiana Department of Environmental Quality	NC	NR	R	B	0	1	Louisiana Reclaimed Water Law La. Stat. tit. 30 § 2392	Chapter 17 - Louisiana Reclaimed Water Law	Louisiana Statutes - Environmental Quality
Maine	Maine Department of Environmental Protection - Water Quality	NC	NC	No regulations or guidelines	D	0	0	Not Applicable		
Maryland	Maryland Department of the Environment - Water Reuse Center	NC	GR	R	A	0	2	Code of Maryland Regulations: Water (COMAR 26.08)	Maryland: Division of State Documents: Water	State Water Reuse Laws, Regulations and Guidelines
Massachusetts	Massachusetts Department of Environmental Protection - Division of Water Pollution Control	GR	NC	R	A	2	2	314 CMR 20: Reclaimed Water Permit Program and Standards	Massachusetts Department of Environmental Protection Regulations	Guide: Groundwater Discharge & Reclaimed Water Permitting Process

Figure 3. Cont.

CONSERVE Map Regulation Projects Reclaimed Wastewater Database - as of December 2023										
State	State's "Responsible" Governing Body	2004 to 2012 Changes in EPA Water Reuse Policies Inventory	2012 to 2023 Changes in EPA Water Policies Inventory	2023 Intentional Water Policies Inventory	States' Classification based on Allowed Reclaimed Water Uses	Adjusted 2012 Ag Map Distinction Value	2023 Ag Map Distinction Value	Regulatory Document Internal Link	Location of Policies (regulations, codes, guidelines, etc.)	Additional Resources
		Guidelines to regulations (GR), no guidelines or regulations to guidelines (NG), no guidelines or regulations to regulations (NR), no change (NC)		Regulations (R), Guidelines (G), Other		No crop irrigation (0), only non food crop irrigation (1), allows food crop irrigation (2)		Links to a PDF document hosted in a UMD Google Drive Folder		
Michigan	Michigan Department of Environment, Great Lakes, and Energy-Water	NC	NC	Water reuse policies are incidental	D	0	0		Not Applicable	
Minnesota	Minnesota Pollution Control Agency-Water	NG	GR	R	A	0	2	115.58 Alternative Discharging Sewage Systems	Minnesota Statutes - Water Pollution Controls	Advancing Safe and Sustainable Water Reuse in Minnesota
Mississippi	Mississippi Department of Environmental Quality-Water	NC	NC	Water reuse policies are incidental	D	0	0		Not Applicable	
Missouri	Missouri Department of Natural Resources-Clean Water Commission	NC	NC	R	B	1	1	10 CSR 206.015 No-Discharge Permits	Code of State Regulations	Wastewater Permits
Montana	Montana Department of Environmental Quality	NC	NC	R	A	2	2	Design Standards for Public Sewer Systems	Montana Administrative Rules: Environmental Quality	Gray Water Reuse
Nebraska	Nebraska Department of Environment and Energy - Water Quality Division	NC	NC	Water reuse policies are incidental	D	0	0		Not Applicable	
Nevada	Nevada Division of Environmental Protection	NC	NC	R	A	1	2	Water Pollution Control	Nevada Chapter 445A - Water Controls	Reclaiming Water for Urban Foodsheds: State of Nevada Regulations and Permitting
New Hampshire	New Hampshire Department of Environmental Services (NHDES)-Water	NC	NR	R	B	0	1	Land Treatment and Disposal of Reclaimed Wastewater	Administrative Rules: Environmental Services	Land Treatment and Disposal of Reclaimed Wastewater: Guidance for Groundwater Discharge Permitting
New Jersey	New Jersey Department of Environmental Protection (NJDEP) - Division of Water Quality	GR	NC	R	B	2	2	7:14A-2.15 Reclaimed water for beneficial reuse, NJ ADC 7:14A-2.15	New Jersey Administrative Code	Reclaimed Water for Beneficial Reuse - Technical Guide
New Mexico	New Mexico Environment Department - Water Resources & Management	NC	GR	R	A	0	2	N.M. Admin. Code 20.6.2.3109	New Mexico Administrative Code	NMED Above Ground Use of Reclaimed Domestic Wastewater
New York	New York Department of Environmental Conservation-Water	NC	GR	R	A	0	1	Section 15-0605 Standards for reuse and disposal of reclaimed wastewater	Article 15: Water Resources New York State Legislation	A Survey of Methods for Implementing and Documenting Water Conservation in New York
North Carolina	North Carolina: Environmental Quality - Division of Water Resources - Non-Discharge Branch	NC	NC	R	A	2	2	15A NCAC 02U: Reclaimed Water	North Carolina Administrative Code: Environmental Quality	Waste Not Discharged to Surface Waters
North Dakota	North Dakota Department of Environmental Quality-Division of Water Quality	NC	GR	R	B	0	1	Pretreatment regulations (833.1-16-01.1)	North Dakota Water Commission Administrative Code	North Dakota State Engineer Policy / Procedure for Transfer and Reuse of Wastewater
Ohio	Ohio Environmental Protection Agency	NC	GR	R	B	0	1	Land application systems (OAC Rule #3745-42-13)	Ohio Division of Surface Water - Effective Rules	Ohio- Drinking Water Source Protection and Land Application of Treated Wastewater
Oklahoma	Oklahoma Department of Environmental Quality	NC	NC	R	A	1	2	Title 252. Department of Environmental Quality - Chapter 656. Operation and Maintenance of Water Reuse Systems	Department of Environmental Quality Administrative Code	Title 252. Department of Environmental Quality - Chapter 627. Operation and Maintenance of Water Reuse Systems
Oregon	Oregon Department of Environmental Quality: Water Quality Programs - Recycled Water	NC	NC	R	A	2	2	Chapter 340 Division 55 Recycled Water Use	Department of Environmental Quality - Division Rules	Reusing Water in Oregon - Fact Sheet
Pennsylvania	Pennsylvania Department of Environmental Protection: Bureau of Clean Water - Wastewater Management	NC	GR	R	A	0	2	The Clean Streams Law	Pennsylvania Code	Reuse of Treated Wastewater Guidance Manual
Rhode Island	Rhode Island Department of Environmental Management: Division of Agriculture	NG	GR	R	A	0	1	Application Guidance For Wastewater Reuse Projects	DEM Regulations: Water Resources	RI Water Resources Board
South Carolina	South Carolina Department of Health and Environmental Control-Bureau of Water	NC	NC	R	B	1	1	Regulation 61-9 Water Pollution Control Permits	DHEC Laws and Regulations: Water	Beaufort - Jasper Water & Sewer Authority

