E1 Water Reclamation and Reuse

This chapter covers the concept of using adequately and reliably treated sewage treatment plant effluent (reclaimed water) for beneficial purposes. Laws, regulations, and other requirements related to water reclamation and reuse are described, as well as design and construction considerations for development of a water reclamation project. The level of treatment and allowable uses for Class A, B, C, and D reclaimed water are discussed. Also included in this chapter is a discussion of the various options for water reuse such as on-site applications, wetlands discharge, ground water recharge, indirect potable reuse, and streamflow augmentation.

Figures

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E1-1 Introduction and Definitions

This section introduces the concept of reclaimed water and outlines planning considerations for a water reclamation system. Reasons why an agency would want to pursue a reclamation plan are discussed, including potential benefits.

E1-1.1 Overview

State legislators agreed that encouraging the use of reclaimed water, while still assuring the health and safety of all Washington citizens and the protection of the environment, could enable the State of Washington to use its water resources in the best interest of present and future generations. The Reclaimed Water Act was approved by the legislature in 1992 and codified as Chapter 90.46 RCW. This act encourages using reclaimed water for land applications and industrial and commercial uses and treating wastewater as a potential resource. The basic premise for reclamation is that the water must be used for direct, beneficial purposes.

Chapter 90.46 RCW was amended by the legislature in 1995 to provide for non-consumptive uses of reclaimed water. This legislation provided for the reuse of reclaimed water through surface percolation (infiltration) or direct injection. Another use of reclaimed water included in Chapter 90.46 RCW is wetland discharges and stream flow augmentation. This legislation established that reclaimed water is no longer considered wastewater.

Ecology has signed a memorandum of understanding (MOU) with the Department of Health (DOH) concerning review and permitting of reclaimed water projects. The basic intent of the MOU is to ensure there will be no duplication (unless required) in the review, processing of permits, and enforcement of reclaimed water requirements.

There are four classes of reclaimed water: A, B, C, and D, with Class A being the highest. Class A water has the most reuse potential and the least restrictions on its use. The major difference between Class A reclaimed water and the other classes is that Class A water is filtered and water in the other classes is not. Refer to the definitions in E1-1.3.

To ensure the product is safe, state regulations require the water be continuously and reliably treated. In order to comply with this requirement, redundant facilities are required in the treatment process. This is one of the primary differences between a wastewater treatment facility and a water reclamation facility. For every unit treatment process, a water reclamation facility requires a fully operational and functional backup component. Even though Class A reclaimed water will meet most drinking-water standards for raw water, **human consumption is not permitted**. Bodily contact with Class A reclaimed water, however, is permitted.

E1-1.2 Water Reclamation and Reuse Standards

In order to gain public confidence and support for water reuse, the legislature directed the Departments of Health and Ecology to jointly develop reclaimed water standards for the reuse of wastewater from municipal treatment plants. The legislature also instructed DOH and Ecology to undertake necessary steps to encourage the development of water reclamation facilities so that reclaimed water may be made available to help meet the growing water needs of the state.

The reuse standards describe allowable direct beneficial reuses of reclaimed wastewater, and the required level of treatment appropriate for each use. The standards require treatment and disinfection that is over and above what most conventional wastewater treatment facilities are required to provide. The standards also require automated alarms, redundancy of treatment units, emergency storage and stringent operator training and certification to meet the reliability criteria.

The reclaimed water standards were developed in a collaborative effort with DOH, Ecology, the Water Reuse Advisory Committee, interested stakeholders, and a consultant team of nationally recognized water reuse experts which has provided Washington State with some of the most comprehensive and technically sound reuse standards in the US.

E1-1.3 Definitions

A list of commonly used terms to describe reclaimed water, its uses, classifications, and related processes, is provided here. The list is intended to help establish a level of understanding in this relatively new and still developing field.

Approved use area is a site with well defined boundaries, designated in a user permit issued by the agency to receive reclaimed water for an approved use, and in conformance with regulations of all applicable regulatory agencies.

Class A reclaimed water means reclaimed water that, at a minimum, is at all times an oxidized, coagulated, filtered, disinfected wastewater. The wastewater shall be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 2.2 per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform organisms does not exceed 23 per 100 milliliters in any sample. See also Table E1-8.

Class B reclaimed water means reclaimed water that, at a minimum, is at all times an oxidized, disinfected wastewater. The wastewater shall be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 2.2 per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform organisms does not exceed 23 per 100 milliliters in any sample. See also Table E1-8.

Class C reclaimed water means reclaimed water that, at a minimum, is at all times an oxidized, disinfected wastewater. The wastewater shall be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 23 per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform organisms does not exceed 240 per 100 milliliters in any sample. See also Table E1-8.

Class D reclaimed water means reclaimed water that, at a minimum, is at all times an oxidized, disinfected wastewater. The wastewater shall be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 240 per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed. See also Table E1-8.

Direct beneficial use means the use of reclaimed water that has been transported from the point of production to the point of use without an intervening discharge to the waters of the state for a beneficial purpose.

Direct recharge means the controlled subsurface addition of water directly to the ground water basin that results in the replenishment of ground water. Direct recharge of reclaimed water is typically accomplished via injection wells but may contain other methods that directly recharge into the ground water saturated zone by a subsurface means.

Greywater means wastewater having the consistency and strength of residential domestic type wastewater. Greywater includes wastewater from sinks, showers, and laundry fixtures, but does not include toilet or urinal waters.

Indirect potable reuse means the discharge of reclaimed water into a reservoir used as a raw water source for drinking water supply, or into a stream which flows into such a reservoir or into an aquifer and extracted for a drinking water source, with the concurrence and participation of the water supply utility in the indirect potable reuse project.

Planned Ground Water Recharge Project means any reclaimed water project designed for the purpose of recharging ground water, via direct recharge or surface percolation.

Reclaimed water means effluent derived in any part from sewage from a wastewater treatment system that has been adequately and reliably treated, so that as a result of that treatment, it is suitable for a beneficial use or a controlled use that would not otherwise occur and is no longer considered wastewater.

Streamflow augmentation means the discharge of reclaimed water to rivers and streams of the state or other surface water bodies, but not wetlands.

Surface percolation means the controlled application of water to the ground surface for the purpose of replenishing ground water.

Wetland or wetlands means areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted to life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands regulated under this chapter shall be delineated in accordance with the manual adopted by Ecology pursuant to RCW 90.58.380 (Reclaimed Water Act, 1997 definition).

Wetland or wetlands means areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including but not limited to irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990 that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands. (Chapter 90.58 RCW, Shoreline Management Act and Growth Management Act, 1995 definition.)

Wetlands constructed beneficial use means those wetlands intentionally constructed on nonwetland sites to produce or replace natural wetland functions and values. Constructed beneficial use wetlands are considered “waters of the state.”

Wetlands constructed treatment means those wetlands intentionally constructed on nonwetland sites and managed for the primary purpose of wastewater or storm water treatment. Constructed treatment wetlands are considered part of the collection and treatment system and are not considered "waters of the state."

Wetland enhancement means actions taken to intentionally improve the wetland functions, processes, and values of existing but degraded wetlands where all three defining criteria are currently met (that is, hydrology, vegetation, and soils).

Wetland restoration means actions taken to re-establish a wetland area, including its functions and values that were eliminated by past actions, in an area that no longer meets the definition of a wetland.

E1-1.4 Applicability

In order to meet the requirements for all classes of reclaimed water, the wastewater must be fully oxidized. Fully oxidized wastewater is a wastewater in which organic matter has been stabilized such that the biochemical oxygen demand (BOD) does not exceed 30 mg/L and the total suspended solids (TSS) do not exceed 30 mg/L, is nonputrescible, and contains dissolved oxygen. Biological treatment to produce oxidized wastewater is discussed in Chapter T3.

What differentiates a water reclamation facility from a wastewater treatment facility is the reclamation facility is required to have additional reliability and redundancy features. These features ensure that the water is being adequately and reliably treated so that, as a result of that treatment, it is suitable for a direct beneficial use. E1-4 provides guidelines for treatment and disinfection technologies that will meet the requirements to produce reclaimed water.

E1-1.5 Examples of Reclaimed Water Use

Reclaimed water can be used for a variety of purposes including irrigation, impoundments, ground water recharge, and various commercial and industrial uses. Examples describing reclaimed water uses and associated treatment and quality requirements are displayed in Table E1-1.

Table E1-1. Treatment and Quality Requirements for Reclaimed Water Use

Use	Type of Reclaimed Water Allowed			
	Class A	**Class B**	**Class C**	**Class D**
Irrigation of Nonfood Crops				
Trees and Fodder, Fiber, and Seed Crops	YES	YES	YES	YES
Sod, Ornamental Plants for Commercial Use, and Pasture to Which Milking Cows or Goats Have Access	YES	YES	YES	NO
Irrigation of Food Crops				
Spray Irrigation				
All Food Crops	YES	NO	NO	NO
Food Crops Which Undergo Physical or Chemical Processing Sufficient to Destroy All Pathogenic Agents	YES	YES	YES	YES
Surface Irrigation				
Food Crops Where There is No Reclaimed Water Contact With Edible Portion of Crop	YES	YES	NO	NO
Root Crops	YES	NO	NO	NO
Orchards and Vineyards	YES	YES	YES	YES
Food Crops Which Undergo Physical or Chemical Processing Sufficient to Destroy All Pathogenic Agents	YES	YES	YES	YES
Landscape Irrigation				
Restricted Access Areas (e.g., Cemeteries and Freeway Landscapes)	YES	YES	YES	NO
Open Access Areas (e.g., Golf Courses, Parks, Playgrounds, School Yards and Residential Landscapes)	YES	NO	NO	NO
Impoundments				
Landscape Impoundments	YES	YES	YES	NO
Restricted Recreational Impoundments	YES	YES	NO	NO
Nonrestricted Recreational Impoundments	YES	NO	NO	NO
Fish Hatchery Basins	YES	YES	NO	NO
Decorative Fountains	YES	NO	NO	NO
Flushing of Sanitary Sewers	YES	YES	YES	YES
Street Cleaning				
Street Sweeping, Brush Dampening	YES	YES	YES	NO
Street Washing, Spray	YES	NO	NO	NO
Washing of Corporation Yards, Lots, and Sidewalks	YES	YES	NO	NO
Dust Control (Dampening Unpaved Roads and Other Surfaces)	YES	YES	YES	NO
Dampening of Soil for Compaction (at Construction Sites, Landfills, etc.)	YES	YES	YES	NO
Water Jetting for Consolidation of Backfill Around Pipelines				
Pipelines for Reclaimed Water, Sewage, Storm Drainage, and Gas, and Conduits for Electricity	YES	YES	YES	NO
Fire Fighting and Protection				
Dumping from Aircraft	YES	YES	YES	NO
Hydrants or Sprinkler Systems in Buildings	YES	NO	NO	NO

Use	Type of Reclaimed Water Allowed			
	Class A	**Class B**	**Class C**	**Class D**
Toilet and Urinal Flushing	YES	NO	NO	NO
Ship Ballast	YES	YES	YES	NO
Washing Aggregate and Making Concrete	YES	YES	YES	NO
Industrial Boiler Feed	YES	YES	YES	NO
Industrial Cooling				
Aerosols or Other Mist Not Created	YES	YES	YES	NO
Aerosols or Other Mist Created (e.g., Use in Cooling Towers, Forced Air Evaporation, or Spraying)	YES	NO	NO	NO
Industrial Process				
Without Exposure of Workers	YES	YES	YES	NO
With Exposure of Workers	YES	NO	NO	NO
Wetlands (see E1-7)				
All Wetlands	YES	YES	YES	YES
Noncontact Recreational or Educational Use With Restricted Access	YES	YES	YES	NO
Fisheries Use, or Noncontact Recreational or Educational Use with Open (Unrestricted) Access	YES	YES	NO	NO
Potential Human Contact Recreational or Educational Use	YES	NO	NO	NO
Ground Water Recharge (see E1-8)	YES	NO	NO	NO
Indirect Potable Reuse (see E1-9)	YES	NO	NO	NO
Streamflow Augmentation (see E1-10)	YES	NO	NO	NO

E1-1.6 Initiating a Water Reuse Project

Many communities in this state are approaching or have reached the limits of their available water supplies. Water reclamation and reuse can become an attractive option for conserving and extending available water resources. Water reuse may also present an opportunity for pollution abatement when it replaces effluent discharge to sensitive surface waters.

The use of reclaimed water to replace potable water in nonpotable applications conserves potable water and stretches the potable water supply. A water reuse facility is a very reliable source of water and using reclaimed water instead of potable water can avoid costs. Furthermore, using reclaimed water can help preserve water rights for potable water sources to accommodate growth.

A reuse program can reduce or totally eliminate the effluent discharge to surface bodies of water, thus reducing pollutant loading in the environment. Protection of salmon runs or shellfish beds is also a benefit. Wastewater reuse is viewed as a very environmentally progressive approach to dealing with a community's waste stream.

Reclaimed water can be viewed as a commodity and sold. Utilizing reclaimed water for a beneficial purpose instead of wasting it can help a community recapture some of its financial investment in wastewater treatment.

Any operating agency considering water reclamation and reuse should start with a staged planning program to determine the feasibility of a reclaimed water project (refer to Chapter G1 for the staged planning process). The various planning stages described in Table E1-2 should lead to a conceptual plan which could be the basis for the design and construction of the proposed system.

Table E1-2. Staged Planning Program to Determine Feasibility of a Reclaimed Water System

Planning Stage	Characterization
1. Preliminary investigations.	The preliminary investigation stage is a fact-finding phase in which physical, economic, institutional, and legal limitations should be identified. All potential sources of reclaimed water and markets should be identified.
2. Screening of potential resources and markets.	The screening of potential markets stage should consist of a comparison between the unit costs of potable water and of reclaimed water to the same market. The costs and pricing constraints should be evaluated under both present and future conditions to ensure that initial capital costs do not overshadow long-term benefits. Present and future quantity and quality requirements should also be taken into consideration to determine if it is, and will remain, cost-effective to serve the users of reclaimed water. Reliability of supply, value of reclaimed water nutrients, and social benefits should also be considered, as well as possible savings in the potable system due to the reduced demand on it.
3. Detailed evaluation of facilities alternatives to serve selected markets, including engineering and economic feasibility, financial analysis, and environmental analysis.	The final stage of the planning program is the detailed evaluation of the selected markets. In this stage, by looking in more detail at the conveyance routes and storage requirements of each alternative system to serve selected markets, refinements to preliminary cost estimates for delivery of reclaimed water can be made. Funding options can be compared, user costs developed, and a comparison made between the unit costs of potable and reclaimed water for each alternative system. It should also be possible to assess in more detail the environmental, institutional, and social aspects of each alternative.

E1-2 Regulatory Framework

The objective of any water reuse project design is to apply proper reclamation techniques to wastewater to allow the resulting product to be beneficially used. Knowledge of specific reclaimed water statutes and applicable administrative regulations is necessary so that appropriate levels of treatment can be used for specific beneficial uses and permitting requirements. Proposers of reclaimed water projects should review this section and corresponding regulations closely before proceeding with detailed design.

These concepts are particularly important in reclaimed water projects because some portions of the reclaimed water statute override administrative rule while all other existing requirements will still apply. One of the main objectives in reclaimed water permitting is issuing a single permit to the generator. While this concept may be different than requirements for other wastewater facilities, it underscores the change from treatment plant effluent to reclaimed water. Table E1-3 lists statutes and rules that apply to reclaimed water projects.

