Division of Drinking and Ground Waters
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Guidelines for Obtaining Approval of Membranes to Meet Particulate and Microbiological Removal Requirements for Surface Water Treatment

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This document was developed for the purpose of providing technical guidance to members of the regulated community to comply with Ohio Administrative Code Rule 3745-81-73. This guidance is not intended to create any new requirement but is merely a suggested approach to comply with OAC Rule 3745-81-73. Nothing herein should be interpreted as precluding other strategies to comply with those requirements.

This document lays out two pathways to gain plan approval:

- submitting a protocol and conducting a successful pilot-scale demonstration study to inform the design for full scale membrane facilities, or
- incorporating established design criteria from Section VII of these guidelines into the design for the full-scale membrane facilities in lieu of conducting a pilot-scale demonstration study.

I. Purpose

This document establishes two possible pathways for obtaining approval of a specific membrane system to meet particulate and microbiological (*Giardia lamblia*, *Cryptosporidium parvum*, bacteria, and if proposed, viruses) removal requirements for surface water treatment.

It is intended that the successful application of these guidelines will result in the design of a treatment system that will provide drinking water meeting or exceeding the requirements of surface water treatment at a reasonable cost. It must be recognized that additional treatment may be required to address other water quality issues such as disinfection, viruses, disinfection byproduct formation, or other contaminants that may be present.

Log removal credit for *Giardia lamblia* and *Cryptosporidium parvum* for a specific membrane module will be based on the data from challenge tests indicating the log removal capability of the specific membrane module. The challenge test may be conducted by the manufacturer or a third party (preferred).

II. Background And Objectives

Ohio Administrative Code (OAC) Rule 3745-81-73 requires public water systems that use a surface water source, or a groundwater source under the direct influence of surface water, to provide conventional filtration, direct filtration, slow sand filtration or other filtration technology for the removal of pathogenic microorganisms.
Membrane technology is a process that may be used to satisfy the filtration requirements of the OAC.

It is not expected that membrane treatment will satisfy all requirements for the treatment of surface water. The total treatment scheme must be evaluated; consideration must be given to pretreatment and post-treatment processes.

Membranes may be used to achieve treatment objectives other than particulate and microbiological removal. These objectives must be addressed in the protocol or the design criteria summary report, depending on which procedure is used by the public water system (PWS). In any case, membrane treatment must satisfy the requirements of OAC Rule 3745-81-73.

The objective of this guideline is to promote consistency throughout the State of Ohio in administering provisions of the Ohio Administrative Code regarding the use of membranes for compliance with surface water treatment requirements.

III. Applicable Regulations Plan Submittal Application for Log Removal Credit

1.0 All membrane projects shall submit a plan submittal application for log removal credit.

1.1 A request for specific log removal credit for *Giardia lamblia*, *Cryptosporidium parvum,* and viruses must be submitted for review and approval by the agency to comply with OAC Rule 3745-81-73(C). Systems providing membrane filtration for compliance with the Long Term 2 Enhanced Surface Water Treatment Rule must also comply with OAC Rule 3745-81-68(K).

The submittal should include supporting performance data from challenge studies conforming to the requirements of the ***Long Term 2 Enhanced Surface Water Treatment Rule*** and the U.S. EPA Membrane Filtration Guidance Manual, EPA 815-R-06-009, November 2005. A membrane product must have an established log-removal efficiency through a product-specific challenge test certified by NSF/ANSI Standard 419 or an equivalent challenge test. The challenge test results must be verifiable. This request must also include a description of all proposed integrity testing procedures for the full-scale system and calculations to justify the requested log removal credits.

1.2 Membranes are eligible for log removal credits up to the level documented by the challenge test results submitted. Log removal credits will be granted up to the requirements of the OAC rules in effect at the time of the approval of the demonstration study. Documented log removal capabilities in excess of current requirements are eligible for log removal credits to satisfy future requirements.

1.3 In order to receive the requested log removal credits, an integrity testing program consistent with the requirements of Long Term 2 Enhanced Surface Water Treatment Rule (or latest draft) and the U.S. EPA Membrane Filtration Guidance Manual, EPA 815-R-06-009, November 2005, for the proposed plant should be submitted for approval.

The integrity testing program submitted for the full-scale plant must be capable of verifying the log removal credits granted. Any changes in the integrity testing program during full-scale operations must be reviewed and approved by the agency. Unapproved changes in integrity testing may reduce or void log removal credits. Calculations to demonstrate the minimum applied start pressure needed to detect a 3-micron breach using the proposed direct integrity method at the specific full-scale application should be provided with the plan submittal application. Calculations to demonstrate the pressure decay result, which correlates to the requested log removal, should also be provided.

Daily direct integrity testing (e.g., pressure decay, vacuum hold, bubble point, sonic, etc.) and continuous turbidity monitoring are required to be performed in accordance with OAC Rule 3745-81-73(C).

IV. Other Applicable Guidance

ANSI/AWWA. 2015. Microfiltration and Ultrafiltration Membrane Systems. Standard B112-15.

ASTM Standard D6908-03 Standard Practice for Integrity Testing of Water Filtration Membrane Systems, ASTM, Unpublished.

AWWA. 1999. Water Quality and Treatment, A Handbook of Community Water Supplies, 5th Edition, R.D. Letterman (Editor), McGraw-Hill, Inc.

AWWA. Microfiltration and Ultrafiltration Membranes for Drinking Water, Manual of Water Supply Practices M53. AWWA. 2016.

Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. 2018. Recommended Standards for Water Works, (also referred to as Ten States Standards).

NSF/ANSI. 2018. Public Drinking Water Equipment Performance – Filtration. Standard 419-2018.

Ohio EPA DDAGW. 2010. Approved Capacity: Planning and Design Criteria for Establishing Approved Capacity for: 1) Surface Water And Ground Water Supply Sources, 2) Drinking Water Treatment Plants (WTPs), and 3) Source/WTP Systems.

Ohio EPA DDAGW. 2018. Ohio EPA Plan Review Procedures for Drinking Water Facilities.

