Memorandum

To: *Charles Dam, P.E.*

From: *Alan LeBlanc, P.E., BCEE*
Maddison Vidal, P.E.

Date: *April 29, 2024*

Subject: *Manchester-by-the-Sea Gravelly Pond Water Treatment Plant and Lincoln Street Well PFAS Treatment Evaluation*
Task 5 – Alternatives Matrix for PFAS Removal Options – Executive Summary

At the request of the Town of Manchester-by-the-Sea, Massachusetts (the Town or MBTS), CDM Smith performed an evaluation of per- and polyfluoroalkyl substances (PFAS) mitigation options for the Gravelly Pond water treatment plant (WTP). The goal of this Task 5 analysis was to summarize the findings from previous work and offer a comparison of these alternatives to determine which will be the best solution for MBTS to achieve continued systemwide PFAS compliance. This alternatives evaluation includes the Town's Gravelly Pond and Lincoln Street Well (LSW) supplies, and frames the alternatives considered and the systemwide PFAS compliance options as summarized herein. CDM Smith is pleased to offer this executive summary, which offers a comparison of the findings from previous work, lifecycle cost analysis, and recommendations for next steps.

Introduction

This executive summary describes the various alternatives that have been investigated as part of CDM Smith's PFAS evaluation work for MBTS, which has been conducted in two separate phases, one each for the two water sources of Lincoln Street Well and Gravelly Pond WTP.

Combinations of alternatives described herein are presented in consideration of systemwide PFAS treatment at both LSW and Gravelly Pond WTP, for overall MBTS water system PFAS compliance with state and federal regulations.

Costs – Capital and Operating

This section summarizes the anticipated capital and PFAS treatment operating costs relative to media replacement and pump power costs for each alternative. Also discussed are the Opinion of Probable Construction Costs (OPCCs) that serve as the basis of the capital costs, and finally a sensitivity analysis for media costs and replacement frequency.

An OPCC was developed for each alternative concept using budget-level, treatment equipment cost estimates from manufacturers, quantity takeoff from the conceptual layout drawings, and material and labor costs typical for New England. The OPCCs presented herein are used as the basis of the capital costs for the Life Cycle Cost Analysis (LCCA) but it should be noted that these capital costs only consider

construction costs, without allowances for engineering and implementation or other project cost additions. A summary of the OPCC for each alternative is presented in **Table ES-1** below.

Table ES-1. Opinions of Probable Construction Cost[1]

Concept	Alternative	OPCC [1] (construction only)
Conveyance of LSW to Gravelly Pond WTP - PVC	1 - PVC	$11,500,000
Conveyance of LSW to Gravelly Pond WTP - DI	1 - DI	$13,000,000
New GAC in Existing Filters - Standard Media	2	$120,000
Post Filter GAC Contactors (1.5 MGD Reuse Garage) – Standard GAC Media	3 - STD 1.5	$10,600,000
Post Filter GAC Contactors (3.0 MGD Standalone Building) – Standard GAC Media	3 - STD 3.0	$13,600,000
Post Filter GAC Contactors (1.5 MGD Reuse Garage) – Double Acid Washed GAC Media	3 - AW 1.5	$10,700,000
Post Filter GAC Contactors (3.0 MGD Standalone Building) – Double Acid Washed GAC Media	3 - AW 3.0	$13,700,000
LSW Greensand and Standard GAC Media	LSW - STD	$9,700,000
LSW Greensand and Double Acid Washed GAC Media	LSW - AW	$9,800,000

[1] Engineering and implementation costs are not included.

Media replacement is the primary contributor to the operating costs, with estimated pump power costs also included for the new PFAS treatment systems only. CDM Smith highlights that all annual cost values presented are for initial estimate purposes only and must be refined upon completion of bench- and/or pilot-scale testing.

A summary of the operating costs for each alternative is presented in **Table ES-2** below.

Table ES-2. Annual Operating Costs (Media Changeout and Pumping) Based on Media Replacement Sensitivity Analysis

Concept	Description	Media Unit Cost1	Assumed Media Replacement Frequency	Annual Operating Cost[1] - Low	Annual Operating Cost[1] - High
Conveyance of LSW to Gravelly Pond WTP - PVC	1 - PVC	Not Applicable	Not Applicable	$14,000	
Conveyance of LSW to Gravelly Pond WTP - DI	1 - DI	Not Applicable	Not Applicable	$14,000	
New GAC in Existing Filters - Standard Media	2	$3.90/lb	Every 3-6 months	$210,000	$420,000
Post Filter GAC Contactors (1.5 MGD Reuse Garage) – Standard GAC Media	3 - STD 1.5	$2.30/lb	Every 6-24 months	$56,000	$159,000
Post Filter GAC Contactors (3.0 MGD Standalone Building) – Standard GAC Media	3 - STD 3.0	$2.30/lb	Every 6-24 months	$110,000	$317,000
Post Filter GAC Contactors (1.5 MGD Reuse Garage) – Double Acid Washed GAC Media	3 - AW 1.5	$4.13/lb	Every 6-24 months	$83,000	$269,000
Post Filter GAC Contactors (3.0 MGD Standalone Building) – Double Acid Washed GAC Media	3 - AW 3.0	$4.13/lb	Every 6-24 months	$165,000	$537,000