Table E1-3. Laws and Regulations That Apply to Reclaimed Water Projects

Statutes (RCWs) and Rules (WACs)	Application
Chapter 90.46 RCW Reclaimed Water	This statute is the basis for permitting, standards, and legislative intent of reuse projects. A key aspect of this law is the definition section. Please refer to specific definitions for reclaimed water, ground water recharge criteria, and reclamation criteria. The statute also provides that facilities that reclaim water shall not impair existing downstream water rights (RCW 90.46.130).
Chapter 90.48 RCW Water Pollution Control	This is the main statute for Ecology's authority to regulate domestic wastes from sewage treatment facilities.
Chapter 90.03 RCW Water Code and Chapter 90.44 RCW Regulation of Public Ground Waters	These statutes are the basis for the appropriation and beneficial uses of public waters. Use and distribution of the reclaimed water is exempt from water rights permit requirements.
Chapter 43.20 RCW State Board Of Health	This statute provides the authority for DOH to adopt rules (WACs) for sewage and drinking water systems.
Chapter 173-200 WAC Water Quality Standards for Ground Waters	This rule would apply, except as amended in Chapter 90.46 RCW, to any reclaimed water beneficial use that discharges to ground water.
Chapter 173-201A WAC Water Quality Standards for Surface Waters	This rule would apply to any reclaimed water that would discharge to surface waters of the state.
Chapter 173-216 WAC State Waste Discharge Permit Program	This rule would permit reclaimed water used for irrigation, impoundments, non-discharging wetlands (not regulated as waters of the state), and planned ground water recharge projects if no other permit existed to allow the generation of reclaimed water.
Chapter 173-220 WAC National Pollution Discharge Elimination System Program (NPDES)	This rule delegates to Ecology the NPDES permitting program from EPA and is one of the primary permits the agencies use for reclaimed water. A NPDES permit could be used for either land application of reclaimed water or certain commercial and industrial uses of reclaimed water.
Chapter 173-240 WAC Submission of Plans and Report for Construction of Wastewater Facilities	This rule governs the engineering submittal requirements for Ecology in addition to the guidance provided in the reclamation criteria.
Chapter 246-271 WAC Public Sewage	This rule covers the basic investigative powers of DOH for regulating municipal sewage system discharges and engineering documents. DOH issues approval of reclaimed water projects under this rule and the authority granted by Chapters 90.46 and 43.20 RCW.
Chapter 246-290 WAC Group A Public Water Systems	This rule establishes requirements for public water systems consistent with the Safe Drinking Water Act and other DOH statutes and WACs. For reclaimed water projects, requirements for water system plans, cross connections, design standards (distribution systems), and source protection may apply to specific projects.
Chapter 173-154 WAC Policies and Procedures	This rule establishes protection of upper aquifer zones from excessive water level declines or reductions in water quality.
Chapter 173-218 WAC Policies and Procedures	This rule establishes an undergound injection control program for the injection of fluids through wells. This rule is applicable to reclaimed water that would discharge to ground water by way of an injection well.

E1-2.1 Management Approaches (DOH Requirements)

A given reuse project may require management approaches by the reclaimed water generator and/or the user. The proponent of a project should be aware of specific management areas for reclaimed water projects, as follows:

E1-2.1.1 Commercial and Industrial Reuse

In areas where workers may be exposed to or come in direct contact with reclaimed water, a specific worker safety program must address potential and actual contact with the reclaimed water. Although reclaimed water can be deemed safe for workers after a given treatment, there are general precautions for hygiene, emergency situations, and ingestion that must be covered in operation and maintenance manuals or user agreements with the generator. Worker safety programs are viewed as part of proper management of the reclaimed water after meeting permit requirements.

Reclaimed water that is delivered to a commercial building is required to have adequate back-flow prevention on the domestic water line entering the building (see cross connection control, Chapter 246-290 WAC). However, the purveyor may not require any additional cross connection control for water facilities within the building. It is recommended that a cross connection management agreement be in place to protect the water supply in the building from cross connection with reclaimed water. The recommendation may be required by DOH for buildings where reclaimed water is used for toilet and urinal flushing.

E1-2.1.2 Land Application

Management approaches for land application projects (typical irrigation) are directed to ensure irrigation water is used in a responsible manner and protects drinking water supplies. A project should be designed to utilize spray irrigation during times when possible human exposure is least likely to happen. While the reclaimed water is safe for direct exposure, irrigation during night and early morning hours ensures limited public contact and helps curb public perception issues about using reclaimed water.

Reclaimed water that is delivered to existing irrigation systems must include provisions for testing and a site survey to identify any faucet or hose bibb that could be used for drinking water. Dye testing of existing systems to verify that no connection with potable water supplies is possible is a good design practice. In proper circumstances, specific conductance can also be used to test for absence of connections.

E1-3 Project Implementation

This section discusses the regulatory aspects of implementing a water reclamation and reuse project and obtaining agency approvals and permits. These items are intended to be consistent with good engineering practices for these types of projects; however, this listing is not intended to be a complete roster of all the engineering or construction practices that may be required for a particular project. Project owners, project managers, and design professionals are reminded to verify and address other legal, technical, managerial, economic, and financial requirements for their project, including land use and right-of-way issues, building code compliance (architectural, structural, mechanical, plumbing, electrical, etc.), contract administration for consultant and construction contracts, economic feasibility evaluation, project financing (internal funds, grants/ loans, bonds, other financial instruments), etc.

E1-3.1 Approval Process for Reuse Projects

Reclaimed water projects are administered jointly by the State Departments of Ecology and Health. Lead roles in permitting and approval are based on the type of reuse proposed. Land application (irrigation) of reclaimed water is permitted by Ecology in RCW 90.46.040. Commercial and industrial reuse is permitted by DOH through Ecology's waste discharge permit program (state permit or NPDES) consistent with RCW 90.46.030. Both agencies will provide review of planning and engineering documents in keeping with roles and responsibilities delineated within a MOU on reuse and land treatment systems. Many reuse projects contain both land application and commercial and industrial reclaimed water uses and applicants should coordinate with each review agency.

The approval process for water reuse projects generally involves the preparation, regulatory review, and approval of planning, design, and implementation products, as follows:

- Comprehensive water system plan.
- Comprehensive sewer plan.
- Facilities plan or project engineering report.
- SEPA compliance documentation.
- Plans and specifications documents.
- Water reuse permit application/permit.

Project Implementation Subject	Cross Reference to Other Chapters/Sections
Approval Process	See Chapter G1 for a discussion of general aspects of the regulatory approval process for facility planning and implementation. Specific aspects of regulatory roles and responsibilities in the review and permit approval for water reuse projects are discussed in E1-2.
Comprehensive Water/Sewer Planning	G1-3
Facility Planning and Engineering	G1-4.1
Environmental Review	G1-2.6
Plans and Specifications	G1-4.2
O&M Manuals	G1-4.4
Reclaimed Water Permits	E1-3

E1-3.2 Reliability and Redundancy

Compliance with reliability and redundancy requirements of Articles 10 and 11 (Table E1-4) of the Water Reclamation and Reuse Standards should be verified.

Table E1-4. Reliability and Redundancy Requirements of Articles 10 and 11 of the Water Reclamation and Reuse Standards

Article	Requirements
Article 10—General Requirements of Design	**1. Flexibility of Design** The design of process piping, equipment arrangement, and unit structures in the reclamation plant must allow for efficiency and convenience in operation and maintenance and provide flexibility of operation to permit the highest possible degree of treatment to be obtained under varying circumstances. There shall be no bypassing of untreated or partially treated wastewater from the reclamation plant or any intermediate unit processes to the point of use.
	2. Power Supply The power supply shall be provided with one of the following reliability features: (a) Alarm and standby power source. (b) Alarm and automatically actuated short-term storage or disposal provisions as specified in Article 11, item 1. (c) Automatically actuated long-term storage or disposal provisions as specified in Article 11, item 1.
	3. Storage Where No Approved Alternative Disposal System Exists (a) Where no alternative disposal system is permitted, a system storage or other acceptable means shall be provided to ensure the retention of reclaimed water under adverse weather conditions or at other times when reuse is precluded. (b) When wet weather conditions preclude the use of reclaimed water, the system storage volume shall be established by determining the storage period that would be required for the duration of a 10-year storm, using weather data that is available from, or is representative of, the area involved. A minimum of 20 years of climatic data shall be used in storage volume determinations. (Note that the designer must select an appropriate storm duration to provide the protection of a 10-year recurrence interval.) (c) At a minimum, system storage capacity shall be the volume equal to three times that portion of the average daily flow of reuse capacity for which no alternative reuse or disposal system is permitted. (d) Reclaimed water storage ponds or quarantine which can impound a volume of 10 acre-feet (equivalent to 435,600 cubic feet or 3.258 million gallons) or more may be subject to state dam safety regulations. See G1-1.4.6E.

Article	Requirements
Article 11—Alternative Reliability Requirements	**1. Emergency Storage or Disposal** (a) Where short-term storage or disposal provisions are used as a reliability feature, these shall consist of facilities reserved for the purpose of storing or disposing of untreated or partially treated wastewater for at least a 24-hour period. The facilities shall include all the necessary diversion works, provisions for odor control, conduits, and pumping and pump-back equipment. All of the equipment other than the pump-back equipment shall be either independent of the normal power supply or provided with a standby power source. (b) Where long-term storage or disposal provisions are used as a reliability feature, these shall consist of ponds, reservoirs, percolation areas, downstream sewers leading to other treatment or disposal facilities, or any other facilities reserved for the purpose of emergency storage or disposal of untreated or partially treated wastewater. These facilities shall be of sufficient capacity to provide disposal or storage of wastewater for at least 20 days, and shall include all the necessary diversion works, provisions for odor and nuisance control, conduits, and pumping and pump-back equipment. All of the equipment other than the pump-back equipment shall be either independent of the normal power supply or provided with a standby power source. (c) Diversion to a different type of reuse is an acceptable alternative to emergency disposal of partially treated wastewater provided that the quality of the partially treated wastewater is suitable for that type of reuse. (d) Subject to prior approval by DOH and Ecology, diversion to a discharge point where the wastewater meets all discharge requirements is an acceptable alternative to emergency disposal of partially treated wastewater. (e) Automatically actuated short-term storage or disposal provisions and automatically actuated long-term storage or disposal provisions shall include, in addition to provisions of (a), (b), (c), and (d) listed above, all the necessary sensors, instruments, valves, and other devices to enable fully automatic diversion of untreated or partially treated wastewater to approved emergency storage or disposal in the event of failure of the treatment process, and a manual reset to prevent automatic restart until the failure is corrected.
	2. Biological Treatment All biological treatment unit processes shall be provided with one reliability feature, as follows: (a) Alarm and multiple biological treatment units capable of producing oxidized wastewater with one unit not in operation. (b) Alarm, short-term storage or disposal provisions, and standby replacement equipment. (c) Alarm and long-term storage or disposal provisions. (d) Automatically actuated long-term storage or disposal provisions.
	3. Secondary Sedimentation All secondary sedimentation unit processes shall be provided with one reliability feature, as follows: (a) Multiple sedimentation units capable of treating the entire flow with one unit not in operation. (b) Standby sedimentation unit process. (c) Long-term storage or disposal provisions.

Article	Requirements
Article 11—Alternative Reliability Requirements (continued)	**4. Coagulation** (a) All coagulation unit processes shall be provided with all features for uninterrupted chemical feed, as follows: • Standby feeders. • Adequate chemical storage and conveyance facilities. • Adequate reserve chemical supply. • Automatic dosage control. (b) All coagulation unit processes shall be provided with one reliability feature, as follows: • Alarm and multiple coagulation units capable of treating the entire flow with one unit not in operation. • Alarm, short-term storage or disposal provisions, and standby replacement equipment. • Alarm and long-term storage or disposal provisions. • Automatically actuated long-term storage or disposal provisions. • Alarm and standby coagulation unit process.
	5. Filtration All filtration unit processes shall be provided with one reliability feature, as follows: (a) Alarm and multiple filter units capable of treating the entire flow with one unit not in operation. (b) Alarm, short-term storage or disposal provisions, and standby replacement equipment. (c) Alarm and long-term storage or disposal provisions. (d) Alarm and standby filtration unit process.

Article	Requirements
Article 11—Alternative Reliability Requirements (continued)	**6. Disinfection** (a) All disinfection unit processes where chlorine is used as the disinfectant shall be provided with all features for uninterrupted chlorine feed, as follows: • Standby chlorinator. • Standby chlorine supply. • Manifold systems to connect chlorine cylinders. • Chlorine scales. • Automatic switchover to full chlorine cylinders. • Continuous measuring and recording of chlorine residual. (b) All disinfection unit processes where chlorine is used as the disinfectant shall be provided with one reliability feature, as follows: • Alarm and standby chlorinator. • Alarm, short-term storage or disposal provisions, and standby replacement equipment. • Alarm and long-term storage or disposal provisions. • Automatically actuated long-term storage or disposal provisions. • Alarm and multiple point chlorination. Each point of chlorination shall have an independent power source, separate chlorinator, and separate chlorine supply. (c) Alarms required for various unit processes as specified in other sections of these regulations shall be installed to provide warnings, as follows: • Loss of power from the normal power supply. • Failure of a biological treatment process. • Failure of a disinfection process. • Failure of a coagulation process. • Failure of a filtration process. • Any other specific process failure for which warning is required by DOH and Ecology. (d) All required alarms shall be independent of the normal power supply of the reclamation plant. (e) All other disinfection unit processes shall be provided with one reliability feature, as follows: • Alarm and standby disinfection unit capable of treating the design flow rate with the largest operating unit out of service. • Alarm, short-term storage or disposal provisions, and standby replacement equipment. • Alarm and long-term storage or disposal provisions. • Automatically actuated long-term storage or disposal provisions.

E1-3.3 Specific Requirements for O&M Manuals

This section describes the requirements for operations and maintenance (O&M) manuals and operator certification specific to water reclamation and reuse. The requirements of G1-4.4 also apply to water reuse projects.

E1-3.3.1 Operator Certifications

The treatment plant (including reclamation facilities) must be rated according to the wastewater treatment plant criteria in Chapter 173-230 WAC to arrive at a plant rating commensurate with the complexity of the treatment processes used at that facility.

Operators at a given facility must hold wastewater certification at a grade commensurate with the complexity of the combined wastewater treatment and water reclamation process at that facility. Since some of the treatment unit processes (coagulation and filtration, for example) are traditionally associated with potable water, it is recommended that plant operators receive special training in O&M for these treatment processes.

E1-3.3.2 Reclamation Treatment Processes

Some treatment unit processes (coagulation and filtration, for example) are traditionally associated with potable water, so those sections of the O&M manual will need to consult references for water treatment O&M as well as for wastewater treatment O&M.

E1-3.3.3 Distribution System

O&M policies and procedures should address the unique operational aspects of the reclaimed water distribution system either as a supplement to the potable water distribution system O&M policies and procedures or as a supplement to the water reclamation plant O&M manual. The text should include a map of the reclaimed water distribution system.

Responsibility for distribution system O&M (either by the water utility or sewer utility) should be clearly identified. Other distribution and on-site requirements are given in E1-5 and E1-6.

E1-3.4 Cross Connection Control Program

The purpose of this section is to provide guidance for protecting potable water systems from contamination by reclaimed water and for protecting reclaimed water from potential contamination by sewage or partially treated wastewater. The provisions of this section apply equally to the protection of potable water supplies, sources, and systems from contamination by sewage and partially treated wastewater.