Patterson, M.E. 2020.Developing Design Standards to enable the use of innovative technology in Ohio Public Water Systems. [Master's thesis, The Ohio State University]

Stantec's Water Treatment: Principles and Design. 2023. J. C. Crittenden, R. R. Trussell, D.W. Hand, K.J. Howe, G. Tchobanoglous, B. Ward, J.H. Borchardt (Editors), John Wiley & Sons, Inc. DOI:10.1002/9781119820086

U.S. EPA. 1991. Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources, U.S. EPA, Contract No. 68-01-6989.

U.S. EPA. 2001. Low-Pressure Membrane Filtration for Pathogen Removal: Application, Implementation, and Regulatory Issues. EPA 815-C-01-001.

U.S. EPA. 2005. Membrane Filtration Guidance Manual. EPA 815-R-06-009.

U.S. EPA. 2023. Long Term 2 Enhanced Surface Water Treatment Rule Documents. Retrieved from ***epa.gov/dwreginfo/long-term-2-enhanced-surface-water-treatment-rule-documents***

V. Policy

DDAGW recommends the following two procedures be used to determine the acceptability of low-pressure membranes (LPM) for treatment of surface waters at water treatment plants. One procedure includes submitting a protocol and conducting a successful pilot-scale demonstration study to inform the design for full scale membrane facilities. Details for this procedure are found in Section VI of these guidelines.

A second procedure for obtaining approval of LPM includes incorporating established design criteria from Section VII of these guidelines into the design for the full-scale LPM facilities in lieu of conducting a pilot-scale demonstration study. This procedure can only be used for public water systems which have membrane influent quality that meets the criteria for the good water quality category or the medium water quality category in Table 1. A public water system that has membrane influent water quality in the poor water quality category below will be required to conduct a pilot-scale demonstration study in accordance with the pilot-scale demonstration

procedure outlined in Section VI of these guidelines or will be required to demonstrate adequate pretreatment as outlined in Section VII.

Table 1: Water Quality Categories for Low-Pressure Membrane Influent Water

Parameter	Section VII		Section VII		Section VI	
	Good Water Quality[a]		Medium Water Quality[a]		Poor Water Quality[b]	
	Avg	95th	Avg	95th	Avg	95th
Turbidity (NTU)	≤ 5	≤ 10	≤ 10	≤ 50	> 10	>50
TOC (mg/L)	≤ 2		≤ 4		> 4	
Fe, dissolved (mg/L)	≤ 0.05		≤ 0.3		> 0.3	
Mn, dissolved (mg/L)	≤ 0.02		≤ 0.05		> 0.05	

[a] Plan Approval at provided flux with no demonstration required, see Section VII
[b] Pilot-scale demonstration required, See Section VI

Regardless of the procedure chosen, if a PWS will be changing the existing treatment scheme by installing LPM, it will likely be considered as a change in treatment which will trigger corrosion control requirements. Refer to ENG-9119-GD Guidelines for Determining When Source and Treatment Changes Trigger Optimal Corrosion Control Evaluation for further guidance. The PWS should provide a plan describing how information needed to complete corrosion control requirements will be obtained and incorporated into the LPM plan-approval process.

VI. Procedure - Site Specific Pilot-Scale Demonstration Study

This procedure was developed in consultation with Ohio Section AWWA - Technology Committee and it outlines the process of using a site-specific pilot-scale demonstration study to gather site specific information related to full-scale plant design, reliability, and O&M issues. It is recommended to submit a protocol prior to conducting the study to ensure appropriate data is collected. Deviations from this protocol may be accepted based on the justification submitted. This procedure is recommended for all LPM applications but this procedure, or justified equivalent, must be used for systems which don't meet the eligibility criteria for the procedure outlined in Section VII of these guidelines.

1.0 Support Information

1.1 Operating parameters to be evaluated should include:

Cold and warm temperature flux, percent recovery, backwash frequency, backwash duration, backwash method, clean-in-place (CIP) method and frequency, transmembrane pressure, pretreatment, and post treatment.

1.2 Where a new membrane process is proposed for an existing water treatment plant, a membrane pilot- scale unit should utilize the water following any existing processes that will precede the membrane units in the proposed design. When a new membrane treatment plant is proposed, all pretreatment processes will need to be included in the pilot-scale demonstration test.

Where rerating of existing membranes or utilization of a different membrane is proposed, the isolation of full-scale membrane units at an existing WTP operated for comparison with all or some of the remaining membrane units is the preferred method. An alternative is the use of a pilot-scale membrane unit for comparison with the full-scale membrane units of the existing WTP. Any rerated or different membrane must meet all regulatory requirements.

1.3 Additional requirements that should be met prior to performing a demonstration study using a full scale WTP are:

1.3.1 The WTP should be under the responsible charge of a properly certified operator.

1.3.2 The WTP should have appropriate redundancies for all essential processes and associated equipment.

1.3.3 All equipment should be maintained in good condition.

1.4 It is strongly recommended that the Division of Surface Water be contacted as early as possible to determine options for disposal of waste streams from both the pilot-scale and the full-scale plant. The following are examples of disposal options that may be approvable:

1.4.1 Direct discharge to a stream. An NPDES permit is required based on waste stream characterization, receiving stream low flow discharge, and protection of water quality standards.

1.4.2 Discharge to a publicly owned treatment works (POTW). If the discharge is to an approved pretreatment program POTW (a list of approved pretreatment program POTWs are available on the Ohio EPA Division of Surface Water website or contact Ohio EPA Division of Surface Water), the local POTW should be contacted for any possible limits or specific pre-treatment needed. If the discharge is to any POTW other than a Ohio EPA approved pretreatment program POTW, then the industry will either be covered by Ohio EPA's permit-by-rule requirements (OAC Rule 3745-36-06) if it is a non-significant industrial user or submit an indirect discharge application to Ohio EPA for possible pretreatment limits (OAC Chapter 3745- 03) if it is a significant industrial user (OAC Rule 3745-36-02(U)).

