NYC Health

New York City Nonpotable Water Systems

Guidance Manual

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SECTION 1: INTRODUCTION

1.1 Purpose of this Manual

This Guidance Manual contains information pertaining to the design and operation of nonpotable water systems (NWS) in New York City (NYC). NWS, also known as on-site nonpotable water reuse systems, capture and treat water sources generated from within or surrounding a building, such as sewage, gray water, stormwater, roof collected rainwater, foundation drainage or clear water waste. The treated water is then reused onsite or locally. This Guidance Manual provides an overview of the basic concepts and benefits of water reuse and introduces design elements and guidance for maintenance and monitoring of NWS when in operation. This document is intended for use by those interested in implementing NWS in new or existing buildings in NYC, including developers, owners, architects, engineers and building maintenance staff. This document features fundamental principles for public health protection and is intended to be used in conjunction with other design and best practice manuals.

SECTION 1: Introduction

What are nonpotable water systems (NWS)?

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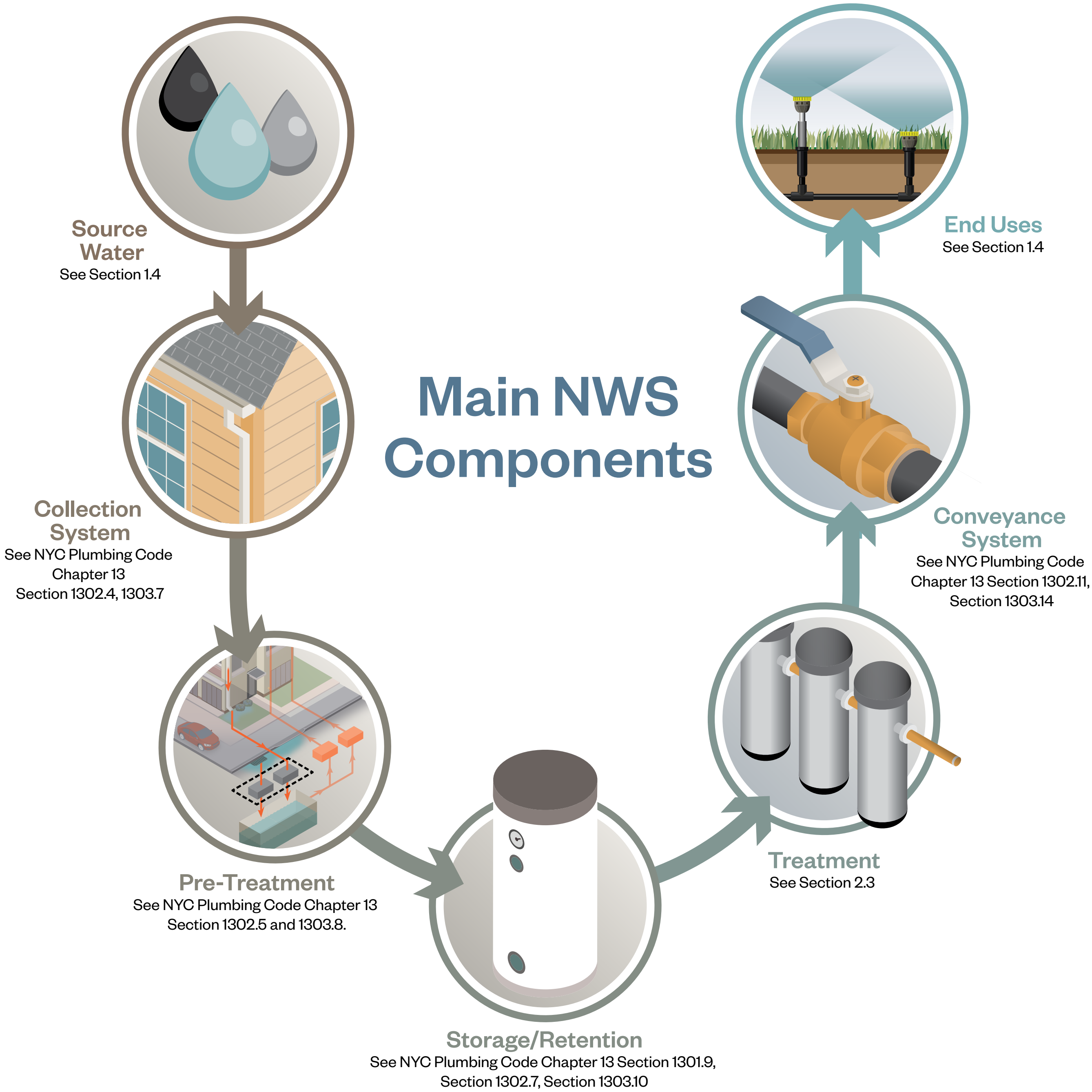
All NWS must abide by current New York State and City laws and regulations including the Department of Buildings (DOB) Construction Codes.

1.2 What are Nonpotable Water Systems (NWS)?

Water reuse (also commonly known as water recycling or water reclamation) collects water from a source and treats it for reuse. Water reuse can be applied in both potable and nonpotable applications. The most common type of water reuse in NYC is nonpotable where the treated water (also known as effluent) is used for approved end uses such as toilet flushing or laundry, but is not intended for human consumption. A NWS is a water system for the collection, treatment, storage, distribution and reuse of nonpotable water generated on site. NWS are engineered systems that need to be thoughtfully designed and continually managed.