Figure 3. Cont.

CONSERVE Map Regulation Projects Reclaimed Wastewater Database - as of December 2023										
State	State's "Responsible" Governing Body	2004 to 2012 Changes in EPA Water Reuse Policies Inventory	2012 to 2023 Changes in EPA Water Policies Inventory	2023 Intentional Water Policies Inventory	States' Classification based on Allowed Reclaimed Water Uses	Adjusted 2012 Ag Map Distinction Value	2023 Ag Map Distinction Value	Regulatory Document Internal Link	Location of Policies (regulations, codes, guidelines, etc.)	Additional Resources
		Guidelines to regulations (GR), no guidelines or regulations to guidelines (NG), no guidelines or regulations to regulations (NR), no change (NC)		Regulations (R), Guidelines (G), Other		No crop irrigation (0), only non food crop irrigation (1), allows food crop irrigation (2)				
South Dakota	South Dakota Department of Environment and Natural Resources: Water Program	NC	NC	G	C	0	0	Recommended Design Criteria Manual Wastewater Collection and Treatment Facilities	Not Applicable	Onsite Wastewater Permit Application
Tennessee	Tennessee Department of Environment and Conservation: Division of Water Resources	NC	NC	G	C	0	0	Not Applicable		Water Reuse: Is Recycled Water a KY or TN Possibility?
Texas	Texas Commission on Environmental Quality - Use of Reclaimed Water	NC	NC	R	A	2	2	Use of Reclaimed Water Title 30 - Subchapter A - Purpose and Scope	Texas Administrative Code for the Texas Commission on Environmental Quality	Domestic Wastewater Permits: The Permitting Process
Utah	Utah Department of Environmental Quality: Division of Water Quality: Water Quality	NC	NC	R	A	2	2	R317-3 Design Requirements for Wastewater Collection, Treatment and Disposal Systems	Utah Administrative Code	R317-13 Approvals and Permits for a Water Reuse Project
Vermont	Vermont Agency of Natural Resources: Department of Environmental Conservation (DEC)	NC	NC	R	A	1	1	Environmental Protection Rules Chapter 14 Indirect Discharge Rules	DEC Rules and Regulatory Summary	Case Study: Cow Water Reuse - Pasteurized Equivalent Water
Virginia	Virginia Department of Environmental Quality: Water Reclamation & Reuse	NR	NC	R	A	2	2	Chapter 740: Water Reclamation and Reuse Regulation	Virginia Administrative Code: Water Reclamation and Reuse Regulation	Frequently Asked Questions About Water Reclamation and Reuse
Washington	Washington State Department of Health-Wastewater Management-Water Reclamation and Reuse	NC	GR	R	A	0	2	Chapter 90.46 RCW Reclaimed Water Use	Washington State Legislature: Reclaimed Water Use	Reclaimed Water Facilities Manual - The Purple Book - Revised Feb 2019
West Virginia	West Virginia Department of Environmental Protection - Water and Waste Management	NC	NC	G	C	0	0	Not Applicable		
Wisconsin	State of Wisconsin - Department of Safety and Professional Services - Plumbing	NC	GR	R	B	0	1	Design, Construction, Installation, Supervision, Maintenance and Inspection of Plumbing	Wisconsin Administrative Code Chapter SPS 382	Water Reuse Pamphlet: Water Reuse Using Water to its Full Potential
Wyoming	Department of Environmental Quality (DEQ) - Water Quality Division	NC	NC	R	A	2	2	Wyoming Water Quality Rules and Regulations - Chapter 3	Wyoming - Administrative Rules Search	Wyoming Water Quality - Chapter 11 - Part H

Last Updated by Elizabeth Thilmany on 11/30/2023

Figure 3. Static version of U.S. reclaimed water use policy online database. Class A: Allowed in all end-use categories by specific regulations; Class B: Allowed in at least one end-use category by specific regulations; Class C: No specific regulations but guidelines for reclaimed water use; Class D: No direct reclaimed water use policies.

