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Economic Analysis for the Filter Backwash Recycling Rule

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1. Executive Summary

1.1 Need for the Proposal

The practice of recycling filter backwash water reintroduces contaminants into the treatment processes. This practice can impair treatment process performance if not performed properly. Filter backwash is the water that results from the backwash of filters, which is an important step in the proper operation of conventional and direct filtration plants. Filter backwash contains all of the particles trapped in the filter during operation, including coagulants, metals, and pathogens such as *Cryptosporidium.* This rule would ensure that these recycle waters are handled with at least the same level of multi-barrier treatment as raw source water.

The Filter Backwash Recycling Rule (FBRR) addresses filter backwash water and two additional recycle streams—sludge thickener supernatant and liquids from dewatering processes. Sludge thickener supernatant is the "clear water" that exists in sedimentation basins or clarifies after particles have been allowed to settle out. Recent research has documented concentrations of *Cryptosporidium* oocysts in thickener supernatant from 82 to 420 oocysts per hundred liters (EE&T, 1999). Dewatering processes remove water from waste solids in order to reduce the solids volume that must disposed. The waters that are removed during these processes can also contain significant levels of *Cryptosporidium* since the waste solids that enter the processes contain *Cryptosporidium* oocysts that have been removed from the treatment train (EE&T, 1999).

According to EPA's Science Advisory Board (SAB), an independent panel of experts established by Congress, disease-causing microbial contaminants (i.e., bacteria, protozoa, and viruses) are probably the greatest remaining health risk management challenge for drinking water suppliers (U.S. EPA/SAB, 1990). The FBRR undertakes the challenge to improve the control of microbial contaminants such as *Cryptosporidium* in public drinking water systems by helping to ensure that recycle practices do not compromise treatment effectiveness.[1]

Cryptosporidium, which is a common protozoan in the environment, is transported in watersheds from sources of oocysts (e.g., agricultural runoff and untreated wastewater) to water bodies that serve as drinking water sources. If a system's treatment operates inefficiently, oocysts may enter finished water at levels that pose health risks. Cryptosporidium is of particular concern to EPA as it develops the LT1ESWTR because—unlike pathogens such as viruses and bacteria—Cryptosporidium oocysts are resistant to inactivation using standard disinfection practices. Although recent research indicates some methods of disinfection may hold promise, such as medium-pressure ultraviolet light disinfection, the results are still preliminary. Until effective and practical disinfection methods are available, the control of Cryptosporidium is

[1] The FBRR and Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR) were proposed together as one rule in the Federal Register (65 FR 19046; April 10, 2000). As a result, all documents supporting the proposal address both rules. These rules have since been split and developed as separate rules for final publication. This RIA addresses only those costs and benefits that apply to the FBRR.

dependent on physical removal processes. Other emerging disinfection-resistant pathogens such as *microsporidia*, *Cyclospora*, and *Toxoplasma* are also a concern for similar reasons.

Cryptosporidiosis is the disease caused by ingesting *Cryptosporidium* oocysts. Dupont, et al. (1995) found that a dose of even a few *Cryptosporidium parvum* (or *C. parvum*) oocysts is sufficient to cause infection in healthy adults. Cryptosporidiosis is a common protozoal infection that usually causes 7 to 14 days of diarrhea with possibly a low-grade fever, nausea, and abdominal cramps in individuals with healthy immune systems (Juranek, 1998). There is currently no therapeutic cure for cryptosporidiosis, but the disease is self-limiting in healthy individuals. It does, however, pose serious health and mortality risks for sensitive subpopulations including children, the elderly, pregnant women, and the immunocompromised[2] (Gerba et al., 1996; Fayer and Ungar, 1986; U.S. EPA 1998a), which represent almost 20 percent of the population in the United States (Gerba et al., 1996).

Cryptosporidium oocysts in drinking water pose both an epidemic health risk and a health risk associated with isolated cases (an endemic health risk). Evidence on epidemic risk suggests that improving the performance of water systems will generate health benefits. Of the 20 waterborne cryptosporidiosis outbreaks that occurred over the past 25 years, 3 took place because of contaminated drinking water from water utilities where waste stream recycle was identified as a possible cause (Craun, 1998). Because statistics on isolated cases of waterborne illnesses are not tracked, there are no systematic data to determine the extent of the endemic health impact in the United States.

The two primary methods for treating drinking water for microbial contaminants are chemical disinfection (inactivation) and physical removal. The main goal of the FBRR, which is discussed in greater detail in Chapter 2, is to improve the physical removal of microbial contaminants through the management of recycle practices. Recycle practices are of concern because recycle of flows such as filter backwash and thickener supernatant within the treatment process can potentially return a significant number of oocysts to the treatment plant in a short amount of time, particularly if the recycle is returned to the treatment process without prior treatment, equalization, or some other type of hydraulic detention. Improper recycle practices can disrupt normal treatment operations and reduce treatment efficiency, thereby increasing the risk that high concentrations of oocysts may pass through the plant into finished drinking water. These improper practices are at the center of the FBRR. In fact, limited studies show that when recycle is performed properly, namely when recycle is returned through all processes of the plant's existing treatment system and normal plant operations are not disrupted with hydraulic surges or increased overall plant flow, the return of recycle does not perceptively impair plant treatment with respect to Cryptosporidium or turbidity removal (Cornwell and MacPhee, 2001).

The FBRR addresses one of the requirements of the Safe Drinking Water Act as amended in 1996. Those amendments established a number of regulatory deadlines, including schedules for a Stage 1 and a Stage 2 Disinfectants and Disinfection Byproducts Rule (DBPR), two stages of the Enhanced Surface Water Treatment Rule (ESWTR) 1412(b)(2)(C), and a requirement that

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[2] For instance, a follow-up study of the 1993 Milwaukee waterborne disease outbreak reported that at least 50 *Cryptosporidium*-associated deaths occurred among the severely immunocompromised (Hoxie et al., 1997).

EPA promulgate regulations to "govern" filter backwash recycling within the treatment process of public utilities (Section 1412(b)(14)). The FBRR applies to all public drinking water systems using surface water or ground water under the direct influence of surface water (GWUDI) as a source. Chapters 2 and 3 describe the provisions of the rule in detail.

1.2 Consideration of Regulatory Alternatives

To reduce the potential burden of the FBRR on systems, EPA developed and evaluated the cost implications and effectiveness of several regulatory alternatives for recycle provisions. Chapter 3 discusses the alternatives in detail and describes why EPA selected the alternative included in the rule. The rule requires (with some exceptions) that recycle be returned through the processes of a system's existing conventional or direct filtration (as defined in §141.2 of 40 CFR) that the Agency has recognized capable of achieving 2-log (or 99%) *Cryptosporidium* removal.[3] The rule also contains provisions that require conventional and direct filtration systems that recycle to collect, report, and maintain data that help the system and State understand the extent to which the treatment process may be susceptible to hydraulic disruptions as a result of improper recycling practices, and whether the existing recycle practices sufficiently address potential health risks.

1.3 Baseline Analysis

The FBRR affects water systems that use surface water or GWUDI, that practice conventional or direct filtration, and that recycle spent filter backwash water, sludge thickener supernatant, or liquids from dewatering processes. Estimates of systems that are affected by each rule provision were developed from an analysis of primary water treatment and recycling practices. Chapter 4 discusses the methods and sources used to arrive at these estimates. Exhibit 1–1 provides the system size categories and the number of systems that may be affected by the provisions of the FBRR.

[3]Systems may apply to the State to recycle at an alternative location.

Exhibit 1–1. Number of Systems Subject to FBRR Provisions

System Population Size Category	Number of Systems
≤100	488
101-500	660
501-1,000	491
1,001-3,300	967
3,301-9,999	885
10,000-50,000	860
50,001-100,000	157
100,001-1,000,000	135
>1,000,000	7[1]
Total	**4,650**

[1]This estimates reflects 7 individual plants that belong to systems serving more than 1,000,000 people.

1.4 Benefits of the FBRR

Health Benefits

Chapter 5 provides EPA's analysis of potential benefits of the rule. As discussed in that chapter, EPA expects that the benefits associated with the FBRR, although impossible to accurately monetize at this time, justify the costs associated with the rule. The Agency expects that the rule's health benefits will accrue from a reduction in mortality and morbidity since improved recycle practices as a result of the FBRR are expected to reduce the levels of *Cryptosporidium* and *Giardia lamblia* in water supplies.

Besides reducing the endemic risk of cryptosporidiosis, the FBRR will reduce the likelihood of major outbreaks, such as the Milwaukee outbreak, from occurring. The economic value of reducing the risk of outbreaks could be quite high when the magnitude of potential costs is considered. For example, based on current-dollar estimates of the mean value of statistical life (62 FR 59485; November 3, 1997), just one death could represent a cost of $6.3 million. Other types of costs associated with outbreaks include spending by local, State, and national public health agencies; emergency corrective actions by utilities; and possible legal costs, if liability is a factor. Additional discussion regarding costs associated with outbreaks is found in Section 5.2.3.

Non-health Benefits

The rule's benefits are expected also to include non-health benefits. The non-health benefits include avoided outbreak responses (e.g., provision of bottled water by water systems and local governments, issuance of public notices) and avoided costs of averting behavior (e.g., out-of-pocket costs such as purchasing bottled water and opportunity costs such as not having to spend time boiling water).

Although the costs of the non-health benefits have not been monetized, these costs can be significant. For example, the costs of averting behaviors, such as hauling in safe water, boiling water, and purchasing bottled water, were estimated at between $1.74 to $5.53 per person per day during one outbreak (Harrington et al., 1989). If these figures are applied to a small drinking water system serving 10,000 customers, total expenditures on averting behavior during a *Cryptosporidium* outbreak could range between $17,400 and $55,300 per day. Determining the precise reduction in outbreak risk and resulting benefits due to reduced or avoided averting behavior is not possible given current information, but potential benefits could be substantial.

1.5 Costs of the FBRR

Chapter 6 summarizes the methods EPA used to analyze costs for the FBRR. Total annual costs for the rule are estimated at $5.84 million assuming a 3 percent discount rate and $7.19 million assuming a 7 percent discount rate (both in 1999 dollars using a 20-year discount period). The cost estimate includes capital and O&M costs for treatment changes and start-up and annual labor costs for reporting activities for the rule's recycle return location and conventional and direct filtration reporting requirements. The labor costs incorporate both system and State estimates.

To reduce the potential cost to systems, EPA developed and evaluated the cost implications of several regulatory alternatives. In addition, EPA reviewed public comments received on the proposed rule. See Chapter 3 for a detailed discussion of the alternatives considered and the chosen rule option, which was further modified from its proposal to reduce the costs imposed on systems and States.

Water system cost increases are often passed on to customers in the form of higher monthly water bills. EPA estimated the potential impact on households by developing a distribution of costs across all affected systems and converting that distribution to a per-household basis. The recycling provisions could affect approximately 31.4 million households based on EPA's assumptions. Annual incremental costs would be less than $1.70 for approximately 99 percent of households and less than $10 for over 99.9 percent of households. The average cost per affected household is estimated at only $0.19 per year.

1.6 Economic Impact Analysis

As part of the rule promulgation process, EPA is required to perform analyses that address the potential regulatory burden placed on entities that are directly or indirectly affected by the rule. The impacts considered were the cost of compliance for State, local, and Tribal governments, and small businesses; the effect of rule implementation on sensitive subpopulations; and the potential for disproportionate impacts on low-income and minority populations. Chapter 7 discusses these economic impact analyses and findings. In addition, EPA's breakeven analysis indicates that the monetized health benefits would exceed the cost of the rule if only one mortality per year were avoided as a result of this rule. This analysis does not include any monetized costs associated with illnesses.

EPA has determined that FBRR does not contain a Federal mandate that may result in expenditures of $100 million or more for the State, local and Tribal governments, in the aggregate, or the private sector in any one year. The estimated annual cost of this rule is approximately $5.84 million. Thus, the rule is not subject to the requirements of Sections 202 and 205 of the Unfunded Mandate Reform Act. In addition, EPA has concluded that this rule will not have a disproportionate effect on systems operated by Indian Tribal governments. In particular, this rule will affect fewer than 22 of the 987 total Tribal government drinking water systems (approximately 2 percent).

The Regulatory Flexibility Act, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA), requires EPA to consider the financial impact of FBRR on small business entities. After considering the economic impact estimates for small entities, EPA certifies that this regulation will not have a significant economic impact on a substantial number of small entities.[4]

A primary purpose of the FBRR is to improve control of microbial pathogens, specifically the protozoan *Cryptosporidium*. Under Executive Order 13045, the implementing agency must evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered. While FBRR is not subject to Executive Order 13045—because it is not economically significant as defined by Executive Order 12866—the Agency believes that the environmental health or safety risk addressed by this action may have a disproportionately positive effect on children—a sensitive subpopulation.

As required under Executive Order 12898, EPA must identify and address disproportionately high and adverse human health or environmental effects the adoption of the FBRR may have on minority and low-income populations. The Agency has identified and addressed environmental justice-related issues concerning the potential impacts of this action and has consulted with minority and low-income stakeholders in the rule development process.

[4] The analyses supporting this certification are contained in the Regulatory Flexibility Screening Analysis prepared for this final rule and can be found in the docket supporting the final rule (EPA, 2000g).

1.7 Weighing of Benefits and Costs

Although data are unavailable to quantify benefits, EPA expects that the benefits of the FBRR justify their cost on a qualitative basis (Chapter 8). For example, the changes to lower risk at over 4,600 water systems nationwide is expected to cost approximately $5.84 million annually assuming a 3 percent discount rate and $7.19 million annually assuming a 7 percent discount rate. The mean estimate for the value of a statistical life is $6.3 million. If these changes prevent even one outbreak and avoid one resulting death per year, the rule is quantitatively justified.

The recycle provisions will reduce the potential for certain recycle practices to lower or upset treatment plant performance during recycle events; therefore, the provisions will help prevent *Cryptosporidium* oocysts from entering finished drinking water supplies and will increase public health protection.

The Agency strongly believes that returning *Cryptosporidium* to the treatment process in recycle flows, if performed improperly, can create additional public health risk. EPA believes the public health protection benefits provided by the FBRR justifies their cost because they are based upon sound engineering principles and are designed to reduce public health risk by eliminating improper recycle practices that increase the risk of high concentrations of oocysts passing through the filtration plant into finished drinking water.

2. Need for the Proposal

The Safe Drinking Water Act (SDWA) requires EPA to promulgate a regulation which "governs" the recycle of filter backwash within the treatment process of public water systems. EPA is publishing a final Filter Backwash Recycling Rule (FBRR)[1] to address this statutory requirement. Executive Order 12866, *Regulatory Planning and Review*, requires EPA to estimate the costs and benefits of regulations in a regulatory impact analysis (RIA) and to submit the analysis in conjunction with publishing the rule. RIAs provide background on the rule, summarize key components, and discuss regulatory alternatives.

The FBRR applies to conventional and direct filtration public drinking water systems that use surface water or ground water under the direct influence of surface water (GWUDI) as a source. It is designed to improve control of waterborne bacterial and viral pathogens, such as *Cryptosporidium* and *Giardia*.

This chapter of the RIA summarizes the technical and regulatory issues associated with the need for the FBRR. It identifies the public health concerns addressed by the rule and summarizes the key components of the rule. Specifically, it is organized into the following sections:

- Section 2.1 - characterizes the issues addressed by the rule.
- Section 2.2 - identifies the public health concerns addressed by the rule.
- Section 2.3 - lists existing regulations and their impact on water quality.
- Section 2.4 - reviews the economic rationale for promulgating the rule.
- Section 2.5 - summarizes key components of the rule.

Chapters 3 through 8 of this document are intended to meet the requirements of Executive Order 12866 by responding to specific analytical questions. Below is a description of each chapter.

- Chapter 3 - reviews alternative approaches considered as the rule was being developed.
- Chapter 4 - presents public water system (PWS) data to establish a baseline of information for use in the following four chapters.
- Chapter 5 - examines the rule's potential benefits by reviewing occurrence data, treatment efficiencies, and dose-response relationships.
- Chapter 6 - presents an estimate of the costs to implement the rule.
- Chapter 7 - reviews the distribution of the costs and benefits of the rule on various entities and subpopulations.
- Chapter 8 - weighs the overall benefits and costs of the various alternatives considered for the rule.

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[1] The Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR) and FBRR were proposed together as one rule in the Federal Register (65 FR 19046; April 10, 2000). As a result, all documents supporting the proposal address both rules. These rules have since been split and developed as separate rules for final publication. This RIA addresses only those costs and benefits that apply to the FBRR.

2.1 Issue Description

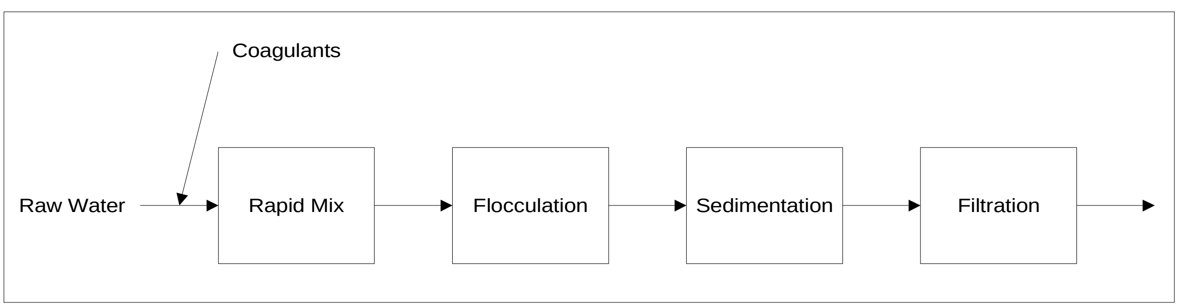
Recycling reintroduces contaminants which were removed during treatment. This practice can degrade influent water quality and impair treatment process performance if not properly performed. The primary issue addressed by the FBRR is the minimization of public health risk through improved physical removal of microbial contaminants. FBRR helps achieve such goals by instituting changes to the return of recycle flows within the treatment process to reduce the potential for improper recycling practices to compromise microbial control.

2.1.1 Treatment Processes

Public water systems use a variety of processes to physically remove particles from the water they treat. The FBRR applies only to plants that employ either conventional or direct filtration, as defined in 40 CFR, Section 141.2. The configuration of unit processes within conventional treatment or direct filtration facilities may include softening processes, contact clarification, dissolved air flotation, and others. In all cases, direct filtration and conventional treatment rely on final particle removal by rapid granular filtration.

Conventional filtration, the most widely used type of filtration, consists of chemical coagulation, rapid mix, flocculation, and sedimentation followed by filtration. A general flow schematic for a conventional water treatment plant is presented in Exhibit 2-1. Source water is treated with chemical coagulant(s), such as aluminum sulfate (alum), ferric or ferrous sulfate, ferric chloride, and/or a coagulant aid to destabilize suspended particles and improve sedimentation as the water enters the treatment system.

Exhibit 2–1. Flow Schematics for Conventional Water Treatment Systems



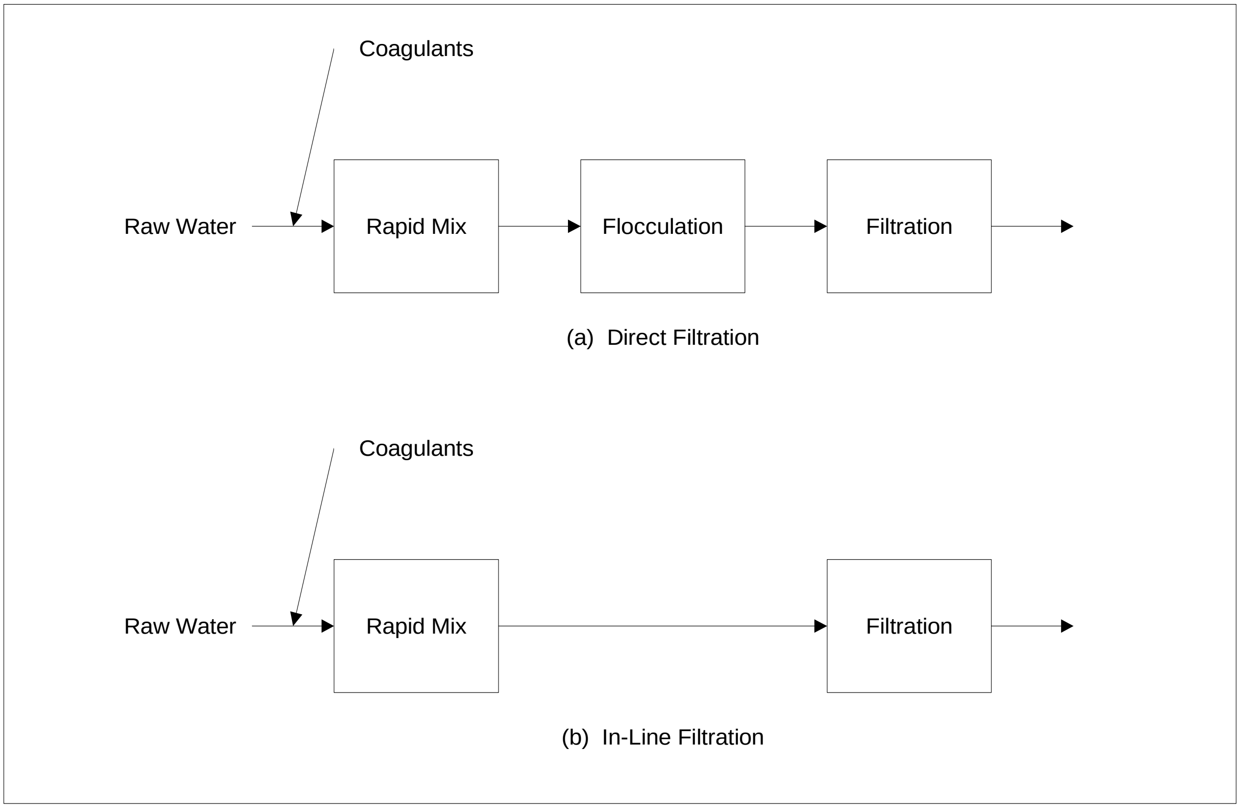
Coagulants promote the attachment of suspended particles to each other by destabilizing particle inherent negative charges or by “sweeping’”particles into an aggregate, or “floc.” Coagulant aids assist floc formation by attaching smaller floc particles to each other to form a stronger and more settleable mass. Application of the appropriate coagulant and coagulant aid dose is critical to optimized and reliable water treatment. As raw water quality changes, coagulant and coagulant aid doses must be adjusted accordingly.

After coagulants and coagulant aids are added in the rapid mix stage, the flocculation step gently stirs the coagulated water to allow particle collision and adherence to form the settleable (or, for direct filtration, a filterable) floc. The speed of stirring and the detention time of the water in the flocculation basin are critical for floc formation. In a conventional treatment process, the formed floc is subsequently removed by sedimentation. As water flows through the sedimentation basin, solids are settled by gravity as the clarified water passes slowly upward and out of the basin. The rate of water flow out of the basin, termed surface overflow rate, is critical to enabling gravity settling of the floc without carryover of particles to the filters. For direct filtration, sedimentation is omitted and floc is removed solely by filtration.

For both conventional and direct filtration, control of the flow of water is critical to effective performance of each of the individual flocculation, sedimentation and filtration steps. Hydraulic surges, which are significant, temporary increases in flow, can disrupt the treatment process. Disruption may result from short-circuiting of water within a flocculation or sedimentation basin or significantly increasing flow through a filter.

In the direct filtration process, suspended solids are removed solely by filters (AWWA/ASCE, 1998). As depicted in Exhibit 2-2, direct filtration consists of coagulation followed by rapid mixing, flocculation, and filtration. Unlike conventional treatment, direct filtration does not include a sedimentation step. Instead, it directly applies the chemically-conditioned and flocculated water to the filters. A variation of direct filtration, in-line filtration, excludes the flocculation process and instead relies on flocculation to occur in the pipes between the rapid mix and the filters. In both direct and in-line filtration, the filters are the only means of suspended solid, particle, and pathogen removal. Some small surface water treatment facilities are configured as package plants. A package plant can be defined as a complete modular treatment plant, designed as a factory-assembled, skid-mounted unit. A package plant may consist of either direct filtration or conventional treatment processes, and therefore may include chemical coagulation, flocculation, sedimentation, and filtration.

Exhibit 2–2. Flow Schematics for Direct Filtration Systems



Another type of treatment used by some systems is the lime softening process. Lime softening is a type of conventional treatment that also removes hardness (calcium and magnesium ions) through chemical precipitation. Most lime softening plants use a contact clarification process to remove turbidity and hardness. In a contact clarification treatment process, the flocculation and sedimentation (and often the rapid mix) processes are combined in one unit—an upflow solids contactor or contact clarifier.

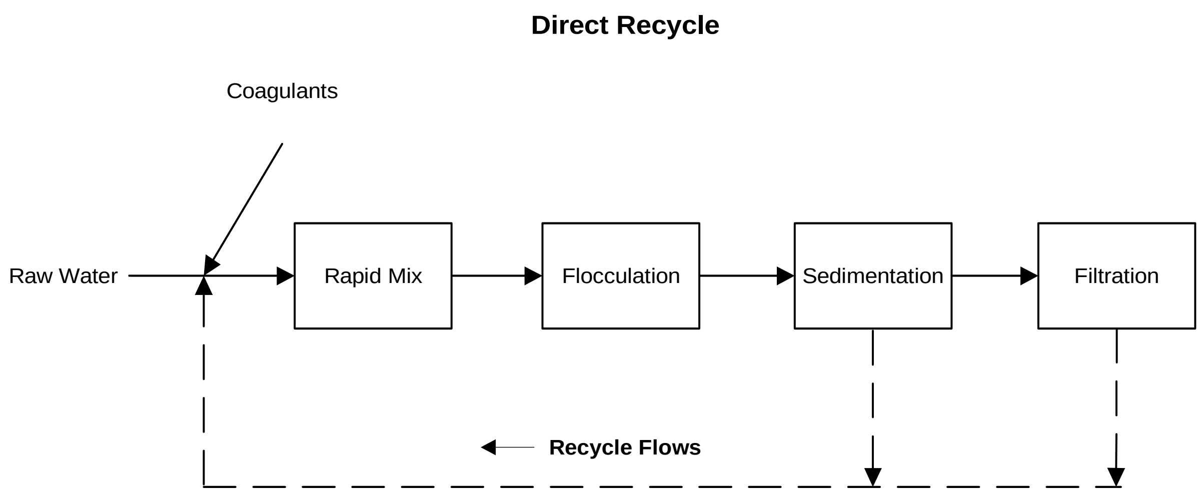
2.1.2 Recycling Practices

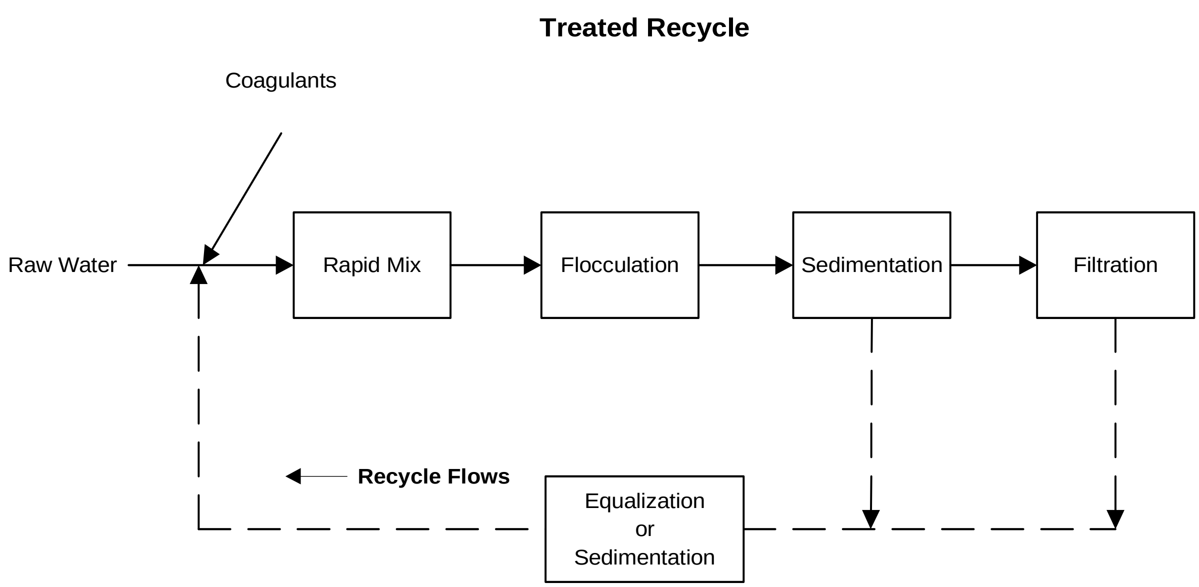
The treatment processes discussed in Section 2.1.1 remove particles and pathogenic microorganisms from the water during the sedimentation and filtration processes. Particles and pathogens are then removed from the treatment facility by discharge of sedimentation basin sludge or by backwashing filters. Water systems may discharge sludge accumulated during sedimentation to a waste-handling facility on a continuous basis or periodically.

Filter backwash is initiated when particle build-up within the filter bed results in increased headloss or imminent turbidity breakthrough. Filter backwash may also be initiated if the filter has been in service for a predetermined maximum period of time. During filter backwash, water is forced through the filter, counter to the flow direction used during treatment operations, to dislodge accumulated particles and pathogens retained in the filter media. This backwashing of the filter reestablishes filter removal capability and is important for maintaining optimal filter performance.

As Exhibit 2-3 shows, recycle flows generated during treatment, such as spent filter backwash water, liquids from sludge dewatering, and sludge thickener supernatant, are often recovered and returned to the treatment train.

Exhibit 2–3. Flow Schematics for Systems that Recycle





Some treatment plants may not perform optimally during filter backwash recycle events and may experience greater risk because of certain recycle practices. Recycle flows may contain high concentrations of pathogens, including disinfection-resistant *Cryptosporidium* oocysts, and chemicals added during the treatment process (e.g., oxidants, coagulants, and polymers). If the recycle flow is not adequately treated before being returned to the primary treatment train, significant numbers of oocysts may be returned to the plant. This increases the overall number of oocysts entering the plant and increases the risk that some disinfectant-resistant pathogens such as *Cryptosporidium* can slip through filtration. Also, recycle flow returned to the clarification process may not achieve sufficient residence time for oocysts in the recycle flow to be removed, or it may create hydraulic currents that lower the unit's overall oocyst removal efficiency. Improper recycle practices may cause plants to exceed State-approved operating capacity during recycle events. This can cause clarification and filter loading rates to be exceeded, which may lower overall oocyst removal provided by the plant and increase finished water oocyst concentrations. The FBRR addresses these concerns. As indicated previously, limited work has shown that when recycle is performed in accordance with the requirements of the FBRR, Cryptosporidium removal is not impaired.

2.1.3 Recycle Flows

The following five recycle flows are discussed in more detail because they are the most likely to present a threat to treatment plant performance or finished water quality when recycled. These recycle flows are also the most likely to contain *Cryptosporidium*.

- ***Untreated Spent Filter Backwash Water.*** Backwash water is generated when water is forced through the filter, counter to the flow direction used during treatment operations to dislodge accumulated particles and pathogens captured by the filter media. Untreated spent filter backwash water refers to water used for filter backwash which has not received treatment to remove oocysts from the waste stream.

- ***Gravity Settled Spent Filter Backwash Water.*** Gravity settled spent filter backwash water is generated by the same process described above, except that this wastestream is treated by gravity settling to remove solids prior to its return to the primary treatment process.

- ***Combined Gravity Thickener Supernatant.*** A combination of the supernatant from spent filter backwash water and a gravity thickener. A gravity thickener removes water from the sedimentation and filtration backwash sludge mass to reduce the volume of sludge that must be handled. Gravity thickeners settle solids to the bottom of a basin by gravity sedimentation. The supernatant remaining on top of the settled sludge is decanted and may be recycled.

- ***Gravity Thickener Supernatant from Sedimentation Solids.*** This potential recycle flow is similar to that for the combined gravity thickener supernatant, but includes only the supernatant from a gravity thickener.

- ***Mechanical Dewatering Device Liquids.*** Liquids resulting from devices used to mechanically separate water treatment plant residuals (usually thickened sludge) into solids and water. Devices used to mechanically dewater thickened sludge include belt filter presses, centrifuges, filter presses, and vacuum filters.

2.2 Public Health Concerns

In 1990, EPA's Science Advisory Board (SAB), an independent panel of experts established by Congress, cited drinking water contamination as one of the most important environmental risks and indicated that disease-causing microbial contaminants (i.e., bacteria, protozoa, and viruses) are probably the greatest remaining health risk management challenge for drinking water suppliers (U.S. EPA/SAB, 1990). Information on the number of waterborne disease outbreaks from the U.S. Centers for Disease Control and Prevention (CDC) underscores this concern. CDC indicates that 401 waterborne disease outbreaks were reported between 1980 and 1996, with over 750,000 associated cases of disease (CDC, 1996). Of these outbreaks, at least nineteen were associated with Cryptospordium, and three occured at water treatment plants where recycle was implicated as a possible cause for the outbreak.

Additional information on waterborne disease outbreaks is provided in Section 2.2.4 of this chapter. Because outbreak information is not required to be reported by State agencies and endemic waterborne disease often goes undiagnosed and unreported, these data likely represent an underestimate of diseases caused by *Cryptosporidium*.

2.2.1 Contaminants and Their Associated Health Effects

Cryptosporidium is of particular concern to EPA as it develops the FBRR because—unlike pathogens such as viruses and bacteria—Cryptosporidium oocysts are resistant to inactivation using standard disinfection practices. Although recent research indicates some methods of disinfection may hold promise, such as medium-pressure ultraviolet light disinfection, the results are still preliminary. Until effective and practical disinfection methods are available, the control of Cryptosporidium is dependent on physical removal processes. In addition, currently there is no therapeutic cure for cryptosporidiosis (unlike giardiasis). Other emerging disinfection-resistant pathogens, such as *microsporidia*, *Cyclospora*, and *Toxoplasma*, are also a concern of FBRR for similar reasons.

The effects of waterborne disease is usually acute—its onset is sudden and its duration typically short in healthy people. Some pathogens (e.g., *Giardia* and *Cryptosporidium*) may cause extended illness that lasts for weeks or longer in otherwise healthy individuals, and the infection can prove fatal to members of sensitive populations, such as the immunocompromised. Most waterborne pathogens cause gastrointestinal illness, with diarrhea, abdominal discomfort, nausea, vomiting, or other symptoms. Other waterborne pathogens cause, or at least are associated with, more serious disorders such as hepatitis, gastric cancer, peptic ulcers, myocarditis, swollen lymph glands, meningitis, and encephalitis, among other diseases.