1.3 NWS in NYC

Existing examples of NWS in NYC are categorized here by source water:

Stormwater

Gray water

Sewage

Tribeca Green

Classification: Multi-Unit
Source: Stormwater & Gray Water
End Use: Irrigation, Cooling Tower, Toilet/Urinal Flushing

Liberty Luxe
✪*Combined heat and power system*

Classification: Multi-Unit
Source: Stormwater & Sewage
End Use: Irrigation, Cooling Tower, Toilet/Urinal Flushing

Stormwater reuse in NYC saves 830,000 gallons per day and reduces combined sewer overflows (CSOs) by 4 million gallons per year

UA Local 1 Plumber's Union

Classification: Multi-Unit
Source: Stormwater & Gray Water
End Use: Toilet/Urinal Flushing

Hallets Point
✪*Excess heat recovered from NWS source water for energy recovery*

Classification: District-Scale
Source: Sewage
End Use: Irrigation, Cooling Tower, Toilet/Urinal Flushing

Forest House

Classification: Multi-Unit
Source: Stormwater
End Use: Irrigation

Domino Sugar Redevelopment
✪*First NWS with permitted discharge to surface water*

Classification: Multi-Unit
Source: Sewage
End Use: Irrigation, Cooling Tower, Toilet/Urinal Flushing

Millennium Tower

Classification: Multi-Unit
Source: Sewage
End Use: Irrigation, Cooling Tower, Toilet/Urinal Flushing

1 World Trade Center

Classification: Multi-Unit
Source: Stormwater
End Use: Irrigation, Cooling Tower

The Solaire and Verdesian
✪*Practices energy recovery*

Classification: District-Scale
Source: Sewage
End Use: Irrigation, Cooling Tower, Toilet/Urinal Flushing

Visionaire
✪*First NWS to implement integrated roof water retention system*

Classification: Multi-Unit
Source: Stormwater & Sewage
End Use: Irrigation, Cooling Tower, Toilet/Urinal Flushing

One Bryant Park
✪*First NWS to use gray water for toilets*

Classification: Multi-Unit
Source: Gray Water
End Use: Irrigation, Cooling Tower, Toilet/Urinal Flushing

The New School
✪*First NWS in residence halls*

Classification: Multi-Unit
Source: Sewage
End Use: Irrigation, Cooling Tower, Toilet/Urinal Flushing, Laundry

Liberty Green
✪*Combined heat and power system*

Classification: Multi-Unit
Source: Stormwater & Sewage
End Use: Irrigation, Cooling Tower, Toilet/Urinal Flushing

1.4 Sources and End Uses

Nonpotable water sources and specific end uses are listed below. NWS source definitions can be referenced in the NYC Plumbing Code, Chapter 2 (DOB, Plumbing Code, 2022).

NWS SOURCES

Rainwater
Precipitation from a rain or snowmelt event that is collected directly from a roof surface with no public access to people or pets.

Clear water waste
The drips from equipment, coil condensate, steam condensate, single pass refrigeration discharge, reduced pressure zone (RPZ) discharge, and similar matter.

Foundation drainage
Subsoil water that is collected in accordance with NYC Building Code §1807 and would otherwise be discharged to the sewer system.

Stormwater
Natural precipitation, including snow melt, that has contacted a surface at or below grade or a roof surface with public access to people or pets.

Gray water
Non-sewage wastewater. Sources include lavatories (bathroom sinks), bathtubs, showers, clothes washers, and laundry trays, but do not include toilets, urinals, kitchen sinks, or dishwashers.

Sewage
Any liquid waste containing animal or vegetable matter in suspension or solution or chemicals in solution. Sources of sewage include water closets (toilets), bidets, urinals, kitchen sinks, utility sinks, and dishwashers.

NWS END USES

- Cooling towers
- Dust control
- Boiler make-up water
- Industrial process water
- Toilet/urinal flushing
- Priming drain taps
- Laundry
- Irrigation (subsurface, spray, surface nonspray)
- Washdown of vehicles (in allowed areas), streets, sidewalks, and buildings

1.5 Public Health Protection

NWS should be designed and operated so that public and environmental health are always protected while beneficially reusing nonpotable water.

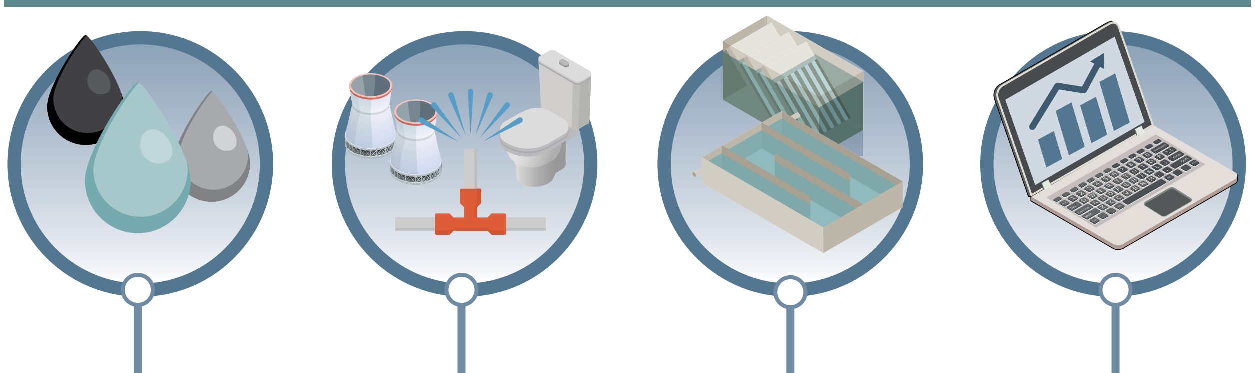
NWS treatment, storage, and conveyance systems must be designed to adequately remove pathogens and other constituents for public and environmental health protection. Additionally, continuous monitoring must be in place to ensure that treatment processes are performing as intended.

To design a safe, functional, and cost-effective NWS, it is best practice to match the water source to the appropriate end uses with respect to flow rates and level of treatment. Additionally, it is recommended to include resilient design principles to maintain functionality during potential emergencies such as flood events or major power service disruptions.

NWS introduce potential health impacts from unintended exposure such as from a cross-connection contamination event, where nonpotable water is accidentally mixed with potable water.

A robust cross connection control program is recommended, such as air gaps and purple colored piping, to prevent potential unintended mixing with potable water (see Section 2.4).

NWS can conserve your water supply **AND** protect your health



1 Identify NWS Sources

Characterize the water quality of NWS source water and the amount of NWS water to be produced.

2 Identify NWS End Uses

Determine minimum water quality standards for treated effluent based on identified end uses and sources.

3 Determine Treatment Requirements

Select treatment processes that, in combination, achieve the minimum water quality standards.