For states classified as Class A, B, or C (states having, at minimum, guidelines), the following additional information was included:

- The regulatory document or guideline with a link to a PDF of each policy document referenced for the findings of this research, hosted by a University of Maryland Google Drive, to prevent the loss of access to the documents referenced for this research's findings;
- The 2012 "ag" (agricultural) map subcategory from the EPA's 2012 Guidelines [8] and the 2023 "ag" map subcategory;
- Additional resources like reclaimed water permitting forms, funding opportunities, graywater regulations, and state water plans, among other sources of information for states, are also included.

2.4. Map Development

The online database was developed in Microsoft Excel and included the following fields for each state: state name, state's governing body, state classification, agriculture ("ag") map subclassification, regulatory document title, location of policies, and additional resources. The simplified Excel table was loaded into ArcGIS Pro, becoming the join table layer. In ArcGIS Pro, the "Join" function incorporated the tabular data of state classifications from the join layer into the feature layer (shapefiles of the U.S.). The U.S. state shapefile

boundaries are sourced from the U.S. Census Bureau and represent the official 2021 state boundaries of the states (U.S. Census Bureau, 2021) [22]. We adopted the projections used by the Census Bureau for the state shapefile data, the Global Coordinate System North American Datum of 1983 (GCS NAD83) [22]. The analysis includes shape files only for the 50 states, excluding the 6 U.S. territories and the District of Columbia.

Table 2 presents information on each EPA region [23], the city locations of the “Regional Offices”, a list of states within each region, the total number of states in each region, and the count of states within each region with reclaimed water regulations in 2004, 2012, and 2023. EPA groups states and territories into EPA regions for program management. EPA regions and states contained in those regions can be found in Table 2. A regulation participation rate was calculated by summing the number of states in each EPA region and then dividing by the number of states within each region for 2004, 2012, and 2023. Lastly, we calculated the change in reclaimed water regulation participation rate for each region by subtracting the 2023 calculated participation rate from the 2012 calculated participation rate.

Then, we created a separate map of agricultural uses utilizing the subcategories in 2.2 Agricultural Reclaimed Water Use Subcategories for agricultural reclaimed water use (0, 1, 2). Varying shades of green indicate the agricultural reclaimed water use subcategories. Class C and D states were assigned an agricultural map value of 0 and the color white on the map.

A value of 1 and a light green color was assigned for states with reclaimed water regulations (Class A and B) that solely permitted direct reclaimed water use for non-food crop irrigation. States intentionally allowing both non-food crop irrigation and some form of food crop irrigation were assigned a value of 2 and a dark green color.

3. Results

3.1. Reclaimed Water Use Regulation Changes 2004–2023

As of November 2023, 37 (74%) states had statewide, direct reclaimed water use regulations (Class A and B), 4 (8%) had only guidelines (Class C), and 9 (18%) had no reclaimed water regulations or guidelines (Class D) (Table 2; Figures 3 and 4). EPA Region 7 (Iowa, Kansas, Missouri, Nebraska) had the lowest participation rate (50%) in direct reclaimed water use regulation in 2023 (Table 2; Figure 5). In contrast, in 2023, the Pacific and Mountain West (EPA Regions 8, 9, 10) had the highest reclaimed water use regulation participation rate, with every state, except Alaska, promulgating direct reclaimed water use regulations (Table 2; Figure 5).