1.5 Since this is an emerging technology in Ohio, it is highly recommended that at least one person be an engineer who has been involved in conducting and interpreting previous membrane filtration studies, at least one of which is comparable to the proposed study. (See footnote 1)

2.0 Demonstration Study

[1] Once a particular membrane and configuration is selected for testing, care should be taken to protect the owner from extreme price fluctuations. The following items should be considered; Obtain firm equipment and membrane prices prior to testing the membrane; Ensure price caps are provided for eventual replacement of membranes; Ensure that the membrane to be piloted will be available for the foreseeable future. Obtain performance guarantees based on seasonal water quality and demands. Also consider piloting more than one membrane.

2.1 Demonstration Criteria

The purpose of the demonstration study is to assess the performance and reliability of the membrane system during the critical conditions, to determine operating parameters, to assess the fouling potential, and to determine the necessary cleaning procedures for receiving approval for the process from Ohio EPA. Prior to the performance of the demonstration study, a protocol should be submitted and approved in compliance with OAC Rules 3745-81-73(C) and 3745-91-02(C). The protocol should include:

2.1.1 Results from analysis of source water or proposed influent to membrane water quality data for at least the previous 12- month period, if available. Variations in source water quality will need to be addressed.

2.1.2 Statement of objectives and conclusions from an evaluation of the source water or proposed influent to membrane water quality identifying time periods when the critical conditions are likely to occur. Critical conditions include, but may not be limited to high turbidity, low temperature, dissolved iron and manganese, and presence of algae.

2.1.3 Schematic drawings and detailed descriptions of the facilities to be used. Differences between the pilot configuration and the proposed full scale WTP should be clearly noted and discussed. The need for additional testing of a modified design will be reviewed on a case-by-case basis.

2.1.4 Mode(s) of operation to be tested. For example: flux, transmembrane pressure, pretreatment, etc.

2.1.5 Time schedules for each mode of operation. The schedule should address the relationship between the modes of operation and the critical conditions identified in 2.1.2 and should encompass all of the periods of critical conditions identified. At a minimum the most challenging water quality condition should be tested.

2.1.6 Sampling locations to be monitored, including pretreatment and post treatment processes, when required. It is expected that most post treatment processes may be tested on the bench scale.

2.1.7 Parameters to be monitored at each sampling location.

2.1.8 Frequency of monitoring for each parameter.

2.1.9 Description of on-line and bench analytical equipment to be used for monitoring each parameter.

2.1.10 Quality assurance/quality control procedures to be used. All parameters for which Ohio EPA laboratory certification is available should be conducted in an Ohio EPA certified laboratory.

2.1.11 Description of analyses to be used for evaluating the data collected.

2.1.12 Additional data collection for treatment objectives beyond particulate and microbiological removal requirements for surface water treatment. The data collection for pretreatment and post treatment are site specific and should be included in the protocol.

2.1.13 Proposed approved capacity ratings

The generally recognized relationship between membrane flux and water temperature suggests that approved capacity will be higher in the warmer months than in the colder months. The nature of membranes is such that economic benefits may be realized by pursuing a dual plant capacity rating based on seasonal water temperature and system demand.

A single plant approved capacity rating will be based on meeting the annual maximum day at the limiting flux, typically the coldest water temperature. In many cases this will result in significantly more membrane area being installed.

If applicant proposes a dual plant approved capacity rating, data must be collected to show that maximum day demands will be met for each period. Data may include manufacturer's temperature versus flux curves, system demand curves and data collected during the pilot testing periods. Data analysis must address the impact of membrane feed water turbidity and temperature on flux.

2.2 A pilot-scale demonstration study should be conducted for at least 2,000 hours. The selection of the test period(s) is to be based on analysis of water quality data for the source water or proposed influent to the membrane water as indicated in Item 2.1.2. At a minimum, the test should include the time period likely to encounter the most challenging water condition.

Examples of acceptable testing schedules are:

- One year, five days per week, eight hours per day.
- One test period starting in late winter and ending in early fall.

Continuous operation of the pilot unit is recommended. However, only periods of time when monitoring is being conducted at the required frequencies should apply towards the minimum recommended 2,000 hours. If a critical continuous 2,000-hour period can be identified for the most challenging water condition, the minimum 2,000 hours may be achieved during this period.

Testing requirements may be reduced where at least one year of acceptable operational data are submitted from a WTP which uses membranes similar to the proposed membranes, treats feed water of similar quality and under similar operating conditions. Data from previous studies conforming to these guidelines will be considered.

Similarity of feed water quality parameters which may affect the operation of the membrane should be statistically demonstrated. Such parameters may include: turbidity, total organic carbon, dissolved iron, dissolved manganese, algae, calcium, magnesium, total hardness, total alkalinity, pH and temperature.

As outlined in Section VII, the testing may not be required if the operational data submitted are for a feed water of similar quality, the same membrane, and the same operating conditions.

2.3 The following data should be collected for the demonstration study.

2.3.1 Turbidity

Turbidity Requirements	Frequency
Piloted Membrane Feed water	every 4 hours[1]
Piloted Membrane Permeate	every 4 hours[1]

[1] Ohio EPA recommends continuous testing for permeate. Continuous turbidity analyzers shall be standardized in accordance with Ohio EPA guidance.

2.3.2 Other Water Quality Parameters

Other water quality parameters	Frequency
Dissolved iron	weekly
Dissolved manganese	weekly
Total organic carbon	weekly

2.3.3 Other parameters

Parameters	Frequency
Water temperature	Daily
Flow rates	Every 4 hours
Backwash method, duration, frequency	(As performed)
Membrane feed and permeate pressures	Every 4 hours
Direct integrity testing and results	Daily

Additional data may be needed for treatment objectives beyond particulate and microbiological removal requirements for surface water treatment.

2.4 Data analysis should be performed for the pilot-scale membrane, and should consist of, at least:

2.4.1 Turbidity

2.4.1.1 Membrane feed and permeate for pilot membrane:

Maximum, average, minimum and standard deviation. Graphical representation versus time, and trend analysis.