4 Design Monitoring Plan

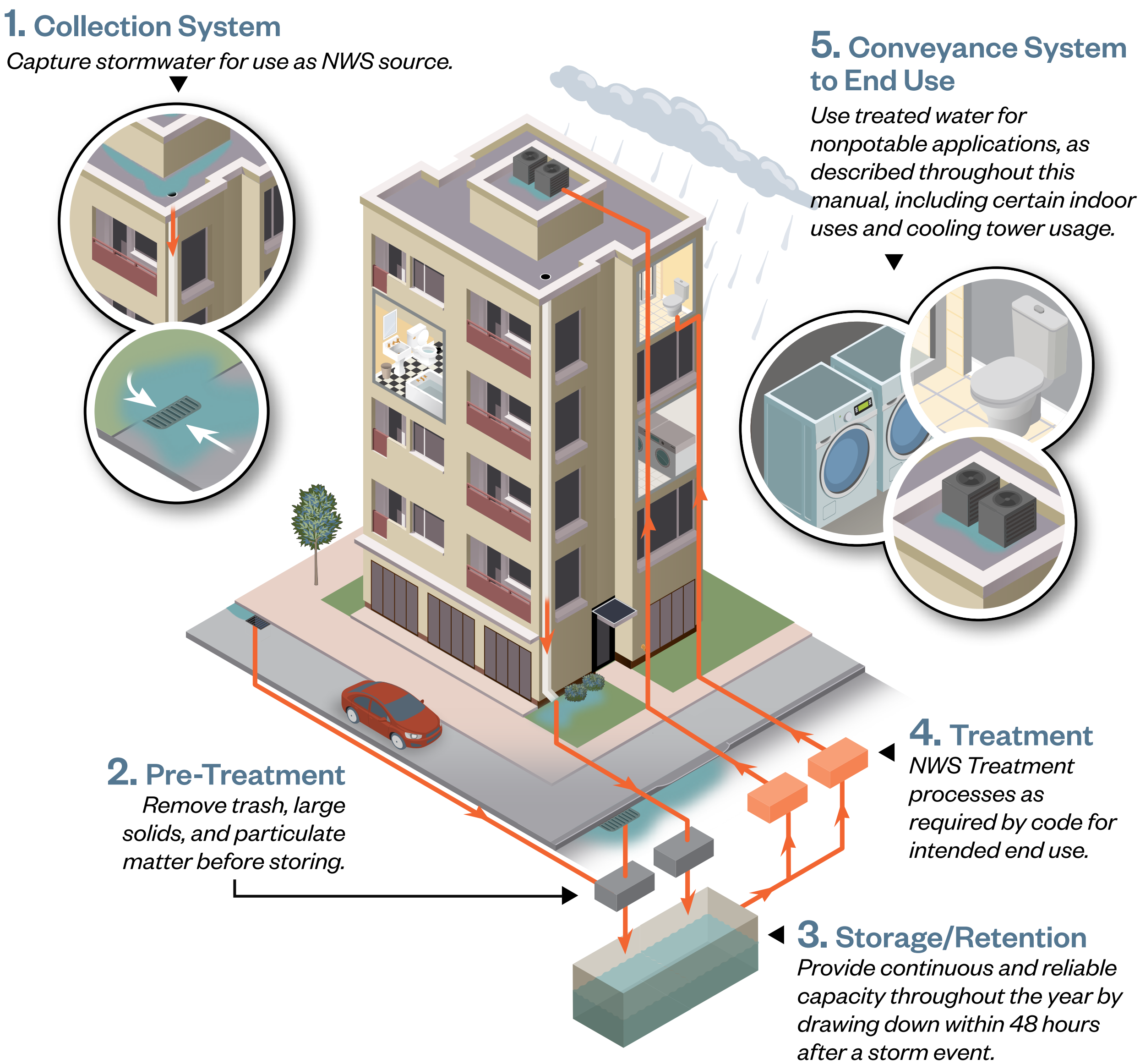
Develop a continuous monitoring plan to ensure treatment processes are operating as intended.

1.6 Benefits

In addition to reducing the strain on existing NYC infrastructure by diverting wastewater, NWS may have other potential benefits for your building described below.

Meeting Stormwater Management Requirements:

The NYC Department of Environmental Protection (DEP) promulgated a Unified Stormwater Rule in 2022 and published an accompanying NYC Stormwater Manual (DEP, 2022). It outlines citywide stormwater management policy for public and private developments. If an NWS is designed with continuous and reliable capacity for stormwater storage throughout the year, the building may be eligible to apply a portion of the total NWS capacity towards meeting certain stormwater management requirements, where applicable.



1.6 Benefits (cont.)

Water Rate Discounts:

NWS are eligible for water and wastewater rate discounts as outlined in Part IV Section 6.A of the NYC Water Board Water and Wastewater Rate Schedule (NYC Water Board, 2022). There are exceptions to the Standard Wastewater Allowances, allowing your NWS to achieve Wastewater Allowances outside of those identified as Standard in Part III Section 7.E. By metering your system in accordance with DEP to quantify wastewater not directly discharged to sewer, a proportional reduction will be applied to the system's wastewater rates.

The Water Conservation and Reuse Pilot Program:

The Water Conservation and Reuse Pilot Program provides funding opportunities for commercial, industrial, and multi-family residential property owners to offset the cost of installing a NWS. Depending on the scale and details of the NWS, incentives can exceed $50,000 for a single private property. Visit the NYC Water Conservation website (DEP, Water Conservation, 2022) for more details.

Energy Recovery:

NWS with a heat pump can recover thermal energy to offset the electricity to operate the NWS and can therefore reduce electric bills and carbon footprint. Recovering thermal energy from NWS-treated effluent in this way can also assist buildings in complying with combustible fuel prohibitions required by NYC Administrative Code §24-177.1 and energy efficiency and greenhouse gas limits as required by NY City Charter, Chapter 26, Section 651. Thermal energy recovery systems may have permitting requirements in addition to the NWS, so the decision to include them should be made early in design. Refer to the Energy Conservation Code and other department websites for additional requirements (DOB, Energy Conservation Code, 2020.)

LEED Certification:

Installing a NWS can contribute to achieving a Leadership in Energy and Environmental Design (LEED) certification for your building (Stanford et al., 2013) and other green building rating systems. LEED certification is a green building rating system that provides guidelines to design healthy, efficient, and cost-saving green buildings and rewards water conservation strategies such as NWS.

SECTION 2: DESIGN CONSIDERATIONS

The following information is provided as high level guidance only. Designers should consult accepted industry best practices such as those published by the National Blue Ribbon Commission for Onsite Non-Potable Water Systems for additional information on how to design NWS. See References for more information.