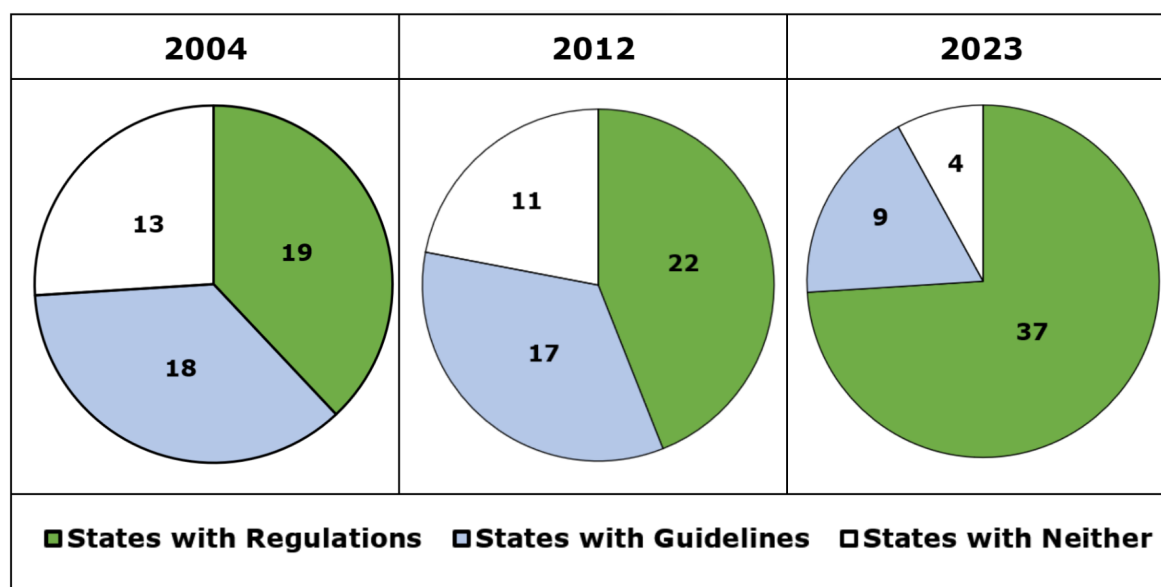


Figure 4. Distribution of states with reclaimed water guidelines or regulations, 2004–2023.

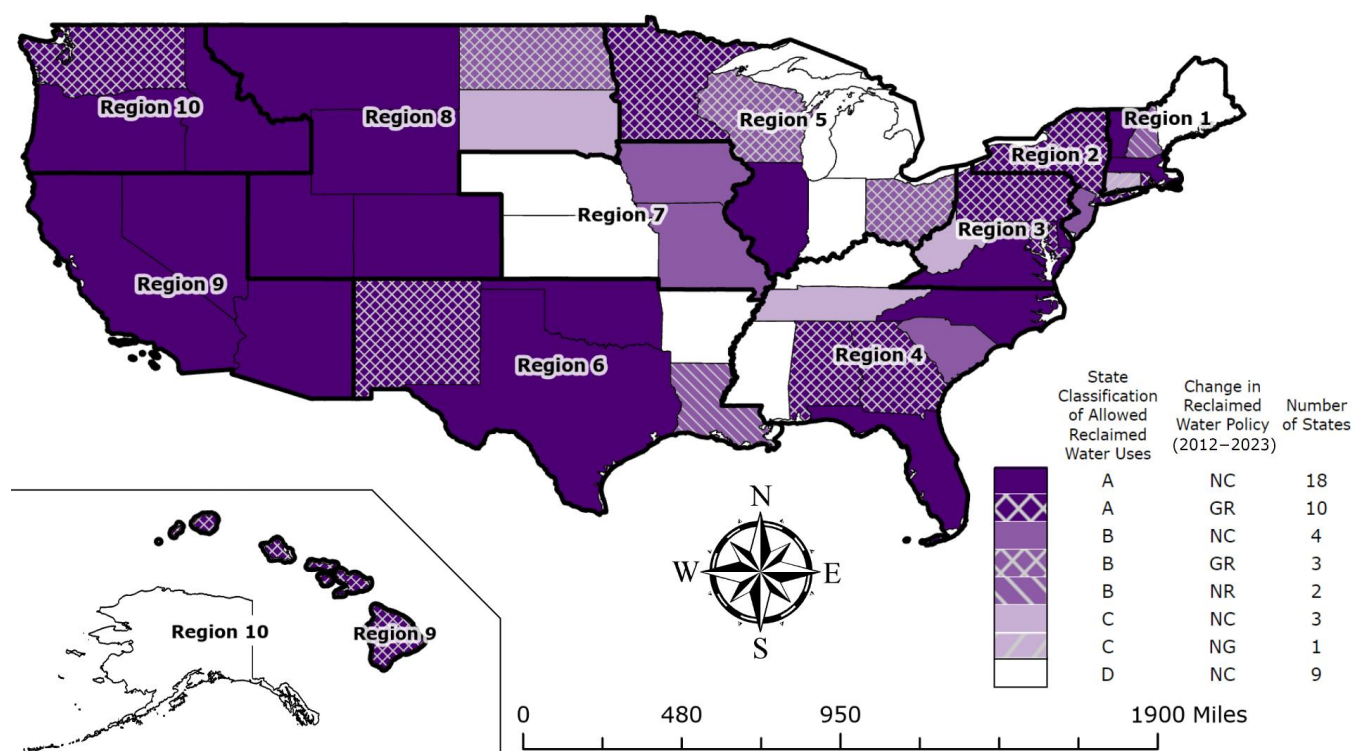


Figure 5. Reclaimed water allowed uses and policy changes from 2012 to 2023. Class A: Allowed in all end-use categories by specific regulations; Class B: Allowed in at least one end-use category by specific regulations; Class C: No specific regulations but guidelines for reclaimed water use; Class D: No direct reclaimed water use policies. GR: Guidelines to regulations; NG: No guidelines or regulations to guidelines; NR: No regulations or guidelines to regulations; NC: No change.

There was a 36% increase in the number of states with reclaimed water use regulation between 2004 and 2023, with a 30% increase in regulation adoption between 2012 and 2023 (Table 2; Figures 4 and 5).