Cryptosporidiosis is caused by ingestion of *Cryptosporidium* oocysts, which are readily carried by the waterborne route. The most common source of oocysts in water is the feces of infected hosts (Walker et al., 1998). Dupont, et al. (1995) found through a human feeding study that a low dose of *Cryptosporidium parvum* (or *C. parvum)* is sufficient to cause infection in healthy adults. Infected humans and other animals may excrete *Cryptosporidium* oocysts, which can then be transmitted to others. Cryptosporidiosis is often spread by ingesting infective oocysts in contaminated food or water, and by direct or indirect contact with infected persons or animals (Casemore, 1990; Cordell and Addiss, 1994).

Cryptosporidiosis is a common protozoal infection that usually causes 7–14 days of diarrhea and possibly a low-grade fever, nausea, and abdominal cramps in individuals with healthy immune systems (Juranek, 1998). There appears to be an immune response to *Cryptosporidium*, but it is not known if this results in complete protection (Fayer and Ungar, 1986). When prior exposure or chronic contamination of the water by low levels of oocysts confers short-term immunity to immunocompetent residents in a community (Okhuysen et al., 1998), most cases of symptomatic illness in that community occur in newly exposed individuals, such as young children, visitors, and new residents (Frost et al., 1997).

2.2.2 Sensitive Subpopulations

A number of sensitive populations are at greater risk of serious illness (morbidity) or mortality than is the general population (Frost et al., 1997) from either epidemic or endemic infection by *Cryptosporidium*. These sensitive populations include children, especially the very young; the elderly; pregnant women; and the immunocompromised. They represent almost 20 percent of the population of the United States (Gerba et al., 1996; Fayer and Ungar, 1986; U.S. EPA, 1998a). Gastrointestinal illness caused by cryptosporidiosis may be chronic in these sensitive populations.

EPA has a particular concern regarding drinking water exposure to *Cryptosporidium*, especially in severely immunocompromised persons, because there is no effective therapeutic drug to cure the disease (Framm and Soave, 1997). Therefore, prevention of infection is critical (Petersen, 1992). The severity and duration of illness is often greater in immunocompromised persons than in healthy individuals and may be fatal among this population. For instance, a follow-up study of the 1993 Milwaukee waterborne disease outbreak reported that at least 50 *Cryptosporidium*-associated deaths occurred among the severely immunocompromised (Hoxie et al., 1997).

2.2.3 Sources of Contaminants

Cryptosporidium is common in the environment (Rose, 1997, Soave, 1995, LeChevallier et al., 1991a). Runoff from unprotected watersheds allows these microorganisms to be transported from sources of oocysts (e.g., feces of wildlife, untreated wastewater, livestock operations, and agricultural runoff) to water bodies used as drinking water sources. If a treatment plant operates inefficiently, oocysts may enter the finished water at levels sufficient to cause public health concerns. Increasing disinfectant dosages (i.e., chlorine or chloramines) is not an effective strategy for controlling *Cryptosporidium*, because the *Cryptosporidium* oocyst is especially resistant to disinfection practices.

Cryptosporidium oocysts have been detected in wastewater, pristine surface water, surface water receiving agricultural runoff or contaminated by sewage, ground water under the direct influence of surface water (GWUDI), water for recreational use, and drinking water (Rose, 1997; Soave, 1995). Over 30 environmental surveys have reported *Cryptosporidium* source water occurrence data from surface water and GWUDI. Many of these studies are summarized in the *Occurrence Assessment for the Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Recycling Rules* (U.S. EPA, 2001a).

2.2.4 Waterborne Disease Outbreaks

CDC, EPA, and the Council of State and Territorial Epidemiologists have maintained a collaborative surveillance program for collection and periodic reporting of data on waterborne disease outbreaks since 1971. The CDC database and biennial CDC–EPA surveillance summaries include data reported voluntarily by the States on the incidence and prevalence of waterborne illnesses. According to the CDC–EPA database, between 1971 and 1996 a total of 672 outbreaks and 567,321 cases of illnesses were reported (see Exhibit 2–4). The reported outbreaks were due to contamination by protozoa, viruses, bacteria, chemicals, and unknown factors.

Exhibit 2–4. Comparison of Outbreaks and Outbreak-related Illnesses from Ground Water and Surface Water for the Period 1971–1996

Water Source	Total Outbreaks	Cases of Illnesses	Outbreaks in Community Water Systems (CWSs)	Outbreaks in Noncommunity Water Systems (NCWSs)[1]
Ground	389 (58%)	85,214 (15%)	71	269
Surface	225 (33%)	471,468 (83%)	104	60
Other	58 (9%)	10,639 (2%)	107	61
All Systems	672 (100%)	567,321 (100%)	282	390

[1]Includes outbreaks in NCWSs and private wells.
Source: Craun and Calderon (1996), Levy et. al. (1998).

From 1984 to 1994, there were 19 reported outbreaks of cryptosporidiosis in the United States (Craun, 1998). As mentioned previously, *C. parvum* was not identified as a human pathogen until 1976. Furthermore, data on cryptosporidiosis outbreaks were not collected in the United States before 1984. Ten of the reported cryptosporidiosis outbreaks were associated with drinking water sources (CWSs, NCWSs, and a private water system) (Moore et al., 1993; Kramer et al., 1996; Levy et al., 1998; Craun, 1996; Craun et al., 1998). They are summarized in Exhibit 2–5. The remaining nine outbreaks were associated with water-based recreational activities (Craun et al., 1998).

Exhibit 2–5. Cryptosporidiosis Outbreaks in U.S. Drinking Water Systems[1]

Year	Location and System Type	Cases of Illness (Estimated)	Source Water	Treatment	Suspected Cause
1984	Braun Station, TX CWS	117 (2,000)	Well	Chlorination	Sewage-contaminated well
1987	Carrollton, GA, CWS	(13,000)	River	Conventional filtration/ chlorination; inadequate backwashing of some filters	Treatment deficiencies
1991	Berks County, PA, NCWS	(551)	Well	Chlorination	Ground water under the influence of surface water
1992	Medford (Jackson County), OR, CWS	(3,000; combined total for Jackson County and Talent, below)	Spring/River	Chlorination/package filtration plant	Source not identified
1992	Talent, OR, CWS	see Medford, OR	Spring/River	Chlorination/package filtration plant	Treatment deficiencies
1993	Milwaukee, WI, CWS	(403,000)	Lake	Conventional filtration	High source water contamination and treatment deficiencies
1993	Yakima, WA, private	7	Well		Ground water under the influence of surface water
1993	Cook County, MN, NCWS	27	Lake	Filtered, chlorinated	Possible sewage backflow from toilet/septic tank
1994	Clark County, NV, CWS	103; many confirmed for cryptosporidiosis were HIV positve	River/Lake	Prechlorination, filtration and post-filtration chlorination	Source not identified
1994	Walla Walla, WA, CWS	134	Well	None reported	Sewage contamination

[1]Adapted from Craun, et al. (1998).

Three of the 10 outbreaks cited in Exhibit 2–5 (Carollton, GA [1987]; Talent, OR [1992]; and Milwaukee, WI [1993]) were caused by water supplied by treatment plants whose process stream recycle was implicated as a possible cause. In total, the nine outbreaks occurring in PWSs caused approximately 419,939 cases of illness with the largest outbreak (Milwaukee, WI [1993]) having recycle flows implicated as a possible cause. They show that, when treatment is not operating optimally or when source water is highly contaminated, *Cryptosporidium* may enter the finished drinking water and cause waterborne disease outbreaks.

The occurrence of waterborne gastrointestinal infections including Cryptosporidiosis may be much greater than suggested by reported surveillance data (Craun and Calderon, 1996). The CDC database is based on responses to a voluntary and confidential survey that is completed by State and local public health officials. The U.S. National Research Council strongly suggests that the number of identified and reported outbreaks in the CDC database (for surface and ground waters) represents a small percentage of actual waterborne disease outbreaks (National Research Council, 1997; Bennett et al., 1987). In practice, most of these outbreaks in CWSs are not recognized until a sizable proportion of the population is ill (Perz et al., 1998; Craun, 1996), perhaps 1 to 2 percent of the population (Craun, 1996).

In addition, healthy adults with cryptosporidiosis may not suffer severe symptoms from the disease; therefore, infected individuals may not seek medical assistance, and their cases may go unreported. Even if infected individuals consult a physician, *Cryptosporidium* is not analyzed by routine diagnostic tests for gastroenteritis and, therefore, tends to be under-reported in the general population (Juranek, 1995; Craun, 1996). Such obstacles to outbreak reporting indicate that the incidence of disease and outbreaks of cryptosporidiosis may be much higher than officially reported by the CDC.

Endemic waterborne disease is a factor that should also be considered and is defined as any waterborne disease not associated with an outbreak. EPA, however, is not aware of any data documenting the incidence of waterborne endemic cryptosporidiosis in the United States. But 14 to 40 percent of the normal gastrointestinal illness in a community in Quebec was associated with treated drinking water from a surface water source (Payment et al., 1997). Given the lack of endemic waterborne disease occurrence data, combined with the strong possibility that outbreaks are under-reported, it is likely that there are more instances of cryptosporidiosis and other waterborne diseases than are currently recorded.

2.2.5 Filter Backwash and Other Process Flows: Occurrence and Impact Studies

In addition to evaluating waterborne disease outbreak data, EPA also evaluated data regarding the occurrence of *Cryptosporidium* in recycle flows. In particular, EPA, in conjunction with the American Water Works Association (AWWA), the American Water Works Service Company (AWWSCo), and Cincinnati Water Works, compiled issue papers on each of these recycle flows: spent filter backwash water, sedimentation basin solids, combined thickener supernatant, ion-exchange regenerate, membrane concentrate, lagoon decant, mechanical dewatering device concentrate, monofill leachate, sludge drying bed leachate, and small-volume flows (e.g., floor, roof, lab drains) (EE&T, 1999). In addition, EPA compiled the existing *Cryptosporidium* occurrence data and occurrence data on other constituents of the recycle flows with the data presented in AWWA's white papers.

These efforts resulted in *Cryptosporidium* occurrence data for five types of recycle flows: untreated spent filter backwash water, gravity settled spent filter backwash water, combined gravity thickener supernatant (a combination of spent filter backwash and clarification process solids), gravity thickener supernatant from clarification process solids, and mechanical dewatering device liquids. Nine studies have reported the occurrence of *Cryptosporidium* in these process flows. Each study's scope and results are presented in Exhibit 2–6, and brief narratives on each major study follow the table. Note that the results of the studies, if not presented in the published report as oocysts per 100L, have been converted into oocysts per 100L.

Exhibit 2–6. *Cryptosporidium* Occurrence in Filter Backwash and Other Recycle Flows

Name/ Location of Study	Number of Samples	Type of Sample	Cyst/Oocyst Concentration	Number of Treatment Plants Sampled	Reference
Drinking water treatment facilities	2	backwash waters from rapid sand filters	sample 1: 26,000 oocysts/gal (calc. as 686,900 oocysts/100L); sample 2: 92,000 oocysts/gal (calc. as 2,430,600 oocysts/100L)	2	Rose et al. 1986
Farmoor water treatment plant, England	not reported	backwash water from rapid sand filter	Over 1,000,000 oocysts/100L in backwash water on 2/19/89 100,000 oocysts/100L in supernatant from settlement tanks during the next few days	1	Colbourne 1989
Potable water supplies in 17 States	not reported	filter backwash from rapid sand filters (10 to 40-L sample vol.)	217 oocysts/100L (geometric mean)	not reported	Rose et al. 1991
Name/Location not reported	not reported	raw water initial backwash water	7 to 108 oocysts/100L detected at levels 57 to 61 times higher than in the raw water	not reported	LeChevallier et al. 1991a
Bangor Water Treatment Plant (PA)	Round 1: 1 (8-hour composite)	raw water filter backwash supernatant recycle	6 oocysts/100L 902 oocysts/100L 141 oocysts/100L	1	Cornwell and Lee 1993a,b
	Round 2: 1 (8-hour composite)	raw water filter backwash supernatant recycle	140 oocysts/100L 850 oocysts/100L 750 oocysts/100L		
Moshannon Valley Water Treatment Plant	Round 1: 1 (8-hour composite)	spent backwash supernatant recycle raw water sludge	16,613 oocysts/100L 82 oocysts/100L 13 oocysts/100L 2,642 oocysts/100L	1	Cornwell and Lee 1993a,b
	Round 2: 1 (8-hour composite)	raw water supernatant recycle	20 oocysts/100L 420 oocysts/100L		
Plant "C"	11 samples using continuous flow centrifu-gation; 39 samples using cartridge filters	backwash water from rapid sand filters; samples collected from sedimentation basins during sedimentation phase of backwash water at depths of 1, 2, 3, and 3.3 m.	continuous flow: range 1 to 69 oocysts/100L; 8 of 11 samples positive cartridge filters: ranges 0.8 to 252/100L; 33 of 39 samples positive	1	Karanis et al. 1996

Exhibit 2–6. *Cryptosporidium* Occurrence in Filter Backwash and Other Recycle Flows

Name/ Location of Study	Number of Samples	Type of Sample	Cyst/Oocyst Concentration	Number of Treatment Plants Sampled	Reference
Pittsburgh Drinking Water Treatment Plant	24 (two years of monthly samples)	filter backwash	328 oocysts/100L (mean); (38 percent occurrence rate) non-detect-13,158 oocysts/100L	1	States et al. 1997
"Plant Number 3"	not reported	raw water spent backwash	140 oocysts/100L 850 oocysts/100L	not reported	Cornwell 1997
"Plant C" (see Karanis, et al., 1996) "Plant A"	12 50 1	raw water backwash water from rapid sand filters rapid sand filter (sample taken 10 min. after start of backwashing)	avg. 23.2 oocysts/100L (max. 109 oocysts/100L) in 8 of 12 samples avg. 22.1 oocysts/100L (max. 257 oocysts/100L) in 41 of 50 samples 150 oocysts/100L	1	Karanis et al. 1998 (Table 8, p.14)

As shown in Exhibit 2–6, oocysts generally are found in greater concentrations in backwash water and other recycle flows than in raw water. For example, four studies (Cornwell and Lee, 1993b; States et al., 1997; Rose et al., 1986; and Colbourne, 1989) have reported *Cryptosporidium* oocysts over a wide range of concentrations in filter backwash water (from zero oocysts/100L to over 1 million oocysts/100L). However, each of these studies reported some samples of oocyst concentration in excess of 10,000 oocysts/100 L. Such concentrations indicate that the treatment plant has been performing properly and is removing oocysts from the influent water during the sedimentation and/or filtration processes. As expected, the oocysts have concentrated on the filters or in the sedimentation basin sludge. Therefore, the recycling of such process flows (e.g., filter backwash, thickener supernatant, sedimentation basin sludge) re-introduces high concentrations of oocysts to the drinking water treatment train since these flow contain the majority of oocysts that were removed by the filters and sedimentation units. Recycle may return a significant number of oocysts to the treatment plant in a short period of time, particularly if the recycle is returned to the treatment process without prior treatment, equalization, or some other type of hydraulic detention. If the recycle disrupts normal treatment operations or if treatment does not function efficiently due to other deficiencies, high concentrations of oocysts may pass through the plant into finished drinking water. The major recycle flow studies presented in Exhibit 2–6 are described in further detail below.

Rose, et al.

Rose, et al. (1991) reported the geometric mean of the backwash samples at 217 *Cryptosporidium* oocysts/100L. This was the highest reported average *Cryptosporidium* concentration of any of the water types tested.

LeChevallier, et al.

In the analysis of pathogen concentrations in raw water and in the filter backwash water of water treatment process, LeChevallier et al. (1991b) found very high oocyst levels in backwash water of systems that had low raw water parasite concentrations. *Cryptosporidium* levels in the initial backwash water were 57 to 61 times higher than in the raw water supplies. Raw water samples were found to contain from 7 to 108 oocysts/100L. LeChevallier et al. (1991b) also noted that for 12 of 13 times when *Cryptosporidium* were detected in plant effluent samples, the organisms were also observed in the backwash samples. They concluded that the consistency of these results shows that the accumulation of parasites in treatment filters (and their subsequent release in the backwash water) could be related to subsequent penetration of the treatment barriers.

Cornwell and Lee

Cornwell and Lee (1993b) detected *Cryptosporidium* concentrations of over 15,000 *Cryptosporidium* oocysts/100L in the spent filter backwash at an adsorption clarifier plant (Moshannon Valley) and over 800 *Cryptosporidium* oocysts/100L in backwash water from a direct filtration plant (Bangor). The parasite levels in the backwash samples were significantly higher than in raw source water, which contained *Cryptosporidium* oocyst concentrations of 6–140 oocysts/100L at the Bangor plant and 13–20 oocysts/100L at Moshannon Valley.

In addition, Cornwell and Lee determined oocyst concentrations for two other recycle flows, combined thickener supernatant and sedimentation basin solids. The supernatant pathogen concentrations was reported at 141 *Cryptosporidium* oocysts/100L at the Bangor plant, and at 82 and 420 cysts/100L for the Moshannon plant in Rounds 1 and 2 of sampling, respectively. The sedimentation basin sludge was reported at 2,642 *Cryptosporidium* oocysts/100L in the clarifier sludge from the Moshannon Valley plant.

States, et al.

Cryptosporidium occurred in raw Allegheny river water supplying a plant at a geometric mean of 31 oocysts/100L in 63 percent of samples collected, and ranged from non-detect to 2,333 oocysts/100L (States et al., 1997). Of the filter backwash samples, a geometric mean of 328 oocysts/100L was found at an occurrence rate of 38 percent of samples, with a range from non-detect to 13,158 oocysts/100L. The fact that the mean concentration of *Cryptosporidium* oocysts can be substantially higher in backwash water than in untreated river water suggests that recycling untreated filter backwash water can be a significant source of this parasite in the treatment process.

2.2.6 Current Control and Potential for Improvement

One of EPA's key regulations to counter pathogens in drinking water is the Surface Water Treatment Rule (SWTR) (54 FR 27486, June 29, 1989). Among its provisions is the requirement that surface water systems have sufficient treatment to reduce the source water concentration of *Giardia* and viruses by at least 99.9 percent (3 logs) and 99.99 percent (4 logs), respectively. A shortcoming of the SWTR, however, is that the rule does not specifically control for the protozoan *Cryptosporidium*. The first report of a recognized outbreak caused by *Cryptosporidium* was published during the development of the SWTR (D'Antonio et al., 1985).

In 1998, the Agency finalized the IESWTR, designed to enhance the SWTR protections from microbial pathogens, specifically *Cryptosporidium*, for systems serving 10,000 or more persons. The IESWTR provisions included a Maximum Contaminant Level Goal (MCLG) of zero for *Cryptosporidium*. In addition, the IESWTR requires a minimum 2-log (99 percent) removal of *Cryptosporidium*, linked to enhanced combined filter effluent and individual filter turbidity monitoring provisions, although this requirement currently applies only to surface and GWUDI systems serving at least 10,000 persons and that must filter under the SWTR. The LT1ESWTR is expected to be finalized in early 2001, and will address these issues for systems serving less than 10,000 people.

Degradation in treatment performance caused by improper plant process flow recycle or other treatment deficiencies may hinder efforts to control *Cryptosporidium, Giardia lamblia*, and other emerging pathogens, particularly during periods of heavy precipitation or high runoff. *Cryptosporidium* oocysts have been found in filtered drinking water from facilities meeting the treatment technique requirements of the SWTR (LeChevallier, et al., 1991a; U.S. EPA, 1993), and many individuals affected by waterborne disease outbreaks caused by *Cryptosporidium* were served by filtered surface water supplies (Solo-Gabriele and Neumeister, 1996). These instances indicate surface water supplies that filter and disinfect may still be vulnerable to *Cryptosporidium*, depending on the quality of their source water and the effectiveness of their treatment. The FBRR will help ensure recycle practices are not contributing excessive concentrations of *Cryptosporidium* to the source water and are not disrupting the multiple barriers of water treatment processes through chemical imbalance or hydraulic surges. As an added benefit, these practices that control *Cryptosporidium* will control other microbiological contaminants of concern, such as *Giardia*.

The FBRR addresses the concern that for all PWSs which recycle their process flow, *Cryptosporidium* (and other emerging pathogens resistant to standard disinfection) are reintroduced to the treatment process by the recycling of spent filter backwash water, solids treatment residuals, and other process flows. Insufficient treatment practices have been cited as the cause of several reported waterborne disease outbreaks (Rose, 1997). Therefore, the recycle flow provisions of the rule would help ensure that the treatment process is not disrupted or operating inefficiently. The regulatory history that led to development of the FBRR is summarized in the next section.

2.3 Regulatory History and Current Controls

2.3.1 1979 Total Trihalomethane Rule

In November 1979 (44 FR 68624), EPA set an interim MCL for total trihalomethanes (TTHM - the sum of chloroform, bromoform, bromodichloromethane, chlorodibromomethane) of 0.10 mg/l as an annual average.

The interim TTHM standard applies to community water systems (CWSs) that use surface water and/or ground water, that serve at least 10,000 persons, and that add a disinfectant to the drinking water during any part of the treatment process. At their discretion, States may extend coverage to smaller water systems; however, most States have not exercised this option.

2.3.2 Surface Water Treatment Rule

Under the Surface Water Treatment Rule (SWTR) (54 FR 27486; June 29, 1989), EPA set maximum contaminant level goals of zero for *Giardia lamblia*, viruses, and *Legionella*; and promulgated regulatory requirements for all PWSs using surface water or GWUDI sources. The SWTR includes treatment technique requirements for filtered and unfiltered systems that are intended to protect against the adverse health effects of exposure to *Giardia lamblia*, viruses, and *Legionella*, as well as many other pathogenic organisms. Briefly, those requirements include 1) requirements for maintenance of a disinfectant residual in the distribution system; 2) removal and/or inactivation of 3 log (99.9 percent) for *Giardia* and 4 log (99.99 percent) for viruses; 3) combined filter effluent turbidity performance standard of 5 nephelometric turbidity units (NTUs) as a maximum and 0.5 NTU at the 95th percentile monthly, based on four-hour monitoring for treatment plants using conventional treatment or direct filtration (with separate standards for other filtration technologies); and 4) watershed protection and other requirements for unfiltered systems.

2.3.3 Information Collection Rule

The Information Collection Rule (ICR), which was promulgated on May 14,1996 (61 FR 24354), applied to large public water systems serving populations of more than 100,000 persons; a more limited set of ICR requirements pertain to ground water systems serving between 50,000 and 100,000 persons.

The purpose of the ICR was to collect occurrence and treatment information to help evaluate the need for possible changes to the current microbial requirements and existing microbial treatment practices, and to help evaluate the need for future regulation for disinfectants and disinfection byproducts (DBPs). The ICR provided EPA with additional information on the national occurrence in drinking water of 1) chemical byproducts that form when disinfectants used for microbial control react with naturally occurring compounds present in source water; and 2) disease-causing microorganisms, including *Cryptosporidium, Giardia,* and viruses. The ICR also collected engineering data on how PWSs currently control for such contaminants. The ICR monthly sampling data provided 18 months worth of information on the quality of the recycle waters via monthly monitoring of pH, alkalinity, turbidity, temperature, calcium and total hardness, TOC, UV_{254}, bromide, ammonia, and disinfectant residual (if disinfection is used). These data will provide some indication of the "treatability" of the water, the extent to which contaminant concentration effects may occur, and the potential for contribution to DBP formation.

2.3.4 Interim Enhanced Surface Water Treatment Rule

Public water systems that serve 10,000 or more persons and use surface water or GWUDI are required to comply with the IESWTR (63 FR 69477; December 16, 1998) by December 2001. The purposes of the IESWTR are to improve control of the protozoan *Cryptosporidium* and to address risk trade-offs between pathogens and disinfection byproducts. Key provisions established by the rule include an MCLG of zero for *Cryptosporidium*; 2-log *Cryptosporidium* removal requirements for systems that filter; strengthened combined filter effluent turbidity performance standards of 1.0 NTU as a maximum and 0.3 NTU at the 95th percentile monthly, based on 4-hour monitoring for treatment plants using conventional treatment or direct filtration; requirements for individual filter turbidity monitoring; disinfection benchmark provisions to assess the level of microbial protection provided as facilities take the necessary steps to comply with new disinfection byproduct standards; inclusion of *Cryptosporidium* in the definition of GWUDI and in the watershed control requirements for unfiltered public water systems; requirements for covers on new finished water reservoirs; and sanitary surveys for all surface water systems regardless of size.

2.3.5 Stage 1 Disinfection Byproduct Rule

The Stage 1 DBPR (63 FR 69389; December 16, 1998) applies to every PWSs that is either a CWS or a nontransient noncommunity water system (NTNCWS) that treats its water with a chemical disinfectant for either primary or residual treatment. In addition, certain requirements for chlorine dioxide apply to transient noncommunity water systems (TNCWSs). The Stage 1 DBPR was published at the same time as the IESWTR (63 FR 69477; December 16, 1998).

The Stage 1 DBPR finalizes maximum residual disinfectant level goals (MRDLGs) for chlorine, chloramines, and chlorine dioxide; MCLGs for four trihalomethanes (chloroform[2], bromodichloromethane, dibromochloromethane, and bromoform), two haloacetic acids (dichloroacetic acid and trichloroacetic acid), bromate, and chlorite; and for three disinfectants (chlorine, chloramines, and chlorine dioxide), two groups of organic disinfection byproducts, total

[2]The chloroform MCLG of 0 is withdrawn per a D.C. Court of Appeals May 2000 decision.

trihalomethanes (TTHMs) and five Halocetic Acids (HAA5), and two inorganic disinfection byproducts (chlorite and bromate). The NPDWRs consist of maximum residual disinfectant levels (MRDLs), maximum contaminant levels (MCLs), or treatment techniques for these disinfectants and their byproducts. The NPDWRs also include monitoring, reporting, and public notification requirements for these compounds. The Stage 1 DBPR includes the best available technologies (BATs) upon which the MRDLs and MCLs are based. EPA believes the implementation of the Stage 1 DBPR will reduce the levels of disinfectants and disinfection byproducts in drinking water supplies. The Agency also believes the rule will extend public health protection to an additional 20 million households that were not previously covered by drinking water rules for disinfection byproducts.

2.3.6 Long Term 1 Enhanced Surface Water Treatment Rule

LT1ESWTR will extend protections against *Cryptosporidium* and other disease-causing microbes to small water systems that serve fewer than 10,000 people annually and that use surface water or GWUDI sources. This rule was originally proposed together with FBRR as one rule in the Federal Register (65 FR 19046; April 10, 2000) and is expected to be finalized early in 2001. Like the IESWTR, which addresses treatment processes at larger systems, the purposes of the LT1ESWTR are to improve control of the protozoan *Cryptosporidium* and to address risk trade-offs between pathogens and disinfection byproducts

LT1ESWTR uses the same framework as the IESWTR, while providing flexibility to small systems. Key provisions established by the rule include an MCLG of zero for *Cryptosporidium*; 2-log *Cryptosporidium* removal requirements for systems that filter; strengthened combined filter effluent turbidity performance standards of 1.0 NTU as a maximum and 0.3 NTU at the 95th percentile monthly, based on four-hour monitoring for treatment plants using conventional treatment or direct filtration; requirements for individual filter turbidity monitoring; disinfection benchmark provisions to assess the level of microbial protection provided as facilities take the necessary steps to comply with new disinfection byproduct standards; inclusion of *Cryptosporidium* in the definition of GWUDI and in the watershed control requirements for unfiltered public water systems; and requirements for covering new finished water reservoirs.

2.3.7 Stakeholder Involvement

EPA conducted two meetings to solicit feedback and information from the regulated community and other concerned stakeholders on issues relating to the FBRR. The first meeting was held on July 22 and 23, 1998 in Lakewood, CO. EPA presented potential regulatory components for the FBRR. Breakout sessions with stakeholders were held to generate feedback on the regulatory provisions being considered and to solicit feedback on next steps for rule development and stakeholder involvement. Additionally, information was presented summarizing ongoing research and data gathering regarding the recycle of filter backwash. The presentations generated useful discussion and provided substantial feedback to EPA regarding technical issues, stakeholder concerns, and possible regulatory options.

The second stakeholder meeting was held in Dallas, TX on March 3 and 4, 1999. EPA presented new analysis, summaries of current research, revised regulatory options, and data collected since the July stakeholder meeting. Four breakout sessions were extremely useful and generated a wide range of information, issues, and technical input from a diverse group of stakeholders.

In early June 1999, EPA mailed an informal draft of the FBRR preamble to the approximately 100 stakeholders who attended either of the public stakeholder meetings. Members of trade associations and the Small Business Advocacy Review (SBAR) panel also received the draft preamble. EPA received valuable comments and stakeholder input from 15 state representatives, trade associations, environmental interest groups, and individual stakeholders.

During the comment period for the rule, the Agency held a public meeting in Washington DC on April 14. Additionally, the proposed rule was either presented or discussed in nearly 50 meetings across the United States. Finally, EPA mailed approximately 200 copies of the proposed rule to stakeholders requesting comment. EPA received 67 comments from a variety of stakeholders including, States, municipalities, tribes, elected officials, consultants, trade groups, and private industry. These comments were reviewed and evaluated while developing the final rule.

2.4 Economic Rationale

2.4.1 Introduction

This section of the RIA discusses the statutory authority and the economic rationale for choosing a regulatory approach to protect public health from drinking water contamination. The economic rationale is provided in response to Executive Order 12866, *Regulatory Planning and Review*, which states:

> [E]ach agency shall identify the problem that it intends to address (including, where applicable, the failures of the private market or public institutions that warrant new agency action) as well as assess the significance of that problem (Sect. 1b(1)).

In addition, OMB guidance dated January 11, 1996, states that "in order to establish the need for the proposed action, the analysis should discuss whether the problem constitutes a significant market failure (p. 3)." Therefore, the economic rationale laid out in this section should not be interpreted as the Agency's approach to implementing the Safe Drinking Water Act (SDWA). Rather, it is the Agency's economic analysis, as required by the Executive Order, to support a *regulatory approach* to the public health issue at hand.

2.4.2 Statutory Authority for Promulgating the Rule

Section 1412(b)(1)(A) of SDWA requires EPA to establish NPDWRs for contaminants that may have an adverse public health effect, that are known to occur, or present a substantial likelihood of occurrence in public water systems at a frequency and level of public health concern and that present a meaningful opportunity for health risk reduction for persons served by PWSs.

SDWA provides the authority to promulgate the FBRR. Specifically, it contains a provision regarding the recycle of process flows, which states, "The Administrator shall promulgate a regulation to govern the recycling of filter backwash water within the treatment process of a public water system."(1412(b)(14)).

2.4.3 The Economic Rationale for Regulation

In addition to the statutory directive to regulate surface water treatment and recycling, there is a strong economic rationale for government regulation. The need for regulation is a direct result of the structure of the market for publically provided drinking water. Economic theory suggests that society's well being is maximized when goods are produced and sold in well-functioning competitive markets. A perfectly competitive market is said to exist when there are many producers of a product selling to many buyers, and producers and consumers have complete knowledge regarding the products of each firm. There must also be no barriers to entry in the industry, and firms in the industry must not have any advantage over potential new producers. Two major factors in the public water supply industry do not satisfy the requirements for a competitive market and lead to market failures that require regulation.

First, the public water market has monopolistic tendencies. These monopolies tend to exist because it is not economically efficient to have multiple suppliers competing to build multiple systems of pipelines, reservoirs, wells, and other facilities in the same locality. Instead, a single firm or government entity performs these functions under public control. Under monopolistic conditions, consumers are provided only one level of service with respect to the quality of a product, in this case drinking water. Because water purveyors often operate in a monopolistic environment, they may not respond to the usual market incentive to satisfy their consumers' desire for safety and high-quality drinking water.

Second, high information and transaction costs impede public understanding of the health and safety issues concerning drinking water quality. The type of health risk potentially posed by trace quantities of drinking water contaminants involve analysis and distillation of complex toxicological and health sciences data. EPA has finalized the development of the Consumer Confidence Report Rule, which makes water quality information more easily available to consumers. This rule requires CWSs to post or to mail to their customers an annual report on local drinking water quality. However, consumers will still have to analyze this information for its health implications. Even if informed consumers are able to engage systems regarding these health issues, the costs of such engagement, known as transaction costs and measured in personal time and commitment, present significant impediments to consumer expressions of risk preference.

SDWA regulations are intended to provide protection that would not otherwise occur from exposure to drinking water contaminants in the existing market environment for public water supply. The regulations set minimum performance requirements for all public water supplies in order to protect all consumers from exposures to contaminants. SDWA regulations are not intended to restructure flawed market mechanisms or to establish competition in supply, but rather, to regulate the "product" produced within these markets. In other words, SDWA standards establish the level of service to be provided in order to better reflect public preferences for safety. Also, by acting on behalf of all consumers in balancing the risk reduction and the social costs of achieving this reduction in risk, the federal regulations remove the high information and transaction costs that would be required for consumers to make informed purchasing decisions.

2.5 Rule Summary

EPA proposes the following requirements to meet the public health protection goals of the FBRR, which will fulfill the statutory requirements of the SDWA. Exhibit 2-7 shows the rule's provisions that address recycle practices. The flow chart in Exhibit 2-8 illustrates how a system using surface water or GWUDI as a source determines which provisions apply to it.

As Exhibit 2-7 shows, the three recycle provisions in the rule apply to water systems that:

- Use surface water or ground water under the direct influence of surface water,
- Use direct or conventional filtration processes, and
- Recycle spent filter backwash water, sludge thickener supernatant, or liquids from dewatering processes.

The first provision generally requires that recycled filter backwash water, sludge thickener supernatant, and liquids from dewatering processes be returned through the processes of a system's existing conventional or direct filtration system as defined in 40 CFR, Section 141.2. Plants that require an alternative recycle location to maintain optimal finished water quality, that are designed to employ recycle flow as an intrinsic component of the treatment process, or that have unique treatment requirements or processes may apply to the State if they want to return recycle to an alternative location.

The second provision requires systems that practice conventional filtration and recycle spent filter backwash, sludge thickener supernatant, or liquids from dewatering processes, notify the State in writing that they practice recycle. When notifying the State, these systems must also provide information characterizing their recycle flows. Specifically, they must provide:

- A plant schematic showing the origin of all recycle flows, the hydraulic conveyance used to transport them, and the location where they are recycled back into the plant; and
- Typical recycle flow in gallons per minute (gpm), highest observed plant flow experienced in the previous year (gpm), design flow for the treatment plant (gpm), and, if applicable, the State-approved operating capacity for the plant.

Additionally, the systems must collect and maintain information for review by the State as listed below. States, which after evaluating the information, may require a system to modify their recycle location or recycle practices.

- Copy of the recycle notification and information submitted to the State.

- List of all recycle flows and the frequency with which they are returned.
- Average and maximum backwash flow rate through the filters and the average and maximum duration of the filter backwash process in minutes.
- Typical filter run length and a written summary of how filter run length is determined.
- The type of treatment provided for the recycle flow.
- Data on the physical dimensions of the equalization and/or treatment units, typical and maximum hydraulic loading rates, type of treatment chemicals used and average dose and frequency of use, and frequency at which solids are removed, if applicable.

If a system does not recycle spent filter backwash water, sludge thickener supernatant, or liquids from dewatering processes through the processes of a system's existing conventional or direct filtration system (including specifically: coagulation, flocculation, sedimentation, and filtration), it must propose a schedule for making the necessary capital improvements associated with managing the location of recycle or request approval of an alternate location.