2.4.1.2 Pilot membrane permeates: Percent of time turbidity exceeds 0.3 NTU

Note: It should be recognized that a well operated membrane system should be capable of achieving turbidity values significantly below 0.3 NTU.

2.4.2 Other data

Pilot membrane results should consist of the following:

- Relevant Pretreatment performance indicators
- Relevant Post treatment performance indicators
- Flow rates - graphical representation versus time, and trend analysis
- Membrane flux - graphical representation versus time, and trend analysis
- Percent recovery- graphical representation versus time, and trend analysis
- Backwash method, duration, frequency
- Transmembrane pressure-graphical representation versus time, and trend analysis
- Direct and indirect integrity testing and results

2.5 Membrane Maintenance Recommendations

The demonstration study data and other relevant data should be evaluated and a recommendation made regarding cleaning frequency and procedures to optimize membrane performance and longevity.

3.0 Approval Criteria

3.1 Piloted membranes should be monitored for the entire period specified as described in section 2. If the proposed membrane for the full-scale water treatment plant is different from the piloted membrane, additional testing may be required. Sufficient justification of performance for changes proposed should be described and potential impacts should be discussed to determine if additional testing is needed.

3.2 A report shall be submitted in which the data collected, results of the data analysis, and the conclusions and recommendations are presented and clearly summarized.

The results of the data analysis should be presented in an acceptable format. Data should also be submitted in an agreed on electronic format. The report should also include all other data collected during start up prior to each test period.

For each operation mode performed during the demonstration study, the pertinent parameters (raw water source, chemical type and dose, pH, etc.) should be clearly defined and presented in the report.

3.3 Permeate turbidity from a pilot-scale membrane must:

3.3.1 Be less than 0.3 NTU in at least 95% of the samples during the test period.

3.3.2 Be less than 1 NTU in all samples during the test period.

VII. Procedure - Membrane Design Criteria

This procedure was developed by the Ohio Water Resources Center at The Ohio State University in consultation with Ohio EPA and the collaborators listed at the end of the document to provide design criteria for low pressure membrane (LPM) filtration for surface water treatment plants.

These design criteria were developed for LPM filtration on the premise that the manufacturer- recommended flux value minimizes the risk of premature irreversible fouling. Following these guidelines does not imply premature or irreversible fouling will not occur at the specific application where it will be installed. It is the responsibility of the PWS to work with the manufacturer to determine if additional testing and other site-specific considerations are warranted. The option for systems to conduct site-specific pilot-scale demonstration studies to allow the use of higher flux values or to gain approval for worse membrane-influent water quality levels will

continue to be available. This site-specific pilot-scale demonstration study should comply with Section VI of these guidelines.

This procedure allows Ohio PWSs to install a specific validated membrane product for good- and medium-quality water (as defined in Table 1 in Section V) at the influent to the membranes without the need for a pilot-scale demonstration study.

For reference purposes only, access to a catalog of membranes that have undergone some demonstration testing, is provided in Appendix A in this document. Any fluxes listed may be maximum rates and not necessarily applicable to all public water system site-specific conditions. Performance flux rates must be verified with the manufacturer and corresponding demonstration data submitted to justify the design flux rate for a PWS.

1.0 Characterize PWS Historical Water Quality from Point in Treatment Scheme Where Membranes will be Installed

1.1 Appropriate data for each of the parameters in Table 1 is needed for proper use of this procedure. Based on at least 12 consecutive months of water quality, preferably 36 consecutive months, determine the average turbidity value, average TOC value, average dissolved iron value, and average dissolved manganese value from water collected at the point in the treatment scheme where membranes will be installed. The 95th percentile turbidity calculations should also be calculated. Turbidity values should have been measured no less frequently than daily. TOC, iron, and manganese values should have been measured no less frequently than monthly. In the event that monitoring is not currently collected from the influent to the planned membrane location in the treatment train, collection frequency will be determined in conjunction with PWS, design engineer, and Ohio EPA. In all cases, expected conditions with higher levels of parameters in Table 1 shall be measured.

1.2 In the event that pre-treatment is part of the project scope, an engineer's report must be prepared (see Appendix C) as justification of performance to meet influent water quality in Table 1.

2.0 Determine Appropriate Water Quality Category from Table 1

2.1 Using the average values for turbidity, TOC, dissolved iron, and dissolved manganese determined in accordance with Section 1.0 above, compare the values for each parameter with the respective values presented for the categories of good water quality, medium water quality, and poor water quality in Table 1 above.

The water quality category should match the worst condition for the required parameters. For example, if turbidity, TOC, and manganese concentrations fall within the good water quality category, but iron concentrations fall within the medium water quality category, then the overall water quality bin would be for the medium water quality category.

2.2 Good Water Quality Category or Medium Water Quality Category

If the PWS Historical Water Quality falls within either the Good Water Quality Category or the Medium Water Quality Category, the PWS may use the design criteria in this procedure for design of the full-scale facilities in lieu of conducting a pilot-scale demonstration study.

To use the design criteria approach, based on the determined water quality category from Table 1, submit a T-RFI to at least 3 LPM manufacturers under consideration (See Appendix B). The purpose of the T-RFI is to obtain information on appropriate design parameters directly from manufacturers.

2.3 Poor Water Quality Category

If the PWS historical data falls within the poor water quality category, the PWS will be required to follow the procedure in Section VI-pilot scale demonstration; or alternatively, may successfully demonstrate pretreatment of source water to values for Turbidity, TOC, dissolved iron, and dissolved manganese that would fall within the good or medium water quality categories, as described in Section VII 2.4 below.

2.4 Altering Water Quality Category Designation

2.4.1 If a PWS intends to install pretreatment, two options may be used to demonstrate pretreatment.

2.4.1.1 An engineer's report submission may be used to demonstrate the ability to achieve pretreatment (see Appendix C for required content).

