Scientific Research Publishing

Journal of Environmental Protection, 2024, 15, 173-192
https://www.scirp.org/journal/jep
ISSN Online: 2152-2219
ISSN Print: 2152-2197

Implications of *de Facto* Reuse on Future Regulatory Developments for Beaufort-Jasper Water & Sewer Authority in Okatie, South Carolina, USA

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How to cite this paper: Kilgore, T.H., Oza, S., Hatfield, J. and Bell, K.Y. (2024) Implications of *de Facto* Reuse on Future Regulatory Developments for Beaufort-Jasper Water & Sewer Authority in Okatie, South Carolina, USA. *Journal of Environmental Protection*, **15**, 173-192.
https://doi.org/10.4236/jep.2024.152012

Received: January 9, 2024
Accepted: February 26, 2024
Published: February 29, 2024

Abstract

A significant portion of the national water supply can be attributed to *de facto* or unplanned potable reuse, though the extent of its contribution is difficult to estimate. Fortunately, the contribution of Water Resource Recovery Facility (WRRF) effluent to waters that supply drinking water treatment plants has been documented by some communities. In the United States (US), among the top 25 most impacted drinking water treatment plants by upstream WRRF, 16% of the influent flow to the drinking water treatment plant under average streamflow and up to 100% under low-flow conditions is WRRF effluent. Currently, the full extent of *de facto* reuse in the US may be much higher because of population growth. The scenario is no different for Beaufort-Jasper Water and Sewer Authority (BJWSA) in South Carolina, US, with contributions to the Savannah River originating from numerous WRRF and other upstream dischargers. South Carolina coastal utilities such as BJSWA are considering direct and indirect potable reuse options, driven by disposal limitations and challenges. Currently, South Carolina does not have a framework, guidelines, or regulations for reuse, but discussions have started among the regulated community. In addition to understanding the extent of *de facto* reuse, the state will need to develop standards and best practices to enable future adoption of planned potable reuse solutions to water resources challenges. Such guidance should address human health risk management and technical considerations regarding treatment in addition to other factors, including source control, storage, fail-safe operation, monitoring, non-cost factors, and public acceptance. This study conducted a mapping assessment specific to BJWSA, sampled at four locations on Savannah River, and observed that *de facto* reuse is approximately 4.6% to 5.9% during low-flow months and is within the range generally observed nationwide. When coupled with evidence that planned potable reuse can improve human health and environmental risks, this practice is a meaningful option in the water supply portfolio for many utilities.

Keywords

Water Reuse, *De Facto* Reuse, Planned Potable Reuse, Water Recycling, Wastewater Derived Contaminants

1. Introduction

When municipal wastewater effluents are discharged into the aquatic environment, the water reenters the hydrological cycle. Public perception is that rivers and lakes help attenuate wastewater-derived contaminants before use as a downstream drinking water source; however, there is growing acknowledgement globally of this unplanned or *de facto* water reuse scenario as a widespread practice [1] [2] [3]. Factors that determine the concentration of wastewater-derived contaminants in drinking water sources include the type and performance of upstream Wastewater Resource Recovery Facility (WRRF), dilution, residence time in the surface water, and water body characteristics (including depth, temperature, turbulence, water quality, and sunlight exposure). Cities that draw drinking water from rivers with numerous upstream wastewater discharges practice *de facto* water reuse and there is a demonstration that the average percent of the water entering the drinking water treatment plant can be substantial [1] [3]. While drinking water treatment technologies used in these *de facto* reuse locations yield potable water that meets current drinking water regulations, many wastewater-impacted source waters in *de facto* potable reuse locations receive less monitoring and treatment prior to entering the potable water supply than planned potable reuse projects.

1.1. History of Potable Reuse

In 1980, the United States (US) Environmental Protection Agency (EPA) sponsored a workshop on "Protocol Development: Criteria and Standards for Potable Reuse and Feasible Alternatives" [4]. In the executive summary, the chairperson of the planning committee noted that "*A repeated thesis for the last* 10 to 20 *years has been that advanced wastewater treatment provides a water of such high quality that it should not be discharged but put to further use. This thesis when joined to increasing problems of water shortage, provides a realistic atmosphere for considering the reuse of wastewater. However, currently, there is no way to determine the acceptability of renovated wastewater for potable purposes*". This demonstrates that nearly 40 years ago, there was recognition of the importance of reuse for potable purposes and an acknowledgement that what was known about the quality of the treated wastewater was limited.

Since that time, a great deal has changed with respect to our understanding of this concept. The 2012 National Research Council report on water reuse presents a summary of the nation's recent history in water use and shows that although reuse is not a panacea, the amount of wastewater discharged to the environment is of such quantity that it could play a significant role in the overall water resource picture and complement other strategies, such as water conservation [2]. One of the most important themes throughout the report is water reuse for potable reuse applications, including a discussion of both planned potable reuse and unplanned or *de facto* reuse.

Today, water reclamation for non-potable applications is well established, with system designs and treatment technologies that are well accepted by communities, practitioners, and regulatory authorities. While use of reclaimed water to augment potable water supplies has significant potential to meet future needs, planned potable water reuse only accounts for a small fraction of the volume of water currently being reused. However, if *de facto* water reuse is considered, potable reuse is certainly significant to the nation's current water supply portfolio. The unplanned reuse of wastewater effluent as a water supply is common with some drinking water treatment plants using waters from which a large fraction originated as wastewater effluent from upstream communities, especially under low-flow conditions [3] [5]. Thus, the term *de facto* reuse will be used to describe unplanned indirect potable reuse and is becoming increasingly recognized by professionals and the public. Examples of *de facto* potable reuse abound in large cities such as Philadelphia, Nashville, Cincinnati, and New Orleans, which draw their drinking water from the Delaware, Cumberland, Ohio, and Mississippi Rivers, respectively. These communities, and most others using unplanned indirect potable reuse sources, provide their customers with potable water that meets drinking water regulations by virtue of the drinking water treatment technologies used [6].

1.2. Examining a Regulatory Framework for Planned Potable Reuse

As interest continues to increase for planned potable reuse, the lack of specific federal regulations governing potable reuse in the US will continue to be a challenge without some guiding principles. Examining potable reuse internationally, the regulatory approach varies from country to country. Australia, for example, published the Australian Guidelines for Water Recycling in a two-phase effort starting in 2006 [7]. Singapore abides by the drinking water guidelines of the World Health Organization, instead of developing its own set of standards. In the US, the Clean Water Act and Safe Drinking Water Act serve as the framework within which potable reuse is currently implemented and EPA has relied on this successful framework for decades, providing only guidance for reuse, as previously noted.