A cross connection could be any physical arrangement whereby a potable water supply is connected, directly or indirectly, with any nonpotable or unapproved water supply system, sewer, drain, conduit, pool, storage reservoir, plumbing fixture, or any other device which contains, or may contain, contaminated water, liquid, gas, sewage, or other waste of unknown or unsafe quality which may be capable of imparting contamination to the potable water supply as a result of backflow. Cross connections include bypass arrangements, jumper connections, removable sections, swivel or change-over devices and other temporary, permanent, or potential connections through which, or because of which, backflow could occur.

E1-3.4.1 Type of Backflow

Backflow is flow in piped systems in reverse of the normal direction. It occurs as a result of pressure or hydraulic head differential between two points in the system. Backflow may occur due to either back siphonage or back-pressure conditions.

A. Back Siphonage

Back siphonage is caused by negative pressures in the supply piping, including piping extensions such as hoses. Common causes include the following:

- High pipeline velocities (Venturi effect).

- Leaks or breaks lower than an entrance point.
- Low pipeline pressure (excessive usage upstream).
- Reduced supply pressure on pump suction.

B. Back Pressure

Back pressure occurs when the protected system is connected to another piping system with higher pressure that forces nonpotable water or fluids back into the distribution system. Examples or common causes include the following:

- Booster pumps.
- High-rise buildings (taller than three stories).
- Pressure tanks.
- Boilers.
- Interties with higher pressure piping.
- Elevated piping (higher than 30 feet above finished grade).

E1-3.4.2 Reclaimed Water/Wastewater Cross Connection

Any cross connection between reclaimed water and raw sewage and/or partially treated wastewater renders the reclaimed water as wastewater and prohibits that water from being delivered for beneficial use.

Reclaimed water and wastewater treatment and pumping facilities present many opportunities for cross connection, some so common that they are often overlooked. Many common cross connections are listed in Table E1-5 to assist in recognizing these situations.

Table E1-5. Cross Connections Associated with Wastewater

Facilities	Water Uses	Equipment
Reclaimed water treatment plants	Pump seal water	Water-operated sewage sump ejectors
Wastewater treatment plants	Foam control	Water-cooled compressors
Lift stations	Flushing	Aspirators (laboratory)
Combined sewage overflows	Cleaning screens and racks	Sterilizers (laboratory)
Pressure regulator stations	Washdown activities	Janitor sinks
	Pump primers	Trap primers
	Chlorinators	Flush-O-Meter valves
	Cooling	Condensers
	Heating (boilers)	Heat exchangers
	Fire systems	Hand tools
	Landscape/irrigation	

E1-3.4.3 Backflow Prevention Methods

The type and degree of backflow prevention is determined by the degree of hazard and type of backflow encountered. Backflow will be the result of either back-pressure or back-siphonage conditions. The degree of hazard must be identified, and adequate protection for the most severe hazard encountered must be provided. The selection of specific backflow-prevention devices is determined from the degree of hazard, probability of occurrence, acceptable risk level, and reliability of the backflow preventer.

Basic types of backflow preventers applicable to reclaimed water facilities and wastewater treatment plants are shown in Table E1-6.

Table E1-6. Relative Level of Protection by Backflow Preventers

Backflow Preventer	Degree of Hazard	Backflow Type
Air gap (AG)	high and low	back pressure and back siphonage
Reduced pressure backflow assembly (RPBA)	high and low	back pressure and back siphonage
Double-check valve assembly (DCVA)	low	back pressure and back siphonage
Pressure vacuum breaker (PVB)	high and low	back siphonage
Spill-resistant vacuum breaker (SBVB)	high and low	back siphonage
Atmospheric vacuum breaker (AVB)	very low	back siphonage
Hose bibb vacuum breaker (HBVB)	very low	back siphonage
Lab faucet vacuum breaker (LFVB)	very low	back siphonage

E1-3.4.4 Approved Backflow Prevention Devices

State regulation requires that all installed RPBAs, DCVAs, and PVBs (see Table E1-6) installed shall be models included on the current list of backflow assemblies approved for installation in Washington State and maintained and published by Ecology (WAC 246-290-490 (2)(b)). The list or information on specific devices is available from the regional offices of DOH, Division of Drinking Water.

E1-3.4.5 Degree of Hazard

Degrees of hazards posed by potential contaminants are classified as severe, high, or low. The Cross connection Control Manual includes lists of facilities, fixtures, and equipment requiring specific types of backflow prevention. Further, Group A Public Water System Regulations, WAC 246-290-490, specifically identifies sewage treatment plants and facilities having a nonpotable auxiliary water supply (among others) as requiring backflow prevention appropriate for the degree of hazard, air gaps, or both to be installed on service connections or within the facilities.

E1-3.4.6 Backflow Prevention Recommendations at Reclaimed Water Facilities and Wastewater Treatment Plants

The purveyor-approved program is as follows:

- An approved cross connection control program is required to receive regulatory approval for all reclaimed water projects and facilities. The cross connection program (CCP) must be created and implemented by the public drinking water systems serving potable water in all reclaimed water treatment facilities, distribution facilities, and disposal or use areas.
- The CCP must conform to the “Cross connection Control Manual, Accepted Procedure and Practice” (latest edition), and must be

approved by DOH, Division of Drinking Water. An approved program may be the program included as a portion of an approved Water System Plan conforming to WAC 246-290-110 (Group A Public Water Systems—Water System Plans), or may be created as a separate, approved document. It is the responsibility of the permit holder or person(s) who distribute reclaimed water to ensure CCP compliance by all public water systems providing potable water service in the treatment, distribution, and use areas.

- For public water systems with an approved water system plan, conformance with these requirements may be demonstrated by proving that a cross connection control program was included in that plan. The permittee or distributor must also ensure coordination with future water system plan updates required of public water systems every six years along with any modifications to the CCP.
- For public water systems that have a CCP approved separately from a water system plan, conformance with these requirements may be demonstrated by producing the letter approving that plan from DOH. Again, the permittee or distributor must also ensure coordination with future program updates and modifications to the CCP.
- If one or more of the public water systems serving the treatment, distribution, or use areas does not have a currently approved water system plan or CCP, the permittee or distributor must coordinate with the water system(s) to ensure submittal and approval of an acceptable CCP by the water system prior to approval of the reclaimed water facilities.

E1-3.4.7 Minimum Wastewater/Reclaimed Water Treatment Plant Backflow Prevention

Wastewater and reclaimed water treatment pumping facilities constitute extreme hazards related to the potential for backflow. Minimum protection for wastewater and reclaimed water treatment plants includes a reduced-pressure backflow assembly on the potable water service line into the facility, appropriate premise protection in the control building and laboratory for standard devices, and an air gap with repumping facilities between potable makeup water and any raw sewage, partially treated wastewater, secondary wastewater, or reclaimed water used at the plant site for any reason. Examples of these requirements are shown in Figure E1-1 and Figure E1-2.

E1-3.4.8 Bypass of Backflow Prevention Assemblies

No bypass of any backflow prevention assembly is allowed.

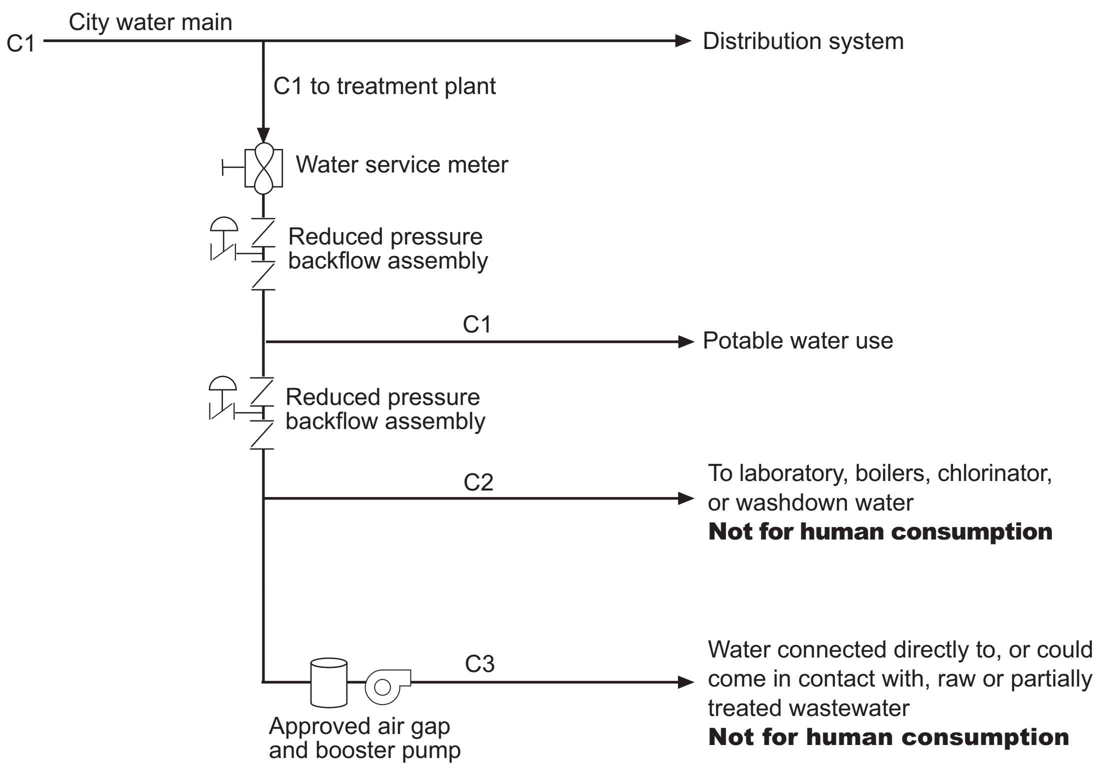


Figure E1-1. Backflow Prevention, Example One

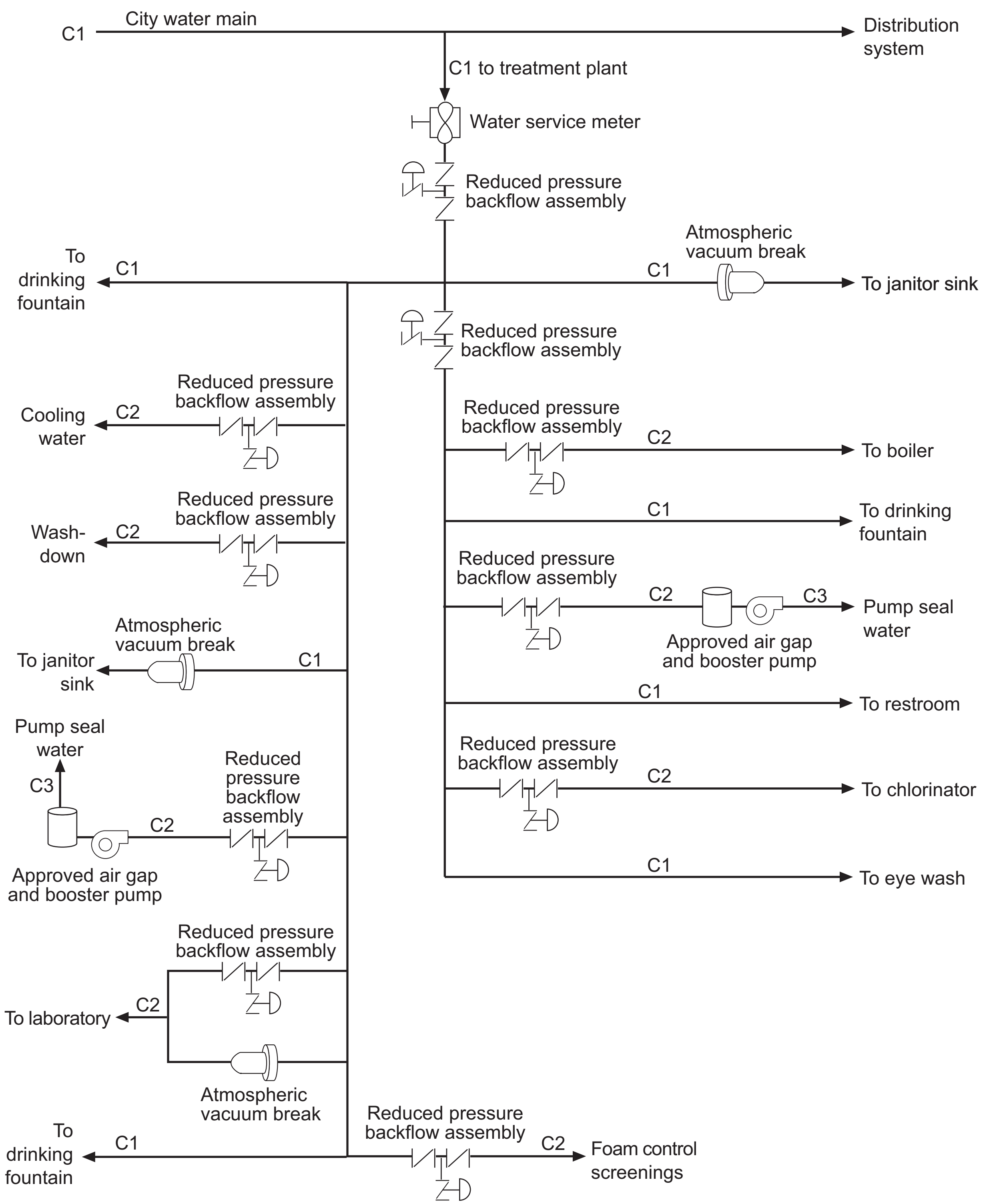


Figure E1-2. Backflow Prevention, Example Two

E1-3.4.9 Distribution System and Use Area Protections

Depending upon the level of treatment provided, reclaimed water presents a high-to-extreme health hazard because of the potential for backflow. Specific backflow prevention needs and situations are identified in Table E1-7.

Table E1-7. Backflow Prevention for Reclaimed Water

Situation	Comment
General	Cross connections between potable water and reclaimed water of any classification are not allowed under any circumstance. The potable water supplier is responsible for ensuring compliance with provisions of their approved cross connection control program. The reclaimed water permit holder is responsible to DOH and Ecology to demonstrate the acceptance of the water purveyor of the CCP for a specific use area. The reclaimed water permit holder shall also ensure the submittal of annual CCP reports documenting annual facilities inspections, test results, repair and replacement requirements, and the proper installation of new backflow prevention assemblies at reclaimed water use sites during the year to DOH and Ecology.
Site with Potable Water	Any site being served with reclaimed water and potable water shall be provided with service-line protection equal to a reduced-pressure backflow prevention assembly or an approved air gap.
Reclaimed Water Lines Serving and Within a Dwelling Unit	Reclaimed water shall not enter any dwelling unit or building containing a dwelling unit except to provide fire protection and/or toilet flushing water at approved sites. The reclaimed water service pipe and building plumbing shall conform to all pipeline separation, marking, and warning requirements of this section, reclaimed water use standards, and state and local plumbing codes.
Pipeline Separation	Inadequate pipeline separation for pipelines installed in trenches is considered a cross connection by some water purveyors. Adequate pipeline separation is defined as 10-feet pipe-to-pipe separation for horizontal separations and 18-inch pipe-to-pipe vertical separation. Separations not conforming to these standards must provide additional protections. The most common means of protection is to provide exterior casing consisting of pressure pipe with sealed joints extending past the area of conflict by at least 10 feet at both ends.
Bypasses	Bypassing any backflow prevention device is not allowed, including bypasses of backflow-prevention assemblies that provide use area or premise protection downstream of service line backflow-protection assemblies.
Hose Bibbs on Potable Water Lines	Hose bibbs within use areas shall be approved hose bibb vacuum-breaker assemblies. The installation of hose bibbs in reclaimed water use areas shall be approved by DOH and Ecology.
Hose Bibbs on Reclaimed Water Lines	Hose bibbs on reclaimed water lines are prohibited, except as authorized by DOH and Ecology.
Markings and Warnings	All backflow-prevention assemblies and downstream piping shall be adequately marked and color-coded in conformance with the industry practice and applicable standards to identify the hazards and fluids downstream of the assembly.
Tank Truck Hauling	Tank trucks used to transport reclaimed water shall be filled from sources protected by an approved air gap. All tank trucks used to transport reclaimed water shall be inspected and approved for such use prior to transporting the reclaimed water by the water supplier that provides potable water to the use area at which the reclaimed water will be used.