2.4.1.2 Demonstration of pretreatment may be provided through data collected from a bench, pilot, or full-scale study on PWS's specific water or appropriate equivalent demonstration (i.e., similar water quality and similar WTP processes).

2.4.2 For a PWS which makes this demonstration, the pretreatment process must be installed in the full-scale design.

2.4.3 If the pretreatment demonstration is successful, determine the appropriate design flux for the demonstrated water quality category for the full-scale design for a specific membrane product.

3.0 Determine Appropriate Design Flux from T-RFI inquiry for same water quality bin for a Specific Validated Membrane

3.1 The specific membrane products targeted in T-RFI inquiries can be used in the full-scale design. For the chosen membrane, the most conservative design flux with accompanying validation data for the given water quality category for the PWS is the expected design flux. If a PWS chooses to use a membrane that does not have a recommended design flux with accompanying validation data, a pilot-scale demonstration study will be required in accordance with Section VI of these guidelines.

3.2 T-RFI data required for a LPM product under consideration for installation must include a recommended flux value with accompanying validation data from previous pilot- or full-scale studies performed for a minimum of 2,000 hours. The validation data must show the following: membrane-influent turbidity and membrane-influent levels of total organic carbon (TOC), dissolved iron, and dissolved manganese; CIP frequency; flux, TMP, or specific flux recovery following CIP events; operating flux value(s), and water temperature throughout the study. Any water quality analysis used for the pilot study must use standard methods and follow appropriate quality assurance and quality control protocols. Submitted data may be reviewed by Ohio EPA. If sufficient data for validation is not provided, or data is not compliant with requirements, that LPM would be able to be installed after a successful demonstration study.

4.0 Submission of Membrane Design Criteria Procedure Report

Submit a report that includes the following, as a minimum, for review and acceptance by Ohio EPA;

4.1 Historical Water Quality Data for Membrane Influent

a) Turbidity data, in spreadsheet form (include sample dates, source in operation at the time (if more than one source), and sample location) with calculation of average and 95th percentile.

b) TOC data, in spreadsheet form (include sample dates, source in operation at the time (if more than one source), and sample location) with calculation of average.

c) Dissolved iron data, in spreadsheet form (include sample dates, source in operation at the time (if more than one source), and sample location) with calculation of average.

d) Dissolved manganese data, in spreadsheet form (include sample dates, source in operation at the time (if more than one source), and sample location) and calculate average

4.2 Analysis

a) Indicate the Water Quality Category to be used in the full-scale membrane design based on the historical water quality data.

b) Provide analysis to justify which water quality category was selected.

c) Indicate the Membrane Product and the Design Flux to be used in the full-scale design.

d) Provide validation data to justify the Design Flux.

4.3 Log removal

a) Indicate the log removal which will be requested for the full-scale membrane design.

b) Provide a copy of challenge study results to justify the log removal being requested and the approval letter from another state if available. (Section III)

c) Provide an integrity testing program.

d) A plan must be submitted as indicated in Section III above in this guidance document.

5.0 Recommendations for Contract and Bidding Documents for PWS

5.1 The PWS is encouraged to include the following criteria or conditions in its contract(s) with the selected design professional and with the contractor submitting the lowest and best bid. The PWS should consult with Ohio EPA on contract language to discuss any issues with approval or funding.

5.1.1 Performance Criteria (based on flux values in design criteria)

5.1.2 Capital and Operation & Maintenance costs

5.1.3 Necessary pretreatment to lower source water levels of the water quality parameters listed in this design standard to the levels for good- or medium-quality membrane influent. Note: An Engineer's Report may be necessary, see Section VII, 1.2.

5.1.4 Useful life of membrane

If the membrane elements fail within the 7-year design life, replacement should be on a prorated basis. This recommendation should not deter from a PWS' ability to set their requirements in the contract documents.

5.1.5 Frequency of routine backwash cycles

5.1.6 Frequency of chemically enhanced backwashes

5.1.7 Frequency of clean-in-place (CIP) events

The minimum time between required CIP events should be no less than 30 days at the recommended design flux with recovery at or above 95% for a minimum design life of seven years.

PWS may consider a different cleaning interval based on an evaluation of downtime.

To justify a shorter cleaning interval, relevant data should be evaluated and a recommendation made regarding cleaning frequency and procedures to optimize membrane performance and longevity.

5.1.8 Cleaning chemicals shall be NSF/ANSI Standard 60 certified.

5.1.9 Energy usage

5.1.10 Upper limit of transmembrane pressure (TMP)

5.1.11 Integrity testing information and frequency and percentage of fiber breakage when running under similar full-scale operation at design flux

5.2 For additional guidance on planning, procurement, selection, construction, and commissioning of LPM, the PWS should consult the ANSI/ AWWA B112-15 Standard for Microfiltration and Ultrafiltration Membrane Systems.

6.0 Collaborators for Design Criteria

Ohio EPA	AECOM	Aqua-Aerobic Systems, Inc.
U.S. EPA	Arcadis	BASF Inge
Avon Lake Regional Water	CTI Engineering Co.	Dupont Water Solutions
Greater Cincinnati Water Works	Hazen & Sawyer	Evoqua Water Technologies
Cleveland Division of Water	Jacobs Engineering Group	Hydranautics
Columbus Division of Water	Shoaf Consulting LLC	Koch Separation Solutions
Newark Division of Water	Stantec Consulting Services, Inc.	Pall Water
Westerville Water Division	Pentair	Toray
WesTech	Ohio Water Resources Center	

VIII. History

The Division of Drinking and Ground Waters first issued this policy on Sept. 16, 2003.

