PNWS-AWWA 2026 Conference | Tacoma, WA

American Water Works Association Pacific Northwest Section

Improving Water Treatment Resilience and Sustainability with Biological Treatment



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Agenda

- Biological Treatment Basics
- Applications of Biological Treatment
  - Aerobic Surface Water Biological Filtration
  - Aerobic Groundwater Biological Treatment
  - Anoxic Groundwater Biological Treatment
  - Aerobic Biological Filtration for Reuse
- Developing Biological Treatment Guidance

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Agenda

- **Biological Treatment Basics**
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Biological Filtration

"Biofiltration of drinking water is an operational practice of managing, maintaining, and ***promoting biological activity on media*** in the filter to ***enhance the removal of organic and inorganic constituents*** before treated water is introduced into the distribution system."

-AWWA Biological Drinking Water Treatment Committee

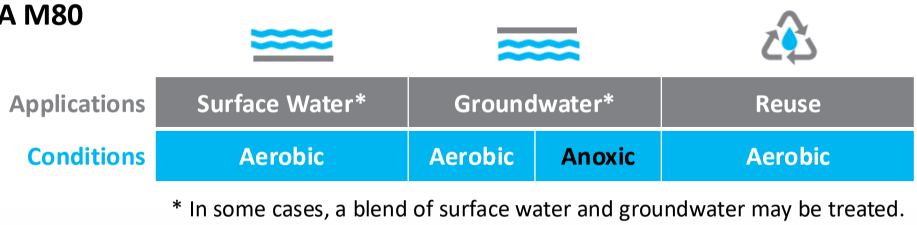


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Biological Treatment

Microorganisms found in natural water systems grow on engineered surfaces or media (i.e., form a biofilm) and biologically transform or degrade compounds in the process influent.

-**AWWA M80**



* In some cases, a blend of surface water and groundwater may be treated.

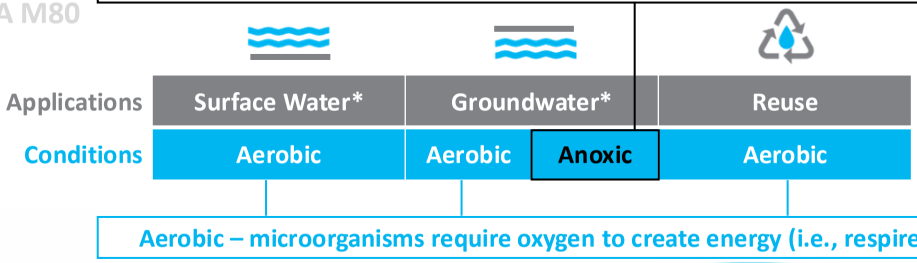
5

Biological Treatment

Microorganisms found in natural water systems grow on engineered surfaces or media (i.e., form a biofilm) and biologically transform or degrade compounds in the process influent.

-AWWA M80

Anoxic – Microorganisms use an alternative electron acceptor (e.g., nitrate) instead of molecular oxygen

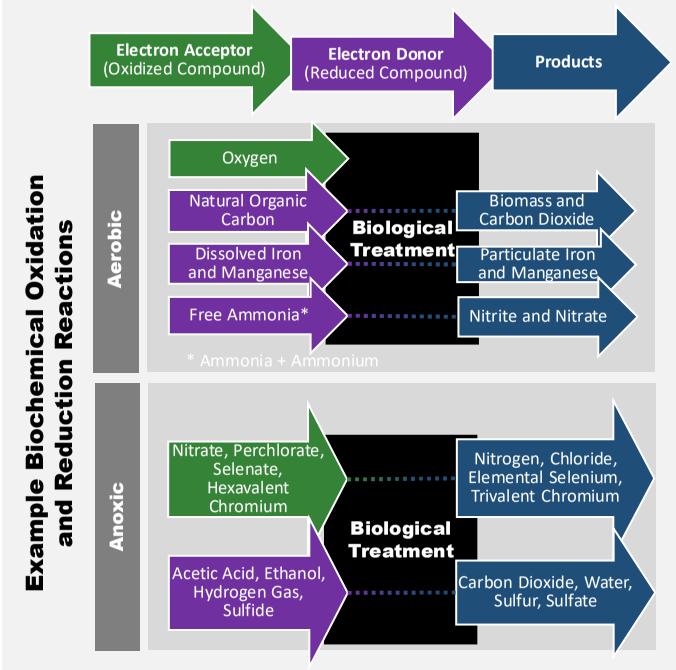


Aerobic – microorganisms require oxygen to create energy (i.e., respire)