E1-4 Treatment Technologies (Rev. 10/2006)

This section summarizes the source water characteristics and treatment requirements from the state's *Water Reclamation and Reuse Standards* (WRR Standards) and provides additional design criteria guidance for reclaimed water production. All reclaimed water must receive adequate and reliable treatment and the permittee must meet these requirements at all times. The designer should use this section to supplement the wastewater treatment criteria in Chapter T3 of this manual.

E1-4.1 Source Water Treatment

The minimum state treatment standards for reclaimed water require a fully oxidized and disinfected effluent. The oxidized effluent must stabilize organic matter and contain measurable dissolved oxygen. Minimum acceptable water quality is secondary treatment with a 5-day BOD and a TSS monthly average concentration of 30 mg/ or lower. Some uses require additional treatment to remove more pathogens, nutrients, metals, dissolved gases, or other substances that may adversely affect the suitability of the water for the intended use. The designer must determine if secondary treatment processes will remove excess amounts of these substances or if removal must take place in advanced treatment processes.

Section E1-4.2 summarizes regulatory requirements. The design engineer should consult Water Reclamation and Reuse Standards to assure that design meets the minimum requirements for all proposed uses. When the standards do not list the proposed uses, Ecology will consult with the Department of Health to determine specific requirements.

Operators of the water reclamation treatment processes must produce consistent, high quality reclaimed water. When using stabilization ponds or lagoons for treatment, reclaimed water engineering design must include additional treatment units for reliable aeration and solids separation. Lagoons and stabilization ponds cannot consistently produce an effluent with BOD_5 and TSS concentrations of 30 mg/L. Chapter G3-3.5 also provides design criteria for secondary treatment pond and lagoon liners.

E1-4.1.1 Source Water Reliability

Reclaimed water requires the highest level of reliability to minimize the potential for release of inadequately treated water that would threaten public health or the environment. At all times, the water must meet the water quality standards for the use before distribution.

E1-4.1.2 Emergency Storage or Disposal

Design must include provisions for emergency storage or alternative disposal of water not meeting the requirements for use. Any release to the environment must also meet the applicable water quality standards for the receiving water. Emergency storage ponds storing wastewater requiring additional treatment must meet the liner requirements in Chapter G3-3.5.

Emergency storage and disposal measures must also comply with the reliability requirements in the state *Water Reclamation and Reuse Standards*.

- SECTION 1, Article 10, Section 4 – Storage, Where NO Approved Alternative Disposal System Exists.
- SECTION 1, Article 11, Section 1 – Alternative Reliability Requirements. Emergency Storage or Disposal

Many facilities and use areas must also store their reclaimed water or have provision for the emergency discharge when weather restrictions or insufficient demand or produced water quality prevents reclaimed water use. See E1-5.2.

E1-4.2 Regulatory Requirements

There are four classes of reclaimed water, differentiated by the degree (or absence) of additional treatment provided following secondary treatment. The four reclaimed water classes are defined in E1-1.3 and further described in Table E1-8. Typical uses for the reclaimed water classes are summarized in Table E1-1.

Table E1-8. Characteristics of the Four Classes of Reclaimed Water

Class	Characteristics
A	Class A reclaimed water will at all times be oxidized, coagulated, filtered, and disinfected wastewater. State water reclamation and reuse standards call for Class A reclamation water to be filtered to a turbidity level which does not exceed an average operating turbidity of 2 nephelometric units (NTU), determined monthly, and which does not exceed 5 NTU at any time. Filtration can be achieved by passing oxidized wastewater through natural undisturbed soils or through filter media such as sand or anthracite. Class A reclaimed water must be disinfected such that the median number of total coliform organisms in the wastewater after disinfection does not exceed 2.2 per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and such that the number of total coliform organisms does not exceed 23 per 100 milliliters in any sample. Class A reclaimed water is currently the only reclaimed water class for which Ecology requires coagulation and filtration. Further, the disinfection requirements for Class A reclaimed water are more stringent than for Class C or D reclaimed water (the disinfection requirements for Class B reclaimed water are identical to those for Class A). Class A reclaimed water must be used where the potential for public exposure to reclaimed water is high.
B	Class B reclaimed water will at all times be oxidized and disinfected wastewater. The wastewater will be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 2.2 per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform organisms does not exceed 23 per 100 milliliters in any sample.
C	Class C reclaimed water will at all times be oxidized and disinfected wastewater. The wastewater will be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 23 per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform organisms does not exceed 240 per 100 milliliters in any sample.
D	Class D reclaimed water will at all times be oxidized and disinfected wastewater. The wastewater will be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 240 per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed.

E1-4.3 Coagulation, Flocculation and Sedimentation (Rev. 10/2006)

Asano (1984) noted that in order to achieve efficient virus removal or inactivation in tertiary treatment, two major criteria must be met:

(1) The effluent must be low in suspended solids and turbidity prior to disinfection to prevent shielding of viruses and chlorine demand.

(2) Sufficient disinfectant must be applied.

The WRR Standards require chemical coagulation followed by filtration and disinfection to produce water suitable for Class A uses from an oxidized, secondary wastewater effluent. Secondary effluent achieves a monthly average total suspended solids concentration of 30 mg/L or lower. Coagulation and media filtration must further reduce solids concentrations to meet the Class A monthly average turbidity maximum of 2 NTU before disinfection. The sequencing of upstream treatment units and processes, fluid viscosity, settling behavior, and effective particle size all influence the effectiveness of particle removal. Since particles may interfere with disinfection effectiveness, removal is particularly important for uses with high public contact. To achieve these limits, standard design uses one of three types of treatment trains:

(1) Conventional filtration refers to sequential coagulation, flocculation and sedimentation units before filtration.

(2) Direct filtration refers to coagulation/flocculation units directly upstream of filtration units when flocculation occurs before the water reaches filtering media.

(3) In-line filtration, sometimes considered as a version of the direct filtration, is a treatment process that includes coagulant addition, rapid mixing and filtration, with flocculation occurring within the filter, requires a turbidity filter influent consistently below 5 NTU to achieve the 2 NTU requirement.

WRR Standards do not require coagulation or filtration for reclaimed water uses with restricted public access (Class B, C or D uses). However, the designer may consider including these processes to improve the water quality.

This section provides criteria for the most common types of chemical coagulation, flocculation, and sedimentation processes. Section E1-4.4 includes criteria for filtration and section E1-4.5 for disinfection.

E1-4.3.1 Coagulation

Coagulation, the destabilization and agglomeration of colloidal particles brought about by the addition of a chemical reagent or coagulant, must occur for effective particle removal. The engineer must determine the type of coagulation and mixing processes to use early in the design, based on water chemistry, pilot studies and experience. Chapter T-1 provides additional information on chemical addition.

A. Coagulant Dosing and Storage

Coagulation design must include the following:

- Provisions for multiple coagulants with separate injection points for each coagulant.
- Provisions for chemical pH control.
- Identification of the injection point for caustic soda or lime upstream of the coagulant addition.
- Contact times and the order of introduction of multiple chemicals
- Pilot studies or jar tests.

Coagulation occurs either by:

1. Charge Neutralization

Most colloidal particles in water have negative surface charges (zeta potential). Highly charged colloids will remain discrete, dispersed, and in suspension. Reducing or eliminating the charge has the opposite effect — the particles collide and form larger, easier to remove particles. Charge neutralization typically:

- Works at low chemical dosages producing small, destabilized pinpoint floc.
- Is ideal for treating low turbidity, low alkalinity effluent.
- Is followed by direct filtration or in-line filtration.

Charge neutralization reactions happen in fractions of a second. Design must disperse the chemical quickly and use rapid, high intensity mixing to allow achieving maximum contact between coagulant and particles in the water within the minimum time.

Charge neutralization depends on the water chemistry, type of coagulant, water temperature, and particles size and concentration in the water. With alum, charge neutralization typically occurs in a pH range of 3 to 5 standard units and chemical dosages less than 20 mg/L

For very low turbidity water, organic polymers are not effective as primary coagulants. Although coagulation by organic polymers occurs by charge neutralization, chemical reactions are slower (between 2 and 10 seconds) than with inorganic salts and dependant on the water temperature and alkalinity. Successful use of organic polymers as the primary coagulant may require a conventional filtration process train or extended contact time for the flocculation.

2. Sweep Coagulation

For sweep coagulation, design sufficiently high coagulant concentrations to cause precipitation of a metal hydroxide. Since reactions take between 1 and 10 seconds, instantaneous chemical dispersion and high intensity mixing are not as critical for this type of coagulation.

Sweep coagulation is typically:

- Suitable for treating low or high turbidity, high alkalinity waters.
- Followed by conventional filtration process trains.

For alum, sweep coagulation occurs with chemical dosages > 20mg/L and a pH range of 6-9 standard units.

Table E1-9 lists the most common coagulants and representative dosing rates.

Table E1-9. Representative Coagulant Dosing Rate

Coagulant	Representative Dosing Rate, ppm
Alum	**30 to 150**
Polyaluminum chloride (PaCl)	**15 to 75**
Ferric Chloride	**15 to 75**
Polymers	**0.05 to 2**

B. Jar Testing

Operators use jar testing as a process control and operation optimization tool for determining the optimal dosage of chemicals. Correct chemical dosing is particularly important in reaching the 2 NTU or less turbidity levels required for Class A reclaimed water. Underdosing will not remove sufficient particles. Chemical overdosing wastes products and may cause charge reversal and restabilization of the suspended colloids. Overdosing of anionic polymers may also cause settling problems since they are less dense than water. The optimal dose and order of chemical use depends upon factors such as:

- Variation in water quality
- Concentration of metals
- Chelants and complexing agents in solution
- Turbidity
- Alkalinity
- pH
- Temperature
- Viscosity (which is temperature dependent)
- Residual oxidizers present
- Other properties of the effluent

Jar testing should follow the manufacturer's protocols and test a range of doses and pH values. A series of several replicates usually provides enough data to determine which coagulant and at what dose, contact time, and pH value produces optimal removal of colloids. Most jar testing devices test 6 jars at once. This allows simultaneous comparison either visually or by turbidimeter.

Although some facilities require infrequent adjustments, this manual recommends weekly jar testing for most Class A reclaimed water facilities. Facilities with wide variations in influent quality, operating near design limits or experiencing operational difficulties may benefit from daily or more frequent testing. Factors to consider in determining jar-testing frequency or adding other process control tests such as a particle counter include:

- How well the jar test simulates the treatment process.
- The range of water quality conditions occuring in the treatment system.
- Coagulants available.
- The usable range of coagulant concentration.
- The pH range.
- Whether the coagulants used alter the pH of the solution.
- Duration of the rapid mix?
- Whether a facility uses an inline mixer or a mixing tank.
- Evidence of flocs breaking up.
- If there a minimum or maximum floc size required.
- Settling time in relation to the existing plant design.
- Evidence of hindered settling.

A more complete laboratory analysis may use particle counters to identify particles in specific size bands and produce "before" and "after" data showing the size and percentage removal of the particles.

Particle counters extend the sensitivity of particle detection beyond that achievable with turbidimeters. The sensitivity of the particle counter can detect the effects on effluent quality due to operational procedures, chemical dosage and type, and parametric changes. As a result, simple and affordable means of filtration enhancement can often be evaluated for their effectiveness before considering more complicated and expensive ones.

C. Rapid Mixing

Proper chemical mixing (also called flash or rapid mixing) is fundamental to satisfactory coagulation. The physical process of dispersing chemical additives into the effluent stream typically takes place either in a mechanical mixing tank or with an in-line mixing device. Additional design information on these units follows below. Engineers should provide justification including pilot testing results when recommending other types of mixing devices.

Asano, (1998) lists hydraulic detention time at peak hour flow as the controlling design criteria for rapid mixing units. Hydraulic detention time is typically 1.0 second with a range of 0.5-5 seconds.

1. Mechanical Mixing

Mechanical rapid mixing units are effective for the addition of coagulants prior to flocculation. Design criteria include the following:

- Average rapid mix detention periods not exceeding 30 seconds.
- A spare motor when only a single mechanical mixer is used.
- Cleaning and draining of the rapid mix basin.

According to Metcalf and Eddy, (Tchobanoglous et al., 2003) applied mixing energy should generally achieve an average velocity gradient (G) value in the range of 1500 sec^{-1} to 6000 sec^{-1} for rapid mixing prior to flocculation. The design engineer should submit the design basis for the G selected, considering the chemicals, water temperature, color and other related parameters.

In design calculations, G is the square root of the power input (P) divided by the product of dynamic viscosity (μ) and the effective volume (V).

$$G = \sqrt{\frac{P}{\mu V}}$$

(1) Effective volume (V) indicates the contact time provided in the process. This is not the physical dimensions of the vessel.

Effective volume depends on tank inlet and outlet locations and conditions, internal baffling, and the type of mixing.

(a) Rectangular, unbaffled contact tanks often provide effective volumes of 10 percent to 15 percent of the physical volume.

(b) The effective volume, often identified as a *baffling factor*, is expressed as a proportion [i.e., 0.1 to 0.15] or *hydraulic efficiency* of the tank expressed as a percentage of the physical volume [i.e., 10 percent to 15 percent].

(2) The dynamic viscosity (μ) varies with temperature and calculations should address the expected range.

2. In-line Mixers

Static in-line mixers use a circuitous path through fixed blades or chambers to achieve rapid mixing. Dynamic in-line mixers use powered impellers. Mixing generally occurs within 1 second. Use manufacturer's recommendations and/or studies for static mixer design. Provide for cleaning or removing in-line mixer components without excavation.

E1-4.3.2 Flocculation

Flocculation is a process of gentle stirring and mixing to enhance contact of destabilized particles and to build floc particles of optimum size, density, and strength for removal through settling or filtration.

Polymeric flocculant aids may improve floc size and settling rates. Floc particles remain fragile and the shear force of mixing can break them easily. For this reason, flocculation requires adequate detention time (t) at low velocity gradients (G), making Gt the basic design parameter.

Flocculation units vary widely and design may provide for flocculation:

- Within plant piping followed by sedimentation or filtration units.
- Directly within the filtration process units.
- In separate flocculation basins.

Flocculation basin design must include baffling to minimize short-circuiting. Typical design values for flocculation basins include:

- Hydraulic detention time (t) of 20 minutes with a range from 10-30 minutes.
- Velocity gradient (G) of 40 sec-1 with a range from 20 to 100 sec^{-1}.
- Typical mixing energy-detention time (Gt) of 50,000 with a range of 20,000 to 150,000.

E1-4.3.3 Sedimentation

Reclaimed water process design may include sedimentation units following coagulation or flocculation unit processes. This is standard practice in conventional potable water treatment. Critical sedimentation design parameters include depth, detention times, surface area, and overflow rates. Units may operate in a variety of configurations including horizontal flow, upflow, or upflow solids-contact. Upflow solids-contact units combine chemical mixing, flocculation, and up-flow sedimentation in a single unit. Hydraulic loading rate during peak hour flow average 800 gal/ft^2-d for conventional settling. High-rate clarification units followed by tube or plate settlers may have much higher overflow rates. The engineer must be able to justify solids removal at high overflow rates using pilot studies and settling column analyses.