The third provision requires systems that practice direct filtration and recycle spent filter backwash, sludge thickener supernatant, or liquids from dewatering processes, notify the State in writing that they practice recycle. When notifying the State, these systems must also provide information characterizing their recycle flows. Specifically, they must provide:

- A plant schematic showing the origin of all recycle flows, the hydraulic conveyance used to transport them, and the location where they are recycled back into the plant; and
- Typical recycle flow in gallons per minute (gpm), highest observed plant flow experienced in the previous year (gpm), design flow for the treatment plant (gpm), and, if applicable, the State-approved operating capacity for the plant.

Additionally, the systems must collect and maintain information for review by the State as listed below. States, which after evaluating the information, may require a system to modify their recycle location or recycle practices.

- Copy of the recycle notification and information submitted to the State.
- List of all recycle flows and the frequency with which they are returned.
- Average and maximum backwash flow rate through the filters and the average and maximum duration of the filter backwash process in minutes.
- Typical filter run length and a written summary of how filter run length is determined.
- The type of treatment provided for the recycle flow.

- Data on the physical dimensions of the equalization and/or treatment units, typical and maximum hydraulic loading rates, type of treatment chemicals used and average dose and frequency of use, and frequency at which solids are removed, if applicable.

Exhibit 2-7. Summary of How the FBRR is Organized

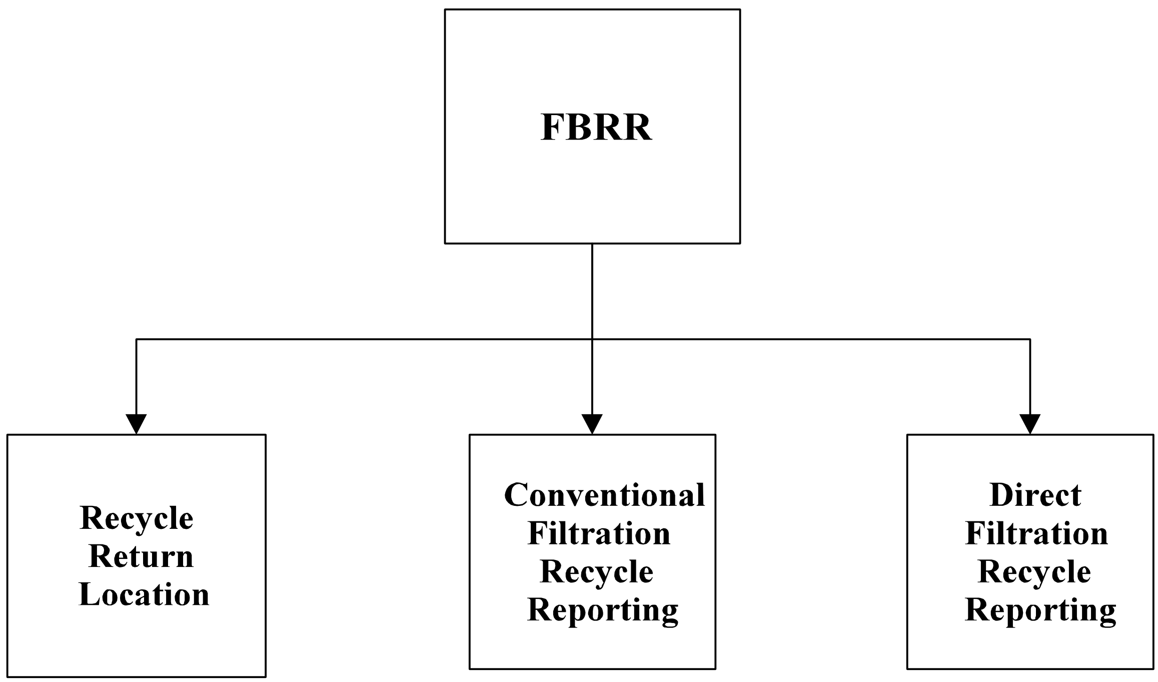
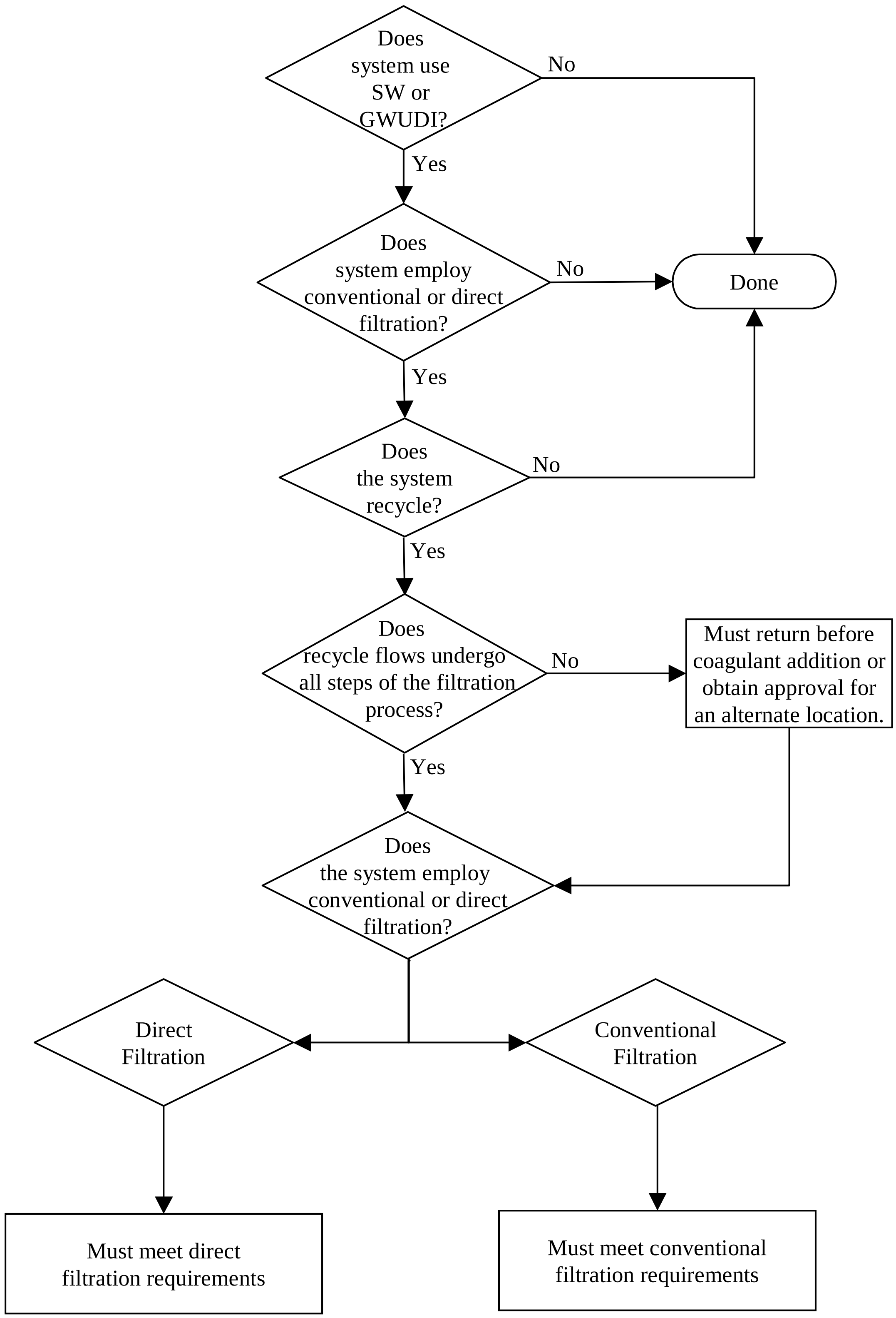


Exhibit 2-8. Illustration of How Provisions Apply to Different Types of Surface Water or GWUDI Systems



3. Consideration of Regulatory Alternatives

In addition to the Filter Backwash Recycling Rule (FBRR) provisions described in the previous section, EPA considered, and sought public comment on, four alternative regulatory options. The remainder of this chapter provides a detailed description of these regulatory alternatives and presents EPA's selected alternative and the rationale underlying its choice.

3.1 Recycle Provisions

EPA considered four regulatory options for the recycle return location requirement. All of the alternatives considered require select recycle flows to be returned prior to the point of primary coagulant addition.[1] Alternatives R2, R3, and R4 place additional requirements on systems that practice direct recycle or direct filtration, as well as other conventional systems that recycle. Exhibit 3-1 provides an overview of the alternatives that EPA considered for the recycling provisions of the rule. Each of these alternatives is discussed in detail following the exhibit.

Exhibit 3-1. Filter Backwash Alternatives (as Proposed)

System Recycle Type	Alternative R1	Alternative R2	Alternative R3	Alternative R4
Recycle Return Location	Prior to primary coagulant addition.			
	State reviews requests for alternate recycle return location.			
Direct Recycle Systems	No Provision.	Report self-assessment to State.	Equalization for recycle flows.	Sedimentation or better for recycle flows.[1]
		State reviews monitoring plan and self-assessment report and reports to EPA whether a change in recycle practice is necessary.		
Direct Filtration Systems	No Provision.	Report recycle practices to State.		Sedimentation or better for recycle flows.
		State reviews data characterizing recycle practice and reports to EPA whether a change in recycle practice is necessary.		

[1]Note: This requirement would apply to all conventional filtration systems that do not provide sedimentation or more advanced treatment for their recycle flows.

[1]EPA has refined the language used to describe this provision, which would have required systems to return recycle flows "prior to the point of primary coagulant addition" under the proposed rule. Language describing the requirements that apply to conventional or direct systems that recycle has also been refined.

Alternative R1

As proposed, the first alternative considered by the Agency required that subject plants using surface water or GWUDI as a source return filter backwash, thickener supernatent, and liquids from dewatering processes prior to the point of primary coagulant addition; see Section 2.1 of this document for a description of these recycle flows. Plants that require an alternative recycle return location to maintain optimal finished water quality (as indicated by finished water or intra-plant turbidity levels), plants that are designed to employ recycle flow as an intrinsic component of the treatment process, or plants with unique treatment requirements or processes may request that the State allow an alternative recycle return location.

Alternative R2

Alternative R2 was the alternative chosen for the rule. As proposed, Alternative R2, like the other alternatives, would have required conventional or direct filtration plants to return select recycle flows prior to the point of primary coagulant addition. This alternative would also have required some direct recycle systems to perform a self-assessment of their recycle practice and report the results to the State. The public water systems that would have been required to conduct a self-assessment were those that met all of the following criteria:

1. Use surface water or GWUDI as a source and employ conventional rapid granular filtration treatment.

2. Employ 20 or fewer filters to meet production requirements during the highest production month in the 12-month period prior to the rule's compliance date.

3. Recycle spent filter backwash or thickener supernatant directly to the treatment process (i.e., recycle flow is returned within the treatment process of a PWS without first passing the recycle flow through a treatment process designed to remove solids, a raw water storage reservoir, or some other structure with a volume equal to or greater than the volume of spent filter backwash water produced by one filter backwash event).

The systems that met all the above criteria would have been required to develop and submit a recycle self-assessment monitoring plan to the State no later than 3 months after the rule's effective date. At a minimum, the monitoring plan was to identify the month during which monitoring will be conducted, contain a schematic identifying the location of raw and recycle flow monitoring devices, describe the type of flow monitoring devices to be used, and describe how data from the raw and recycle flow monitoring devices will be simultaneously retrieved and recorded.

As proposed, systems were to submit a self-assessment report containing the results of monitoring to the State within 1 month of completing the monitoring. At a minimum, the report was to provide the following information:

1. All source and recycle flow measurements taken and the dates they were taken. For all events monitored, a report of the times the filter backwash recycle event was initiated, the flow measurements taken at three minute intervals, and the time the filter backwash recycle event ended. The system must also report the number of filters in use when the backwash recycle event was monitored.

2. All data used and calculations performed to determine whether the system exceeded operating capacity during monitored recycle events and the number of event flow values that exceeded State approved operating capacity.

3. A plant schematic showing the origin of all recycle flows, the hydraulic conveyance used to transport them, and their final destination in the plant.

4. A list of all the recycle flows and the frequency at which they are returned to the plant.

5. Average and maximum backwash flow through the filters and the average and maximum duration of backwash events in minutes, for each monitoring event.

6. Typical filter run length, number of filters typically employed, and a written summary of how filter run length is determined (e.g., preset run time, headloss, or turbidity level).

The proposal envisioned that systems would develop and submit the self-assessment monitoring plan to the State within three months after the rule’s compliance date for each plant subject to the requirements.

EPA had proposed to require that the States review all self-assessment reports submitted by PWSs and report to the Agency one of the following for each individual plant:

1. A finding that modifications to recycle practice are necessary, followed by a brief description of the required change and a summary of the reason(s) the change is required.

2. A finding that changes to recycle practice are not necessary and a brief description of the reason(s) this determination was made.

As proposed, Alternative R2 also required direct filtration plants using surface water and GWUDI that recycle to the treatment process to report certain data that characterize their recycle practice to the State:

1. Whether recycle flow treatment or equalization is in place.

2. The type of treatment provided for the recycle flow.

3. If equalization, sedimentation, or some type of clarification process is used, the following information should be provided: the physical dimensions of the unit sufficient to allow calculation of its volume, and the type, typical dose, and frequency at which treatment chemicals are used, if applicable.

4. The minimum and maximum hydraulic loading the treatment unit experiences.

5. The maximum backwash rate, duration, typical filter run length, and the number of filters at the plant.

The purpose of this requirement was to allow States to assess whether the existing recycle practice of direct filtration plants addresses the potential risks posed by recycle. The Agency believes that direct filtration plants need to remove oocysts from recycle flow prior to reintroducing it to the treatment process. The proposal anticipated that States would be required to report their determination for each system to EPA and provide a brief explanation of the reason(s) for the decision.

Alternative R3

As with the previously described alternatives, this alternative (R3) would require conventional or direct filtration systems to return select recycle flows prior to the point of primary coagulant addition. Unlike Alternative R2, however, this option would not require a self-assessment. It would, instead, require all recycle plants without existing recycle flow equalization or treatment to install recycle flow equalization. In addition, direct filtration plants would have to report data on recycle treatment to the State.

Alternative R4

As with all other alternatives, Alternative R4 would require conventional or direct filtration systems to return select recycle flows prior to the point of primary coagulant addition. Unlike Alternatives R2 and R3, respectively, this option would not require a self-assessment nor would it require direct filtration plants to report on their recycle practices. It would, instead, require conventional filtration plants that recycle within the treatment process to provide sedimentation or more advanced recycle treatment. Similarly, direct filtration plants would also need to provide sedimentation or more advanced recycle treatment.

3.2 EPA's Selected Alternative

EPA evaluated all of the above alternatives and considered public comments received on these alternatives in making its choice to promulgate a refinement of Alternative R2. EPA concluded that a national treatment requirement is inappropriate at this time due to data deficiencies. However, the Agency believes that the collection and reporting of information characterizing recycle practices will aid the States in targeting recycle treatment for higher risk recycle practices.

Regarding recycle return location, the Agency recognizes the value of having recycle be returned early in the treatment train; however, it also recognizes unique site-specific conditions. As a result, the recycle return provision provides flexibility. Specifically, it allows the State to approve an alternate recycling location for systems on a case-by-case basis.

Each of the final three FBRR requirements and rationale for their selection is discussed in detail below.

Recycle Location

Many commenters agreed with the proposal requiring recycle be returned prior to the point of primary coagulant addition was appropriate, while several others noted that recycle should be allowed concurrent with the point of primary coagulant addition. Still others, most notably EPA's Science Advisory Board (SAB), indicated that because of the site-specific characteristics of recycle, defining a single acceptable recycle return location was inappropriate because it could reduce the performance of the system.

After evaluating the data provided by those submitting public comments, EPA believes that a level of health protection comparable to the proposal can be achieved by refining the recycle return location. Specifically, the FBRR requires that recycled filter backwash water, sludge thickener supernatant, and liquids from dewatering processes be returned through the processes of a system's existing conventional or direct filtration system as defined in 40 CFR, Section 141.2.[2] EPA believes this alternate recycle location will ensure that recycle flows are given adequate treatment to achieve 2-log (99%) removal of *Cryptosporidium*. The proposal originally required that recycle be returned prior to the point of primary coagulant addition.

Like all of the proposed alternatives, plants that require an alternate location to maintain optimal finished water quality, that are designed to employ recycle flow as an intrinsic component of the treatment process, or that have unique treatment requirements or processes may request an alternative recycling location from the State.

Conventional Filtration Recycle Requirement

Given the variety and site-specific nature of recycle practices throughout the country, the Agency believes it is necessary to require systems to notify States that they practice recycle, and provide information the State could utilize to evaluate whether a treatment plant may be susceptible to hydraulic disruptions as a result of recycling. The second FBRR provision specifies the components of this notification requirement. Specifically, it requires systems that practice conventional filtration and recycle spent filter backwash, sludge thickener supernatant, or liquids from dewatering processes notify the State in writing that they practice recycle.

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[2]EPA has refined the language used to describe this provision, which would have required systems to return recycle flows "prior to the point of primary coagulant addition" under the proposed rule. Language describing the requirements that apply to conventional or direct systems that recycle has also been refined.

The original proposal addressed the need for recycle information by attempting to identify the subset of systems that would be most susceptible to hydraulic surges by requiring that only systems without equalization or treatment (referred to as “direct recycle”) meet the reporting requirements. This provision required that systems employing 20 or fewer filters and recycling spent filter backwash water, thickener supernatant, or liquids from dewatering process within the treatment process must perform a one month, one-time recycle self-assessment. The self assessment required a monitoring plan, hydraulic flow monitoring, and a self-assessment report containing additional recycle information be submitted to the State, which could require modifications to a system’s recycle practice in order to protect public health.

The Agency received many comments regarding what was originally titled Direct Recycle Reporting in the proposed rule. Many commenters believed that the operational values used in the analysis conducted by the Agency to arrive at a 20 filter cut-off did not accurately represent the true range of values witnessed throughout the country. Similarly, many commenters noted that excluding systems that treat or equalize recycle flows was inappropriate because of the lack of clearly defined, widely-used parameters for the definitions of equalization and treatment of recycle. Once again this requirement may fail to accurately characterize hydraulic surge potential at systems with significantly different equalization or treatment practices than those assumed by the Agency and documented by research. Accordingly, EPA has modified this requirement, such that it now applies to all conventional filtration systems that recycle.

The system reporting and recordkeeping components of the requirements are discussed below. These requirements were also refined from the proposal to collect basic flow information rather than flow monitoring data originally required. EPA believes these less burdensome requirements still provide information that can be used by States to evaluate whether hydraulic surges may pose problems.

<u>System Reporting Requirements</u>

When notifying the State, these systems must also provide information characterizing their recycle flows. Specifically, they must provide:

- A plant schematic showing the origin of all recycle flows, the hydraulic conveyance used to transport them, and the location where they are recycled back into the plant; and

- Typical recycle flow in gallons per minute (gpm), highest observed plant flow experienced in the previous year (gpm), design flow for the treatment plant (gpm), and, if applicable, the State-approved operating capacity for the plant.

<u>System Recordkeeping Requirements</u>

Additionally, the systems must collect and maintain information for review by the State as listed below. States, which after evaluating the information, may require a system to modify their recycle location or recycle practices.

- Copy of the recycle notification and information submitted to the State.
- List of all recycle flows and the frequency with which they are returned.
- Average and maximum backwash flow rate through the filters and the average and maximum duration of the filter backwash process in minutes.
- Typical filter run length and a written summary of how filter run length is determined.
- The type of treatment provided for the recycle flow.
- Data on the physical dimensions of the equalization and/or treatment units, typical and maximum hydraulic loading rates, type of treatment chemicals used and average dose and frequency of use, and frequency at which solids are removed, if applicable.

Direct Filtration Recycle Requirement

The third FBRR provision is identical to the second provision described immediately above, except it extends the recycle information recordkeeping and reporting requirements to direct filtration systems.

The Agency believes the reporting and maintenance of the recycle information is critical given the nature of direct filtration systems. By definition, direct filtration does not have a sedimentation or solids removal step. Any solids which enter the process either are deposited on the filter or travel through the filter. If the recycle flow is not adequately treated before being returned to the primary treatment train, significant numbers of the oocysts captured on a filter during a filter run will be returned to the plant. These oocysts are again loaded onto the filters, increasing the risk that disinfectant-resistant pathogens such as *Cryptosporidium* can slip through filtration, thereby posing a public health risk. Therefore, EPA believes States should be provided with and have access to information they can use to evaluate whether a treatment plant may be susceptible to hydraulic disruptions as a result of recycling, and whether the existing recycle practices sufficiently addresses potential health risks.

Many States commented that information required to be submitted as part of the proposed Direct Filtration Reporting was often duplicative of information already available to the State. States also noted that submittal of direct filtration reports would result in an increased burden, and could be problematic, given resource limitations.

To eliminate redundant reporting and minimize burden, EPA modified the Direct Filtration Reporting requirement, so that a system must collect the data and keep it on file for State review. This will provide States the ability to reduce transaction costs by incorporating review of the recycle practice data into Sanitary Surveys, other inspections (i.e., comprehensive performance evaluations), or other State-specific program elements.

EPA believes that data collection and maintenance for this FBRR requirement allows systems and States to evaluate recycle practices and determine whether existing recycle practices sufficiently address potential health risks.

4. Baseline Analysis

To understand the benefits of the Filter Backwash Recycling Rule (FBRR) and estimate the economic and financial impact of the rule's regulatory options on the water supply industry and ultimately on customers, EPA developed a baseline before considering the effect of any single regulatory option. A baseline is defined as a characterization of the industry and its operations prior to the rulemaking. Much of the data used to develop the baseline are provided in the *Occurrence Assessment for the Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Recycling Rules* (U.S. EPA, 2001a), which provides data on the occurrence of *Cryptosporidium* in recycle flows and on the health effects and hazards posed by *Cryptosporidium* in drinking water.

To develop additional baseline information for the FBRR, EPA collected and analyzed data on the number of systems that use surface water and ground water under the direct influence of surface water (GWUDI), the percentage of GWUDI systems that use conventional or direct filtration, and the percentage of these systems that recycle. These data are used to estimate the number of water systems impacted by the rule. The exception to this approach is EPA's analysis of systems serving more than one million persons. EPA used the system schematics submitted as part of the Information Collection Rule (ICR) and data from the Safe Drinking Water Information System (SDWIS) to determine whether systems serving more than 1 million persons would be affected by the rule.

This chapter discusses the sources of information used to develop the baseline, the approaches used to analyze these data, key assumptions associated with the analyses, and the resulting estimates. Specifically, this chapter presents the information used to estimate the number of systems affected by the rule's provisions in the following sections:

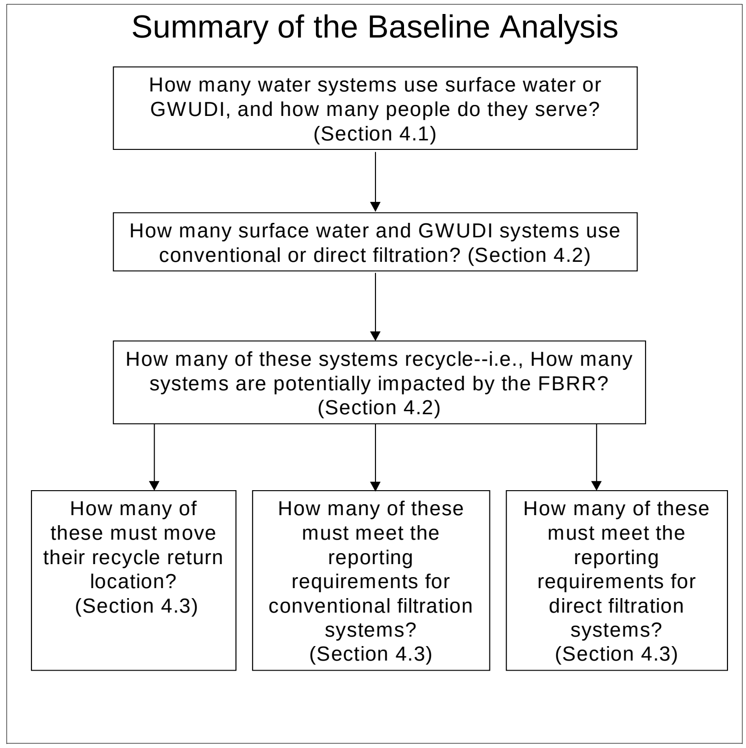
- Section 4.1, *Baseline Profile of Surface Water and GWUDI Systems*, provides information on the universe of surface water systems and the populations they serve.

- Section 4.2, *Profile of Systems Subject to the FBRR*, explains how EPA estimated the number of systems potentially affected by the FBRR—i.e., those surface water and GWUDI systems that use conventional or direct filtration and recycle spent filter backwash water, sludge thickener supernatant, or liquids from dewatering processes.

- Section 4.3, *Profile of Systems Subject to Each FBRR Provision*, uses the assumptions in Sections 4.1 and 4.2 to estimate the number of systems subject to each provision of the FBRR.

4.1 Baseline Profile of Surface Water and GWUDI Systems

EPA analyzed data on the number of systems that use surface water and GWUDI and the resources available to the systems. Data inputs included the total number of affected systems, the households and populations served by these systems, average and maximum system flow rates, costs of employing system operators, and system revenues and expenses. This analysis involved input from knowledgeable stakeholders and incorporated the latest available research.



Prior to presenting baseline information for public surface water and GWUDI water systems, it is necessary to first define some terms used to describe water systems. EPA uses the following classifications.

- A public water system (PWS) is one that serves 25 or more persons or has 15 or more service connections and operates at least 60 days per year. PWSs can be publicly or privately owned. They can also be classified as either a community or a noncommunity system (as defined below).

- A community water system (CWS) is one that serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.

- A noncommunity water system (NCWS) does not have year-round residents, but serves at least 15 service connections used by travelers or intermittent users for at least 60 days each year, or serves an average of 25 individuals for at least 60 days a year.

Noncommunity water systems can be further classified as either transient or nontransient:

- A nontransient noncommunity water system (NTNCWS) serves at least 25 of the same persons over six months per year (e.g., factories, schools, office buildings, and hospitals with their own water source).

- A transient noncommunity water system (TNCWS) meets the definition of a "public water system," but does not serve at least 25 of the same persons over six months per year (e.g., many restaurants, rest stops, parks).

Public water systems are also classified by the source water they use as being either surface water (e.g., drawn from lakes, streams, rivers, etc.) or ground water (e.g., drawn from wells or springs). Some ground water sources (e.g., riverbank infiltration/galleries) are directly impacted by adjacent surface water bodies and are referred to as "ground water under the direct influence of surface water." As noted in Chapter 2, the FBRR addresses surface water systems and GWUDI systems.

The Agency used two sources to characterize the universe of surface water and GWUDI systems: the Safe Drinking Water Information System (SDWIS) and the Community Water Supply Survey. The following paragraphs provide a brief overview of each of the data sources.

- *Safe Drinking Water Information System (SDWIS).* SDWIS contains information about public water systems including violations of EPA's regulations for safe drinking water. Although SDWIS includes a variety of information including system name, identification number, population served, geographic location, type of source water, type of treatment (if provided), and known violations, the only SDWIS data that were used in this RIA were type of PWS (CWS, NTNCWS, or TNCWS), population served; and type of source water (surface water, GWUDI, or ground water).

- *Community Water System Survey (CWSS).* EPA conducted the 1995 Community Water System Survey to obtain data to support its development and evaluation of drinking water regulations. The survey consisted of a stratified random sample of 3,700 water systems nationwide (surface water and ground water). The survey asked 24 operational and 13 financial questions.

EPA has compiled much of this information in the *Drinking Water Baseline Handbook* (EPA 2000b). The Baseline Handbook was developed to serve as a single integrated set of data that defines baseline characteristics or conditions of the regulated community, the customers, and governmental entities. Data contained in the handbook were compiled from SDWIS (fourth quarter 1998) and the CWSS.

4.1.1 Number of Systems

Nationally, SDWIS indicates that there are approximately 13,608 public water systems that use surface water or GWUDI as the primary source (U.S. EPA, 2000b). This number includes 13 systems that serve one million persons or more.

Exhibit 4–1 presents the number of surface water systems in the United States by population served. The totals in Exhibit 4–1 include water systems that treat their own surface water (either drawn from their own source or purchased from other systems), as well as systems that purchase treated water from other systems (called "purchased water systems"). Although the provisions of the FBRR apply only to systems that treat their water, the Agency chose to include purchased water systems in order to estimate the total population affected by FBRR. Purchased water systems must be included to properly estimate the total number of persons affected by the rule. When EPA estimates the number of persons served by a water system, it counts only the local retail population of each system. Thus, the official "population served" by a system that sells water to other systems does not count the customers of those other systems that purchase its water. EPA included purchased water systems in the analysis to obtain an estimate for benefits passed on the purchased water systems, whose customers are not included in EPA's data on retail population served.

Exhibit 4–1. Total Number of Systems Using Surface Water or GWUDI by System Type and Service Population Category

Population Size Categories	System Type			
	CWS	TNCWS	NTNCWS	Total
<100	1,092	1,363	271	2,726
101 - 500	2,003	517	295	2,815
501 - 1,000	1,220	88	106	1,414
1,001 - 3,300	2,420	61	80	2,561
3,301 - 9,999	1,844	28	23	1,895
Small System Subtotal	8,579	2,057	775	11,411
10,000 - 50,000	1,607	7	4	1,618
50,001 - 100,000	300	3	1	304
100,001 - 1,000,000	261	0	1	262
> 1,000,000	13	0	0	13
Large System Subtotal	2,181	10	6	2,197
Total Number of Systems	10,760	2,067	781	13,608

Of the 13,608 water systems that use surface water or GWUDI, about 79 percent are CWSs, with TNCWSs making up 15 percent and NTNCWSs making up about 6 percent. In addition, systems are divided into the seven size categories used throughout the analysis. These categories are consistent with industry definitions of system size categories. According to SDWIS, about 80 percent of the CWSs and over 99 percent of both the TNCWSs and NTNCWSs that use surface water or GWUDI serve fewer than 10,000 persons, which EPA defines as a small system. Collectively, almost 84 percent of water systems that use surface water or GWUDI systems are small systems.

EPA integrated data on the number of systems in each size category into the national compliance cost model to estimate unit costs, determine treatment developed for compliance forecast or decision trees, and size equipment. Average and system design flows, expressed in millions of gallons per day (mgd), were developed separately from the cost model but are key components in generating unit costs. The model uses data on system flows to estimate equipment size, basin dimensions, filter bed and media requirements, and energy costs.

4.1.2 Population Served

System population characteristics are important to this analysis for several reasons. For example, it is important to know the total population served by surface water and GWUDI systems in order to address the distribution of costs and to estimate household costs. As presented in Exhibit 4–2, CWSs that use surface water or GWUDI serve over 170 million persons. Although almost 84 percent of surface water and GWUDI systems serve fewer than 10,000 persons (Exhibit 4–1), these small systems serve just over 10 percent of the consumers who use surface water or GWUDI.

Exhibit 4–2. System Population Size Categories and Total Population Potentially Affected

System Population Size Category	Total Population Potentially Affected
<100	135,138
101–500	773,064
501–1,000	1,068,556
1,001–3,300	5,051,439
3,301–9,999	11,276,617
Small System Subtotal	18,304,814
10,000–50,000	37,085,605
50,001–100,000	20,772,814
100,001-1,000,000	65,527,262
>1,000,000	28,658,586
Large System Subtotal	152,044,447
Total	170,349,081

4.2 Profile of Systems Subject to the FBRR

This section summarizes the number of systems potentially affected by the FBRR. For water systems that serve fewer than one million people (the vast majority of systems), Sections 4.2.1 and 4.2.2 explain how EPA used the results of the baseline profile of surface water and GWUDI systems, along with data on treatment and recycle practices, to estimate the number of systems that meet the rule's criteria. The number systems serving greater than 1 million persons is also presented in Sections 4.2.1 and 4.2.2. However, an alternative approach was used to estimate how the rule applies to water systems that serve more than one million people—Section 4.3.4 summarizes this approach.

The FBRR applies to all surface water and GWUDI systems that use conventional or direct filtration and recycle spent filter backwash water, sludge thickener supernatant, or liquids from dewatering processes. The previous section presented the derivation of the number of surface water and GWUDI systems, based on data from SDWIS and compiled in the Drinking Water Baseline Handbook (U.S. EPA, 2000b). This section shows EPA's approach for characterizing filtration and recycle practices of surface water and GWUDI systems, based on data from the CWSS (U.S. EPA 1997a), the 1996 Information Collection Rule, as well as data from a survey performed by the American Water Works Association (AWWA, 1998).

4.2.1 Profile of Filtration Practices

The FBRR applies to water systems using surface water or GWUDI, that use conventional and direct filtration, and practice recycling. Using the data contained in Exhibit 4–1, the Agency applied the percentages of surface water and GWUDI systems that filter (as noted in the CWSS) to develop an estimate of the number of systems that filter. This resulted in an estimated 11,062 surface water and GWUDI systems that filter, as shown below:

Number Systems Using Surface Water or GWUDI	X	% of Systems that Filter	=	Number of Systems that Filter	=	11,062

Exhibit 4-3 provides this estimate broken down by system size and type.

Given the estimate of 11,062 systems that filter, EPA used information in the CWSS database to estimate the number of systems that use conventional or direct filtration. This resulted in an estimated 7,738 surface water and GWUDI systems that use conventional or direct filtration, as shown below immediately following Exhibit 4-3.

Exhibit 4–3. Estimated Number of Systems that Filter[1]

Population Size Categories	Est. % that Filter[2]	Number of Systems by System Type[3]			
		Community	TNCWS	NTNCWS	Total
<100	75.1%	857	1,070	213	2,140
101 - 500	71.0%	1,422	367	209	1,999
501 - 1,000	79.3%	967	70	84	1,121
1,001 - 3,300	81.7%	1,977	50	65	2,092
3,301 - 9,999	86.5%	1,595	24	20	1,639
Small System Subtotal		6,818	1,581	591	8,991
10,000 - 50,000	96.3%	1,548	7	4	1,558
50,001 - 100,000	88.0%	264	3	1	268
100,001 - 1,000,000	93.4%	244	0	1	245
Large System Subtotal		2,055	9	6	2,070
Total Number of Systems		8,874	1,590	598	11,062

Note: Columns and row might not add to total due to rounding.
[1]Because the recycling practices for systems serving more than 1 million persons are determined directly from ICR data, the intermediate step of determining the number of these systems that filter is not included in this analysis. See Section 4.3.4 in this chapter for a detailed explanation of this calculation.
[2]Source: CWSS (U.S. EPA, 1997a).
[3]Based on the number of systems reported in Exhibit 4–1.

Number Systems That Filter	X	% of Filtration Systems that Are Conventional or Direct	=	Number of Systems that Use Conventional or Direct Filtration	=	7,738

Exhibit 4–4 provides this estimate broken down by system size and type.