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Removal Goals & Mechanisms

- **Organic Carbon Compounds**
- **Inorganic Compounds**
- **Trace Organic Compounds**



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Biological Drinking Water Treatment is not New, But Need for Guidance

Surface Water Biofiltration

- **4000 B.C.E** Incidental biofiltration
- **Early 1800s** Low-rate biofiltration of drinking water
- **1970s** Rapid-rate biofiltration in Europe
- **1998** U.S. Stage 1 DBPR
- **2006** U.S. Stage 2 DBPR
- **2012** New WRF biofiltration focus area

Biological Treatment of Groundwater

- **Pre-1980s** Implementation not well documented
- **1980s** Design to optimize removal of iron, manganese and ammonia
- **1999** 1st full-scale anoxic biotreatment (denitrification)

Biofiltration for Reuse

- **1969** First DPR facility
- **2002** 1st DPR with biofiltration
- **2011** 1 MGD demonstration facility online in the U.S.

2008 AWWA Committee on Biological Drinking Water Treatment founded

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Agenda

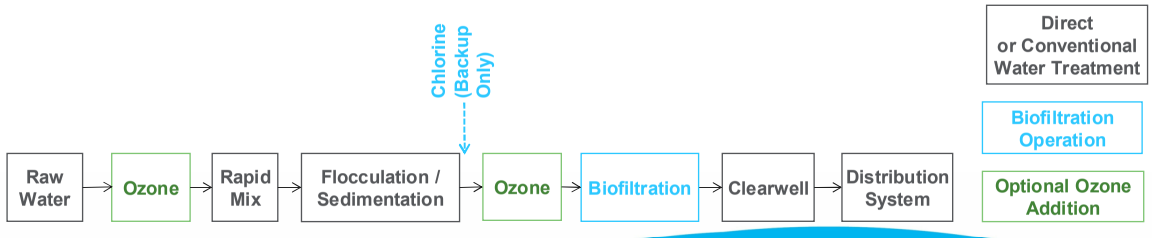
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Aerobic Surface Water Biofiltration

Operating conventional/direct gravity filters with low/absent oxidant residuals to encourage biofilm formation

- **Primary goal:** Particle Removal
- **Additional goals:** DOC, inorganic contaminants, and trace organic contaminants



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Benefits

Simultaneous contaminant removal:
- Particles (and pathogens)
- Natural organic matter
- DBP precursors
- Taste and odor compounds
- Cyanotoxins
- Pharmaceuticals, personal care products, pesticides, flame retardants, and plasticizers
- Iron, manganese, and ammonia

Increased distribution system biostability

Sustainable & Cost-Effective:
- Low energy/operational costs
- Can be retrofitted into existing filters
- No additional residual waste stream

Optimization

Media Type

Empty Bed Contact Time

Backwash Protocols

Influent Water Quality:
Biodegradable organic matter
Temperature, pH, nutrients
Upstream treatment