Reclaimed water facility design may consider using chemical coagulation prior to secondary clarifiers designed similarly to CEP units (see T-4-1). This may reduce chemical costs and aid in sludge dewatering. However, Class A reclaimed water design must still include design provisions for coagulant addition *after* secondary clarification. In general, coagulants are necessary *after* secondary clarification when the filter influent turbidity exceeds 5 NTU for more than 15 minutes. Class A water reclamation facilities using this design, must install continuous on-line turbidimeters prior to filtration units

E1-4.4 Filtration

The unit treatment processes in this section include media and membrane filtration. State standards require filtration for Class A or higher reclaimed water uses. Filtration minimizes virus and pathogen carryover to the disinfection process. Turbidity indicates filtration effectiveness. When filtration is required for reclamation or reuse of wastewater, state standards also require the addition of coagulants before filtration.

Although filtration is not required for reclaimed water uses restricting public access, design should consider the potential for filtration to improve the quality of Class B, C or D reclaimed water. The 2004 Ten State Standards recommend filters to reliably obtain effluent concentrations less than 20 mg/L or phosphorus concentrations below 1 mg/L. Section E1-4.4 includes criteria for filtration and section E1-4.5 for disinfection.

E1-4.4.1 Media Filtration

Upstream treatment processes influence the ability of media filtration to produce an effluent meeting an average turbidity below 2 NTU and a maximum turbidity of 5 NTU prior to disinfection. Class A reclaimed water must meet this requirement at all times. Section E1-4.3 explains the differences in the upstream treatment processes for conventional, direct and in-line filtration treatment methods.

To demonstrate meeting the turbidity requirement, Ecology requires, at a minimum, a single continuous on-line effluent turbidimeter installed prior to the disinfection units

- Preferred design equips each filter with an individual on-line continuous monitoring turbidimeter. Individual setpoints allow for better operational controls to meet overall plant reliability.
- When using upstream processes other than conventional filtration, Ecology also requires monitoring the filter influent turbidity. Although facilities may use grab samples, preferred design provides continuous on-line monitoring. The facility recovers costs of the on-line equipment with reduced operator and laboratory time.
- Ecology may require additional turbidity monitoring at facilities that do not consistently achieve the turbidity standards.

A. Media Filtration Methods

To achieve Class A reclaimed water standards, facilities generally use one of four basic types of media filters: rapid sand filters, continuous backwash filters, cloth media filters, and compressible media filters. Filter design should follow guidelines in Chapter T4-2 and manufacturer's recommendations. Critical parameters generally include porosity and filter depth. Table E1-10 provides representative hydraulic loading rates for different filter types.

Table E1-10. Representative Filter Hydraulic Loading Rates

Filter Type	Hydraulic Loading, gpm/sf
Rapid sand	
Single medium	**3**
Multimedia	**6**
Slow sand	**0.1**
Automatic backwash	**3**
Moving bed, continuous backwash (all media)	**Dependant on demonstrated or justified manufacturer's values**

The California Department of Health Services' (CDHS) *Treatment Technology Report for Recycled Water* contains typical design specifications for commonly used filters. For other types of filters, the proponent should provide pilot testing data demonstrating the reliability of the filter in meeting the turbidity standard prior to Ecology acceptance of the technology. Pilot testing should include or closely approximate the range of water quality and upstream unit processes proposed. Pilot testing should be sufficiently long to demonstrate reliable treatment during various seasonal and other expected conditions. See G1-5.4.1.

B. Filter Backwashing

Backwashing is used to clean filter media and restore its initial capacity to remove particulate matter from water. As particles collect on the surface or within the filter media, pressure increases to maintain filtration capacity. These higher pressures push more accumulated particles through the filter resulting in degraded filtrate quality. Some filters backwash continuously. Other filters backwash at pre-determined set-points. Design must assure removal of all inadequately filtered water from the reclaimed water process stream.

1. High-Rate Rapid Sand Filters Backwashing

Rapid sand filters initiate backwashing at predetermined setpoints for high effluent turbidity, high head loss, time, throughput (produced volume of the water), or operator preference. Typical cycles begin with an initial surface wash for 5 to 10 minutes.

The standard hydraulic backwash cycle design provides water flowing in an up-flow mode at a rate of 15 to 25 gpm/sf (30-percent bed expansion). Typically, the filter operates in backwash mode for 10 to 15 minutes and uses 3 to 5 percent of the total filter throughput. The backwash flow rate depends on the water temperature and may need adjustment in response to temperature restrictions on bed expansion.

There are a wide variety of air-water backwash processes and combinations designed to maximize removal of the accumulated filter particles while using the minimum backwash water volume. In a typical design using air scour to supplement hydraulic washing, air is injected at a rate of 2 to 5 scfm/sf for 2 to 5 minutes, followed by hydraulic backwashing at rates of approximately 10 gpm/sf (to achieve a bed expansion of 10 percent). This sequence will generally consume less water (approximately 2 to 3 percent of the filter throughput) than conventional hydraulic backwashing. When the backwashed filter returns to service, an increased numbers of particles and pathogens pass through a filter until completion of a filter "ripening" or maturation period. The removal capacity of the filter then returns to normal levels. Filtration units must include a filter-to-waste cycle to allow the return of lower quality water produced in the first 10 to 30 minutes of a filter run for treatment.

Design must provide control elements and piping to divert the initial filter production to a waste stream. Design may tie the duration of the filter-to-waste cycle to the actual turbidity of the wasted water or to a pre-determined time.

Design should include precautions to prevent backflow from the filter-to-waste stream to any component of the potable water supply system.

2. Continuous Backwashing Counter-Current Upflow Filters

This filter operates with continuous backwash using an airlift tube located in the center of the filter. Unfiltered water enters near the bottom of the filter and flows to the top of the filter. The airlift tube also continuously pumps a small portion of the dirty filter media from the bottom of the filter to the top of the filter.

During passage up the airlift tube, air and water scrub the dirty media separating the lighter debris from the heavier media. The cleaned media returns to the top of the filter and the backwash waste stream carries off the debris.

The backwash waste stream is 3 to 5 percent of the total filter throughput. The backwashing process usually operates at a rate of 0.1 to 0.5 gpm of water per square foot of filter media surface area and 0.4 to 0.1 scfm air flow per square foot of media surface area.

3. Rotating Filter Disk Type

A rotating filter disk device consists of a series of disks covered in a fabric media. This type of unit is backwashed intermittently (depending on raw water quality) with two of the filter disks under backwashing while the remainder of the filter remains in filtration mode. As the disks rotate, they expose a small portion of the disk to an automatic backwash stream. The process uses approximately 1 percent of the filter throughput for backwashing. This backwashing procedure reverses the flow of water across the filter media by conveying clean water through the filter fabric to the inlet side of the backwash pump.

4. Compressible Fiber Filters

These filters, consisting of compressible fiber sphere media, are backwashed with an air scour/hydraulic backwash regimen. Since the media is very light, compressible, and filtration is done in an upflow mode, an upper plate (movable) is used to retain media in the filter. This filter retaining plate is moved upwards during the backwash cycle to permit media expansion. Air is applied at a rate of up to 15 scfm/sf and backwash water is applied at values of 10 gpm/sf. Backwashing typically utilizes approximately 2 to 4 percent of the filtered water throughput. After the backwashing cycle in which the media is allowed to expand, a flush cycle is used to complete the backwashing procedure while the media retaining plate is lowered to its "filtration" position.

E1-4.4.2 Membrane Filtration

RESERVED - See Chapter T-6 for a discussion of membrane bioreactors.

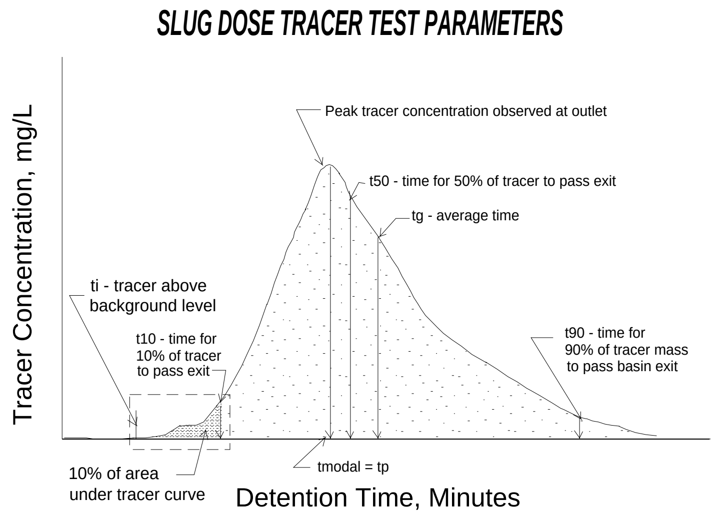
E1-4.5 Disinfection Requirements

Disinfection is one of the most important steps in the production of reclaimed water. The Water Reclamation and Reuse Standards differentiate the different classes of reclaimed water (Class A, B, C, and D) primarily through the respective levels of disinfection required. Table E1-11 lists regulatory requirements. Chapter T5 provides basic information on disinfection design requirements.

E1-4.5.1 Chlorine Disinfection

A. Definitions

- CT is the product of disinfectant residual concentration in mg/L and effective contact time in minutes.
- Free available chlorine is the quantity of dissolved gas Cl2, hypochlorous acid HOCl and hypochlorite ions OCl^- present in the water.
- Combined available chlorine is the quantity of chlorine combined with ammonia to form one of three types of chloramines . Chloramines provide much lower inactivation rates than free chlorine in the same concentration.
- Total chlorine is the sum of both free and combined chlorine.
- t_{10} is the amount of time required for 10 percent of the volume of a slug of tracer material introduced at the entrance to a basin to reach the basin exit. In other words, the basin retains 90 percent of the fluid entering the basin for this length of time.
- t modal is the amount of time for the peak concentration of a tracer slug to reach the basin exit



Slug Dose Tracer Test Performance Determinations		Recommended Values
Index of average detention time	tg/T =	0.8
Index of mean detention time	t50/T =	0.8 - 1.2
Index of modal detention time	tp/T =	> 0.9
Morrill Index	t90/t10 =	< 2.0
Short circuiting index	ti/T =	> 0.5

Figure E1- 3 Slug Dose Tracer Test Parameters

B. Design Criteria

Design of all chlorination systems should generally follow the criteria listed in Chapter T5-4.

When using chlorine as the disinfectant, state reclaimed water standards require a minimum CT of 30, based on a minimum free available chlorine residual of 1.0 mg/L after a t_{10} contact time of at least 30 minutes. The basis for using this method is disinfection requirements developed for the safe drinking water act.

An alternative approach is to provide a CT of 450 based on a total chlorine residual of at least 5 mg/L after a *modal* contact time of at least 90 minutes. Note that this approach may not provide the same level of pathogen inactivation as will the first. This approach, used in the state of California, presumes a level of disinfection to provide essentially pathogen free water.

In addition, the conveyance system to the use areas must maintain a minimum residual chlorine concentration of 0.5 mg/L at all locations within the distribution system. State standards do not require maintaining a chlorine residual in reclaimed water impoundments or storage ponds. However, Department of Health (DOH) or Ecology (ECY) may require a chlorine residual when distributing reclaimed water from storage. DOH and ECY may waive the minimum chlorine residual requirement under certain conditions. For approval, proponents must demonstrate that their alternative provides an equal degree of reliability and document their distribution system maintenance procedures.

E1-4.5.2 Ultraviolet Disinfection (UV)

Chapter T5-2 describes UV disinfection. UV is a highly effective means of disinfection when applied to water with relatively low TSS, high transmittance, and small particles. The design of UV disinfection systems depends on the effectiveness of the upstream unit processes in removing solids and reducing effluent turbidity. For reliable performance, filtration units should precede ultraviolet disinfection.

Although UV disinfection without pre-filtration may be sufficient for water reuse activities requiring less stringent pathogen removal, most secondary effluents contain particles that shade microorganisms making UV disinfection less effective. Since the type of biological treatment affects the type of solid generated during treatment, treatment processes have a significant effect on the effectiveness of disinfection provided by UV. Proponents of UV disinfection systems without pre-filtration must demonstrate consistently reliable performance based on the type of secondary treatment before DOH and ECY will approve these systems for reclaimed water uses.

The 2003 Guidelines published by the National Water Research Institute (NWRI) in collaboration with the American Water Works Association Research Foundation (AWWARF) provides the basis for the following minimum criteria

A. Design Dose

Section T5-2.1.5 defines basic UV terminology including the UV dose as the product of intensity (milliwatts per square centimeter) and the exposure time of the fluid or particle treated (seconds). The units of UV dose are $mW{\cdot}s/cm^2$ or mJ/cm^2.

Non-ideal hydraulics and non-uniform intensity profiles result in a distribution of dose applied in continuous-flow UV reactors. Given the high levels of disinfection required for reclaimed water, the following subcategories further define UV dose for the reliability of performance required in reclaimed water.

- Design dose – The dose required for specific log inactivation of the target pathogens – the dose used to size the disinfection units.
- Delivered dose – The measured dose assigned to a reactor based on reactor validation testing by collimated-beam apparatus.
- Operational dose – the dose established for a reactor based on equipment validation testing. Operational dose allows the most efficient use of the disinfection system while maintaining the required design dose.

The UV system must be designed for the maximum flow (peak hour) rate at the end of the lamp life. The following design conditions apply to the design UV dose for reclaimed water use:

- UV lamp output at 50 percent of new (nominal) UV lamp output after an appropriate burn-in period, unless the manufacturer establishes the lamp age factor for another time period corresponding to the lamp change-out intervals specified in the Operations and Maintenance Manual.

- 80 percent UV transmittance through the quartz sleeve excluding the transmittance characteristics of the quartz sleeve. For automatic cleaning systems, the designer may provide test data to substantiate a higher value based on the manufacturer's cleaning frequency.
- The designer may use a 10-percentile UV transmittance value based on actual UV transmittance data collected for a period of at least six months, including wet weather periods. Data must include a minimum of three samples per day spaced equally over the operating period.
- Shelf life of the replacement lamps are in accordance with the manufacturer's recommendations.

B. Reactor Design Validation and Field Commissioning Test

Section T5-2.2 discusses the major parameters considered in UV designed for wastewater effluent. Much of the same information applies to reclaimed water. Because of the numerous system configurations, UV systems will have different scale-up, layout, and mechanical redundancy requirements. For reclaimed water applications, DOH and ECY will not allow scale-up of pilot data for full-scale design unless the designer adequately quantifies the systems velocity profiles of both the validation testing equipment and the full-scale reactor.

DOH and ECY require validation testing of UV equipment performance. Design must specify a validation protocol such as the NWRI/AWWRF 2003 Guidelines, EPA Guidelines or other standard engineering practice. Field validation is required if the UV unit has not been validated under accepted third party protocols such as NWRI./AwwaRF 2003 Guidelines the EPA ETV Guidance or the German DVGW or Austrian ONORM validation protocols for prefabricated UV reactors. For previously validated UV equipment, the UV installation shall be field commissioned in conformance with acceptable protocols such as those in Part 2, Section 6 of the NWRI/AwwaRF 2003 Guidelines.