Concept	Description	Media Unit Cost1	Assumed Media Replacement Frequency	Annual Operating Cost[1] - Low	Annual Operating Cost[1] - High
LSW Greensand[2] and Standard GAC Media	LSW - STD	$2.30/lb	Every 12-24 months	$16,000	$27,000
LSW Greensand[3] and Double Acid Washed GAC Media	LSW - AW	$4.13/lb	Every 12-24 months	$25,000	$45,000

[1] Media unit costs consider the removal, disposal, placement of virgin GAC and labor costs associated with changeout.

[2] Includes estimated costs associated with media changeout which vary as a function of the sensitivity analysis. Also included are estimated pumping costs which are fixed based on design capacity.

[3] Media replacement costs do not consider GreensandPlus filter media for LSW, which has been known to have a 20-year or more lifespan based on industry experience.

Lifecycle Cost Analysis

Based on the capital costs and operational and maintenance (O&M) costs, a LCCA was conducted as a means of comparing the net present value (NPV) for each alternative over a 25-year lifespan. The costs for each alternative were inflated and compounded annually and then brought to NPV for comparison. The analysis assumed the same inflation and interest rates and project lifecycle period for all alternatives. The interest rate of 5.0%, the Operating Cost inflation of 3.0%, and the project lifespan of 25 years were used. Project contingency, engineering, and implementation, permitting and pilot testing costs are not included in this analysis. Graphical representation of the capital costs and the range of Net Present Values of the 25-year lifecycle costs for each alternative are presented in **Figure ES-1** in ascending order.