Regulations refer to laws enacted and enforced by governmental agencies. Consequently, guidelines are not enforceable, but can be used in developing a reuse program. In some states, guidelines are referenced in regulations and are enforceable. In addition to providing treatment and water quality standards, comprehensive rules or guidelines also support reuse by defining the parameters where projects must demonstrate compliance. They provide confidence that if a project meets certain requirements, it will be permitted. While state regulatory programs for water reuse may be more stringent, they must be consistent with other federal and state laws, regulations, rules, and policies.

From a technical standpoint, planned potable reuse is a logical part of the overall water supply and water resources management solution. However, there are projects for planned potable reuse that are technically feasible but are not implemented. In these cases, the barriers to implementing reuse are often institutional, more specifically due to a lack of regulatory structure.

Under the current regulatory status, states are responsible for developing rules or regulations to govern potable reuse practices, and these programs must also comply with existing federal regulations that impact water quality requirements for these applications. The challenge is that while the Clean Water Act and Safe Drinking Water Act provide a framework for potable reuse, the details or policy of implementation for potable reuse projects can be uncertain. Therefore, it is important to understand how these comprehensive rules intersect and to answer the question regarding what is different about planned potable reuse in the context of our current *de facto* practices that have been deemed protective of public health.

The answer to this question is that potable reuse is purposeful in using treated wastewater effluent as a source or partial source to blend with other environmental water. As a result, there is potentially a higher concentration of wastewater-derived microbials and unregulated chemicals that may be present. Thus, understanding the function of an environmental buffer is important such that it can be replaced with an advanced water reclamation facility to provide the treatment to achieve water quality that is as protective of public health as current practices.

1.3. Overarching Principles of a Potable Reuse Policy Framework

A similar policy has been undertaken by the EPA in the Integrated Municipal Stormwater and Wastewater Planning Approach Framework. This framework is a simple, 7-page guidance document that lays out principles and elements of an integrated plan and plans implementation procedures. A proposed potable reuse policy framework would be similar in simplicity and flexibility and address overarching principles that municipalities and states would address in potable reuse plans. These policies would support agencies in meeting treated reclaimed water requirements for providing source water to be used as a drinking water supply:

- Maintain existing regulatory standards and criteria that protect public health.
- Allow a municipality to balance Clean Water Act and Safe Drinking Water Act water quality requirements in a manner that addresses the most pressing water supply and public health issues first.
- Assign responsibility to develop a potable reuse plan with the municipality that chooses to pursue this approach; where a municipality has developed an initial plan, the state or other primacy authority will determine appropriate actions, which may include developing requirements and schedules in enforceable documents.
- Innovative technologies are important tools that can generate many benefits and may be fundamental aspects of municipalities' plans for potable reuse solutions with the appropriate demonstration of those technologies.
- Any potable reuse plan must provide appropriate opportunities for meaningful stakeholder input.

1.4. Clarifications Needed under a Proposed Policy Framework

While there are no federal regulations governing potable reuse in the US, there are also no legal prohibitions against this practice. Potable reuse projects have already been implemented in the nation by using the existing regulatory framework. While the Clean Water Act and Safe Drinking Water Act are federal laws that provide specific water quality criteria and standards, respectively, any rules or regulations specifically for water reuse in the USA are developed at the state level. Thus, it is important to understand how these two Acts intersect for developing requirements for potable reuse. With respect to direct potable reuse, there are several clarifications that are needed [8].

- Assessment of when a treated wastewater discharge is no longer defined as effluent and instead becomes classified as a drinking water source is not apparent. Thus, the objective of clarifying the point at which reclaimed water is classified as a source water could address some of the regulatory challenges of potable reuse.
- Excluded from the definition of "Waters of the United States" are components of engineered waste treatment systems, such as treatment ponds and constructed wetlands. Clarity regarding whether engineered buffers, such as a water storage reservoir, in planned indirect potable reuse scenarios are also exempt from the Clean Water Act provisions is needed.
- EPA and primacy states will determine the appropriate roles of permitting and enforcement for addressing the requirements identified in the plan. For example, determination of whether the potable reuse plan should be incorporated into the National Pollution Discharge Elimination System (NPDES) permit as producing a source water appropriate for water supply; and, as part of the requirements for the drinking water treatment facility as it relates to requirements for source water protection.

- Clarification is needed on the definition of an engineered buffer. For example, if a natural pond or existing reservoir is adapted for indirect potable reuse, it would be of pertinent to local regulatory authorities to have clarity regarding whether the discharge to this water body falls under the Clean Water Act. In another example, if reclaimed water is sent to an engineered buffer only for storage as a drinking water source, then it would be useful to know whether the WRRF should be required to hold an NPDES or some other kind of operating permit.
- In cases where indirect potable reuse is used for groundwater recharge as a source of drinking water, it is not clear whether periodic sanitary surveys should include analysis of the water reclamation facility.

Guidance regarding how these systems should be regulated regarding water monitoring requirements would be helpful to regulatory authorities. While these areas of clarification are immediately notable, there are other questions that will emerge during the process of development of a proposed framework policy. A proposed path forward should include flexibility to document and explore opportunities for additional clarification.

1.5. Policy Considerations

While there are no federal regulations governing potable reuse in the US, the Clean Water Act and Safe Drinking Water Act serve as a framework for states to develop their own rules or guidance within which all reuse is currently implemented [8] [9]. The EPA has relied on this framework with water reuse guidance to address additional minimum recommendations for *de facto* potable reuse for decades. For surface water, permitting return flows of reclaimed water is conducted through the NPDES, a permit program authorized to state governments by EPA and a provision of the Clean Water Act. Additionally, return flows to groundwater are permitted through the Underground Injection Control Program, which is a provision of the SDWA. If additional standards or criteria are needed for potable reuse, these are developed, implemented, and enforced by individual states that have primacy under these programs. Other southeast states, including Georgia, North Carolina, and Tennessee have taken a similar approach to addressing this water management strategy—leveraging the existing regulatory framework.