C. Design Reliability

For reclaimed water uses, the reliability of any proposed UV disinfection system is critical. Reclaimed water must meet all performance standards prior to distribution. Engineering design must provide for all of the following:

- A minimum of two UV reactors must operate simultaneously in any on-line reactor train. This ensures that disinfection occurs while operators bring the standby reactor on-line.
- Standby equipment must provide either a standby reactor for each reactor train, a standby reactor train, alternative disinfection such as chlorine, or adequate storage.
- A contingency plan when feed water quality is not suitable for UV disinfection due to excessive turbidity, low transmittance, a high number of particles or the like.
- A contingency plan to contain any released mercury due to lamp breakage.

- Operation and maintenance procedures and training.
- Provisions for power supply reliability must include short-term power interruptions, ambient temperature, and system harmonics.
- Continuous monitoring of the following parameters per reactor: flow, UV intensity, UV transmittance, turbidity, and operational UV dose.
- Monitoring of the following components: individual UV reactor status, individual lamp status, lamp age in hours, cumulative number of reactor on/off cycles, cumulative power consumption, reactor power set point, liquid level in reactor train for all free water surfaces and other installation where lamps may be exposed to air.
- Protocols for verification and calibration of all monitoring equipment.
- Minimum alarms and protocols for predetermined set points.
  - Lamp failure alarms – individual, adjacent lamps, more than 5 percent total.
  - UV intensity – low and low-low set points.
  - UV transmittance – low and low-low set points.
  - High and high – high turbidity set points.
  - Low and low – low operational dose.
  - High and low water levels.
  - Ground fault interrupter (GFI)

D. Post-filtration UV Performance Design Criteria

The 2003 Guidelines published by the National Water Research Institute (NWRI) in collaboration with the American Water Works Association Research Foundation (AWWARF) provides the basis for the following minimum criteria. Criteria listed below apply to the disinfection of a Class A (oxidized, coagulated, filtered) reclaimed water that is essentially pathogen free. Pre-disinfection TSS concentrations below 5 mg/L are usually necessary to consistently achieve Class A quality. State WRR standards require a pre-disinfection turbidity of less than 2 nephelometric turbidity units (ntu). Post disinfection Class A presumes that the combined virus removal through filtration and disinfection processes will be a minimum of 5-log inactivation.

The following guidelines establish separate performance criteria for disinfection following media filtration, membrane filtration and reverse osmosis filtration systems:

(a) Media Filtration (Granular, Cloth or Other Synthetic Media listed under E1-4.3.2)

- Design (and delivered) dose of at least 100 mJ/ cm^2 under maximum day flow.
- Filtered UV transmittance at least 55 percent at 254 nm.

- 24-hour average turbidity no greater than 2 ntu and not exceeding 5 ntu at any time.
- 7-day median total coliform equal or less than 2.2 MPN/100 mL and no sample above 23 MPN/100 mL.

(b) Microfiltration or Ultrafiltration Membrane Filtration

- Design (and delivered) dose of at least 80 mJ/ cm^2 under maximum day flow.
- Filtered permeate UV transmittance of at least 65 percent at 254 nm.
- 24-hour average turbidity no greater than 0.2 ntu and not exceeding 0.5 ntu at any time.
- No detectable total coliform.

(c) Reverse Osmosis Filtration (RO)

- Design (and delivered) dose of at least 50 mJ/ cm^2 under maximum day flow.
- RO permeate UV transmittance of at least 90 percent at 254 nm.
- 24-hour average turbidity no greater than 0.2 ntu and not exceeding 0.5 ntu at any time.
- No detectable total coliform.

E1-5 Distribution and Storage

This section is intended to provide criteria for protection against the misuse of distribution facilities. Assurances that reclaimed water is adequately disinfected are required to ensure public safety and to minimize growth in the distribution systems. Cross connection control is needed to prevent a reclaimed main from mistakenly being connected to a potable system. Therefore, the location, depth, identification, and type of aboveground appurtenances, such as air/vac assemblies and blow-offs, should be studied carefully to avoid cross connections or inappropriate uses.

E1-5.1 Conveyance Requirements

E1-5.1.1 Disinfection

See E1-4.5 for a discussion of disinfection requirements for the four classifications of reclaimed water. The distribution system should take into account several important concerns about disinfection from Article 9, Section 5 of the water reclamation and reuse standards. See also general information in Chapter T4.

E1-5.1.2 Distribution System Requirements

Where the reclaimed water distribution system is not under direct control of the permittee, a binding agreement among the parties involved is required to ensure that construction, operation, maintenance, and monitoring meet all requirements of DOH and Ecology. All reclaimed water valves and outlets shall be of a type (or secured in a manner) that permits operation only by authorized personnel.

A. Pressure

Pressure requirements should be based on system design and practice. In any case, minimum pressure at the user's meter should be maintained at the peak demand hour. It is desirable that a pressure differential of 10 psi or greater be maintained, with the potable water supply having the higher pressure.

B. Minimum Depth

The top of the pipe should be a minimum of 36 inches below the finished street grade.

C. Minimum Separation (Rev. 10/2006)

When running parallel, reclaimed water lines should be installed a minimum of 10 feet horizontal from any potable water lines or sanitary sewer lines. Whether running parallel or crossing, reclaimed water lines should be installed a minimum of 18 inches below any potable water lines and a minimum of 18 inches above any sanitary sewer lines. Measurements should be taken from the outer diameter of the pipes. See Figure E1- 4.

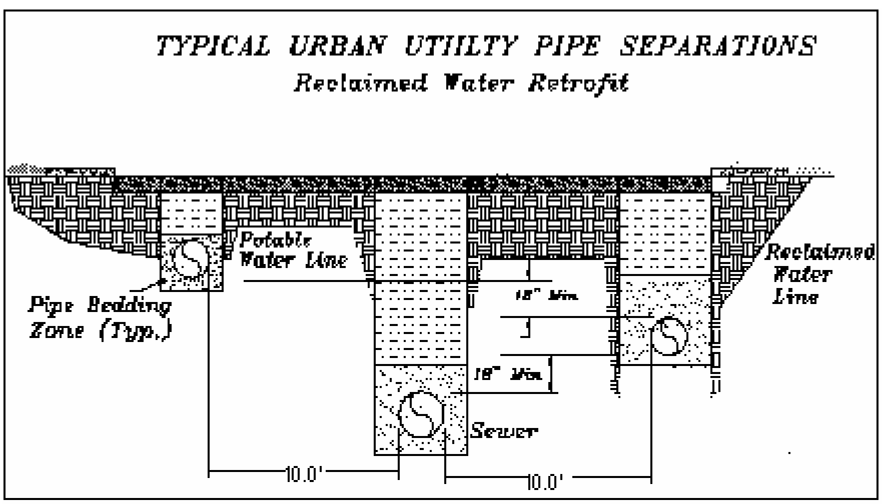


Figure E1- 4 Standard Horizontal Pipe Separation New Construction Detail of Reclaimed Water in Developed Utility Corridor

In urban retrofit or similar situations where the above separations cannot be maintained, the project should use special construction mitigation techniques approved by DOH and Ecology. The Washington State Department of Ecology and the Department of Health have developed a more detailed guidance to assist utility engineers with non-standard pipeline separation design and installation. See Ecology publication number 06-10-029, *Pipeline Separation Design and Installation Reference Guide*.

E1-5.1.3 Pipe Identification

A. General

All new, buried distribution piping in the reclaimed water system, including service lines, valves, and other appurtenances, should be identified as follows:

- Be color-coded and embossed or be integrally stamped/marked with the approved warning (see Table E1-9).
- Be installed with identification tape or a polyethylene vinyl wrap (see Table E1-9).

The warning shall be stamped on opposite sides of the pipe and repeated every 3 feet or less.

Table E1-9. Identification Standards for Reclaimed Water Systems

Item	Suggested Standard (Must be Acceptable to the Review Agencies)
Color	Pantone 512 or 522, or other shades of purple acceptable to review agencies.
Warning	Should be either one of the following phrases: • WARNING: RECLAIMED WATER-—DO NOT DRINK • WARNING: NONPOTABLE WATER-—DO NOT DRINK
Identification (Warning) Tape	The tape (color-coded, as listed above) should include the warning (listed above) in high-contrast lettering. The overall width of the tape should be at least 3 inches.
Equipment Tags and Surface Identification	The words RECLAIMED WATER should be clearly inscribed on equipment tags and the top surface of below-grade appurtenances, such as valve boxes.
Facility Signs	Signs (color-coded, as listed above) should include the warning (listed above) in high-contrast lettering and must have the universal symbol for “do not drink.” An adequate number of signs in English and other primary languages spoken in the area should also be posted on the surrounding fence and at the entrance of each facility.

B. Conversion of an Existing Potable System to a Reclaimed System

Existing potable water lines that are being converted to reclaimed use should first be accurately located and tested in coordination with regulatory agencies. If required, the necessary actions to bring the water line and appurtenances into compliance with the water reclamation and reuse standards should be taken. If the existing lines meet approval of the water supplier and regulatory agency, the lines may be approved for reclaimed distribution. If verification of the existing lines is not possible, the lines should be uncovered, inspected, and identified prior to use. Specific precautions should be made to ensure there are no unintended connections to the existing water system. Prior to being used, the line should be thoroughly tested, using dye, pressure, or other methods, to ensure there are no cross connections or unapproved connections.

In actual practice, it will be very difficult to fulfill the above requirements, verify that there are no cross connections or unapproved connections, and ensure that all potable water customers have been removed from the intended water lines.

There are serious concerns for converting an existing potable water system to a reclaimed water system and accordingly this practice is discouraged by Ecology.

C. Identification Tape

Tape (see Table E1-9) should be installed and centered on top of the transmission pipe longitudinally. The identification should be continuous on the pipe and fastened to each pipe length at least every 10 feet. Tape attached to sections of pipe before they are placed in the trench should have flaps sufficient for continuous coverage. Other satisfactory means of securing the tape during backfill of the trench may be used if approved by the review agency.

Color-coded identification tape differentiating the reclaimed piping from other utility lines should be consistent throughout the service area. The agency should develop a standard specification and details for meeting these requirements, and be consistent.

Other pipe and construction warning tape schemes may be acceptable to the review agencies provided the colors and messages are consistent with the details of E1-5.1.3.

E1-5.1.4 Valve Box and Other Surface Identification

A. General

Valve boxes should be a standard concrete or fiberglass box with a special triangular, heavy-duty cover. All valve covers on offsite reclaimed transmission water lines should be of noninterchangeable shape with potable water covers and a recognizable inscription cast on the top surface (see Table E1-9).

B. Identification

All aboveground facilities should be consistently color-coded (see Table E1-9) and marked to differentiate reclaimed water facilities from potable water or wastewater facilities.

E1-5.1.5 Blow-Off Assemblies

Either an inline or end-of-line type blow-off or drain assembly should be installed for removing water or sediment from the pipe. The line tap for the assembly should be no closer than 18 inches to a valve, coupling, joint, or fitting unless it is at the end of the line. If there are restrictions on discharge or runoff, the regulatory agencies should be consulted to find an acceptable alternative.

E1-5.1.6 Fire Hydrants

Where the reclaimed water system includes fire hydrants, each fire hydrant shall be identified with a tag in addition to being color-coded (see Table E1-9). The fire department and municipal water department should be instructed in the use and care of the equipment when the hydrants are being flushed to avoid overspray, and on the care of any equipment that may be subsequently used for a potable water use.

E1-5.2 Storage and Supply (Rev. 10/2006)

Because there are daily and seasonal imbalances between reclaimed water supply and demand, the reclaimed water system frequently includes operational or seasonal storage facilities. Subsequent ponds storing reclaimed water are also subject to the requirements in this section.

State standards, SECTION 1, Article 12, Section 4 in *Water Reclamation and Reuse Standards* specify the required setback distances from potable water supply wells.

Typical design solutions for reclaimed water storage include:

- Storage of reclaimed water in leak-proof, fabricated tanks where feasible.
- Design of all storage ponds or reservoirs to prevent groundwater contamination.
- Use of synthetic membrane liners meeting the requirements in Chapter G3-3.5.
- Justification for use of earthen or other liners designs based on the reclaimed water quality and site conditions. See E1-5.2.1.

E1-5.2.1 Alternative Design for Reclaimed Water Storage Ponds

Ecology may consider other designs if, after the review of data submitted by the reclaimed water provider or user, the agency determines complete containment of the reclaimed water is not necessary. Factors include the reclaimed water quality, volume of storage, soil and geologic data, and ground water data, including its quality, uses, quantity and yield, and an adequate demonstration that the reclaimed water will not impair ground water quality.

If design proposes earthen liners, include the following or justify alternatives:

- Soils used for pond lining free from foreign material such as paper, brush, trees, and large rocks.
- All soil liners constructed of compacted material at least 24 inches thick, compacted in lifts no greater than 6 inches thick, and compacted to 95 percent of Standard Proctor Density.
- In-situ clay soils meeting the soils liner requirements, excavate and re-compact a minimum of 6 inches below planned grade to assure a uniformly compacted finished surface.
- Soil liners meeting the following particle size gradation and Atterberg limits:
  - Thirty percent or more passing a number 200 mesh sieve.
  - A liquid limit of 30 percent or greater.
  - A plasticity index of 15 or greater.
  - A permeability less than or equal to 1 X 10-7 cm/sec.
- Soil embankment walls with a top width of at least five feet.
- The interior and exterior slopes of soil embankment walls should be no steeper than one foot vertical to three feet horizontal.

- Protection for all soil embankment walls with a vegetative cover or other stabilizing material to prevent erosion.
- Installation of erosion stops and water seals on all piping penetrating the embankments.

E1-5.2.2 Seasonal Storage

Open reservoirs may be the most economical alternative for seasonal storage. However, algal growth and suspended solids from open reservoirs are sources of particles that may clog the sprinkler system. Reservoirs may also require additional measures to prevent breeding of vectors and the creation of odors, slimes, or aesthetically displeasing deposits.

All irrigation water that enters the distribution system from open reservoirs should be filtered or screened. The minimum acceptable screen size is 200-mesh (microstrainer). The use of a very fine strainer or filter will remove the greatest percentage of suspended solids at central reservoir sites and minimize the need for special maintenance of the local sprinkler systems. Most sprinkler system control valves and sprinkler heads readily pass particles through a 30-mesh screen (screen opening of 0.0233 inch or 600 microns).

E1-5.2.3 Operational Storage Facilities

Operational storage provides a continuous supply of water during periods of downtime at the treatment plant, meets peak daily fluctuations in water demands, and allows for optimum plant operation. Standard design for operational storage facilities is 1.5 to 2.0 times the average summer-day demand volume.

When sizing the storage facilities, consider the degree of fluctuation and availability of supplemental supplies. Reducing peak period pumping charges may also reduce costs. When supplementary water sources (potable or other supplies) can meet peak demands, smaller operational storage facilities may be sufficient to control supplies into the distribution system.

E1-5.2.4 Backup Supply and Storage Requirements

Distribution systems may require supplementary sources to meet demand during a plant disruption or main supply interruption. Each system’s required storage capacity will be different, depending on the following factors:

- Reliability of treatment processes
- Peak summer demands
- Availability of other sources
- The proposed reliability of the system
- End user (customer) agreements
- Ability to recover to normal conditions

Seasonal or operational storage facilities may be able to meet emergency storage requirements, depending on their storage capacities. If a system lacks necessary emergency storage capacity and the agency has made commitments ensuring an uninterrupted supply, it should have at least one reliable supply source to meet its demand. If the system requires potable water makeup, introduce the potable water into the reclaimed water system with an air-gap pump station. When reclaimed water contracts allow interruption of supply, emergency storage systems may not be necessary.