Exhibit 4–4. Estimated Number of Filtration Systems that Use Conventional or Direct Filtration[1]

Population Size Categories	Est. % that Use Conv. or Direct[2]	Number of Systems by System Type[3]			
		Community	TNCWS	NTNCWS	Total
<100	38%	326	407	81	813
101 - 500	55%	782	202	115	1,099
501 - 1,000	73%	706	51	61	819
1,001 - 3,300	77%	1,522	38	50	1,611
3,301 - 9,999	90%	1,436	22	18	1,475
Small System Subtotal		4,772	720	326	5,817
10,000 - 50,000	92%	1,426	6	4	1,434
50,001 - 100,000	98%	259	3	1	262
100,001 - 1,000,000	92%	224	0	1	225
Large System Subtotal		1,909	9	5	1,921
Total Number of Systems		6,695	728	331	7,738

Note: Columns and row might not add to total due to rounding.
[1]Because the recycling practices for systems serving more than 1 million persons are determined directly from ICR data, the intermediate step of determining the number of these systems that use conventional or direct filtration is not included in this analysis. See Section 4.3.4 in this chapter for a detailed explanation of this calculation.
[2]Source: CWSS (U.S. EPA, 1997a).
[3]Based on the number of systems reported in Exhibit 4–3.

4.2.2 Profile of Recycling Practices

As noted above, the FBRR applies to conventional or direct filtration systems that recycle spent filter backwash water, sludge thickener supernatant, or liquids from dewatering processes. EPA estimated this universe of potentially affected systems (except for those serving 1 million persons or more) as follows:

Number Conventional Filtration Systems that Use Surface Water or GWUDI	X	% That Recycle	=	Universe of Systems Potentially Affected by the FBRR (≤1,000,000)	=	4,643

EPA then added to this estimate seven plants operated by systems serving greater than 1 million people (see Section 4.3.4 for discussion), resulting in a total of 4,650 systems.

The total number of conventional and direct filtration systems was derived based on filtration techniques cited in the CWSS (Exhibit 4–4). EPA estimates that 60 percent of these systems recycle filter backwash (Cornwell and Lee, 1994). Exhibit 4-5 applies this estimated percentage to the universe of conventional and direct filtration systems to derive the number of potentially affected systems by size and type category.

Exhibit 4–5. Number of Conventional or Direct Systems that Use Surface Water or GWUDI and Recycle[1]

Population Size Categories	Est. Percent of Systems that Recycle[1]	Number of Systems by System Type[2]			
		CWS	TNC	NTNCWS	Total
<100	60%	196	244	49	488
101 - 500	60%	469	121	69	660
501 - 1,000	60%	424	31	37	491
1,001 - 3,300	60%	913	23	30	967
3,301 - 9,999	60%	861	13	11	885
Small System Subtotal		2,863	432	195	3,490
10,000 - 50,000	60%	854	4	2	860
50,001 - 100,000	60%	155	2	1	157
100,001 - 1,000,000	60%	135	0	1	135
>1,000,000	see Section 4.3.4	7	0	0	7
Large System Subtotal		1,151	5	4	1,160
Total Number of Systems		4,014	437	199	4,650

Note: Columns and row might not add to total due to rounding.

[1]Source: Cornwell and Lee, 1994.
[2]Based on the number of systems reported in Exhibit 4–4.

4.3 Profile of Systems Subject to Each FBRR Provision

The FBRR contains three key provisions. Sections 4.3.1 through 4.3.4 summarize the derivation of the estimated portion of the 4,650 recycling systems that are expected to be impacted by each of these provisions.

4.3.1 Recycle Return Location

The purpose of the first provision of the FBRR is to protect the integrity of chemical treatment and ensure that recycle flows are passed through as many physical removal processes as possible to provide maximum opportunity for removal of *Cryptosporidium* oocysts from the recycle flow. The first provision of FBRR requires surface water and GWUDI systems that use conventional or direct filtration to provide complete treatment for recycled filter backwash, thickener supernatant, and liquids from dewatering processes, or obtain State approval to recycle to an alternate location. In other words, systems potentially affected by the provision include systems that:

- Use surface water or GWUDI,
- Use conventional or direct filtration,
- Recycle backwash waters, and
- Do not return backwash flows through the processes of a system's existing conventional or direct filtration system as defined in 40 CFR, Section 141.2.

To characterize water systems' recycle practices, EPA analyzed data from the Information Collection Rule and the AWWA "FAX" Survey (1998). The ICR (61 FR 24354) required large PWSs to monitor for microbial contaminants and disinfection byproducts. The rule also required these systems to report whether recycle is practiced for sample washwater (i.e., recycle flow) between the washwater treatment plant (if one existed) and the point at which recycle is added to the process train. The AWWA sent the FAX survey (AWWA, 1998) to its membership in June 1998 to gather information on recycle practices. The survey was completed by water systems operating a total of 335 plants. The Regulatory Impact Analysis for the proposed LT1ESWTR and FBRR (U.S. EPA., 2000e) contains a detailed analysis of the ICR and FAX survey data.

EPA used data from the ICR and FAX survey to calculate an estimation of the number of systems that must move their recycle return location or obtain State approval to recycle at an alternate location, as follows:

Number Conventional and Direct Filtration Systems that Use Surface Water or GWUDI and Recycle	X	% Whose Recycle Flows Do Not Undergo all Filtration Steps	=	Number of Systems Potentially Impacted by the Recycling Return Location Provision (≤1,000,000)	=	464

EPA then added to this estimate two plants operated by systems serving greater than 1 million people (see Section 4.3.4 for discussion), resulting in a total of 466 systems.

Based on an analysis of survey results, EPA estimates that 23 percent of recycling systems return prior to rapid mix. Of those that do not return prior to rapid mix, EPA estimates that 50 to 60 percent return to another location that ensures that all steps of a system's conventional or direct filtration are employed. Thus, between 40 and 50 percent of systems that do not currently return to a point prior to rapid mix—conservatively about 10 percent of all systems that recycle—are affected by the recycling return provision. Exhibit 4–6 presents these systems by type and size category.

Exhibit 4–6. Number of Systems that Must Move Their Recycle Return Location or Obtain State Approval to Recycle at an Alternate Location

Population Size Categories	Est. Percent of Systems[1]	Number of Systems by System Type[2]			
		CWS	TNCWS	NTNCWS	Total
<100	10%	20	24	5	49
101 - 500	10%	47	12	7	66
501 - 1,000	10%	42	3	4	49
1,001 - 3,300	10%	91	2	3	97
3,301 - 9,999	10%	86	1	1	89
Small System Subtotal		286	43	20	349
10,000 - 50,000	10%	85	<1	<1	86
50,001 - 100,000	10%	16	<1	<1	16
100,001 - 1,000,000	10%	14	-	<1	14
>1,000,000	see Section 4.3.4	2	0	0	2
Large System Subtotal		116	<1	<1	117
Total Number of Systems		403	44	20	466

Note: Columns and row might not add to total due to rounding.

[1]Percentages reflect the estimated percent of systems that use surface water or GWUDI, that recycle, and that do not return recycle flows to a point in the treatment train such that all step's of a system's conventional or direct filtration are not employed. Source: FAX Survey.
[2]Based on the number of systems reported in Exhibit 4–5.

4.3.2 Conventional Filtration Recycle Reporting

The FBRR requires systems which practice conventional filtration and recycle spent filter backwash, sludge thickener supernatant, or liquids from dewatering processes to notify the State in writing that they practice recycle. To calculate the number of systems that must meet this reporting requirement, EPA used FAX survey data to calculate the number of systems that use conventional filtration, as follows:

Number Conventional and Direct Filtration Systems that Use Surface Water or GWUDI and Recycle	X	% that Use Conventional Filtration	=	Number of Systems that Use Conventional Filtration (≤1,000,000)	=	4,318

EPA then added to this estimate three plants operated by systems serving greater than 1 million people (see Section 4.3.4 for discussion), resulting in a total of 4,321 systems. Exhibit 4–7 shows the estimated number of conventional filtration systems, by size and type.

Exhibit 4–7. Number of Systems Affected by Conventional Filtration Reporting Requirements

Population Size Categories	Est. Percent of Systems[1]	Number of Systems by System Type[2]			
		CWS	TNCWS	NTNCWS	Total
<100	93%	182	227	45	454
101 - 500	93%	436	113	64	613
501 - 1,000	93%	394	28	34	457
1,001 - 3,300	93%	849	21	28	899
3,301 - 9,999	93%	801	12	10	823
Small System Subtotal		2,663	402	182	3,246
10,000 - 50,000	93%	794	3	2	800
50,001 - 100,000	93%	144	1	<1	146
100,001 - 1,000,000	93%	125	-	<1	126
>1,000,000	see Section 4.3.4	3	0	0	3
Large System Subtotal		1,067	5	3	1,075
Total Number of Systems		3,730	406	185	4,321

Note: Columns and row might not add to total due to rounding.

[1]Percentages reflect the potentially affected universe that use conventional filtration.
[2]Based on the number of systems reported in Exhibit 4–5.

4.3.3 Direct Filtration Recycling Reporting

The FBRR requires systems that practice direct filtration and recycle spent filter backwash, sludge thickener supernatant, or liquids from dewatering processes to report their recycling practices to the State. This provision is expected to impact about 325 water systems serving fewer than 1 million people, as shown in the calculation below:

Number Conventional and Direct Filtration Systems that Use Surface Water or GWUDI and Recycle	X	% that Use Direct Filtration	=	Number of Recycling Systems that Use Direct Filtration (≤1,000,000)	=	325

EPA then added to this estimate four plants operated by systems serving greater than 1 million people (see Section 4.3.4 for discussion), resulting in a total of 329 systems. Exhibit 4–8 breaks down this number of systems by size and type:

Exhibit 4–8. Number of Systems Affected by Direct Filtration Reporting Requirements

Population Size Categories	Est. Percent of Systems[1]	Number of Systems by System Type[2]			
		CWS	TNCWS	NTNCWS	Total
<100	7%	14	17	3	34
101 - 500	7%	33	8	5	46
501 - 1,000	7%	30	2	3	34
1,001 - 3,300	7%	64	2	2	68
3,301 - 9,999	7%	60	1	1	62
Small System Subtotal		200	30	14	244
10,000 - 50,000	7%	60	<1	<1	60
50,001 - 100,000	7%	11	<1	0	11
100,001 - 1,000,000	7%	9	-	0	9
>1,000,000	see Section 4.3.4	4	0	0	4
Large System Subtotal		84	<1	<1	85
Total Number of Systems		285	31	14	329

Note: Columns and row might not add to total due to rounding.

[1]Percentages reflect the potentially affected universe that use direct filtration.
[2]Based on the number of systems reported in Exhibit 4–5.

4.3.4 Systems Serving More Than 1 Million Persons

As discussed above, EPA determined the number of affected systems by analyzing water systems' treatment and recycling practices and, based on this analysis, estimating the percent of surface water systems potentially affected by the rule. The exception to this approach is EPA's analysis of systems serving more than 1 million. EPA used the schematic of ICR systems and SDWIS to determine whether these systems would be affected by the recycle provisions.

First, EPA reviewed the schematics of the individual plants within the 13 ICR systems that serve more than 1 million persons. This review identified 24 plants, only seven of which would be affected by the rule. Two plants (both serving 10,000 to 50,000 people) would have to move their recycle return location, three plants (all serving 10,000 to 50,000 people) would be required to meet conventional filtration reporting requirements, and four direct filtration plants (two serving 50,001 to 100,000 people and two serving more than 100,000 people) would be required to meet direct filtration reporting requirements. EPA included these individual plants in the cost analysis.

5. Benefits Analysis

5.1 Introduction

The health benefits of a drinking water standard come from reducing the probability that consumers will suffer health damages and other losses due to contaminants present in finished water. For the Filter Backwash Recycling Rule (FBRR), benefits reflect reductions in the risks of microbial illness. The benefits associated with the recycle provisions are summarized in Exhibit 5–1.

Exhibit 5–1. Overview of FBRR Benefit Categories and Associated Components

Health Benefits	
Reduced mortality and morbidity rates by changes to recycle practices in small and large surface water and GWUDI treatment facilities	• Changing recycle practices is expected to generate positive benefits by lowering the risk of contracting cryptosporidiosis from drinking water. See Sections 5.2.1 and 5.2.2.
Non-Health Benefits	
Reduced outbreak responses	• Avoided costs to affected water systems and local governments (provision of alternative water, issuing warnings and alerts, and costs associated with negative publicity). • Time spent on averting behavior during outbreaks (e.g., hauling/boiling water). • See Section 5.2.3.
Costs to households to avert infection	• Averting behavior is associated with both out-of-pocket costs (e.g., purchase of bottled water) and opportunity costs (e.g., time required to boil water) to the consumer. See Section 5.2.4.

EPA has not developed a national benefit estimate because the overall impact on finished water quality of different treatment changes brought about by the provisions depends on a wide variety of system operational parameters that cannot be easily modeled. In order to model the effect of recycle practice, data regarding the ability of a wide range of unit processes (sedimentation, dissolved-air flotation [DAF], contact clarification, filtration) to remove oocysts from a wide variety of source water types, under a range of treatment conditions, is needed to calibrate the model. These data are currently not extensive enough to model the impact of recycle on a wide variety of treatment configurations.

However, data show that oocysts occur in recycle flows and in the finished water of unchallenged, well-performing plants. Recycle adds additional oocysts to the plant and risks reducing plant treatment efficiency during improperly conducted recycle events because of hydraulic and chemical disruption. Research of the available literature demonstrates that increased hydraulic loadings or disruptive hydraulic current, which may be experienced when plants exceed State-approved operating capacity, can disrupt filter and sedimentation performance. However, the literature does not quantify the extent to which performance can be reduced and, more specifically, does not quantify the log reduction in *Cryptosporidium* removal that may be experienced during direct recycle events. Section 5.2 discusses the risks associated with the improper recycle of filter backwash and of exposure to waterborne pathogens such as *Cryptosporidium* and *Giardia lamblia*. Section 5.3 discusses the health benefits of the rule. It also reviews the approaches used by EPA to monetize health benefits associated with drinking water regulations and describes how these benefits could apply to the FBRR, and Section 5.4 summarizes the discussion of benefits. As discussed in Chapter 8 of this document, EPA expects that the health benefits associated with the FBRR, although impossible to accurately monetize at this time, justify the costs associated with the rule.

5.2 Risks Associated with the Improper Recycle of Filter Backwash

The FBRR recycle provisions apply to surface water and GWUDI drinking water systems that recycle treatment process flows within the primary treatment process. EPA has identified three primary public health concerns arising from the improper recycle of spent filter backwash, thickener supernatant, and liquids from dewatering processes within the treatment process of public water systems.

1. Data show that recycle flows can contain *Cryptosporidium* oocysts, often at higher concentrations than plant source waters, and recycling these flows may increase the number of oocysts entering the plant, reaching the filters, and entering the finished water. Since *Cryptosporidium* is not inactivated by standard disinfection practice, it is critical that all available physical removal processes (coagulation, flocculation, clarification, filtration) be protected from the hydraulic and chemical treatment disruptions recycle events may cause. Recycle returns oocysts to the plant at precisely the time treatment efficiency may be challenged by hydraulic and chemical disruption caused by improper recycle practices. This may cause more oocysts to enter the finished water.

2. Returning spent filter backwash, thickener supernatant, or liquids from dewatering to a location that does not precede processes of a system's existing conventional or direct filtration (as defined in Section, 141.2 of 40 CFR) may disrupt treatment chemistry by introducing residual coagulant or other treatment chemicals to the process stream. If recycle flows are improperly managed and returned directly into a sedimentation basin, these flows may not reside in the basin long enough for recycled oocysts to settle. Additionally, if these recycle flows are improperly managed they can create hydraulic currents within the basin that reduce the unit's overall oocyst removal efficiency. Additionally, improper recycle practices can cause large variations in influent flow, which may reduce treatment efficiency if chemical doses are not adjusted appropriately. (Patania et al., 1995; Edzwald and Kelley, 1998; Bellamy et al., 1993; Conley, 1965; Dugan et al., 1999; Robeck et al., 1964).

3. The direct recycle of spent filter backwash without first providing treatment, equalization, or some form of hydraulic detention for the flow, may cause plants to exceed State-approved operating capacity during recycle events. Exceeding operating capacity can cause sedimentation/clarification and filter loading rates to be exceeded, which may lower

overall oocyst removal provided by the plant and increase finished water oocyst concentrations.

The FBRR is intended to reduce the risk of *Cryptosporidium* and other pathogens passing through treatment into finished drinking water and reduce the risk of waterborne disease outbreaks. The four stages associated with a waterborne outbreak that may impose costs on society are discovery, survey and testing, reaction, and aftermath (Harrington et al., 1985):

1. **Discovery.** Health care providers or State, local, or hospital laboratory technicians send reports to State authorities notifying them of the need for further investigation when the rate of new cases suddenly increases above the normal rate.

2. **Survey and testing.** A host of epidemiological surveys may be conducted, along with tests of the water supply, once a few cases are confirmed.

3. **Reaction.** Local authorities and the water system may issue boil-water advisories, or other warnings to reduce exposure, once a link is made between the drinking water supply and the disease outbreak. Businesses, as well as households, may be affected by such action, requiring government agencies to begin surveillance and enforcement activities and in some cases, provide alternative water sources.

4. **Aftermath.** This final stage involves discussions of any long-term solutions to the problem, and how the costs of the outbreak and prevention of future ones may be shared. These discussions can only take place once the outbreak is contained by actions taken during the previous phase.

The reductions in the risk of waterborne disease outbreaks and in the expenditures that are avoided as a result of outbreak prevention are benefits of the FBRR. These benefits are discussed in the following sections.

5.2.1 Reduction in *Cryptosporidium*

Health Risks Associated with Cryptosporidium

Cryptosporidium and other pathogens have been identified as the cause of waterborne disease outbreaks (Centers for Disease Control, 1996). In particular, drinking water supplies contaminated with *Cryptosporidium* pose a health risk to the public because the pathogen is highly infectious, resistant to inactivation by chlorine, widespread among many animal species, and small in size and consequently difficult to filter (Guerrant, 1997). This benefits analysis discusses the potential benefits of reducing human exposure to *Cryptosporidium* in drinking water supplies through improved operation and performance of the drinking water recycling process. Other benefits from the rule include reduced exposure to *Giardia lamblia* and other emerging pathogens in drinking water.

As discussed in Chapter 2, *Cryptosporidium* in surface water sources is relatively common. *Cryptosporidium* oocysts can cause cryptosporidiosis, an acute, self-limiting illness lasting 7 to

14 days. Its symptoms include diarrhea, abdominal cramping, nausea, vomiting, and fever (Juranek, 1995). There is no effective treatment for cryptosporidiosis (Guerrant, 1997).

Several subpopulations are especially sensitive to cryptosporidiosis. They include young, elderly, malnourished, disease impaired persons (especially those with diabetes), and a broad group whose immune systems are compromised (Rose, 1997). This last group includes persons with AIDS, Lupus, or cystic fibrosis; transplant recipients; and persons undergoing chemotherapy (Rose, 1997). Symptoms in the immunocompromised subpopulations are much more severe than those in other groups (Juranek, 1995). Mortality is a substantial threat to the immunocompromised infected with *Cryptosporidium*:

> "The duration and severity of the disease are significant: whereas 1 percent of the immunocompetent population may be hospitalized with very little risk of mortality (< 0.001), *Cryptosporidium* infections are associated with a high rate of mortality in the immunocompromised (50 percent)" (Rose, 1997).

Waterborne disease outbreak data from the Centers for Disease Control and Prevention (CDC) for the period 1993–1994 estimates that *Cryptosporidium* was responsible for over 400,000 cases of gastrointestinal infection (Craun et al., 1998). The vast majority of these cases occurred in a single outbreak in Milwaukee, Wisconsin, the largest recorded outbreak of waterborne disease in the United States. CDC estimated that of the approximately 800,000 persons served by the water system, over 400,000 (50 percent) became ill (Exhibit 5–2). Of those, 4,000 required hospitalization (approximately 1 percent of those who become ill), and at least 50 immunocompromised individuals died from causes related to cryptosporidiosis (as reported on death certificates) (Mackenzie et al., 1994; Hoxie et al., 1997). Exhibit 5–2 contains detailed information on some of the symptoms of patients with cryptosporidiosis observed during the Milwaukee outbreak.

Exhibit 5–2. Symptoms of 205 Patients with Confirmed Cases of Cryptosporidiosis during the Milwaukee Outbreak

Symptom	Percent of Patients	Mean	Range
Diarrhea	93	Duration: 12 days	1–55 days
Abdominal Cramps	84	N/A	N/A
Weight Loss	75	10 pounds	1–40 pounds
Fever	57	100.9˚F	99.0˚–104.9˚F
Vomiting	48	N/A	N/A

Source: Mackenzie et al., 1994.

The Milwaukee outbreak represents the largest number of cases in a single cryptosporidiosis outbreak in the United States, but most cryptosporidiosis outbreaks have occurred in small systems serving fewer than 10,000 persons (Exhibit 2–5). Between 1991 and 1996, sixteen outbreaks caused by either *Cryptosporidium* or *Giardia lamblia* in small water systems resulted in 1,036 reported cases of cryptosporidiosis and 518 reported cases of giardiasis. Two of the 16 outbreaks were associated with *Cryptosporidium* in small surface-water systems, and four *Cryptosporidium* outbreaks occurred in ground water assumed to be under the direct influence of surface water. During small system *Cryptosporidium* outbreaks, between 28 and 80 percent of the exposed population can become ill (U.S. EPA, 2001a).

Outbreak data represent only a portion of the incidence of cryptosporidiosis. Only numerous cases of cryptosporidiosis concentrated in a specific location have a chance of being detected and reported. Isolated cases (endemic) are much less likely to be reported. Many, perhaps most, infected individuals may not seek medical treatment for their symptoms, so primary care physicians may not be able to isolate *Cryptosporidium* as the cause of the illness. Even if cryptosporidiosis is diagnosed, physicians may not make a report to the CDC. These compounded impacts could lead to gross under-reporting and under-estimating of cryptosporidiosis cases (Okun et al., 1997).

How the FBRR Addresses Risks Associated with Cryptosporidium

Cryptosporidium is exceptionally resistant to inactivation by chlorine, so physical removal by clarification and filtration is extremely important to control this organism. Over time, these pathogens accumulate with other particles in the treatment plant filters. During backwash events to clear filters and maintain performance, plants run a higher risk of pathogens reaching the finished water if recycle is performed improperly. The FBRR has three recycle provisions designed to help prevent *Cryptosporidium* from reaching the finished water supply. They are based on the assumption that improving practices will prevent the accumulation of *Cryptosporidium* within the treatment plant and minimize the risk of oocysts entering into the finished water. The provisions are as follows:

1. First, the rule requires (with some exceptions) that recycle be returned through the processes of a system's existing conventional or direct filtration (as defined in Section, 141.2 of 40 CFR). The rule includes a provision allowing States to approve alternate recycling locations for systems on a case-by-case basis.

2. Second, plants that practice conventional filtration must report their recycle practices to the State in writing. When notifying the State, systems must provide a plant schematic showing the origin of all recycle flows, the hydraulic conveyance used to transport them and the location where they are recycled back into the plant. In addition, systems must also provide typical recycle flow in gallons per minute (gpm), highest observed plant flow experienced in the previous year (gpm), design flow for the treatment plant (gpm), and if applicable, the State-approved operating capacity for the plant.

3. Third, direct filtration plants must report their recycle practices to the State, including a plant schematic showing the origin of all recycle flows, the hydraulic conveyance used to transport them and the location where they are recycled back into the plant. Direct filtration plants must also report typical recycle flow (gpm), highest observed plant flow experienced in the previous year (gpm), design flow for the treatment plant (gpm), and if applicable, the State-approved operating capacity for the plant.

5.2.2 Reduction of Other Pathogens

The FBRR is intended to decrease the risk that improper recycle practices will allow Cryptosporidium oocysts to pass through the treatment plant and into the finished water. However, EPA expects that the FBRR will also reduce the risk that other microbial pathogens such as *Giardia lamblia* will pass through the treatment plant and into the finished water due to improper recycle practices, since *Giardia* has been identified in backwash water. For example, a study of 25 water treatment plants (Arora et al., 1999) found levels of *Giardia* and *Cryptosporidium* to be 16 and 21 times higher, respectively, in spent filter backwash water than in raw water. The researchers concluded that, based on the observed levels of *Giardia* and *Cryptosporidium,* a recycle ratio of 5 to 10 percent should be sufficient to minimize the impact of the protozoa on raw water levels.

Cornwell and Lee (1993) found that *Cryptosporidium* and *Giardia* can be present in spent filter backwash water. One plant in their study had more than 150 cysts/L in its spent filter backwash water, compared to 0.2 to 3 cysts/L in its raw water. They also found that sedimentation was effective in reducing cysts prior to recycle.

The changes in recycle practices that result from this rule also may reduce the risk from other disinfection-resistant pathogens, such as *Toxoplasma*, *microsporidia*, and *Cyclospora*, that may be found in source water and so in filter backwash. Data from the Information Collection Rule (ICR) Initial Sampling database, which mainly consists of large water treatment plants, found that 90 percent of them (226 facilities) had a recycle stream that could contain such organisms (Hamele and Bonner, 1998).

As indicated previously, limited work has shown that when recycle is performed in accordance with the requirements of the FBRR, *Cryptosporidium* removal is not impaired.

5.2.3 Reduction in Outbreak Risk

Besides reducing the endemic risk of cryptosporidiosis, the FBRR will reduce the likelihood of major outbreaks, such as the Milwaukee outbreak. The economic value of reducing the risk of outbreaks could be quite high when the magnitude of potential costs associated with illnesses is considered. Other types of costs associated with outbreaks include spending by local, State, and national public health agencies; emergency corrective actions by utilities; and possible legal costs, if liability is a factor. Affected water systems and local governments may incur costs to provide alternative water supplies and issue customer water use warnings and health alerts. Commercial establishments (e.g., restaurants) and their customers may incur costs due to interrupted and lost service (e.g., lost producer and consumer surplus). To the extent that FBRR reduces the likelihood of waterborne disease outbreaks, avoided response costs are potentially significant.

5.2.4 Costs to Households to Avert Infection

Local businesses, institutions, and households may incur costs associated with undertaking averting and defensive actions. During outbreaks or periods of high turbidity, consumers and businesses may use alternative water sources or practice behaviors to reduce risk, such as boiling water. If the rule reduces the need for these averting behaviors, an economic benefit will accrue.

During an outbreak of giardiasis, expenditures on averting behaviors, such as hauling in safe water, boiling water, and purchasing bottled water, were estimated at between $1.74 and $5.53 per person per day during the outbreak (Harrington et al., 1989). If these figures are applied to a small drinking water system serving 10,000 customers, daily expenditures on averting behavior during a *Cryptosporidium* outbreak could total between $17,400 and $55,300. Determining the precise reduction in outbreak risk and resulting benefits due to reduced or avoided averting behavior is not possible given current information, but potential benefits are expected to be substantial.

Five additional studies were identified that used the averting cost approach to estimate household and other costs attributable to short-term contamination of drinking water supplies (Abdalla, 1990; Abdalla et al., 1992; Harrington et al., 1985; Sun et al., 1992; Van Houtven, et al., 1997). The most relevant of these for the FBRR analysis is a study by Harrington et al., (1985), that analyzes the costs associated with drinking water contamination by *Giardia* in Luzerne County, Pennsylvania. The December 1983 outbreak resulted in 366 confirmed giardiasis cases resulting from sewage leaking into the unfiltered source water. The total affected population was 75,000 individuals across Pittston Burough and 17 other municipalities. The Harrington study also developed a theoretical and empirical example of how outbreak costs are incurred, based on the Luzerne County example.

The Luzerne County outbreak resulted in estimated losses, due to actions taken by individuals to avoid the contaminated water, of between $20.8 million and $61.8 million. The predominant cost was time lost to boiling water. Estimated losses due to averting actions for restaurants, bars, schools and other businesses during the outbreak averaged $1.0 million. The burden for government agencies was $230,000 and the outbreak cost the water supply utility $1.8 million. These costs do not include legal fees, outbreak effects on businesses that were not investigated, leisure activities, or net losses due to substituting more expensive beverages for tap water.

5.3 Health Benefits from Recycle Provisions

This section describes the health benefits associated with the FBRR and discusses approaches for monetizing these benefits. Although available data limits EPA’s ability to accurately monetize the health benefits associated with FBRR, the information provided in this section provides the basis for EPA’s assumption that the rule provides significant health-related benefits.

Benefits Associated with Reduced Exposure to Cryptosporidium

Reducing the risk of exposure to *Cryptosporidium*, *Giardia*, and other pathogens is a benefit of the FBRR. Often, the value of such a benefit (risk reduction) is estimated to be the health damages (medical cost and lost productivity) that will be avoided—referred to as “cost-of-illness” (COI). COI measures, however, are thought to understate total benefits because they do not capture the full value that consumers place on reducing risk and avoiding illness.

COI avoided due to adverse health effects includes medical costs, lost income, reduced productivity, and averting expenditures. These goods have observable market values and are, therefore, easier to quantify than willingness-to-pay (WTP) values.

The WTP concept goes beyond the expected value of avoided COI to include the total value of health benefits. In principle, WTP is a comprehensive measure of the welfare effect of a change in risk and is expected to exceed the out-of-pocket financial effect of the change (Chestnut and Alberini, 1997). WTP includes the intuitive notion that illness is disagreeable and that one would be willing to pay to avoid the pain and suffering associated with an adverse health effect beyond the cost of the illness. Since there are no markets for avoided pain and suffering, there are no observable market transactions by which their value can be measured.

Another reason that WTP for reduced health risk is likely to exceed the expected value of avoided COI is the general acceptance of additional costs to avoid risk. WTP values for avoidance of premature death include the value of reductions in the risk of out-of-pocket costs (i.e., COI) plus the value of reduced risk of the lost enjoyment of life (Chestnut and Alberini, 1997). The use of expected COI, instead of WTP, tends to understate the economic value of risk reduction because COI does not incorporate nonpecuniary benefits such as avoided pain and suffering.

Monetizing Illness

Information is not available on direct measurements of either COI or WTP to reduce risk specifically for *Cryptosporidium*.

These results can be compared against previous studies. Mauskopf and French (1991) estimated WTP to avoid food-borne illnesses based on the nature and length of the illness, integrated with the value of a statistical life and indices of self-reported health status to value the losses in quality and length of life. The WTP estimates (1999$) for illnesses similar to cryptosporidiosis range from $166 to $7,424 for mild to moderate cases of botulism (5 to 21 days of weakness, vomiting, and nausea) and $284 to $1,139 for salmonellosis (3 to 7 days of similar symptoms). Using these estimates, the value for cryptosporidiosis (7 to 14 day duration) could range from $233 ($33.25/day for 7 days) to $4,942 ($353/day for 14 days). The cost of illness estimates (with a mean of $2,403) fall within this range and are a reasonable approximation of the value to avoid health damages associated with cryptosporidiosis, recognizing that some costs (such as averting expenditures, and pain and suffering) have not been monetized.

Monetizing Mortality

A recent EPA study characterized a range of credible estimates of the VSL saved as a Weibull distribution with a mean of $4.8 million and a standard deviation of $3.24 million, capped at $13.5 million (in 1990$), based on 26 individual study estimates (62 FR 59485; November 3, 1997). Updating the VSL to 1999 price levels results in a distribution with a mean of $6.3 million.

Because cryptosporidiosis mortalities are expected to occur primarily in sensitive subpopulations, there may be some arguments for adjusting the VSL. The typical valuation methodology used to derive the VSL generally measures the individuals' WTP to reduce the risk of a premature death by a small amount. The small reduction in risk is then spread across a broad population. The mortality risk associated with cryptosporidiosis is different because a smaller sensitive subpopulation faces a higher baseline risk.

Monetizing Health Effects to Sensitive Subpopulations

As noted in Section 5.2, the health effects of *Cryptosporidium* on sensitive subpopulations are much more severe and debilitating than the health effects on the general public. The estimated COI avoided calculated above likely does not capture the total costs to sensitive subpopulations; health trials were conducted only with healthy individuals, and symptomatic responses are more severe in sensitive populations. For example, the duration of cryptosporidiosis in persons whose immune systems are compromised is considerably longer than in those with competent immune systems, and the more severe symptoms suffered by immunocompromised individuals often require lengthy hospital stays.

COI from cryptosporidiosis for sensitive subpopulations is expected to be much greater than the COI for the general population. During the Milwaukee outbreak, 33 AIDS patients with cryptosporidiosis accounted for 400 hospital days at an additional cost of nearly $760,000 (Rose, 1997). COI due to these hospital days alone was estimated at $23,000 per case ($760,000/33 patients). Although the COI for sensitive populations is expected to be greater than the general population, no attempt was made to quantify these effects for this regulatory impact analysis. Also, the cost of averting expenditures could be higher in sensitive subpopulations. Sensitive subpopulations are more susceptible to *Cryptosporidium* infections, thus these individuals may purchase bottled water, boil water, or take other health precautions on a daily basis.

Monetizing Risk Reduction from Emerging Pathogens

EPA is unable to quantify the benefit associated with a reduction in risk from exposure to emerging pathogens due to current data limitations.

5.4 Summary

EPA expects that there will be a variety of positive benefits associated with the FBRR. In summary, benefits associated with changes to recycle practices are expected to include the following:

- Reducing mortality and morbidity rates, in the general population and among sensitive subpopulations, by reducing the risk of *Cryptosporidium, Giardia,* and other pathogens passing through the treatment plant into finished drinking water.
- Avoided outbreak response costs, including:
  - Avoided costs to affected water systems and local governments (provision of alternative water, issuing warnings and alerts, and costs associated with negative publicity).
  - Avoided costs to households to avert illness.

As discussed in Chapter 8 of this document, EPA expects that the health benefits associated with the FBRR, although impossible to accurately monetize at this time, justify the costs associated with the rule.

6. Cost Analysis

6.1 Introduction

This chapter reports national cost estimates for the Filter Backwash Recycling Rule (FBRR) and discusses the methods EPA used to estimate implementation costs incurred by drinking water systems and States.[1] EPA anticipates that water system compliance with the FBRR provisions will increase reporting burdens and, in some cases, require changes to treatment processes and plant operations. EPA also expects the rule to increase the labor requirements for additional compliance tracking activities for States. Consequently, the cost analysis includes labor costs associated with additional reporting and compliance requirements, as well as capital and operating and maintenance (O&M) expenditures associated with changes in water treatment processes.[2]

Chapter 6 contains the following sections:

- Section 6.2 - provides detailed cost information for each component included in the quantitative analysis. It includes the cost assumptions and data elements used in the analysis, descriptions of how the costs were estimated, and reports of the results. Additional documentation for the cost estimates in this chapter are in the appendices.
- Section 6.3 - summarizes total national costs for the provisions of the final FBRR. This section also includes a discussion of the impact of potential biases, omissions, and uncertainties on the national cost estimate.
- Section 6.4 - discusses how system-level costs were translated into annual cost increases per household.
- Section 6.5 - compares costs associated with the final FBRR with the costs of the proposed alternative presented in Chapter 3.