North Carolina. In 2016, North Carolina passed legislation making planned potable reuse “legal” in that state. This legislation was drafted following a study in the Neuse River, which exemplifies a typical *de facto* potable reuse scenario where drinking water sources are located downstream of treated wastewater effluent discharges. The study results implied that planned potable water reuse might provide better control over water quality than the documented *de facto* conditions [10]. Today, North Carolina approves the use of the “highest reclaimed water effluent standards established by the Commission” as a source water for drinking water treatment plants in a way that is “both environmentally acceptable and protective of public health" (N.C. Gen. Stat. §143-355.5). While the state statute outlines requirements for indirect potable reuse, there is no specific reference to "potable reuse" in the North Carolina state regulation for reclaimed water (15A N.C. Admin. Code 02U). In effect, a local water system can combine reclaimed water with other raw water sources before drinking water treatment if several conditions are satisfied under the statute (N.C. Gen. Stat. §143-355.5), as follows:

"1) *The reclaimed water use is not permitted for compliance with flow limitations imposed by a permit issued pursuant to G.S.* 143-215.1(a4) (1).

2) *The reclaimed water and source water are combined in a pretreatment mixing basin owned and controlled by the drinking water supplier from which water is pumped to the water treatment plant.*

3) *The pretreatment mixing basin is sized to hold a minimum volume corresponding to five days' storage at the authorized operating capacity of the water treatment plant under normal operating conditions.*

4) *The pretreatment mixing basin design and pumping infrastructure incorporate features to ensure mixing of reclaimed water and source water.*

5) *The reclaimed water is treated to comply with the highest reclaimed water effluent standards established by the Commission.*

6) *The average daily flow of reclaimed water into the pretreatment mixing basin, as measured over a* 24-*hour period, is no more than twenty percent* (20%) *of the sum of the average daily flow of source water and reclaimed water, as measured over the same* 24-*hour period, into the pretreatment mixing basin.*

7) *The local water system has implemented conservation and efficiency measures designed to achieve water use reductions.*

8) *Unbilled leakage from the local water system is maintained below fifteen percent* (15%) *of annual average potable water consumption of the local water system.*

9) *The local water system has a master plan that evaluates alternatives for reclaimed water use.*

10) *The local water system provides public notice to potable water recipients with opportunity for public participation.*

11) *The potable water supply provided pursuant to this subsection shall comply with all State and federal laws for the provision of safe drinking water.*

12) *Any discharge into the waters of the State must be pursuant to a permit issued under G.S.* 143-215.1."

All drinking water in the US must meet Safe Drinking Water Act requirements, including its implementing regulations (40 C.F.R. § 141) for chemical and microbial contaminants; and pollutant discharges from a point source for surface water augmentation require a federal NPDES permit (40 C.F.R. § 122). Thus, leveraging this framework, North Carolina does not define or require additional water quality criteria for indirect potable reuse.

Georgia. Like North Carolina, the Environmental Protection Department acknowledges the importance of indirect potable reuse and the role that it plays in bridging a gap between water needs and availability, while utilizing technology to address any challenges that may arise due to the connectivity of these systems. As a result, the Georgia Environmental Protection Department has taken a pragmatic approach to potable reuse, specifically in cases where discharge of treated wastewater into surface water by one entity impacts the downstream drinking water source of another entity, *i.e. de facto* reuse. When faced with this scenario, Georgia Environmental Protection Department recognizes that integrating existing permitting processes is necessary and instead of developing separate regulations, has developed a guidance document for providing information to users about leveraging existing regulatory processes when the proposed project is classified as indirect potable reuse. *The Georgia Indirect Potable Reuse Guidance Document* (October 2022, Version 3.0), specifically outlines considerations to ensure protection of human health and aquatic life while continuing to manage water supply resources in a sustainable, equitable, and safe manner through transparent processes and procedures [11] [12] without imposing additional water quality criteria beyond those required under existing regulations.

Tennessee. Like Georgia, Tennessee explicitly acknowledges that *de facto* potable reuse occurs as documented in the Tennessee's Roadmap to Securing the Future of Our Water Resources [13].

"*In Tennessee, de facto reuse has essentially always occurred whether we chose to acknowledge it or not. Non-potable reuse is a relative newcomer to Tennessee, and the various forms of potable reuse are still currently on the horizon in our State. Other states with considerable water supply challenges like California, Texas, Florida, and Georgia are currently in various stages of adopting and regulating potable water usage, and it is just a matter of time before Tennessee faces the same challenge.*"

While the state recognizes the fact that potable reuse is on the horizon, and cities like Franklin, Tennessee are pilot testing and permitting reclaimed water discharges into waters that are designated as domestic water supply sources [14], the Tennessee Department of Environment and Conservation has only published rules related to non-potable reuse. Interestingly, the Tennessee rules of the Division of Water Resources, Chapter 0400-40-05, for Individual National Pollutant Discharge Elimination Permits, in section 0400-40-05-05 Permit Application, Issuance, states that "*Applicants proposing a new or increased discharge of pollutants to surface waters shall include in the application a consideration of alternatives, including, but not limited to, land application, beneficial reuse of the wastewater, and, for proposed increased discharges, reduction of inflow and infiltration*". Thus, because there are only non-potable reuse rules that have been promulgated, the approach to planned potable reuse, while not specifically stated in the Tennessee rules is to leverage the framework of the Clean Water Act and the Safe Drinking Water Act to support communities that have the technical, managerial, financial capabilities to advance planned potable reuse where stakeholder engagement has cleared the path for implementation.

1.6. Considerations for South Carolina

In response to regulations and recent wastewater permitting actions in South Carolina related to nutrient discharges and water quality classifications, numerous utilities have identified planned potable reuse as a strategy in an integrated portfolio of water management options. While South Carolina has ample drinking water sources now, disposal options are limited, especially on the coast. When higher levels of treatment are required for discharging effluent, it is possible that the effluent could have a higher quality than drinking water supplies that are impacted by *de facto* reuse—particularly where multiple small dischargers that are not typically held to stringent discharge standards dominate effluent flows to the receiving water body. To demonstrate this concept, a point-in-time surveillance study was conducted to document the extent of *de facto* reuse in the Savannah River. Data from the river, which is a source of supply for the BJWSA Chelsea and Purrysburg Water Treatment Plants (**Figure 1**) were compared to effluent from one of the BJSWA WRRF that discharge to the Savannah River and could serve as a source for reuse water.