Additional states in every EPA region adopted reclaimed water regulations between 2004 and 2023 (Table 2). Combined, EPA regions 2 and 3 had the most significant regional increase in regulation adoption between 2004 and 2023, with 5 of the 7 states adopting water regulations, resulting in a 71.4% increase in direct reclaimed water use regulations. This combination of regions for analysis is because Region 2 has 2 states (New York and New Jersey).

Further, between 2012 and 2023, 13 states went from guidelines to regulations, 2 transitioned from no policy to regulations, 1 state (Connecticut) moved from having no guidelines or regulations to adopting guidelines, and 34 states did not significantly change their reclaimed water policies to result in reclassification (Figures 3 and 5). Regions 1, 2, 3, and 5 had the highest percentage increases in state participation rates in reclaimed water regulations between 2012 and 2023 (Table 2; Figures 3 and 5).

3.2. Agricultural Reclaimed Water Use Regulation Changes 2004–2023

For agricultural reclaimed water use regulations, in 2023, 23 states allowed for non-food crop and food-crop irrigation, 14 allowed for non-food crop irrigation only, and 13 had no agricultural reclaimed water use regulations (Figures 3 and 6). The 13 states that do not regulate reclaimed water for agricultural use are the same 13 states with no direct reclaimed water regulations (Classes C and D).

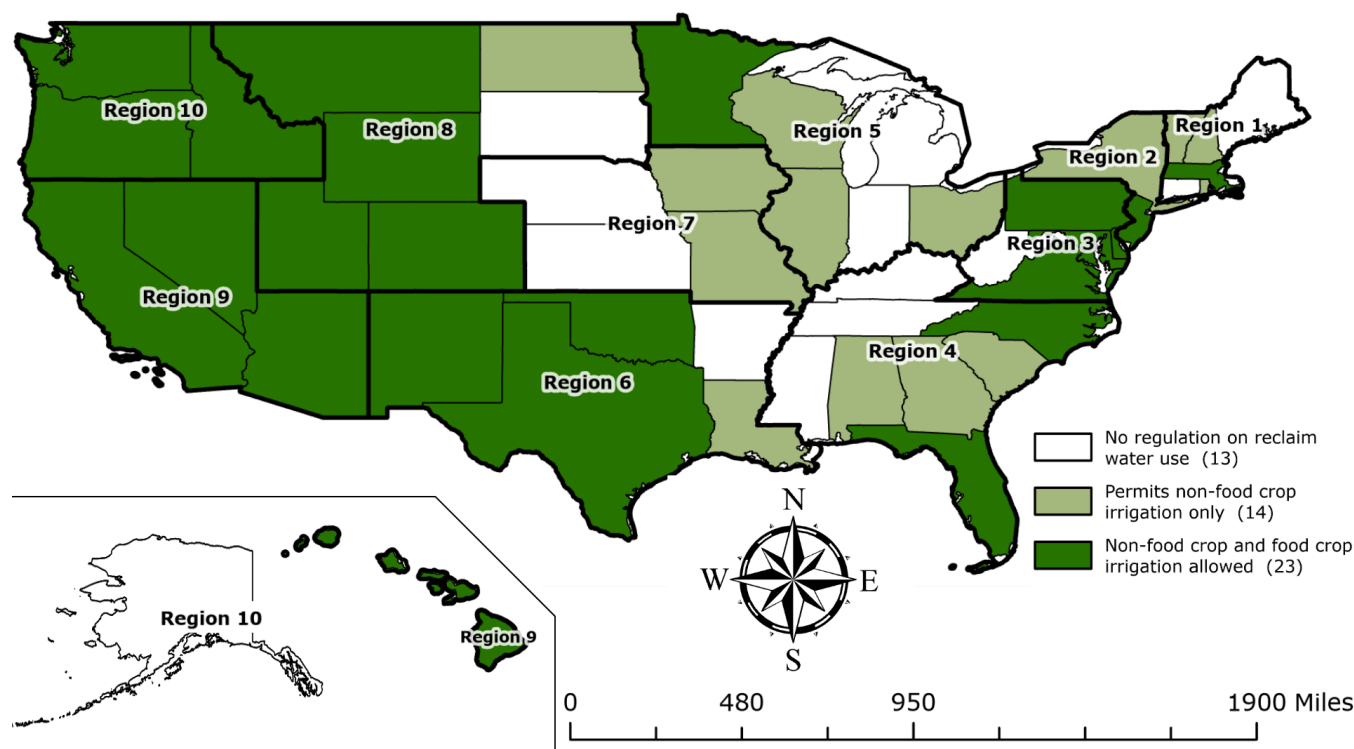


Figure 6. State reclaimed water regulations for agricultural uses in 2023.