2.1 Water Budget

A water budget provides an understanding of the sources available to a NWS at a property and how much nonpotable demand may be met by reusing the NWS effluent. In a water budget, the inflows of a system are equivalent to the outflows of the system. Nonpotable water reuse can reduce the overall water budget of the building by offsetting demand for potable water and reducing discharge to sewer.

Factors that influence a building's water budget:

- Building infrastructure
- Building classification and usage
- Number of occupants
- Occupancy rate and variability
- Rainwater runoff
- Onsite NWS source(s)
- Onsite NWS end use(s)
- Cooling tower use
- Irrigation and outdoor uses
- Water conservation and efficiency

The water budget can be calculated using the NYC DEP On-site Water Reuse Calculator, available on the NYC DEP Water Conservation website. There are two versions of this tool, one for multi-unit and one for district-scale projects (DEP, Water Conservation, 2022).

2.2 Treatment Standards

Treatment standards for NWS have been developed to guide safe implementation of these systems using the log reduction target approach. This section provides an overview of Log Reduction Targets (LRTs) and gives examples.

LRTs for NWS

LRTs represent the required level of treatment to minimize the risk to human health when using a particular source for a particular end use. Different LRTs are provided for three classes of pathogens: viruses, protozoa, and bacteria. Higher LRTs represent a greater degree of pathogen removal and/or inactivation. NWS must include treatment processes that, in combination, achieve total log reduction values (LRVs) equal or greater than the LRTs stipulated in the table below. NWS design must also include sensors that continuously monitor the integrity of the treatment process. Examples are given in the table below.

For NWS with multiple sources, processes/trains shall be designed for the lowest quality source water. For instance, a system using sewage and stormwater as water source shall be designed to meet the LRTs for sewage.

Example Log Reduction Targets[1]

NWS Source	Indoor End Use			Outdoor End Use		
	Virus	Protozoa	Bacteria	Virus	Protozoa	Bacteria
Sewage	8.5	7	6	8	7	6
Gray Water	6	4.5	3.5	5.5	4.5	3.5
Stormwater/Foundation Drainage	3.5	3.5	3	3	2.5	2
Rainwater/Clear Water Waste	N/A	N/A	3.5	N/A	N/A	3.5

Maximum Attainable Log Reduction Values (LRVs) for Common Treatment Processes

Individual treatment processes are credited with LRVs representative of its ability to remove different pathogens. A treatment process can be more effective against one group of pathogens than another, therefore NWS design typically uses a combination of different types of treatment processes in series for treatment. This method of increasing the redundancy of the treatment train is commonly referred to as the multiple barrier approach (Sharvelle, 2017). More information on the correct order of treatment processes to achieve pathogen removal goals can be found in the documents referenced by this manual. The table below includes the maximum attainable LRVs and key integrity monitoring sensors for common treatment processes. The ability of an individual process to achieve the maximum credible log reduction is dependent on the treatment train order. The summed LRVs across a treatment train should be greater than or equal to the system's LRT.

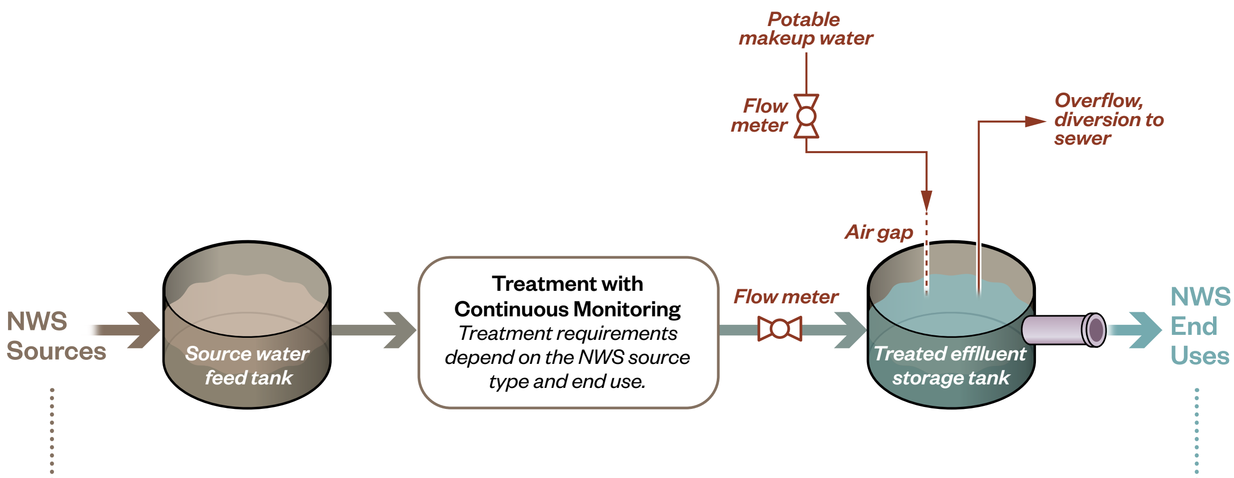
Example Log Reduction Values[1]

Treatment Process	Virus	Protozoa	Bacteria	Key Process Parameters for Treatment Validation
Filtration Processes				
Membrane Biological Reactor (MBR)[2]	1.5	2	4	Solids retention time (SRT), turbidity
Microfiltration or Ultrafiltration	0	4	0	Daily pressure decay test, effluent turbidity
Reverse Osmosis	2	2	2	Total organic carbon (TOC), Electrical conductivity
Disinfection Processes				
Chlorine Disinfection (dose dependent)	Up to 5	Up to 0	Up to 5	Free chlorine residual
Ultraviolet (UV)[3] (dose dependent)	Up to 6	Up to 6	Up to 6	Ultraviolet transmittance (UVT), flow rate
Ozone	4	3	4	Oxidation reduction potential

[1] Adapted from US Water Alliance, (2017).
[2] The MBR process is a combination of a suspended growth bioreactor with a microfiltration or ultrafiltration membrane unit.
[3] Technology may require validation to demonstrate that the dosage achieves the claimed LRV.

2.3 Key System Design Elements

The elements of a NWS achieve end use demands, ensure delivery of target water quality, and provide continuous monitoring of treatment and diversion of unsuitable reuse water from the end use.