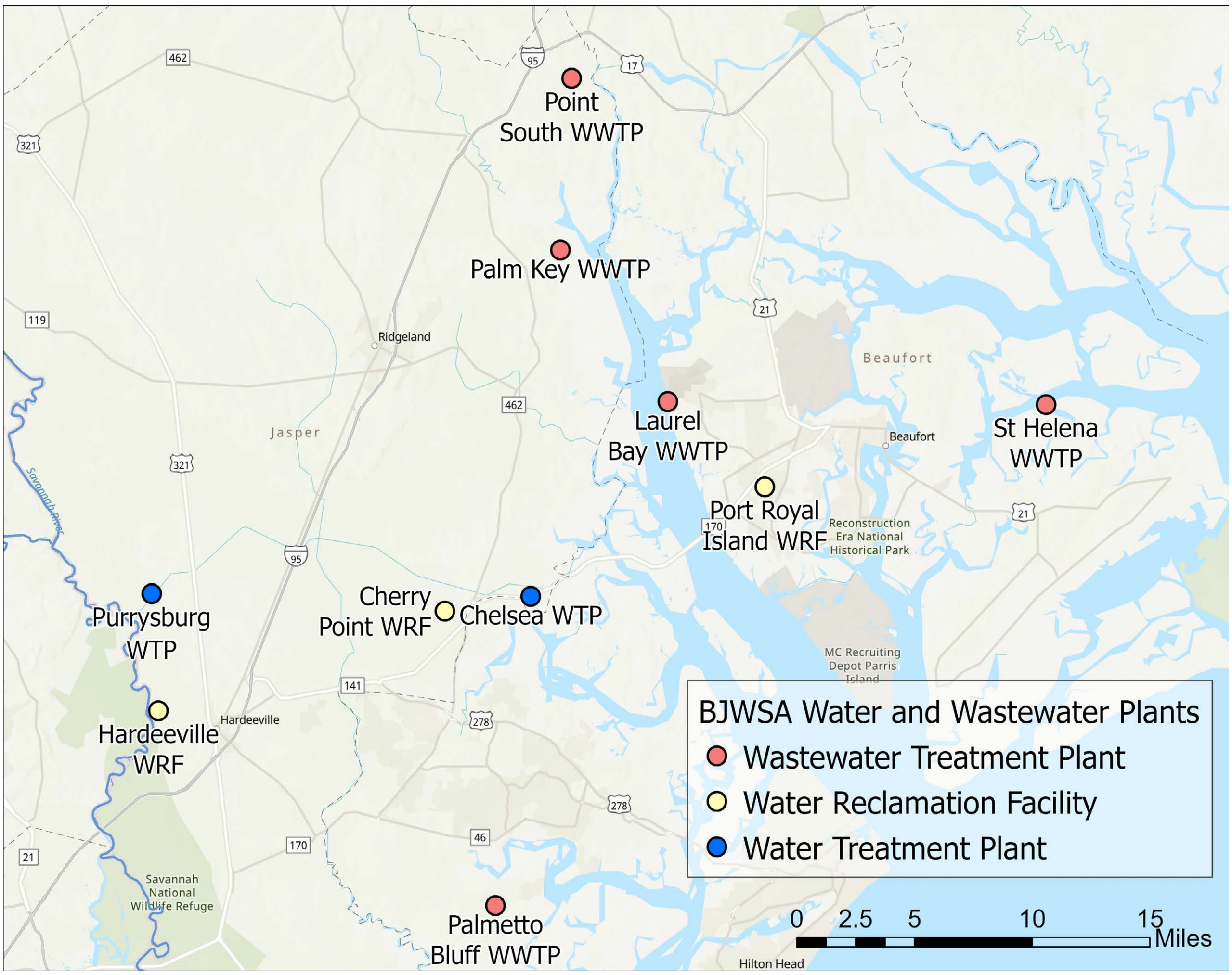

Figure 1. Water and WWTP of BJWSA.

The Savannah River Basin is in eastern Georgia and western South Carolina and defines the state boundary between these two States. The river basin spans 10,577 square miles, of which 5821 square miles is in Georgia, 4581 square miles in South Carolina and 175 square miles is in North Carolina [15]. The Savannah River water quality is satisfactory for most designated uses, including its current use as a drinking water source; however, there is evidence of anthropogenic impacts throughout the basin. The river has areas of low dissolved oxygen, historical polychlorinated biphenyl contamination, and elevated nutrient, chlorophyll a, copper, and zinc concentrations [11]. The degree of impact of wastewater effluent discharge on the Savannah River has not been specifically quantified and published to date.

Considering the potential discussion around planned potable reuse for BJSWA, a key objective was to inform a policy discussion around the impacts of NPDES dischargers on the BJSWA drinking water supply in context of the ongoing *de facto* reuse and assess whether planned potable reuse could be viable in this basin.

2. Materials and Methods

Because the sampling event was conducted as a point-in-time surveillance study, timing of sampling was carefully considered by evaluating the flow rate of the Savannah River. Several US Geological Survey (USGS) flow gauges were used to obtain historical and real-time flow data for the Savannah River (**Figure 2**); USGS gauges 2,197,000 and 2,198,500 were chosen to inform the evaluation because extensive historical data are available for these gauges. Flow data were obtained from January 1, 2018, through December 31, 2022 (**Figure 3**) and analyses of the data indicated a seasonal trend, with the lowest flow in fall and the highest flow in spring (**Figure 4** and **Figure 5**). To align sampling with a low-flow scenario, sampling was conducted on November 1, 2022, at four locations:

- Savannah River at Elijah Clark State Park (upstream of BJWSA water treatment plants).
- BJWSA's intake for drinking water on the Savannah River.
- Hardeeville Water Reclamation Facility—effluent, which is discharged to the Savannah River.
- Savannah River downstream of Hardeeville effluent discharge.