Shutdown/Start-Up Procedures

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CASE STUDY

Acclimation of New Surface Water Biofilters

Denton, Texas

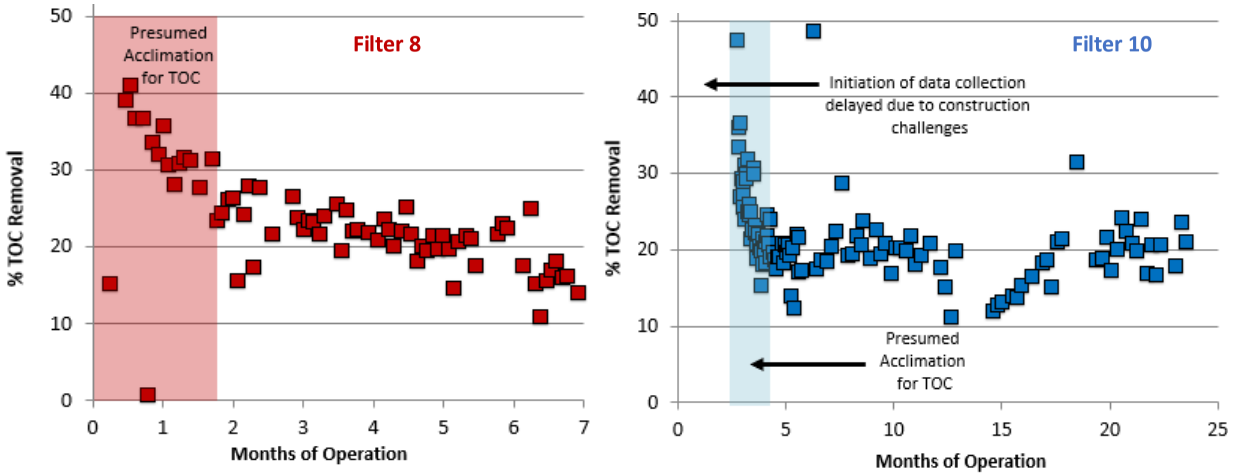
30 MGD Conventional Treatment with Ozone and Biofiltration

- GAC (26”) and Sand (12”) Biofilters
- 9-minute EBCT (during study)
- Non-chlorinated backwash



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Filter 8 (converted in summer) acclimated in half the time as Filter 10 (converted in winter)



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Filter 8 (converted in summer) acclimated in half the time as Filter 10 (converted in winter)

Performance Goal	Filter 8	Filter 10
Steady TOC Removal (21-23%)	2 months	4 months
>90% Manganese Removal	2.5 months	7 months
Steady-State ATP	2.5 months	5 months

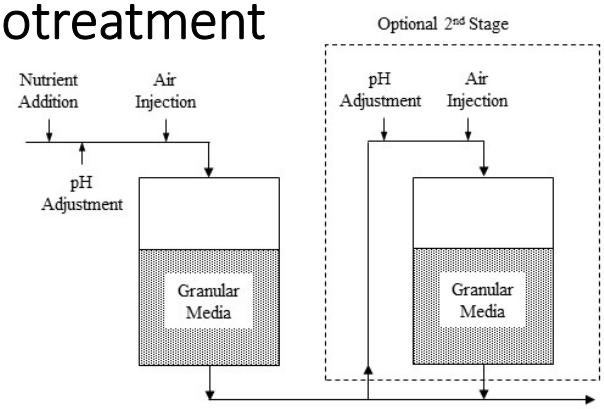
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Aerobic Groundwater Biotreatment

Growth of natural microorganisms on media to oxidize dissolved contaminants in multiple configurations:

- Open aeration followed by filtration
- Air/oxygen injection and pressurized filtration system
- Aeration contactor through a coarse bed followed by filtration

May be referred to as a biofilter if a granular media also designed to remove particles, such as iron, is used



Example of Air Injection Followed and Pressurized Filtration

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Benefits

Simultaneous (one or two-stage) contaminant removal:

- Ammonia
- Iron
- Manganese
- Arsenic
- Organic Carbon

Sustainable & Cost-Effective:

- Low energy/operational costs
- No concentrated waste stream
- Minimal downstream treatment