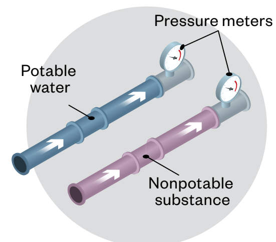
NWS Source	Minimum Types of Treatment Processes Required[4]
Sewage	Biological treatment, filtration, primary disinfection
Gray water	Filtration, primary disinfection
Stormwater/ Foundation drainage	Filtration, primary disinfection
Rainwater/Clear water waste	Primary disinfection

NWS End Use	End Use-Specific Requirements
Subsurface irrigation	Disinfection is not required
Other irrigation (spray, surface nonspray)	NWS effluent shall not be applied to irrigated areas when soils are saturated NWS effluent shall not enter surface waters as runoff or spray from irrigation NWS effluent shall not enter/ contact a dwelling, food handling facility, and/or drinking water fountain as runoff or spray from irrigation
Cooling towers	Must comply with Title 24 of the Rules of the City of New York, Chapter 8

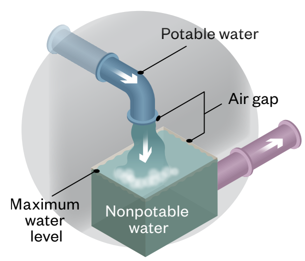
[4] A NWS with subsurface irrigation as the only end use does not require disinfection as per the NYC Plumbing Code Chapter 14 Section 1401.5

2.4 Cross Connection Prevention

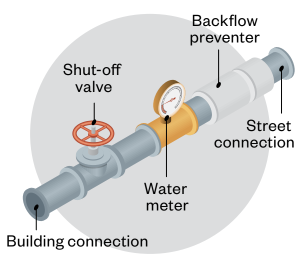
Preventing cross connections in plumbing systems is critical for continued protection of public health. A cross connection is any actual or potential physical connection between a potable (drinking water) supply line and a nonpotable substance, which can lead to the contamination of the potable water supply. Cross connection prevention aims to ensure separation between nonpotable and potable water systems. The following are the main components of a cross connection prevention program for a NWS:



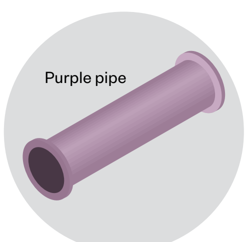
Cross connection testing must be completed according to the shutdown procedure outlined in Section 1502.3 of the Uniform Plumbing Code to ensure there are no inadvertent cross connections throughout the NWS conveyance system (DOB, Plumbing Code, 2022). Cross connection testing will require temporary disruption to water supply in serviced buildings.



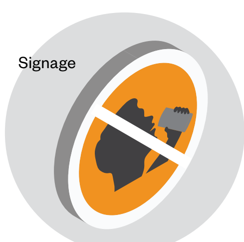
The NYC Plumbing Code requires an **air gap** at any device serviced by both potable and nonpotable water, including NWS treated effluent storage tanks with potable water makeup. An air gap is required by these systems to protect potable water from backflow. Air gaps must be inspected annually according to NYC Plumbing Code 312.10 (DOB, Plumbing Code, 2022).



Backflow prevention devices are required by DOB to protect the public water system from building backflow. Backflow prevention assemblies must be inspected annually. Refer to the NYC Cross-Connection Program Handbook for additional requirements.



Buildings serviced by NWSs are often referred to as **'purple pipe'** areas, meaning they have two separate pipelines, meters and taps for their recycled and drinking water supplies. NWS conveyance lines are typically colored purple for identification purposes, which can further reduce the risk of cross connections between potable and nonpotable sources.



Appropriate signage as necessary should be installed to reduce the likelihood of accidental cross connections between potable and nonpotable sources. Signage may include labeling of nonpotable distribution piping and signs at terminal fixtures and fittings that water is nonpotable.

SECTION 3: OPERATIONS AND MONITORING

The following information is provided as high level guidance only. Operators should consult accepted industry best practices such as those published by the National Blue Ribbon Commission for Onsite Non-Potable Water Systems for additional information on how to safely operate a NWS in the interest of public health protection. See References for more information.

3.1 Operations and Maintenance

Operating a NWS requires careful planning, diligent management, and a commitment to public health. Regular maintenance and a robust monitoring system are vital to ensuring compliance with regulations and continuous protection of public health. The operating considerations may vary depending on the size of the NWS and the treatment complexity required by the source and end use. A comprehensive Operations and Maintenance Plan should be developed, updated annually and kept on-site. Key considerations for the Operations and Maintenance Plan are outlined below:

Water Use Planning	Develop a comprehensive plan for the building's nonpotable water use, including identifying specific applications (e.g., toilet flushing, irrigation) and identifying periods of high and low usage due to changes in building occupancy. Optimize the system for operation at varying flowrates.
Treatment Process Monitoring	Use continuous on-line monitoring systems to validate that the integrity of various treatment processes is maintained. Establish a schedule for remote and on-site operations by an appropriately qualified operator.
Routine Maintenance Schedule	Establish a regular maintenance schedule for all components of the NWS, and maintain an inventory of spare components according to manufacturer recommendations.
System Wide Integrity	Ensure that, beyond the treatment processes, the conveyance system, including pipes, pumps, and storage tanks, is well-maintained and free from leaks, corrosion, or other issues that could compromise water quality or system efficiency.
Water Quality Monitoring	Regularly test the quality of the treated water (effluent) using certified and approved standard laboratory methods to ensure it meets the required standards for its intended use and to validate the performance of continuous monitoring systems.
Record Keeping	Maintain thorough records of water quality data, maintenance activities, and any incidents or issues that arise for at least 5 years. This documentation may be required for regulatory reporting and can be useful for system optimization.
Emergency Response	Develop and regularly update emergency response plans in case of system failures or water quality issues. These plans should outline triggers to divert nonpotable water from distribution to protect public health, notification procedures, and corrective actions.

3.2 Testing and Monitoring

NWS testing and monitoring are performed to validate and control that treatment processes are performing as designed. Testing occurs on finished treated nonpotable water, at the point of connection between the NWS and conveyance. This section provides an overview of typical testing and monitoring requirements in accordance with industry guidance. Develop protocols and procedures for your specific NWS including water quality monitoring parameters, sample collection and testing, field logs, analytical laboratory test methods, data validation and reporting. Backflow prevention device and air gaps must be inspected annually.