E1-5.2.5 Fencing

Reclaimed water supply reservoirs that are closed to the public should be enclosed within a fenced area or other acceptable enclosure that will prohibit public access. Fencing also helps minimize vandalism or damage from animals. Adequate measures shall be taken to prevent breeding of vectors with potential effects on public health and the creation of odors, slimes, or aesthetically displeasing deposits.

E1-5.2.6 Identification

Use signs to identify all storage facilities. (see Table E1-12).

E1-5.3 Pumping

Agencies with pumping facilities to distribute reclaimed water should make special provisions to identify the type of water being handled, provide acceptable backflow protection, and avoid release of reclaimed water in an uncontrolled manner.

E1-5.3.1 Marking

All exposed and aboveground piping, fittings, pumps, valves, and so on should be color-coded (see Table E1-9). In addition, all piping should be identified using an accepted means of labeling with the approved warning (see Table E1-9).

In a fenced pump station area, at least one sign (see Table E1-9) should be posted on the fence which can be easily read by all operations personnel using the facility.

E1-5.3.2 Sealing Water

Any potable water used as seal water for reclaimed water pump seals should be adequately protected from backflow, and proper drainage of the packing seal water should be provided.

E1-5.3.3 Surge Protection

All pumping systems should have proper surge protection facilities to prevent damage resulting from water hammer and pressure surges that can cause broken piping or damage to pumping equipment.

E1-5.4 Tank Trucks

Tank trucks and other equipment used to distribute reclaimed water shall meet certain criteria, as follows:

- Be clearly identified with advisory signs.
- Not be used to transport potable water that is used for drinking or other potable purposes.
- Not be filled using onboard piping or hoses that may subsequently be used to fill tanks with water from a potable water supply.

- Be inspected and approved for such use by the water supplier that provides potable water to the use area prior to transporting reclaimed water.

E1-6 On-Site Applications

The purpose of this section is to describe operational features and design issues with the distribution of reclaimed water. Because suspended matter may exist in the reclaimed water, certain features must be incorporated into the design of a project for safe and adequate distribution of the water.

E1-6.1 Strainers at Meter

Depending on the quality of reclaimed water and the type of storage used, strainers may be required at the consumer's meter. Strainer types that are generally satisfactory are as follows:

- **Wye strainers.** Not recommended for belowground installations (in vaults).
- **Basket strainers.** Suitable for aboveground or belowground installations (in vaults).
- **Filter strainers.** Normally used above ground on drip systems.

Strainers are normally the same size as the line and can be installed before or after the meter. In choosing the location, consider the following:

- Installation **before** the meter will protect the meter as well as the on-site reclaimed water system. Maintenance of the strainer will be the responsibility of the reclaimed water purveyor.
- Installation **after** the meter will not provide meter protection, and maintenance is usually not the responsibility of the purveyor. It should be noted in advance of this placement if there will be debris in the reclaimed water that may plug the screen in the meter.

Strainers can range in mesh size from 20 to 325. A mesh size of 20 to 80 is normally adequate. An analysis of the potential debris in the reclaimed water will aid in prescribing the optimum size. In order to reduce maintenance, material that will not plug on-site irrigation nozzles should normally be allowed to pass.

E1-6.2 Controllers

Controllers are used to automatically open and close on-site distribution valves. The following design features should be followed:

- Controllers should be fully automatic.
- Controllers should have multiple starting times that can be selected for any time of day, seven days a week, and should be equipped with moisture sensors to avoid activation during rainy periods.
- A station's duration should be capable of delivering water from 1 to 60 minutes per each start time.
- Controllers for reclaimed water shall be color-coded to distinguish them from potable water.

- Controllers shall be labeled inside and outside to indicate that the system uses reclaimed water. The labels should also alert the system owner/maintenance personnel of any operational constraints.
- An appropriately sized drawing of the area served by the controller should be sealed in a plastic cover, placed in the controller, and updated as needed.

E1-6.3 Pipe Identification

See E1-5.1.3.

E1-6.4 System Identification

In differentiating a reclaimed water system from a potable water system, specific identification needs are as follows.

E1-6.4.1 Hose Bibbs

Hose bibbs are not allowed on reclaimed water systems. Quick couplers should be used if hose connections are necessary. Fittings should be designed to prevent interconnection between potable and nonpotable systems. Hoses used with reclaimed water shall not be used with the potable water systems. Signs (see Table E1-9) should be used to identify reclaimed-water quick couplers. When potable-water quick couplers are within 60 feet of a reclaimed water system, both should be equipped with appropriate signs.

E1-6.4.2 Potable Water Systems Lines

When potable water is being supplied to an area also being supplied with reclaimed water, the potable main should be clearly identified. A warning tape with the words CAUTION—DRINKING WATER LINE should be fastened directly to the top of the potable water pipe and run continuously the entire length of the pipe. In addition, the color of the potable water pipe shall differentiate it from reclaimed water.

E1-6.5 Drinking Fountain/Public Facilities

Potable drinking water fountains and other public facilities shall be located away from the irrigation area in which reclaimed water is used or otherwise isolated and protected.

Exterior drinking fountains and other public facilities should be shown on the construction plans. If no exterior drinking fountains, picnic tables, food establishments, or other public facilities are present in the design area, then it should specifically state in the plans that none are planned.

E1-6.6 Construction Water

Water trucks, hoses, drop tanks, etc. should be identified as containing reclaimed water and unsuitable for drinking.

E1-6.6.1 Permits

The use of reclaimed water for construction purposes requires a permit from the regulatory agencies. The reclaimed water permit issued to the generator must authorize the construction water use. Additional permits may be required for construction water from the purveyor of the reclaimed water.

E1-6.6.2 Equipment

Equipment operators should be instructed about the requirements in applicable reuse standards, regulations outlined in this chapter, and the potential health hazards involved with using reclaimed water.

Reclaimed water shall not be introduced into any domestic water piping system. No unprotected connection should be made between equipment containing reclaimed water and any part of a domestic water system.

E1-6.6.3 Ponds

Ponds used for storage of construction reclaimed water should be fenced and posted to limit public access.

E1-6.7 Special Provisions

Some special restrictions are placed on the operation of reclaimed water systems as a matter of good practice and to protect public health. Restrictions applied by the regulatory agencies should be in the detailed design, as follows:

Runoff conditions	Conditions which directly or indirectly cause runoff outside the approved use area are prohibited.
Ponding conditions	Conditions which directly or indirectly cause ponding outside or within the approved use area are prohibited.
Overspray conditions	Conditions which directly or indirectly permit windblown spray or overspray to pass outside the approved use area are prohibited.
Unapproved uses	Using reclaimed water for any purpose other than explicitly approved in a current effective user permit/agreement issued by the operating agency, and without the prior knowledge and approval of the appropriate regulatory agencies, is prohibited.
Reuse/disposal in unapproved areas	Reuse/disposal of reclaimed water for any purpose, including approved uses, in areas other than those explicitly approved in the current effective user permit/agreement issued by the operating agency, and without prior knowledge and approval of the appropriate regulatory agencies, is prohibited.
Cross connections	Cross connections resulting from using a reclaimed water service, whether by design, construction practice, or system operations, is prohibited.
Hose bibbs	Hose bibbs on reclaimed water systems are prohibited. Replacement of hose bibbs with quick couplers is required (see E1-6.4.1).
Food establishments/ public facilities	To prevent food from being exposed to spray from irrigation systems, reclaimed water irrigation systems should not be installed near food establishments or public facilities such as picnic tables and drinking fountains (see E1-6.5).

E1-6.8 Irrigation Application Rate and Practice

An irrigation system designed with reclaimed water should specify type and placement of sprinkler, type of soil, type of plants, slope, landscape to be used to prevent runoff, ponding, and overspray.

Reclaimed water should be applied at a rate that does not exceed the infiltration rate of the soil. The irrigation system should not be allowed to operate longer than the landscape's water requirements dictate. If runoff or ponding occurs before the landscape's water requirement is met, the automatic controls should be reprogrammed with additional watering cycles to meet the requirements and prevent runoff.

As much as possible, the irrigation system should be operated during periods of minimal public use of the approved area.

E1-6.9 Equipment and Facilities

Any equipment or facilities such as tanks, temporary piping, valves, or potable pumps that have been used with reclaimed water should be cleaned and disinfected before removal from the approved use area for use at another job site. The disinfection and cleaning should ensure protection of public health in the event of any subsequent use as approved by the agency supervisor. The disinfection process should be performed in his/her presence.

E1-6.10 Warning Signs and Labels

Agency warning signs and labels should be installed on designated facilities, including, but not limited to, controller panels, washdown, or blow-off hydrants on water trucks, and temporary construction services. The signs and labels should indicate that the system contains reclaimed water that is unsafe to drink (see Table E1-9).

Where reclaimed water is used for recreational impoundments, warning signs should be installed to notify that the water in the impoundment is unsafe to drink. A detailed plan should be prepared showing placement and spacing of the proposed signs. Where reclaimed water is used for irrigation, warning signs should be installed.

E1-7 Wetlands Discharge

This section discusses the end use of reclaimed water for wetlands discharge. Prior to that discharge, the reclaimed water must meet all other requirements for treatment, reliability, distribution, labeling, etc. as addressed in other sections. In order to utilize a wetland discharge, complete project details must be included in a comprehensive water/sewer planning document (see E1-3.1, G1-4, and G1-5.1). The wetlands discussed in this section function as receiving waters. The use of constructed treatment wetlands as part of the treatment process is discussed in G3-3.7. Wetlands that are candidates to receive reclaimed water fall into four general types, as follows:

- Natural wetlands in a healthy, fully functional condition.
- Natural wetlands in a degraded condition.
- Mitigation wetlands.
- Constructed beneficial use wetlands.

Natural wetlands and mitigation wetlands are considered jurisdictional wetlands and waters of the US and state. Beneficial use wetlands constructed on upland sites to produce natural habitat or for water quality enhancement, but not required as mitigation for loss of natural wetlands, are considered nonjurisdictional wetlands and are regulated as treatment facilities equivalent to constructed treatment wetlands.

Wetland functions typically fall into general categories, as follows:

- **Hydrologic.** Storm/flood peak reduction, shoreline stabilization, ground water exchange (recharge, base flow).
- **Water quality.** Sediment accretion, nutrient uptake, etc.
- **Food chain support.** Structural and species-diversity components of habitat for plants, aquatic organisms, and wildlife.
- **Recreation/aesthetic.** Open space, passive recreation, education, etc.

The beneficial uses of a wetland are closely related to the wetland's functions. In order for a wetlands discharge project to be considered a beneficial use of reclaimed water, some enhancement, restoration, or creation of wetland functions should be demonstrated.

E1-7.1 Site Conditions and Constraints

For projects that propose to discharge reclaimed water to wetlands, information must be included within the facilities plan or project engineering report as follows:

(1) A detailed map of site soils and topography to a 1-foot contour interval. Show existing wetland area, surrounding upland area, relevant natural and manmade features, soil types, and property boundaries. (Wetlands must be delineated per "Washington State Wetlands Identification and Delineation Manual," Ecology Publication No. 96-94, March 1997 or latest edition.)

(2) For jurisdictional wetlands, list wetland rating category (I, II, III, or IV). See Ecology Publication No. 93-74 or No. 91-58.

(3) Identify property owner(s) and other property controls (lease, easement, covenant, etc.) for original wetland property, adjacent property to accommodate increase in wetland area, and surrounding upland buffer zone. Verify owners' permission to use their land for this project.

E1-7.2 Hydrologic Regime

For projects that propose to discharge reclaimed water to wetlands, information must be included within the facilities plan or project engineering report as follows:

(1) Show entire flow of reclaimed water from pipe outlet through the wetland to hydraulically connected surface or ground water. List surface water body, aquifer, or geologic formation by name.

(2) Describe site soils, geology, and hydrogeology. Verify suitability of adjacent upland soils for increase in wetland area due to volume increase in water balance. Verify suitability for increased ground water exchange in the projected water balance under new conditions.

(3) Measure or compute monthly baseline water balance for existing conditions. Include the following:

   - Surface inflows and outflows; natural fluctuations.
   - Subsurface inflows and outflows; natural fluctuations.
   - Hydroperiod; water depths; natural fluctuations.
   - Permanent pool; depth/surface area relationships.

(4) Compute monthly projected water balance for new conditions, including reclaimed water flows. Include the following:

- Surface inflows and outflows.
- Subsurface inflows and outflows.
- Hydroperiod; water depths; changes induced by reclaimed water inflows.
- Permanent pool; depth/surface area relationships; changes induced by reclaimed water inflows.
- Increase in wetland surface area due to volume increase in water balance.

(5) Verify compliance with hydrologic and hydraulic requirements of Article 3 of the Water Reclamation and Reuse Standards for wetlands discharge.

(6) Show preliminary design of hydraulic buffer between pipe outlet and inlet to the wetland to control water velocities going into the wetland, with brief description of the hydraulic operation or performance of the buffer. (The hydraulic buffer may be a detention pond, constructed wetland, surge tank, or similar feature, with weir, orifice, or similar outlet control features to moderate the instantaneous discharge of reclaimed water into the wetland.)

(7) Describe the overall management and operation controls to limit the volume discharge of reclaimed water to allowable limits in the water reclamation and reuse standards.

(8) Describe the overall management and operational long-term commitment to maintain a reliable discharge of reclaimed water to the wetland once the wetland ecosystem has come to depend upon this inflow of water.

E1-7.3 Water Quality

Verify compliance with the water quality criteria of Article 3 of the Water Reclamation and Reuse Standards for wetlands discharge.

E1-7.4 Biology/Ecology

(1) Verify compliance with biological criteria requirements of Article 4 of the Water Reclamation and Reuse Standards for wetlands discharge, in particular for baseline reference conditions, mature biological structure, sampling methods, and locations.

(2) Discuss expected biological and ecological adjustments to the new hydrologic regime (with reclaimed water inflows), including vegetation within the area of wetland expansion into adjacent upland areas. Describe the proposed planting scheme and schedule for wetlands plants, or conversely, the expected rates of natural propagation of wetlands vegetation into the new wetland areas.

(3) Discuss the size and dimensions of an upland buffer zone necessary for the functions to be performed by the wetland. Show location of upland buffer zone, with property ownership and control and map. Verify that property ownership or control is consistent with upland buffer requirements, or conversely, identify land use conflicts with upland buffer requirements.

(4) Discuss the role of this wetland within fisheries and wildlife management by agencies such as US Fish and Wildlife Service and State Department of Fish and Wildlife. For example:

- Identify whether wetland is used by migratory birds or anadromous fish.

- Determine whether the wetland is part of a larger habitat corridor or is isolated from other wildlife habitat.

E1-7.5 Wetland Mitigation, Enhancement, or Restoration Plans

Verify compliance with the requirements from any separate wetland mitigation plan, enhancement plan, or restoration plan, if applicable. Conversely, if not applicable, verify that a separate wetland mitigation plan, enhancement plan, or restoration plan has not been required by regulatory agencies.

E1-8 Ground Water Recharge

This section discusses the end use of reclaimed water for ground water recharge. Prior to this stage in the reuse project, the reclaimed water must meet all other requirements for treatment, reliability, storage, distribution, identification, and so on as addressed in other sections. In order to use reclaimed water for ground water recharge, the complete project details must be included in a comprehensive water/sewer planning document (see E1-3.1, G1-4, and G1-5.1).

The primary recharge mechanisms are surface percolation and direct injection. Recharge that may occur as outflow from a wetland is addressed in E1-7.

Water quality requirements for ground water recharge by surface percolation are codified in RCW 90.46.080. See also Chapter 173-154 WAC for state policy to protect upper aquifer zones from excessive water level declines or reductions in water quality.