Samples were collected and shipped on ice to Eurofins Laboratory, Monrovia, California, US for analyses of one hundred and four Pharmaceutical and Personal Care Products (PPCPs) as presented in **Table 1**. Solid-phase extraction coupled with high performance liquid chromatographic separation in combination with highly selective electron spray ionization tandem mass spectrometry was used to measure PPCP. For the compounds ionizing in the positive ion mode Sciex Triple Quad 7500 mass spectrometer and Shimadzu LC40 for liquid chromatography was adopted. For the compounds ionizing in the negative ion mode Sciex Triple Quad 5500+ mass spectrometer and Sciex ExionLC for liquid

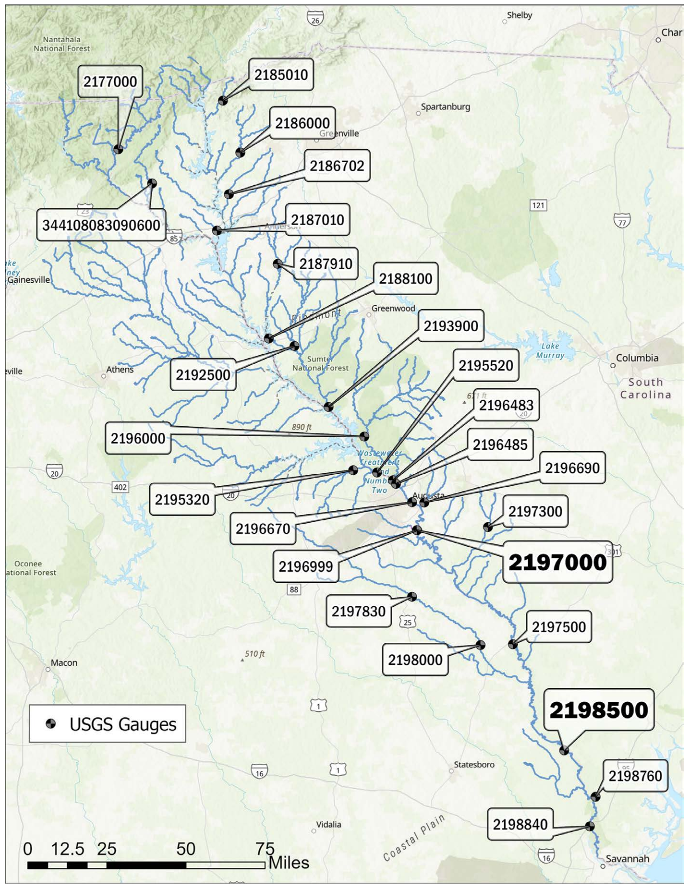

Figure 2. USGS gauges along the Savannah River.

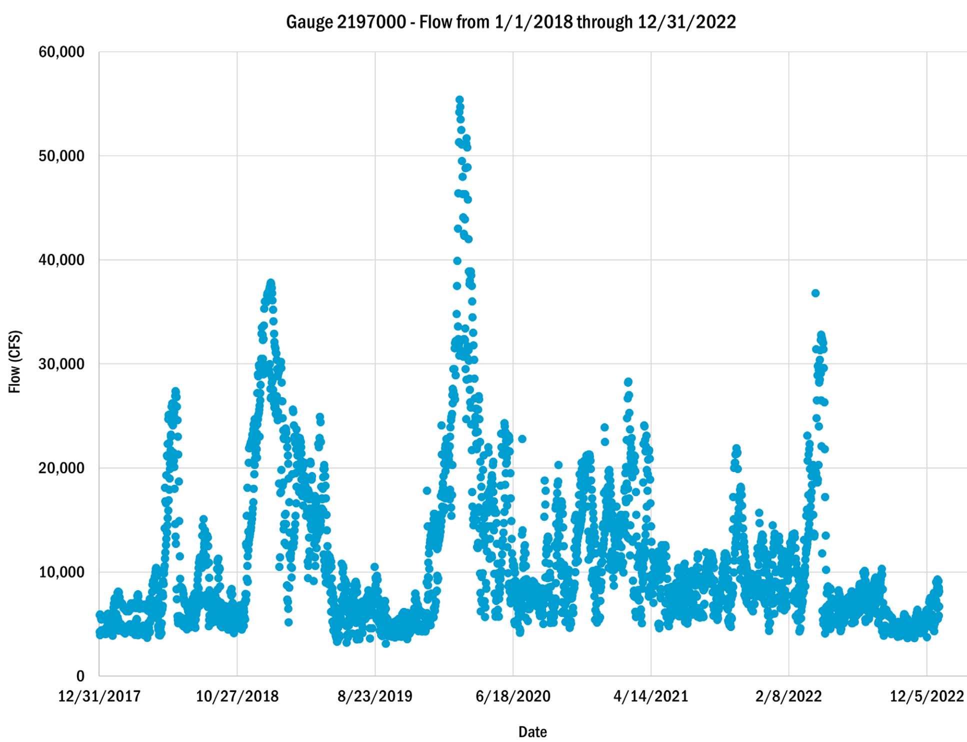

Figure 3. Flow data for gauge 219,700 from 2018 through 2022.

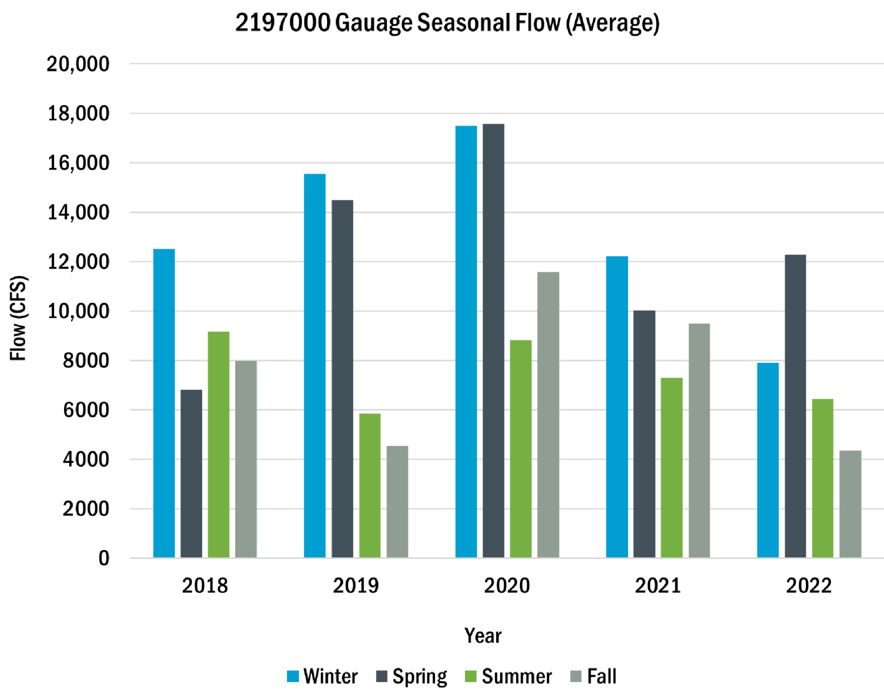

Figure 4. Seasonal trend of Savannah River based on the gauge 2,197,000.