Example Testing Schedule and Water Quality Standards

Water Quality Parameter	NWS Effluent Testing Schedule (Based on NWS Source Type)				Effluent Water Quality Standards (All NWS Source Types)		
	Rainwater / Clear Water Waste	Stormwater/ Foundation Drainage	Gray Water	Sewage	Control Limit	Applicability	Control Limit Exceedance Triggers Diversion to Sewage
Total Coliform	Monthly			Weekly	<= 23MPN/ 100mL	All sources	No
					< 100MPN/ 100mL	All sources	Yes
Turbidity	Continuous monitoring				< 2.0 NTU for 95% of measurements. At no time above 5 NTU	All sources	No
pH	Continuous monitoring				6.5-8.0	All sources	No

Total Coliform

Total coliform is a key bacteriological indicator and provides a quantitative validation that the NWS disinfection and treatment processes are working. In addition to the maximum control limit of 100 MPN per 100 mL identified above, additional corrective actions are recommended when analyzing the water sampling results.

Example Corrective Actions

NWS Effluent Total Coliform Sample Results	Corrective Actions
>23 MPN/100 mL	Retest for Total Coliform within 24 hours; Preform daily until < 2.2 MPN/100 mL
>100 MPN/100 mL	Divert nonpotable water to sewer and retest for Total Coliform; Use nonpotable water effluent only when testing result is < 2.2 MPN/100 mL

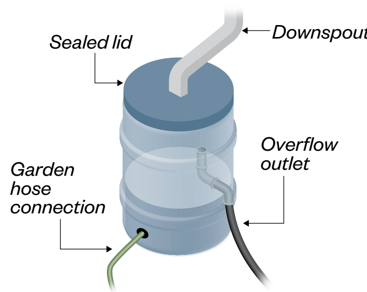
SECTION 4:
SPECIAL SYSTEMS

4.1 One- and Two-Family Homes

Homeowners of one- or two- family homes can implement practices that reduce household water consumption and help you save money. The full definition for one- and two- family dwellings can be found in the NYC Building Code definitions (DOB, Building Code, 2022). This section illustrates allowable water reuse options available to one- and two- family homeowners including rainwater barrels, water closet-sink combinations, and subsurface landscape irrigation systems.

Rain Barrels

Rain barrels connect directly to your property's gutter or downspout to capture and store rainwater deposited on your rooftop. This stored water can be used for outdoor uses like irrigation or washdown, reducing household water consumption and helping you save money.

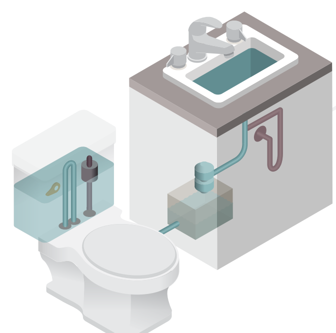


Suggested Guidance:
NYC Stormwater Manual Table 5.7

Resources:
DEP Rain Barrel Giveaway Program

Water Closet-Sink Combinations

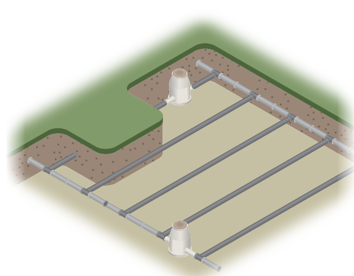
Water closet-sink combinations are fixtures that allow wastewater from a sink to discharge directly into the flushing tank of a toilet. The toilet and sink must be located in the same room.



Required Regulation:
NYC Plumbing Code Appendix C

Subsurface Landscape Irrigation Systems

Subsurface landscape irrigation systems connected to nonpotable water from on-site water reuse systems must be designed and installed in compliance with the NYC Plumbing Code Chapter 14. Disinfection is not required for water reuse for subsurface landscape irrigation systems.



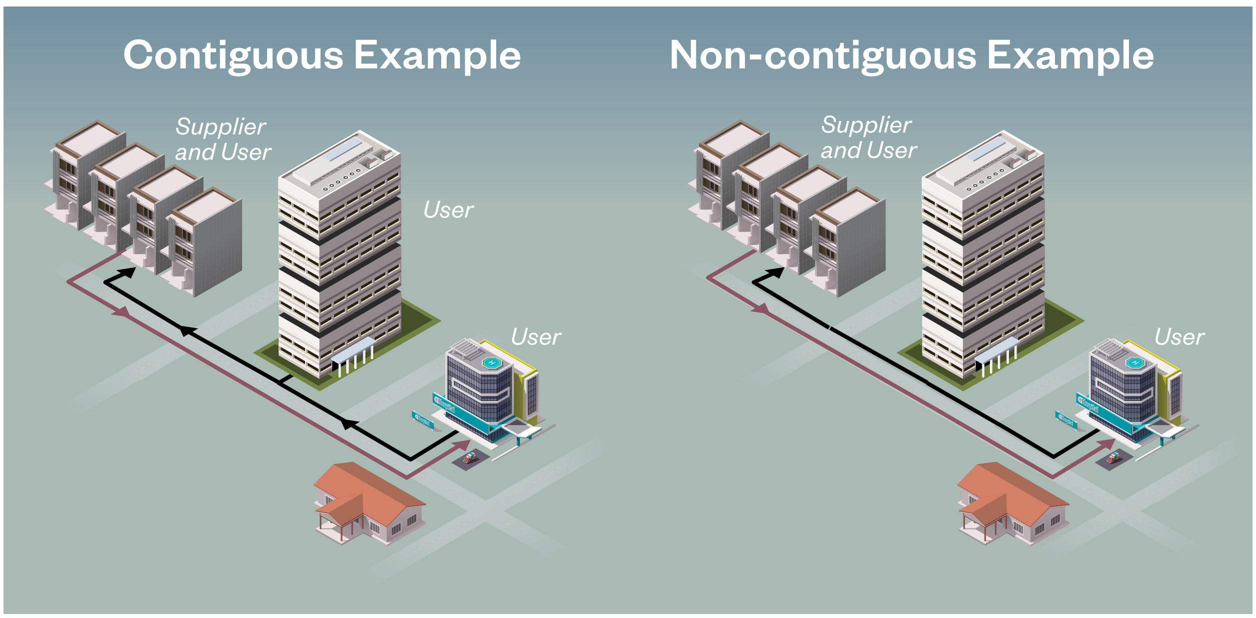
Required Regulation:
NYC Plumbing Code Ch. 14

4.2 District-Scale Systems

A district-scale system is a NWS with sources, end uses, treatment processes, and/or conveyance components that are located within two or more tax lots. Involved properties may be contiguous or non-contiguous but must fall under a singular ownership/management scheme.