6.1.1 Cost Assumptions

EPA estimated costs at the water system- and State-level, then multiplied these costs by the number of affected entities to obtain total costs. EPA relied on existing data sources and input from stakeholders to identify potential treatment process improvements, estimate their cost, and estimate the labor burden associated with the reporting requirements. These costs were based on industry cost models, equipment prices, wage rates from standard engineering sources, and

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[1] Throughout the cost analysis, the term "State" refers to the 56 States, Commonwealths, Territories, and the District of Columbia that are eligible for primary enforcement authority or primacy. This definition is consistent with the assumption used for the cost analysis in the final IESWTR RIA. Currently, however, Wyoming and the District of Columbia do not have primacy; EPA regional offices administer their drinking water programs. Indian Tribes are also eligible for primacy, although none have yet obtained it and EPA regional offices also administer drinking water programs for Tribal lands.

[2] This analysis of costs is limited to compliance cost estimates.The analysis assumes that drinking water systems pass incremental costs on to consumers in the form of higher water prices and there are no savings from system consolidation or adverse impacts such as system closure.

stakeholder inputs. System costs were estimated for several different service population size categories to account for cost differences attributable to system size. Chapter 4 discusses the assumptions that EPA used to estimate the number of systems affected by the FBRR. This section summarizes additional assumptions that were used to estimate costs.

- *Total and annual costs.* The RIA presents costs on a total and annual basis. All one-time costs such as investments in capital equipment or training were annualized before they were added to annual O&M expenditures. Capital costs for most process improvements were annualized over a 20-year period to reflect a typical capital investment lifetime. Two results are reported because EPA used two different discount rates that have been recommended for policy analysis: a 3 percent rate, which is in the range recommended in EPA's publication, *Guidelines for Preparing Economic Analyses* (U.S. EPA, 1999b) and a 7 percent rate, which is recommended by OMB guidance (OMB, 1993 and 1996). Start-up labor costs were also annualized over 20 years to obtain equivalent annual values.

- *Unit costs for process improvements.* The set of feasible process improvements was limited. To develop a list of potential treatment changes, EPA relied on information provided in stakeholder and SBREFA meetings, best professional judgment, the schematics of Information Collection Rule (ICR) systems, and the AWWA survey (1998) of recycling practices, which collectively indicated the current range of recycling techniques. Appendix H, Costs and Technologies for the FBRR, explains how EPA estimated the unit costs associated with treatment modifications.

- *Costs associated with noncommunity water systems.* System-level cost estimates for all recycle modifications are described in detail in Appendix H. Capital and O&M costs are functions of system flow rates, which were obtained from the Community Water System Survey database. Consequently, these costs are more representative of costs for community water systems, but EPA used the same flows for noncommunity systems as well, because of a lack of data concerning the flow capacities and technologies employed by these systems. Because noncommunity systems may have smaller flows than community systems, this assumption may overestimate costs for noncommunity systems.

- *Systems with multiple treatment plants.* As described in Appendix H, unit capital and O&M costs were estimated using engineering models and system-level flow rates. Using these unit costs to develop cost estimates for large systems introduced some uncertainty because total system flows at large systems—especially systems serving more than 100,000—may be treated by two or more plants, some of which may not recycle flow to the treatment process. Consequently, EPA potentially overestimated compliance costs for large systems that do not need to change recycle practices at all of their plants. Conversely, EPA may have underestimated compliance costs for large systems that need to change recycle practices for all of their plants. This underestimation is possible because installing new equipment at two or more plants with smaller flow rates may cost more than the estimated unit cost of installing equipment at a single large plant that handles the same flow rate. Although these biases will tend to offset one another, EPA cannot determine whether total costs are more likely to be over or underestimated because it does not have details about the plant configurations of all large plants that recycle.[3]

- *Hourly labor rates.* EPA's labor cost estimates incorporate assumptions about incremental system and State labor hours and hourly labor rates for managerial and technical labor categories. The Agency proposed the FBRR in early 2000 using labor rate recommendations of a Technical Design Panel of industry engineers which met in Denver for two days in the fall of 1997. Additional analysis as recommended by the panel has yielded updated labor rates which were used in developing costs for the final FBRR. EPA has included these analyses in the docket for the final rule (EPA, 2001). The loaded technical labor rate for systems serving 9,999 or fewer people is $14.50 per hour, and the rate for systems serving 10,000 or more is $28.00 per hour. EPA assumed that systems serving 1,000 or more also have a management labor category, which has a loaded labor rate of $40.00 per hour. The loaded hourly rate for State technical staff is $21.29 and the loaded rate for State managerial staff is $31.23.

[3] The exception to this approach is EPA's analysis of systems serving more than 1 million people. EPA used the schematics of ICR systems and SDWIS to determine whether these systems would be affected by the recycle provisions. First, EPA identified 13 systems in SDWIS that serve populations greater than 1 million. Then EPA identified schematics of the individual plants within these systems. Of the 24 plants identified, only 7 would be affected by the rule. Two plants (both serving 10,000 to 50,000) would have to move their recycle return location. One conventional filtration plant (serving 10,000 to 50,000) and and 4 direct filtration plants (two serving 50,000 to 100,000 and 2 serving more than 100,000) would be required to report their recycle practices to the State. EPA included these individual plants in the cost analysis.

6.2 FBRR Cost Analysis

The FBRR applies to surface water or GWUDI systems that employ either conventional or direct filtration and recycle spent filter backwash, sludge thickener supernatent, or liquids from dewatering processes. Exhibit 6–1 summarizes the number of systems potentially affected by system type and population size category.

Exhibit 6–1. Number of Systems Potentially Affected by the Rule's Recycling Provisions

Type of System Affected by a Provision	System Population Size Category		
	Small Systems $<$10,000	Large Systems $\geq$10,000[1]	Total
Total conventional and direct filtration systems that recycle (see Exhibit 4-5)	3,490	1,160	4,650
Systems affected by the recycle return location provision (see Exhibit 4-6)	349	117	466
Systems affected by conventional filtration reporting requirements (see Exhibit 4-7)	3,246	1,075	4,321
Systems affected by direct filtration reporting requirements (see Exhibit 4-8)	244	85	329

[1]Totals include systems that serve more than 1 million people, which were analyzed on a case-by-case basis. Seven of these systems are affected by the rule. Of those, two are affected by the recycle return location provision, four are impacted by the conventional filtration reporting requirements, and three are impacted by the direct filtration reporting requirements.

6.2.1 Startup Costs

System Startup Costs

EPA assumed that systems will incur start-up costs for reading and understanding the rule as well as mobilization and planning for rule implementation. Exhibit 6-2 summarizes system startup costs.

Exhibit 6–2. Total Annualized System Startup Costs for FBRR (January 1999 dollars)

Compliance Activity	Number of Systems	Annual Cost (3%)	Annual Cost (7%)
Read and Understand the Rule	4,650	$48,860	$68,609
Mobilization and Planning		$97,720	$137,218
Total Annual Cost	**4,650**	**$146,580**	**$205,827**

State Startup Costs

State start-up activities are classified in two categories, regulatory adoption/program development and miscellaneous training. EPA estimated that these activities will require an average of 260 hours per State. Exhibit 6-3 summarizes these start-up costs.

Exhibit 6–3. Total Annualized State Startup Costs for FBRR (January 1999 dollars)

Compliance Activity	Number of States	Annual Cost (3%)	Annual Cost (7%)
Regulatory Adoption/Program Development	56	$17,528	$24,613
Miscellaneous Training		$5,258	$7,383
Total Annual Cost	**56**	**$22,786**	**$31,996**

6.2.2 Recycle to New Return Location

Generally, conventional and direct filtration systems that do not return select recycle flows through the processes of a system's existing treatment system, as defined in 40 CFR, Section 141.2, will be required to move the return point to such a location. As noted in Exhibit 6–1, an estimated 466 systems will be affected by this provision. EPA based this estimate on information provided by a sample of large and small systems that responded to a 1998 AWWA survey on recycle practices (AWWA, 1998) and plant schematics gathered under the Information Collection Rule (61 FR 24354; May 14, 1996).

Systems that must move their recycle return location will need to install additional pipe and may need to install additional pump capacity to recycle to the new location. Additional energy will be required to pump water the extra distance, which increases annual operating costs. Thus, EPA also estimated capital and O&M expenditures associated with these changes in recycling practices.

The rule allows water systems to request State approval for use of an alternative recycle location. States will review the requests and decide whether to approve them on a case-by-case basis.

Based on its review of data from the AWWA Survey (1998), EPA estimates that 20 percent of affected systems will obtain State approval to use an alternate location.

Reporting Costs

EPA assumed that systems will incur reporting costs to request an alternate recycle location, meet with the State, and maintain records. The system-level burden across these activities totals 21 hours. Exhibit 6–4 summarizes total costs by system size category. Total cost is $38,071, and annualized cost is approximately $2,559, assuming a 3 percent discount rate and $3,594 using a 7 percent discount rate.

Exhibit 6–4. Total Annualized System Costs for Requesting an Alternate Recycle Return Location by System Size (January 1999 dollars) [1]

System Size	Number of Affected Systems	Cost Per System	Total Cost
≤ 1,000	33	$305	$9,979
1,001–3,300	19	$361	$6,983
3,301–9,999	18	$361	$6,394
≥ 10,000 [2]	23	$638	$14,715
Total	**93**	**N/A**	**$38,071**
Annualized Cost (3%) **Annualized Cost (7%)**			**$2,559** **$3,594**

[1] See Appendices E–1a through E–1c for detail.

System Capital and O&M Costs

To obtain total capital and O&M costs for this provision, unit costs were first multiplied by the 373 systems EPA assumed would move their recycle return location.[4] Capital costs were then annualized over a 20-year period, assuming a 3 percent and a 7 percent discount rate. EPA added 1 year of O&M expenditures to annualized capital costs to obtain total annualized capital and O&M costs. Appendices B and C provide detailed cost estimates by system size category and Exhibit 6–5 summarizes capital and O&M costs. The total capital and O&M cost of this provision is $5.5 million, assuming a 3 percent discount rate and $6.8 million using a 7 percent discount rate.

[4]Appendices A-2 and A-3 summarize the capital and O&M costs per system for conventional and direct filtration systems that need to redirect their recycle flows. Appendix F discusses how these costs were derived.

Exhibit 6–5. Total Annualized Capital and O&M Costs for New Recycling Return Location by System Size (January 1999 dollars)[1]

System Size Category	Number of Affected Systems	Total Cost at 3% Discount Rate	Total Cost at 7% Discount Rate
≤ 1,000	131	$289,045	$330,112
1,001–3,300	77	$249,529	$287,884
3,301–9,999	71	$380,148	$442,231
≥ 10,000[2]	94	$4,606,754	$5,693,849
Total[3]	**373**	**$5,525,475**	**$6,754,076**

[1] See Appendices B–3 and C–3 for detail.
[2] Total cost includes expected modification costs (i.e., probability of modification multiplied by unit cost) for two plants that belong to systems serving 1 million or more.
[3] Detail may not add to total due to independent rounding.

Review Costs

States will also need to review the requests submitted by systems, and meet with systems to discuss recycling changes. These State activities will require about 13 hours per system. Total costs for all State activities, which are summarized in Exhibit 6–6, are approximately $28,104 for this rule provision. The annualized costs are $1,889, assuming a 3 percent discount rate and $2,653 using a 7 percent discount rate.

Exhibit 6–6. State Cost Estimate to Review and Approve Plans to Move Recycle Return Location (January 1999 dollars) [1]

Compliance Activities	Number of Reviews	Cost Per Review	Total Cost
State Plan Review Cost	93 (1 per system)	$303	$28,104
Annualized Cost (3%) **Annualized Cost (7%)**			**$1,889** **$2,653**

[1] See Appendices E–1a, E–1b, and E–1d for detail.

6.2.3 Conventional Filtration Recycle Reporting Costs

EPA developed a provision to address the risks posed by recycle practices of conventional filtration systems. Costs for this provision include only a reporting component.

System Reporting Costs

A system will need to prepare a recycle report only if it satisfies ***all*** of the following criteria:

- The system uses surface water or GWUDI as a source;
- Employs conventional filtration treatment; and
- The system recycles spent filter backwash, sludge thickener supernatant, or liquids from dewatering processes.

The rule requires that each affected system notify the State in writing that they practice recycle. When notifying the State, systems must also provide the following information:

- A plant schematic showing the origin of all recycle flows, the hydraulic conveyance used to transport them, and the location where they are recycled back into the plant; and
- Typical recycle flow in gallons per minute (gpm), highest observed plant flow experienced in the previous year (gpm), design flow for the treatment plant (gpm), and if applicable, the State-approved operating capacity for the plant.

Additionally, systems must collect and maintain the following information for review by the State:

- Copy of the recycle notification and information submitted to the State;
- List of all recycle flows and the frequency with which they are returned;
- Average and maximum backwash flow rate through the filters and the average and maximum duration of the filter backwash process in minutes;
- Typical filter run length and a written summary of how filter run length is determined;
- The type of treatment provided for the recycle flow; and
- Data on the physical dimensions of the equalization and/or treatment units, typical and maximum hydraulic loading rates, type of treatment chemicals used and average dose and frequency of use, and frequency at which solids are removed, if applicable.

EPA estimated that the reporting and recordkeeping activities will require 15 hours. This consists of 6 hours to report recycle status and plant information to the State, 8 hours to collect additional recycle data, and 1 hour for recordkeeping. Costs per system range from $102 to $222 and vary with system size because the labor rate assumptions and labor mix between operator and manager, as well as the burden assumptions, differ by system size.

Exhibit 6–7 summarizes total conventional filtration reporting provision cost estimates by system size category, combining the three smallest categories in one entry and all of the large systems in another. The total cost is estimated at approximately $1.27 million. Annualized cost for the provision is $85,092, assuming a 3 percent discount rate and $119,486 using a 7 percent discount rate.

Exhibit 6–7. Total System Reporting and Recordkeeping Costs by System Size for the Conventional Filtration Recycle Reporting Provision (January 1999 dollars)[1]

System Size Category	Number of Affected Systems	Cost
≤ 1,000	1,524	$331,445
1,001–3,300	899	$231,940
3,301–9,999	823	$212,384
≥ 10,000 [2]	1,075	$490,108
Total[3]	**4,321**	**$1,265,877**
Annualized Cost (3%) **Annualized Cost (7%)**		**$85,092** **$119,486**

[1] See Appendices E–2a through E–2c for detail.
[2] The cost estimates include four plants belonging to systems that serve more than 1 million.
[3] Detail may not add to total due to independent rounding.

State Review Costs

State activities include reviewing reports and recordkeeping. EPA estimates that this represents an incremental increase to States' burden for sanitary surveys. The estimated State burden is 6 hours per system.

Exhibit 6–8 summarizes State costs. The total cost is estimated at $620,342. The annualized cost for the States is $41,699, assuming a 3 percent discount rate and $58,554 using a 7 percent discount rate.

Exhibit 6–8. Total State Review Costs for the Conventional Filtration Recycle Report Provision (January 1999 dollars)[1]

Compliance Activities	Cost
Review and Follow-up Costs	$603,297
Recordkeeping	$16,766
Total Cost[2]	**$620,342**
Annualized Cost (3%) **Annualized Cost (7%)**	**$41,699** **$58,554**

[1] See Appendices E–2a, E–2b, and E–2d for detail.
[2] Detail may not add to total due to independent rounding.

6.2.4 Direct Filtration Recycle Reporting Costs

EPA estimated that direct filtration plants account for approximately 7 percent of all systems that use conventional or direct filtration (i.e., 329 systems). Because these plants do not have sedimentation basins in their main treatment train, recycling can lead to higher concentrations of *Cryptosporidium* oocysts in the system compared to conventional filtration systems, unless recycle streams are treated to remove oocysts. This rule provision requires that all direct filtration systems report their recycling practices to their State.

System Start-up and Reporting Costs

The provision requires that each affected system notify the State in writing that they practice recycle. When notifying the State, systems must also provide the following information:

- A plant schematic showing the origin of all recycle flows, the hydraulic conveyance used to transport them, and the location where they are recycled back into the plant; and
- Typical recycle flow in gallons per minute (gpm), highest observed plant flow experienced in the previous year (gpm), design flow for the treatment plant (gpm), and if applicable, the State-approved operating capacity for the plant.

Additionally, systems must collect and maintain the following information for review by the State:

- Copy of the recycle notification and information submitted to the State;
- List of all recycle flows and the frequency with which they are returned;
- Average and maximum backwash flow rate through the filters and the average and maximum duration of the filter backwash process in minutes;
- Typical filter run length and a written summary of how filter run length is determined;
- The type of treatment provided for the recycle flow; and
- Data on the physical dimensions of the equalization and/or treatment units, typical and maximum hydraulic loading rates, type of treatment chemicals used and average dose and frequency of use, and frequency at which solids are removed, if applicable.

It is estimated that these reporting and recordkeeping activities will require a total of 15 hours per system.

Exhibit 6–9 reports total costs and annualized costs for system start-up and reporting activities by system size category. Total costs for the provision are estimated at $97,002, resulting in annualized costs of $6,520, assuming a 3 percent discount rate and $9,156 using a 7 percent discount rate.

Exhibit 6–9. Total System Reporting Costs for the Direct Filtration Recycle Reporting Provision by System Size (January 1999 dollars)[1]

System Size Category	Number of Affected Systems	Total Cost
≤ 1,000	115	$24,947
1,001–3,300	68	$17,458
3,301–9,999	62	$15,986
≥ 10,000 [2]	85	$38,611
Total Cost	**329**	**$97,002**
Annualized Cost (3%)		**$6,520**
Annualized Cost (7%)		**$9,156**

[1] See Appendices E–3a through E–3c for detail.
[2] Costs include three plants that belong to systems serving more than 1 million.

State Review Cost

EPA assumed that States will spend 4 hours reviewing a system's report and incur a recordkeeping burden of 2 hours. Total cost for all States is estimated at $47,234 resulting in an annualized cost of $3,175, assuming a 3 percent discount rate and $4,458 using a 7 percent discount rate(Exhibit 6–10).

Exhibit 6–10. Total State Review Costs for the Direct Filtration Recycle Reporting Provision (January 1999 dollars)[1]

Compliance Activities	Total Cost
State Review and Follow-up Costs	$45,958
Recordkeeping	$1,277
Total Cost[2]	**$47,234**
Annualized Cost (3%)	**$3,175**
Annualized Cost (7%)	**$4,458**

[1] See Appendices E–3a through E–3c for detail.
[2] Detail may not add to total due to independent rounding.

6.3 Summary of Costs

National costs for the FBRR are the sum of individual requirement costs (Exhibit 6–11). Annual costs include annualized capital and start-up costs, as well as annual O&M and labor costs. On an annual basis, the cost of the FBRR is estimated to be $5.84 million, assuming a 3 percent discount rate and $7.19 million using a 7 percent discount rate.

Exhibit 6–11. Total Annual Costs for the FBRR Provisions (January 1999 dollars)

Compliance Activity	Costs ($000)	
	Using 3% Discount Rate	Using 7% Discount Rate
System Costs		
Startup Costs	$147	$206
Recycle Return Location	$5,528	$6,758
Conventional Filtration Recycling Reporting	$85	$119
Direct Filtration Recycling Reporting	$7	$9
Total System Costs	$5,766	$7,092
State Costs		
Startup Costs	$23	$32
Recycle Return Location	$2	$3
Conventional Filtration Recycling Reporting	$42	$59
Direct Filtration Recycling Reporting	$3	$4
Total State Costs	$70	$98
Total Costs[1]	**$5,836**	**$7,190**

[1] Detail may not add to total due to independent rounding.

Exhibit 6-12 shows the system, State, and total cost broken down by system size category.

Exhibit 6–12a. Summary of Total Annual Costs for the Recycle Provisions by System Size (3% discount rate & January 1999 dollars)

Compliance Activity	Total Annual Costs by System Size Category					
	≤100	101–500	501–1,000	1,001–3,300	3,301–9,999	≥10,000
System Costs	$86,934	$147,126	$117,942	$293,586	$420,490	$4,700,087
Total State Costs	$7,298	$9,865	$7,346	$14,459	$13,240	$17,061
Total Costs	**$94,232**	**$156,991**	**$125,288**	**$308,045**	**$433,730**	**$4,717,148**

Exhibit 6–12b. Summary of Total Annual Costs for the Recycle Provisions by System Size (7% discount rate & January 1999 dollars)

Compliance Activity	Total Annual Costs by System Size Category					
	≤100	101–500	501–1,000	1,001–3,300	3,301–9,999	≥10,000
System Costs	$105,643	$178,789	$143,324	$356,770	$510,986	$5,796,488
Total State Costs	$10,217	$13,811	$10,284	$20,242	$18,536	$24,910
Total Costs	**$115,860**	**$192,600**	**$153,608**	**$377,012**	**$529,522**	**$5,821,398**

6.3.1 Biases and Uncertainty

There are several biases and uncertainties that affect EPA's estimate of total costs, which are summarized in Exhibit 6–13.

Exhibit 6–13. Summary of Cost Analysis Uncertainty

Item	Potential Effect on Costs if Resolved	Comments
Biases		
Assumed no market responses to system cost increases	–	Demand responses to price changes may mitigate total costs.
Assumed system-level costs for community systems were applicable to noncommunity systems	–	Noncommunity systems may have lower flow rates than community systems, which would generate lower system-level costs using the engineering cost models.
Included purchased water systems	–	Excluding these systems from the baseline and compliance forecast would reduce costs.
Uncertainties		
Cost estimates based on model drinking water systems and aggregate costs based on compliance forecasts constructed from SDWIS, AWWA, and ICR data	+/–	The engineering models and burden analyses are based on model systems or expected burdens. Actual costs and burdens will differ across systems. The compliance forecasts are based on sample data; the actual number of systems implementing treatment changes may differ from EPA's projections.

+ = resolving the omission, bias, or uncertainty will tend to increase costs.
– = resolving the omission, bias, or uncertainty will tend to reduce costs.
+/– = the effect of the omission, bias, or uncertainty on costs is undetermined.

Capital and O&M costs are functions of system flow rates, which were obtained from the Community Water System Survey database. Consequently, these costs are more representative of costs for community water systems, but EPA used the same flows for noncommunity systems as well, because of a lack of data concerning the flow capacities and technologies employed by these systems. Because noncommunity systems may have smaller flows than community systems, this assumption may overestimate costs for noncommunity systems.

The system estimates in the compliance forecasts include purchased water systems. The majority of these systems will not actually incur the costs discussed in this chapter because they purchase treated water from a wholesale system. This approach will overstate costs for the provisions that affect only small systems because EPA is including costs for small wholesale systems and for the small systems that purchase treated water from them, although only the wholesale systems treat water. EPA cannot determine the extent of this effect on the cost analysis and chose to retain all small systems to develop consistent cost and benefit analyses.

Finally, the methods used to estimate costs introduced uncertainty into the analysis because actual system- and State-level costs will vary from the modeled treatment costs or estimated burden costs. Furthermore, the compliance forecasts are EPA's estimates of the numbers of systems potentially affected by various provisions. These forecasts are based on a variety of sources including sample data from the AWWA recycle survey and information gathered under the ICR. They may over or under estimate the actual number of systems affected by various provisions and/or the number of systems altering treatment practices. EPA cannot determine whether the methods and data tend to over or under estimate total costs.

6.4 Household Costs

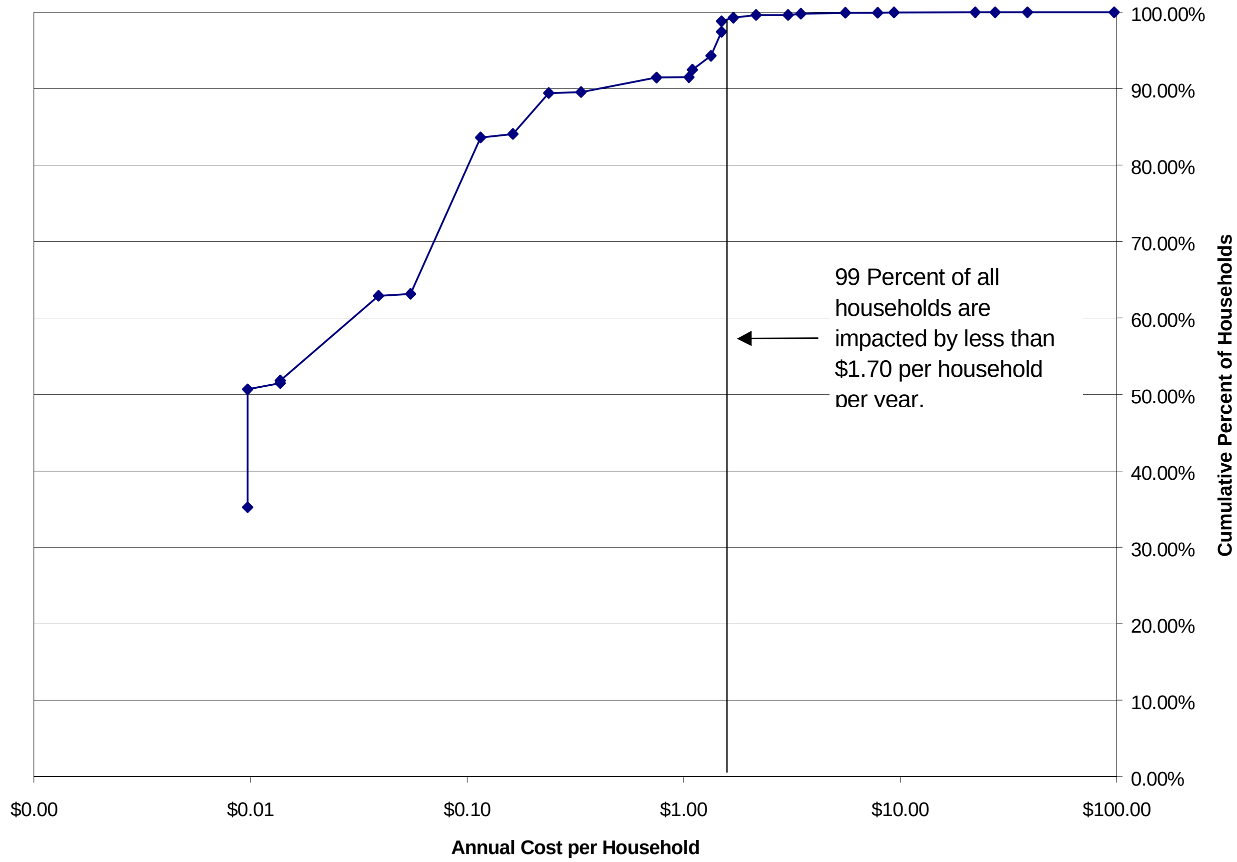
Water system cost increases are often passed on to customers, on a per household basis, in the form of higher monthly water bills. This section approximates potential household impacts of the FBRR by estimating a distribution of household costs based on the system costs for the recycle provisions discussed above. EPA expects approximately 4,650 systems to be affected by the FBRR. The procedure used to calculate household costs and the results of those calculations are described below.

Using the Drinking Water Baseline Handbook data, system populations for all community drinking water systems were cross-tabulated according to source (i.e., SW, GWUDI, and GW) against the established system size categories. EPA limited the analysis to community water systems because only those systems serve residential customers. The proportion of the total that each size/source category represented was multiplied by the total number of households using public water reported in U.S. Census data to arrive at a household distribution by source and system size. The number of households affected by the rule was then estimated based on the ratios used in the baseline to calculate the number of systems affected by the rule.

This approach was used to calculate the number of households affected by each of the three regulatory outcomes (i.e., direct/conventional reporting, applying for an alternate recycle location, and relocating recycle return) were then calculated by multiplying the percentage of systems affected by each regulatory outcome. Using Drinking Water Baseline Handbook data for water consumption by system size category, household water consumption by regulatory outcome and size was calculated. Finally, to arrive at household costs by system size category, household flow data (kgal) and cost ($/kgal) were organized by system size and regulatory outcome, and were multiplied together. Since the direct/conventional reporting procedure is required for all systems, the flow costs ($/kgal) for the direct/conventional reporting requirement were added to both the alternate location and the recycling outcomes prior to multiplying the flow cost data by the household data. These cost data were then matched with the household data to compile a cumulative distribution of household costs. Household cost estimate details are shown in Appendix F.

Exhibit 6-14 illustrates the distribution of household costs for the recycle provisions. The average cost per household is $0.19 per year. The household cost is less than $1.70 per year for over 99 percent of the 31.4 million households potentially affected by the rule and less than $9.36 per year for 99.97 percent. The maximum cost of $97.37 per year ($8.11 monthly) is potentially incurred by a subset of only 321 households.

Exhibit 6–14. Distribution of Annual Household Costs for the Recycle Provisions



6.5 Cost of Regulatory Alternatives

EPA also developed cost estimates for each of the alternative provisions described in Chapter 3 of this RIA. Exhibit 6-15 summarizes the costs for each of the different provisions considered.

Exhibit 6-15. Annual Cost Comparison of Alternate Rule Provisions

Recycle Return Location Provision	
Option	**Cost ($ million, 3% discount rate)**
Alternative R1	**$6.47**
Alternative R2 (Rule Option)	**$5.54**
Alternative R3	**$6.47**
Alternative R4	**$6.47**
Conventional/Direct Recycle Provision	
Option	**Cost ($ million, 3% discount rate)**
Alternative R1	**$0.00**
Alternative R2 (Rule Option)	**$1.27**
Alternative R3	**$30.21**
Alternative R4	**$106.82**
Direct Filtration Provision	
Option	**Cost ($ million, 3% discount rate)**
Alternative R1	**$0.00**
Alternative R2 (Rule Option)	**$0.01**
Alternative R3	**$1.62**
Alternative R4	**$1.25**

EPA's rational for selection of the rule options along with a detailed description of all the alternatives considered is given in Chapter 3. Cost differences for each alternative are a function of the frequency and duration of system monitoring, reporting and recordkeeping activities, variations in capital requirements, and variations in O&M requirements. These variations between the different provisions are also described in Chapter 3. Overall, EPA chose a combination of regulatory options that provided adequate public health protection while trying to minimize the financial burdens imposed on small systems.

7. Economic Impact Analysis

As part of the rule promulgation process, EPA is required to perform a series of distributional analyses that address the potential regulatory burden placed on entities that are affected directly or indirectly by the various rule requirements. This chapter contains all or part of EPA's analyses and statements with regard to the following six Federal mandates:

1. Executive Order 13084 (Consultation With Indian Tribal Governments);
2. The Regulatory Flexibility Act (RFA) of 1980, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996;
3. Technical, Financial, and Managerial Capacity Assessment required by Section 1420(d)(3) of the 1996 amendments to the Safe Drinking Water Act (SDWA);
4. Impacts on Sensitive Sub-Populations as required by Section 1412(b)(3)(c)(i) of the SDWA Amendments;
5. Executive Order 13045 (Protection of Children From Environmental Health Risks and Safety Risks); and
6. Executive Order 12898 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations).

This chapter discusses these six mandates; several of which contain provisions requiring an explanation of why the rule is necessary, the statutory authority upon which it is based, and the primary objectives it is intended to achieve. A complete discussion of the background information and the statutory authority for this rulemaking is located in Chapter 2, "Need for the Proposal."

In addition, this chapter contains a summary of the analysis conducted to fulfill requirements set forth by the Paperwork Reduction Act. A separate Information Collection Request (ICR) document, the *Information Collection Request for the Filter Backwash Recycling Rule*, contains the complete analysis and is available in the Office of Water Docket.

This chapter is organized into three sections. Specifically:

- Section 7.1 - addresses how the rule pertains to those mandates concerning potential impacts to government and business entities.
- Section 7.2 - considers the impact of the rule on possible sensitive subpopulations, such as children.
- Section 7.3 - evaluates the potential impact to minority and low-income populations.

7.1 Impacts on Governments and Business Units

The following sections contain the analyses necessary to fulfill Executive Orders pertaining to governments and businesses. Section 7.1.1 discusses possible impacts on Indian Tribal Governments. Section 7.1.2 is the required RFA and SBREFA analysis. Section 7.1.3 is the capacity analysis, and Section 7.1.4 provides a summary of the ICR.

7.1.1 Indian Tribal Governments

Under Executive Order 13084, EPA may not issue a regulation, which is not required by statute, that significantly or uniquely affects the communities of Indian Tribal governments, and that imposes substantial direct compliance costs on those communities, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by the Tribal governments or EPA consults with those governments.

If EPA complies by consulting, Executive Order 13084 requires EPA to provide to the Office of Management and Budget, in a separately identified section of the preamble to the rule, a description of the extent of EPA's prior consultation with representatives of affected Tribal governments, a summary of the nature of their concerns, and a statement supporting the need to issue the regulation. In addition, Executive Order 13084 requires EPA to develop an effective process permitting elected officials and other representatives of Indian Tribal governments "to provide meaningful and timely input in the development of regulatory policies on matters that significantly or uniquely affect their communities." In developing this rule, EPA consulted with representatives of Tribal governments pursuant to the Unfunded Mandates Reform Act (UMRA) and Executive Order 13084. EPA held extensive meetings that provided the opportunity for meaningful and timely input in the development of the rule. The public docket for this rulemaking includes summaries of the meetings.

EPA has concluded that this rule does not significantly or uniquely affect the communities of Indian Tribal governments, nor will it impose substantial direct compliance costs on them. This rule will affect fewer than 22 of the 987 (or 2 percent) total Tribal drinking water systems. Of these 22 systems, 20 are estimated to incur annualized compliance costs of more than $50 per year or 0.001 percent of average annual revenue. The remaining two systems are estimated to incur annualized compliance costs of approximately $2,200 per year or 0.08 percent of average annual revenue. Accordingly, the requirements of Section 3(b) of Executive Order 13084 do not apply to this rule.

7.1.2 Regulatory Flexibility Act and Small Business Regulatory Enforcement Fairness Act

The provisions of the Regulatory Flexibility Act, 5 U.S.C. 601 et seq., as amended by the Small Business Regulatory Enforcement Fairness Act of 1996, require EPA to prepare a regulatory flexibility analysis unless the Agency certifies that the rule will not have "a significant economic impact on a substantial number of small entities." A regulatory flexibility analysis describes the impact of the regulatory action on small entities as part of the rule promulgation process.

The 1996 amendments to the SDWA define a small public water system (PWS) as a system serving fewer than 10,000 persons. This definition reflects the fact that the original 1979 standard for total trihalomethanes applied only to systems serving at least 10,000 people. The definition thus recognizes that baseline conditions from which systems serving fewer than 10,000 people will approach disinfection byproduct control and simultaneous control of microbial pathogens is different from that for systems serving 10,000 or more persons.