Between 2012 and 2023, 7 more states allowed reclaimed water use for food crop irrigation ($n = 16$ in 2012; $n = 23$ in 2023). Of the 16 states in 2012 with regulations allowing reclaimed water use on food crops, all 16 continued to allow reclaimed water use on food crops through 2023. During this period, Colorado updated their reclaimed water use regulations for agricultural use; Colorado allowed for both food and non-food crop use. Further, as of 2012, Oklahoma only allowed reclaimed water use on non-food crops, but by 2023, they updated their regulations (in 2015) to allow for reclaimed water on both non-food and food crops. Hawaii, Maryland, Minnesota, New Mexico, Pennsylvania, and Washington went from reclaimed water use guidelines in 2012 to allowing reclaimed water for non-food crops and food crop irrigation by 2023. All states that allowed food crop irrigation also allowed non-food crop irrigation with reclaimed water in 2012 and 2023.

4. Discussion

There were notable increases in states moving to regulate reclaimed water between 2004 and 2023, with an additional 38% of states ($n = 19$) adopting reclaimed water use regulations during this time. Further, most U.S. states regulate, and therefore legally allow reclaimed water for most use types. Between 2004 and 2023, no state reversed previously implemented guidelines or regulations regarding the use of reclaimed water. States regulating reclaimed water usage for decades (Iowa, California, and Florida) [8] continue to update their reclaimed water policies. Distinct regional variations in reclaimed water use regulations were evident, with EPA Region 5 exhibiting the lowest participation rate in reclaimed water use regulation in 2023.

4.1. Increase in State Reclaimed Water Use Regulations

Since 2004, there has been a remarkable increase in the number of states implementing regulations for reclaimed water use, with the most notable increase occurring between 2012 and 2023 (Table 2). As of 2023, 74% of states intentionally regulated reclaimed water use, and every EPA region had at least 2 states with reclaimed water regulations. From 2012 to 2023, 11 states transitioned from having only reclaimed water use guidelines to establishing

regulations. Previous work by Shoushtarian et al. found that there is great variability in regulation content and standards even among states that have regulations, although most regulations used human health-focused standards [13]. The increase in state water reuse regulations could be due to the need for alternative water resources because of climate change impacts on precipitation and freshwater sources.

In 2016, regions experiencing water scarcity were home to 52% of the world's population, a percentage expected to rise to nearly 57% by 2050 [24]. Increasing temperatures due to climate change can increase evaporation and decrease snowfall, both leading to more droughts [25]. Water demands are also rising by 55%, with 57% of the world's major aquifers in decline, including 56% of groundwater wells in the U.S. Mid-Atlantic region [26]. Furthermore, the National Oceanic and Atmospheric Administration (NOAA) reported a national increase of over 70% in heavy precipitation events in recent decades [27]. Climate change can increase extreme precipitation because as oceans warm there is more evaporation which leads to storm systems increasing over land masses [28]. The Northeast U.S. is anticipated to face more extreme precipitation and droughts [1,29]. In Maryland, annual average precipitation rose by 8.5% from 1991 to 2020. Notably, in 2018, Baltimore experienced double the annual average rainfall, yet the city's longest streak of dry days ($n = 24$) occurred in 2015 [1,27]. Both increasing droughts and extreme precipitation due to climate change can impact water resources. Droughts reduce recharge of groundwater and surface waters, while extreme precipitation leads to erosion and introduction of contaminants to surface water that negatively impacts water quality. Using reclaimed water and other reclaimed water practices holds significant potential to alleviate the future adverse impacts of increasingly unpredictable precipitation events.

4.2. Regional Differences in State-Reclaimed Water Use Policies

Despite the Midwest region having increasingly frequent droughts and drought conditions compared to the Northeast region [30], the South-Midwest regions (EPA Region 4 and 7) (Table 2) had the lowest rate of regulatory participation in reclaimed water use as of 2023. Meanwhile, more states in the Northeast U.S. adopted reclaimed water use policies during the study period. Our results, alongside observed climatic and agricultural trends, indicate a need to encourage geographically targeted reclaimed water use policies. In particular, agricultural reclaimed water use policies in the Midwest U.S.

4.3. Agricultural Reclaimed Water Use

In 2023, agricultural reclaimed water use was permitted in 37 states; 23 states authorized its use for food and non-food crop irrigation. Expanding statewide regulations allowing reclaimed water use in agriculture may correspond with the growing demands for agricultural irrigation. Water withdrawals for agricultural irrigation increased by 2% between 2010 and 2015 [5]. Irrigation accounted for 46% of all freshwater withdrawals to irrigate approximately 63,500 thousand acres in 2015 [5]. One mitigation strategy for states looking to address increased demands on their freshwater sources is to consider allowing and encouraging the use of reclaimed water for agricultural irrigation.

Water scarcity carries economic consequences for agricultural use, particularly impacting major agriculture-producing zones dependent on irrigation. According to the Farm Bureau Market Intel report released in January 2023, 76% of producers indicated that a decline in harvest yields due to drought was either prevalent or more severe in their respective areas during Fall 2022 drought conditions [31]. Producers' bottom lines suffer in drought conditions, while widespread drought conditions in production areas can increase consumer food prices [31]. Globally, countries in the Middle East which often face limited freshwater resources and/or drought conditions reuse large percentages of their wastewater for agricultural purposes. For example, Israel uses 86% of its reclaimed water for agricultural purposes. It is also projected that Middle Eastern countries, along with those in Northern Africa, will face 6–14% in economic losses due to water scarcity [18].