Appendix A – Low Pressure Membranes with Some Historical Demonstration Data

California Surface Water Treatment Rule Alternative Filtration Technology - Membrane Filtration SWRCB-DDW Water Treatment Committee - June 2018, Table: ***atf_mem sum_tables.pdf (ca.gov)*** *

*These are max fluxes, and likely higher than what would be applied based on-site specific water quality conditions. (fluxes listed in CA table are higher than what was determined for development of Table 2)

Table 2: Example Validated Design Flux Values Using Table 1 Water Quality Ranges

Manufacturer	Product[b]	Temperature Corrected Flux at 20°C[a] (gfd)	
		Good Water Quality[d]	Medium Water Quality[d]
BASF Inge	dizzer® XL 0.9 MB 60/70WT	53	insufficient data
Dupont Water Solutions	IntegraFlux SFD-2880XP; IntegraFlux SFD-2860XP; IPD-77XP; IPD-51XP; and IntegraFlux UXA-2680XP	24	insufficient data
Evoqua Water Technologies MEMCOR	L10N, L20N, L40N (Pressure)	62	52
	S10N (Submerged)	44	insufficient data
Koch Separation Solutions	PURON MP	50	50
Pall Water	Microza	56	56
	LGV-3B	93	93
Toray	HFUG-2020AN	70	70

[a] Temperature correction calculation shall match the equations provided in the U.S. EPA's 2005 Membrane Filtration Guidance Manual.
[b] These products are not endorsed by Ohio EPA.
[c] Design flux will be the maximum flux recommended in a 24-hr period for a PWS running at their maximum-day production, assuming one train/skid is out of service. The maximum-day production is the average rate at which finished water exits the water treatment plant on the largest production day in a year. Refer to Ohio EPA's Approved Capacity Document for additional guidance.
[d] When operated at or below the design flux value, at the end of a design life of seven years, the membrane should be able to meet the established log removal credit and have a minimum time between required CIP events of no less than 30 days.

Appendix B - Example Technical Request for Information (T-RFI)

To:	[At least three vendors of LPM under consideration]
From:	[Design Engineer/PWS]
Date:	
Subject:	Technical Request for Information Design of Low-Pressure Membrane Filtration System using Ohio EPA Design Criteria

1. Purpose

This public water system is considering the installation of low-pressure membrane filtration using Ohio EPA design criteria. This document is a technical request for information (T-RFI) to collect technical information related to [insert membrane product under consideration] that would allow use of the LPM guideline and design criteria to install LPM filtration in select circumstances without a pilot-scale demonstration study.

The objective of this T-RFI is to:

- obtain manufacturer-recommended design flux values based on stated water quality ranges;
- gather data to support these recommended flux values; and
- evaluate product-specific design considerations in partnership with the manufacturer.

Ohio EPA, Ohio Water Resources Center, and Ohio AWWA developed design criteria on the premise that there is a reasonable flux value for each membrane that minimizes the risk of premature irreversible fouling. Manufacturer-provided information will be used to determine a water quality specific design flux to ensure LPM filtration design in surface water and Ground Water Under the Direct Influence (GWUDI) public water systems will meet drinking water public health requirements for particle removal. The option for systems to pursue site- specific pilot-scale demonstration studies to allow the use of higher flux values and poorer water quality conditions will continue to be available.

To be eligible to be considered for use of design criteria in lieu of a pilot study, the manufacturer must have with at least one drinking water installation in the United States.

The design team would like to conduct a call with you the week of [insert date], to provide clarity on this T-RFI. Please contact [design engineer] if further clarification is needed on data requested in this document or to discuss concerns. The design team may request additional information based on responses to this request to determine the design flux.

2. LPM Filtration System Requirements

2.1 LPM Filtration Performance Requirements

1. LPM product must have an established log-removal efficiency through a product-specific challenge test as outlined in the U.S. EPA's Membrane Filtration Guidance Manual. The established log-removal value must be greater than or equal to 2 log for Cryptosporidium, and 3 log for Giardia.
2. The minimum time between required clean-in-place (CIP) events shall be no less than 60 days at the recommended design flux for a minimum design life of 10 years.
3. The LPM shall meet all applicable SWTR performance requirements from Ohio EPA, including but not limited to:
    a. Permeate turbidity from a membrane must:
        i. Be less than 0.3 NTU in at least 95% of the samples during the test period.
        ii. Be less than 1 NTU in all samples during the test period.

2.2 LPM Filtration Water Quality Ranges

The LPM design criteria established water quality ranges for select water quality parameters. Water quality ranges influent to the membrane for this PWS are [insert appropriate water quality ranges for turbidity, TOC, dissolved Fe, and dissolved Mn] placing this PWS in the [insert good or medium] water quality bin for purposes of determining a manufacturer-recommended flux values for this PWS water quality condition as requested in Section 3.2. The water quality parameters of manufacturer-provided data must fit within the [insert appropriate bin for PWS] consistent with the water quality for this PWS or be of worse water quality. If pretreatment is included as part of the design project that allows water quality influent to the LPMs to be within one of these bins, efficacy of pretreatment shall be demonstrated.

Note that these water quality ranges are provided for the Manufacturer to estimate fouling tendency and provide a flux value for each LPM which minimizes the risk of premature irreversible fouling. When operated at the recommended flux value, the membrane should be able to meet performance requirements outlined in section 2.1 at the end of a design life of seven years. At the time of writing this T-RFI, design criteria using provided flux values will be for particle/pathogen removal as required by the LT2ESWTR and associated Ohio EPA requirements. A pilot-scale demonstration study will be required to demonstrate treatment efficacy for other purposes (removal of metals, cyanotoxins, etc.).

Table 1: Water Quality Categories for Membrane Influent Water

Parameter	Section VII Good Water Quality[a]		Section VII Medium Water Quality[a]		Section VI Poor Water Quality[b]	
	Avg	95th	Avg	95th	Avg	95th
Turbidity (NTU)	≤ 5	≤ 10	≤ 10	≤ 50	> 10	>50
TOC (mg/L)	≤ 2		≤ 4		> 4	
Fe, dissolved (mg/L)	≤ 0.05		≤ 0.3		> 0.3	
Mn, dissolved (mg/L)	≤ 0.02		≤ 0.05		> 0.05	

[a] Plan Approval at provided flux with no demonstration required, see Section VII
[b] Pilot-scale demonstration required, See Section VI

3. Technical Request for Information

3.1 General

1. The objective of this T-RFI is to obtain manufacturer-recommended design flux values for the good and medium water quality ranges provided in Table 1; to gather full-scale or pilot-scale operating data supporting these recommended flux values; and to evaluate product-specific design considerations in partnership with the manufacturer.
2. Design flux will be the maximum flux that the manufacturer would recommend using the suggested water quality ranges for a public water system running at their maximum-day production, assuming one train/skid is out of service. The maximum-day production is the average rate at which finished water exits the water treatment plant on the largest production day in a year.
3. The manufacturer should respond to this T-RFI by providing all information requested in Section 3.2.