Background and Quantitative Analysis

When a rule may potentially have an adverse effect on one or more small entities, RFA and SBREFA require EPA to determine the extent of the impact and the number of small entities affected. If it is determined that the rule would not have a "significant impact on a substantial number of small entities," then the Agency can certify the rule. If the Agency determines that the rule will have an impact then the RFA/SBREFA requires that EPA prepare an Initial Regulatory Flexibility Analysis (IRFA) for a proposed rule, or Final Regulatory Flexibility Analysis (FRFA) for a final rule. Chapter 4 of this document provides data on the small entities potentially affected by the FBRR, and Chapter 6 discusses the changes systems would have to make and the likely costs. Using information found in these two chapters, along with additional information from Safe Drinking Water Information System (SDWIS) and Community Water System Survey (CWSS), EPA conducted a quantitative analysis to assist in determining whether to certify the rule or prepare an FRFA.

The Agency recognizes that economic characteristics will vary among entities affected by a given rule. Therefore, EPA evaluated the potential economic impact by comparing compliance costs as a percentage of sales, revenues, and operating expenses for small businesses, governments, and non profit organizations respectively. Statistics on the characteristics of water systems are updated frequently, making it difficult to describe the universe of surface water systems at any given time. Similarly, ownership data is difficult to ascertain because most data sets, such as SDWIS, do not maintain such information. For this analysis, the number of publicly and privately owned water systems was derived using the ratio of public to private water systems as reported in the 1995 CWSS. Using SDWIS and CWSS, EPA evaluated the universe of 11,411 small surface water and GWUDI systems to estimate the distribution of ownership type (i.e., public vs. private).[1] EPA estimates that for small systems, 34.0 percent are owned by small businesses, 59.7 percent are owned by small governments, and 6.3 percent are owned by nonprofit organizations.[2] While it was not possible to use existing data to establish the exact profile of water system ownership, EPA used information in the Drinking Water Baseline

[1]EPA used 11,411 systems in this analysis, recognizing that only 4,650 systems are expected to be subject to the FBRR. Using the entire universe of small surface and GWUDI systems allowed an accurate calculation of ownership type.

[2]The Drinking Water Baseline Handbook separates system ownership data into public, private or other (U.S. EPA, 2000b). For this analysis, EPA assumed, for the small systems, that public represents small government, private represents small business, and other represented small non-profit.

Handbook (U.S. EPA, 2000b) to approximate an ownership profile. As shown in Exhibit 7–1, the data suggest that a majority of small systems are publicly owned.[3]

Exhibit 7–1. Number and Percent of Small Public and Private Systems, by Size of System

System Type	System Population Size Category					Total
	<100	101–500	501–1,000	1,001–3,300	3,301–9,999	
Public	725 (26.6%)	1,346 (47.8%)	979 (69.2%)	2,075 (81.0%)	1,683 (88.8%)	6,808 (59.7%)
Private	1,635 (60.0%)	1,266 (45.0%)	369 (26.1%)	428 (16.7%)	188 (9.9%)	3,886 (34.0%)
Other	366 (13.4%)	203 (7.2%)	66 (4.7%)	58 (2.3%)	24 (1.3%)	717 (6.3%)
Total	**2,726 (24%)**	**2,815 (25%)**	**1,414 (12%)**	**2,561 (23%)**	**1,895 (16%)**	**11,411 (100%)**

Note: Figures represent number (percent) of systems within system size category.

The FBRR contains a provision for filter backwash recycling. Chapter 6 discusses this provision in detail and Exhibit 7–2 summarizes EPA's estimate of the number of small entities that the provision will affect. The 349 systems affected by the recycle return location provision are also affected by one of the other two provisions.

Exhibit 7–2. Small Entities Affected by the Filter Backwash Recycle Provisions of the FBRR

System Size (population served)	Systems Moving Recycle Return Location or Requesting Approval of Alternate Location	Systems that Must Meet Conventional Filtration Requirements	Systems that Must Meet Direct Filtration Requirements
< 100	49	454	34
101–500	66	613	46
501–1,000	49	457	34
1,001–3,300	96	899	68
3,301–9,999	89	823	62
Totals	**349**	**3,246**	**244**

[3]A public water system provides piped water for human consumption. The term "public water system" applies not only to water utilities, but also to a wide range of privately or publicly owned businesses and entities that provide drinking water (e.g., campgrounds, factories, restaurants, and schools). Public water systems are classified as community, nontransient noncommunity, or transient noncommunity systems.

After considering the economic impacts of the rule on small entities, EPA certifies that this regulation will not have a significant economic impact on a substantial number of small entities.[4]

7.1.3 Effect of Compliance With the FBRR on the Technical, Financial, and Managerial Capacity of Public Water Systems

Section 1420(d)(3) of the SDWA as amended requires that, in promulgating a National Primary Drinking Water Regulation (NPDWR), the Administrator shall include an analysis of the likely effect of compliance with the regulation on the technical, financial, and managerial capacity of PWSs. The following analysis fulfills this statutory obligation. In EPA guidance (EPA 816-R-98-006) (U.S. EPA, 1998) the Agency defines water system capacity as the ability to plan for, achieve, and maintain compliance with applicable drinking water standards.

Capacity has three components: technical, managerial, and financial. Technical capacity is the physical and operational ability of a water system to meet SDWA requirements. Technical capacity refers to the physical infrastructure of the water system, including the adequacy of source water and the adequacy of treatment, storage, and distribution infrastructure. It also refers to the ability of system personnel to adequately operate and maintain the system and to otherwise implement requisite technical knowledge. Examining key issues and questions can determine a water system's technical capacity, including:

- **Source water adequacy**. Does the system have a reliable source of water? Is the source of generally good quality and adequately protected?

- **Infrastructure adequacy**. Can the system provide water that meets SDWA standards? What is the condition of its infrastructure, including well(s) or source water intakes, treatment, storage, and distribution? What is the infrastructure's life expectancy? Does the system have a capital improvement plan?

- **Technical knowledge and implementation**. Is the system's operator certified? Does the operator have sufficient technical knowledge of applicable standards? Can the operator effectively implement this technical knowledge? Does the operator understand the system's technical and operational characteristics? Does the system have an effective operation and maintenance program?

Managerial capacity is the ability of a water system to conduct its affairs in a manner enabling the system to achieve and maintain compliance with SDWA requirements. Managerial capacity can be assessed through key issues and questions, including:

- **Ownership accountability**. Are the system owner(s) clearly identified? Can they be held accountable for the system?

[4]The analyses supporting this certification are contained in the Regulatory Flexibility Screening Analysis prepared for this final rule and can be found in the docket supporting the final rule (U.S. EPA, 2000g).

- **Staffing and organization**. Are the system operator(s) and manager(s) clearly identified? Is the system properly organized and staffed? Do personnel understand the management aspects of regulatory requirements and system operations? Do they have adequate expertise to manage water system operations? Do personnel have the necessary licenses and certifications?

- **Effective external linkages**. Does the system interact well with customers, regulators, and other entities? Is the system aware of available external resources, such as technical and financial assistance?

Financial capacity is a water system's ability to acquire and manage sufficient financial resources to allow the system to achieve and maintain compliance with SDWA requirements. Financial capacity can be assessed through key issues and questions, including:

- **Revenue sufficiency**. Do revenues cover costs? Are water rates and charges adequate to cover the cost of water?

- **Credit worthiness**. Is the system financially healthy? Does it have access to capital through public or private sources?

- **Fiscal management and controls**. Are adequate books and records maintained? Are appropriate budgeting, accounting, and financial planning methods used? Does the system manage its revenues effectively?

A total of 4,650 large and small systems are potentially subject to the FBRR. Of these, EPA estimates that 373 systems would need to modify treatment to come into compliance with the rule—the remainder or subject to reporting requirements only. Some large or small systems may require significantly increased technical, financial, or managerial capacity to comply with these new requirements.

Systems modifying treatment to meet recycling provisions may need to move recycle return to the plant headworks or alter treatment processes. As noted above, the compliance forecast estimated that 373 plants would need to move their recycling return flow to the head of the plant. Exhibits in the appendices detail the unit capital and O&M costs for direct and conventional filtration plants that need to redirect their recycle flows. Generally, systems affected by this rule are not required to make significant modifications to the treatment process to meet FBRR requirements. Therefore, systems are not expected to experience a significant impact on their technical, financial, or managerial capacity.

The final rule also requires that systems which practice conventional filtration and recycle spent filter backwash, sludge thickener supernatant, or liquids from dewatering processes, must notify the State in writing that they practice recycle. Additionally, systems must collect and maintain information for review by the State. When notifying the State, systems must also provide the following information:

- A plant schematic showing the origin of all recycle flows, the hydraulic conveyance used to transport them, and the location where they are recycled back into the plant; and

- Typical recycle flow in gallons per minute (gpm), highest observed plant flow experienced in the previous year (gpm), design flow for the treatment plant (gpm), and, if applicable, the State-approved operating capacity for the plant.

7.1.4 Paperwork Reduction Act

The information collected as a result of this rule will allow the States and EPA to determine appropriate requirements for specific systems, in some cases, and to evaluate compliance with the rule. For the first 3 years after promulgation of this rule, the major information requirements pertain to compliance reporting. Responses to the request for information are mandatory (40 CFR, Part 141). The information collected is not confidential.

The Paperwork Reduction Act requires EPA to estimate the burden on PWS, States, and territories for complying with the final rule. Burden refers to the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal agency. This includes the time needed to review instructions; develop, acquire, install, and utilize technology and systems for the purposes of collecting, validating, and verifying information, processing and maintaining information, and disclosing and providing information; adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to a collection of information; search data sources; complete and review the collection of information; and transmit or otherwise disclose the information.

Information collection activities of PWSs required under this rule during the first 3 years following promulgation will result in an average annual burden of 60,513 person-hours collectively for the PWSs. For States and territories, the analysis suggests the annual average burden to be 5,849 hours. The national, average annual labor cost of PWSs associated with information collection activities averages $1,281,512. Nationally, States will incur annual average costs of $136,182. Exhibit 7–3 presents a summary of the burden hours and costs associated with the FBRR for the 3 years covered by the ICR.

The costs and burdens during ICR approval period do not reflect all the costs and burdens that would result from the rule. The total burden and costs to systems for the FBRR provisions would be 183,295 hours and $3.5 million, respectively. For States, the FBRR provisions would result in a burden of 17,548 hours, and a cost of $408,546.

Exhibit 7–3. Summary Average Annual Burden and Costs for PWSs and States for the ICR Approval Period

	Average Annual Burden	Average Annual Labor Cost
PWSs	60,513	$1,281,512
States	5,849	$136,182
Total	**66,362**	**$1,417,694**

The derivation of all FBRR burdens and costs for start-up and annual information collection activities can be found in *Information Collection Request for the Filter Backwash Recycling Rule*.

7.1.5 Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Public Law 104-4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and Tribal governments and the private sector. Under UMRA Section 202, EPA generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with "Federal mandates" that may result in expenditures by State, local, and Tribal governments, in the aggregate, or to the private sector, of $100 million or more in any one year. Before promulgating an EPA rule, for which a written statement is needed, Section 205 of the UMRA generally requires EPA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule. The provisions of Section 205 do not apply when they are inconsistent with applicable law. Moreover, Section 205 allows EPA to adopt an alternative other than the least costly, most cost-effective or least burdensome alternative if the Administrator publishes with the final rule an explanation why that alternative was not adopted.

Before EPA establishes any regulatory requirements that may significantly or uniquely affect small governments, including Tribal governments, it must have developed, under Section 203 of the UMRA, a small government agency plan. The plan must provide for notification to potentially affected small governments, enabling officials of affected small governments to have meaningful and timely input in the development of EPA regulatory proposals with significant Federal intergovernmental mandates and informing, educating, and advising small governments on compliance with the regulatory requirements.

EPA has determined that this rule does not contain a Federal mandate that may result in expenditures of $100 million or more for the State, local and Tribal governments, in the aggregate, or the private sector in any one year. Thus, FBRR is not subject to the requirements of Sections 202 and 205 of the UMRA. The Agency estimated annual aggregate State, local, and Tribal government expenditures by adding State program costs to the share of system costs potentially incurred by publicly owned systems. These systems account for approximately 64 percent of the $5.77-$6.18 million (3 percent and 7 percent discount rates) in total annual system costs, which is $3.71-$3.96 million (3 percent and 7 percent discount rates) per year. Thus, State program costs and publicly owned system costs total $3.78-$4.05 million (3 percent and 7 percent discount rates) per year.

Consistent with the intergovernmental consultation provisions of Section 204 of UMRA, EPA consulted with small governments to address impacts of regulatory requirements in the rule that might significantly or uniquely affect small governments. As discussed next, a variety of stakeholders, including small governments, were provided the opportunity for timely and meaningful participation in the regulatory development process. EPA used these opportunities to notify potentially affected small governments of regulatory requirements being considered.

EPA began outreach efforts to develop the FBRR in the summer of 1998. Two public stakeholder meetings, which were announced in the *Federal Register*, were held on July 22-23, 1998, in Lakewood, Colorado, and on March 3-4, 1999, in Dallas, Texas. In addition to these meetings, EPA has held several formal and informal meetings with stakeholders including the Association of State Drinking Water Administrators. A summary of each meeting and attendees is available in the public docket for this rule. EPA also convened a Small Business Advocacy Review (SBAR) Panel in accordance with the RFA, as amended by SBREFA to address small entity concerns including those of small local governments. The SBAR Panel allows small regulated entities to provide input to EPA early in the regulatory development process. In early June, 1999, EPA mailed an informal draft of the FBRR preamble to the approximately 100 stakeholders who attended one of the public stakeholder meetings. Members of trade associations and the SBREFA Panel also received the draft preamble. EPA received valuable suggestions and stakeholder input from 15 State representatives, trade associations, environmental interest groups, and individual stakeholders. The majority of concerns dealt with reducing burden on small systems and maintaining flexibility.

7.2 Impacts on Subpopulations

A primary purpose of the FBRR is to improve control of microbial pathogens, specifically the protozoan *Cryptosporidium*. The health effect of cryptosporidiosis on sensitive subpopulations is much more severe and debilitating than on the general population. Several subpopulations are more sensitive to cryptosporidiosis, including the young, elderly, malnourished, disease impaired (especially those with diabetes), and a broad category of those with compromised immune systems, such as AIDS patients, those with Lupus or cystic fibrosis, transplant recipients, and those on chemotherapy (Rose, 1997).

7.2.1 Impacts on the Immunocompromised

Mortality, as a result of cryptosporidiosis infection, is a much greater risk for sensitive subpopulations than it is for the general population, particularly for the immunocompromised.

> The duration and severity of the disease are significant: whereas the disease may hospitalize 1 percent of the immunocompetent population with very little risk of mortality (< 0.001),

Cryptosporidium infections are associated with a high rate of mortality in the immunocompromised (50 percent) (Rose, 1997).

The duration of cryptosporidiosis in those with compromised immune systems is considerably longer than in those with competent immune systems, with more severe symptoms often requiring lengthy hospital stays. In those subpopulations, the cost-of-illness (COI) from cryptosporidiosis would be much greater than for the general populace. During a 1993 outbreak in Milwaukee, 33 AIDS patients with *Cryptosporidium* accounted for 400 hospital days at an additional cost of nearly $760,000 (Rose, 1997). COI due to these hospital days alone is estimated at $23,000 per case ($760,000/33 patients).

Because of the severity of illness and high costs for treatment experienced by sensitive subpopulations, as a result of *Cryptosporidium* infection, the Agency expects the FBRR to have a disproportionately positive impact on the subpopulations mentioned earlier.

7.2.2 Protecting Children From Environmental Health Risks and Safety Risks

Executive Order 13045 (62 FR 19885; April 23, 1997) applies to any rule initiated after April 21,1997, or after April 21, 1998, that (1) is determined to be "economically significant" as defined under Executive Order 12866 and (2) concerns an environmental health or safety risk that EPA has reason to believe may have a disproportionate effect on children. If the regulatory action meets both criteria, EPA must evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by EPA.

While FBRR is not subject to the Executive Order because it is not economically significant as defined by Executive Order 12866, the Agency nonetheless has reason to believe that the environmental health or safety risk addressed by this action may have a disproportionate effect on children. As a matter of policy, EPA assessed available *Cryptosporidium*-related health effects data for children.

In promulgating the FBRR, EPA recognizes that the health risks associated with exposure to the protozoan *Cryptosporidium* are of particular concern for certain sensitive subpopulations, including children and immunocompromised individuals. The risk of illness and death due to cryptosporidiosis depends on several factors, including age, nutrition, exposure, genetic variability, disease and immune status of the individual. Mortality resulting from diarrhea shows the greatest risk of mortality occurring among the very young and elderly (Gerba et al., 1996). For *Cryptosporidium*, young children are a vulnerable population subject to infectious diarrhea (CDC 1994). Cryptosporidiosis is prevalent worldwide, and its occurrence is higher in children than in adults (Fayer and Ungar, 1986).

Cryptosporidiosis appears to be more prevalent in populations such as infants, that may not have established immunity against the disease and may be in greater contact with environmentally contaminated surfaces (DuPont et al., 1995). An infected child may spread the disease to other children or family members. Evidence of such secondary transmission of cryptosporidiosis from children to household and other close contacts has been found in a number of outbreak investigations (Casemore, 1990; Cordell et al., 1997; Frost et al., 1997). Chapell et al. (1999) found that prior exposure to *Cryptosporidium* through the ingestion of a low oocyst dose provides protection from infection and illness. However, it is not known whether this immunity is life-long or temporary. Data also indicate that either mothers confer short term immunity to their children or that babies have reduced exposure to *Cryptosporidium*, resulting in a decreased incidence of infection during the first year of life. For example, in a survey of over 30,000 stool sample analyses from different patients in the United Kingdom, the 1-5 year age group suffered a much higher infection rate than individuals less than one year of age. For children under one year of age, those older than six months of age showed a higher rate of infection than individuals aged fewer than six months (Casemore, 1990).

EPA has not been able to quantify the health effects for children as a result of *Cryptosporidium*-contaminated drinking water. However, the result of the FBRR will be a reduction in the risk of illness for the entire population, including children. Because available evidence indicates that children may be more vulnerable to cryptosporidiosis than the rest of the population, the FBRR would, therefore, result in greater risk reduction for children than for the general population.

7.3 Environmental Justice

Executive Order 12898 (59 FR 7629) establishes a Federal policy for incorporating environmental justice into Federal agency missions by directing agencies to identify and address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations. The Agency has considered environmental justice-related issues concerning the potential impacts of this action and has consulted with minority and low-income stakeholders.

The overall nature of the FBRR mimics the 1998 IESWTR by regulating small PWSs to improve control of microbial pathogens. As such, the Agency also built on the efforts conducted during the IESWTR's development to comply with Executive Order 12898. On March 12, 1998, the Agency held a stakeholder meeting to address various components of pending drinking water regulations and how they may impact sensitive sub-populations, minority populations, and low-income populations. Topics discussed included treatment techniques, costs and benefits, data quality, health effects, and the regulatory process. Participants included national, State, Tribal, municipal, and individual stakeholders. EPA conducted the meetings by video conference call between eleven cities. This meeting was a continuation of stakeholder meetings that started in 1995 to obtain input on the Agency's Drinking Water Programs. The major objectives for the March 12, 1998 meeting were to:

(1) Solicit ideas from stakeholders on known issues concerning current drinking water regulatory efforts;

(2) Identify key issues of concern to stakeholders, and;

(3) Receive suggestions from stakeholders concerning ways to increase representation of communities in Office of Ground Water and Drinking Water regulatory efforts.

In addition, EPA developed a plain-English guide specifically for this meeting to assist stakeholders in understanding the multiple and sometimes complex issues surrounding drinking water regulation.

8. Weighing the Benefits and the Costs

This chapter compares the benefit estimates discussed in Chapter 5 with the cost estimates discussed in Chapter 6. Because data were not available to accurately estimate the annual benefits, the Regulatory Impact Analysis (RIA) does not present a mathematical comparison between costs and benefits. Instead, a breakeven analysis is presented to assess potential benefits of the rule in relation to the calculated costs. EPA expects that the benefits associated with the FBRR justify the costs associated with the rule.

The chapter is organized as follows:

- Section 8.1 - briefly discusses the cost and benefit analyses in this RIA.
- Section 8.2 - describes EPA's determination that the costs associated with the Filter Backwash Recycling Rule (FBRR) are justified by potential benefits.
- Section 8.3 - describes how the breakeven analysis was used to assess the benefits of the recycle provisions, given the scientific uncertainties surrounding the risk posed by the recycling practices.
- Section 8.4 - describes the uncertainties involved in the development of the benefit and cost analyses.
- Section 8.5 - examines the cost effectiveness of the rule, based on the value of avoided illness.
- Section 8.6 - shows the combined regulatory affect of the FBRR and several other rules that potentially affect drinking water systems that use surface water or ground water under the direct influence of surface water (GWUDI).

8.1 Incremental and Marginal Analysis

Chapter 6 of this RIA estimates the incremental costs of the FBRR, which are the costs expected to accrue compared to a baseline in which the provisions of the rule are not implemented. Annual costs are estimated at $5.84 million (assuming a 3 percent discount rate) and $7.19 million (assuming a 7 percent discount rate). This cost includes annualized capital investments to alter treatment processes, annual reporting and recordkeeping costs, and annual operation and maintenance (O&M) expenditures. It also includes annualized start-up cost estimates for all of the provisions of the rule. EPA has also presented a comparison of the costs associated with the final rule provisions with the costs that would be associated with proposed provisions. Data are not available to accurately estimate the benefits associated with the rule.

8.2 Benefit-Cost Comparisons

Under the 1996 amendments to the Safe Drinking Water Act, EPA is required to make a determination of whether benefits justify costs for the rulemaking. EPA has determined that the benefits of the FBRR justify the costs.

The Agency has determined that the benefits of the provisions justify their cost on a qualitative basis although the analysis in the following section provides a quantitative perspective on the health benefits needed to break even given EPA's cost estimates. The recycle provisions will reduce the potential for certain recycle practices to lower or upset treatment plant performance during recycle events. Therefore, the provisions will help prevent *Cryptosporidium* oocysts from entering finished drinking water supplies and will increase the level of public health protection.

Returning *Cryptosporidium* to the treatment process in recycle flows, if performed in a manner that is inconsistent with fundamental engineering and water treatment principles, can increase public health risks. EPA believes that there are three instances, in particular, that potentially increase health risks. First, returning recycle flow directly to the plant—without equalization or treatment—can cause large variations in the influent flow magnitude and the influent water quality. If chemical dosing is not adjusted to reflect these variations, then less than optimal chemical dosing can occur, which may lower sedimentation and filtration performance. Returning recycle flows through the processes of a system's existing conventional or direct filtration system, as defined in 40 CFR, Section 141.2, will help diminish the likelihood of this occurring. Second, exceeding State-approved operating capacity, which may be more likely to occur if recycle equalization or treatment is not in place, can hydraulically overload plants and diminish the ability of individual unit processes to remove *Cryptosporidium*. Exceeding approved operating capacity violates fundamental engineering principles and water treatment objectives. States set limits on plant operating capacity and loading rates for individual unit processes to ensure that treatment plants and individual treatment processes operate within their capabilities and, thereby, provide the necessary levels of public health protection. Third, improper recycle practices, such as returning recycle flows directly into flocculation or sedimentation basins, generate disruptive hydraulic currents, which may lower the performance of these units and increase the risk *Cryptosporidium* will be present in finished water supplies.

The objective of the FBRR is to eliminate practices that do not use sound engineering judgement and that create additional and preventable risk to public health. EPA's rule addresses these practices, while providing States and affected systems with the flexibility necessary to implement the most cost-effective solutions. Consequently, EPA believes the public health protection benefit provided by the FBRR justifies its cost.

8.3 Breakeven Analysis for the Recycle Provisions

The FBRR provisions are expected to improve recycle practices, thereby preventing the accumulation of *Cryptosporidium* within the treatment plant and minimizing the risk of oocysts entering into the finished water. EPA cannot estimate the magnitude of the risk reduction because the overall impact on finished water quality of different treatment changes brought about by the provisions depends on a wide variety of system operational parameters that cannot be easily modeled. Given the large population served by systems that are potentially subject to the rule (over 80 million people) small risk reduction could have a substantial impact. To assess the costs of the recycle provisions against the possible range of risks, EPA used a breakeven analysis to explore net benefits of the alternatives. Breakeven analysis represents an approach to assessing the benefits of the recycle provisions given the scientific uncertainties surrounding the risk posed by recycling practices.

Breakeven is a standard benchmark of cost effectiveness and economic efficiency and is essentially the point where the benefits of the recycle provisions would be equal to the costs. Normally, the benefits and costs of an option are calculated separately and then compared to assess whether and by what amount benefits exceed costs. In the case of the recycle provisions, independently estimating benefits is difficult, if not impossible, because of the uncertainty surrounding the risk and resulting risk reduction. Instead, the breakeven analysis works backwards from those variables that are less uncertain. In this case, implementation costs for the rule and the monetary value associated with the health endpoints are used to calculate what risk reduction estimates are needed for the rule to just pay for itself in avoided health damages associated with cryptosporidiosis.

In an ideal situation, the first step in the breakeven analysis is to calculate the number of cryptosporidiosis cases that would need to be avoided for the benefits of avoiding those cases to be equal to the cost of the rule. The simple calculation is to divide the annual costs of the rule by the value per cryptosporidiosis case to derive the number of cryptosporidiosis cases needed to cover the costs of the rule. However as indicated previously, information is not available on direct measurements of either COI or WTP to reduce risk specifically for *Cryptosporidium*. The Agency was able to develop a breakeven analysis based solely on mortalities. Exhibit 8-1 shows that the estimated annual cost of the FBRR (assuming a 3 percent discount rate) is less than the estimated value of one statistical life.

Exhibit 8–1. Breakeven Analysis Summary

Annual cost of FBRR:	$5.8 and $7.19 million (at 3% and 7% respectively)
Estimated cost of 1 mortality avoided:	$6.3 million
Breakeven Point:	1 mortality

8.4 Summary of Uncertainty/Sensitivity Analysis

Uncertainties affected EPA's ability to estimate the benefits and costs associated with the FBRR. EPA expects that there will be a variety of positive benefits associated with the FBRR, but, because of uncertainties, EPA cannot quantify these benefits. EPA has not developed a national benefit estimate because the overall impact on finished water quality of different treatment changes brought about by the provisions depends on a wide variety of system operational parameters that cannot be easily modeled. In order to model the effect of recycle practice, data regarding the ability of a wide range of unit processes (sedimentation, dissolved-air flotation [DAF], contact clarification, filtration) to remove oocysts from a wide variety of source water types, under a range of treatment conditions, is needed to calibrate the model. These data are currently not extensive enough to model the impact of recycle on a wide variety of treatment configurations.

Capital and O&M expenditures account for a majority of total costs. EPA derived these costs for a "model" system in each size category using engineering models, best professional judgement, and existing cost and technology documents. To account for uncertainty, EPA presents costs at both a 3 percent and a 7 percent discount rate throughout Chapter 6. Additional uncertainties associated with the cost analysis are caused primarily by baseline assumptions made about how many systems will be affected by various provisions. Costs for systems affected by the rule could be higher or lower, which would affect total costs. Section 6.3.1 provides more detail on the biases and uncertainties associated with the cost estimate.

8.5 Cost Effectiveness

The cost effectiveness of the rule can be measured as the cost per case of avoided illness. EPA expects the FBRR to be cost effective, but data are not available to formally assess the actual number of cryptosporidiosis cases that would be reduced by the rule. For illustrative purposes, Exhibit 8–2 provides a cost-effectiveness analysis under two example scenarios—a scenario in which implementation of the FBRR results in the prevention of 2 percent of the illnesses remaining after implementation of LT1ESWTR and IESWTR and a scenario in which the FBRR results in the prevention of 5 percent of the remaining illnesses.

Exhibit 8-2. Example Cost Effectiveness Derivations (January 1999 dollars)

Annual Cost of FBRR: $5.84 million		
Assumption[1]	**Number of Illnesses Avoided**	**Cost per Illness Avoided**
The FBRR prevents 2% of the illnesses remaining after implementation of IEWSTR and LT1ESWTR	1,800 - 5,400	$1,100 - $3,200
The FBRR results prevents 5% of the illnesses remaining after implementation of IEWSTR and LT1ESWTR	4,500 - 13,500	$400 - $1,300

[1]Number of illnesses avoided is based on mid-improved *Cryptosporidium* removal assumptions from the RIAs for LT1ESWTR and IESWTR. For small systems, 2.0- and 2.5-log baseline removal assumptions are used; for large systems, baseline removal assumptions of 2.5 logs and 3 logs are used.

8.6 Combined Regulatory Effects with Other Rules

The FBRR is one of several proposed and final rules that potentially affect surface water and GWUDI drinking water systems. Other rules include the IESWTR, the Stage 1 Disinfectants and Disinfection Byproducts Rule (Stage 1 DBPR), and the LT1ESWTR. Thus far, EPA's cost estimates suggest that costs associated with small surface water systems will total approximately $93 million. Costs associated with larger surface water systems are greater, potentially totaling approximately $575 million. These costs do not include costs associated with the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) or Stage 2 Disinfection Byproducts Rule (Stage 2 DBPR) which are expected to be proposed in the near future. Adding costs across rules may overstate the social costs of regulatory activities because actions to satisfy one rule may reduce the costs of subsequent rules that have related public health goals.

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Appendix A

Compliance Forecasts and Total Capital Costs of Treatment

Appendix A-1: FBRR Compliance Forecast for Final FBRR Provisions

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,001-1,000,000
TOTAL RECYCLE PLANTS (Conventional & Direct):	488	660	491	967	885	860	157	135
CONVENTIONAL FILTRATION PLANTS ONLY:	454	613	457	899	823	800	146	126
DIRECT FILTRATION PLANTS ONLY:	34	46	34	68	62	60	11	9

CONVENTIONAL FILTRATION PLANTS ONLY:	454	613	457	899	823	800	146	126
	%							
Install piping to move recycle to headworks	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0

DIRECT FILTRATION PLANTS ONLY:	34	46	34	68	62	60	11	9
	%							
Install piping to move recycle to headworks	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0

Appendix A2: FBRR System-Level Capital Costs for Recycle Modifications

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,001-1,000,000
TOTAL RECYCLE PLANTS (Conventional & Direct):	488	660	491	967	885	860	157	135
CONVENTIONAL FILTRATION PLANTS ONLY:	454	613	457	899	823	800	146	126
DIRECT FILTRATION PLANTS ONLY:	34	46	34	68	62	60	11	9

CONVENTIONAL FILTRATION PLANTS ONLY:	454	613	457	899	823	800	146	126
	------$000------							
Install piping to move recycle to headworks	6.7	13.5	13.7	18.3	32.3	84.1	291.0	2826.1

DIRECT FILTRATION PLANTS ONLY:	34	46	34	68	62	60	11	9
	------$1,000------							
Install piping to move recycle to headworks	6.7	13.5	13.7	18.3	32.3	84.1	291.0	2826.1

Appendix A-3: FBRR System-Level O&M Costs for Recycle Modifications

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,001-1,000,000
TOTAL RECYCLE PLANTS (Conventional & Direct):	**488**	**660**	**491**	**967**	**885**	**860**	**157**	**135**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**800**	**146**	**126**
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**60**	**11**	**9**

CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**800**	**146**	**126**
	$000							
Install piping to move recycle to headworks	1.3	1.4	1.6	2.0	3.2	10.2	22.5	86.2

DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**60**	**11**	**9**
	$000							
Install piping to move recycle to headworks	1.3	1.4	1.6	2.0	3.2	10.2	22.5	86.2

Appendix A-4: FBRR Total Capital Costs for All Systems Requiring Modifications for Final FBRR Provisions

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	Subtotal Small Systems	10,001-50,000	50,001-100,000	100,001-1,000,000	Subtotal Large Systems	Total
TOTAL RECYCLE PLANTS (Conventional & Direct):	**488**	**660**	**491**	**967**	**885**	**3,490**	**860**	**157**	**135**	**1,152**	**4,643**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**800**	**146**	**126**	**1,072**	**4,318**
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**802** [a]	**146**	**126**	**1,072**	**4,318**
	---------------------$000---------------------										
Install piping to move recycle to headworks	241.4	662.9	501.0	1312.5	2124.5	4842.3	5393.1	3405.8	28402.2	37201.1	42043.5
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
	---------------------$000---------------------										
Install piping to move recycle to headworks	18.2	49.9	37.7	98.8	159.9	364.5	404.9	256.3	2137.8	2799.1	3163.5
Total Cost	**259.6**	**712.8**	**538.7**	**1411.3**	**2284.4**	**5206.8**	**5798.1**	**3662.1**	**30540.0**	**40000.2**	**45207.0**

a. In the conventional filtration section, the recycle location costs include two additional plants that belong to systems serving more than one million. (See Section 4.3.4 of the RIA for discussion)

Appendix B

Annualized Capital and O&M Costs at 3 Percent Discount Rate

Appendix B-1: FBRR Total Annualized Capital Costs ($000s) at 3% Discount Rate for Final FBRR Provisions

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	Subtotal Small Systems	10,001-50,000	50,001-100,000	100,001-1,000,000	Subtotal Large Systems	Total
TOTAL RECYCLE PLANTS (Conventional & Direct):	**488**	**660**	**491**	**967**	**885**	**3,490**	**860**	**157**	**135**	**1,152**	**4,643**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**800**	**146**	**126**	**1,072**	**4,318**
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**802** [a]	**146**	**126**	**1,072**	**4,318**
	$000										
Install piping to move recycle to headworks	16.2	44.6	33.7	88.2	142.8	325.5	362.5	228.9	1909.1	2500.5	2826.0
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
	$000										
Install piping to move recycle to headworks	1.2	3.4	2.5	6.6	10.7	24.5	27.2	17.2	143.7	188.1	212.6
Total Cost	**17.4**	**47.9**	**36.2**	**94.9**	**153.5**	**350.0**	**389.7**	**246.2**	**2052.8**	**2688.6**	**3038.6**

a. In the conventional filtration section, the recycle location costs include two additional plants that belong to systems serving more than one million. (See Section 4.3.4 of the RIA for discussior

Appendix B-2: FBRR Total Annual Operation & Maintenance Costs for Final FBRR Provisions

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	Subtotal Small Systems	10,001-50,000	50,001-100,000	100,001-1,000,000	Subtotal Large Systems	Total
TOTAL RECYCLE PLANTS (Conventional & Direct):	**488**	**660**	**491**	**967**	**885**	**3,490**	**860**	**157**	**135**	**1,152**	**4,643**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**800**	**146**	**126**	**1,072**	**4,318**
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**802** [a]	**146**	**126**	**1,072**	**4,318**
							$000				
Install piping to move recycle to headworks	47.2	68.7	58.5	143.8	210.7	528.9	654.3	263.3	866.3	1784.0	2312.9
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
							$000				
Install piping to move recycle to headworks	3.6	5.2	4.4	10.8	15.9	39.8	49.1	19.8	65.2	134.2	174.0
Total Cost	**50.7**	**73.9**	**62.9**	**154.7**	**226.6**	**568.7**	**703.5**	**283.1**	**931.5**	**1918.1**	**2486.9**

a. In the conventional filtration section, the recycle location costs include two additional plants that belong to systems serving more than one million. (See Section 4.3.4 of the RIA for discussion)

Appendix B-3: FBRR Total Annual Costs (Capital and O&M) at 3% Discount Rate for Final FBRR Provisions