The database of state reclaimed water use policies created in this study can be paired with water demand, agricultural growth, and drought information to guide policymakers on where reclaimed water use could be most beneficial. For example, Nebraska and Arkansas are both excellent candidates to create statewide regulatory frameworks for reclaimed water use, specifically for agricultural use, as seen in Figure 6. Arkansas and Nebraska (both classified as Class D) withdrew a significant amount of freshwater for agricultural irrigation, and many farming operations recorded diminished crop yields attributed to irrigation interruptions [5,32]. For Nebraska, reclaimed water use is indirectly permitted through the NPDES program via land application of treated wastewater for irrigation purposes (119 Neb. Admin. Code § 04) [33]. For additional context, Nebraska is located in the central United States in EPA Region 7 (Figures 5 and 6). The agricultural industry in Nebraska plays a crucial role in the U.S.'s food production. To address water challenges, the Nebraska's Department of Natural Resources has been actively exploring opportunities to reuse water, collaborating with neighboring Missouri to develop a "Voluntary Integrated Management" plan that includes a specific goal category (3.3) to "explore opportunities to reuse water, where feasible" in August 2014 [34]. Due to the current mismatch in the NPDES program, diminished potable water supply, and freshwater water demand by the agriculture sector, Nebraska would benefit from targeted reclaimed water use regulation.

4.4. State and Community Case Studies

Much like Nebraska and Arkansas, Connecticut has no statewide, legally binding, reclaimed water regulations, only guidelines; however, Connecticut examines local reclaimed water initiatives on a case-by-case basis. Connecticut is located in the Northeast U.S. in EPA Region 1 (Figures 5 and 6). For example, the Mashantucket Pequot Tribal Nation and the University of Connecticut have successful water reclamation facilities [35]. Further, the 2019 Connecticut State Water Plan Final Report suggests that these facilities could be models for other operations in the state that also have control over property and accessible treated effluent, such as the Connecticut State University system and large industries [35]. Connecticut is not alone in adopting case-by-case approved projects without statewide reclaimed water regulations. This approach, evident in various states (e.g., Alaska, Maine, and Wisconsin), raises important considerations for developing a more standardized and comprehensive regulatory framework for directly using reclaimed water. However, not all states lacking water reuse regulations take this approach.

In the arid West, states actively champion the utilization of reclaimed water, demonstrating a proactive stance to address water scarcity challenges. California, in particular, has embraced reclaimed water as a secure alternative to fresh or potable water, as outlined in the "Water Quality Control Policy for Recycled Water" (CA-SWRCB, 2018) [36]. This stance is particularly crucial in California, a state that represented 9% of all U.S. water withdrawals in 2015, with nearly three-fourths of its freshwater withdrawals allocated to irrigation [5]. Notably, agriculture irrigation constituted 33%, and landscape irrigation contributed 19% to California's total recycled water usage in 2015 [37]. This highlights the strategic allocation and prioritization of reclaimed water in addressing diverse water needs, emphasizing its significance in sustainable water resource management.

Our study tracked reclaimed water use regulations and guidelines at the state level, yet local communities are going beyond their state's current efforts. For example, local entities (counties, cities, and private utilities) in California, Florida, Washington, and Maryland mandate the utilization of reclaimed water when available in residential or other developments [8].

Expansion of direct reclaimed water use can positively impact water scarcity and poor water quality concerns as reclaimed water is a reliable and highly regulated water source. For agricultural uses in particular, previous research has found that reclaimed water quality is often better than surface water traditionally used in agriculture in the U.S. [38]. Throughout this research process, we discovered a growing trend in researching

and implementing “Environmental reuse.” For example, Pennsylvania’s “Reuse of Treated Wastewater Guidance Manual” [10] asserts that individuals can use reclaimed water to improve natural wetlands, establish artificial wetlands as wildlife habitats, and support or increase streamflow.

4.5. Limitations

There are incidental allowances for reclaimed water use within states that do not explicitly regulate the use of reclaimed water. For our project, we did not include these states in Class A or B as their reclaimed water use policies were not intentional or direct. The EPA also recognizes such cases in the “Summary of State and U.S. Territory Reuse Regulations and Guidelines” table in the EPA’s “2012 Guidelines for Water Reuse” [8].

The most commonly disallowed use of reclaimed water was found to be irrigation for food crops, subject to varying standards and requirements for states permitting the use of reclaimed water in food crop irrigation. To facilitate understanding, we have compiled an up-to-date database housing the regulation documents from each state, eliminating the need for detailed summaries. Instead of summarizing each state’s requirements, we have provided an updated database containing the referenced regulation documents for each state. There was also a need to generalize between each state’s policies to successfully classify and categorize the extent of allowed direct reclaimed water uses. One prime example was categorizing crops as “food” or “non-food.” For example, Florida prohibits spray irrigation of edible (food) crops that were not going to be “peeled, skinned, cooked, or thermally processed before consumption” unless the “application method will preclude direct contact with the reclaimed water” with the following methods of irrigation given as examples: “ridge and furrow irrigation, drip irrigation, or a subsurface distribution system” [9].