Optimization

Aeration

pH Adjustment

Nutrient Addition

MediaType, Size and Configuration

Backwash Protocols and Residuals Handling

Post-Treatment

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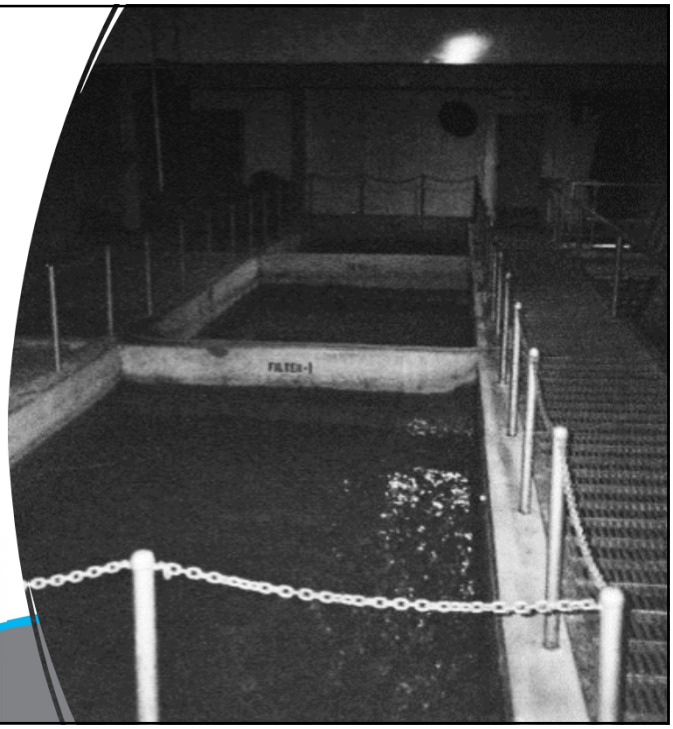
CASE STUDY

Performance of Groundwater Biofilters

Xenia, Ohio

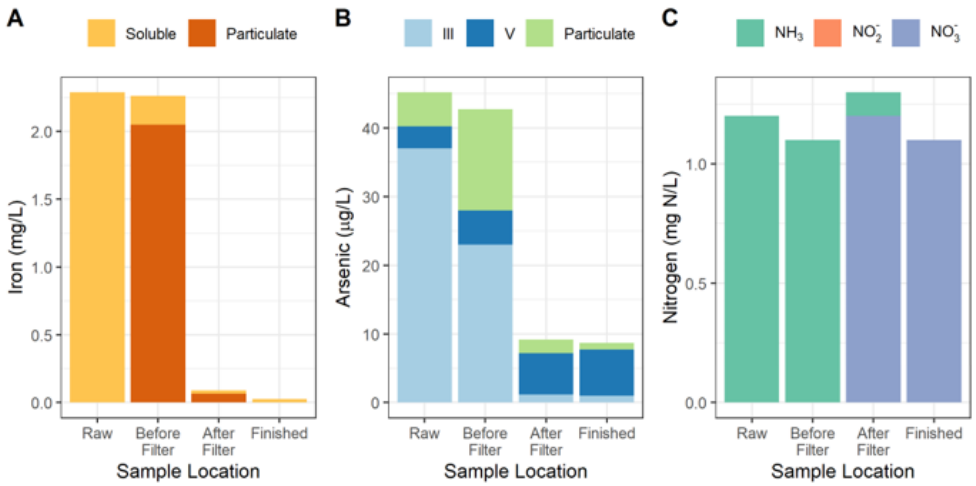
1.2 MGD

- Aeration
- Single-Stage Biofiltration
- Chlorination



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Simultaneous Removal of Multiple Contaminants Achieved Across Single-Stage Biofilters

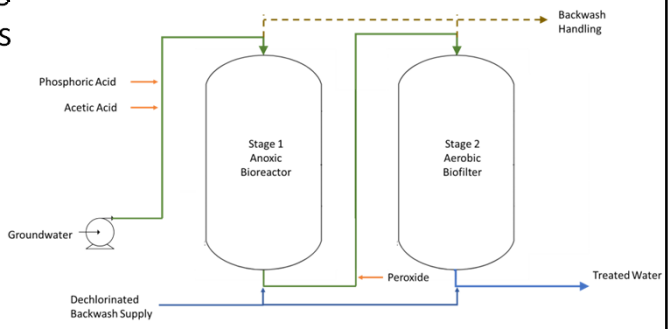


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Anoxic Groundwater Biotreatment