4. The manufacturer may submit separate T-RFI responses for each LPM product sold by the manufacturer that meets the requirements outlined in Section 2. This can include separate responses for products operating in submerged or pressurized conditions, or any other differences in membrane material, construction, configuration, or operation that change the manufacturer-recommended design flux value.
5. The manufacturer is requested to reply electronically by no later than close of business on [insert date] by email to the design team.

3.2 LPM Filtration Product Data Request

1. Provide manufacturer-recommended design flux value, temperature corrected to 20^0C, for the PWS appropriate Table 1 water quality bin or lower. Note that for installations in the poor water quality ranges a pilot-scale study will be required according to the existing Ohio EPA Guidelines for Obtaining Approval of Membranes to Meet Particulate and Microbiological Removal Requirements for Surface Water Treatment. Additionally, any public water systems may high rate their system by demonstrating through a pilot- or full-scale study a higher operating flux than is specified in the design criteria, provided they are always meeting Ohio EPA capacity requirements. The system may demonstrate after installation a higher flux at full-scale. This higher flux value must be demonstrated immediately for systems where demand is not growing or that are not initially constructing their complete facility; while for systems with growing demand, a higher flux can be demonstrated before the full production capacity is needed in operation.
2. Provide manufacturer specifications for LPM product.
3. Provide the manufacturer's warranty language and membrane replacement language that would be proposed for a system provided.
4. Provide manufacturer operating and maintenance recommendations, including recommended CIP chemical(s) and CIP frequency. This design standard specifies the minimum time between required CIP events should be no less than 30 days at the recommended design flux with recovery at or above 95% for a minimum design life of seven years.
5. Provide full-scale performance data and pilot-scale study data (if one was performed) from three existing installations of LPM product (U.S. installations preferred), including for each installation:
    a. Plant process description, temperature corrected recommended design flux, year of membrane installation
    b. Accompanying validation data for recommended design flux from previous pilot- or full-scale studies performed for a minimum of 2,000 hours that show: membrane-influent turbidity and membrane-influent levels of total organic carbon (TOC), dissolved iron, and dissolved manganese (or if unavailable at the nearest measuring point prior); CIP frequency; flux, TMP, or specific flux recovery following CIP events; operating flux value(s), and water temperature throughout the study. Any water quality analysis used for the pilot study must use standard methods and follow appropriate quality assurance and quality control protocols
    c. Daily operational average and maximum flux records, TMP records, and cleaning records
    d. Record of direct or indirect integrity test failures, identified cause, and issue resolution
    e. At least two utility contacts for technical, performance, and maintenance questions

6. Provide challenge test report showing established log-removal values for the product.
7. Comment on other relevant water quality parameters or relevant design considerations not specified above.

Subcommittee for LPM design document: Tanushree Courlas; Maria Lucente; Linda Weavers; Sid Hoover; Josh Fuchs; Tim Wolfe; Jeff Davidson; Matt Charles; David Kohlmeier; Rob Shoaf; John Krinks; Megan Patterson; Judy Stottsberry

Appendix C - Engineer's Report Content Requirements for LPM Design Standard

This document identifies required content for an engineer's report submission to validate design parameters and conditions for LPM projects using the design standard approach. The engineer's report submission will document effectiveness of the LPM and pre-treatment ahead of the LPM from technical-request for information (T-RFI) inquiries to manufacturers.

1. Project introduction
2. Project background
3. Existing conditions at PWS: what is being replaced or treatment objective addressed.
4. Methodology used
5. Summary of T-RFI submission and Manufacturer responses
    a. Summary information required in engineer's report
        i. Performance data from at least three pilot or full-scale demonstration studies from each manufacturer (at least three required) conforming to requirements described in LPM design standard along with manufacturer recommended design criteria
        ii. Demonstrated ability to meet water quality goals, i.e., effluent values rather than percent removal
    b. In appendix to engineer's report, include detailed technical request for information (T-RFI) that was submitted to three manufacturers along with responses sent from three manufacturers.
6. Historical source water quality for PWS. Consider all approved source waters, capacities, and operating scenarios.
7. Characterize influent to LPM historical water quality.
    a. Water quality data may be measured or expected based on justification of expected removal.
    b. Determine and justify most challenging water quality for proposed LPM installation.
    c. Compare influent to LPM water quality parameters in submitted demonstration study data from T-RFI responses with PWS water quality historical and most challenging conditions.
        i. Describe seasonality in water quality influent to LPM.
        ii. Characterize PWS historical water quality as described in Section VII 1.0
            1. Historic total values for iron and manganese can be accepted unless the total is high enough that dissolved becomes a potential problem.
            2. With appropriate justification, source water quality values may be accepted rather than influent to membrane.
            3. Justification of use of historical data from nearby WTP using same source water, if relevant.
            4. Contact Ohio EPA with unique situations with less data collection, e.g., pathogen barrier for ground water applications with low turbidity and if less concerned for fouling.

d. Other key water quality parameters identified by manufacturer.