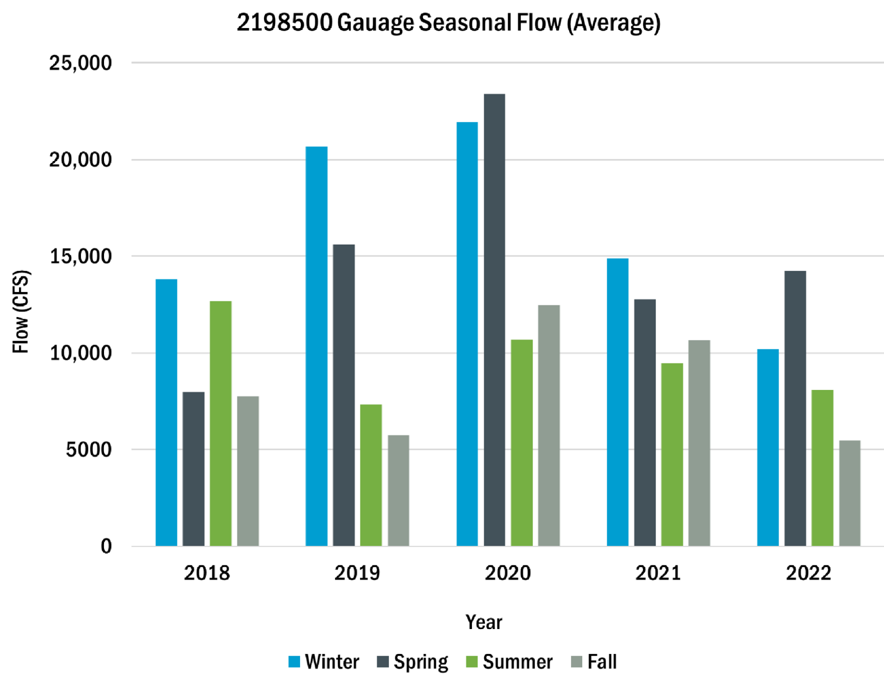

Figure 5. Seasonal trend of Savannah River based on the gauge 2,198,500.

chromatography was adopted. Matrix effects were corrected by using isotopically labeled standards when available.

3. Results

The EPA Enforcement and Compliance History Online website was referenced

Table 1. PPCP analyzed.

1,7-Dimethylxanthine (Paraxanthine)	Clofibric Acid	Isobutylparaben	Propanolol
17a-Ethinylestradiol	Codeine	Isoproturon	Propazine
1H-Benzotriazole	Cotinine	Ketoprofen	Propylparaben
2,4-D	DACT	Ketorolac	Quinoline
4-Nonylphenol	DEA	Lidocaine	Salicylic Acid
4-Tert-Octylphenol	DEET	Lincomycin	Simazine
Acesulfame K	Dehydronifedipine	Linuron	Sucralose
Acetaminophen	DIA	Lopressor	Sulfachloropyridazine
Albuterol	Diazepam	Meclofenamic Acid	Sulfadiazine
Amoxicillin	Diclofenac Acid	Meprobamate	Sulfadimethoxine
Androstenedione	Dilantin	Metazachlor	Sulfamerazine
Atenolol	Diltiazem	Metformin	Sulfamethazine
Atrazine	Diuron	Methadone	Sulfamethizole
Bendroflumethiazide	Epitestosterone	Methylparaben	Sulfamethoxazole
Bezafibrate	Erythromycin	Metolachlor	Sulfathiazole
BPA	Estradiol	Morphine	TCPP
Bromacil	Estriol	Naproxen	TDCPP
Butalbital	Estrone	Nifedipine	Testosterone
Butylparaben	Ethylparaben	Norethindrone	Theobromine
Caffeine	Flumequine	Sulfometuron, Methyl	Theophylline
Carbadox	Fluoxetine	Oxolinic Acid	Thiobendazole
Carbamazepine	Gemfibrozil	Oxybenzone	Triclocarban
Carisoprodol	Hydrocodone	Pentoxifyline	Triclosan
Chloramphenicol	Ibuprofen	Phenazone	Trimethoprim
Chlorotoluron	Iohexol	Primidone	Venlafaxine
Cimetidine	Iopromide	Progesterone	Warfarin

to evaluate all major (flow > 0.1 Million Gallons per Day (MGD)) and minor (flow < 0.1 MGD) NPDES dischargers to the Savannah River and tributaries that impacted the four sample locations, as shown in Figure 6. There were a total of 57 NPDES dischargers with a combined flow of 153 MGD to the Savannah River. Of the 57 dischargers, 25 were major dischargers contributing 68.8 MGD (45.1%) and 32 were minor dischargers contributing a flow of 83.9 MGD (54.9%) of treated effluent to the flow of the river. During fall of 2022, flow in the Savannah River varied from 2600 MGD to 3300 MGD. Considering reported NPDES flows of 153 MGD, the calculated *de facto* reuse ranged from 4.6% to 5.9%. This is consistent with other studies that indicate that the *de facto* reuse in the USA averages 1% to 15% [3].