Growth of natural microorganisms on media to remove contaminants in the absence of oxygen, in multiple configurations:

- Fixed-bed bioreactor
- Fluidized bed bioreactor
- Submerged membrane
- Continuously stirred-tank reactor



Example: Two-Stage Fixed Bed Bioreactor

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Benefits

Simultaneous contaminant removal:
- Inorganic contaminants (nitrate, perchlorate, bromate, chromium, and selenium)
- Radiological contaminants
- Volatile Organic Compounds (trichloroethylene and dichloroethylene)

Sustainable & Cost-Effective:
- Low energy/operational costs
- No concentrated waste stream

Optimization

Media Type and Design

Electron Donor (Substrate)

Nutrient Addition

Contact Time

Biomass Control

Post Treatment

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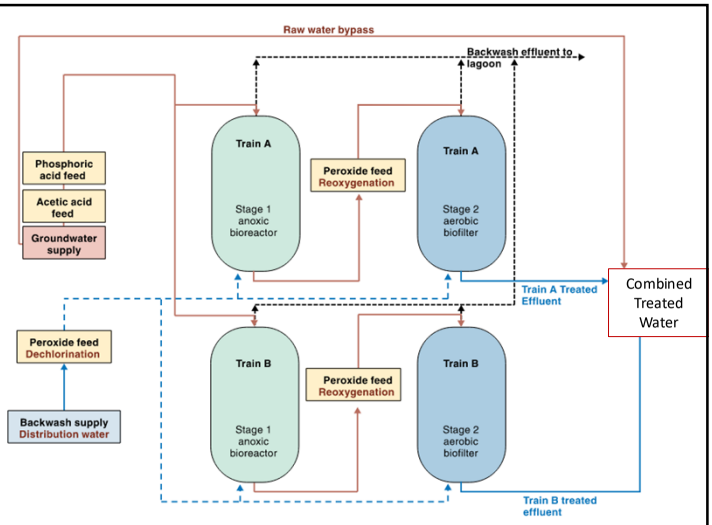
CASE STUDY

Removal of Nitrate

City of Taylorville, IL

2,100 gpm two-stage fixed bed bioreactor

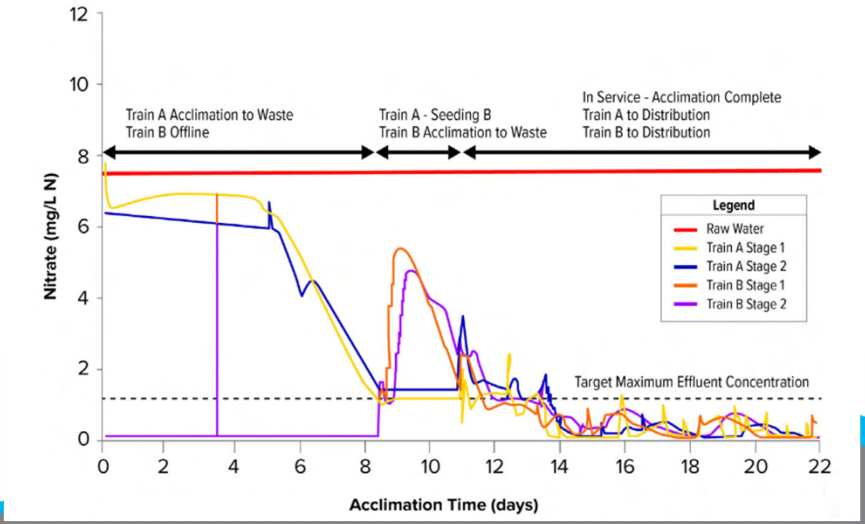
- Targets:
  - < 1 mg/L N out of Stage 2
  - < 7 mg/L N in blend
  - Maintaining 2.5 mg/L DO in the FXB effluent