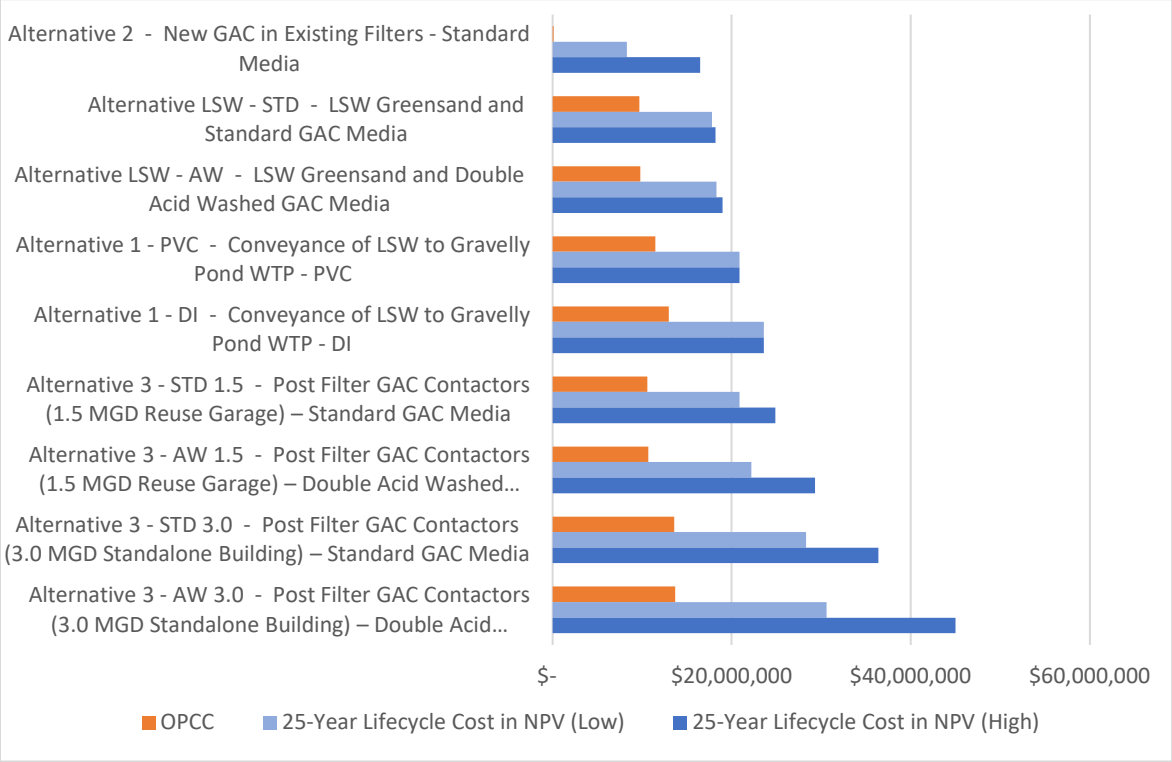

Figure ES-1. Summary of Capital and 25-Year Net Present Value Lifecycle Costs

The figure presents the range of LCCA costs estimated for each alternative, inclusive of the capital cost (OPCC) to construct each alternative and the annualized costs to operate the system over a 25-year lifespan. This overall cost is presented in terms of NPV. Based on the results of this comparative financial analysis, replacement of the existing Gravelly Pond filter media with GAC media is the most cost-effective alternative. However, it is important to emphasize the importance of pilot testing as it is not guaranteed that this alternative will function as intended and may not provide an adequate means of PFAS removal based on MBTS's treatment goals and long-term objectives for Gravelly Pond WTP. Additionally, this alternative does not address systemwide PFAS concerns.

It is important to also consider the combinations or 'scenarios' that would pair alternatives to achieve MBTS's treatment objectives of systemwide PFAS compliance. The combinations of alternatives considered are summarized below:

- Scenario 1 – Alternative 2 + LSW Alternative (AW GAC)
- Scenario 2 – Alternative 3 (3.0 mgd AW GAC) + LSW Alternative (AW GAC)
- Scenario 3 – Alternative 1 (DI) + Alternative 3 (3.0 mgd AW GAC) + Supplemental Booster Station

These scenarios were selected based on MBTS's treatment goals and the most conservative variation (full design capacity, double acid washed GAC) of each alternative was carried. The overall cost of each scenario (or combination of alternatives) is presented in **Table ES-3**.

Table ES-3. Lifecycle Cost Analysis of Scenarios

Scenario	Concept	Capital Cost[1]	25-Year Lifecycle Cost (Low)		25-Year Lifecycle Cost (High)
Scenario 1	Replace existing filter media at Gravelly Pond WTP with GAC and construct LSW treatment	$9,900,000	$26,600,000	to	$35,500,000
Scenario 2	Treat water matrices separately at Gravelly Pond WTP and LSW	$23,500,000	$48,900,000	to	$64,000,000
Scenario 3	Conveyance of LSW to Gravelly Pond WTP for centralized treatment, includes provisions for booster pump station	$27,900,000	$57,200,000	to	$71,600,000

[1] Capital costs consider treatment of the full GPWTP capacity and assumes the use of AW GAC media. Engineering and implementation costs are not included.

Based on the results of this comparative financial analysis, Scenario 1, replacement of the existing Gravelly Pond filter media with GAC media when paired with construction of LSW iron and manganese and PFAS treatment is the most cost-effective systemwide PFAS mitigation solution. However, this is contingent upon GAC media installation in the existing Gravelly Pond filters operating optimally and achieving appreciable PFAS removal, which is still to be pilot tested before a conclusion can be made.

Next Steps for MBTS Consideration and Recommendations

Based on the results of the comparative financial analysis, it is recommended that the Town of Manchester-by-the-Sea proceed with individual PFAS treatment of both water supplies.

Based on the results of the alternative analysis and LCCA presented in this memorandum, the following recommendations are made:

CDM Smith recommends that that the Town consider the following next steps:

- Continue to regularly monitor PFAS concentrations at Gravelly Pond and LSW to stay informed and remain proactive, with a goal of making decisions on systemwide treatment objectives.
- Based on the results of the financial analysis, it is recommended that MBTS proceed with full-scale piloting at the Gravelly Pond WTP. It is recommended that MBTS proceed with bench scale testing of the individual water matrices in parallel, to ensure long term compliance can be achieved even if the pilot testing of GAC in the existing Gravelly Pond filters proves unsuccessful.
- It is recommended that MBTS proceed with bench-scale and pilot testing of the LSW water matrix to assess iron and manganese and PFAS removal efficacy with the proposed technologies.
- Non-cost-related criteria to be considered when adding treatment at either water supply include the resiliency provided by maintaining two water supply sources and the impact to daily operation, among other criteria.
- If MBTS is interested in further understanding the cost impact to customers by proceeding with the construction of two PFAS treatment systems, a rate study is recommended.

cc: Dave Burnett, P.E., PMP, Michaela Bogosh, P.E., PMP, Lisa Gove, P.E. – CDM Smith