Results for the percentages of the 104 PPCP detected at each site are provided

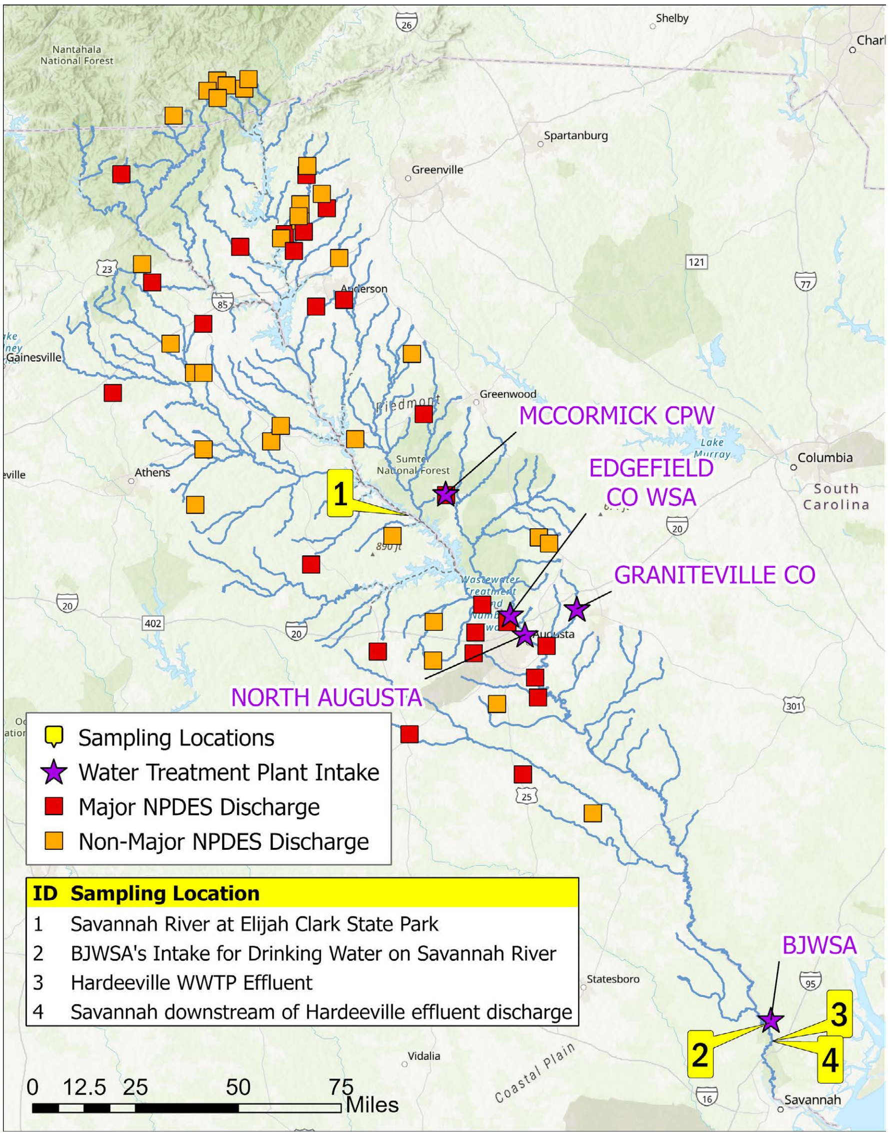

Figure 6. Sampling locations, water treatment plant intakes on Savannah and its tributaries, along with major and minor NPDES dischargers.

Table 2. PPCPs detected versus non-detects.

Sample Locations	Savannah River at Elijah Clark State Park	BJWSA Drinking Water Uptake	Hardeeville WRF Effluent	Savannah Downstream of Hardeeville WRF Discharge
Analytes Detected	7	10	22	10
Percentage Analytes Detected	6.7%	9.6%	21%	9.6%

in Table 2. Among the 104 PPCP measured, around 10% were detected in the Savannah River samples and 21% were detected in the Hardeeville Water Reclamation Facility effluent (Table 2).

Table 3. PPCP analytes detected in the four sampling locations.

Analytes	Location			
	1	2	3	4
1H-Benzotriazole	13	150	270	120
Acesulfame K	0	26	0	28
Amoxicillin	43	0	110	140
BPA	18	42	0	0
Caffeine	12	24	0	0
Diuron	0	7	11	9.2
Iohexol	0	42	72	67
Lidocaine	0	5.9	0	7.7
Norethindrone	0	0	16	19
Simazine	7.1	5.7	5.9	6.3
Sucralose	210	1100	61,000	1000
Venlafaxine	0	30	63	36
Androstenedione	22	0	0	0
Atenolol	0	0	43	0
Carbamazepine	0	0	31	0
Chlorotoluron	0	0	6.4	0
Cotinine	0	0	11	0
DACT	0	0	25	0
DEET	0	0	30	0
Fluoxetine	0	0	35	0
Ketorolac	0	0	7.4	0
Lopressor	0	0	150	0
Meprobamate	0	0	43	0
Nifedipine	0	0	26	0
Primidone	0	0	100	0
Sulfamethazine	0	0	7.6	0
Thiobendazole	0	0	5.8	0

Except sucralose (artificial sweetener used in various consumer food and beverage products) the concentration of the detected PPCP in the Savannah River was low (**Figure 7**). The concentration of all detected analytes is summarized in **Table 3** and is consistent with other studies reporting concentrations of PPCP in rivers [16].