Source: Modified from AWWA M80 2026

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Acclimation occurred in less than 15 days

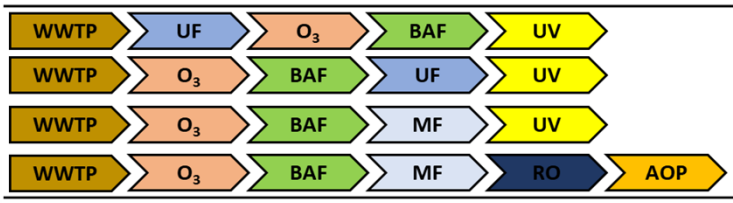


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Aerobic Biofiltration for Potable Reuse

Operating rapid-rate filters with low/absent oxidant residuals to encourage biofilm formation as part of multibarrier approach

Treatment Trains



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Benefits

Simultaneous contaminant removal:
- Dissolved organic carbon
- Trace contaminants (e.g., pharmaceuticals and nitrogenous DBPs)
- Inorganic compounds (e.g., metals, salts)
- Ozonated byproducts

Sustainable & Cost-Effective:
- Critical for inland utilities as part of multibarrier approach (non-RO)
- No concentrated waste stream

Optimization

Upstream Treatment

Pre-Oxidation

Media Type and Design

Empty Bed Contact Time

Backwash Strategies

Post Treatment

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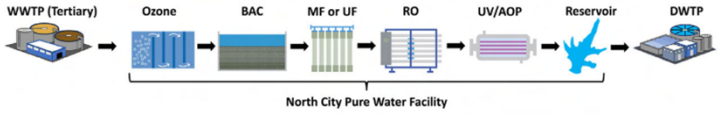
CASE STUDY

Indirect Potable Reuse

San Diego Pure Water, CA

1 MGD Advanced Treatment Demonstration Facility

- BAC with EBCT of 15 minutes

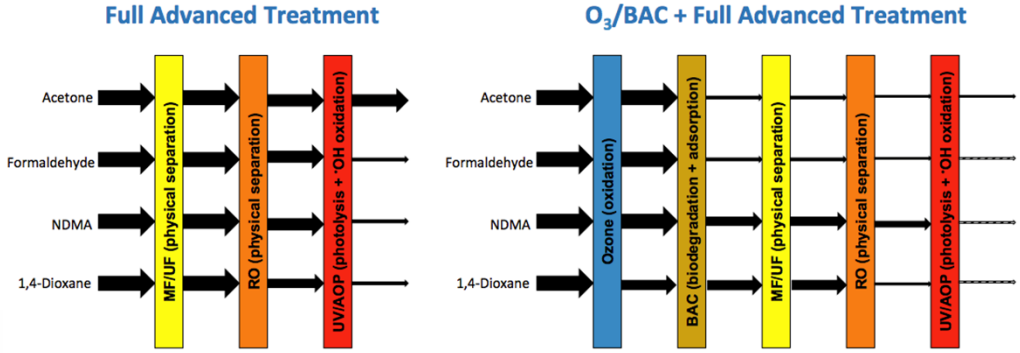


AOP—advanced oxidation process, AWPF—advanced water purification facility, BAC—biologically active carbon, DWTP—drinking water treatment plant, MF—microfiltration, RO—reverse osmosis, UF—ultrafiltration, UV—ultraviolet



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Incorporating Ozone-BAC into the Pure Water San Diego AWPF Removes Compounds that Persist through RO



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Advancing Biofiltration Knowledge Over the Last Two Decades



2006
Stage 2 DBPR

2008
AWWA **Biological Drinking Water Treatment Committee** *founded*

2013
1st International Symposium on Biological Treatment
March 28-29, Denver, Colo.

2016
2nd International Symposium on Biological Treatment
Jan. 27-28, Long Beach, Calif.