Development of standards for ground water recharge by direct injection was authorized by RCW 90.46.042. See also Chapter 173-154 WAC for state policy and authority to restrict new or additional large-volume withdrawals to lower aquifer zones.

E1-8.1 Ground Water Protection Areas

The following ground water protection areas have been recognized in state and federal laws and regulations:

(1) Wellhead protection areas: Zones 1, 2, 3; contribution; influence.

(2) Sole source aquifer.

(3) Aquifer protection area (Chapter 36.36 RCW).

(4) Critical aquifer recharge area (Growth Management Act).

(5) Special (ground water) protection area (WAC 173-200-090).

(6) Ground water management area (RCW 90.44.400; Chapter 173-100 WAC).

For project sites located within or near a designated ground water protection area, the facilities plan or project engineering report should identify the type of area and any special requirements to be placed on the project.

E1-8.2 Hydrogeologic Conditions and Constraints

For projects that propose to use reclaimed water for ground water recharge, the following information must be included within the facilities plan or project engineering report:

(1) As much as possible based on existing data, provide a complete hydrogeologic characterization of the project site. Be sure to include:

- Topographic and geologic maps and cross sections.
- Ground water elevations, contours and hydraulic grade lines, and natural fluctuations.
- Hydrologic/hydraulic features, recharge areas, streams, springs, wells, and other discharge areas, such as leakage to other aquifers, and deep seepage to marine waters.
- Water balance, recharge, follow-through, discharge, precipitation, evapotranspiration, runoff, base flow, and natural fluctuations.
- Aquifer co-efficients, hydraulic conductivity/permeability, transmissivity, storage, leakage, and directional transmissivity in anisotropic aquifers.
- Basic data, well logs, pumping test data sheets, and sample calculations.

(2) Discuss adequacy of existing data and whether new test wells and/or aquifer testing might be needed to provide an adequate hydrogeologic characterization of the project site.

(3) Show location of spreading basins or injection wells relative to hydrologic/hydraulic features on a map. Be sure to show proximity to nearby wells (both monitoring and water supply wells), surface discharges from the aquifer, and other discharges from the aquifer. Show plan and profile views of spreading basins, including key dimensions and elevations. Show profile view of injection wells, including key design features, dimensions, and elevations.

(4) Calculate height, elevation, and lateral dimensions of ground water mound that will form beneath the spreading basins or around injection wells. Show water levels for pre-recharge conditions and predicted water levels for post-recharge conditions.

(5) Calculate and discuss hydraulic residence time in the aquifer and time of travel to nearby water supply wells.

(6) Discuss hydraulic continuity between ground water and surface water. Calculate impacts of recharged ground water on surface base flows.

(7) Discuss physical impacts of recharged ground water on areas of seawater intrusion, ground water contamination, or other degraded ground water quality. How will changes in hydraulic gradients induce movement of poor quality ground water to new areas?

(8) Intent for water rights.

- Describe the intended water rights status for the recharged ground water. Will the recharged ground water be reserved as artificially stored ground water per Chapter 173-136 WAC; available for appropriation by others; reserved for instream flow needs for surface streams in hydraulic continuity with ground water; or a combination of these? Discuss.
- If it is intended to be reserved, file the appropriate water rights applications and include a copy in the facilities plan or engineering report.

E1-8.3 Geotechnical Conditions and Constraints

For projects that propose to use reclaimed water for ground water recharge, information must be included within the facilities plan or project engineering report, as follows:

(1) Provide map showing features that might be vulnerable to high water tables or high artesian pressures, including building foundations, buried tanks (septic tanks, fuel tanks), pipelines (water, sewer, gas, fuels), surface slopes, and deep excavations. Show soil and subsurface conditions near these features.

(2) Discuss water table or artesian pressure elevations, including capillary fringe and natural fluctuations, relative to these features. Discuss changes in soil strength and slope stability that might be induced by higher water tables or higher artesian pressures resulting from recharged ground water. Verify that changes in soil strength and slope stability will not jeopardize these features or cause other property damage.

E1-8.4 Water Quality

The designer must verify compliance with the water quality requirements of the water reclamation and reuse standards for ground water recharge. The required quality of reclaimed water depends on the method of ground water recharge.

E1-8.4.1 Surface Percolation

The basic water quality requirement in RCW 90.46.080 is that the reclaimed water must meet the ground water recharge criteria (specifically, the contaminant criteria found in the drinking water quality standards) as measured in ground water beneath or down-gradient of the recharge project site. Toward this end, specific items must be addressed as follows:

(1) Reclaimed water must comply with or exceed standards for Class A reclaimed water. Include calculation of CT values for the disinfection process.

(2) The advanced secondary treatment or tertiary treatment process used to provide oxidized wastewater must include appropriate treatment to reduce the nitrogen content in the final reclaimed water to the level required by the ground water recharge criteria.

(3) Verify adoption of an approved pretreatment program (either by local delegation or in conjunction with Ecology), and discuss the sewer utility's implementation policies and practices. Identify major industrial dischargers to the sewer system, and discuss their compliance history and performance with regard to pretreatment requirements.

(4) Document background/natural ground water quality. Be sure to include bacteria, physical and inorganic chemicals, organic chemicals, and radionuclides. Identify areas of seawater intrusion, ground water contamination, or other degraded ground water quality.

(5) Verify compliance with drinking water quality criteria as measured in ground water beneath or down-gradient of the recharge project site for the new mixture of ground water and reclaimed water. Discuss ability of soil and aquifer materials and processes to provide a safe, potable ground water; the fate of residual pollutants from the reclaimed water

while in residence within the vadose (unsaturated) zone and the aquifer; and hydraulic residence time for reclaimed water in the vadose zone and the aquifer before extraction by nearby water supply wells and/or discharge to nearby surface waters.

(6) Discuss additional water quality monitoring for constituents found in reclaimed water for which drinking water criteria have not been established. Identify recommended sampling locations within the treatment and conveyance facilities and from monitoring wells.

(7) For nearby surface waters in hydraulic continuity with ground water, discuss surface water quality impacts of surface discharges from the aquifer.

(8) Discuss water quality impacts of recharged ground water on areas of seawater intrusion, ground water contamination, or other degraded ground water quality.

E1-8.4.2 Direct Injection

Verify compliance with treatment, water quality, operational, and pilot plant study requirements of Articles 3, 4, 6, and 11 of the Water Reclamation and Reuse Standards for direct ground water recharge. The treatment and water quality requirements apply to the reclaimed water at the point of injection.

Designers should note that the reverse-osmosis process produces water that is quite pure, but may also be rather aggressive. Typical design practice is to include a step for water quality stabilization following the reverse-osmosis step. To avoid undesirable reactions between sodium compounds and any clay particles that may be in the aquifer, it may be prudent to use calcium compounds to reduce the corrosivity of the reverse-osmosis treated water. These issues should be examined during the pilot study.

Designers also need to consider the disposal problems associated with reject water from the reverse-osmosis process. Reject water is a concentrated brine solution containing organic constituents, inorganic constituents such as salts and metals, and, in some cases, microbial agents not removed by preceding treatment processes. Means of disposal that have been successful elsewhere include discharge to the ocean, pumping back to the headworks of a wastewater treatment plant, deep well injection to nonpotable aquifers, and disposal via evaporation ponds if site-specific conditions are acceptable to Ecology. It is important to resolve this issue early in the facilities planning process.

E1-8.5 Injection Wells and Monitoring Wells

Injection wells and monitoring wells must be designed and constructed in accordance with requirements of state minimum standards for construction and maintenance of wells. (See Chapter 173-160 WAC.) Injection and monitoring wells should be designed and well locations selected with the assistance and concurrence of a qualified hydrogeologist.

Injection wells and monitoring wells must be installed by a licensed well driller in accordance with requirements of Chapter 173-162 WAC.

E1-9 Indirect Potable Reuse

This section discusses the beneficial use of reclaimed water for indirect potable reuse. As used here, indirect potable reuse means the discharge of reclaimed water into a reservoir used as a raw water source for drinking water supply, or into a stream which flows into such a reservoir, with the concurrence and participation of the water supply utility in the indirect potable reuse project. The intent is to augment the natural flow of the stream/reservoir system with additional flow from the reclaimed water system. These drinking water sources are subject to the requirements of the Surface Water Treatment Rule of the Safe Drinking Water Act. Potable use of ground water through recharge using reclaimed water is addressed in E1-8. For projects that propose to use reclaimed water for indirect potable reuse, the complete project details must be included in a comprehensive water/sewer planning document (see E1-3.1, G1-4, and G1-5.1).

Prior to discharge into the receiving stream or reservoir, the reclaimed water must meet all other requirements for treatment, reliability, conveyance, distribution, identification, and so on as addressed in other sections. The reclaimed water may be discharged directly to the receiving stream or reservoir, or may pass through a wetland (see also E1-7) on its way to the stream or reservoir.

According to Chapter 90.46 RCW, reclaimed water projects for streamflow augmentation, including indirect potable reuse, must comply with the federal Clean Water Act and the State's Water Pollution Control Act (Chapter 90.48 RCW). In practice, this means the discharge must be allowed by an NPDES permit and meet the surface water quality standards in Chapter 173-201A WAC. The provision in state law that "reclaimed water is no longer wastewater" does not supersede these requirements of federal law.

Washington State currently has no specific requirements for indirect potable reuse. Requirements for specific reuse projects will be determined on a case-by-case basis in consultation with Ecology and DOH, with general elements in mind as described in this section.

E1-9.1 Hydraulic Regime

For projects that propose to use reclaimed water for indirect potable reuse, information must be included within the facilities plan or project engineering report, as follows:

(1) Provide a site map to show the stream/reservoir system, reclaimed water outfall location, and drinking water intake location. Identify the receiving surface water body by name.

(2) Provide a stage-storage curve for the reservoir. Presentation may be graphical or tabular format, with presentation in both formats preferred.

(3) Calculate the shortest hydraulic residence time for reclaimed water in the reservoir prior to withdrawal for drinking water supply. Consider the combination of low stream flows, high diversion flows, and low reservoir water levels and storage volumes that will give the shortest hydraulic residence time in the reservoir.

(4) Intent for water rights:

- Describe the intended water rights status for the augmented streamflows. Will the project increase appropriation and diversion for drinking water supply; provide additional surety just for current appropriation and diversion; reserve a portion for instream flow needs downstream of the reservoir; or a combination of these? Discuss.

- If it is intended to increase the appropriation and diversion for water supply, and/or to be reserved for instream flows, file the appropriate water rights applications, and include a copy in the facilities plan or engineering report.

(5) Describe the overall management and operational long-term commitment to maintain a reliable discharge of reclaimed water to the stream/reservoir system once the water supply system and downstream instream flows have come to depend upon this inflow of water.

(6) Outfall design as outlined in E1-10.3.

E1-9.2 Water Quality

As noted previously, Washington State currently has no specific requirements for indirect potable reuse. Reclamation treatment processes and water quality requirements for specific reuse projects will be determined on a case-by-case basis in consultation with Ecology and DOH, with general elements in mind as follows:

(1) Reclaimed water must comply with or exceed standards for Class A reclaimed water. Actual treatment and quality requirements will probably be similar to those for direct injection for ground water recharge (see E1-8.4.2), and may be more stringent for some constituents.

(2) Verify compliance with the surface water quality standards for lake class waters as required by the NPDES permit. Consult with Ecology and DOH regarding nutrient removal requirements for protection of aquatic habitat and for aesthetic qualities of the water supply including taste, impacts on disinfection, and so on.

(3) Verify adoption of an approved pretreatment program (either by local delegation, or in conjunction with Ecology), and discuss the sewer utility's implementation policies and practices. Identify major industrial dischargers to the sewer system, and discuss their compliance history with regard to pretreatment requirements.

(4) Verify compliance with surface water treatment rule requirements for the new mixture of natural and reclaimed water. Discuss hydraulic residence time for reclaimed water in the reservoir; fate of residual pollutants from the reclaimed water while in residence within the reservoir; and the ability of the filtration treatment process to provide a safe, high-quality drinking water.

E1-10 Streamflow Augmentation

This section discusses the beneficial use of reclaimed water for streamflow augmentation, including maintenance of lake water levels. Indirect potable reuse is a special case of streamflow augmentation, addressed separately in E1-9. For projects that propose to use reclaimed water for streamflow augmentation, the complete project details must be included in a comprehensive water/sewer planning document (see E1-3.1, G1-4, and G1-5.1).

Prior to discharge into the receiving stream or lake, the reclaimed water must meet all other requirements for treatment, reliability, conveyance, distribution, identification, and so on as addressed in other sections. The reclaimed water may be discharged directly to the receiving lake or stream, or may pass through a wetland (see E1-7) on its way to the lake or stream.

According to RCW 90.46.100, reclaimed water projects for streamflow augmentation must comply with the federal Clean Water Act and the State's Water Pollution Control Act (Chapter

90.48 RCW). In practice, this means the discharge must be allowed by an NPDES permit, and must meet the surface water quality standards in Chapter 173-201A WAC. The provision in state law that "reclaimed water is no longer wastewater" does not supersede these requirements of federal law.

For projects that propose to use reclaimed water for streamflow augmentation, additional information must be included within the facilities plan or project engineering report, as follows:

E1-10.1 Receiving Water

Identify receiving water class (AA, A, B, C, or lake), and any TMDL requirements, and verify compliance with respective water quality criteria as required by NPDES permit. See Chapter E2 for additional information on effluent disposal to surface water.

E1-10.2 Hydraulic Regime

(1) Intent for water rights:

- Describe the intended water rights status for the augmented streamflows. Is it reserved for instream flow needs, or available for appropriation and diversion?
- If intended to be reserved for instream flows, file a water rights application for instream flow reservation and include a copy in the facilities plan or engineering report.

(2) Describe the overall management and operational long-term commitment to maintain a reliable discharge of reclaimed water to the stream or lake once the downstream ecosystem and diversion water rights (if any) have come to depend upon this inflow of water.

E1-10.3 Outfall Design

The physical discharge of reclaimed water to the receiving stream, lake, or reservoir may occur directly through a piped outfall or indirectly through a pond or wetland (See E2-3.2 for additional information). The respective information requirements are as follows:

(1) Provide a site map showing outfall location and key design features.

(2) For a direct piped outfall, provide information as follows:

- Reclaimed water pipeline diameter and material.
- If pumping is required, show pump location and capacity (flow, TDH, hp).
- A drawing showing details for diffuser or other outfall structure.
- A hydraulic profile for reclaimed water discharges. Verify hydraulic performance over the normal range of water levels for the stream, lake, or reservoir.
- Outfall site soils, geology, and fluvial geomorphology. Is the natural stream channel migrating? Is the channel subject to significant scour or sedimentation at this location?
- Discuss design features that will keep the outfall pipeline, diffuser, and/or structure in place and functioning during the normal range of streamflows, especially during high flow periods.

(3) For a pond or wetland outfall, provide information as follows:

- Specify the pipe diameter and material for the reclaimed water pipeline to the pond or wetland.
- If pumping is required, show pump location and capacity (flow, TDH, hp).
- Provide a drawing showing details for outfall structure from pipeline into the pond or wetland. Identify whether the pond or wetland is natural or constructed.
- Provide a drawing showing details of the outlet from pond or wetland to the receiving stream, lake, or reservoir. Note that the pond or wetland outlet may be constructed or natural.
- Provide the hydraulic profile for reclaimed water discharges from pipeline through the pond or wetland to the receiving stream, lake, or reservoir. Verify hydraulic performance over the normal range of water levels for the stream, lake, or reservoir.
- For a wetland outfall to a receiving stream, see also requirements in E1-7.

E1-11 References

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