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	Subtotal Small Systems	10,001-50,000	50,001-100,000	100,001-1,000,000	Subtotal Large Systems	Total
TOTAL RECYCLE PLANTS (Conventional & Direct):	**488**	**660**	**491**	**967**	**885**	**3,490**	**860**	**157**	**135**	**1,152**	**4,643**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**800**	**146**	**126**	**1,072**	**4,318**
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**802** [a]	**146**	**126**	**1,072**	**4,318**
	$000										
Install piping to move recycle to headworks	63.4	113.3	92.1	232.1	353.5	854.4	1016.8	492.2	2775.4	4284.5	5138.9
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
	$000										
Install piping to move recycle to headworks	4.8	8.5	6.9	17.5	26.6	64.3	76.3	37.1	208.9	322.3	386.6
Total Cost	**68.2**	**121.8**	**99.1**	**249.5**	**380.1**	**918.7**	**1093.2**	**529.3**	**2984.3**	**4606.8**	**5525.5**

a. In the conventional filtration section, the recycle location costs include two additional plants that belong to systems serving more than one million. (See Section 4.3.4 of the RIA for discussion)

Appendix C

Annualized Capital and O&M Costs at 7 Percent Discount Rate

Appendix C-1: FBRR Total Annualized Capital Costs at 7% Discount Rate for Final FBRR Provisions

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	Subtotal Small Systems	10,001-50,000	50,001-100,000	100,001-1,000,000	Subtotal Large Systems	Total
TOTAL RECYCLE PLANTS (Conventional & Direct):	**488**	**660**	**491**	**967**	**885**	**3,490**	**860**	**157**	**135**	**1,152**	**4,643**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**800**	**146**	**126**	**1,072**	**4,318**
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**802** [a]	**146**	**126**	**1,072**	**4,318**
						$000					
Install piping to move recycle to headworks	22.8	62.6	47.3	123.9	200.5	457.1	509.1	321.5	2681.0	3511.5	3968.6
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
						$000					
Install piping to move recycle to headworks	1.7	4.7	3.6	9.3	15.1	34.4	38.2	24.2	201.8	264.2	298.6
Total Cost	**24.5**	**67.3**	**50.8**	**133.2**	**215.6**	**491.5**	**547.3**	**345.7**	**2882.8**	**3775.7**	**4267.2**

a. In the conventional filtration section, the recycle location costs include two additional plants that belong to systems serving more than one million. (See Section 4.3.4 of the RIA for discussion)

Appendix C-2: FBRR Total Annual Operation & Maintenance Costs for Final FBRR Provisions

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	Subtotal Small Systems	10,001-50,000	50,001-100,000	100,001-1,000,000	Subtotal Large Systems	Total
TOTAL RECYCLE PLANTS (Conventional & Direct):	**488**	**660**	**491**	**967**	**885**	**3,490**	**860**	**157**	**135**	**1,152**	**4,643**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**800**	**146**	**126**	**1,072**	**4,318**
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**

CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**802** [a]	**146**	**126**	**1,072**	**4,318**
	$000										
Install piping to move recycle to headworks	47.2	68.7	58.5	143.8	210.7	528.9	654.3	263.3	866.3	1784.0	2312.9
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
	$000										
Install piping to move recycle to headworks	3.6	5.2	4.4	10.8	15.9	39.8	49.1	19.8	65.2	134.2	174.0
Total Cost	**50.7**	**73.9**	**62.9**	**154.7**	**226.6**	**568.7**	**703.5**	**283.1**	**931.5**	**1918.1**	**2486.9**

a. In the conventional filtration section, the recycle location costs include two additional plants that belong to systems serving more than one million. (See Section 4.3.4 of the RIA for discussion)

Appendix C-3: FBRR Total AnnualCosts (Capital and O&M) at 7% Discount Rate for Final FBRR Provisions

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	Subtotal Small Systems	10,001-50,000	50,001-100,000	100,001-1,000,000	Subtotal Large Systems	Total
TOTAL RECYCLE PLANTS (Conventional & Direct):	**488**	**660**	**491**	**967**	**885**	**3,490**	**860**	**157**	**135**	**1,152**	**4,643**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**800**	**146**	**126**	**1,072**	**4,318**
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**3,246**	**802** [a]	**146**	**126**	**1,072**	**4,318**
	$000										
Install piping to move recycle to headworks	70.0	131.3	105.8	267.7	411.3	986.0	1163.4	584.8	3547.3	5295.5	6281.5
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**244**	**60**	**11**	**9**	**81**	**325**
	$000										
Install piping to move recycle to headworks	5.3	9.9	8.0	20.2	31.0	74.2	87.4	44.0	267.0	398.4	472.6
Total Cost	**75.2**	**141.2**	**113.7**	**287.9**	**442.2**	**1060.2**	**1250.8**	**628.8**	**3814.3**	**5693.8**	**6754.1**

a. In the conventional filtration section, the recycle location costs include two additional plants that belong to systems serving more than one million. (See Section 4.3.4 of the RIA for discussion)

Appendix D

Annualized Capital and O&M Costs in Cents per Thousand Gallons

Appendix D-1: FBRR Annualized System-Level Capital Costs (cents/kilogallon) at 7% Discount Rate for Final FBRR Provisions

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,001-1,000,000
TOTAL RECYCLE PLANTS (Conventional & Direct):	488	660	491	967	885	860	157	135
CONVENTIONAL FILTRATION PLANTS ONLY:	454	613	457	899	823	800	146	126
DIRECT FILTRATION PLANTS ONLY:	34	46	34	68	62	60	11	9

CONVENTIONAL FILTRATION PLANTS ONLY:	454	613	457	899	823	802 [a]	146	126
	cents							
Install piping to move recycle to headworks	7.7	4.0	1.5	0.8	0.5	0.3	0.4	0.9

DIRECT FILTRATION PLANTS ONLY:	34	46	34	68	62	60	11	9
	cents							
Install piping to move recycle to headworks	7.7	4.0	1.5	0.8	0.5	0.3	0.4	0.9

a. In the conventional filtration section, the recycle location costs include two additional plants that belong to systems serving more than one million. (See Section 4.3.4 of the RIA for discussion)

Appendix D-2: FBRR Annualized System-Level Capital Costs (cents/kilogallon) at 3% Discount Rate for Final FBRR Provisions

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,001-1,000,000
TOTAL RECYCLE PLANTS (Conventional & Direct):	**488**	**660**	**491**	**967**	**885**	**860**	**157**	**135**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**800**	**146**	**126**
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**60**	**11**	**9**

CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**802** [a]	**146**	**126**
	cents							
Install piping to move recycle to headworks	5.5	2.8	1.1	0.6	0.3	0.2	0.3	0.6

DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**60**	**11**	**9**
	cents							
Install piping to move recycle to headworks	5.5	2.8	1.1	0.6	0.3	0.2	0.3	0.6

a. In the conventional filtration section, the recycle location costs include two additional plants that belong to systems serving more than one million. (See Section 4.3.4 of the RIA for discussion)

Appendix D-3: FBRR Annual System-Level O&M Costs (cents/kilogallon) for Final FBRR Provisions

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,001-1,000,000
TOTAL RECYCLE PLANTS (Conventional & Direct):	**488**	**660**	**491**	**967**	**885**	**860**	**157**	**135**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**800**	**146**	**126**
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**60**	**11**	**9**

CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**802** [a]	**146**	**126**
	cents							
Install piping to move recycle to headworks	51.3	13.9	5.9	2.6	1.2	0.9	0.6	0.6

DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**60**	**11**	**9**
	cents							
Install piping to move recycle to headworks	51.3	13.9	5.9	2.6	1.2	0.9	0.6	0.6

a. In the conventional filtration section, the recycle location costs include two additional plants that belong to systems serving more than one million. (See Section 4.3.4 of the RIA for discussion)

Appendix D-4: FBRR Total Annual System-Level Costs (Capital and O&M) at 3% Discount Rate for Final FBRR Provisions (cents/kgal)

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,001-1,000,000
TOTAL RECYCLE PLANTS (Conventional & Direct):	**488**	**660**	**491**	**967**	**885**	**860**	**157**	**135**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**800**	**146**	**126**
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**60**	**11**	**9**

CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**802** [a]	**146**	**126**
	--------	--------	--------	--------	cents	--------	--------	--------
Install piping to move recycle to headworks	56.8	16.8	6.9	3.1	1.5	1.1	0.9	1.2

DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**60**	**11**	**9**
	--------	--------	--------	--------	cents	--------	--------	--------
Install piping to move recycle to headworks	56.8	16.8	6.9	3.1	1.5	1.1	0.9	1.2

a. In the conventional filtration section, the recycle location costs include two additional plants that belong to systems serving more than one million. (See Section 4.3.4 of the RIA for discussion)

Appendix D-5: FBRR Total Annual System-Level Costs (Capital and O&M) at 7% Discount Rate for Final FBRR Provisions (cents/kgal)

SYSTEM POPULATION SIZE CATEGORY:	≤100	101-500	501-1,000	1,001-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,001-1,000,000
TOTAL RECYCLE PLANTS (Conventional & Direct):	**488**	**660**	**491**	**967**	**885**	**860**	**157**	**135**
CONVENTIONAL FILTRATION PLANTS ONLY:	**454**	**613**	**457**	**899**	**823**	**800**	**146**	**126**
DIRECT FILTRATION PLANTS ONLY:	**34**	**46**	**34**	**68**	**62**	**60**	**11**	**9**

CONVENTIONAL FILTRATION PLANTS ONLY:	454	613	457	899	823	802 [a]	146	126
	cents							
Install piping to move recycle to headworks	59.1	17.9	7.4	3.4	1.6	1.2	1.0	1.4

DIRECT FILTRATION PLANTS ONLY:	34	46	34	68	62	60	11	9
	cents							
Install piping to move recycle to headworks	59.1	17.9	7.4	3.4	1.6	1.2	1.0	1.4

a. In the conventional filtration section, the recycle location costs include two additional plants that belong to systems serving more than one million. (See Section 4.3.4 of the RIA for discussion)

Appendix E

System and State Reporting and Record Keeping Costs

Appendix E-1a

System and State Costs for New Return Location at 3% Discount Rate, Alternative R2

System Population Size Category:	≤1,000	1,001-3,300	3,301-10,000	10,001 - 1 million[a]	Total[a]	Annualized Costs[b]
Systems Expected to Move Return Location:	131	77	71	94	373	
Systems Requesting a Waiver:	33	19	18	23	93	
Compliance Activities						
SYSTEMS						
Submit Alternate Location Requests to State	$7,603	$5,320	$4,872	$11,211	$29,007	
Consultation with State	$1,901	$1,330	$1,218	$2,803	$7,252	
Recordkeeping	$475	$333	$304	$701	$1,813	
Total Cost for Systems	**$9,979**	**$6,983**	**$6,394**	**$14,715**	**$38,071**	**$2,559**
STATES						
Review Recycle Plans, Alternate Location Requests	$6,104	$3,601	$3,297	$4,293	$17,295	
Consult with System	$3,052	$1,800	$1,649	$2,146	$8,647	
Recordkeeping	$763	$450	$412	$537	$2,162	
Total Costs for States	**$9,919**	**$5,851**	**$5,358**	**$6,976**	**$28,104**	**$1,889**
Total System and State Costs					**$66,175**	**$4,448**

Notes:

a. Costs include two plants that belong to systems serving more than 1 million people.

b. All costs are annualized by a capitalization factor (CF) of 0.06722. The CF is calculated using the discount rate (3%) and the number of years of capitalization (20 years).

Appendix E-1b

System and State Costs for New Return Location at 7% Discount Rate, Alternative R2

Compliance Activities	≤1,000	1,001-3,300	3,301-10,000	10,001 - 1 million[a]	Total[a]	Annualized Costs[b]
System PopulationSize Category:	**≤1,000**	**1,001-3,300**	**3,301-10,000**	**10,001 - 1 million[a]**	**Total[a]**	**Annualized Costs[b]**
Systems Expected to Move Return Location:	**131**	**77**	**71**	**94**	**373**	
Systems Requesting a Waiver:	**33**	**19**	**18**	**23**	**93**	
SYSTEMS						
Submit Alternate Location Requests to State	$7,603	$5,320	$4,872	$11,211	$29,007	
Consultation with State	$1,901	$1,330	$1,218	$2,803	$7,252	
Recordkeeping	$475	$333	$304	$701	$1,813	
Total Cost for Systems	**$9,979**	**$6,983**	**$6,394**	**$14,715**	**$38,071**	**$3,594**
STATES						
Review Recycle Plans, Alternate Location Requests	$6,104	$3,601	$3,297	$4,293	$17,295	
Consult with System	$3,052	$1,800	$1,649	$2,146	$8,647	
Recordkeeping	$763	$450	$412	$537	$2,162	
Total Costs for States	**$9,919**	**$5,851**	**$5,358**	**$6,976**	**$28,104**	**$2,653**
Total System and State Costs					**$66,175**	**$6,246**

Notes:

a. Costs include two plants that belong to systems serving more than 1 million people.

b. All costs are annualized by a capitalization factor (CF) of 0.09439. The CF is calculated using the discount rate (7%) and the number of years of capitalization (20 years).

Appendix E1c
System Reporting Activities and Burden for New Return Location
Alternative R2

Detail of System Activities, System Size: ≤1,000

				Management[a]			Technical[a]			Total Burden	
	Freq.	Hrs./ Freq.	Annual Hours	Hrs.	Rate/ Hour	Cost	Hrs.	Rate/ Hour	Cost	Costs	FTE[b]
Activities											
Submit Alternate Location Requests to State	1	16	16	0	$0.00	$0	16	$14.50	$232	$232	0.01
Consult with State	1	4	4	0	$0.00	$0	4	$14.50	$58	$58	0.00
Recordkeeping	1	1	1	0	$0.00	$0	1	$14.50	$15	$15	0.00
Total Cost per System						**$0**			**$305**	**$305**	**0.01**

Detail of System Activities, System Size: 1,000-3,300

				Management[a]			Technical[a]			Total Burden	
	Freq.	Hrs./ Freq.	Annual Hours	Hrs.	Rate/ Hour	Cost	Hrs.	Rate/ Hour	Cost	Costs	FTE[b]
Activities											
Submit Alternate Location Requests to State	1	16	16	3.2	$28.00	$90	12.8	$14.50	$186	$275	0.01
Consult with State	1	4	4	0.8	$28.00	$22	3.2	$14.50	$46	$69	0.00
Recordkeeping	1	1	1	0.2	$28.00	$6	0.8	$14.50	$12	$17	0.00
Total Cost per System						**$118**			**$244**	**$361**	**0.01**

Detail of System Activities, System Size: 3,300-10,000

Alternative R2

				Management[a]			Technical[a]			Total Burden	
	Freq.	Hrs./ Freq.	Annual Hours	Hrs.	Rate/ Hour	Cost	Hrs.	Rate/ Hour	Cost	Costs	FTE[b]
Activities											
Submit Alternate Location Requests to State	1	16	16	3.2	$28.00	$90	12.8	$14.50	$186	$275	0.01
Consult with State	1	4	4	0.8	$28.00	$22	3.2	$14.50	$46	$69	0.00
Recordkeeping	1	1	1	0.2	$28.00	$6	0.8	$14.50	$12	$17	0.00
Total Cost per System						**$118**			**$244**	**$361**	**0.01**

Detail of System Activities, System Size: 10,000-1 million

Alternative R2

				Management[a]			Technical[a]			Total Burden	
	Freq.	Hrs./ Freq.	Annual Hours	Hrs.	Rate/ Hour	Cost	Hrs.	Rate/ Hour	Cost	Costs	FTE[b]
Activities											
Submit Alternate Location Requests to State	1	16	16	3.2	$40.00	$128	12.8	$28.00	$358	$486	0.01
Consult with State	1	4	4	0.8	$40.00	$32	3.2	$28.00	$90	$122	0.00
Recordkeeping	1	1	1	0.2	$40.00	$8	0.8	$28.00	$22	$30	0.00
Total Cost per System						**$168**			**$470**	**$638**	**0.01**

a. Labor is split between management and technical. Generally, 20% is allocated to management and 80% to technical.

Appendix E-1d
State Reporting Activities for New Return Location

Compliance Activities	Activity Frequency			Management Labor[a]			Technical Labor[a]			Total Burden	
		Hrs./	Annual		Rate/			Rate/			
	Freq.	Freq.	Hours	Hrs.	Hour	Cost	Hrs.	Hour	Cost	Total Cost	FTE[b]
STATES											
Costs per System											
Review Recycle Plans, Alternate Location Requests	1	8	8	1.6	$31.23	$50	6.4	$ 21.29	$136	$186	0.004
Consult with System	1	4	4	0.8	$31.23	$25	3.2	$ 21.29	$68	$93	0.002
Recordkeeping	1	1	1	0.2	$31.23	$6	0.8	$ 21.29	$17	$23	0.0005
Subtotal	93	*Systems*								$303	0.006
Total Recycle Review Costs										**$28,104**	**0.58**
Total Annualized Recycle Review Costs (3%)[c]										**$1,889**	
Total Annualized Recycle Review Costs (7%)[c]										**$2,653**	

Notes:

a. Labor is split between management and technical. Generally, 20% is allocated to management and 80% to technical.

b. Full Time Equivalent (FTE) is based on 2080 hours worked annually.

c. All start-up costs are annualized by a capitalization factor (CF) of 0.06722 or 0.9439. The CF is calculated using the discount rate (3% or 7%) and the number of yea (20 years).

Appendix E-2a
System and State Conventional Filtration Recycle Reporting Costs at 3% Discount Rate, Alternative R2

System Population Size Category:	≤1,000	1,001-3,300	3,301-10,000	10,001 - 1 million[a]	Total[a]	Annualized Costs[b]
Systems Preparing Recycle Reports:	1524	899	823	1075	4321	
Compliance Activities						
SYSTEMS						
Report Recycle Status, Schematic, Flows	$132,578	$92,776	$84,954	$196,043	$506,351	
Collect Additional Recycle Data	$176,770	$123,702	$113,271	$261,391	$675,134	
Recordkeeping	$22,096	$15,463	$14,159	$32,674	$84,392	
Total Costs for Systems	**$331,445**	**$231,940**	**$212,384**	**$490,108**	**$1,265,877**	**$85,092**
STATES						
Review System Submittal	$141,913	$83,719	$76,661	$100,091	$402,384	
Review Additional Data	$70,956	$41,860	$38,330	$50,046	$201,192	
Recordkeeping	$5,913	$3,488	$3,194	$4,170	$16,766	
Total Costs for States	**$218,782**	**$129,067**	**$118,185**	**$154,307**	**$620,342**	**$41,699**
Total System and State Recycle Reporting Costs	**$550,227**	**$361,008**	**$330,569**	**$644,415**	**$1,886,219**	**$126,792**

Notes:
a. Costs include three plants that belong to systems serving more than 1 million people.
b. All costs are annualized by a capitalization factor (CF) of 0.06722. The CF is calculated using the discount rate (3%) and the number of years of capitalization (20 years).

Appendix E-2b
System and State Conventional Filtration Recycle Reporting Costs at 7% Discount Rate, Alternative R2

	System Population Size Category:	≤1,000	1,001-3,300	3,301-10,000	10,001 - 1 million[a]	Total[a]	Annualized Costs[b]
	Systems Preparing Recycle Reports:	1524	899	823	1075	4321	
Compliance Activities							
SYSTEMS							
Report Recycle Status, Schematic, Flows		$132,578	$92,776	$84,954	$196,043	$506,351	
Collect Additional Recycle Data		$176,770	$123,702	$113,271	$261,391	$675,134	
Recordkeeping		$22,096	$15,463	$14,159	$32,674	$84,392	
Total Costs for Systems		**$331,445**	**$231,940**	**$212,384**	**$490,108**	**$1,265,877**	**$119,486**
STATES							
Review System Submittal		$141,913	$83,719	$76,661	$100,091	$402,384	
Review Additional Data		$70,956	$41,860	$38,330	$50,046	$201,192	
Recordkeeping		$5,913	$3,488	$3,194	$4,170	$16,766	
Total Costs for States		**$218,782**	**$129,067**	**$118,185**	**$154,307**	**$620,342**	**$58,554**
Total System and State Recycle Reporting Costs		**$550,227**	**$361,008**	**$330,569**	**$644,415**	**$1,886,219**	**$178,040**

Notes:
a. Costs include three plants that belong to systems serving more than 1 million people.
b. All costs are annualized by a capitalization factor (CF) of 0.09439. The CF is calculated using the discount rate (7%) and the number of years of capitalization (20 years).

Appendix E-2c
System Conventional Filtration Recycle Reporting Activities and Burden
Alternative R2

Detail of System Activities, System Size: <1,000

				Management[a]			Technical[a]			Total
	Freq.	Hrs./ Freq.	Total Hours	Hrs.	Rate/ Hour	Cost	Hrs.	Rate/ Hour	Cost	Costs
Recycle Reporting Activiites										
Report Recycle Status, Schematic, Flows	1	6	6	0	$0.00	$0	6	$14.50	$87	$87
Collect Additional Recycle Data	1	8	8	0	$0.00	$0	8	$14.50	$116	$116
Recordkeeping	1	1	1	0	$0.00	$0	1	$14.50	$15	$15
Total Cost per System						**$0**			**$218**	**$218**

Detail of System Activities, System Size: 1,001-3,300

				Management[a]			Technical[a]			Total
	Freq.	Hrs./ Freq.	Total Hours	Hrs.	Rate/ Hour	Cost	Hrs.	Rate/ Hour	Cost	Costs
Recycle Reporting Activiites										
Report Recycle Status, Schematic, Flows	1	6	6	1.2	$28.00	$34	4.8	$14.50	$70	$103
Collect Additional Recycle Data	1	8	8	1.6	$28.00	$45	6.4	$14.50	$93	$138
Recordkeeping	1	1	1	0.2	$28.00	$6	0.8	$14.50	$12	$17
Total Cost per System						**$84**			**$174**	**$258**

Detail of System Activities, System Size: 3,301-10,000

				Management[a]			Technical[a]			Total
	Freq.	Hrs./ Freq.	Total Hours	Hrs.	Rate/ Hour	Cost	Hrs.	Rate/ Hour	Cost	Costs
Recycle Reporting Activiites										
Report Recycle Status, Schematic, Flows	1	6	6	1.2	$28.00	$34	4.8	$14.50	$70	$103
Collect Additional Recycle Data	1	8	8	1.6	$28.00	$45	6.4	$14.50	$93	$138
Recordkeeping	1	1	1	0.2	$28.00	$6	0.8	$14.50	$12	$17
Total Cost per System						**$84**			**$174**	**$258**

Detail of System Activities, System Size: 10,001-1 million

				Management[a]			Technical[a]			Total
	Freq.	Hrs./ Freq.	Total Hours	Hrs.	Rate/ Hour	Cost	Hrs.	Rate/ Hour	Cost	Costs
Recycle Reporting Activiites										
Report Recycle Status, Schematic, Flows	1	6	6	1.2	$40.00	$48	4.8	$28.00	$134	$182
Collect Additional Recycle Data	1	8	8	1.6	$40.00	$64	6.4	$28.00	$179	$243
Recordkeeping	1	1	1	0.2	$40.00	$8	0.8	$28.00	$22	$30
Total Cost per System						**$120**			**$336**	**$456**

a. Labor is split between management and technical. Generally, 20% is allocated to management and 80% to technical.

Appendix E-2d
State Conventional Filtration Recycle Reporting Activities and Burden, Alternative R2

Compliance Activities	Activity Frequency			Management Labor[a]			Technical Labor[a]			Total Burden	
	Freq.	Hrs./ Freq.	Annual Hours	Hrs.	Rate/ Hour	Cost	Hrs.	Rate/ Hour	Cost	Total Cost	FTE[b]
Recycle Reporting Costs per System											
Review System Submittal	1	4	4	0.8	$31.23	$25	3.2	$ 21.29	$68	$93	0.002
Review Additional Data	1	2	2	0.4	$31.23	$12	1.6	$ 21.29	$34	$47	0.001
Recordkeeping	1	0.17	0.17	0.03	$31.23	$1	0.13	$ 21.29	$3	$4	0.000
Subtotal	*4321*	*Systems*								*$144*	0.003
Total Recycle Reporting Costs										**$620,342**	**12.46**
Total Annualized Recycle Reporting Costs (3%)c										**$41,699**	
Total Annualized Recycle Reporting Costs (7%)c										**$58,554**	

Notes:

a. Labor is split between management and technical. Generally, 20% is allocated to management and 80% to technical.

b. Full Time Equivalent (FTE) is based on 2080 hours worked annually.

c. All start-up costs are annualized by a capitalization factor (CF) of 0.06722 or 0.9439. The CF is calculated using the discount rate (3% or 7%) and the number of years (20 years).

Appendix E-3a

System and State Direct Filtration Recycle Reporting Costs at 3% Discount Rate, Alternative R2

System Population Size Category:	≤1,000	1,001-3,300	3,301-10,000	10,001 - 1 million[a]	Total[a]	Annualized Costs[c]
Direct Filtration Systems Reporting Recycling Practices:	115	68	62	85	329	
Compliance Activities						
SYSTEMS						
Report Recycle Status, Schematic, Flows	$9,979	$6,983	$6,394	$15,444	$38,801	
Collect Additional Recycle Data	$13,305	$9,311	$8,526	$20,592	$51,734	
Recordkeeping	$1,663	$1,164	$1,066	$2,574	$6,467	
Total Costs for Systems	**$24,947**	**$17,458**	**$15,986**	**$38,611**	**$97,002**	**$6,520**
STATES						
Review System Submittal	$10,682	$6,301	$5,770	$7,885	$30,638	
Review Additional Data	$5,341	$3,151	$2,885	$3,943	$15,319	
Recordkeeping	$445	$263	$240	$329	$1,277	
Total Costs for States	**$16,467**	**$9,715**	**$8,896**	**$12,156**	**$47,234**	**$3,175**
Total System and State Recycle Reporting Costs	**$41,415**	**$27,173**	**$24,882**	**$50,767**	**$144,236**	**$9,696**

Notes:
a. Costs include three plants that belong to systems serving more than 1 million people.
b. All costs are annualized by a capitalization factor (CF) of 0.06722. The CF is calculated using the discount rate (3%) and the number of years of capitalization (20 years).

Appendix E-3b

System and State Direct Filtration Recycle Reporting Costs at 7% Discount Rate, Alternative R2

System Population Size Category:	≤1,000	1,001-3,300	3,301-10,000	10,001 - 1 million[a]	Total[a]	Annualized Costs[c]
Direct Filtration Systems Reporting Recycling Practices:	115	68	62	85	329	
Compliance Activities						
SYSTEMS						
Report Recycle Status, Schematic, Flows	$9,979	$6,983	$6,394	$15,444	$38,801	
Collect Additional Recycle Data	$13,305	$9,311	$8,526	$20,592	$51,734	
Recordkeeping	$1,663	$1,164	$1,066	$2,574	$6,467	
Total Costs for Systems	**$24,947**	**$17,458**	**$15,986**	**$38,611**	**$97,002**	**$9,156**
STATES						
Review System Submittal	$10,682	$6,301	$5,770	$7,885	$30,638	
Review Additional Data	$5,341	$3,151	$2,885	$3,943	$15,319	
Recordkeeping	$445	$263	$240	$329	$1,277	
Total Costs for States	**$16,467**	**$9,715**	**$8,896**	**$12,156**	**$47,234**	**$4,458**
Total System and State Recycle Reporting Costs	**$41,415**	**$27,173**	**$24,882**	**$50,767**	**$144,236**	**$13,614**

Notes:

a. Costs include three plants that belong to systems serving more than 1 million people.

b. All costs are annualized by a capitalization factor (CF) of 0.09439. The CF is calculated using the discount rate (7%) and the number of years of capitalization (20 years).

Appendix E3c

System Direct Filtration Recycle Reporting Activities and Burden

Alternative R2

Detail of System Activities, System Size: <1,000

	Freq.	Hrs./ Freq.	Annual Hours	Management [a] Hrs.	Management [a] Rate/ Hour	Management [a] Cost	Technical [a] Hrs.	Technical [a] Rate/ Hour	Technical [a] Cost	Total Burden Costs	Total Burden FTE[b]
Recycle Reporting Activiites											
Report Recycle Status, Schematic, Flows	1	6	6	0	$0.00	$0	6	$14.50	$87	$87	0.00
Collect Additional Recycle Data	1	8	8	0	$0.00	$0	8	$14.50	$116	$116	0.00
Recordkeeping	1	1	1	0	$0.00	$0	1	$14.50	$15	$15	0.00
Total Cost per System						**$0**			**$218**	**$218**	**0.01**

Detail of System Activities, System Size: 1,000-3,300

Alternative R2

	Freq.	Hrs./ Freq.	Annual Hours	Management [a] Hrs.	Management [a] Rate/ Hour	Management [a] Cost	Technical [a] Hrs.	Technical [a] Rate/ Hour	Technical [a] Cost	Total Burden Costs	Total Burden FTE[b]
Recycle Reporting Activiites											
Report Recycle Status, Schematic, Flows	1	6	6	1.2	$28.00	$34	4.8	$14.50	$70	$103	0.00
Collect Additional Recycle Data	1	8	8	1.6	$28.00	$45	6.4	$14.50	$93	$138	0.00
Recordkeeping	1	1	1	0.2	$28.00	$6	0.8	$14.50	$12	$17	0.00
Total Cost per System						**$84**			**$174**	**$258**	**0.01**

Detail of System Activities, System Size: 3,300-10,000

Alternative R2

	Freq.	Hrs./ Freq.	Annual Hours	Management [a] Hrs.	Management [a] Rate/ Hour	Management [a] Cost	Technical [a] Hrs.	Technical [a] Rate/ Hour	Technical [a] Cost	Total Burden Costs	Total Burden FTE[b]
Recycle Reporting Activiites											
Report Recycle Status, Schematic, Flows	1	6	6	1.2	$28.00	$34	4.8	$14.50	$70	$103	0.00
Collect Additional Recycle Data	1	8	8	1.6	$28.00	$45	6.4	$14.50	$93	$138	0.00
Recordkeeping	1	1	1	0.2	$28.00	$6	0.8	$14.50	$12	$17	0.00
Total Cost per System						**$84**			**$174**	**$258**	**0.01**

Detail of System Activities, System Size: 10,000-1 million

Alternative R2

	Freq.	Hrs./ Freq.	Annual Hours	Management [a] Hrs.	Management [a] Rate/ Hour	Management [a] Cost	Technical [a] Hrs.	Technical [a] Rate/ Hour	Technical [a] Cost	Total Burden Costs	Total Burden FTE[b]
Recycle Reporting Activiites											
Report Recycle Status, Schematic, Flows	1	6	6	1.2	$40.00	$48	4.8	$28.00	$134	$182	0.00
Collect Additional Recycle Data	1	8	8	1.6	$40.00	$64	6.4	$28.00	$179	$243	0.00
Recordkeeping	1	1	1	0.2	$40.00	$8	0.8	$28.00	$22	$30	0.00
Total Cost per System						**$120**			**$336**	**$456**	**0.01**

a. Labor is split between management and technical. Generally, 20% is allocated to management and 80% to technical.

Appendix E-3d
State Direct Filtration Recycle Reporting Review Activities and Burden, Alternative R2

Compliance Activities	Activity Frequency			Management Labor[a]			Technical Labor[a]			Total Burden	
	Freq.	Hrs./ Freq.	Annual Hours	Hrs.	Rate/ Hour	Cost	Hrs.	Rate/ Hour	Cost	Total Cost	FTE[b]
Recycle Reporting Costs per System											
Review System Submittal	1	4	4	0.8	$31.23	$25	3.2	$ 21.29	$68	$93	0.002
Review Additional Data	1	2	2	0.4	$31.23	$12	1.6	$ 21.29	$34	$47	0.001
Recordkeeping	1	0.17	0.17	0.03	$31.23	$1	0.13	$ 21.29	$3	$4	0.000
Subtotal	*329*	*Systems*								*$144*	0.003
Total Recycle Reporting Costs										**$47,234**	**0.95**
Total Annualized Recycle Reporting Costs (3%)[c]										**$3,175**	
Total Annualized Recycle Reporting Costs (7%)[c]										**$4,458**	

Notes:

a. Labor is split between management and technical. Generally, 20% is allocated to management and 80% to technical.

b. Full Time Equivalent (FTE) is based on 2080 hours worked annually.

c. All start-up costs are annualized by a capitalization factor (CF) of 0.06722 or 0.9439. The CF is calculated using the discount rate (3% or 7%) and the number of yea
(20 years), and current value of money ($1).

Appendix E-4
State and System Start-Up Activities

Compliance Activities	Activity Frequency: Freq.	Hrs./ Freq.	Annual Hours	Management Labor[a]: Hrs.	Rate/ Hour	Cost	Technical Labor[a]: Hrs.	Rate/ Hour	Cost	Total Burden: Total Cost	FTE[b]
STATES											
Start-up Costs											
Reg Adoption/Program Development	1	200	200	40	$31.23	$1,249	160	$ 21.29	$3,407	$4,656	0.10
Miscellaneous training	1	60	60	12	$31.23	$375	48	$ 21.29	$1,022	$1,397	0.03
Subtotal	*56 States*									**$6,053**	0.13

SYSTEMS

Detail of System Activities, System Size: <u><</u>1,000

	Freq.	Hrs./ Freq.	Annual Hours	Management[a,b]: Hrs.	Rate/ Hour	Cost	Technical[a]: Hrs.	Rate/ Hour	Cost	Total Burden: Costs	FTE[b]
Start-up Cost per System											
Read & Understand Rule	1	8	8	0	$0.00	$0	8	$14.50	$116	$116	0.00
Mobilization/Planning	1	16	16	0	$0.00	$0	16	$14.50	$232	$232	0.01
Subtotal	1639 *Systems*									**$348**	0.01

Detail of System Activities, System Size: 1,000-3,300

Alternative R2

	Freq.	Hrs./ Freq.	Annual Hours	Management[a,b]: Hrs.	Rate/ Hour	Cost	Technical[a]: Hrs.	Rate/ Hour	Cost	Total Burden: Costs	FTE[b]
Start-up Cost per System											
Read & Understand Rule	1	8	8	1.6	$28.00	$45	6.4	$14.50	$93	$138	0.00
Mobilization/Planning	1	16	16	3.2	$28.00	$90	12.8	$14.50	$186	$275	0.01
Subtotal	967 *Systems*									**$413**	0.01

Detail of System Activities, System Size: 3,300-10,000

Alternative R2

	Freq.	Hrs./ Freq.	Annual Hours	Management[a,b]: Hrs.	Rate/ Hour	Cost	Technical[a]: Hrs.	Rate/ Hour	Cost	Total Burden: Costs	FTE[b]
Start-up Cost per System											
Read & Understand Rule	1	8	8	1.6	$28.00	$45	6.4	$14.50	$93	$138	0.00
Mobilization/Planning	1	16	16	3.2	$28.00	$90	12.8	$14.50	$186	$275	0.01
Subtotal	885 *Systems*									**$413**	0.01

Detail of System Activities, System Size: 10,000-1 million

Alternative R2

	Freq.	Hrs./ Freq.	Annual Hours	Management[a,b]: Hrs.	Rate/ Hour	Cost	Technical[a]: Hrs.	Rate/ Hour	Cost	Total Burden: Costs	FTE[b]
Start-up Cost per System											
Read & Understand Rule	1	8	8	1.6	$40.00	$64	6.4	$28.00	$179	$243	0.00
Mobilization/Planning	1	16	16	3.2	$40.00	$128	12.8	$28.00	$358	$486	0.01
Subtotal	1159 *Systems*									**$730**	0.01

Total State Start-Up Costs	*56 States*	**$338,978**	7.00
Total System Start-Up Costs	*4650 Systems*	**$2,180,606**	53.65

State Annualized Start-Up Costs (3%)[c]	**$22,786**	
State Annualized Start-Up Costs (7%)[c]	**$31,996**	
System Annualized Start-Up Costs (3%)[c]	**$146,580**	
System Annualized Start-Up Costs (7%)[c]	**$205,827**	
Total Start Up Costs	**$2,519,584**	**53.78**
Total Annualized Start-Up Costs (3%)[c]	**$169,366**	
Total Annualized Start-Up Costs (7%)[c]	**$237,824**	

Notes:

a. Labor rates include a load facter of 1.4.

b. Full Time Equivalent (FTE) is based on 2080 hours worked annually.

c. All start-up costs are annualized by a capitalization factor (CF) of 0.06722 or 0.9439. The CF is calculated using the discount rate (3% or 7%) and the number of years of capitalization (20 years).

d. Number of conventional filtration systems expected to require different recycle return location.