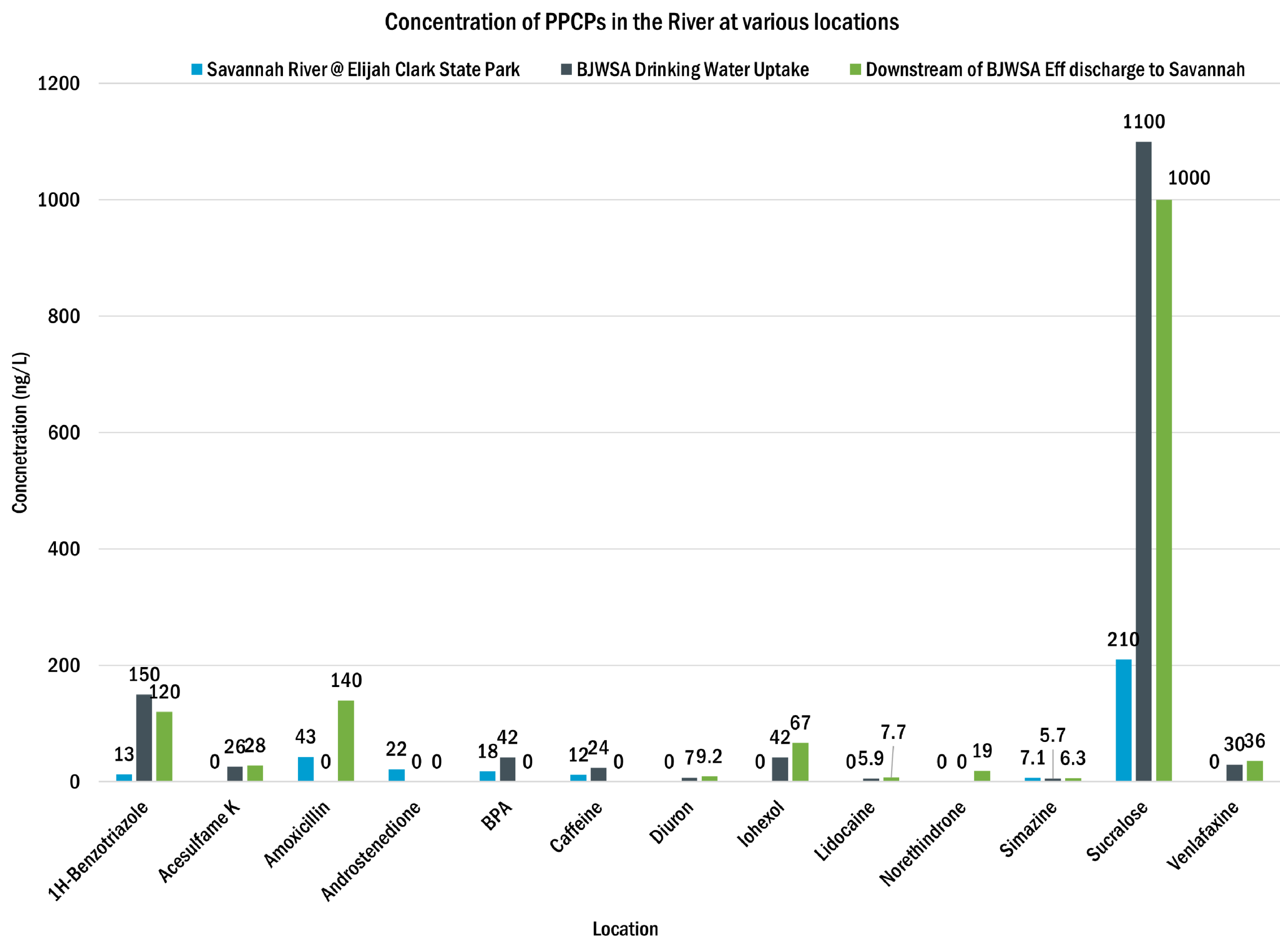

Figure 7. Detected compounds in the Savannah River at various locations.

4. Discussion

The concentrations of the detected PPCP compounds in the Savannah River at various locations were similar. A high concentration of sucralose was observed in the Hardeeville Water Reclamation Facility effluent which is expected because it is one of the most common sweeteners used in diet beverages. Sucralose is often used as an indicator of anthropogenic influences on surface water because it is ubiquitous in municipal wastewater and resistant to degradation. The concentration in the Hardeeville Water Reclamation Facility effluent was at 61,000 ng/L, which was reduced to 1000 ng/L in the river downstream, consistent with a 1000 - 10,000 dilution factor that could occur in the river. Four other compounds that were detected in the effluent (ranging from 0.1 to 0.3 ug/L) were 1H-benzotriazole (used as anti-fogging agent and corrosion inhibitor), amoxicillin (antibiotic), lopressor (beta-blocker), and primidone (anticonvulsant), but downstream of the effluent discharge, these were not detected.

Regarding the major and minor NPDES dischargers to the Savannah River, the minor facilities contributed to a higher percentage of flow to the overall river flow than major dischargers. These factors must be considered during policy development. Smaller facilities are typically providing lower levels of treatment compared to larger facilities, such that, considering their flow contribution, they can contribute higher level of contaminants compared to larger facilities. Further, larger facilities often have more stringent discharge limits, which often require longer retention times in the treatment plant in comparison to the smaller facilities. Interestingly, studies have indicated that longer sludge retention time in biological treatment processes at the WRRF result in improved PPCP removal [17] [18].

5. Recommendations

Although it is not feasible to eliminate all risks from water recycling used as a source of drinking water supply, it is possible to produce a high-quality water that, from a scientific standpoint, does not present an undue risk and is as safe or even of potentially higher quality than current drinking water supplies, particularly considering *de facto* reuse. In fact, there are numerous quantitative microbial risk assessments that demonstrate water reuse does not create undue risk of pathogen exposure to those consuming drinking water using recycled water as a source [19] [20] [21]. Similarly, for chemical risks, quantitative relative chemical assessments could be used to compare the quality of recycled water to drinking water supply [22]. In practice, the Texas Water Development Board has documented an evaluation of 8 chemicals considered for cancer risks and 27 chemicals for non-carcinogenic (threshold-based) hazard [23] to assess water recycling as a source of water supply to demonstrate the safety of water reuse. Together, considering the quantitative microbial risk assessment and quantitative relative chemical assessment approaches that have demonstrated potentially reduced human health risks under planned potable reuse scenarios, providing a mechanism for implementation of this practice to address both drivers of water supply as well as effluent disposal is important. Interestingly, effluent disposal limitations have become an increased driver for reuse in Florida where the state has banned marine discharges of treated effluent. Chapter 2008-232, Laws of Florida, prohibits the construction of new domestic wastewater ocean outfalls and expansion of existing outfalls and requires the discharge of domestic wastewater through ocean outfalls to meet advanced wastewater treatment and management requirements by December 31, 2018. Additionally, a timeline was set for elimination of existing discharges, except as a backup discharge during periods of reduced reclaimed water demands or during peak flows.

There are important considerations needed for protecting human health when planned potable reuse is implemented. Regardless of the lack of a policy with guiding principles, potable reuse continues to occur in a *de facto* scenario. Considering that there is interest by BJWSA and other utilities in South Carolina to study, plan and eventually implement planned potable reuse, policy or guidance for utilities is needed to bolster public confidence, particularly considering the potential reduction in human health risks when reuse is planned. A framework policy that leverages answers to these and other questions, could be identified through a stakeholder process. This process should engage stakeholders (utilities, state regulators, water organizations and professionals, etc.) to support and enable the development of a guiding framework to provide clarity and consistency on a statewide policy. The policy should provide flexibility such that details of implementation are addressed from a local level considering regional and geographic factors. There are numerous other examples of such a framework in the southeast US, and approaches in states including those used in Georgia, North Carolina and Tennessee can be considered as workable approaches to planned potable reuse.

6. Conclusion

Currently, South Carolina's coastal utilities have disposal limitations on treated wastewater effluent from their WRRFs and are considering reuse. The state does not have a framework, guidelines, or regulations for reuse, but discussions have started among the regulated community. This study evaluated the extent of *de facto* reuse at a coastal utility in South Carolina, *i.e*. Beaufort-Jasper Water and Sewer Authority, for which the Savannah River is the source of drinking water. Confirmed *de facto* reuse was estimated at 4.6% - 5.9% of the total flow in the Savannah River during low-flow months. This observed percentage of *de facto* reuse is consistent with the nationally reported trends.

Acknowledgements

The authors would like to acknowledge funding for this project from the Brown and Caldwell's Research and Innovation program as well as Jill Stachura's assistance with sampling.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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