If all entities involved in the district-scale system are located adjacent to one another, the NWS is a contiguous system. If the involved entities under singular ownership/management do not share a common property line, then the system is non-contiguous.

In district-scale systems, a "supplier" is an entity supplying appropriately treated nonpotable water from an NWS to the system and a "user" is an entity accepting nonpotable water for end use applications. An entity can be both a supplier and an end user.



For each building in the district served by the NWS, the building owner is required to submit the NWS as a private water supply to the Commissioner of the DOB for approval and recording as per NYC Building Code, §27-907 (DOB, Building Code, 2022). Any use of a private source of water supply must comply with all relevant Plumbing Codes and Health Codes.

Example of District Scale Reuse in NYC: the Solaire and the Verdesian

The NWS at the Solaire treats sewage from the building and conveys treated water for indoor end use (toilet/urinal flushing) for the Solaire and the neighboring Verdesian, which is a contiguous district-scale NWS under single ownership. In addition, the NWS also provides treated water for other building end uses including cooling towers and subsurface irrigation to contiguous Tear Drop Park.

Appendices

A. Glossary
B. Example Treatment Trains
C. References

Appendix A
Glossary

Term (Acronym)	Definition	Section
Combined Sewer Overflow (CSO)	A mix of excess stormwater combined with untreated or partially treated domestic sewage and industrial wastewater from a combined sewer outfall directly into the city's waterways to prevent sewage from backing up in the system and causing upstream flooding.	1.3
Department of Environmental Protection (DEP)	New York City's agency responsible for managing the city's water supply, collecting and treating wastewater, and reducing air, noise, and hazardous materials pollution.	1.6
Department of Buildings (DOB)	New York City's agency responsible for helping provide housing and commercial space, and for enforcing the City's Construction Codes and zoning regulations.	1.1
Department of Health and Mental Hygiene (NYC Health Department)	New York City's agency responsible for protecting and promoting the City's health.	1.1
Leadership in Energy and Environmental Design (LEED)	A rating system developed by the U.S. Green Building Council (USGBC) to evaluate the environmental performance of buildings and measure their sustainability. The LEED system provides a framework for healthy, efficient, carbon and cost-saving green buildings, which includes water conservation strategies.	1.6
Log Reduction Targets (LRT)	The level of pathogen removal and/or inactivation required to maintain an acceptable level of risk based on source water and end use.	2.2
Log Reduction Values (LRV)	The logarithm reduction "credit" assigned to each unit process representative of its ability to reduce pathogens in a treatment train.	2.2
Membrane Biological Reactor (MBR)	A water and wastewater treatment process that combines a suspended growth bioreactor with a microfiltration or ultrafiltration membrane unit.	2 .2
Most Probable Number (MPN)	A statistical estimate of the number of pathogenic cells per unit volume in a sample of water, generally expressed as the microbial population per 100mL.	3.2
Nephelometric Turbidity Units (NTU)	The unit of measure for turbidity, representative of the prevalence of suspended particles in a sample of water.	3.2
Nonpotable Water System (NWS)	A water system for the collection, treatment, storage, distribution and reuse of nonpotable water generated on site.	1.2
Reduced Pressure Zone (RPZ)	A device used to prevent backflow in potable water piping systems that could occur due to fluctuations in system pressure.	1.4
Solids Retention Time (SRT)	The average amount of time that wastewater solids spend in a unit treatment process.	2.2
Total Organic Carbon (TOC)	A unit of measure for the concentration of organic carbon in a sample of water.	2.2
Ultraviolet Light (UV) Disinfection	A disinfection process used in water and wastewater treatment to inactivate microorganisms using electromagnetic light radiation. Ma	2.2
Ultraviolet Transmittance (UVT)	A unit of measure for the amount of ultraviolet light that is able to pass through a sample of water. The higher the level of transmittance, the more likely that UV disinfection is effective.	2.2

Appendix B

Example Treatment Train 1

Classification: Indoor End Use **Source:** Stormwater **End Use:** Toilet Flushing

STEP ONE: Determine Required LRTs[5]

Identify the required pathogen log reduction targets (LRTs) for this NWS system.

NWS Source	Indoor End Use			Outdoor End Use		
	Virus	Protozoa	Bacteria	Virus	Protozoa	Bacteria
Sewage	8.5	7	6	8	7	6
Gray Water	6	4.5	3.5	5.5	4.5	3.5
Stormwater/Foundation Drainage	3.5	3.5	3	3	2.5	2
Rainwater/Clear Water Waste	N/A	N/A	3.5	N/A	N/A	3.5

STEP TWO: Identify Minimum Treatment Requirements

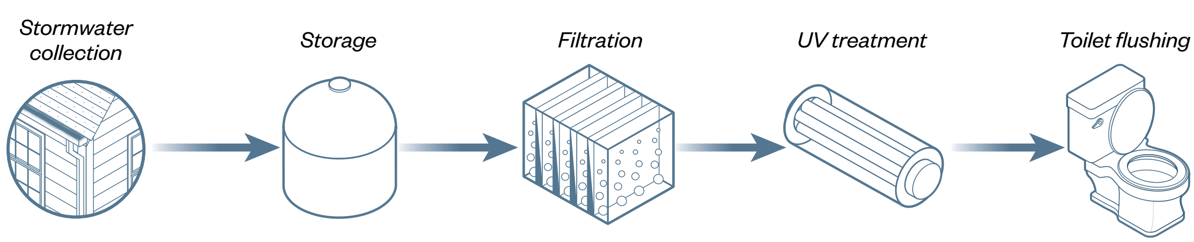
Based on LRVs for treatment processes, possible treatment options to achieve LRTs for each pathogen is indicated below. To achieve target LRTs for treatment, the NWS designer may elect to use UV disinfection or chlorine disinfection with ultrafiltration.