8. Finished water quality, flux rate, and production goals.
9. Planned location in treatment train and why this location is chosen.
10. Water treatment plant schematic indicating location of proposed LPM and planned pre-treatment.
11. Planned pre-treatment
    a. Discuss pre-treatment options considered and justification for chosen pre-treatment.
        i. Examples of pre-treatment options
        ii. Performance data
        iii. Adequacy of treatment to meet treatment objectives
    b. Indicate expected % removal of four water quality parameters listed in Table 1
    c. Address any other membrane specific influent water quality to membrane considerations from membrane manufacturers
        i. Examples: use of coagulants, chemicals or products (i.e., polymers) prior to membranes and manufacturer performance data from pilot or full-scale applications.
    d. Loading rates to pre-treatment technology
    e. Treatment unit capacities
    f. Number of units
12. Demonstration of pre-treatment for justification of chosen alternative.
    a. Must include at least one of the following methodologies for collection of performance data:
        i. Use pre-treatment T-RFI template to collect information from three manufacturers on performance.
        ii. Use of data from full scale operation of existing treatment at plant
        iii. Results of bench-scale testing
        iv. Use of similar WTP/water quality data from another PWS
        v. Reference or documentation to justify expected removal (e.g., Draft OAWWA's Simultaneous Compliance document)
    b. For treatment that doesn't have established design criteria in RSWW (aka TSS), the performance data from a pilot study or other full-scale study must reflect and meet criteria outlined in Ohio EPA guidelines (e.g. ENG-01-003: Guidelines for Clarifier and Granular Media Filter Ratings at Surface Water Treatment Plants).
    c. Use currently established Ohio EPA guidelines (pilot or meet criteria for equivalent performance data from similar water quality and same treatment)
    d. If guidelines are not established for identified pre-treatment, demonstration may be necessary.

e. Ability to meet influent water quality goals, i.e., influent to membrane water quality goals in Table 1.

Note: In addition to this engineer's report, for a more detailed list of items to be included in an initial plan approval submittal to agency, see Appendix C* of Ohio EPA DDAGW's Plan Review Procedures Guidance, April 2018 (***epa.ohio.gov/static/Portals/28/documents/engineering/PlanReviewProcedures.pdf***).

*Minimum Information Required for Plan Review by Ohio EPA DDAGW (Appendix C of Ohio EPA's Plan Review Procedures Guidance)

In general, plans submitted to DDAGW for review need to contain sufficient information to allow the reviewer to assess compliance with all relevant requirements contained in:

- Recommended Standards for Water Works
- Planning and Design Criteria for Establishing Approved Capacity for 1) Surface Water and Ground Water Supply Sources, 2) Drinking Water Treatment Plants (WTPs), and 3) Source/WTP Systems (2010)
- Guidelines for Arsenic Removal Treatment for Small Public Drinking Water Systems
- Guidelines for Design of Small Public Water Systems
- All applicable rules of the Ohio Administrative Code
- American Water Works Association Standards

The following is a summary of relevant information required for plan review, as applicable for DW projects. Projects to be funded through the WSRLA loan program will require additional information related to specific loan requirements.

Additionally, in accordance with HB 512 and OAC Rule 3745-81-81, Ohio EPA requires the owner or operator of a community or non-transient non-community water system to conduct a new or updated corrosion control treatment study and submit a new or updated corrosion control treatment plan not later than 18 months after any of the following events:

a. The system changes or adds a source from which water is obtained.

b. The system makes a substantial change in water treatment.

c. The system operates outside of acceptable ranges for lead, copper, pH, or other corrosion indicators, as determined by the director.

d. Any other event determined by the director to have the potential to impact the water quality or corrosiveness of water in the system.

Administrative Information

- Complete, current electronic water supply data sheet and upon receipt of invoice, submit applicable fee payment
- Owner acceptance. This can be done by the owner signing the title sheet of the plans or submitting a letter stating they will own and operate the system (typically needed for water line extensions when the plans are submitted by the developer and not the PWS which will ultimately own and maintain the system)
- Capability Assurance Plan (CAP) – required for all new community and non- transient non-community systems
- General Plan - See criteria in OAC Rule 3745-91-02. General plans are required to be submitted for water treatment plant design or construction projects that are seeking funding through the Water Supply Revolving Loan Account (WSRLA) and for public water systems, which conform to any one or

combination of the following: (a) More than 500 service connections. (b) Treat for a primary MCL or HAL. (c) Use a surface water source, building a new water treatment plant or those planning major improvements to water treatment plants that are beyond the water treatment plant's useful life.
- Approved capacity basis of design table required if changing capacity of sources or treatment
- Easement information

Source Water Information

- Information to assure an adequate quantity and quality of raw water.
- For wells:
    - Site approval required. System must complete a well site application and have a well site acceptance letter.
    - Ensure proper construction by submitting a well profile and construction form
    - Well log
    - Pump test or aquifer test reports
    - Complete well analysis results
- For surface water sources:
    - Safe yield study
    - Source water sampling in accordance with OAC 3745-81-71

Plant Project Information

- Project location
- Site plan
- Demolition plan
- Grading plan
- Yard piping
- Stormwater, sanitary service at site
- Plan view of building and rooms, storage areas, etc. for dimensions and location of equipment
- Floor plan
- Laboratory construction for DDAGW's laboratory certification approval
- Containment volume dimensions shown for chemical storage areas (if not provided elsewhere)
- Shared walls for raw and finished water
- Sections which show relevant plant equipment locations and detail of piping
- Process schematics or P&IDs (piping and instrumentation diagrams/drawings)
- Building plan showing process piping from one area to another
- Location of chemical application points in the plan view
- Plan views and cross sections of plant process units to adequately show how all parts of the process work, include dimensions and elevations. Used to determine detention times, loading rates, etc.
- Process equipment specifications
- Waste handling information
- Schedules of HVAC equipment to show adequate HVAC for chemical storage areas
- Plumbing schematic – water and sewer
- Show adequate backflow prevention
- Standby power/generator information
- Plan and profile drawings for distribution system projects

Additional Items for Gaseous Chlorine Systems

- Electrical details
- HVAC
- Directional views and roof views for exhausts and fans. Door and window details of gaseous chlorine room and any engineering controls.

Engineer's Report Subcommittee: Linda Weavers; Maria Lucente; Jeff Davidson; Tim Wolfe; Matt Charles; Dave Kohlmeier.