Appendix F

Calculation of Average Household Costs

Constants and Assumptions

Households*	92,228,739
Percent that must meet conventional or direct reporting requirements only.	90.00%
Percent that must meet conventional or direct reporting requirements plus apply for a waiver.	2.00%
Percent that must meet conventional OR direct reporting requirements plus move recycle return location.	8.00%

Percentages of Affected System Processes

System Size	Filtration	Direct/Conventional	Recycle
0-100	78.50%	38.00%	60.00%
101-500	71.00%	55.00%	60.00%
501-1000	79.30%	73.00%	60.00%
1,000-3,300	81.70%	77.00%	60.00%
3.300 - 10,000	86.50%	90.00%	60.00%
10,000 - 50,000	96.30%	92.00%	60.00%
50,000-100,000	88.00%	98.00%	60.00%
100,000-1,000,000	93.40%	92.00%	60.00%
1 mill+	93.40%	92.00%	60.00%

* Source: U.S. Census Data

System Population Data by Size Category and Water Source*

System Size	Surface Water	GWUDI	GW	All Systems
0-100	55,600	5,850	859,777	921,227
101-500	544,621	25,827	3,741,017	4,311,465
501-1000	889,855	31,594	3,457,163	4,378,612
1,000-3,300	4,679,394	118,461	10,631,422	15,429,277
3.300 - 10,000	10,770,339	225,641	14,095,015	25,090,995
10,000 - 50,000	36,496,803	322,772	25,004,779	61,824,354
50,000-100,000	20,440,370	60,000	8,609,455	29,109,825
100,000-1,000,000	64,955,183	420,000	14,575,556	79,950,739
1 mill+	28,658,586	0	2,855,494	31,514,080
Total	167,490,751	1,210,145	83,829,678	252,530,574

* Source: Drinking Water Baseline Handbook

Household Calculations for Surface and GWUDI Systems that Recycle by System Size

System Size	Surface Water Percent	Households	GWUDI Percent	Households	GW Percent	Households	All Systems Percent	Households	Affected SW and GWUDI Systems (Recycle, Filtration, and Direct/Conventional) Households
0-100	0.02%	20,306	0.00%	2,137	0.34%	314,006	0.36%	336,449	4,017
101-500	0.22%	198,905	0.01%	9,432	1.48%	1,366,287	1.71%	1,574,625	48,814
501-1000	0.35%	324,991	0.01%	11,539	1.37%	1,262,619	1.73%	1,599,148	116,888
1,000-3,300	1.85%	1,708,999	0.05%	43,264	4.21%	3,882,788	6.11%	5,635,051	661,399
3.300 - 10,000	4.26%	3,933,523	0.09%	82,408	5.58%	5,147,755	9.94%	9,163,686	1,875,841
10,000 - 50,000	14.45%	13,329,293	0.13%	117,882	9.90%	9,132,198	24.48%	22,579,374	7,148,196
50,000-100,000	8.09%	7,465,193	0.02%	21,913	3.41%	3,144,329	11.53%	10,631,435	3,874,128
100,000-1,000,000	25.72%	23,722,809	0.17%	153,392	5.77%	5,323,257	31.66%	29,199,458	12,309,805
1 mill+	11.35%	10,466,635	0.00%	0	1.13%	1,042,878	12.48%	11,509,513	5,396,262
Total	66.32%	61,170,656	0.48%	441,967	33.20%	30,616,117	100%	92,228,739	31,435,350

Annual Consumption by Regulatory Outcome and System Size

	Households				Household Consumption (kgal/year)			
System Size	**Total**	**Report Only**	**Report plus Waiver**	**Report and Move**	**Average Annual***	**Report Only (Total)**	**Report plus Waiver (Total)**	**Report and Move (Total)**
0-100	4,017	3,615	80	321	123	444,658	9,881	39,525
101-500	48,814	43,932	976	3,905	99	4,349,290	96,651	386,604
501-1000	116,888	105,199	2,338	9,351	104	10,940,741	243,128	972,510
1,000-3,300	661,399	595,259	13,228	52,912	87	51,787,532	1,150,834	4,603,336
3.300 - 10,000	1,875,841	1,688,257	37,517	150,067	97	163,760,953	3,639,132	14,556,529
10,000 - 50,000	7,148,196	6,433,376	142,964	571,856	109	701,238,010	15,583,067	62,332,268
50,000-100,000	3,874,128	3,486,715	77,483	309,930	119	414,919,144	9,220,425	36,881,702
100,000-1,000,000	12,309,805	11,078,825	246,196	984,784	125	1,384,853,072	30,774,513	123,098,051
1 mill+	5,396,262	4,856,636	107,925	431,701	125	607,079,461	13,490,655	53,962,619
Total	31,435,350	28,291,815	628,707	2,514,828		3,339,372,862	74,208,286	296,833,143

*** Source: Drinking Water Baseline Handbook**

Annual Costs by Regulatory Outcome and System Size

System Size	Report (Cost/kgal)	Report plus Waiver (Cost/kgal)	Report and Move (Cost/kgal)	Report (Cost/Household)	Report plus Waiver (Cost/Household)	Report and Move (Cost/Household)
0-100	$0.2232	$0.3148	$0.7916	$27.46	$38.72	$97.37
101-500	$0.0563	$0.0795	$0.2241	$5.58	$7.87	$22.18
501-1000	$0.0207	$0.0292	$0.0900	$2.16	$3.04	$9.36
1,000-3,300	$0.0086	$0.0122	$0.0400	$0.75	$1.06	$3.48
3.300 - 10,000	$0.0025	$0.0035	$0.0175	$0.24	$0.34	$1.70
10,000 - 50,000	$0.0011	$0.0015	$0.0123	$0.12	$0.16	$1.34
50,000-100,000	$0.0003	$0.0005	$0.0092	$0.04	$0.05	$1.10
100,000-1,000,000	$0.0001	$0.0001	$0.0120	$0.01	$0.01	$1.49
1 mill+	$0.0001	$0.0001	$0.0120	$0.01	$0.01	$1.49

Appendix G

Baseline Data

Population Categories **System Type**	**0-100**	**101-500**	**501-1000**	**1,001-3,300**	**3,301 - 9,999**	**10,001 - 50,000**	**50,001-100,000**	**100,001-1M**	**1 mill+**	**Total <10,000**	**Total >10K**	**Total**
Systems												
Surface Water												
Community	996	1,899	1,178	2,356	1,802	1,592	299	259	13	8,231	2,163	10,394
TNC	1,308	491	85	58	28	7	3	0	0	1,970	10	1,980
NTNC	261	284	102	79	22	4	1	1	0	748	6	754
Total	2,565	2,674	1,365	2,493	1,852	1,603	303	260	13	10,949	2,179	13,128
GWUDI												
Community	96	104	42	64	42	15	1	2	0	348	18	366
TNC	55	26	3	3	0	0	0	0	0	87	0	87
NTNC	10	11	4	1	1	0	0	0	0	27	0	27
Total	161	141	49	68	43	15	1	2	0	462	18	480
All Systems												
Community	1,092	2,003	1,220	2,420	1,844	1,607	300	261	0	8,579	2,168	10,760
TNC	1,363	517	88	61	28	7	3	0	0	2,057	10	2,067
NTNC	271	295	106	80	23	4	1	1	0	775	6	781
Total	2,726	2,815	1,414	2,561	1,895	1,618	304	262	0	11,411	2,184	13,608
Population												
Surface Water												
Community	55,600	544,621	889,855	4,679,394	10,770,339	36,496,803	20,440,370	64,955,183	28,658,586	16,939,809	150,550,942	167,490,751
TNC	57,445	119,180	64,476	102,909	155,833	148,030	179,240	0	0	499,843	327,270	827,113
NTNC	13,339	76,151	77,693	142,987	119,104	118,000	93,204	152,079	0	429,274	363,283	792,557
Total	126,384	739,952	1,032,024	4,925,290	11,045,276	36,762,833	20,712,814	65,107,262	28,658,586	17,868,926	151,241,495	169,110,421
GWUDI												
Community	5,850	25,827	31,594	118,461	225,641	322,772	60,000	420,000	0	407,373	802,772	1,210,145
TNC	2,470	5,002	1,935	6,151	0	0	0	0	0	15,558	0	15,558
NTNC	434	2,283	3,003	1,537	5,700	0	0	0	0	12,957	0	12,957
Total	8,754	33,112	36,532	126,149	231,341	322,772	60,000	420,000	0	435,888	802,772	1,238,660
All Systems												
Community	61,450	570,448	921,449	4,797,855	10,995,980	36,819,575	20,500,370	65,375,183	28,658,586	17,347,182	151,353,714	168,700,896
TNC	59,915	124,182	66,411	109,060	155,833	148,030	544	0	0	515,401	327,270	842,671
NTNC	13,773	78,434	80,696	144,524	124,804	118,000	93,204	152,079	0	442,231	363,283	805,514
Total	135,138	773,064	1,068,556	5,051,439	11,276,617	37,085,605	20,772,814	65,527,262	28,658,586	18,304,814	152,044,267	170,349,081
System Provides Filtration	78.5%	71.0%	79.3%	81.7%	86.5%	96.3%	88.0%	93.4%	Note 1			
Number of Systems												
Community	857	1,422	967	1,977	1,595	1,548	264	244	N/A	6,819	2,055	8,874
TNC	1,070	367	70	50	24	7	3	0	N/A	1,581	9	1,590
NTNC	213	209	84	65	20	4	1	1	N/A	591	6	597
Total	2,140	1,999	1,121	2,092	1,639	1,558	268	245	N/A	8,991	2,070	11,062
Sum of Population Served												
Community	48,238	405,018	730,709	3,919,848	9,511,523	35,457,251	18,040,326	61,060,421	N/A	14,615,335.6	114,557,997.2	129,173,333
TNC	47,033	88,169	52,664	89,102	134,796	142,553	479	0	N/A	411,764.0	143,031.6	554,796
NTNC	10,812	55,688	63,992	118,076	107,955	113,634	82,020	142,042	N/A	356,523.4	337,695.3	694,219
Total	106,083	548,875	847,365	4,127,026	9,754,274	35,713,438	18,122,824	61,202,463	N/A	15,383,623.0	115,038,724.2	130,422,347

Population Categories System Type	0-100	101-500	501-1000	1,001-3,300	3,301 - 9,999	10,001 - 50,000	50,001-100,000	100,001-1M	1 mill+	Total <10,000	Total >10K	Total
Direct/Conventional	38.0%	55.0%	73.0%	77.0%	90.0%	92.0%	98.0%	92.0%	Note 1			
Number of Systems												
Community	325.7	782.2	706.2	1,522.4	1,435.6	1,423.7	258.7	224.3	N/A	4,772.1	1,906.7	6,679
TNC	406.6	201.9	50.9	38.4	21.8	6.2	2.6	-	N/A	719.6	8.8	728
NTNC	80.8	115.2	61.4	50.3	17.9	3.5	0.9	0.9	N/A	325.6	5.3	331
Total	813.2	1,099.3	818.6	1,611.1	1,475.3	1,433.5	262.2	225.1	N/A	5,817.3	1,920.8	7,738
Sum of Population Served												
Community	18,330.5	222,759.9	533,417.6	3,018,282.6	8,560,370.4	32,620,670.7	17,679,519.1	56,175,587.2	N/A	12,353,161.1	106,475,777.0	118,828,938
TNC	17,872.6	48,493.1	38,444.7	68,608.6	121,316.0	131,148.7	469.1	-	N/A	294,734.9	131,617.8	426,353
NTNC	4,108.5	30,628.5	46,714.1	90,918.6	97,159.9	104,543.3	80,379.1	130,678.4	N/A	269,529.6	315,600.9	585,130
Total	40,311.7	301,881.5	618,576.4	3,177,809.8	8,778,846.3	32,856,362.6	17,760,367.4	56,306,265.7	N/A	12,917,425.6	106,922,995.7	119,840,421
Systems That Recycle	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	Note 1			
Number of Systems												
Community	195.4	469.3	423.7	913.4	861.3	854.2	155.2	134.6	7.0	2,863.3	1,151.0	4,014
TNC	243.9	121.1	30.6	23.0	13.1	3.7	1.6	-	-	431.8	5.3	437
NTNC	48.5	69.1	36.8	30.2	10.7	2.1	0.5	0.5	-	195.4	3.2	199
Total	487.9	659.6	491.1	966.7	885.2	860.1	157.3	135.1	7.0	3,490.4	1,159.5	4,650
Sum of Population Served												
Community	10,998.3	133,656.0	320,050.6	1,810,969.6	5,136,222.3	19,572,402.4	10,607,711.5	33,705,352.3	715,053.6	7,411,896.7	64,600,519.8	72,012,416
TNC	10,723.6	29,095.8	23,066.8	41,165.1	72,789.6	78,689.2	281.5	-	-	176,841.0	78,970.7	255,812
NTNC	2,465.1	18,377.1	28,028.5	54,551.2	58,295.9	62,726.0	48,227.5	78,407.1	-	161,717.8	189,360.5	351,078
Total	24,187.0	181,128.9	371,145.8	1,906,685.9	5,267,307.8	19,713,817.6	10,656,220.4	33,783,759.4	715,053.6	7,750,455.4	64,868,851.0	72,619,306
Recycle Does Not Receive All Filtration Steps	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	Note 1			
Number of Systems												
Community	19.5	46.9	42.4	91.3	86.1	85.4	15.5	13.5	2.0	286.3	116.4	403
TNC	24.4	12.1	3.1	2.3	1.3	0.4	0.2	-	-	43.2	0.5	44
NTNC	4.9	6.9	3.7	3.0	1.1	0.2	0.1	0.1	-	19.5	0.3	20
Total	48.8	66.0	49.1	96.7	88.5	86.0	15.7	13.5	2.0	349.0	117.2	466
Sum of Population Served												
Community	1,099.8	13,365.6	32,005.1	181,097.0	513,622.2	1,957,240.2	1,060,771.1	3,370,535.2	46,318.9	741,189.7	6,434,865.5	7,176,055
TNC	1,072.4	2,909.6	2,306.7	4,116.5	7,279.0	7,868.9	28.1	-	-	17,684.1	7,897.1	25,581
NTNC	246.5	1,837.7	2,802.8	5,455.1	5,829.6	6,272.6	4,822.7	7,840.7	-	16,171.8	18,936.1	35,108
Total	2,418.7	18,112.9	37,114.6	190,668.6	526,730.8	1,971,381.8	1,065,622.0	3,378,375.9	46,318.9	775,045.5	6,461,698.6	7,236,744
System Will Move Recycle Location	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	Note 1			
Number of Systems												
Community	14.5	34.9	31.5	68.0	64.1	63.6	11.5	10.0	2.0	213.0	87.1	300
TNC	18.1	9.0	2.3	1.7	1.0	0.3	0.1	-	-	32.1	0.4	33
NTNC	3.6	5.1	2.7	2.2	0.8	0.2	0.0	0.0	-	14.5	0.2	15
Total	36.3	49.1	36.5	71.9	65.9	64.0	11.7	10.0	2.0	259.7	87.7	347
Sum of Population Served												
Community	818.3	9,944.0	23,811.8	134,736.1	382,134.9	1,456,186.7	789,213.7	2,507,678.2	46,318.9	551,445.1	4,799,397.6	5,350,843
TNC	797.8	2,164.7	1,716.2	3,062.7	5,415.5	5,854.5	20.9	-	-	13,157.0	5,875.4	19,032
NTNC	183.4	1,367.3	2,085.3	4,058.6	4,337.2	4,666.8	3,588.1	5,833.5	-	12,031.8	14,088.4	26,120
Total	1,799.5	13,476.0	27,613.2	141,857.4	391,887.7	1,466,708.0	792,822.8	2,513,511.7	46,318.9	576,633.9	4,819,361.4	5,395,995

Population Categories												
System Type	**0-100**	**101-500**	**501-1000**	**1,001-3,300**	**3,301 - 9,999**	**10,001 - 50,000**	**50,001-100,000**	**100,001-1M**	**1 mill+**	**Total <10,000**	**Total >10K**	**Total**
System Will Request and Obtain Waiver	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	Note 1			
Number of Systems												
Community	3.6	8.7	7.9	17.0	16.0	15.9	2.9	2.5	N/A	53.3	21.3	75
TNC	4.5	2.3	0.6	0.4	0.2	0.1	0.0	-	N/A	8.0	0.1	8
NTNC	0.9	1.3	0.7	0.6	0.2	0.0	0.0	0.0	N/A	3.6	0.1	4
Total	9.1	12.3	9.1	18.0	16.5	16.0	2.9	2.5	N/A	64.9	21.4	86
Sum of Population Served												
Community	204.6	2,486.0	5,952.9	33,684.0	95,533.7	364,046.7	197,303.4	626,919.6	N/A	137,861.3	1,188,269.7	1,326,131
TNC	199.5	541.2	429.0	765.7	1,353.9	1,463.6	5.2	-	N/A	3,289.2	1,468.9	4,758
NTNC	45.9	341.8	521.3	1,014.7	1,084.3	1,166.7	897.0	1,458.4	N/A	3,008.0	3,522.1	6,530
Total	449.9	3,369.0	6,903.3	35,464.4	97,971.9	366,677.0	198,205.7	628,377.9	N/A	144,158.5	1,193,260.6	1,337,419
Conventional Filtration	93.0%	93.0%	93.0%	93.0%	93.0%	93.0%	93.0%	93.0%	Note 1			
Community	181.8	436.5	394.1	849.5	801.0	794.4	144.4	125.1	3.0	2,662.8	1,067.0	3,730
TNC	226.9	112.7	28.4	21.4	12.2	3.5	1.4	-	-	401.5	4.9	406
NTNC	45.1	64.3	34.2	28.1	10.0	2.0	0.5	0.5	-	181.7	2.9	185
Total	453.7	613.4	456.8	899.0	823.2	799.9	146.3	125.6	3.0	3,246.1	1,074.8	4,321
												-
Sum of Population Served												-
Community	10,228.4	124,300.0	297,647.0	1,684,201.7	4,776,686.7	18,202,334.2	9,865,171.7	31,345,977.7	69,478.3	6,893,063.9	59,482,961.9	66,376,026
TNC	9,972.9	27,059.1	21,452.1	38,283.6	67,694.3	73,181.0	261.8	-	-	164,462.1	73,442.7	237,905
NTNC	2,292.5	17,090.7	26,066.5	50,732.6	54,215.2	58,335.2	44,851.6	72,918.6	-	150,397.5	176,105.3	326,503
Total	22,493.9	168,449.9	345,165.6	1,773,217.8	4,898,596.3	18,333,850.3	9,910,285.0	31,418,896.3	69,478.3	7,207,923.5	59,732,509.9	66,940,433
Direct Filtration	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	Note 1			
Community	13.7	32.9	29.7	63.9	60.3	59.8	10.9	9.4	4.0	200.4	84.1	285
TNC	17.1	8.5	2.1	1.6	0.9	0.3	0.1	-	-	30.2	0.4	31
NTNC	3.4	4.8	2.6	2.1	0.8	0.1	0.0	0.0	-	13.7	0.2	14
Total	34.2	46.2	34.4	67.7	62.0	60.2	11.0	9.5	4.0	244.3	84.7	329
Sum of Population Served												
Community	769.9	9,355.9	22,403.5	126,767.9	359,535.6	1,370,068.2	742,539.8	2,359,374.7	645,575.3	518,832.8	5,117,557.9	5,636,391
TNC	750.7	2,036.7	1,614.7	2,881.6	5,095.3	5,508.2	19.7	-	-	12,378.9	5,527.9	17,907
NTNC	172.6	1,286.4	1,962.0	3,818.6	4,080.7	4,390.8	3,375.9	5,488.5	-	11,320.2	13,255.2	24,575
Total	1,693.1	12,679.0	25,980.2	133,468.0	368,711.5	1,379,967.2	745,935.4	2,364,863.2	645,575	542,531.9	5,136,341.1	5,678,873

Note 1: Calculations for systems serving >1 million persons are based on a separate analysis of individual plants within those systems. See Section 4.3.4 of the RIA for a detailed explanation of this process.

Appendix H

Costs and Technologies for the Filter Backwash Recycling Rule

Filter Backwash Recycling Rule: Costs and Technologies

The purpose of this appendix is to describe, in detail, the cost estimating approach for recycle process modifications that may be required in order to comply with the Filter Backwash Recycling Rule (FBRR). EPA developed provisions requiring systems that recycle filter backwash water, sludge thickener supernatant, and liquids from dewatering processes to return these flows through the processes of a system's existing conventional or direct filtration (as defined in 40 CFR, Section 141.2) that the Agency has recognized as capable of achieving 2-log *Cryptosporidium* removal. To comply with this requirement, systems may be required to install piping and additional pump capacity.

Selection of Representative Systems for Cost Analysis

Based on data submitted by community water systems for the 1995 Community Water Systems Survey (CWSS), EPA has estimated representative mean populations for eight population categories. EPA has also developed a regression equation correlating population with system characteristics like design and average flow.

Systems from all population size categories are covered by the FBRR. Small treatment systems are defined as systems serving a population of fewer than 10,000 persons. Systems serving a population serving fewer than 10,000 persons are stratified into five population size categories. They are: <100; 101-500; 501-1,000; 1,001-3,300; and 3,301-10,000. In addition, three population size categories for service populations of 10,001-50,000; 50,001-100,000; and greater than 100,000 persons are employed.

To estimate a representative system's design flow for each population size category, the estimated mean population for the population size category was used in the equation below. The average flow was calculated from the design flow using a design to average flow ratio developed from CWSS data. These average flow estimates are then used in determining the cost curves for capital and operation and maintenance (O&M) costs. Table H-1 presents the design and average flows that were used to determine the cost of the options considered. The filter area and backwash production used in the cost calculations are also presented in this table.

$$Design\ Flow\ (mgd) = 0.3697\ x\ population^{0.97757}$$

Table H-1. Backwash Production and Filtration Assumptions for Flow Categories Used to Estimate Costs

Population Size Category	Design Flow (mgd)	Average Flow (mgd)	Area per Filter[1,2] (sq. ft.)	One Backwash Volume (mgd/filter)	Number of Filters	Backwash Volume from all Filters (mgd)
< 100	0.022	0.0069	6.5	0.0019	2	0.0038
101–500	0.088	0.0275	26	0.0077	2	0.0154
501–1,000	0.239	0.074	69	0.0208	2	0.0416
1,001–3,300	0.593	0.211	57	0.0171	4	0.0684
3,301–10,000	1.800	0.747	104	0.0312	6	0.1872
10,001–50,000	7.36	3.06	427	0.128	6	0.768
50,001–100,000	19.87	9.93	640	0.192	10	1.92
>100,000	83.59	41.79	692	0.208	36	7.488

[1] The number of filters and filter areas presented in this table were used for calculation of backwash volumes only.
[2] Maximum filter area is assumed to be 700 square feet per the IESWTR RIA.

The backwash volume calculation was determined by using the following methodology:

Backwash Volume = Filter Area × Backwash Rate × Backwash Duration

where Filter Area = Design Flow /Filter Loading Rate × Hours per Day Filter in Use

The following inputs were used:

- Backwash rate = 20 gpm/sq. ft. (*Ten State Standards*)
- Backwash duration = 15 minutes (*Ten State Standards*)
- Filter loading rate = 2.5 gpm/sq. ft.
- Hours per day filter is in use = 23

Cost Estimating Approach

Capital and O&M cost estimates were developed for installation of piping and additional pump capacity in order to enable systems to return recycle flows to a location such that they are returned through the processes of a system's existing conventional or direct filtration (as defined in 40 CFR, Section 141.2) that the Agency has recognized as capable of achieving 2-log *Cryptosporidium* removal.. These estimates are based on the backwash volume from all filters for that population size category. Specific cost estimation models were not available for these process improvements, and, as a result, a direct engineering cost estimation method was used. This method entails the use of best professional engineering judgement (BPJ) and manufacturer- or vendor-supplied data.

To employ BPJ and direct cost estimating to develop unit process costs, a conceptual design for each unit process was formulated. The conceptual design utilizes all of the major design parameters that have a meaningful affect on costs. Equipment is sized using system production as the primary design parameter. Other design parameters used to size equipment or treatment units are based on engineering experience. Some equipment and material costs were obtained from manufacturers or from R.S. Means cost estimating references.

Using best professional judgment, the installation costs (construction costs) for the major elements of the technology are used to estimate non-construction cost components. Non-construction costs, or indirect capital costs such as engineering design fees, contractor's overhead and profit, and contingencies are estimated by applying a percentage factor to direct capital costs (equipment installation costs).

For estimating the total annual labor costs for technologies costed using engineering judgment, the labor rate is $14.50 for systems serving populations less than 10,000 (average flow ≤ 0.75 mgd) and $28.00 for systems serving populations 10,000 or greater (average flow > 0.75 mgd). The Agency proposed the FBRR in early 2000 using labor rate recommendations of a Technical Design Panel of industry engineers which met in Denver for two days in the Fall of 1997. Additional analysis as recommended by the panel has yielded updated labor rates, which were used in developing costs for the final FBRR. EPA has included these analyses in the docket for the final rule (EPA, 2000f).

Costs of Installing Piping and Additional Pump Capacity

Additional piping and pump capacity may have to be installed to convey the spent filter backwash, thickener supernatant, and liquids from dewatering processes such that it passes through the processes of a system's existing conventional or direct filtration (as defined in 40 CFR, Section 141.2) that the Agency has recognized as capable of achieving 2-log *Cryptosporidium* removal.

Cost and Process Description — Cost estimates for the installation of additional piping were estimated by using BPJ. The calculations assumed that the length of flanged cast iron pipes needed to recycle from filters to headworks is the sum of four times the length of a single filter multiplied by the width and the number of filters. For redundancy, the cost of two pumps capable of delivering 150 ft of total dynamic head (TDH) and a pump motor efficiency of 0.67 were costed. The fittings include one solenoid valve per filter and a gate valve, check valve, and two reducers per pump. It also included four horizontal and vertical elbows and one tee per filter. The unit costs for pipes and fittings were obtained from the 1998 R.S. Means *Plumbing Cost Data Handbook (4th edtition)*. Total costs also included an additional 25 percent for contingencies, engineering and permitting costs and interest. The unit costs for installing piping to move recycle flow to the headworks were assumed to be similar, regardless of whether the system practices direct recycle or has an existing recycle treatment.

Operation and Maintenance Cost — The O&M costs include the annual cost of painting the pipes, replacement of pipe sections and fittings, and pump and motor service. These costs were estimated assuming 15 minutes of labor per day. Total O&M costs were obtained by adding the above cost component and the power cost per annum to operate the pumps. Relative to the power costs of the smaller flows, the annual power costs are much higher than the maintenance costs for the piping and pumps for design flows greater than 7.36 mgd. It is likely that in smaller systems, the extra pumping distance is small and requires negligible additional power. This cost estimate conservatively assumes additional power is necessary for all system sizes. For flows in the vicinity of 83 mgd, the general maintenance costs are almost negligible compared to the annual power costs.

Estimated Cost Equations — The estimated capital and O&M costs for each design flow size are presented in Table H-2. Microsoft Excel was used to fit a flow versus cost equation using the trendline function, which generates an equation for the best-fit curve. The estimated cost equations are presented in Table H-3.

Table H–2. Capital and O&M Costs for Installing Piping and Additional Pump Capacity

Design Flow (mgd)	Capital Cost ($)	Average Flow (mgd)	O&M Cost ($)
0.022	$6,600	0.0069	$1,350
0.088	$13,400	0.028	$1,450
0.24	$13,600	0.075	$1,570
0.59	$18,100	0.21	$1,950
1.8	$32,000	0.75	$3,170
7.37	$83,400	3.07	$10,200
19.87	$288,700	9.94	$22,550
83.59	$2,803,700	41.79	$86,200

Table H–3. Cost Equations for Installing Piping and Additional Pump Capacity

Capital Cost Equation	O&M Cost Equation
Capital Cost ($) = $305.9x^2 + 7830.2x + 11790$ for $0.022 \le x \le 83.59$ mgd; x = design flow	O&M Cost ($) = $-4.57y^2 + 2213.4y + 1650.1$ for $0.0069 \le y \le 41.79$ mgd; y = average flow

Detailed Cost Summary — The following tables present the detailed cost information used to develop the equations described above.

Install Piping to Move Recycle Flow to the Headworks

Assumptions:

1. Recycling via equalization basin, which discharges the backwash flow over a 23 hour period.
2. Recycling costs presented below are those incurred for a single filter only.
3. Backwash rate = 20 gpm/sq. ft. for 15 minutes per filter.
4. Conceptual design parameters assume a filter loading rate of 2.5 gpm/sq. ft.

Design flow (mgd)	Average flow (mgd)	Total filter area (ft2)	BW vol. (gallons)	Area per filter (ft2)	Filter dim. (ft*ft)	No. of filters
0.02	0.0069	7	1050	3.5	5x0.7	2
0.09	0.028	25	3750	12.5	5x2.5	2
0.24	0.075	67	10050	33.5	7x4.8	2
0.59	0.21	164	12300	41	10x4.1	4
1.80	0.75	500	25200	84	10x8.4	6
7.37	3.07	2048	102600	342	30x11.4	6
19.87	9.94	5520	165600	552	40x13.8	10
83.59	41.79	23220	193500	645	43x15	36

Design flow (mgd)	Average flow (mgd)	Recycle flow 23 hr recycle (gpm)	BW recycle pipe dia. (inches)*	Return to design flow ratio (23 hr based)	Recycle flow 15 min. recycle (gpm)	Return to design flow ratio (15 min based)
0.02	0.0069	0.8	0.5	0.053	70	4.59
0.09	0.028	2.8	1	0.046	250	4.1
0.24	0.075	7.3	1	0.044	670	4.02
0.59	0.21	9	1	0.022	820	2.01
1.80	0.75	18.3	2	0.015	1680	1.35
7.37	3.07	74.4	3.5	0.015	6840	1.34
19.87	9.94	120	3.5	0.009	11040	0.81
83.59	41.79	140.3	8	0.003	12900	0.23

* Based on BPJ and RS Means data.

flow (gpm)	pipe dia. (inches)	cost ($/ft)
2	0.5	$7
7	1	$9
15	1	$9
39	2	$12
115	3.5	$13
478	8	$20
1261	14	$60
5283	24	$90

Capital Costs: With Equalization

Item	Design Flows (mgd)								Comments
	0.022	**0.088**	**0.24**	**0.59**	**1.8**	**7.37**	**19.87**	**83.59**	
Pipe length (ft)	60	60	70	80	120	230	400	720	
Unit cost of pipe ($/ft)	$7	$9	$9	$9	$12	$13	$13	$20	
Total pipe cost ($)	$420	$540	$630	$720	$1,440	$2,990	$5,200	$14,400	
No. of elbows	8	8	8	12	28	36	44	164	4 horizontal and vertical elbows per filter
No. of tees	2	2	2	3	7	9	11	41	1 tee per filter
Unit cost of elbows ($/#)	$65	$75	$75	$75	$100	$140	$140	$310	
Unit cost of tees ($/#)	$100	$120	$120	$120	$140	$180	$180	$282	
Total cost of pipe fittings ($)	$720	$840	$840	$1,260	$3,780	$6,660	$8,140	$62,402	
Unit cost of solenoidal valves ($/#)	$200	$400	$400	$400	$850	$1,000	$1,000	$3,063	1 per filter
Unit cost of gate val. ($/#)	$100	$200	$200	$200	$425	$525	$525	$835	1 per pump
Unit cost of check valves ($/#)	$100	$200	$200	$200	$340	$400	$400	$1,225	1 per pump
No. of pumps/motors	2	2	2	2	2	2	2	2	
Unit cost of pumps ($/#)	$628	$2,223	$2,223	$2,223	$2,981	$4,100	$9,075	$26,732	
Total cost of pumps ($)	$1,256	$1,256	$1,256	$1,256	$1,256	$1,256	$1,256	$1,256	
Total cost of pump fittings ($)	$600	$1,200	$1,200	$1,200	$2,380	$2,850	$2,850	$7,183	
Control panels cost ($)	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	Lumpsum (BPJ)
Subtotal	$5,996	$10,226	$10,316	$13,766	$24,377	$63,585	$219,970	$2,136,139	
Appurtenances($)	$600	$1,023	$1,032	$1,377	$2,438	$3,180	$10,999	$106,807	10% of cost for < 2 mgd and 5% for >= 2 mgd
Total ($)	**$6,596**	**$13,400**	**$13,600**	**$18,100**	**$32,000**	**$83,400**	**$288,700**	**$2,803,700**	Includes 25% of subtotal for contingen., eng. & permitting.

O&M Costs: With Equalization

Item	Average Flows (mgd)								Comments
	0.0069	**0.028**	**0.075**	**0.21**	**0.75**	**3.07**	**9.93**	**41.79**	
Pump HP	0.1	1	1	3	7	27	71	297	150 ft TDH and pump & motor efficiency = 0.67
kWhr/year	410	1800	4100	10400	30700	127000	333000	1394000	
Power costs ($)	$25	$108	$246	$624	$1,842	$7,620	$19,980	$83,640	$ 0.06/kWhr (BPJ)
General maintenance ($)	$1,323	$1,323	$1,323	$1,323	$1,323	$2,555	$2,555	$2,555	Pipe painting, pump/motor servicing. 15 mins./day @ $28/hr for > 10K systems and $14.5/hr for <= 10K systems
Total ($)	**$1,348**	**$1,431**	**$1,569**	**$1,947**	**$3,165**	**$10,175**	**$22,535**	**$86,195**	