Although the specific treatment requirements for reclaimed water varied, it was always the case that the more likely reclaimed water was to come into contact with humans, the more exacting and resource-intensive the treatment requirements were. Accordingly, some states explicitly restricted the methods of irrigation allowed when irrigation of food crops was allowed. In California, reclaimed water used for food-crop production with the possibility of coming into contact with the edible portion of the crop must be “Disinfected Tertiary Recycled Water”, as defined by California as wastewater that is filtered and “subsequently disinfected” [19].

4.6. Future Research

Exploring reclaimed water use policies unveils persistent questions and promising avenues for future research, such as a comprehensive analysis to understand the drivers behind policy adoption, emphasizing the relationships between adoption patterns and the unique water needs of individual states. Further quantifying the increase in reclaimed water regulations can unveil valuable insights, particularly by investigating if a correlation exists between the adoption of water regulations and the availability of water resources across different states.

Introducing a technological facet, the online database consolidates referenced regulations, streamlining future policy analyses. This new tool provides a centralized platform for policymakers, researchers, and stakeholders, facilitating streamlined and comprehensive future analyses of reclaimed water policies.

Moreover, the analysis parallels the interplay observed in state and federal involvement in developing organic standards, reinforcing that the rising tide of state policies can catalyze federal lawmakers to pursue comprehensive national laws [39]. The positive relationship between federal adoption and state activity echoes the intricate dynamics shaping policy landscapes, emphasizing the need for nuanced analyses to comprehend the evolution of reclaimed water regulations fully. This interconnected relationship between state and federal policies, witnessed in the organic production sector [39] through modeling, can be a future study to understand the trajectory of reclaimed water regulations in the U.S.

5. Conclusions

To support the expansion of allowed reclaimed water use in the U.S., we classified and compiled an exhaustive list of state reclaimed water policies in the “Static version of U.S. reclaimed water use policy online database” (Figure 3) for use by researchers, extension educators, public and private utilities, and other stakeholders. The reclaimed water policy database, original classification system, and accompanying maps create a foundation for continued research and policy pursuits regarding reclaimed water use, such as identifying states or regions prime for policy changes or statewide regulatory adoption. Further, the “Reclaimed water allowed uses and policy changes from the 2012–2023” map (Figure 5) is a national snapshot of promulgated regulated direct reclaimed water use allowances. The geospatial component of this research reveals opportunities for states to collaborate in the continued creation and refinement of reclaimed water policies. Our research highlighted specific U.S. states and regions with a high potential for increasing the adoption of intentional state-reclaimed water use policies.

We found that most states regulate and allow for non-food crop irrigation with reclaimed water ($n = 37$; 74%), yet there is still potential for expansion into food crop irrigation with reclaimed water. Increasing scholarship into reclaimed water treatment presents an opportunity for states not regulating or explicitly banning food crop irrigation with reclaimed water sources to consider, especially as agriculture continues to account for a significant percentage of U.S. and global water withdrawals [4].

This study illustrates the growing adoption of reclaimed water guidelines and policies. However, each state’s dynamic reclaimed water policies and resulting allowances for direct reclaimed water use constrain the statutory landscape for reclaimed water use in the U.S. Drawing on the insights from Mosier and Thilmany’s work in 2016 and highlighting the intricate interdependence between state and federal governments, we underscore the evolving landscape of policy development [39]. Their findings, particularly the delayed development of federal rules and the reliance on state standards echo the journey toward comprehensive opportunities for nationwide reclaimed water use. The imperative for increased reclaimed water use becomes more pronounced as climate change further stresses freshwater sources. Thus, the urgency to expand and coordinate reclaimed water use policies intensifies, highlighting the critical role of collaborative efforts in navigating the evolving water management landscape.

Author Contributions: Conceptualization, R.E.R.G., P.G. and E.A.T.; methodology, E.A.T.; software, E.A.T.; validation, E.A.T. and P.G.; formal analysis, E.A.T.; investigation, E.A.T. and S.N.; resources, P.G. and R.E.R.G.; data curation, E.A.T.; writing—original draft preparation, E.A.T. and S.N.; writing—review and editing, P.G. and R.E.R.G.; visualization, E.A.T.; supervision, P.G. and R.E.R.G.; project administration, R.E.R.G.; funding acquisition, P.G. and R.E.R.G. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the United States Department of Agriculture-National Institute of Food and Agriculture, Grant number 2016-68007-25064, awarded to the University of Maryland School of Public Health that established CONSERVE: A Center of Excellence at the Nexus of Sustainable Reclaimed water use, Food and Health. The University of Maryland also supports this work: MPowering the State, a strategic alliance between UMB and UMCP created in 2012 to significantly expand research, business development, and student opportunities at both universities.

Data Availability Statement: Publicly available datasets were analyzed in this study and referenced as Figure 3. The data can be found here: go.umd.edu/CONSERVE_map.

Acknowledgments: We thank Mayhah R. Suri for her help in initially conceptualizing this manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

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