Organization Involvement
- Regulations/State Standards
- Water Research Foundation
- American Water Works Association

2007 – 2010
Study of "Biological Drinking Water Treatment Perceptions and Actual Experiences in North America," WRF 4129

2016
Biofiltration Knowledge Base *published*, WRF 4459

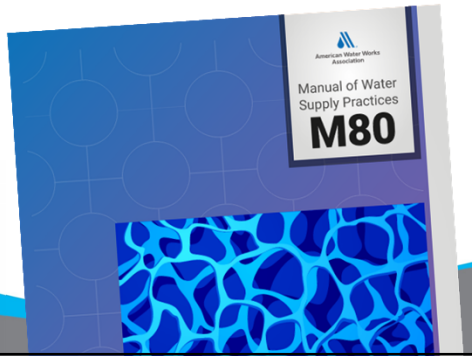
Proformance Tracking Tool *published*, WRF 4525

2017
Conversion Guidance Manual and **Conversion Assessment Tool** *published*, WRF 4496

WRF Focus Area – Biofiltration: Defining Benefits & Developing Utility Guidance

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Advancing Biofiltration Knowledge Over the Last Two Decades



2018
3rd International Symposium on Biological Treatment
Jan. 24-25, Austin, Tex.

2018
Recommended Standards for Waterworks (10 States Standards) including Surface Water and Groundwater Biological Treatment *published*

2019
Guidance Manual for Monitoring Biological Filtration of Drinking Water *published*, WRF 4620

2020
4th International Symposium on Biological Treatment
Feb. 12-13, Atlanta, Ga.

2021
Biofiltration Guidance Manual for Potable Surface Water Treatment, WRF 4719

2025
AWWA Manual of Water Supply Practices, M80: *Biological Drinking Water Treatment*

WRF Focus Area – Biofiltration: Defining Benefits & Developing Utility Guidance

Organization Involvement
- Regulations/State Standards
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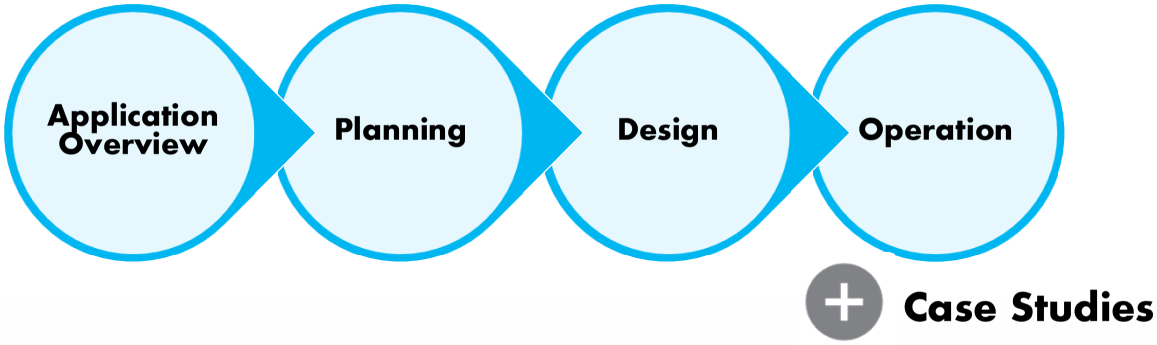
AWWA M80: The first guidance document covering all common biological treatment processes in practice today

Applications	Surface Water*	Groundwater*		Reuse
Conditions	Aerobic	Aerobic	Anoxic	Aerobic

* In some cases, a blend of surface water and groundwater may be treated.

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M80 Provides Practice Guidance for Water Systems



+ Case Studies

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Improving Treatment Sustainability and Resilience with Biological Treatment

https://store.awwa.org/M80-Biological-Drinking-Water-Treatment?whence=

$111 for AWWA members



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Acknowledgements

- Chapter Authors, Co-Authors and Reviewers
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2 – Lynn Stephens

3 – Asher Keithley & Darren Lytle

4 – Giridhar Upadhyaya & Jess Brown

5 – Christina Alito & Jen Hooper

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Thank you.
Questions?

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