Treatment Process	Virus	Protozoa	Bacteria	Key Process Parameters for Treatment Validation
Filtration Processes				
Membrane Biological Reactor (MBR)	1.5	2	4	Solids retention time (SRT), turbidity
Microfiltration or Ultrafiltration[6]	0	4	0	Daily pressure decay test,effluent turbidity
Reverse Osmosis	2	2	2	Total organic carbon (TOC), Electrical conductivity
Disinfection Process				
Chlorine Disinfection (dose dependent)	Up to 5	Up to 0	Up to 5	Free chlorine residual
Ultraviolet (UV)(dose dependent)[7]	Up to 6	Up to 6	Up to 6	Ultraviolet transmittance (UVT), flow rate
Ozone[9]	4	3	4	Oxidation reduction potential

STEP THREE: Design Treatment Process

The NWS designer elects to use UV disinfection at a dosage of 180 mJ/cm^2. As shown in the table below, a combination of ultrafiltration and UV in series is sufficient to meet the required pathogen LRTs. Water quality requirements are satisfied. The system below highlights the processes of the treatment train that can contribute to meeting LRTs, but there are other sections of the treatment train not shown, such as treated water storage and odor control.

Pathogen Crediting	Virus	Protozoa	Bacteria
Treatment Process #1: Mircofiltration or Ultrafiltration Treatment	0	4	0
Treatment Process #2: UV at a dosage of 180 mJ/cm^2	3.5	6	4
Total	3.5	10	4
Required	>= 3.5 ✓	>= 3.5 ✓	>= 3 ✓



[5] Refer to National Blue Ribbon Committee's A Guidebook for Developing and Implementing Regulations for Onsite Nonpotable Water Systems for more information on log reduction credits associated with different disinfection dosages (US Water Alliance, 2017).

[6] LRVs for microfiltration and ultrafiltration are adapted from the National Blue Ribbon Committee's A Guidebook for Developing and Implementing Regulations for Onsite Nonpotable Water Systems (US Water Alliance, 2017).

[7] LRVs for ultraviolet disinfection are adapted from the 2020 USEPA Innovative Approaches for Validation of Ultraviolet Disinfection Reactors for Drinking Water Systems (Wright et al., 2020) and the National Blue Ribbon Committee's A Guidebook for Developing and Implementing Regulations for Onsite Nonpotable Water Systems (US Water Alliance, 2017)

Example Treatment Train 2

Classification: Indoor and Outdoor End Use **Source:** Sewage **End Use:** Irrigation and Toilet Flushing

STEP ONE: Determine Required LRTs[5]

Identify the required pathogen log reduction targets (LRTs) for this NWS system. Indoor end use LRTs for sewage were selected as this was the greatest risk out of the two end uses, as reflected by the more conservative LRTs.

NWS Source	Indoor End Use			Outdoor End Use		
	Virus	Protozoa	Bacteria	Virus	Protozoa	Bacteria
Sewage	8.5	7	6	8	7	6
Gray Water	6	4.5	3.5	5.5	4.5	3.5
Stormwater/Foundation Drainage	3.5	3.5	3	3	2.5	2
Rainwater/Clear Water Waste	N/A	N/A	3.5	N/A	N/A	3.5

STEP TWO: Identify Minimum Treatment Requirements

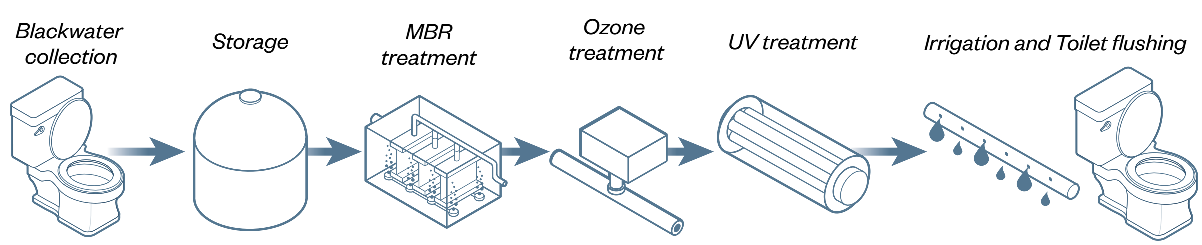
Based on LRVs for treatment processes, possible treatment options to achieve LRTs for each pathogen is indicated below. To achieve target LRTs for treatment, the NWS designer may elect to use MBR for filtration and ozone and UV for disinfection.

Treatment Process	Virus	Protozoa	Bacteria	Key Process Parameters for Treatment Validation
Filtration Processes				
Membrane Biological Reactor (MBR)[8]	1.5	2	4	Solids retention time (SRT), turbidity
Microfiltration or Ultrafiltration	0	4	0	Daily pressure decay test,effluent turbidity
Reverse Osmosis	2	2	2	Total organic carbon (TOC), Electrical conductivity
Disinfection Process				
Chlorine Disinfection (dose dependent)	Up to 5	Up to 0	Up to 5	Free chlorine residual
Ultraviolet (UV)(dose dependent)[7]	Up to 6	Up to 6	Up to 6	Ultraviolet transmittance (UVT), flow rate
Ozone[9]	4	3	4	Oxidation reduction potential

STEP THREE: Design Treatment Process

The NWS designer elects to use a UV disinfection at a dosage of 150 mJ/cm^2. Testing must be performed to validate that the pathogen reduction is achieved before installation, usually in a test facility, and after installation, during the commissioning period for field verification (Sharvelle et al., 2017). As shown in the table below, a combination of MBR, ozone and UV disinfection in series are sufficient to meet the required pathogen LRVs. Water quality requirements are satisfied. The system below highlights the processes of the treatment train that can contribute to meeting LRTs, but there are other sections of the treatment train not shown, such as treated water storage, membrane backwash, and pumping.

Pathogen Crediting	Virus	Protozoa	Bacteria
Treatment Process #1: MBR	1.5	2	4
Treatment Process #2: Ozone	4	3	4
Treatment Process #3: UV at a dosage of 150 mJ/cm^2	3	6	4
Total	8.5	11	12
Required	>=8.5 ✓	>=7 ✓	>=6 ✓



[8] LRVs for MBR filtration are adapted from Australian WaterSecure Innovations Ltd's Membrane bio-reactor: WaterVal validation protocol (WaterSecure, 2017)

[9] LRVs for ozone disinfection are adapted from Australian WaterSecure Innovations Ltd's Ozone disinfection: WaterVal validation protocol (WaterSecure, 2017).

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